# SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT A1 – TECHNICAL SCHEDULE OF SUBMITTALS

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| | | | Bidder name | |
| **General Remarks:** | | | | |
| Unless otherwise noted: | | | | |
| Data are per unit | | | | |
| Operational data are for BMCR, TMCR, 75% TMCR & 50% TMCR for design coal and check / worst coal as per Attachment B3. | | | | |
| | | | | |
| **Boiler** | | | | |
| Number of Steam Generator units | - | Two (2) | | |
| Type/characteristics | - | ultra-supercritical variable-pressure operation, Two pass Direct coal firing boiler,single reheat, tangential firing , balanced draft, outdoor arrangement, dry ash extraction, all-steel suspension structure. | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Type and Model | - | | | |
| Standards to which Steam Generator will be designed and manufactured | - | ASME | | |
| Cladding (i.e. outdoor or indoor type) | - | outdoor or semi-outdoor type | | |
| | | | | |
| **Ambient conditions:** | - | Refer Section-5,Chapter-1 | | |
| | | | | |
| **Fuel specification:** | | | | |
| main fuel: coal | - | Refer Attachment B3 | | |
| start-up fuel: high-speed diesel (HSD) | - | Refer Attachment B3 | | |
| | | | | |
| **Emissions** | - | Refer Section-5**,** Chapter-1 | | |
| | | | | |
| **Operational characteristics:** | | | | |
| Maximum load with high speed diesel oil (LD0) | % | 30 | | |
| Minimum load with coal fire | % | 30 | | |
| Maximum load with coal fire (at all coals) | % | BMCR | | |
| Operation mode | - | base load | | |
| Minimum uninterrupted operation (capable) | h | 6500 | | |
| Expected operation hours per year | h/a | 6500 | | |
| Expected number of starts during per year | | | | |
| Number of cold starts per year* | | | | |
| Number of warm starts per year* | | | | |
| Number of hot starts per year* | | | | |
| *The starts shall be defined as follows:<br>i. Cold start: Steam section at ambient conditions (The unit out of services for 48 hours or more).<br>ii. Warm start: Boiler bottled up (The unit out of service more than 8 hours but no more than 48 hours).<br>iii. Hot start: Restart as soon as trip or down condition identified and addressed. Normally this is less than 8 hours after trip or shutdown. | | | | |
| Required start-up times<br>(from first fire to ST full load) | - | | | |
| Required rates of load change | - | | | |
| Number of pulverizers | - | Minimum 6 | | |
| Maximum loss on ignition acc. to ASTM C311 for bottom ash (for all coals) | % | ASTM C311 | | |
| Maximum loss on ignition acc. to ASTM C311 for fly ash (for all coals) | % | ASTM C311 | | |
| Max. pressure deviation from setpoint (steady load) | bar | + / - 2.0 | | |
| Max. temperature deviation HP/RH from setpoint (steady load) | °C | + / - 5.0 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Max. temperature deviation HP from setpoint (load changes) | °C | + / - 5.0 | | |
| Max. temperature deviation RH from setpoint (load changes) | °C | + / - 5.0 | | |
| | | | | |
| **Allowable (nominal) working pressure** | | | | |
| Main steam section | bar(g) | according to plant optimization: more than 276 | | |
| Reheat steam section | bar(g) | according to plant optimization | | |
| Reheater pressure drop (inlet header to outlet header) | bar | | | |
| | | | | |
| **Nominal live steam pressure** | | | | |
| Main steam section | bar(g) | according to plant optimization | | |
| Reheat steam section | bar(g) | according to plant optimization | | |
| Nominal live steam temperatures | | | | |
| Main Steam (at turbine inlet) | °C | according to plant optimization: | | |
| Reheat Steam (at turbine inlet) | °C | according to plant optimization: | | |
| | | | | |
| **Feedwater conditions** | | | | |
| Feedwater pressure | bar(g) | according to plant optimization | | |
| Feedwater temperature | °C | according to plant optimization | | |
| | | | | |
| **Water and steam qualities** | | | | |
| Feedwater quality | - | ASME | | |
| Boiler water quality | - | ASME | | |
| Spray water quality | - | ASME | | |
| Steam purity (HP) | - | ASME | | |
| | | | | |
| **Design construction criteria** | | | | |
| **Heating surfaces** | | | | |
| Temperature of metal surfaces in contact with flue gas | °C | | | |
| Minimum distance between convective tube banks | m | 1.5 | | |
| Maximum height of convective tube bundles (plain tubes) | m | 2 | | |
| Minimum horizontal tube pitch (across flue gas path) | - | 2.2 x tube diameter | | |
| Absolute minimum horizontal tube pitch (across flue gas path) | mm | 75 | | |
| Minimum longitudinal tube pitch (along flue gas path) | - | 2 x tube diameter | | |
| Absolute minimum longitudinal tube pitch (along flue gas path) | mm | 55 | | |
| Maximum heat-up rate of final SH and final RH (BMCR, performance fuel) | °/min | 2.8 | | |
| Minimum add-on reserve for SH & RH heating surfaces | % | 10 | | |
| Minimum add-on reserve for economizer heating surfaces | % | 20 | | |
| Minimum add-on reserve for air heater heating surfaces | % | 15 | | |
| Clear (free) opening of access, maintenance, inspection doors and manholes | mm | minimum 600 | | |
| Maximum flue gas velocity at furnace outlet / furnace throat | m/s | | | |
| Maximum flue gas velocity in SH and RH section | m/s | ≤ 12 | | |
| Maximum flue gas velocity in economizer section | m/s | ≤ 12 | | |
| Maximum flue gas velocity in air heater | m/s | ≤ 12 | | |
| Minimum angle of bottom hopper (w.r.t. horizontal) | ° | 55 | | |
| Minimum width of bottom opening | m | 1.0 | | |
| Minimum transverse pitch where flue gas temperature exceed the ash initial deformation temperature | mm | | | |
| | | | | |
| **Steel structure** | | | | |
| Manufacturer | - | | | |
| Codes to which steel structure will be manufactured | - | Refer Section-5, Chapter-3 | | |
| Estimated total quantity of steel per boiler | t | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Design criteria of supporting structure for furnace buckstays | - | | | |
| Design criteria for FG ducts with respect to ash | - | | | |
| Design criteria for ESP hoppers | - | | | |
| | | | | |
| **Boiler insulation and refractory** | | | | |
| Max. temperature at outer face of insulation | °C | Temp.range above 300 °C = Δt = 20 °C<br>тemp. range from 200 to 300 °C = Δt = 15 °C<br>Temp. Less than 200 °C = Δt = 10 °C | | |
| Total heat loss of boiler | kW | | | |
| Type of refractory | - | | | |
| Components with refractory | - | | | |
| Operational lifetime | h | | | |
| Type of brick setting | - | | | |
| Components with brick setting | - | | | |
| Operational lifetime | h | | | |
| | | | | |
| **Coal bunkers:** | | | | |
| Number of bunkers | - | To be decided based on number of pulverizers installed. | | |
| Coal bunker shape | - | Round | | |
| Total useable storage capacity per bunker | t | Equivalent to 12 h operation with worst fuel at BMCR with one pulverizer out of operation | | |
| Sheet thickness | mm | | | |
| Lining material | - | Stainless steel | | |
| Lining thickness | mm | Minimum 6 | | |
| Width of bunker discharge | m | Minimum 1 | | |
| hopper walls minimum inclination | ° | 70(min) | | |
| Type of bunker discharge isolating gates | - | Motorized | | |
| | | | | |
| **Coal feeders:** | | | | |
| Number of feeders | - | To be decided based on number of pulverizers installed. | | |
| Type of feeder | - | Gravimetric | | |
| Max. capacity | t/h | at least 1.25 times pulverizer capacity | | |
| Speed variation (max./min.) | rpm | | | |
| Conveying width | mm | | | |
| Max. coal bed height | mm | | | |
| Max. design explosion pressure | bar | As per NFPA85 | | |
| Rated power | kW | | | |
| Inner lining material | - | | | |
| Chute material | - | | | |
| weighting accuracy | % | +/- 0.5 | | |
| weighting repeatability | % | +/- 0.1 | | |
| capacity of feeder with respect to pulverizer | % | 125 | | |
| | | | | |
| **Pulverizer system:** | | | | |
| Number of pulverizers | - | To be decided based on the Boiler design. However, there shall be ONE spare pulverizer with worst coal at BMCR | | |
| Type and model of pulverizers | - | Vertical Spindle | | |
| Manufacturer of pulverizer | - | | | |
| Origin of Manufacturer | | | | |
| Classifier type | - | | | |
| Classifier range | | | | |
| Number of pulverizers in operation / BMCR / Design Coal | - | | | |
| Number of pulverizers in operation / BMCR / Worst Coal | - | n+1 | | |
| Coal flow rate / BMCR / Performance Fuel | kg/s | | | |
| Coal flow rate / BMCR / Worst Coal | kg/s | | | |
| Hot air flow rate / BMCR / Performance Fuel | kg/s | | | |
| Hot air flow rate / BMCR / Worst Coal | kg/s | | | |
| Cold or tempering air flow rate / BMCR / Performance Fuel | kg/s | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Cold or tempering air flow rate / BMCR / Worst Coal | kg/s | | | |
| Pressure difference across pulvarizer BMCR / Performance Fuel | mbar | | | |
| Pressure difference across pulvarizer BMCR / Worst Coal | mbar | | | |
| Fineness of grinding<br>(Min 85% through 200 mesh for design fuel) | % | | | |
| Fineness of grinding<br>(Min 85% through 200 mesh worst fuel) | % | | | |
| Temperature / BMCR / Performance Fuel | °C | | | |
| Classifier temperature / BMCR / Worst Coal | °C | | | |
| Classifer temperature, maximum allowable value | °C | | | |
| Power consumption at BMCR, 100 (660MW), 75 & 50% TMCR/Performance Fuel with break-up | kW | | | |
| Cooling water consumption of various equipment | kg/s | | | |
| Pulverizer driving motor rating | kW | | | |
| Pulverizer driving motor speed | $min^{-1}$ | | | |
| Total mass incl. gear and motor for pulvarizer | t | | | |
| Lube oil system type | | | | |
| Number and capacity of lube oil pumps | - / % | | | |
| Number and capacity of lube oil coolers | - / % | | | |
| Inertising medium for coal pulverizers and pipes | - | | | |
| Pulverizer reject / pyrite rate (maximum, average) | t/h | | | |
| Design pressure of pulverizer housing | bar | As per NFPA85 | | |
| | | | | |
| **Pulverized coal dust piping:** | | | | |
| PC dust velocity (minimum / maximum) | m/s | | | |
| number of splitters | - | | | |
| number of PC dust elbows | - | | | |
| Lining material of PC dust elbows | - | ceramic | | |
| Provision for equalizing coal / air mixture | - | | | |
| | | | | |
| **Firing system layout:** | | | | |
| Firing concept (tangential, ...) | - | | | |
| Number of burner levels | - | | | |
| Total number of burners | - | | | |
| | | | | |
| **Coal burners:** | | | | |
| Number | - | | | |
| Burner type (swirl, jet, ...) | - | | | |
| Manufacturer and Model | - | | | |
| Burner maximum thermal rating | MW | | | |
| Type and model of flame monitor | - | | | |
| Turn-down ratio | | | | |
| maximum angle upward for tilting burner | ° | | | |
| Type of tilting mechanism | - | | | |
| | | | | |
| **HSD firing system:** | | | | |
| Number of burners | - | | | |
| Manufacturer and Type | - | | | |
| Maximum HSD firing capacity (as proportion of MCR) | % | | | |
| Maximum HSD firing rate (per burner) | kg/h | | | |
| Burner maximum thermal rating (oil fire) | MW | | | |
| HSD atomization type (pressurized, rotary, etc...) | - | | | |
| Type and Model of Ignitor | - | | | |
| Type and model of flame monitor | - | | | |
| Slop oil tank capacity | $m^3$ | | | |
| Slop oil pump capacity | kg/s | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| | | | | |
| **Stoichiometry (BMCR, Design Coal):** | | | | |
| Excess air number with primary air | - | | | |
| Excess air number with secondary air | - | | | |
| Excess air number with tertiary air | - | | | |
| Excess air number with overfire air (OFA) | - | | | |
| | | | | |
| **Furnace** | | | | |
| Burner belt area<br>(measured from bottom of lowest burner in operation to top of highest burner in operation) | $m^2$ | | | |
| Furnace cross-section | $m^2$ | | | |
| Furnace volume | $m^3$ | | | |
| Bottom hopper angle (w.r.t. horizontal) | ° | | | |
| Bottom hopper opening width | m | | | |
| | | | | |
| **Furnace limiting values according to boiler manufacturers experience (to be proven, heat input by fuel and hot air):** | | | | |
| Maximum burner belt heat release | $MW/m^2$ | | | |
| Maximum furnace cross-sectional heat release | $MW/m^2$ | | | |
| Maximum furnace volume heat release | $MW/m^3$ | | | |
| Residence time between top of burner and furnace exit | s | | | |
| | | | | |
| **Furnace characteristics<br>(BMCR, Design Coal, heat input by fuel and hot air):** | | | | |
| Burner belt heat release | $MW/m^2$ | | | |
| Furnace cross-sectional heat release | $MW/m^2$ | | | |
| Furnace volume heat release | $MW/m^3$ | | | |
| Furnace exit gas temperature (FEGT) | °C | | | |
| Residence time between top of burner and furnace exit | s | | | |
| | | | | |
| **Furnace characteristics<br>(BMCR, worst coal*, heat input by fuel and hot air):** | | | | |
| Burner belt heat release | $MW/m^2$ | | | |
| Furnace cross-sectional heat release | $MW/m^2$ | | | |
| Furnace volume heat release | $MW/m^3$ | | | |
| Furnace exit gas temperature (FEGT) | °C | | | |
| Residence time between top of burner and furnace exit | s | | | |
| * worst coal being here defined as the coal leading to the highest of these parameters at BMCR | | | | |
| | | | | |
| **Operational data<br>(at BMCR, with Design and worst coal):** | | | | |
| Live steam flow rate | kg/s | | / / | |
| Feedwater flow rate | kg/s | | / / | |
| SH spray attemperation flow rate | kg/s | | / / | |
| RH entry flow rate | kg/s | | / / | |
| RH spray attemperation flow rate | kg/s | | / / | |
| RH exit flow rate | kg/s | | / / | |
| Feedwater temperature | °C | | / / | |
| Economizer outlet temperature | °C | | / / | |
| Evaporator temperature | °C | | / / | |
| Superheater 1 inlet (after support tubes) | °C | | / / | |
| Attemperator 1 outlet temperature | °C | | / / | |
| Superheater 2 outlet temperature | °C | | / / | |
| Attemperator 2 outlet temperature | °C | | / / | |
| Live steam temperature | °C | | / / | |
| Reheater inlet temperature | °C | | / / | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Reheater 1 outlet temperature | °C | | / / | |
| Reheater attemperator outlet temperature | °C | | / / | |
| Reheater outlet temperature | °C | | / / | |
| Feedwater pressure | bar(g) | | / / | |
| Separator pressure | bar(g) | | / / | |
| Live steam pressure | bar(g) | | / / | |
| Reheater inlet pressure | bar(g) | | / / | |
| Reheater outlet pressure | bar(g) | | / / | |
| Excess air number at top of burners | - | | / / | |
| Excess air number at furnace outlet | - | | / / | |
| Excess air number at economizer (air heater inlet) | - | | / / | |
| Excess air number at air heater outlet | - | | / / | |
| Flue gas exit temperature before air heater | °C | | / / | |
| Flue gas exit temperature after air heater | °C | | / / | |
| | | | | |
| **Operational data (at 100% TMCR, with Design and worst coal):** | | | | |
| Live steam flow rate | kg/s | | / / | |
| Feedwater flow rate | kg/s | | / / | |
| SH spray attemperation flow rate | kg/s | | / / | |
| RH entry flow rate | kg/s | | / / | |
| RH spray attemperation flow rate | kg/s | | / / | |
| RH exit flow rate | kg/s | | / / | |
| Feedwater temperature | °C | | / / | |
| Economizer outlet temperature | °C | | / / | |
| Evaporator temperature | °C | | / / | |
| Superheater 1 inlet (after support tubes) | °C | | / / | |
| Attemperator 1 outlet temperature | °C | | / / | |
| Superheater 2 outlet temperature | °C | | / / | |
| Attemperator 2 outlet temperature | °C | | / / | |
| Live steam temperature | °C | | / / | |
| Reheater inlet temperature | °C | | / / | |
| Reheater 1 outlet temperature | °C | | / / | |
| Reheater attemperator outlet temperature | °C | | / / | |
| Reheater outlet temperature | °C | | / / | |
| Feedwater pressure | bar(g) | | / / | |
| Separator pressure | bar(g) | | / / | |
| Live steam pressure | bar(g) | | / / | |
| Reheater inlet pressure | bar(g) | | / / | |
| Reheater outlet pressure | bar(g) | | / / | |
| Excess air number at top of burners | - | | / / | |
| Excess air number at furnace outlet | - | | / / | |
| Excess air number at air heater inlet | - | | / / | |
| Excess air number at air heater outlet | - | | / / | |
| Flue gas exit temperature before air heater | °C | | / / | |
| Flue gas exit temperature after air heater | °C | | / / | |
| | | | | |
| **Operational data (at 75% TMCR, with Design and worst coal):** | | | | |
| Live steam flow rate | kg/s | | / / | |
| Feedwater flow rate | kg/s | | / / | |
| SH spray attemperation flow rate | kg/s | | / / | |
| RH entry flow rate | kg/s | | / / | |
| RH spray attemperation flow rate | kg/s | | / / | |
| RH exit flow rate | kg/s | | / / | |
| Feedwater temperature | °C | | / / | |
| Economizer outlet temperature | °C | | / / | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Evaporator temperature | °C | | / / | |
| Superheater 1 inlet (after support tubes) | °C | | / / | |
| Attemperator 1 outlet temperature | °C | | / / | |
| Superheater 2 outlet temperature | °C | | / / | |
| Attemperator 2 outlet temperature | °C | | / / | |
| Live steam temperature | °C | | / / | |
| Reheater inlet temperature | °C | | / / | |
| Reheater 1 outlet temperature | °C | | / / | |
| Reheater attemperator outlet temperature | °C | | / / | |
| Reheater outlet temperature | °C | | / / | |
| Feedwater pressure | bar(g) | | / / | |
| Separator pressure | bar(g) | | / / | |
| Live steam pressure | bar(g) | | / / | |
| Reheater inlet pressure | bar(g) | | / / | |
| Reheater outlet pressure | bar(g) | | / / | |
| Excess air number at top of burners | - | | / / | |
| Excess air number at furnace outlet | - | | / / | |
| Excess air number at air heater inlet | - | | / / | |
| Excess air number at air heater outlet | - | | / / | |
| Flue gas exit temperature before air heater | °C | | / / | |
| Flue gas exit temperature after air heater | °C | | / / | |
| | | | | |
| **Operational data (at 50% TMCR, with Design and worst coal):** | | | | |
| Live steam flow rate | kg/s | | / / | |
| Feedwater flow rate | kg/s | | / / | |
| SH spray attemperation flow rate | kg/s | | / / | |
| RH entry flow rate | kg/s | | / / | |
| RH spray attemperation flow rate | kg/s | | / / | |
| RH exit flow rate | kg/s | | / / | |
| Feedwater temperature | °C | | / / | |
| Economizer outlet temperature | °C | | / / | |
| Evaporator temperature | °C | | / / | |
| Superheater 1 inlet (after support tubes) | °C | | / / | |
| Attemperator 1 outlet temperature | °C | | / / | |
| Superheater 2 outlet temperature | °C | | / / | |
| Attemperator 2 outlet temperature | °C | | / / | |
| Live steam temperature | °C | | / / | |
| Reheater inlet temperature | °C | | / / | |
| Reheater 1 outlet temperature | °C | | / / | |
| Reheater attemperator outlet temperature | °C | | / / | |
| Reheater outlet temperature | °C | | / / | |
| Feedwater pressure | bar(g) | | / / | |
| Separator pressure | bar(g) | | / / | |
| Live steam pressure | bar(g) | | / / | |
| Reheater inlet pressure | bar(g) | | / / | |
| Reheater outlet pressure | bar(g) | | / / | |
| Excess air number at top of burners | - | | / / | |
| Excess air number at furnace outlet | - | | / / | |
| Excess air number at air heater inlet | - | | / / | |
| Excess air number at air heater outlet | - | | / / | |
| Flue gas exit temperature before air heater | °C | | / / | |
| Flue gas exit temperature after air heater | °C | | / / | |
| | | | | |
| **Operational data (at BMCR, with Design and worst coal w/o HP heater):** | | | | |
| Live steam flow rate | kg/s | | / / | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Feedwater flow rate | kg/s | | / / | |
| SH spray attemperation flow rate | kg/s | | / / | |
| RH entry flow rate | kg/s | | / / | |
| RH spray attemperation flow rate | kg/s | | / / | |
| RH exit flow rate | kg/s | | / / | |
| Feedwater temperature | °C | | / / | |
| Economizer outlet temperature | °C | | / / | |
| Evaporator temperature | °C | | / / | |
| Superheater 1 inlet (after support tubes) | °C | | / / | |
| Attemperator 1 outlet temperature | °C | | / / | |
| Superheater 2 outlet temperature | °C | | / / | |
| Attemperator 2 outlet temperature | °C | | / / | |
| Live steam temperature | °C | | / / | |
| Reheater inlet temperature | °C | | / / | |
| Reheater 1 outlet temperature | °C | | / / | |
| Reheater attemperator outlet temperature | °C | | / / | |
| Reheater outlet temperature | °C | | / / | |
| Feedwater pressure | bar(g) | | / / | |
| Separator pressure | bar(g) | | / / | |
| Live steam pressure | bar(g) | | / / | |
| Reheater inlet pressure | bar(g) | | / / | |
| Reheater outlet pressure | bar(g) | | / / | |
| Excess air number at top of burners | - | | / / | |
| Excess air number at furnace outlet | - | | / / | |
| Excess air number at air heater inlet | - | | / / | |
| Excess air number at air heater outlet | - | | / / | |
| Flue gas exit temperature before air heater | °C | | / / | |
| Flue gas exit temperature after air heater | °C | | / / | |
| | | | | |
| Minimum load with full-load SH outlet temperature | % | | | |
| Minimum load with full-load RH outlet temperature | % | | | |
| | | | | |
| **Expected Emissions at air heater outlet (BMCR, Performance fuel):** | | | | |
| Total particles * | mg/m³ | | | |
| Nitrogen oxide (NOx)-emissions (measured values converted to $NO_2$) * | mg/m³ | | | |
| Sulfur dioxide ($SO_2$)-emissions * | mg/m³ | | | |
| Carbon monoxide (CO)-emissions * | mg/m³ | | | |
| Opacity | % | | | |
| * measured values converted to standard conditions ( 1013mbar, 0°C) and 6% $O_2$ in moisture free flue gas | | | | |
| | | | | |
| **Sootblowers** | | | | |
| Number of blowing cycles per day | - | 3 | | |
| | | | | |
| **Sootblowers in furnace** | | | | |
| Number | - | | | |
| Type | - | | | |
| | | | | |
| **Sootblowers for SH** | | | | |
| Number | - | | | |
| Type | - | | | |
| | | | | |
| **Sootblowers for RH** | | | | |
| Number | | | | |
| Type | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| | | | | |
| **Sootblowers for ECO** | - | | | |
| Number | - | | | |
| Type | | | | |
| | | | | |
| **Sootblowers for RAPH** | | | | |
| Number | - | | | |
| Type | - | | | |
| | | | | |
| **Water/Steam system:** | | | | |
| Circulation system | - | Once-through with part load circulation | | |
| Superheater temperature control (spray attemperator,...) | - | spray attemperator | | |
| Reheater temperature control (spray attemp., dampers, ...) | - | spray attemperator + flue gas damper, tilting burner, reheat bypass | | |
| | | | | |
| **Low load circulation pumps** | | | | |
| Number | - | | | |
| Type | - | | | |
| Capacity | kg/s | | | |
| | | | | |
| **Safety valve manufacturer** | | | | |
| **Safety valve type** | | | | |
| **Separator safety valve** | | | | |
| Number | - | | | |
| Capacity | % BMCR steam | | | |
| Set pressure | bar | | | |
| | | | | |
| **Superheater safety valve** | | | | |
| Number | - | | | |
| Capacity | % BMCR steam | | | |
| Set pressure | bar | | | |
| **Hot reheat safety valve** | | | | |
| Number | - | | | |
| Capacity | % BMCR steam | | | |
| Set pressure | bar | | | |
| | | | | |
| **HP-steam bypass station** | | | | |
| HP bypass capacity (referring to BMCR) | % | minimum 60<br>(sizing must ensure that SH safety valves to not open at full load turbine trip) | | |
| Number of HP bypass valves per Unit | | 2 | | |
| Capacity of steam | t/h | | | |
| Spray water injection flow | t/h | | | |
| Type of drives /actuators | - | | | |
| Type of construction | - | | | |
| Number of stages | - | | | |
| Manufacturer | - | | | |
| Origin of manufacturer | - | | | |
| | | | | |
| **Blow-down / flash tank** | | | | |
| Blow-down rate | kg/h | | | |
| Flash tank volume | $m^3$ | | | |
| | | | | |
| **Boiler drain flash tank** | | | | |
| Design flow rate | kg/h | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Volume | $m^3$ | | | |
| | | | | |
| **Separators** | | | | |
| Number of separators | - | | | |
| Internal diameter | mm | | | |
| Length of cylinder | mm | | | |
| Total volume | $m^3$ | | | |
| Wall material | - | | | |
| Wall thickness of cylinder | mm | | | |
| Erosion allowance | mm | | | |
| Corrosion allowance | mm | | | |
| Maximum saturated steam velocity in connecting tubes to SH | m/s | < 12 | | |
| | | | | |
| **Levelling vessel** | | | | |
| Number of separators | - | | | |
| Internal diameter | mm | | | |
| Length of cylinder | mm | | | |
| Wall thickness of cylinder | mm | | | |
| Total volume | $m^3$ | | | |
| Water level operating range (max. - min.) during start-up | mm | | | |
| Wall material | - | | | |
| Minimum size of elliptical manholes | mm | 380 x 425 | | |
| | | | | |
| **Start-up recirculation pump** | | | | |
| Location | - | | | |
| Pump and motor type | - | | | |
| Design flow rate | kg/s | | | |
| Suction pressure at rated capacity | bar | | | |
| Discharge pressure at rated capacity | bar | | | |
| Speed | $min^{-1}$ | | | |
| Pump and motor efficiency | % | | | |
| Power consumption / BMCR / Performance Fuel | kW | | | |
| | | | | |
| **Economizer** | | | | |
| Type of tubes | - | plain tubes | | |
| Number of stages | - | | | |
| Number of tube banks | - | | | |
| Height of each tube bank | m | | | |
| Distance between tube banks | m | | | |
| Material of tubes | - | | | |
| Tube outer diameter | mm | | | |
| Tube wall thickness | mm | | | |
| Erosion allowance | mm | | | |
| Corrosion allowance | mm | | | |
| Effective heating surface | $m^2$ | | | |
| Tube pitch parallel to gas flow | mm | | | |
| Tube pitch across gas flow | mm | | | |
| | | | | |
| **Evaporator (lower furnace)** | | | | |
| Inclination of tubes in waterwall | ° | | | |
| Type of tubes | - | Rifled tubes in case of vertical tubes | | |
| Material of tubes | - | | | |
| Tube outer diameter | mm | | | |
| Tube wall thickness | mm | | | |
| Erosion allowance | mm | | | |
| Corrosion allowance | mm | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Effective heating surface | $m^2$ | | | |
| Tube pitch | mm | | | |
| | | | | |
| **Evaporator (lower furnace)** | | | | |
| Inclination of tubes in waterwall | ° | | | |
| Type of tubes | - | plain tubes or rifled tubes | | |
| Material of tubes | - | | | |
| Tube outer diameter | mm | | | |
| Tube wall thickness | mm | | | |
| Erosion allowance | mm | | | |
| Corrosion allowance | mm | | | |
| Effective heating surface | m2 | | | |
| Tube pitch | mm | | | |
| | | | | |
| **Superheater 1/2/3** | | | | |
| Number of stages | - | | | |
| Number of tube banks | - | | | |
| Height of each tube bank | m | | | |
| Distance between tube banks | m | | | |
| Material of tubes | - | | | |
| Tube outer diameter | mm | | | |
| Tube wall thickness | mm | | | |
| Erosion allowance | mm | | | |
| Corrosion allowance | mm | | | |
| Effective heating surface | $m^2$ | | | |
| Tube pitch parallel to gas flow | mm | | | |
| Tube pitch across gas flow | mm | | | |
| | | | | |
| **Reheater 1/2** | | | | |
| Number of stages | - | | | |
| Number of tube banks | - | | | |
| Height of each tube bank | m | | | |
| Distance between tube banks | m | | | |
| Material of tubes | - | | | |
| Tube outer diameter | mm | | | |
| Tube wall thickness | mm | | | |
| Erosion allowance | mm | | | |
| Corrosion allowance | mm | | | |
| Effective heating surface | $m^2$ | | | |
| Tube pitch parallel to gas flow | mm | | | |
| Tube pitch across gas flow | mm | | | |
| | | | | |
| **Auxiliary Pressure Reducing and Desuperheating Station (PRDS)** | | | | |
| Number of stations | - | | | |
| Type | - | | | |
| Design flow rate | kg/s | | | |
| Auxiliary steam pressure | bar | | | |
| Auxiliary steam temperature | °C | | | |
| Desuperheating design flow rate | kg/s | | | |
| | | | | |
| **Lifetime of wear parts** | | | | |
| **Pulverizer** | | | | |
| Wear parts of pulverizer housing | hours | 24000 | | |
| Rotating nozzle ring elements | hours | 24000 | | |
| Grinding elements on the pulveizer bowl | hours | 10000 | | |
| Grinding roller tyres | hours | 24000 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks by Bidder/Contractor |
|---|---|---|---|---|
| Sealing elements for grinding rollers | hours | 24000 | | |
| Classifier cone | hours | 24000 | | |
| Classifier elements | hours | 24000 | | |
| Other wear parts in pulverizer | hours | 24000 | | |
| **PC piping** | | | | |
| Pulverized coal dust piping elbows | hours | 24000 | | |
| Pulverized coal dust splitters | hours | 24000 | | |
| **Burners** | | | | |
| **Coal nozzle** | hours | 16000 | | |
| Other burner wear parts | hours | 16000 | | |
| | | | | |
| **Auxiliary Boiler** | | | | |
| Number | - | 1 | | |
| Type of auxiliary steam generator | - | | | |
| Location | - | outdoor | | |
| Fuel | - | HSD | | |
| Steam capacity, maximum continuous rating | t/h | | | |
| Steam pressure | bar | | | |
| Design pressure | bar | | | |
| Steam temperature | °C | | | |
| Operating range related to MCR | % | | | |
| Excess air ratio | % | | | |
| Combustion air flow at MCR | kg/s | | | |
| Flue gas flow at MCR | kg/s | | | |
| Flue gas temperature at stack outlet | ºC | | | |
| Firing rate | MW | | | |
| No. Of burners | - | | | |
| Type of burners | - | | | |
| Burner turn-down ratio | - | | | |
| No. Of FD fans | - | Refer Section-5,Chapter-13 | | |
| Total pressure head | mbar | | | |
| Total heating surface | $m^2$ | | | |
| Number and capacity of feedwater pumps | % | Refer Section-5,Chapter-14 | | |
| Capacity of feedwater tank / deaerator | $m^3$ | | | |
| Stack height | m | 275 (minimum) | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | | |
| General Remarks: | | | | |
| Unless otherwise noted:<br>• data are per unit<br>• operational data are for BMCR and Design Coal as per Attachment B3 | | | | |
| | | | | |
| **Steam Turbine Generator Unit (general)** | | | | |
| Number of steam turbine generator units in total | - | 2 | | |
| Turbine type | | Reheat condensing steam turbine | | |
| Operation mode | - | Refer section-5, Chapter 10 | | |
| Turbine design | - | Refer section-5, Chapter 10 | | |
| Permissible deviations of live steam pressure and live steam temperature | - | According to IEC recommendations, latest edition | | |
| Absorption capacity at increased nominal live steam pressure | % | 105 | | |
| Permissible tolerance of absorption capacity | % | -0 / +4 | | |
| Frequency | Hz | 50 | | |
| Permissible frequency deviations at Maximum Continuous Rating | - | Refer section-5, Chapter 6 | | |
| Following operating cases are to be considered as minimum: | | | | |
| Operation time | h | At least 200,000 | | |
| Number of cold, warm and hot starts | - | 4, 12 & 48 | | |
| Max. overspeed in case of full load rejection | % | 8 | | |
| | | | | |
| **Steam turbine** | | Refer section-5, Chapter 10 | | |
| Steam pressure at HP-turbine inlet at TMCR | bar(a) | | | |
| Steam temperature at HP-turbine inlet at TMCR | °C | | | |
| Steam temperature at IP-turbine inlet at TMCR | °C | | | |
| Maximum Continuous Rating of turbine generator (TMCR) | MW | | | |
| Live steam flow at TMCR of turbine generator | kg/s | | | |
| No-load steam consumption | kg/s | | | |
| Number of extractions | - | 8 (3 HP Heaters, 4 LP Heaters & 1 Deaerator) | | |
| Number of feedwater preheating stages | - | See Feedwater heaters | | |
| Final feedwater temperature at MCR | - | | | |
| Exhaust pressure at MCR | bar(a) | | | |
| Exhaust moisture | % | | | |
| Coupled critical speeds of turbine and generator up to 150% of nominal speed | % | < 85 / > 125 | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Sectional drawing No. | - | | | |
| Applied Standard | | | | |
| Expected oper. hours between major overhauls | h | | | |
| | | | | |
| **Casings** | | | | |
| Number of casings | - | | | |
| Casing design HP | - | | | |
| Casing design IP/LP | - | | | |
| Casing design LP | - | | | |
| Applied Standard | - | | | |
| | | | | |
| **Rotors** | | | | |
| Number of turbine shafts | - | | | |
| Distance between bearing centres HP shaft | mm | | | |
| IP/LP shaft | mm | | | |
| LP shaft | mm | | | |
| Applied Standard | | | | |
| | | | | |
| **Blading** | | | | |
| HP regulating stage: | | | | |
| Type of wheel | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Mean blading diameter | mm | | | |
| Pressure in the regulating wheel chamber at MCR | bar(a) | | | |
| **HP blading:** | | | | |
| Type of H.P. blading (impulse/reaction) | - | | | |
| Number of stages | - | | | |
| Length of blades last row | mm | | | |
| Mean blading diameter last row | - | | | |
| **IP/LP blading:** | | | | |
| Type of LP blading (impulse/reaction) | - | | | |
| Number of stages | - | | | |
| Length of blades last row | mm | | | |
| Mean blading diameter last row | mm | | | |
| Exhaust area of last row (axially) | $m^2$ | | | |
| **LP blading:** | | | | |
| Type of LP blading (impulse/reaction) | - | | | |
| Number of stages | - | | | |
| Length of blades last row | mm | | | |
| Mean blading diameter last row | mm | | | |
| Exhaust area of last row (axially) | $m^2$ | | | |
| | | | | |
| **Materials** | | | | |
| HP outer casing | - | | | |
| HP inner casing | - | | | |
| HP blade carriers | - | | | |
| IP/LP outer casing | - | | | |
| IP/LP inner casing | - | | | |
| IP/LP blade carriers | - | | | |
| HP rotor | - | | | |
| IP/LP rotor | - | | | |
| HP nozzles | - | | | |
| HP rotor blades | - | | | |
| IP/LP nozzles | - | | | |
| IP/LP rotor blades | - | | | |
| Casing of emergency stop valves (HP-steam; reheat-steam) | - | | | |
| Casing of HP-steam governor valves | - | | | |
| Casing of reheat steam governor valves | - | | | |
| | | | | |
| **Emergency stop valves** | | | | |
| Number of valves for HP-steam | - | | | |
| Size (Diameter of one valve) | mm | | | |
| Number of valves for IP steam | - | | | |
| Size (Diameter of one valve) | mm | | | |
| | | | | |
| **HP-steam governor valve** | | | | |
| Number of valves | - | | | |
| Size (Diameter of one valve) | mm | | | |
| Type | - | | | |
| Actuator | - | | | |
| | | | | |
| **Reheat-steam governor valve** | | | | |
| Number of valves | - | | | |
| Size (diameter of one valve) | mm | | | |
| Type | - | | | |
| Actuator | - | | | |
| | | | | |
| **Bleed steam emergency shut-off valves** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | | |
| **Turbine glands** | | | | |
| Type | - | | | |
| | | | | |
| **Bearings** | | | | |
| Number of journal/thrust bearings | - | | | |
| Type: Journal | - | | | |
| Thrust | - | | | |
| Maximum oil outlet temperature | °C | | | |
| | | | | |
| **Dimensions** | | | | |
| Total length of the unit | m | | | |
| Length of foundation | m | | | |
| Width of foundation | m | | | |
| Height of foundation | m | | | |
| | | | | |
| **Weights** | | | | |
| Weight of rotor | t | | | |
| Weight of heaviest part to be handled by crane | t | | | |
| Operating weight of the complete unit | t | | | |
| | | | | |
| **Turning device** | | | | |
| Method of operation | - | | | |
| Turbine rotor speed | rpm | | | |
| Drive | - | | | |
| Rating | kW | | | |
| | | | | |
| **Gland steam condenser** | | | | |
| Type | | | | |
| Number of condensers | - | | | |
| Cooling surface (outside diameter) | $m^2$ | | | |
| Materials: | | | | |
| Tubes | - | | | |
| Tube plates | - | | | |
| Shell | - | | | |
| Applied Standard | - | | | |
| | | | | |
| **Gland exhauster** | | | | |
| Number of exhausters | - | | | |
| Type | - | | | |
| Rating | kW | | | |
| | | | | |
| **Turbine lube oil system** | | | | |
| Lube oil tank capacity | $m^3$ | | | |
| Lube oil and control oil tanks separate? | yes/no | | | |
| Number of lube oil recirculation for design of oil tank | 1/hr | | | |
| Lubrication oil system pressure | bar(g) | | | |
| Material of lube oil pipes before filter | | | | |
| Material of lube oil pipes after filter | | | | |
| | | | | |
| **Main lube oil pump** | | | | |
| Number/capacity of pumps | -/% | 1x100% | | |
| Capacity per pump | $m^3/h$ | | | |
| Type | - | | | |
| Rating | kW | | | |
| Drive | - | | | |
| Speed | rpm | | | |
| Material of pump casing | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | | |
| **Auxiliary oil pump** | | | | |
| Number/capacity of pumps | -/% | 1x100% | | |
| Type | - | | | |
| Rating | kW | | | |
| Speed | rpm | | | |
| Material of pump casing | - | | | |
| | | | | |
| **Emergency oil pump (DC driven)** | | | | |
| Number/capacity of pumps | -/% | 1x100% | | |
| Type | - | | | |
| Drive | - | | | |
| Rating | kW | | | |
| Speed | rpm | | | |
| Material of pump casing | - | | | |
| | | | | |
| **HP jacking system** | | | | |
| Jacking oil system pressure | bar(g) | | | |
| Number/capacity of pumps | -/% | 2x100% | | |
| Type | - | | | |
| Rating | kW | | | |
| Speed | rpm | | | |
| Material of pump casing | - | | | |
| | | | | |
| **Oil vapor extraction** | | | | |
| Number/capacity of fans | -/% | 2x100% | | |
| Type | - | | | |
| Rating | kW | | | |
| | | | | |
| **Lube oil cooler** | | | | |
| Number/capacity of coolers | -/% | 2x100% | | |
| Type | - | | | |
| Cooling surface per cooler | $m^2$ | | | |
| Max. oil outlet temperature | °C | | | |
| Cooler dimensions | mm | | | |
| Materials: | | | | |
| | | | | |
| **Oil separator** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Flow rate per separator of lubrication oil flow | % | | | |
| Heat rating | kW | | | |
| Rating of drive | kW | | | |
| | | | | |
| **Lubrication oil filter** | | | | |
| Type | - | | | |
| Number of lubrication oil filter | - | 2x100% | | |
| Grade of filtration | µm | | | |
| | | | | |
| **Oil purification plant** | | | | |
| Type | - | | | |
| Circulating oil flow rate | % | | | |
| Grade of filtration | µm | | | |
| Material | - | | | |
| | | | | |
| **Control oil system** | | | | |
| System pressure | bar(g) | | | |
| Control oil tank capacity | $m^3$ | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Control oil and control oil tanks separate? | yes/no | | | |
| Number of control oil recirculation for design of oil tank | 1/hr | | | |
| Material of control oil pipes before filter | | | | |
| Material of control oil pipes after filter | | | | |
| | | | | |
| **Control oil pump (where applicable)** | | | | |
| Number of control oil pumps (AC motor driven) | -/% | 2x100% | | |
| Capacity per pump | $m^3/h$ | | | |
| Type | - | | | |
| Rating | kW | | | |
| Speed | rpm | | | |
| Material of pump casing | - | | | |
| | | | | |
| **Control oil filter** | | | | |
| Type | - | | | |
| Number control oil filter | - | 2x100% | | |
| Grade of filtration | µm | | | |
| | | | | |
| **Control oil cooler** | | | | |
| Number/capacity of coolers | -/% | 2x100% | | |
| Type | - | | | |
| Cooling surface per cooler | $m^3$ | | | |
| Max. oil outlet temperature | °C | | | |
| Cooler dimensions | mm | | | |
| Materials: | | | | |
| | | | | |
| **Pressure accumulator** | | | | |
| Number/capacity of accumulators | -/% | 2x100% | | |
| Volume per accumulator | $m^3$ | | | |
| | | | | |
| **Downtime ventilation plant** | | | | |
| Manufacturer | - | | | |
| Maximum air humidity downstream the turbine | % | | | |
| (ref. to ambient temperature) | | | | |
| Method of operation | - | | | |
| | | | | |
| **Fire protection system** | | Section-5, Chapter-20 | | |
| System pressure required | bar(g) | | | |
| Pressure vessel (if applicable) | | | | |
| No. of vessels | - | | | |
| Volume | $m^3$ | | | |
| Design pressure | bar(g) | | | |
| Safety valve design flow | $m^3/h$ | | | |
| Booster pumps (if applicable) | | | | |
| No. of pumps | | | | |
| Capacity of pumps | $m^3/h$ | | | |
| Delivery head | m | | | |
| | | | | |
| **Condenser** | | Refer Section-5, Chapter-17 | | |
| Cooling water inlet temperature | °C | | | |
| Cooling water temperature increase | °C | | | |
| Terminal temperature difference of condenser at operating conditions | °C | | | |
| Cooling water velocity in condenser tubes | m/s | According to requirement of sponge ball cleaning equipment, at least 1.5 | | |
| Design pressure | bar(a) | | | |
| Cleanliness factor referred to design cooling surface | % | max. 110 | | |
| Cooling water velocity in condenser tubes with 10% blocked tubes | m/s | | | |
| Tube bore of condenser tubes | mm | min. 17 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Total number of condensers | - | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement | - | | | |
| Turbine max. capability (TMCR): | | | | |
| • Steam flow | kg/s | | | |
| • Cooling water flow | $m^3/h$ | | | |
| • Cooling water temperature rise | °C | | | |
| • Cooling water pressure loss | bar(g) | | | |
| Heat transfer coefficient | $kJ/m^2sK$ | | | |
| Fouling factor (which is considered in the cooling surface) | % | | | |
| Cooling surface (outside diameter) | $m^2$ | | | |
| Number of flow passes | - | | | |
| Diameter of tubes (bore) | mm | | | |
| Wall thickness of tubes | mm | | | |
| Length between tube plates | mm | | | |
| Number of tube support plates | - | | | |
| Number and size of cooling water connections | -/mm | | | |
| Materials: | | | | |
| • Tubes | - | | | |
| • Tube plates | - | | | |
| • Shell | - | | | |
| • Water boxes | - | | | |
| • Lining of water boxes | - | | | |
| • Hotwell capacity referring to TMC | minutes | | | |
| | | | | |
| Debris Filter | | | | |
| Number/capacity | -/% | 2x50% (one at each condenser inlet) | | |
| Mesh size | | 2 x 2 | | |
| | | | | |
| Continuous condenser cleaning equipment | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement | - | | | |
| ball recirculating pump | -/% | | | |
| | | | | |
| Evacuation units - steam space | | | | |
| Number/capacity | -/% | 2x100% | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Nominal capacity | $m^3/h$ | | | |
| Motor rating | kW | | | |
| Speed | rpm | | | |
| | | | | |
| Hogging unit | | | | |
| Number/capacity | -/% | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Nominal capacity | $m^3/h$ | | | |
| Steam data in case of ejector | | | | |
| Inlet pressure | bar(g) | | | |
| Inlet temperature | °C | | | |
| Flow rate | kg/s | | | |
| | | | | |
| **Condensate extraction pumps** | | Refer section-5, Chapter -18 | | |
| Number/capacity of pumps | -/% | 3x50% | | |
| Manufacturer | - | | | |
| Type | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Nominal capacity | $m^3/h$ | | | |
| Delivery head | m | | | |
| Closed valve head | m | | | |
| Motor rating | kW | | | |
| Closed valve head | m | | | |
| NPSH required | | | | |
| Speed | rpm | | | |
| Type of bearings | - | | | |
| Type of shaft sealing | - | | | |
| Material of pump casing/shaft/impeller | - | | | |
| If vertical pump: Overall depth of pump below floor level | mm | | | |
| | | | | |
| Motor | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Rated power | kW | | | |
| Rated voltage | kV | | | |
| Rated current | A | | | |
| Locked rotor current | A | | | |
| Rated speed | rpm | | | |
| Rated efficiency | % | | | |
| Rated power factor | - | | | |
| Starting time | sec. | | | |
| Protection system | - | | | |
| Insulation class | - | | | |
| Type of bearings | - | | | |
| Type of lubrication | - | | | |
| Method of cooling the motor | - | | | |
| (external fan / internal fan / water-cooled) | - | | | |
| | | | | |
| Bypass System | | | | |
| HP-steam bypass station | | | | |
| | | | | |
| LP-steam bypass station | | | | |
| LP bypass capacity | - | Corresponding to HP bypass plus spray water | | |
| Number of LP bypass valves | - | 2x50% | | |
| Capacity of steam | t/h | | | |
| Spray water injection flow | t/h | | | |
| Type of drives /actuators | - | Hydraulic | | |
| Type of construction | - | | | |
| Number of stages | - | | | |
| Manufacturer | - | | | |
| | | | | |
| **Generator** | | Refer Section-5,Chapter-29 | | |
| Applicable standards | - | IEC | | |
| Manufacturer | - | | | |
| Manufacturers Type/Designation | - | | | |
| Rated generator output according to class B insulation | MVA | *** | | |
| Rated generator output according to class F insulation | MVA | *** | | |
| Generator output according to class B insulation and one cooler section out of operation | MVA | *** | | |
| Protection class | - | | | |
| Rated voltage at generator terminals | kV | | | |
| Voltage variation range | % | ±5 | | |
| Rated current (at rated gen. output) | A | | | |
| Rated frequency | Hz | 50 | | |
| Rated speed | rpm | 3000 | | |
| Rated power factor (lagging) | cos phi | 0.85 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Rated power factor (leading) | cos phi | 0.9 | | |
| Saturated subtransient reactance x"d | % | | | |
| Rated short-circuit ratio kc (without minus tolerance) | - | min. 0.48 ** | | |
| Inertia constant H of complete turbine and generator set (based on rated generator output, (without minus tolerance) | kWs<br>kVA | | | |
| Insulation class for generator and exciter | - | F | | |
| Current transformer secondary rate | - | | | |
| Voltage transformer secondary rate | A | | | |
| Generator power characteristic curve Doc. No. | V | | | |
| Generator unbalanced load-time-curve Doc. No. | - | | | |
| Generator saturation curves Doc. No. | - | | | |
| Maximum asym. three-phase short-circuit current (at rated gen. output) | - | | | |
| Max. permissible angle between generator and grid voltage | °El. | | | |
| Permissible unbalanced load | kA (peak) | | | |
| • continuous | % | | | |
| • $(J2 / Jr)^2 \times t$ | sec | | | |
| Test voltage of stator winding | - | | | |
| Test voltage of rotor winding | kV | | | |
| Generator efficiency at P.F. = 0,85 lagging | kV | | | |
| • 4/4 load | % | | | |
| • 3/4 load | % | | | |
| • 2/4 load | % | | | |
| • 1/4 load | % | | | |
| Direct axis sub-transient reactance saturated/minimum value x"d | % | | | |
| Direct axis sub-transient reactance unsaturated minimum value x"d | % | | | |
| Xd (saturated) | % | | | |
| XD (unsaturated) | % | | | |
| X2 (negative sequence) | % | | | |
| Xo (zero sequence) | % | | | |
| | | | | |
| **Generator dimensions** | | | | |
| Total length | m | | | |
| Total height | m | | | |
| Total width | m | | | |
| | | | | |
| **Generator weights** | | | | |
| Stator weight (with end shields) | t | | | |
| (without end shields) | t | | | |
| Rotor weight | t | | | |
| Transport weight complete generator | T | | | |
| | | | | |
| **Stator** | | | | |
| Number of bushings | - | | | |
| Type of winding | - | | | |
| Core length | m | | | |
| Inside diameter of core | mm | | | |
| Insulation class | - | | | |
| Type of insulation | - | | | |
| | | | | |
| **Rotor** | | | | |
| Diameter of rotor body | mm | | | |
| Length between bearing centres | m | | | |
| Type of windings | - | | | |
| Type of damper winding | - | | | |
| Insulation class | - | | | |
| Type of insulation | - | | | |
| | | | | |
| **Generator cooler system** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Manufacturer | - | | | |
| Type of cooling | water/H | | | |
| Number of coolers and capacity | -/% | | | |
| Location of coolers | - | | | |
| Material of tubes | - | | | |
| Secondary cooling water inlet temperature | °C | | | |
| Cold gas temperature | °C | | | |
| Primary water inlet temperature (downstream cooler) | °C | | | |
| Mean temperature rise<br>• motor winding<br>• stator winding | <br>K<br>K | | | |
| | | | | |
| **Excitation system** | | | | |
| Manufacturer | - | | | |
| Type | - | Static Excitation | | |
| Protection class of cubicles | IP | | | |
| Rated voltage | V | | | |
| DC current at no load | A | | | |
| DC current at rated continuous load and rated power factor | A | | | |
| Overload current for 10 sec. | A | | | |
| No. of the thyristors in parallel | - | | | |
| Rated current of individual thyristors | A | | | |
| Number of cubicles | - | | | |
| Dimensions L x W x H | mm | | | |
| | | | | |
| **Excitation transformer** | | | | |
| Number of transformers | Nos. | *** | | |
| Manufacturer | - | | | |
| Type | | 3-phase cast resin | | |
| Rated output AN | MVA | *** | | |
| Type of cooling | - | AN | | |
| Rated frequency | Hz | 50 | | |
| Off-load tap changer regulation | ± | ±5% in ± 2 x 2.5% | | |
| Voltages at full load and off-load tap-changer in 0 position H.V./L.V. side | kV/kV | ***/*** kV | | |
| Voltages at no-load and on-load tap-changer in 0 position H.V./L.V. side | kV/kV | ***/*** kV | | |
| Impedance voltage | % | * | | |
| Vector group and numerical inday | - | *** | | |
| Impulse withstand voltage(IEC 60076-3)<br>H.V. | kV<br>(peak) | 145 or 170 *** | | |
| Impulse withstand voltage<br>L.V. side<br>L.V. neutral | <br>kV<br>(peak)<br>kV<br>(peak) | <br>***<br>*** | | |
| Power frequency withstand voltage<br>H. V.<br>L. V.<br>Neutral | <br>kV<br>kV<br>kV | <br>50 or 70 ***<br>***<br>*** | | |
| Earthing:<br>Neutral | - | *** | | |
| Short circuit duration | sec. | 3 | | |
| No load losses at rated voltage | kW | - | | |
| Load losses at AN | kW | - | | |
| Connection on H.V. side | - | *** | | |
| Connection on L.V. side | - | *** | | |
| Protection clas of enclosure | IP | min. IP23 | | |
| Total weight | kg | - | | |
| Transport weight | kg | - | | |
| Overall dimensions • Height | mm | - | | |
| • Length | mm | - | | |
| • Width | mm | - | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Automatic voltage and reactive power control | | | | |
| Manufacturer | - | | | |
| Manufacturers Type/Designation | - | | | |
| Accuracy of control over load range within<br>0,5 % | - | | | |
| Steady state voltage regulation grade | - | | | |
| Transient state voltage regulation grade | | | | |
| Power factor setpoint adjustment range | - | | | |
| Recovery time to within 2% volts when shedding rated MVA | - | | | |
| Number of channels<br>• Automatic<br>• Manual | Sec | | | |
| Manual control range | % | | | |
| Power system stabilizer (PSS) | yes/no | yes | | |
| | | | | |
| **Synchronizing equipment** | | | | |
| Manufacturer | - | | | |
| Manufacturers Type/Designation | - | | | |
| Double channel | yes/no | yes | | |
| Power supply voltage | V | | | |
| Input range from - to | V | | | |
| Frequency range from - to | Hz | | | |
| Circuit breaker closing time, from - to | msec. | | | |
| | | | | |
| Digital unit protection system | | | | |
| Manufacturer of protection system | - | | | |
| Manufacturers Type/Designation | - | | | |
| Number of cabinets | - | | | |
| Auxiliary voltage | V | | | |
| Control voltage / ± % | V/% | | | |
| Size (height x width x depth) | mm | | | |
| Weight | kg | | | |
| Each relay with self check facilities | yes/no | | | |
| List of all protection relay functions on separate sheets | - | | | |
| | | | | |
| **Generator main connections** | | | | |
| Secondary current of current transformer | A | | | |
| Class of current transformer measuring core | . | | | |
| Class of current transformer protection core | - | | | |
| Secondary voltage of voltage transformer | V | | | |
| Class of voltage transformer | - | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Rated system voltage | kV | | | |
| Rated frequency | Hz | | | |
| Rated current | | | | |
| a) generator to generator transformer | A | | | |
| b) generator neutral | A | | | |
| c) Tie branch to unit aux. transformer & excitation transformer | A | | | |
| Impulse withstand voltage (to earth) | kV (peak) | | | |
| Power frequency withstand voltage | kV | | | |
| Rated short time current (3 sec) | | | | |
| a) generator to generator transformer | kA | | | |
| b) generator neutral | kA | | | |
| c) Tie branch to unit aux. transformer &<br>excitation transformer | kA | | | |
| Max. asymmetric three-phase short-circuit withstand current | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| a) generator to generator transformer | KA (peak) | | | |
| b) generator neutral | kA (peak) | | | |
| c) Tie branch to unit aux. transformer | kA (peak) | | | |
| Type of busbars/material | - | | | |
| Type of enclosure/material | - | | | |
| Busbar overpressure | bar(g) | | | |
| | | | | |
| **Control and monitoring equipment** | | | | |
| Electro-hydraulic governor | | | | |
| Manufacturer | - | | | |
| Designation of system | - | | | |
| Type or name of system | - | | | |
| Number of sensors in total | - | | | |
| Interface to DCS-system | - | | | |
| • hard wired | - | | | |
| • DCS-system bus | - | | | |
| Local operating station per plant | - | | | |
| • Manufacturer | - | | | |
| • Type | - | | | |
| | | | | |
| **Turbine protection system** | | | | |
| Manufacturer | - | | | |
| Designation of system | - | | | |
| Type or name of system | kW | | | |
| Principle of monitoring (e.g. 1 out of 2, 2 out of 3, 2 out of 2 with self-monitoring etc.) to be entered for: | kV | | | |
| Steam inlet pressure | A | | | |
| Steam inlet temperature | A | | | |
| Speed, high | rpm | | | |
| Condenser pressure and level high | % | | | |
| Temperature of exhaust steam or bypass steam, high | - | | | |
| Relative expansion, high | sec. | | | |
| Shaft displacement, high | - | | | |
| Difference temperature of casing (diametrical clearance), high | - | | | |
| Vibration, high (housing or rotor) | - | | | |
| Bearing metal temperature, high | - | | | |
| Control oil pressure low | - | | | |
| Lube oil pressure, low | - | | | |
| Generator protection | - | | | |
| Lube oil tank level, low | - | | | |
| Wall temperature difference of turbine casing | - | | | |
| | | | | |
| **Vibration measurements** | | | | |
| Manufacturer | - | | | |
| Designation of system | - | | | |
| Type or name of system | - | | | |
| Total number of shaft vibration sensors | - | | | |
| Total number of bearing vibration sensors | - | | | |
| | | | | |
| **Boiler feedwater supply and feedwater pumps** | | Refer Section-5, Chapter-14 | | |
| Design code | - | | | |
| Number and capacity (per unit) | No. x % | 2 x 50% steam driven<br>2 x 25% motor driven | | |
| | | | | |
| **Feedwater pump** | | Refer Section-5, Chapter-14 | | |
| Design code to be applied for the feed water supply | - | | | |
| Number of pumps per unit/capacity referring to BMCR | -/% | | | |
| Manufacturer | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Type | - | | | |
| No. of stages | - | | | |
| Minimum capacity | $m^3/h$ | | | |
| Speed | rpm | | | |
| Minimum flow required | $m^3/h$ | | | |
| Type of journal bearings | - | | | |
| Method of axial thrust hydraulic compensation | - | | | |
| Type of axial bearings | - | | | |
| Type of bearing lubrication | - | | | |
| Oil supply from | - | | | |
| Type of glands or seals | - | | | |
| Closed valve head | m | | | |
| Materials: | | | | |
| Pump casing | - | Stainless steel with at least 13% Cr. | | |
| Shaft | - | | | |
| Impeller | | | | |
| Total power requirement of feedpump sets of one unit when the turbine is running at MCR | kW | | | |
| Speed control of main FW pumps | - | By turbine drive | | |
| Speed control of FW standby pump | - | | | |
| Pump NPSH over the whole operating range | m | | | |
| Zero flow head | bar | | | |
| | | | | |
| **One pump set in single operation (at max. speed):** | | | | |
| Delivery rate | $m^3/h$ | | | |
| Delivery head | m | | | |
| Pump head at design point | m | | | |
| Pump Head at 125% of design flow | m | | | |
| Pump Head at 110% of boiler drum pressure and nominal delivery flow | m | | | |
| Discharge flow at design point | $m^3/h$ | | | |
| Design flow range | from - to | | | |
| Net position suction head required | m | | | |
| Power requirement of feed water pump at nominal capacity and nominal head | kW | | | |
| Power requirement of one pump set at motor terminals | kW | | | |
| Pump efficiency at rated capacity | % | | | |
| | | | | |
| **Coupling** | | | | |
| Type | - | | | |
| Maximum allowable transmitted load | kW | | | |
| | | | | |
| **Booster pump (where applicable)** | | | | |
| Number of pumps | - | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| No. of stages | - | | | |
| Speed | rpm | | | |
| Minimum capacity | $m^3/h$ | | | |
| Type of journal bearings | - | | | |
| Type of thrust bearings | - | | | |
| Type of bearing lubrication | - | | | |
| Oil supply from | - | | | |
| Type of glands or seals | - | | | |
| Materials: | | | | |
| Pump casing | - | | | |
| Shaft | - | | | |
| Impeller | - | | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| **One pump in single operation (at max. speed):** | | | | |
| Nominal capacity | $m^3/h$ | | | |
| Nominal delivery head | m | | | |
| Minimum capacity | $m^3/h$ | | | |
| Delivery rate | $m^3/h$ | | | |
| Delivery head | m | | | |
| Closed valve head | m | | | |
| Max. power requirement of booster pump | | | | |
| Power requirement of one pump set at motor terminals | kW | | | |
| | | | | |
| **Coupling** | | | | |
| Type | - | | | |
| Maximum allowable transmitted load | kW | | | |
| | | | | |
| **Feedwater pump drive turbine unit** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Live steam pressure | bara | | | |
| Live steam temperature | °C | | | |
| Steam outlet pressure | bara | | | |
| Steam outlet temperature | °C | | | |
| Minimum operational speed | rpm | | | |
| Maximum operational speed | rpm | | | |
| Rated power | kW | | | |
| | | | | |
| **Feedwater pump motor** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Rated power | kW | | | |
| Rated voltage | kV | | | |
| Rated current | A | | | |
| Locked rotor current | A | | | |
| Rated speed | rpm | | | |
| Rated efficiency | % | | | |
| Rated power factor | - | | | |
| Starting time | sec. | | | |
| Protection system | - | | | |
| Insulation class | - | | | |
| Type of bearings | - | | | |
| Type of lubrication | - | | | |
| Method of cooling the motor<br>(external fan/internal fan/water-cooled) | - | | | |
| | | | | |
| **Feedwater heaters** | | | | |
| Number of feedwater heaters | | Up to Bidder's optimization | | |
| Deaerator/feedwater tank | - | | | |
| Design pressure of heater tube side | | Zero flow head of supply pumps | | |
| Fouling factor consideration /Overdesign of heat exchanger surface | | 8% overdesign of heat surface | | |
| Design pressure of heater shell side | | | | |
| Capacity of safety valves at heater shell side | | At least corresponding to flow of 2 busted tubes at max pump pressure | | |
| Final feedwater temperature at MCR | °C | | | |
| | | | | |
| **LP heater 1** | | | | |
| Number per unit / capacity in % TMC | - / % | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement (horizontal / vertical) | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Drain condensate pumps : number / % TMC | - / % | | | |
| Design code | - | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Turbine max. capability (TMC): | | | | |
| Steam flow | kg/s | | | |
| Condensate flow | kg/s | | | |
| Average log. temp. difference | K | | | |
| Pressure loss condensate side | bar | | | |
| Heat transfer coefficient | $kJ/m^2sK$ | | | |
| Fouling factor (which is considered in the cooling surface) | % | | | |
| Heating surface (outside diameter) | | | | |
| Desuperheater surface | $m^2$ | | | |
| Condenser surface | $m^2$ | | | |
| Drain cooler surface | $m^2$ | | | |
| Number of flow passes | - | | | |
| Diameter of tubes (bore) | mm | | | |
| Wall thickness of tubes | mm | | | |
| Outside Diameter | mm | | | |
| Overall Length | mm | | | |
| Weight | tons | | | |
| Materials: | | | | |
| Tubes | - | | | |
| Tube plates | - | | | |
| Shell | - | | | |
| | | | | |
| **LP heater 2** | | | | |
| Number per unit / capacity in % TMC | - / % | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement (horizontal / vertical) | - | | | |
| Drain condensate pumps : number / % TMC | - / % | | | |
| Design code | - | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Turbine max. capability (TMC): | | | | |
| Steam flow | kg/s | | | |
| Condensate flow | kg/s | | | |
| Average log. temp. difference | | | | |
| Pressure loss condensate side | $m^2$ | | | |
| Heat transfer coefficient | $m^2$ | | | |
| Fouling factor (which is considered in the cooling surface) | $m^2$ | | | |
| Heating surface (outside diameter) | - | | | |
| Desuperheater surface | mm | | | |
| Condenser surface | mm | | | |
| Drain cooler surface | mm | | | |
| Number of flow passes | mm | | | |
| Diameter of tubes (bore) | tons | | | |
| Wall thickness of tubes | | | | |
| Outside Diameter | - | | | |
| Overall Length | - | | | |
| Weight | - | | | |
| Materials: | | | | |
| Tubes | | | | |
| Tube plates | - / % | | | |
| Shell | - | | | |
| | - | | | |
| **LP heater 3** | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Number per unit / capacity in % TMC | - / % | | | |
| Manufacturer | - | | | |
| Type | bar(g) | | | |
| Arrangement (horizontal / vertical) | °C | | | |
| Drain condensate pumps : number / % TMC | | | | |
| Design code | kg/s | | | |
| Design pressure | kg/s | | | |
| Design temperature | K | | | |
| Turbine max. capability (TMC): | bar | | | |
| Steam flow | kJ/m$^2$sK | | | |
| Condensate flow | % | | | |
| Average log. temp. difference | K | | | |
| Pressure loss condensate side | bar | | | |
| Heat transfer coefficient | kJ/m$^2$sK | | | |
| Fouling factor (which is considered in the cooling surface) | % | | | |
| Heating surface (outside diameter) | | | | |
| Desuperheater surface | m$^2$ | | | |
| Condenser surface | m$^2$ | | | |
| Drain cooler surface | m$^2$ | | | |
| Number of flow passes | - | | | |
| Diameter of tubes (bore) | mm | | | |
| Wall thickness of tubes | mm | | | |
| Outside Diameter | mm | | | |
| Overall Length | mm | | | |
| Weight | tons | | | |
| Materials: | | | | |
| Tubes | - | | | |
| Tube plates | - | | | |
| Shell | | | | |
| | | | | |
| **LP heater 4** | | | | |
| Number per unit / capacity in % TMC | - / % | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement (horizontal / vertical) | - | | | |
| Drain condensate pumps : number / % TMC | - / % | | | |
| Design code | - | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Turbine max. capability (TMC): | | | | |
| Steam flow | kg/s | | | |
| Condensate flow | kg/s | | | |
| Average log. temp. difference | K | | | |
| Pressure loss condensate side | bar | | | |
| Heat transfer coefficient | kJ/m$^2$sK | | | |
| Fouling factor (which is considered in the cooling surface) | % | | | |
| Heating surface (outside diameter) | | | | |
| Desuperheater surface | m$^2$ | | | |
| Condenser surface | m$^2$ | | | |
| Drain cooler surface | m$^2$ | | | |
| Number of flow passes | - | | | |
| Diameter of tubes (bore) | mm | | | |
| Wall thickness of tubes | mm | | | |
| Outside Diameter | mm | | | |
| Overall Length | mm | | | |
| Weight | tons | | | |
| Materials: | | | | |
| Tubes | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Tube plates | - | | | |
| Shell | - | | | |
| | | | | |
| **HP Feedwater heater 1** | | | | |
| Number per unit / capacity in % TMC | - / % | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement (horizontal / vertical) | - | | | |
| Drain condensate pumps : number / % TMC | - / % | | | |
| Design code | - | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Turbine max. capability (TMC): | | | | |
| Steam flow | kg/s | | | |
| Condensate flow | kg/s | | | |
| Average log. temp. difference | K | | | |
| Pressure loss condensate side | bar(g) | | | |
| Heat transfer coefficient | $kJ/m^2sK$ | | | |
| Fouling factor (which is considered in the cooling surface) | % | | | |
| Heating surface (outside diameter) | | | | |
| Desuperheater surface | $m^2$ | | | |
| Condenser surface | $m^2$ | | | |
| Drain cooler surface | $m^2$ | | | |
| Number of flow passes | - | | | |
| Diameter of tubes (bore) | mm | | | |
| Wall thickness of tubes | mm | | | |
| Outside Diameter | mm | | | |
| Overall Length | mm | | | |
| Weight (empty/filled) | tons | | | |
| Materials: | | | | |
| Tubes | - | | | |
| Tube plates | - | | | |
| Shell | - | | | |
| | | | | |
| **HP Feedwater heater 2** | | | | |
| Number per unit / capacity in % TMC | - / % | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement (horizontal / vertical) | - | | | |
| Drain condensate pumps : number / % TMC | - / % | | | |
| Design code | - | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Turbine max. capability (TMC): | | | | |
| Steam flow | kg/s | | | |
| Condensate flow | kg/s | | | |
| Average log. temp. difference | K | | | |
| Pressure loss condensate side | bar | | | |
| Heat transfer coefficient | $kJ/m^2sK$ | | | |
| Fouling factor (which is considered in the cooling surface) | % | | | |
| Heating surface (outside diameter) | | | | |
| Desuperheater surface | $m^2$ | | | |
| Condenser surface | $m^2$ | | | |
| Drain cooler surface | $m^2$ | | | |
| Number of flow passes | - | | | |
| Diameter of tubes (bore) | mm | | | |
| Wall thickness of tubes | mm | | | |
| Outside Diameter | mm | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Overall Length | mm | | | |
| Weight (empty/filled) | tons | | | |
| Materials: | | | | |
| Tubes | - | | | |
| Tube plates | - | | | |
| Shell | - | | | |
| | | | | |
| **HP Feedwater heater 3** | | | | |
| Number per unit / capacity in % TMC | - / % | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Arrangement (horizontal / vertical) | - | | | |
| Drain condensate pumps : number / % TMC | - / % | | | |
| Design code | - | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Turbine max. capability (TMC): | | | | |
| Steam flow | kg/s | | | |
| Condensate flow | kg/s | | | |
| Average log. temp. difference | K | | | |
| Pressure loss condensate side | bar | | | |
| Heat transfer coefficient | $kJ/m^2sK$ | | | |
| Fouling factor (which is considered in the cooling surface) | % | | | |
| Heating surface (outside diameter) | | | | |
| Desuperheater surface | $m^2$ | | | |
| Condenser surface | $m^2$ | | | |
| Drain cooler surface | $m^2$ | | | |
| Number of flow passes | - | | | |
| Diameter of tubes (bore) | mm | | | |
| Wall thickness of tubes | mm | | | |
| Outside Diameter | mm | | | |
| Overall Length | mm | | | |
| Weight (empty/filled) | tons | | | |
| Materials: | | | | |
| Tubes | - | | | |
| Tube plates | - | | | |
| Shell | - | | | |
| | | | | |
| **Deaerator for feedwater system** | | | | |
| Manufacturer | - | | | |
| Type | - | Preferably spray type | | |
| Mode of operation | - | Variable pressure with fixed minimum pressure | | |
| Deaerator capacity | | 110% of boiler feed water flow plus make up water | | |
| Outside diameter | mm | | | |
| Total length (where applicable) | mm | | | |
| Materials: | | | | |
| Shell (where applicable) | - | | | |
| Internals | - | | | |
| Residual oxygen content in the feed water after | mg/l | < 0.02 | | |
| deaeration over the whole operating range | | | | |
| Overflow design capacity | - | 1x100% | | |
| Start-up time feedwater tank from ambient conditions up to 200°C | h | max. 2 | | |
| No of feed water tank recirculation pumps(if applicable) | - | | | |
| | | | | |
| **Feedwater tank** | | | | |
| Number of feedwater tank per unit | - | 1 | | |
| Mode of operation | - | Variable pressure with fixed minimum pressure | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Design pressure | - | 120% of the respective maximum possible turbine bleed pressure and full vacuum | | |
| Design temperature | °C | Max. turbine low load temperature | | |
| Manufacturer | - | | | |
| Feedwater tank volume | | Corresponding to min. 10 minutes of feedwater flow at BMCR* | | |
| Nominal capacity | $m^3$ | | | |
| Normal working capacity | $m^3$ | | | |
| Outside diameter | mm | | | |
| Total length | mm | | | |
| Materials: | | | | |
| Shell | - | | | |
| Internals | - | | | |
| Operating weight | kg | | | |
| Time for warming up at: | minutes | | | |
| • Normal working capacity | | | | |
| • 20°C to 150°C | | | | |
| Steam for warming up: | | | | |
| • Source | - | | | |
| • Pressure | bar(g) | | | |
| • Temperature | °C | | | |
| Feedwater tank recirculation pumps (if applicable) | | | | |
| No of pumps | - | 2x100% | | |
| Discharge flow | $m^3/h$ | | | |
| | | | | |
| **Balance of Steam Turbine Generator Plant** | | | | |
| Cold condensate tank | | | | |
| Number of Cold Condensate Tanks per unit | | | | |
| Net capacity | $m^3$ | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Material | | | | |
| | | | | |
| **Cold condensate tank pumps** | | | | |
| Number and capacity | No. x % | 2x100% | | |
| | | | | |
| **Condensate Collecting Tanks** | | | | |
| Number of Condensate Collecting Tanks per unit | | | | |
| Net capacity | $m^3$ | | | |
| Design pressure | bar(g) | | | |
| Design temperature | °C | | | |
| Material | | | | |
| | | | | |
| **Cold condensate tank pumps** | | | | |
| Number and capacity | No. x % | 2x100% | | |

Notes:

*** According to Chapter 6 of Section 5**

**** for reference only, exact value to be determined by the Bidder**

***** to be determined by the Bidder**

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| **General Remarks:** | | | Bidder name | |
| Unless otherwise noted: | | | | |
| • data are per unit | | | | |
| • operational data are for BMCR, 100% TMCR, 75% TMCR, 50% TMCR and Design and check/worst Coal as per Attachment B3. | | | | |
| • fulfillment of guaranteed emission values | | | | |
| Number of air and flue gas systems | - | | | |
| | | | | |
| **Ambient conditions:** | | Refer Section-5, Chapter-1 | | |
| **Fuel specification:** | | Attachment- B3 | | |
| **Operational characteristics:** | | | | |
| **Emissions:** | | | | |
| | | | | |
| **Flue gas:** | | Refer Attachment - B3 | | |
| **Flue gas upstream of regenerative air preheater:** | | | | |
| Volume flow rate (STP, wet) | m³/h | | | |
| Temperature | °C | | | |
| $H_2O$ (operating value) | Vol. % | | | |
| $O_2$ (operating value) | Vol. % | | | |
| $SO_2$ (STP, dry 6% $O_2$) | mg/m³ | | | |
| Dust (STP, dry 6% $O_2$) | mg/m³ | | | |
| | | | | |
| **Flue gas downstream of regenerative air preheater:** | | | | |
| Volume flow rate | m³/h | | | |
| Temperature | °C | | | |
| $H_2O$ (operating value) | Vol. % | | | |
| $O_2$ (operating value) | Vol. % | | | |
| $SO_2$ (STP, dry 6% $O_2$) | mg/m³ | | | |
| Dust (STP, dry 6% $O_2$) | mg/m³ | | | |
| | | | | |
| **Flue gas downstream of ESP** | | | | |
| Volume flow rate | m³/h | | | |
| Temperature | °C | | | |
| $H_2O$ (operating value) | Vol. % | | | |
| $O_2$ (operating value) | Vol. % | | | |
| $SO_2$ (STP, dry 6% $O_2$) | mg/m³ | | | |
| Dust (STP, dry 6% $O_2$) | mg/m³ | | | |
| | | | | |
| **Flue gas downstream of ID Fans** | | | | |
| Volume flow rate | m³/h | | | |
| Temperature | °C | | | |
| $H_2O$ (operating value) | Vol. % | | | |
| $O_2$ (operating value) | Vol. % | | | |
| $SO_2$ (STP, dry 6% $O_2$) | mg/m³ | | | |
| Dust (STP, dry 6% $O_2$) | mg/m³ | | | |
| | | | | |
| **Flue gas downstream of absorber:** | | | | |
| Volume flow rate | m³/h | | | |
| Temperature | °C | | | |
| $H_2O$ (operating value) | Vol. % | | | |
| $O_2$ (operating value) | Vol. % | | | |
| $SO_2$ (STP, dry 6% $O_2$) | mg/m³ | | | |
| Dust (STP, dry 6% $O_2$) | mg/m³ | | | |
| | | | | |
| **Flue gas at chimney outlet:** | | | | |
| Volume flow rate | m³/h | | | |
| Temperature | °C | | | |
| $H_2O$ (operating value) | Vol. % | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| $O_2$ (operating value) | Vol. % | | | |
| $SO_2$ (STP, dry 6% $O_2$) | mg/m³ | | | |
| Dust (STP, dry 6% $O_2$) | mg/m³ | | | |
| $NO_x$ (as $NO_2$, STP, dry 6% $O_2$) | mg/m³ | | | |
| CO (STP, dry 6% $O_2$) | mg/m³ | | | |
| Opacity | % | | | |
| | | | | |
| **Flue gas pressure:** | | Bidder to Confirm | | |
| Combustion chamber | mbar(g) | | | |
| Upstream of superheater | mbar(g) | | | |
| Upstream of economizer | mbar(g) | | | |
| Upstream of regenerative air heater | mbar(g) | | | |
| Upstream of ESP | mbar(g) | | | |
| At scrubber inlet | mbar(g) | | | |
| At ID fan suction side | mbar(g) | | | |
| At ID fan outlet | mbar(g) | | | |
| At stack outlet | mbar(g) | | | |
| At flue gas recirculation fan inlet (if applicable) | mbar(g) | | | |
| At flue gas recirculation fan outlet (if applicable) | mbar(g) | | | |
| | | | | |
| **Fans:** | | Refer Section-5, Chapter-13 | | |
| **FD Fans** | | | | |
| Number of fans | - | 2x50 of BMCR | | |
| Design flow (each) | % | | | |
| plus margin on flow (each) | % | | | |
| Design pressure | % | | | |
| plus margin on pressure | % | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Arrangement | - | | | |
| Flow control mechanism | - | | | |
| Design temperature | °C | | | |
| FD/SA fan outlet temperature | °C | | | |
| Max temperature | °C | | | |
| Design flow rate | m³/h | | | |
| Flow rate at BMCR | m³/h | | | |
| Design pressure difference | mbar(g) | | | |
| Pressure difference at BMCR | mbar(g) | | | |
| FD/SA fan outlet pressure | mbar(g) | | | |
| Zero discharge (e.g. in case of closed gas path) | mbar(g) | | | |
| Power demand at coupling (at BMCR) | kW | | | |
| Efficiency at | | | | |
| • BMCR | % | | | |
| • 100% TMCR | % | | | |
| • 75% TMCR, 50% TMCR | % | | | |
| • design point | % | | | |
| Speed | 1/min | | | |
| Critical speed | 1/min | | | |
| Motor type | - | | | |
| Motor efficiency | % | | | |
| Max power (shaft) | kW | | | |
| Vibration monitoring | - | | | |
| | | | | |
| **PA Fans:** | | Refer Section-5, Chapter-13 | | |
| Number of fans | - | 2x50 of BMCR | | |
| Design flow (each) | % | | | |
| plus margin on flow (each) | % | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Design pressure | % | | | |
| plus margin on pressure | % | | | |
| Flow control mechanism | - | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Arrangement | - | | | |
| Design temperature | °C | | | |
| Max temperature | °C | | | |
| Design flow rate | $m^3/h$ | | | |
| Flow rate at BMCR | $m^3/h$ | | | |
| Design pressure difference | mbar | | | |
| Pressure difference at BMCR | mbar | | | |
| PA fan outlet pressure | mbar(g) | | | |
| Zero discharge (e.g. in case of closed gas path) | mbar(g) | | | |
| Power demand at coupling (at BMCR) | kW | | | |
| Efficiency at | | | | |
| • BMCR | % | | | |
| • 100% TMCR | % | | | |
| • 75% TMCR, 50% TMCR | % | | | |
| • design point | % | | | |
| Speed | 1/min | | | |
| Critical speed | 1/min | | | |
| Motor type | - | | | |
| Motor efficiency | % | | | |
| Max power (shaft) | kW | | | |
| Vibration monitoring | - | | | |
| | | | | |
| **ID-fans** | | Refer Section-5, Chapter-13 | | |
| Number of fans | - | 2 | | |
| Design flow (each) | % | 50 of BMCR | | |
| plus margin on flow (each) | % | | | |
| Design pressure | % | | | |
| plus margin on pressure | % | | | |
| Flow control mechanism | - | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Arrangement | - | | | |
| Design temperature | °C | | | |
| Max temperature | °C | | | |
| Flue gas mass flow rate | kg/s | | | |
| Flue gas temperature (at exit) | °C | | | |
| Design flow rate (STP, wet) | $m^3/h$ | | | |
| Flow rate at BMCR (STP, wet) | $m^3/h$ | | | |
| Design pressure difference | mbar | | | |
| Pressure difference at BMCR | mbar | | | |
| Zero discharge<br>(e.g. in case of closed gas path) | mbar(g) | | | |
| Efficiency at | | | | |
| • BMCR | % | | | |
| • 100% TMCR, 75% TMCR | % | | | |
| • 50% TMCR | % | | | |
| • design point | % | | | |
| Power consumption at coupling at BMCR | kW | | | |
| Installed motor capacity | kW | | | |
| Motor efficiency | % | | | |
| Speed | 1/min | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Critical speed | 1/min | | | |
| Voltage | V | | | |
| Insulation class | - | | | |
| Protection class | - | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| Silencer upstream ID fan | | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| Silencer downstream ID fan | | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| Materials | | | | |
| • Blades | - | | | |
| • Enclosure | - | | | |
| • Rotor | - | | | |
| Main dimensions (incl. motor) | m | | | |
| Total weight | t | | | |
| Vibration measurement | | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| • Coupling | - | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| Blade adjustment | | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| Hydraulic system | | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| Noise protection (insulation) | - | | | |
| Noise level (in 1m distance) | dbA | | | |
| | | | | |
| **Mill sealing air fans:** | | | | |
| Fan purpose | - | | | |
| Number & capacity | n x % | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Arrangement | - | | | |
| Design temperature | °C | | | |
| Max temperature | °C | | | |
| Design flow rate (STP, wet) | $m^3/h$ | | | |
| Flow rate at BMCR (STP, wet) | $m^3/h$ | | | |
| Excess margin | % | | | |
| Design pressure difference | mbar | | | |
| Pressure difference at BMCR | mbar | | | |
| Excess margin | % | | | |
| Zero discharge<br>(e.g. in case of closed gas path) | mbar(g) | | | |
| Efficiency at BMCR | % | | | |
| Speed | 1/min | | | |
| Motor type | - | | | |
| Max power (shaft) | kW | | | |
| Vibration control | - | | | |
| | | | | |
| **Other fans:** | | | | |
| Fan purpose | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Number & capacity | n x % | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Arrangement | - | | | |
| Design temperature | °C | | | |
| Max temperature | °C | | | |
| Design flow rate | m³/h | | | |
| Flow rate at BMCR | m³/h | | | |
| Design pressure difference | mbar | | | |
| Pressure difference at BMCR | mbar | | | |
| Zero discharge<br>(e.g. in case of closed gas path) | mbar(g) | | | |
| Power demand at coupling (at BMCR) | kW | | | |
| Efficiency at BMCR , 100% TMCR. 75% TMCR and 50% TMCR | % | | | |
| Speed | 1/min | | | |
| Motor type | - | | | |
| Max power (shaft) | kW | | | |
| Vibration control | - | | | |
| | | | | |
| **Flue gas** | | | | |
| **Downstream of regenerative air heater at** | | | | |
| **BMCR** | | | | |
| Flue gas mass flow rate | **kg/s** | | | |
| Flue Gas Temperature (at exit) | °C | | | |
| Flue gas flow rate (standardized) | Nm³/s | | | |
| Flue gas flow rate | m³/s | | | |
| Static pressure rise | mbar | | | |
| Static pressure rise fan | mbar | | | |
| Total pressure rise | mbar | | | |
| Efficiency | % | | | |
| Power consumption at coupling | kW | | | |
| Required motor power | kW | | | |
| Speed | min-1 | | | |
| | | | | |
| **MCR (100% TMCR)** | | | | |
| Flue gas mass flow rate | kg/s | | | |
| Flue Gas Temperature (at exit) | °C | | | |
| Flue gas flow rate (standardized) | Nm³/s | | | |
| Flue gas flow rate | m³/s | | | |
| Static pressure rise | mbar | | | |
| Static pressure rise fan | mbar | | | |
| Total pressure rise | mbar | | | |
| Efficiency | % | | | |
| Power consumption at coupling | kW | | | |
| Required motor power | kW | | | |
| Speed | min-1 | | | |
| | | | | |
| **75% TMCR** | | | | |
| Flue gas mass flow rate | kg/s | | | |
| Flue Gas Temperature (at exit) | °C | | | |
| Flue gas flow rate (standardized) | Nm³/s | | | |
| Flue gas flow rate | m³/s | | | |
| Static pressure rise | mbar | | | |
| Static pressure rise fan | mbar | | | |
| Total pressure rise | mbar | | | |
| Efficiency | % | | | |
| Power consumption at coupling | kW | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Required motor power | kW | | | |
| Speed | min-1 | | | |
| | | | | |
| **50% TMCR** | | | | |
| Flue gas mass flow rate | kg/s | | | |
| Flue Gas Temperature (at exit) | °C | | | |
| Flue gas flow rate (standardized) | $Nm^3/s$ | | | |
| Flue gas flow rate | $m^3/s$ | | | |
| Static pressure rise | mbar | | | |
| Static pressure rise fan | mbar | | | |
| Total pressure rise | mbar | | | |
| Efficiency | % | | | |
| Power consumption at coupling | kW | | | |
| Required motor power | kW | | | |
| Speed | $min^{-1}$ | | | |
| | | | | |
| **MNCR** | | | | |
| Flue gas mass flow rate | kg/s | | | |
| Flue Gas Temperature (at exit) | °C | | | |
| Flue gas flow rate (standardized) | $Nm^3/s$ | | | |
| Flue gas flow rate | $m^3/s$ | | | |
| Static pressure rise | mbar | | | |
| Static pressure rise fan | mbar | | | |
| Total pressure rise | mbar | | | |
| Efficiency | % | | | |
| Power consumption at coupling | kW | | | |
| Required motor power | kW | | | |
| Speed | $min^{-1}$ | | | |
| | | | | |
| **Air ducts:** | | | | |
| Air velocity (design flow rate) | m/s | <20 | | |
| Design pressure | mbar(g) | According to occurring minimum and maximum pressure, additionally $\pm$ 10 mbar | | |
| | | | | |
| **Flue gas ducts:** | | | | |
| Flue gas velocity (design flow rate) | m/s | <18 | | |
| Design pressure | mbar(g) | According to occurring minimum and maximum pressure, additionally $\pm$ 10 mbar | | |
| | | | | |
| **Flue gas duct upstream of air preheater** | | | | |
| Flue gas temperature | °C | | | |
| Design pressure | mbar | | | |
| Dimensions (width x height) | m x m | | | |
| Material | - | | | |
| Wall thickness | mm | | | |
| Corrosion allowance | mm | | | |
| Coating (yes/no) | - | | | |
| Type of coating | - | | | |
| Flue gas velocity (max.) | m/s | 15 | | |
| Insulation (yes/no) | - | | | |
| insulation thickness | mm | | | |
| Insulation material | - | | | |
| Material expansion joint | - | | | |
| | | | | |
| **Flue gas duct from air preheater to ESP** | | | | |
| Flue gas temperature | °C | | | |
| Design pressure | mbar | | | |
| Dimensions (width x height) | m x m | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Material | - | | | |
| Wall thickness | mm | | | |
| Corrosion allowance | mm | | | |
| Coating (yes/no) | - | | | |
| Type of coating | - | | | |
| Flue gas velocity (max.) | m/s | 15 | | |
| Insulation (yes/no) | - | yes | | |
| insulation thickness | mm | | | |
| Insulation material | - | | | |
| Material expansion joint | - | | | |
| | | | | |
| **Flue gas duct from ESP to ID-fan** | | | | |
| Flue gas temperature | °C | | | |
| Design pressure | mbar | | | |
| Dimensions (width x height) | m x m | | | |
| Material | - | | | |
| Wall thickness | mm | | | |
| Corrosion allowance | mm | | | |
| Coating (yes/no) | - | | | |
| Type of coating | - | | | |
| Flue gas velocity (max.) | m/s | 18 | | |
| Insulation (yes/no) | - | yes | | |
| insulation thickness | mm | | | |
| Insulation material | - | | | |
| Material expansion joint | - | | | |
| | | | | |
| **Flue gas duct from ID-fan to FGD** | | | | |
| Flue gas temperature | °C | | | |
| Design pressure | mbar | | | |
| Dimensions (width x height) | m x m | | | |
| Total length | m | | | |
| Material | - | | | |
| Wall thickness | mm | | | |
| Corrosion allowance | mm | | | |
| Coating (yes/no) | - | | | |
| Total length horizontal | m | | | |
| Clear height (bottom edge duct) | m | | | |
| Flue gas velocity (max.) | m/s | 18 | | |
| Insulation (yes/no) | - | yes | | |
| insulation thickness | mm | | | |
| Insulation material | - | | | |
| Material expansion joint | - | | | |
| | | | | |
| **Flue gas duct from emergency cooling to absorber** | | | | |
| Flue gas temperature | °C | | | |
| Design pressure | mbar | | | |
| Dimensions (width x height) | m x m | | | |
| Total length | m | | | |
| Material | - | | | |
| Wall thickness | mm | | | |
| Corrosion allowance | mm | | | |
| Coating (yes/no) | - | | | |
| Total length horizontal | m | | | |
| Clear height (bottom edge duct) | m | | | |
| Flue gas velocity (max.) | m/s | 18 | | |
| Insulation (yes/no) | - | yes | | |
| insulation thickness | mm | | | |
| Insulation material | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Material expansion joint | - | | | |
| | | | | |
| **Flue gas duct from FGD to stack** | | | | |
| Flue gas temperature | °C | | | |
| Design pressure | mbar | | | |
| Diameter | m | | | |
| Total length | m | | | |
| Material | - | | | |
| Wall thickness | mm | | - | |
| Abrasion allowance | mm | | - | |
| Slope | ° | | | |
| Total length horizontal | m | | | |
| Total length vertical | m | | | |
| Clear height (bottom edge duct) | m | | | |
| Flue gas velocity (max.) | m/s | 18 | | |
| Insulation (yes/no) | - | | | |
| Insulation thickness | mm | | | |
| Insulation material | - | | | |
| Compensator material | - | | | |
| Straight length upstream emission measurement | m | | | |
| Straight length downstream emission measurement | m | | | |
| Material support construction outside cooling tower | - | | | |
| Support structure inside cooling tower | - | | | |
| Base material | - | | | |
| Coating | - | | | |
| | | | | |
| **Expansions joints (1):** | | | | |
| Position | - | | | |
| Type | - | | | |
| Material | - | | | |
| Max. allowable flue gas temperature | °C | | | |
| | | | | |
| **Expansions joints (2):** | | | | |
| Position | - | | | |
| Type | - | | | |
| | | | | |
| Material | - | | | |
| Max. allowable flue gas temperature | °C | | | |
| | | | | |
| **Expansions joints (3):** | | | | |
| Position | - | | | |
| Type | - | | | |
| Material | - | | | |
| Max. allowable flue gas temperature | °C | | | |
| | | | | |
| **Expansions joints (4):** | | | | |
| Position | - | | | |
| Type | - | | | |
| Material | - | | | |
| Max. allowable flue gas temperature | °C | | | |
| | | | | |
| **Expansions joints (5):** | | | | |
| Position | - | | | |
| Type | - | | | |
| Material | - | | | |
| Max. allowable flue gas temperature | °C | | | |
| | | | | |
| **Expansions joints (6):** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Position | - | | | |
| Type | - | | | |
| Material | - | | | |
| Max. allowable flue gas temperature | °C | | | |
| | | | | |
| **Steam air preheater (If applicable)** | | | | |
| Material of tubes and fins | - | Hot dip-galvanized steel | | |
| Tube wall thickness | mm | > 2.0 | | |
| Fin thickness | mm | > 0.4 | | |
| Fin pitch | mm | > 5.0 | | |
| | | | | |
| **Steam air preheater – primary air** | | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Number | - | 2 | | |
| Heat exchanger area | $m^2$ | | | |
| Steam flow | kg/s | | | |
| Steam pressure at inlet | bar(g) | | | |
| Shell & design coil pressure | bar(g) | | | |
| Condensate temperature at outlet | °C | | | |
| Combustion air mass flow rate | kg/s | | | |
| Combustion air inlet temperature | °C | | | |
| Combustion air temperature at outlet | °C | | | |
| Pressure loss on the combustion side | mbar | | | |
| Primary air steam heater outlet | mbar(g) | | | |
| Tube material | - | | | |
| Forms of tubes (oval or round) | - | | | |
| Fin material | - | | | |
| Pitching of fins | mm | | | |
| Thickness of fins | mm | | | |
| Total mass of preheater | t | | | |
| Accessoires | | | | |
| • Condensate collection tank (y/n) | - | | | |
| • Local instruments | - | | | |
| • Isolating regulation valves (y/n) | - | | | |
| | | | | |
| **Steam air preheater – secondary air** | | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Number | - | 2 | | |
| Heat exchanger area | $m^2$ | | | |
| Steam flow | kg/s | | | |
| Steam pressure at inlet | bar(g) | | | |
| Condensate temperature at outlet | °C | | | |
| Combustion air mass flow rate | kg/s | | | |
| Combustion air inlet temperature | °C | | | |
| Combustion air temperature at outlet | °C | | | |
| Pressure loss on the combustion side | mbar | | | |
| Secondary air steam heater outlet | mbar(g) | | | |
| Tube material | - | | | |
| Forms of tubes (oval or round) | - | | | |
| Fin material | - | | | |
| Pitching of fins | mm | | | |
| Thickness of fins | mm | | | |
| Total mass of preheater | t | | | |
| | | | | |
| **Regenerative air heater:** | | | | |
| Capacity of one single regenerative air heater | %BMCR | 60 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Thickness of hot elements | mm | > 0.8 | | |
| Thickness of cold (enamelled) elements | mm | > 1.2 | | |
| Height of cold elements | mm | > 300 | | |
| Space for adding further heating elements | mm | > 500 | | |
| $CO_2$ drop in air heater, assuming that the time the seals were readjusted no more than 8 days before starting the test at 100% load | % | < 1.0 | | |
| $CO_2$ drop in air heater, assuming that the time the seals were readjusted no more than 8 days before starting the test at 60% load | % | < 1.5 | | |
| Shaft arrangement | - | Vertical | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Number per unit | - | 2 | | |
| Type | - | | | |
| Heat exchanged | MW | | | |
| Total heat exchange area | $m^2$ | | | |
| Hot end layer height | mm | | | |
| Intermediate layer height | mm | | | |
| Cold end layer height (ceramic/enamelled) | mm | | | |
| Stator or rotor diameter | mm | | | |
| Hot end plate thickness | mm | | | |
| Intermediate plate thickness | mm | | | |
| Cold end plate thickness | mm | | | |
| Material of the hot end plates | - | | | |
| Material intermediate plate | - | | | |
| Material of the cold end plates (ceramic/enamelled) | - | | | |
| Inlet flue gas flow rate (with dust) | kg/s | | | |
| Outlet flue gas flow rate (with dust) | kg/s | | | |
| Inlet combustion air flow rate | kg/s | | | |
| Outlet combustion air flow rate | kg/s | | | |
| Inlet flue gas temperature | °C | | | |
| Outlet flue gas temperature | °C | | | |
| Inlet combustion air temperature | °C | | | |
| Primary air at regenerative air heater outlet | °C | | | |
| Secondary air at regenerative air heater outlet | °C | | | |
| Minimum mean cold end heating surface temperature | °C | | | |
| Reg. air preheater/cold side: | mbar(g) | | | |
| Pressure at hot end | mbar(g) | | | |
| Pressure at cold end | mbar(g) | | | |
| • primary section | mbar(g) | | | |
| • secondary section | mbar(g) | | | |
| Reg. air preheater/hot side: | mbar(g) | | | |
| • primary section | mbar(g) | | | |
| • secondary section | mbar(g) | | | |
| Secondary air before burners | mbar(g) | | | |
| Rotational speed | $min^{-1}$ | | | |
| Power consumption | kW | | | |
| Total mass of preheater with motors | t | | | |
| Type of seals | | | | |
| • Radial (HE & CE) | - | | | |
| • Axial | - | | | |
| • Bypass | - | | | |
| Type of speed reducer | - | | | |
| Type of emergency drive | - | | | |
| Speed ratio | | | | |
| | | | | |
| **Cleaning equipment for regererative air heater** | | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Number of sootblowers per air heater | - | | | |
| Type | - | | | |
| Duration of one sootblowing cycle | min | | | |
| Operating time of a sootblower per cycle | min | | | |
| Steam consumption per sootblower and cycle/air heater | kg | | | |
| Steam consumption of all sootblowers per cycle/air heater | kg | | | |
| Number of sootblower cycles per day | - | | | |
| | | | | |
| **Regenerative air heater washing installation** | | | | |
| Washing medium | - | | | |
| Wash water flow rate | kg/s | | | |
| Wash water pressure | bar(g) | | | |
| Duration of wash process | min | | | |
| | | | | |
| **Wash water pumps** | | | | |
| Manufacturer | - | | | |
| Origin of Manufacturer | - | | | |
| Number | - | | | |
| Flow rate | kg/s | | | |
| | | | | |
| **Electrostatic Precipitator (ESP)** | | Refer Section-5,Chapter-22 | | |
| Number of ESPs per ESP system | - | 2 | | |
| Manufacturer | - | | | |
| Volumetric flow rate | $m^3/s$ | | | |
| Dust loading clean gas at normal operation | $mg/m^3$ | | | |
| Dust loading clean gas at soot blowing | $mg/m^3$ | | | |
| Max. negative pressure at outlet hood | mbar | | | |
| Flue gas temperature | °C | | | |
| design | °C | | | |
| 100% load | °C | | | |
| 70% load | °C | | | |
| 40% load | °C | | | |
| $CO_2$ content | % | | | |
| Unburnt gases | % | | | |
| Max. raw gas dust load | $mg/Nm^3$ ** | | | |
| Max. raw gas dust load at soot blowing | $mg/Nm^3$ ** | | | |
| Max. gas dust load at ESP outlet | $mg/Nm^3$ ** | < 50 | | |
| ** $mg/Nm^3$ , *dry at 6% $O_2$* | | | | |
| Number of filters | - | | | |
| Number of chambers | - | | | |
| Number of fields per chamber | - | | | |
| Aspect ratio | - | | | |
| Length (from inlet to outlet flange) including distribution ductwork | m | | | |
| Width (inside) | m | | | |
| Width (outside) | m | | | |
| Wall thickness casing | mm | | | |
| Overall height | m | | | |
| Active length of field | m | | | |
| Incoming flow | m | | | |
| Active height of field | m | | | |
| Plate length per field | m | | | |
| Effective width and height of field | m x m | | | |
| Incoming flow area | $m^2$ | | | |
| Number of electrical fields along flue gas path | - | | | |
| Number of electrical fields across flue gas path | - | | | |
| Effective free cross-section in electrical field | m | | | |
| Number of discharge electrodes per field | - | | | |
| Number of collecting electrodes per field | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Number of electrical fields out of operation at full dust removal capacity | - | min. 1 | | |
| Type of discharge electrodes per field | - | | | |
| Type of discharge electrodes per field | - | | | |
| Gas Velocity in electrical field | m/s | | | |
| Effective gas velocity | m/s | | | |
| Transgression Speed | cm/s | | | |
| Retention in electrical field | s | | | |
| Projected deposit surface | $m^2$ | | | |
| Specific collection area (SCA) | $m^2/(m^3/s)$ | | | |
| Specific power consumption of deposit surface | $W/m^2$ | | | |
| Pressure loss of filter with inlet and outlet | mbar | | | |
| Max. permissible pressure | mbar | | | |
| Continuous operation | mbar | | | |
| Pressure, static normal minimum | mbar | | | |
| Fly ash hopper | | | | |
| • Number | - | | | |
| • Total volume | $m^3$ | | | |
| • Minimum storage capacity | h | 10 | | |
| Surface insulated (excluding roof) | | | | |
| • Casing with inlet and outlet nozzles | $m^2$ | | | |
| • Raw gas duct | $m^2$ | | | |
| • Clean gas duct | $m^2$ | | | |
| Erection length from inlet to | | | | |
| • Outlet flange (without covers) | mm | | | |
| • Outlet flange (with covers) | mm | | | |
| Filter Width (inner) | mm | | | |
| Filter Width (outer) | mm | | | |
| Plate thickness casing / ducts | mm | | | |
| Erection height from ash hopper to roof girder | mm | | | |
| Number of HV-units | - | | | |
| Type of rectifier | - | | | |
| Rated output current of HV-aggregates | mA | | | |
| Rated output current of HV-aggregates | mA | | | |
| Rated voltage of HV-aggregates | $kV_{eff}$ | | | |
| Rated voltage of HV-aggregates at no-load | kV | | | |
| Rated power per aggregate | kW | | | |
| Number of plate rapper motors | - | | | |
| Hammerings per drive | - | | | |
| Power consumption per plate rapper motor | kW | | | |
| Number of wire rapper motors | - | | | |
| Power consumption per wire rapper motor | kW | | | |
| Total number of insulators | - | | | |
| Insulators heating | kW | | | |
| Power supply for rapper and insulators | kW | | | |
| Total power consumption | kW | | | |
| Insulation thickness | | | | |
| • Raw gas duct | mm | | | |
| • Filter casing | mm | | | |
| • Bunker | mm | | | |
| • Clean gas cover | mm | | | |
| • Clean gas duct | mm | | | |
| | | | | |
| **FGD** | | | | |
| **Absorber** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Total height | m | | | |
| Pressure loss between raw gas inlet and outlet | mbar | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Pressure loss between clean gas inlet and outlet | mbar | | | |
| Weight empty | t | | | |
| Weight during operation | t | | | |
| Diameter sump | m | | | |
| Sump volume | m³ | | | |
| Min. hold-up time | min | | | |
| Sump height | m | | | |
| Solid content (sump) | wt.% | | | |
| Number of stirring units | - | | | |
| Installation position | - | | | |
| Installed power per stirring unit | kW | | | |
| Stirring unit power input | kW | | | |
| Diameter absorption zone | m | | | |
| Height absorption zone (from bottom edge raw gas inlet) | m | | | |
| Raw gas velocity at | | | | |
| • BMCR, worst coal | m/s | | | |
| • MCR | m/s | | | |
| • MNCR | m/s | | | |
| Number of spray levels installed (in op/spare) | - | | | |
| Number of recirculation pumps | - | | | |
| Design capacity | | 100% for each spray level | | |
| Number of spray layers in operation | - | | | |
| Circulation volume per spray layer | m³/h | | | |
| Circulation volume total (at 100% load) | m³/h | | | |
| Liquid/gas (100% load) | l/m³ | | | |
| Distance between spray layers | m | | | |
| Number of spray nozzles top layer | - | | | |
| Number of spray nozzles lower layers | - | | | |
| Type of nozzles in top layer (e.g. eccentric concave cone nozzle) | - | | | |
| Spraying direction (flow) | - | | | |
| Nozzle initial pressure | bar | | | |
| Flow rate per nozzle/per nozzle mouth | m³/h | | | |
| Type of nozzles in lower layers (e.g. eccentric concave cone nozzle) | - | | | |
| Spraying direction interior zone (flow) | % | | | |
| Spraying direction border & header (flow) | % | | | |
| Nozzle initial pressure | bar | | | |
| Flow rate per nozzle/per nozzle mouth | m³/h | | | |
| **Mist eliminator (ME)** | | | | |
| Number | | min 2 (+ 1 spare) | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Number of layers | - | | | |
| Drop concentration after ME (after 2 layers) | $mg/m^3$ | | | |
| Drop concentration after ME (after 3 layers) | $mg/m^3$ | | | |
| Max. approach velocity | m/s | | | |
| Pressure loss (2 stages) | mbar | | | |
| Pressure loss (3 stages) | mbar | | | |
| | | | | |
| **Oxidation air compressor** | | | | |
| Type | - | | | |
| Number | - | 2 | | |
| Design capacity | % | 2 x 100 | | |
| Installed motor power | kW | | | |
| El. demand (max. /100%) | kW | | | |
| Air flow rate per compressor | $m^3/h$ | | | |
| Type of oxidation air distribution | - | | | |
| | | | | |
| **Materials** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Raw gas inlet | - | | | |
| Emergency spraying system | - | | | |
| Sump + Bottom / thickness | - /mm | | | |
| Absorption zone / thickness | - /mm | | | |
| Clean gas outlet | - | | | |
| Stirrer Shaft | - | | | |
| Stirrer Propeller | - | | | |
| Supporting structure (within absorber) | - | | | |
| Oxidation air distributor | - | | | |
| Suspension distribution pipes | - | | | |
| Spray nozzles lance | - | | | |
| Demister | - | | | |
| | | | | |
| **Circulation pumps** | | | | |
| Number | - | | | |
| Design capacity | % | 100 for each spry level | | |
| Flow rate | $m^3/h$ | | | |
| Delivery height | bar | | | |
| Speed | 1/min | | | |
| Shaft power | kW | | | |
| Installed motor capacity | kW | | | |
| Required NPSH | m | | | |
| Available NPSH | m | | | |
| Nominal width suction pipe | DN | | | |
| Nominal width pressure pipe | DN | | | |
| Material adapter | - | | | |
| Dimension intake strainer | m | | | |
| approach surface | $m^2$ | | | |
| | | | | |
| **Materials** | | | | |
| Casing | - | | | |
| Impeller | - | | | |
| Side wear plate | - | | | |
| Intake strainer | - | | | |
| | | | | |
| **Other pumps (if different from above named circulation pumps)** | | | | |
| Name | | | | |
| Flow rate | $m^3/h$ | | | |
| Delivery height | bar | | | |
| Speed | 1/min | | | |
| Shaft power | kW | | | |
| Installed capacity | kW | | | |
| Required NPSH | m | | | |
| Available NPSH | m | | | |
| Nominal width suction pipe | DN | | | |
| Nominal width pressure pipe | DN | | | |
| Materials | | | | |
| • Case | - | | | |
| • Impeller | - | | | |
| • Side wear plate | - | | | |
| • Intake strainer | - | | | |
| | | | | |
| **FGD drain system** | | | | |
| **Emergency drain tank** | | | | |
| Capacity | $m^3$ | | | |
| Diameter | m | | | |
| Ratio to sump volume | - | | | |
| Material | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Stirrers | | | | |
| • Number | - | | | |
| • Installation position | - | | | |
| • Installed power per stirrer | kW | | | |
| • Power input | kW | | | |
| Materials | | | | |
| • Stirrer shaft | - | | | |
| • Stirrer impeller | - | | | |
| | | | | |
| **Emergency drain pumps** | | | | |
| Number | - | | | |
| Flow rate | $m^3/h$ | | | |
| Discharging time | h | | | |
| Material | - | | | |
| Installed power | kW | | | |
| | | | | |
| **Slop pit** | | | | |
| Volume | $m^3$ | | | |
| Dimensions (l x b x h) | m | | | |
| Material | - | | | |
| Coating | - | | | |
| Number of stirrers | - | | | |
| Materials | | | | |
| • Stirrer shaft | - | | | |
| • Stirrer Impeller | - | | | |
| | | | | |
| **Slop pit pumps** | | | | |
| Number | - | | | |
| Flow rate | $m^3/h$ | | | |
| Material | - | | | |
| Installed power | kW | | | |
| NPSH | bar | | | |
| | | | | |
| **FGD Gypsum dewatering** | | | | |
| **Gypsum suspension pumps** | | | | |
| Number | - | 2 | | |
| Design capacity | % | 2 x 100 | | |
| Flow rate | $m^3/h$ | | | |
| Design buffer | % | | | |
| Installed power | kW | | | |
| Intake strainer type | - | | | |
| | | | | |
| **Gypsum hydrocyclone stations** | | | | |
| Number of stations | - | 2 | | |
| Design capacity | % | 2 x 70 | | |
| Number of cyclones per station | | | | |
| • Total | - | | | |
| • Operation | - | | | |
| • Stand-by | - | | | |
| Material | - | | | |
| Flow rate per station | $m^3/h$ | | | |
| Design buffer | % | | | |
| Supplier | - | | | |
| Solid content cyclone overflow | wt.% | | | |
| Solid content cyclone underflow | wt.% | | | |
| | | | | |
| **Vacuum belt filter** | | | | |
| Manufacturer | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
| --- | --- | --- | --- | --- |
| Number | - | 2 | | |
| Design capacity | % | 2 x 70 | | |
| Filtration surface | m² | | | |
| Dewatering rating | $m^3/h$ | | | |
| Flow rate | t/h | | | |
| Design capacity of one vacuum belt filter | % of MCR*** | | | |
| Design buffer | % | | | |
| Operation mode | - | | | |
| Power input for vacuum pump | kW | | | |
| Power input for belt | kW | | | |
| Gypsum residual moisture | wt.% | | | |
| Gypsum $Cl^-$ content after gypsum washing | ppm | | | |
| Demand of washing water | $m^3/h$ | | | |
| Material vacuum pumps | | | | |
| Impeller | - | | | |
| Control discs | - | | | |
| Side shield | - | | | |
| ***operating capacity at MCR with worst coal | | | | |
| | | | | |
| **Filtering cloth washing water tank** | | | | |
| Number | - | | | |
| Capacity | $m^3$ | | | |
| Diameter | m | | | |
| Material | - | | | |
| | | | | |
| **Filtering cloth washing water pump** | | | | |
| Number | - | | | |
| Flow rate | $m^3/h$ | | | |
| Material | - | | | |
| Installed power | kW | | | |
| NPSH, required | m | | | |
| | | | | |
| **Filter cake washing water vessel** | | | | |
| Number | - | | | |
| Capacity | $m^3$ | | | |
| Diameter | m | | | |
| Material | - | | | |
| | | | | |
| **Filter cake washing water pump** | | | | |
| Number | - | | | |
| Flow rate | $m^3/h$ | | | |
| Material | - | | | |
| Installed power | kW | | | |
| NPSH, required | bar | | | |
| | | | | |
| **Recirculation water cyclone pump** | | | | |
| Number | - | | | |
| Flow rate | $m^3/h$ | | | |
| Design buffer | % | | | |
| Material | - | | | |
| Installed power | kW | | | |
| NPSH, required | m | | | |
| | | | | |
| **Waste water tank** | | | | |
| Number | - | | | |
| Volume | $m^3$ | | | |
| Diameter | m | | | |
| Material | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Installed power | kW | | | |
| | | | | |
| **Waste water pumps** | | | | |
| Number | - | | | |
| Flow rate | $m^3/h$ | | | |
| Material | - | | | |
| Installed power | kW | | | |
| NPSH, required | m | | | |
| Nominal flow rate at 100 % guarantee loading case | $m^3/h$ | | | |
| Max. flow rate | $m^3/h$ | | | |
| | | | | |
| **Gypsum handling** | | | | |
| **Gypsum intermediate silo** | | | | |
| Number (per unit) | - | 1 | | |
| Net capacity at MCR with design coal | h | 24 | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Gypsum bulk density | $t/m^3$ | | | |
| Max. particle diameter | mm | | | |
| Repose angle (gypsum slope) | ° | | | |
| Moisture content | wt.% | | | |
| Max. moisture content | wt.% | | | |
| Useful volume | $m^3$ | | | |
| Capacity | d * | 1 | | |
| External diameter | m | | | |
| Inner diameter | m | | | |
| Max. filling height | m | | | |
| Height bottom edge penthouse level | m | | | |
| Height bottom edge gypsum storage | m | | | |
| Total height | m | | | |
| Material | - | | | |
| Coating | - | | | |
| Nominal capacity | t/h | | | |
| Unloading flow rate | t/h | | | |
| Loading mechanism | - | | | |
| Mechanism for spreading the bulk material in the silo | - | | | |
| Mechanism for reclaiming the bulk material | - | | | |
| Type of discharge | - | | | |
| * operating days at MCR with Performance coal | | | | |
| | | | | |
| **Limestone system** | | | | |
| Number of limestone supply & handling systems total | - | | | |
| Number of limestone supply & handling systems per unit | - | | | |
| **Limestone dumping stations** | | | | |
| Front end loader dumping | | | | |
| Number of stations | - | 1 | | |
| Type | - | | | |
| Discharge capacity to intermediate silo | t/h | | | |
| Max. time for unloading one front end loader and providing to silo | min | | | |
| Belt conveyor | | | | |
| Type | - | | | |
| Vertical conveyor | | | | |
| Type | - | | | |
| Max. dust emissions exhaust air filter while front end loader dumping | $mg/m^3$ | | | |
| Compressed air demand exhaust air filter | $m^3/h$ | | | |
| | | | | |
| **Limestone intermediate silo** | | Refer Section-5, Chapter-9 | | |
| Number | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Capacity | $m^3$ | | | |
| Capacity | d * | | | |
| Diameter | | | | |
| • External | m | | | |
| • Internal | m | | | |
| Cylindrical height | m | | | |
| Material | - | | | |
| Number of discharge stations | - | | | |
| Weigh belt feeder | - | | | |
| • Number | - | | | |
| • Capacity | % | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| • Capacity | t/h | | | |
| Pre crusher | | | | |
| • Number | - | | | |
| • Capacity | % | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| • Milling capacity | t/h | | | |
| Mills | | | | |
| • Number | - | | | |
| • Capacity | % | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| • Milling capacity | t/h | | | |
| * operating days at BMCR with worst coal | | | | |
| | | | | |
| **Mill receiver tank** | | | | |
| Number | - | 2 | | |
| Capacity | % | 2 x 100 | | |
| Volume | $m^3$ | | | |
| Capacity | d * | | | |
| Diameter | m | | | |
| Material | - | | | |
| Height | m | | | |
| Material | - | | | |
| Number of stirrers | - | | | |
| Rated motor capacity per stirrer | kW | | | |
| | | | | |
| **Limestone slurry pumps** | | | | |
| Number | - | 3 (2 working + 1 Standby) | | |
| Capacity | % | 3 x 60 | | |
| Flow rate | $m^3/h$ | | | |
| Design buffer | % | | | |
| Delivery height | m | | | |
| Material casing | - | | | |
| Material impeller | - | | | |
| Installed motor capacity | kW | | | |
| NPSH | m | | | |
| | | | | |
| **Limestone slurry - hydrocyclone stations** | | | | |
| Number of stations | - | 3 | | |
| Capacity | % | 2 x 60 | | |
| Number of cyclones per station | | | | |
| • Total | - | | | |
| • Operation | - | | | |
| • Stand-by | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Material | - | | | |
| Flow rate per station | $m^3/h$ | | | |
| Design buffer | % | | | |
| Supplier | - | | | |
| Solid content cyclone overflow | wt.% | | | |
| Solid content cyclone underflow | wt.% | | | |
| | | | | |
| **Limestone slurry tank** | | | | |
| Number | - | 1 (Common for 2 Boiler) | | |
| Capacity | % | | | |
| Volume | m³ | | | |
| Capacity | h * | | | |
| Diameter | m | | | |
| Material | - | | | |
| Height | m | | | |
| Material | - | | | |
| Number of stirrers | - | | | |
| Rated motor capacity per stirrer | kW | | | |
| | | | | |
| **Limestone slurry feed pumps** | | | | |
| Number | - | | | |
| Capacity | % | | | |
| Flow rate | m³/h | | | |
| Design buffer | % | | | |
| Delivery height | m | | | |
| Material casing | - | | | |
| Material impeller | - | | | |
| Installed motor capacity | kW | | | |
| NPSH | m | | | |
| | | | | |
| **Sump pit** | | 2 | | |
| Volume | m³ | | | |
| Dimensions (l x b x h) | m | | | |
| Material | - | | | |
| Number of stirrer | - | | | |
| Stirrers capacity per stirrer | kW | | | |
| Materials | | | | |
| Stirrer shaft | - | | | |
| Stirrer impeller | - | | | |
| | | | | |
| **Sump pumps** | | | | |
| Number | - | 2 | | |
| Flow rate | m³/h | | | |
| Material casing | - | | | |
| Material impeller | - | | | |
| | | | | |
| **Residues & operation materials** | | | | |
| Filter ash (ESP) | t/h | | | |
| Limestone | | | | |
| design | t/h | | | |
| min | t/h | | | |
| max | t/h | | | |
| Limestone slurry | $m^3/h$ | | | |
| Process water | | | | |
| FGD absorber | $m^3/h$ | | | |
| Gypsum dewatering | $m^3/h$ | | | |
| Filter cloth washing | $m^3/h$ | | | |
| Electrical needs | kW | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Gypsum, 10% residual moisture | | | | |
| design | t/h | | | |
| min | t/h | | | |
| max | t/h | | | |
| Gypsum from absorber | t/h | | | |
| Gypsum from absorber | $m^3/h$ | | | |
| Gypsum downstream of hydrocyclone, max | t/h | | | |
| Gypsum downstream of hydrocyclone, max | $m^3/h$ | | | |
| Compressed air as conveyance air for ash handling system | $Nm^3/h$ | | | |
| Waste water | | | | |
| design | $m^3/h$ | | | |
| min | $m^3/h$ | | | |
| max | $m^3/h$ | | | |
| Antifoam medium | kg/h | | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | Bidder name | |
| | | **Refer Section-5, Chapter-11** | | |
| **Pipes and valves** | | | | |
| Suction capacity ( dust etc. ) | t/h | | | |
| Max. particle size | mm | | | |
| Pipe material | - | | | |
| Pipe diameter | mm | | | |
| Pipe wall thickness | mm | | | |
| Total length of piping system | m | | | |
| Number of suction points DN50 | - | | | |
| Number of suction points DN150 | - | | | |
| Number of suction hoses | - | | | |
| Design pressure | bar g | | | |
| | | | | |
| **Pre-separator** | | | | |
| Number | - | | | |
| Type of pre-separator | - | | | |
| Capacity ( dust and other solids ) | t/h | | | |
| Max. particle size | mm | | | |
| Separation particle size | mm | | | |
| Design pressure | bar g | | | |
| Casing material | - | | | |
| Casing thickness | mm | | | |
| | | | | |
| **Rotary valve below pre-separator** | | | | |
| Number | - | | | |
| Capacity | t/h | | | |
| Max. particle size | mm | | | |
| Design pressure | bar g | | | |
| | | | | |
| **Fine dust filter** | | | | |
| Number | - | | | |
| Type of filter | - | | | |
| Capacity ( dust and other solids ) | t/h | | | |
| Max. particle size | mm | | | |
| Dust emission | $mg/m^3{}_N$ | | | |
| | | | | |
| | | | | |
| Spec. filter loading | $M^3/m^2 min$ | | | |
| Fabric quality | - | | | |
| Design pressure | bar g | | | |
| | | | | |
| **Rotary valve below fine filter** | | | | |
| | | | | |
| Capacity | t/h | | | |
| Max. particle size | mm | | | |
| Design pressure | bar g | | | |
| | | | | |
| **Vacuum blower** | | | | |
| Number | - | | | |
| Type of vacuum blower | - | | | |
| Pressure increase | mbar | | | |
| Capacity | $m^3{}_N/h$ | | | |
| Mode of operation | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | Bidder name | |
| **Instrument & Service Air** | | **Refer Section-5, Chapter-15** | | |
| **• Air compressors** | | | | |
| • Number | | 6 | | |
| • Type | - | | | |
| • Number of pressure stages | - | | | |
| • Manufacturer | - | | | |
| • Design capacity of each compressor | $Nm^3$/min | | | |
| • Discharge pressure | bar(g) | | | |
| • Power demand per compressor | kW | | | |
| • Cooling water demand per compressor | kW or kg/s | | | |
| • Discharge air temperature | °C | | | |
| | | | | |
| **• Air cooler, where required** | | | | |
| • Number | | | | |
| • Type | - | | | |
| • Manufacturer | - | | | |
| • Design capacity | $Nm^3$/min | | | |
| • Cooling water demand per air cooler | kW or kg/s | | | |
| • Discharge air temperature | °C | | | |
| | | | | |
| **• Filter** | | | | |
| • Number | - | | | |
| • Manufacturer | - | | | |
| • Design volume flow | $m^3$/min | | | |
| • Design pressure | bar | | | |
| • Filter material | - | | | |
| • No. of Particels per m³ | - | acc. ISO 8573-1 Class 2 | | |
| • Oil & Oil Vapour | mg/m³ | acc. ISO 8573-1 Class 2 | | |
| | | | | |
| **• Adsorption dryer** | | | | |
| • Design | | | | |
| • Number | | 6 | | |
| • Manufacturer | - | | | |
| • Design volume flow | $m^3$/min | | | |
| • Design pressure | bar | | | |
| • Dew point at operating pressure | °C | | | |
| • Switching frequency Dying/Regeneration | 1/h | < 5 | | |
| • Regeneration time | min | | | |
| | | | | |
| **• Air Receiver / Reservoir** | | Main receiver provided in Compressor House. Individual receiver tanks required each area like Boiler, STG Building, WTP, ASH Handling & Coal Handling, Other BOP areas wherever required. | | |
| • Number | - | | | |
| • Manufacturer | - | | | |
| • Volume | $m^3$ | | | |
| • Material | - | | | |
| • Design pressure | bar | | | |
| • Design temperature | °C | | | |
| | | | | |
| **• Local PLC** | | | | |
| • Number of | - | 1 | | |
| • Manufacturer | - | | | |
| • Type | - | | | |
| • System | - | | | |
| • Type of Interface to DCS | - | | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | **Refer Section-5, Chapter-20** | Bidder name | |
| **Fire main pumps** | | | | |
| **Fire jockey pump(electric driven)** | | | | |
| | | | | |
| **Fire main pumps (electric driven)** | | | | |
| Description | - | | | |
| Number off | - | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Construction standard | - | | | |
| Pumped fluid | | | | |
| • Density | $kg/m^3$ | | | |
| • Temperature | °C | | | |
| | | | | |
| Performance Requirements: | | | | |
| • Duty capacity | l/s | | | |
| • Capacity at best efficiency | l/s | | | |
| • Minimum continuous flow | l/s | | | |
| • Suction head | bar (a) | | | |
| • Total head | bar (a) | | | |
| • Total head at close valve | bar (a) | | | |
| • Efficiency | % | | | |
| • NPSH required | bar (a) | | | |
| • NPSH available | bar (a) | | | |
| • Absorbed power | kW | | | |
| • Speed | rpm | | | |
| | | | | |
| Material of Construction: | - | | | |
| • Casing | - | | | |
| • Impeller | - | | | |
| • Shaft | - | | | |
| • Shaft sleeves | - | | | |
| | | | | |
| Total weight of complete unit | kg | | | |
| | | | | |
| **Fire main pump motors** | | | | |
| Description | - | | | |
| Number off | - | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Construction standard | - | | | |
| Enclosure classification (IP No.) | - | | | |
| Rated power | kW | | | |
| Speed | rpm | | | |
| Voltage | V | | | |
| Full load current | A | | | |
| Total weight | kg | | | |
| | | | | |
| **Fire main pump diesel engine (If requiered)** | | | | |
| Description | - | | | |
| Number off | - | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Construction standard | - | | | |
| Type designation | - | | | |
| Frame size | - | | | |
| Rated capacity (ISO) | kW | | | |
| Rate power (t = 48°C) | kW | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Fuel consumption (at rating) | l/s | | | |
| Fuel tank capacity | $m^3$ | | | |
| Speed | rpm | | | |
| Weight | kg | | | |
| | | | | |
| **Fire main pumps diesel driven (If required)** | | | | |
| | | | | |
| Description | - | | | |
| Number off | - | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Construction standard | - | | | |
| Pumped fluid | | | | |
| • Density | $kg/m^3$ | | | |
| • Temperature | °C | | | |
| | | | | |
| Performance Requirements: | | | | |
| • Duty capacity | l/s | | | |
| • Capacity at best efficiency | l/s | | | |
| • Minimum continuous flow | l/s | | | |
| • Suction head | bar (a) | | | |
| • Total head | bar (a) | | | |
| • Total head at close valve | bar (a) | | | |
| • Efficiency | % | | | |
| • NPSH required | bar (a) | | | |
| • NPSH available | bar (a) | | | |
| • Absorbed power | kW | | | |
| • Speed | rpm | | | |
| | | | | |
| Material of Construction: | - | | | |
| • Casing | - | | | |
| • Impeller | - | | | |
| • Shaft | - | | | |
| • Shaft sleeves | - | | | |
| | | | | |
| Total weight of complete unit | kg | | | |
| | | | | |
| **Fire jockey pump(electric driven)** | | | | |
| | | | | |
| Description | - | | | |
| Number off | - | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Construction standard | - | | | |
| Pumped fluid | | | | |
| • Density | $kg/m^3$ | | | |
| • Temperature | °C | | | |
| | | | | |
| Performance Requirements: | | | | |
| • Duty capacity | l/s | | | |
| • Capacity at best efficiency | l/s | | | |
| • Minimum continuous flow | l/s | | | |
| • Suction head | bar (a) | | | |
| • Total head | bar (a) | | | |
| • Total head at close valve | bar (a) | | | |
| • Efficiency | % | | | |
| • NPSH required | bar (a) | | | |
| • NPSH available | bar (a) | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| • Absorbed power | kW | | | |
| • Speed | rpm | | | |
| | | | | |
| Material of Construction: | - | | | |
| • Casing | - | | | |
| • Impeller | - | | | |
| • Shaft | - | | | |
| • Shaft sleeves | - | | | |
| | | | | |
| Total weight of complete unit | kg | | | |
| | | | | |
| **Expansion Tank** | | | | |
| Expansion tank capacity | $m^3$ | | | |
| Type of pressure rising (describe) | | | | |
| | | | | |
| **Fire Hydrants** | | | | |
| Type | - | | | |
| Number off | - | | | |
| Manufacturer | - | | | |
| Model/type No. | - | | | |
| Inlet coupling size/type | mm | | | |
| Number of outlets | - | | | |
| Type/size of coupling | mm | | | |
| Materials | - | | | |
| | | | | |
| **Hose Reels** | | | | |
| Type | - | | | |
| Number off | - | | | |
| Manufacturer | - | | | |
| Hose diameter | mm | | | |
| Hose length | m | | | |
| Nozzle: | | | | |
| Type | - | | | |
| Material | - | | | |
| Cabinet (if applicable) | - | | | |
| Size (Width x height x depth) | mm | | | |
| Material | - | | | |
| | | | | |
| **Sprinkler Systems** | | | | |
| Number off | - | | | |
| Locations | - | | | |
| Manufacturer | - | | | |
| Type of control | - | | | |
| | | | | |
| **Spray Water Systems** | | | | |
| Number off | - | | | |
| Locations | - | | | |
| Manufacturer | - | | | |
| Type of control | - | | | |
| | | | | |
| **Inert Gas System** | | | | |
| Number off | - | | | |
| Locations | - | | | |
| Manufacturer | - | | | |
| Type of operation | - | | | |
| Concentration | % Vol | | | |
| No. of Inert Gas Cylinders | - | | | |
| Reserve Supply | % | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | | |
| **Fire Protection Water/ Foam System** | | | | |
| Number off | - | | | |
| Locations | - | | | |
| Manufacturer | - | | | |
| Type of foam | | | | |
| Type of operation | - | | | |
| Concentration | % Vol | | | |
| No. of foam tanks | - | | | |
| Tank capacity | $m^3$ | | | |
| | | | | |
| **Gas Detection** | | | | |
| 1) Detection and alarm system | - | | | |
| 2) Portable detectors | - | | | |
| | | | | |
| Number off | - | | | |
| Locations | - | | | |
| Manufacturer | - | | | |
| Type of detector | - | | | |
| No. of detectors | - | | | |
| | | | | |
| **CO2 Fire Extinguisher** | | | | |
| Manufacturer | - | | | |
| Model | - | | | |
| Capacity | kg | | | |
| Full weight | kg | | | |
| Discharge time | seconds | | | |
| | | | | |
| **Foam Fire Extinguishers** | | | | |
| Manufacturer | - | | | |
| Model | - | | | |
| Capacity | kg | | | |
| Full weight | kg | | | |
| Discharge time | seconds | | | |
| | | | | |
| **Dry Powder Extinguisher** | | | | |
| Manufacturer | - | | | |
| Model | - | | | |
| Capacity | kg | | | |
| Full weight | kg | | | |
| Discharge time | seconds | | | |
| | | | | |
| **Water Fire Extinguisher** | | | | |
| Manufacturer | | | | |
| Model | | | | |
| Capacity | l | | | |
| Full weight | kg | | | |
| Discharge time | seconds | | | |
| | | | | |
| **Fire and Gas Detection System** | | | | |
| | | | | |
| **1. General** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Year of first commercial operation | - | | | |
| Applicable standards | - | | | |
| | | | | |
| **2. Local control and alarm panels** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| No. of local control panels | - | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Addressable fire/gas detectors | yes/no | | | |
| | | | | |
| **3. Local control panels are installed in following locations** | | | | |
| Administration building including control room | yes/no | | | |
| Workshop & warehouse building | yes/no | | | |
| UF & RO Electrical Building | yes/no | | | |
| Water Intake Electrical Building | yes/no | | | |
| Product Water Electrical Building (if applicable) | yes/no | | | |
| Other locations (to be indicated by Tenderer) | yes/no | | | |
| | | | | |
| **4. Operator stations in the CCR** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Number of VDU's | - | | | |
| Screen size | mm x mm | | | |
| Type/manufacturer of workstation | - | | | |
| Number of workstations | - | | | |
| Mimic panel size | mm x mm | | | |
| | | | | |
| **5. Repeater stations in the fire brigade building** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Number of VDU | - | | | |
| Screen size | mm x mm | | | |
| Type/manufacturer of workstation | - | | | |
| Mimic panel size | mm x mm | | | |
| | | | | |
| **Fire areas** | | | | |
| Number of fire area per unit | | | | |
| Number of fire areas in total plant | | | | |
| | | | | |
| **List of fire detection equipment** | | | | |
| Location/area: | | | | |
| | | | | |
| **Stationary fire fighting equipment** | | | | |
| Location/area: | | | | |
| | | | | |
| **Potable/ manual fire fighting equipment** | | | | |
| Location/area: | | | | |
| | | | | |
| **Fire Water Retention** | | | | |
| Locations: | $m^3$ | | | |
| | | | | |
| **Fire Fighting Truck** | | | | |
| Manufacturer | | | | |
| Capacity | $m^3$ | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| | | | Bidder name | |
| **General Remarks:** | | | | |
| Unless otherwise noted:<br>• data are per unit<br>• operational data are for BMCR and Design Coal Attachment B3 | | | | |
| | | | | |
| **Transformers** | | | | |
| **Generator Step-up Transformer** | | | | |
| Number of transformers | - | 6 + 1 spare | | |
| Manufacturer | - | - | | |
| Origin of manufacturer | - | - | | |
| Type | - | single phase oil immersed | | |
| Number of windings | - | 2 | | |
| Type of cooling | - | (ONAN)ONAF/ODAF | | |
| Rated frequency | Hz | 50 | | |
| Rated output ODAF | MVA | 260 | | |
| Rated output ONAF | MVA | - | | |
| Rated power ONAN | MVA | - | | |
| On-load tap-changer (OLTC) (full power tappings acc. to DIN EN 60076-1, section 3.5.11) | yes/no | yes | | |
| Number of taps | ± | ±8** | | |
| Voltage range total | ± % | ±1.25** | | |
| Voltages at full load and on-load tap-changer in 0 position H.V./L.V. side | kV/kV | 400/20 | | |
| Voltages at no-load and on-load tapchanger in 0 position H.V./L.V. side | kV/kV | 420/20 | | |
| Impedance voltage (nominal pos.) at max. rating | % | 18 ** | | |
| Vector group and numerical index | - | YNd11 ** | | |
| Winding Hot spot temperature at 40 °C ambient temperature | °C | - | | |
| Star point of H.V. side solidly earthed | Yes/no | yes | | |
| Impulse withstand voltage(IEC 60076-3):<br>• H. V.<br>• L. V.<br>• H. V. neutral | kV(peak)<br>kV(peak)<br>kV(peak) | 1425<br>145 or 170 ***<br>650 | | |
| Power frequency withstand voltage:<br>• H. V.<br>• L. V.<br>• H.V.neutral | kV<br>kV<br>kV | 630<br>50 or 70 ***<br>275 | | |
| Connections:<br>• H. V.<br>• L. V.<br>• H.V. neutral | | OHL bushings<br>Isolated phase bus<br>Solidly groundet | | |
| H. V. neutral earthing | | Direct grounded | | |
| Specific creepage distance of HV bushings | mm/kV | 31 | | |
| | | | | |
| On-load tap-changer | | | | |
| • Number of steps | ± | ±8** | | |
| • Voltage range total | ± % | ±1.25** | | |
| Duration of symmetrical short-circuit current | s | 3 | | |
| OLTC AVQR | yes/no | yes | | |
| OLTC AVQR manufacturer | | - | | |
| OLTC AVQR type | | - | | |
| Sensitivity of AVQR | % | - | | |
| No load losses at rated voltage | kW | - | | |
| Load losses at ODAF/ONAF/ONAN | | | | |
| • at 4/4 load | kW | - | | |
| • at 3/4 load | kW | - | | |
| • at 2/4 load | kW | - | | |
| • at 1/4 load | kW | - | | |
| • Total weight | kg | - | | |
| • Transport weight | kg | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| • Overall dimensions • Height | mm | - | | |
| • Length | mm | - | | |
| • Width | mm | - | | |
| Current transformers on the H.V. bushings | | | | |
| • Rated output | VA | - | | |
| • Accuracy class | - | - | | |
| • Number of cores | - | - | | |
| | | | | |
| **Unit Auxiliary Transformer** | | | | |
| Number of transformers | - | 2 | | |
| Manufacturer | - | - | | |
| Origin of manufacturer | - | - | | |
| Type | | three phase secondary split two windings | | |
| Number of windings | - | 3 | | |
| Frequency | Hz | 50 | | |
| Low voltage side at full load and tap changer in nominal position | kV | 6.6 | | |
| Rated power ONAN HV/LV | MVA/MVA | 63/35-35 | | |
| Rated power ONAF HV/LV | MVA/MVA | * | | |
| Type of cooling | - | ONAN/ONAF | | |
| Voltages at full load and on-load tap-changer in 0 position H.V./L.V. side | kV/kV | 20/6.9-6.9 | | |
| Voltages at no-load and on-load tap changer in 0 position H.V./L.V. side | kV/kV | …/….*** | | |
| Impedance voltage | % | 20** | | |
| Vector group and numerical index | - | Dyn1yn1 | | |
| Winding Hot spot temperature at 40 °C ambient temperature | °C | - | | |
| Star point of L.V. side resistance earthed | Yes/no | yes | | |
| Impulse withstand voltage(IEC 60076-3/Table II)<br>• H. V.<br>• L. V.<br>• L. V. neutral | kV(peak)<br>kV(peak)<br>kV(peak) | 145 or 170 ***<br>75<br>75 | | |
| Power frequency withstand voltage: | | | | |
| • H. V. | kV | 50 or 70 *** | | |
| • L. V. | kV | 28 | | |
| • L. V. neutral | kV | 28 | | |
| On-load tap changer manufacturer | | - | | |
| On-load tap changer type | | - | | |
| On-load tap changer regulation | | | | |
| • Number of steps | ± | ±2 | | |
| • Voltage range total | ± % | ±12.5 | | |
| OLTC AVQR | yes/no | No | | |
| OLTC AVQR manufacturer | | - | | |
| OLTC AVQR type | | - | | |
| Sensitivity of AVQR | % | - | | |
| Short circuit duration | sec. | 3 | | |
| No load losses at rated voltage | kW | - | | |
| Load losses at ONAN/ONAF | | | | |
| • at 4/4 load | kW | - | | |
| • at 3/4 load | kW | - | | |
| • at 2/4 load | kW | - | | |
| • at 1/4 load | kW | - | | |
| Earthing: H.V.neutral/L.V. neutral | | resitance grounded (400A) | | |
| Connections: H. V. | | IPB | | |
| Connection: L.V. side | - | PSB | | |
| Connection: L.V. neutral side | | *** | | |
| Total weight | kg | - | | |
| Transport weight | kg | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| Overall dimensions • Height | mm | - | | |
| • Length | mm | - | | |
| • Width | mm | - | | |
| | | | | |
| **Start-up/Stand-by Transformer** | | | | |
| Number of transformers | - | 1 | | |
| Manufacturer | - | - | | |
| Origin of manufacturer | - | - | | |
| Type | | three phase secondary split two windings | | |
| Number of windings (with equalizing winding - if required) | - | 3 | | |
| Frequency | Hz | 50 | | |
| Low voltage side at full load and tap changer in nominal position | kV | 6.9 | | |
| Rated power ONAN HV/LV | MVA/MVA | 63/35-35 | | |
| Rated power ONAF HV/LV | MVA/MVA | * | | |
| Type of cooling | - | ONAN/ONAF | | |
| Voltages at full load and on-load tap-changer in 0 position H.V./L.V.1/L.V.2 side | kV/kV/kV | 400/6.9/6.9 ** | | |
| Voltages at no-load and on-load tap changer in 0 position H.V./L.V.1/L.V.2 side | kV/kV/kV | 420/6.9/6.9*** | | |
| Impedance voltage | % | 22 ** | | |
| Vector group and numerical index | - | YNynyn0 | | |
| Winding Hot spot temperature at 40 °C ambient temperature | °C | - | | |
| Star point of L.V. side resistance (400A) earthed | Yes/no | yes | | |
| Impulse withstand voltage(IEC 60076-3/Table II)<br>• H. V.<br>• L. V.<br>• H.V./L. V. neutral | kV(peak)<br>kV(peak)<br>kV(peak) | 1050<br>75<br>650/75 | | |
| Power frequency withstand voltage: | | | | |
| • H. V. | kV | 460 | | |
| • L. V. | kV | 28 | | |
| • H.V./L. V. neutral | kV | 275/28 | | |
| On-load tap changer manufacturer | - | - | | |
| On-load tap changer type | - | - | | |
| On-load tap changer regulation | | | | |
| • Number of steps | ± | ±2 | | |
| • Voltage range total | ± % | ±2.5 | | |
| OLTC AVQR | yes/no | yes | | |
| OLTC AVQR manufacturer | | - | | |
| OLTC AVQR type | | - | | |
| Sensitivity of AVQR | % | - | | |
| Short circuit duration | sec. | 3 | | |
| No load losses at rated voltage | kW | - | | |
| Load losses at ONAN/ONAF | | | | |
| • at 4/4 load | kW | - | | |
| • at 3/4 load | kW | - | | |
| • at 2/4 load | kW | - | | |
| • at 1/4 load | kW | - | | |
| Earthing: H.V.neutral/L.V. neutral | | resitance grounded (400A) | | |
| Connections: H. V. | | IPBD | | |
| Connection: L.V. side | - | SPBD | | |
| Connection: H.V.neutral/L.V. neutral side | | *** | | |
| Total weight | kg | - | | |
| Transport weight | kg | - | | |
| Overall dimensions • Height | mm | - | | |
| • Length | mm | - | | |
| • Width | mm | - | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| **LV Auxiliary Transformer 6.6 kV/0.415 kV** | | | | |
| #data to be provided for each type and rating of transformer | | | | |
| Number of transformer | Nos. | *** | | |
| Manufacturer | - | 3-phase cast resin | | |
| Type | | Dry type | | |
| Rated output ONAN | MVA | *** | | |
| Type of cooling | - | AN/AF | | |
| Rated frequency | Hz | 50 | | |
| Off-load tap changer regulation | ± | ±5% in ± 2 x 2.5% | | |
| Voltages at full load and off-load tap-changer in 0 position H.V./L.V. side | kV/kV | 6.6/0.415 kV | | |
| Voltages at no-load and on-load tapchanger in 0 position H.V./L.V. side | kV/kV | 6.9/0.415 kV | | |
| Impedance voltage | % | * | | |
| Vector group and numerical inday | - | Dyn11 | | |
| Impulse withstand voltage(IEC 60076-3)<br>• H.V. | kV(peak) | 75 or 40 | | |
| Impulse withstand voltage<br>• L.V. side<br>• L.V. neutral | kV (peak)<br>kV (peak) | ***<br>*** | | |
| Power frequency withstand voltage<br>• H. V.<br>• L. V.<br>• L. V. neutral | kV<br>kV<br>kV | 20 or 10<br>***<br>*** | | |
| Earthing:<br>• L V. neutral | - | Direct grounded | | |
| Short circuit duration | sec. | 1 | | |
| No load losses at rated voltage | kW | - | | |
| Load losses at ONAN | kW | - | | |
| Connection on H.V. side | - | *** | | |
| Connection on L.V. side | - | *** | | |
| Total weight | kg | - | | |
| Transport weight | kg | - | | |
| Overall dimensions • Height | mm | - | | |
| • Length | mm | - | | |
| • Width | mm | - | | |
| | | | | |
| **6.6 kV Switchgear** | | | | |
| # data to be provided for each type and rating of switchgear | | | | |
| Number of switchgears | Nos. | * | | |
| Manufacturer | - | - | | |
| Type of switchgear | - | SF6/VCB | | |
| Rated voltage | kV | 6.6 | | |
| Operating voltage | kV | 6.6KV | | |
| Rated frequency | Hz | 50 | | |
| Rated current of: | | | | |
| • busbars | A | *** | | |
| • infeed circuit breaker and coupling circuit breaker | A | *** | | |
| • outgoing circuit breaker | A | *** | | |
| Max. voltage | kV | 7.2 | | |
| Max. asymmetric 3-phase short-circuit withstand current of switchgear | kA(peak) | min. 100 | | |
| Rated short-time current (1 sec) of switchgear | kA | min. 40 | | |
| Power frequency withstand voltage (to earth) | kV | 28 | | |
| Impulse withstand voltage (to earth) | kV(peak) | 75 | | |
| Impulse withstand voltage (accross isolating distance) | kV(peak) | 85 | | |
| Type of circuit breaker | - | SF6/VCB | | |
| Circuit breaker withdrawable | Yes/no | yes | | |
| Rated short-circuit breaking current (sym.) of the CB | kA | - | | |
| Rated short-circuit breaking current (asym.) of the CB | kA | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| Rated short-time current (1 sec.) of the CB | kA | 40 | | |
| Total opening time | msec | - | | |
| Rated short-circuit making current of the CB | kA(peak) | - | | |
| Maintenance intervals after switching cycles with | | | | |
| • nominal current | - | - | | |
| • rated short circuit current | - | - | | |
| Type of circuit breaker driving mechanism | - | DC motor driven; stored energy | | |
| Arc extinguish medium in circuit breaker | - | Vacuum/SF6 | | |
| Type of earthing switch | - | Manual operated & Make proof | | |
| Rated short circuit making current of the earthing switch | kA | - | | |
| Rated short time current (1 sec.) of the earthing switch | kA | - | | |
| Secondary current of current transformer | A | 1 | | |
| Accuracy class: measuring | - | | | |
| • Metering | - | - | | |
| • Protection | - | - | | |
| Secondary voltage of voltage transformer | V | 110√3 | | |
| Control voltage | V | 220VDC | | |
| Accuracy class: measuring | - | | | |
| • Metering | - | - | | |
| • Protection | - | - | | |
| Type of protection relays | - | Digital | | |
| Protection class of switchgear | IP | IP4X | | |
| Cubicles dimensions (HxWxD) | mm | | | |
| Total length of the switchgear | mm | - | | |
| Total weight | kg | - | | |
| | | | | |
| **Isolated Phase Bus Duct** | | | | |
| Manufacturer | | | | |
| Type | Isolated Phase | | | |
| Rated Insulation Voltage | KV | | | |
| Rated current | A | | | |
| Rated short time withstand current (1 sec) | kA | | | |
| Rated peak withstand current | kA(peak) | | | |
| Bus conductor Material | - | | | |
| Cross ´section of phase conductor | $mm^2$ | | | |
| Cross ´section of neutral conductor | $mm^2$ | | | |
| Cross ´section of earth conductor | $mm^2$ | | | |
| Material of Enclosure | - | | | |
| | | | | |
| **6.6 kV Segregated Phase Bus Duct** | | | | |
| Manufacturer | | | | |
| Type | Segregated Phase | | | |
| Rated Insulation Voltage | V | | | |
| Rated current | A | | | |
| Rated short time withstand current (1 sec) | kA | | | |
| Rated peak withstand current | kA(peak) | | | |
| Bus conductor Material | - | | | |
| Cross section of phase conductor | $mm^2$ | | | |
| Cross section of neutral conductor | $mm^2$ | | | |
| Cross section of earth conductor | $mm^2$ | | | |
| Material of Enclosure | - | | | |
| Dimensions (hight x width) | mm x mm | | | |
| | | | | |
| **0.415 kV  Non Segregated Phase Bus Duct** | | | | |
| Manufacturer | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| Type | Non Segregated Phase | | | |
| Rated Insulation Voltage | V | | | |
| Rated current | A | | | |
| Rated short time withstand current (1 sec) | kA | | | |
| Rated peak withstand current | kA(peak) | | | |
| Bus conductor Material | - | | | |
| Cross section of phase conductor | $mm^2$ | | | |
| Cross section of neutral conductor | $mm^2$ | | | |
| Cross section of earth conductor | $mm^2$ | | | |
| Material of Enclosure | - | | | |
| Dimensions (hight x width) | mm x mm | | | |
| | | | | |
| **0.415 kV switchgear** | | | | |
| # data to be provided for each type and rating of switchgear | | | | |
| Number of switchgears | Nos. | * | | |
| Manufacturer | - | - | | |
| Type | - | Metal clad; | | |
| Draw-out design | Yes/no | Yes | | |
| Frequency | Hz | 50 * | | |
| Rated current of busbars (40°C ambient) | A | * | | |
| Rated voltage | V | 415 | | |
| Test voltage | V | 2500 | | |
| Rated short-time withstand current (1 sec.) – min | kA | min. 50 * | | |
| Rated peak withstand current – min | kA | min. 110 * | | |
| Control voltage | V | 240V AC/110V DC | | |
| Protection class | IP | IP42 | | |
| Cubicle dimensions (HxWxD) | mm | - | | |
| Total dimensions of the main distribution (H x W x D) | mm | - | | |
| Total weight | kg | - | | |
| | | | | |
| **Circuit breaker** (to be completed for each type) | | | | |
| Manufacturer | - | - | | |
| Type of circuit breaker driving mechanism | - | DC motor driven; stored energy | | |
| Rated current | A | * | | |
| Rated short-circuit breaking current (power factor = 0.2) | kA | - | | |
| Rated short-circuit making current | kA(peak) | - | | |
| Rated short time withstand current (1 sec) | kA | - | | |
| Numerical protection relays | Yes/no | yes | | |
| Short circuit protection | Yes/no | yes | | |
| Overload protection | Yes/no | yes | | |
| | | | | |
| **Load-break switch** (to be completed for each type) | | | | |
| Manufacturer | | | | |
| Intended application | | | | |
| Type | - | | | |
| Rated current | A | | | |
| Rated short time withstand current (1 sec) | kA | | | |
| Rated peak withstand current | kA(peak) | | | |
| Rated short-circuit making current | kA | | | |
| Fuse monitoring | Yes/no- | yes | | |
| | | | | |
| **Current transformer** | | | | |
| Type | - | | | |
| Current ratio | A/A | | | |
| Dynamic current | $XI_N$ | | | |
| Secondary current of current transformer | A | 1 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| | | | | |
| **MV Motors** (to be filled up for each motors) | | | | |
| Manufacturer | | | | |
| Voltage | KV | 6.6 | | |
| Application | | | | |
| Rating | KW | | | |
| Speed | rpm | | | |
| Type | | | | |
| Cooling category | IC | | | |
| Full load Power factor | | | | |
| Full load current | A | | | |
| Efficiency | % | | | |
| Starting Current (in % of FLC) | % | | | |
| Starting Torque | % | | | |
| Method of Starting | | | | |
| Space heater rating | W | | | |
| | | | | |
| **LV Motors** (to be filled up for each higher rating motors) | | | | |
| Manufacturer | | | | |
| Voltage | KV | 0.415 | | |
| Application | | | | |
| Rating | KW | | | |
| Speed | rpm | | | |
| Type | | | | |
| Cooling category | IC | | | |
| Full load Power factor | | | | |
| Full load current | A | | | |
| Efficiency | % | | | |
| Starting Current (in % of FLC) | % | | | |
| Starting Torque | % | | | |
| Method of Starting | | | | |
| Space heater rating | W | | | |
| | | | | |
| **220V DC Systems, 415/230V Safe AC and Associated Equipment** | | | | |
| Number of 220 V DC Systems | - | * | | |
| Number of 415/240V Safe AC systems | - | * | | |
| | | | | |
| **220 V DC Main Distribution** | | | | |
| # data to be provided for each type and rating of distribution | - | | | |
| Number of Distributions | - | one per system; sectionalized | | |
| Manufacturer | - | - | | |
| Origin of manufacturer | - | - | | |
| Design with fixed mounted components (yes/no) | - | yes | | |
| Nominal voltage DC | V | 220 | | |
| Test voltage | V | 2500 | | |
| Rated current | A | *** | | |
| Short-time withstand current (1 sec) | kA | *** | | |
| Control voltage | VDC | | | |
| Protection class | IP | 41 | | |
| Busbars | | L+, L-; PE | | |
| Overall dimensions (HxWxD) | mm | - | | |
| Total weight | kg | - | | |
| | | | | |
| *Maximum voltage supervision* | | | | |
| Relay type | - | - | | |
| Tripping voltage setting range DC | V | - | | |
| Tripping time setting range | sec. | - | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| *Minimum voltage supervision (Alarm)* | | | | |
| Relay type | - | - | | |
| Voltage setting DC | V | - | | |
| Time setting range | sec | - | | |
| | | | | |
| *Earth fault/insulation monitoring device* | | | | |
| Manufacturer | | - | | |
| Relay type | - | - | | |
| Setting range (alarm) | - | - | | |
| | | | | |
| *Circuit breaker* | | | | |
| Manufacturer | - | - | | |
| Type | - | - | | |
| Rated voltage | V | - | | |
| Rated current | A | - | | |
| Rated short circuit breaking current | kA | - | | |
| Rated short-circuit making current | kA | - | | |
| Rated short time withstand current (1 sec) | kA | - | | |
| | | | | |
| *Miniature circuit breakers* | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Rated current | A | | | |
| Rated short circuit breaking current | kA | | | |
| | | | | |
| *Fused load break switch* | | | | |
| (to be completed for each type) | | - | | |
| Type | - | - | | |
| Rated current DC | A | - | | |
| Rated breaking current DC | kA | - | | |
| Fuse type | - | - | | |
| Fuse monitoring | yes/no | yes | | |
| | | | | |
| **Battery Charger for 220 VDC System** | | | | |
| No. of battery chargers | - | 2 x 100% per system | | |
| Manufacturer | - | - | | |
| Type | - | - | | |
| Rectifiers with thyristors | yes/no | yes | | |
| Rated input voltage | V ± % | 415 | | |
| Frequency | Hz | 50 | | |
| Rated DC voltage | V | 220 | | |
| Rated current DC | A ± % | * | | |
| Range of adjustment for DC voltage | V/cell | 2.1 to 2.7 | | |
| Efficiency | - | - | | |
| Trickle charging voltage | V/cell | 2.23 | | |
| Float charging voltage per cell | V/Cell | - | | |
| Boost charging voltage per cell | V/Cell | - | | |
| Charging characteristics IU (yes/no) | - | - | | |
| Residual ripple without battery | % | - | | |
| Voltage ripple (within charger rating) | % | - | | |
| Voltage ripple (battery disconnected) | % | - | | |
| Radio interference suppression (DIN EN 61000-6-2) | - | N Criterion A | | |
| Type of cooling | - | preferably self-ventilating | | |
| Protection class | IP | 41 | | |
| Noise level (1m) | dB(A) | - | | |
| Main dimension (HxWxD) | mm | - | | |
| Weight | kg | - | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| **Batteries for 220 VDC System** | | | | |
| Manufacturer | - | - | | |
| Capacity of batteries | | - | | |
| No. of batteries | - | 2 x 100% per system | | |
| Type of operation | - | stand-by parallel | | |
| Load supply time in case voltage failure<br>(one battery in operation) | h | 30 Minutes | | |
| Load supply time in case voltage failure<br>(both batteries in operation) | h | - | | |
| Recharge time | | - | | |
| Type | | ultra low maintenance | | |
| Material / Electrolyte | - | nickel-cadmium or<br>lead acid plante | | |
| Rated voltage | V | 220 | | |
| Maximum voltage | V | 242 | | |
| Minimum voltage | V | 201 | | |
| Number of cells | - | | | |
| Rated discharge current (1 h) | A | - | | |
| Rated capacity for 1 hour | Ah | - | | |
| Design and aging factor | % | 25% | | |
| Charging current | A | - | | |
| Short-circuit current | A | - | | |
| Final voltage of cell after 1 h rated discharge current | V | 1 | | |
| Main dimensions | | - | | |
| Single cell (Length x width x height) | mm | - | | |
| Total dimensions of assembled battery<br>(length x width x height) | mm | - | | |
| Total weight of one battery | kg | - | | |
| | | | | |
| **Battery Charger for 415/240V Safe AC System** | | | | |
| No. of battery chargers | - | 2 x 100% per system | | |
| Manufacturer | - | - | | |
| Type | - | - | | |
| Rectifiers with thyristors | yes/no | yes | | |
| Rated input voltage | V ± % | 415 | | |
| Frequency | Hz | 50 | | |
| Rated DC voltage | V | *** | | |
| Rated current DC | A ± % | *** | | |
| Range of adjustment for DC voltage | V/cell | 1.2 to 1.7 | | |
| Efficiency | - | - | | |
| Trickle charging voltage | V/cell | 1.2 to 1.7 or 2.1 to 2.7 | | |
| Float charging voltage per cell | V/Cell | - | | |
| Boost charging voltage per cell | V/Cell | 1.4 or 2.23 | | |
| Charging characteristics IU (yes/no) | - | - | | |
| Residual ripple without battery | % | - | | |
| Voltage ripple (within charger rating) | % | - | | |
| Voltage ripple (battery disconnected) | % | - | | |
| Radio interference suppression<br>(DIN EN 61000-6-2) | - | N Criterion A | | |
| Type of cooling | - | preferably self-ventilating | | |
| Protection class | IP | 41 | | |
| Noise level (1m) | dB(A) | - | | |
| Main dimension (HxWxD) | mm | - | | |
| Weight | kg | - | | |
| | | | | |
| **220 V Batteries for 415/240V Safe AC System** | | | | |
| Manufacturer | - | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| Capacity of batteries | | - | | |
| No. of batteries | - | 2 x 100% per system | | |
| Type of operation | - | stand-by parallel | | |
| Load supply time in case voltage failure (one battery in operation) | h | 60 Minutes | | |
| Load supply time in case voltage failure (both batteries in operation) | h | - | | |
| Recharge time | | - | | |
| Type | | ultra low maintenance | | |
| Material / Electrolyte | - | nickel-cadmium or lead acid plante | | |
| Rated voltage | V | *** | | |
| Maximum voltage | V | *** | | |
| Minimum voltage | V | *** | | |
| Number of cells | - | | | |
| Rated discharge current (1 h) | A | *** | | |
| Rated capacity for 1 hour | Ah | *** | | |
| Design and aging factor | % | 25% | | |
| Charging current | A | - | | |
| Short-circuit current | A | - | | |
| Final voltage of cell after 1 h rated discharge current | V | 1 | | |
| Main dimensions | | - | | |
| Single cell (Length x width x height) | mm | - | | |
| Total dimensions of assembled battery (length x width x height) | mm | - | | |
| Total weight of one battery | kg | - | | |
| | | | | |
| **Inverter for Safe AC system** | | | | |
| Number of Inverters | - | 2 x 100% per system | | |
| Manufacturer | - | - | | |
| Origin of manufacture | - | - | | |
| Type | - | - | | |
| DC input voltage from the battery | V | 220 +10/-15% | | |
| Rated input DC current at full load (cos phi = 0.8) | A | - | | |
| AC output voltage | V | 415/240 | | |
| Accuracy voltage average | % | ±1 static | | |
| Output frequency | Hz | 50 ±0.5% | | |
| Rated power at cos phi = 0.8 | kVA | - | | |
| Consumer cos phi | - | - | | |
| Dyn. voltage deviation at 100% load cycle | % | max. 10% of rated voltage fopr 20 msec. | | |
| Correction time in case of load changes from 0% to 100% load | msec | - | | |
| Regulation range of output AC voltage | ± % UN | - | | |
| Distortion factor over the load range | % | <4% | | |
| Wave form | - | - | | |
| Radio interference suppression (DIN EN 61000-6-2) | - | - | | |
| Type of cooling | - | preferably self-ventilating | | |
| Overload capability | | - | | |
| • 10 minutes | x $I_N$ | 1.25 | | |
| • 1 minutes | x $I_N$ | 1.5 | | |
| • 5s | x $I_N$ | - | | |
| Protection class of cubicles | IP | 41 | | |
| Height x width x depth of cubicles for one inverter | mm | - | | |
| Total weight | kg | - | | |
| | | | | |
| **Static by-pass switch for Safe AC system** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| Number ofstativ by-pass switch | - | one per inverter | | |
| Manufacturer | - | - | | |
| Origin of manufacture | - | - | | |
| Type | - | - | | |
| Thyristor, switches, electronic controlled | yes/no | yes | | |
| Input voltage | V | 415/240 | | |
| Response value of voltage deviation at the inverter output | % | - | | |
| Rated output | kVA | - | | |
| Rated power at cos phi = 0.8 | kVA | - | | |
| Overload capability for 5 sec. | $xP_N$ | - | | |
| Radio interference suppression (DIN EN 61000-6-2) | - | N | | |
| Protection class of cubicles | IP | 41 | | |
| Type of cooling | - | self-ventilating | | |
| Height x width x depth of cubicles for one electronic change-over equipment | mm | - | | |
| Total weight | kg | - | | |
| | | | | |
| **415/240 V Safe AC distribution (UPS)** | | | | |
| Number of Distributions | - | one per system; sectionalized | | |
| Manufacturer | - | - | | |
| Origin of manufacturer | - | - | | |
| Type | - | - | | |
| Distribution with fixed mounted components | (yes/no) | yes | | |
| Frequency | Hz | 50 | | |
| Rated voltage | V | 415/240 | | |
| Nominal phase - neutral voltage | V | 240 | | |
| Rated current of busbars | A | - | | |
| Short time withstand current (1 sec) | kA | - | | |
| Test voltage | V | 2500 | | |
| Protection class | IP | 41 | | |
| Total weight | kg | - | | |
| Rated short circuit breaking current | kA | - | | |
| | | | | |
| *Circuit breaker (to be completed for each type)* | | | | |
| Manufacturer | - | | | |
| Type | - | - | | |
| Rated voltage | V | - | | |
| Rated current | A | - | | |
| Rated short circuit breaking current | kA | - | | |
| Rated short-circuit making current | kA(peak) | - | | |
| Rated short time withstand current (1 sec) | kA | - | | |
| | | | | |
| *Miniature circuit breakers* | | | | |
| Manufacturer | - | - | | |
| Type | - | - | | |
| Rated current | A | - | | |
| Rated short circuit breaking current | kA | | | |
| | | | | |
| *Fused load break switch* | | | | |
| Manufacturer | - | - | | |
| Type | - | - | | |
| Rated breaking current | kA | - | | |
| Fuse monitoring | (yes/no) | - | | |
| | | | | |
| **Emergency diesel generator** | | | | |
| Type | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| Numbers per total plant | - | 2 | | |
| Design | - | | | |
| Rated output at guarantee site conditions<br>(see DIN 6270 A/ISO 3046 measured at generator terminals) | kW | 1200 | | |
| LTP Operating hours per year/continuously | h | | | |
| Rated speed (max.) | rpm | | | |
| Number of strokes | - | | | |
| Cooling system | - | | | |
| Starting time to full load operation | sec. | max. 30 | | |
| Starter | - | battery fed electric motor | | |
| Type of fuel | - | HSD | | |
| Capacity of fuel oil day tank | l | | | |
| Vibration displacement at rated speed and steady load conditions | mm | * | | |
| Vibration root mean square velocity of | cm/s | | | |
| | | | | |
| **Generator** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Apparent power at guarantee site conditions measured at generator terminals * | kVA | | | |
| Power factor | - | | | |
| Generator cooling system | - | air | | |
| Frequency | Hz | 50 | | |
| Terminals | - | L1, L2, L3 & N | | |
| Voltage | V | 415/240 | | |
| Neutral | - | solid grounded | | |
| Voltage regulator | - | AVR with a range of ±10% | | |
| Protection class of generator | - | min. IP44 | | |
| Insulation class of generator and exciter | - | F | | |
| Permissible operation according to insulation class | - | battery fed electric motor | | |
| Type of excitation system | - | rotating diodes | | |
| | | | | |
| **Cables and cable trays** | | | | |
| **Power Cables General** | | | | |
| Maximum permissible continuous conductor temperature for the different insulation types: | | | | |
| • XLPE | °C | 90 | | |
| • PE | °C | 70 | | |
| • PVC | °C | 70 | | |
| | | | | |
| Maximum permissible conductor temperature under short circuit conditions: | | | | |
| • XLPE | °C | 250 | | |
| • PE | °C | 150 | | |
| • PVC up to 300 mm² | °C | 150 | | |
| above 300 mm² | °C | 140 | | |
| | | | | |
| **6.6 kV MV power cables, single core** | | | | |
| Manufacturer | - | | | |
| Origin of manufacturer | - | | | |
| Cable type | - | | | |
| Conductor material | - | | | |
| Rated voltage | kV | | | |
| Impulse withstand voltage | kV (peak) | | | |
| Frequency | Hz | | | |
| Insulation | - | | | |
| Outer sheath material | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| | | | | |
| **6.6 kV MV power cables, three-core** | | | | |
| Manufacturer | - | | | |
| Cable type | - | | | |
| Conductor material | - | | | |
| Rated voltage | kV | | | |
| Impulse withstand voltage | kV (peak) | | | |
| Frequency | Hz | | | |
| Insulation material | - | XLPE | | |
| Outer sheath material | | | | |
| Fire Retardant Low Smoke | yes/no | yes | | |
| | | | | |
| **0.415 kV LV power cables** | | | | |
| Manufacturer | - | | | |
| Cable type | - | | | |
| Conductor material | - | | | |
| Rated voltage | kV | | | |
| Test voltage | kV | | | |
| Frequency | Hz | | | |
| Insulation material | - | XLPE | | |
| Outer sheath material | | | | |
| Fire Retardant Low Smoke | yes/no | yes | | |
| | | | | |
| **Cable trays (normal areas)** | | | | |
| Manufacturer | - | | | |
| Basic material | - | | | |
| Corrosion resistant | yes/no - | yes | | |
| Hot-dip galvanized | yes/no - | yes | | |
| Coating thickness for hot-dip galvanized material | mm | acc. To ASTM A123/123M | | |
| Additional coating and treatment for cable trays in areas with increased exposure to corrosion | yes/no | yes | | |
| Which additional coating/treatment in exposed areas? (short explanation of measures) | - | Additional Coating or Fibre Reinforsed Plastic | | |
| | | | | |
| **Cable trays (in areas with increased exposure to corrosion)** | | | | |
| Manufacturer | - | | | |
| Basic material | - | FRP | | |
| Corrosion resistant | yes/no - | yes | | |
| | | | | |
| **Fire alarm central station** | | | | |
| Manufacturer | | | | |
| Number of cubicles | - | | | |
| Dimension per cubicle | mm | | | |
| Power requirements | VA | | | |
| Main supply voltage | V | | | |
| Operating voltage of fire alarm lines | V | | | |
| Maximum number of alarm lines possible | - | | | |
| Fault detection system for wire breakage | yes/no | yes | | |
| Earth fault, short circuit | yes/no | yes | | |
| | | | | |
| **Small power and lighting installations** | | | | |
| | | | | |
| **Lighting system**<br>**Illumination intensities** | | | | |
| Location, room | Type of lighting fixture | Intensity new/utilized (lux) | | |
| Washrooms, toilets, shower, kitchen | 3 and 4 | 300/250 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| Reception hall | 5 | 300/250 | | |
| All workshops, tool rooms | 1 and 2 | 500/400 | | |
| Turbine hall, compressor room | 3,4,7, 8 and 11, 12 | 300/250 | | |
| Intermediate level in plant and boiler house | 3,4,7, 8 and 11, 12 | 120/100 | | |
| Switchgear rooms | 1 and 2 | 300/250 | | |
| AHU rooms, fire pump rooms | 3 and 4 | 300/250 | | |
| All offices, laboratory, supervisor room, plant manager room, Meeting rooms, lounges, lobbies | 5 | 600/500 | | |
| Central control room (# to match the requirements of the control equipment) | 5 # | 600#/500# | | |
| All store rooms | 1 and 2 | 240/200 | | |
| Battery rooms | 9 and 10 | 300/250 | | |
| Driveway (street light), transformer yard | 6 | 18/15 | | |
| External yard (street light), parking area | 6, 11 and 12 | 18/15 | | |
| Briefing room | 5 | 360/300 | | |
| Computer room, relay room | 1 and 2 | 360/300 | | |
| Recreation room | 5 | 360/300 | | |
| Diesel generator room, plant rooms, shift engineer rooms, lift motor rooms | 1, 2, 3 and 4 | 360/300 | | |
| Corridor, staircase | 1, 2, 3 and 4 | 144/120 | | |
| Coal conveyer | 3, 4, 7, 11 and 12 | 60/50 | | |
| Coal yard | 3, 4, 7, 11 and 12 | 60/50 | | |
| | | | | |
| **Notes:** | | | | |
| Throughout the rooms and ground, the lighting intensity shall be at least 200 Lux on local measuring and control stands and instrument panels (operating points). | | | | |
| Explosion proof light fittings shall be provided in areas subject to danger of explosion. | | | | |
| Intensity new values are to be verified at acceptance measurement | | | | |
| | | | | |
| *[1] Shall match the requirements of the control equipment | | | | |
| | | | | |
| **Lighting system**<br>**Key to type of lighting fixture numbers on previous page** | | | | |
| | | | | |
| 1. LED, General Purpose, Industrial Pendant Type with Aluminum Reflector, approx. 1 x 24 W | | | | |
| 2. LED, General Purpose, Industrial Pendant Type with Aluminum Reflector, approx. 2 x 24 W | | | | |
| 3. LED, Dust Tight /Water Proof, Ceiling or Pendant Mounting Type, GFR Polyester Canopy Body, and Acrylic Difuser, Protection Class IP 65, approx. 1 x 24 W | | | | |
| 4. LED, Dust Tight /Water Proof, Ceiling or Pendant Mounting Type, GFR Polyester Canopy Body, and Acrylic Difuser, Protection IP 65, approx. 2 x 24 W | | | | |
| 5. LED, General Purpose, Recessed mounting Type with Aluminum Reflector, approx. 4 x 10 W | | | | |
| 6. LED, Street Lighting,Weather Proof, Cast Aluminum Housing, Aluminum Mirror, Heat Resistant Cleatr Acryl Bowl, Protection Class IP 65, Approx.1 x 60 W | | | | |
| 7. LED, Corrosion and Dust Proof, Chain or Bracket Mounting, Cast Aluminum Alloy Body, Dome Type Aluminum Reflector, Protection Class IP 65, approx. 1 x 50 W | | | | |
| 8. LED, Corrosion and Dust Proof, Chain or Bracket Mounting, Cast Aluminum Alloy Body, Dome Type Aluminum Reflector, Protection Class IP 65, approx. 1 x 100 W | | | | |
| 9. LED, Pendant or Ceiling Mounted Type, Explosion proof, IP 65, Approx. 1x24W | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remark |
|---|---|---|---|---|
| 10. LED, Pendant or Ceiling Mounted Type,  Explosion proof, IP 65, Approx. 2x24W | | | | |
| 11. LED, Flood-light, Wheather-proof, Cast Aluminum Body, Aluminum Reflector, Protection Class IP65, Approx. 1x80W | | | | |
| 12. LED, Flood-light, Wheather-proof, Cast Aluminum Body, Aluminum Reflector, Protection Class IP65, Approx. 1x130W | | | | |

Notes:

*** According to Chapter 10 and 29 of Section 5**

**** for reference only, exact value to be determined by the Bidder in accordance to requirements of Power Grid Company of Bangladesh Ltd (PGCB)**

***** to be determined by the Bidder**

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| | | | |
| **1. General data for DCS** | | | |
| | | | |
| Permissible ambient conditions | | | |
| • temperature from - to | °C | 15 - 40 | |
| • relative humidity from - to | % | 40 - 60 | |
| • dust concentration from - to | $mg/m^3$ | | |
| | | | |
| Permissible duration for voltage dip to -10% | ms | | |
| Are outputs short circuit-proof? | yes/no | | |
| Can status of outputs be defined in the event of a fault? | yes/no | | |
| Is the condition of the I/O modules monitored centrally? | yes/no | | |
| On which server are programs stored? | primary only / both primary & backup | | |
| Can all inputs and outputs be simulated? | yes/no | | |
| Can system conditions and I/O conditions as well as allocations be displayed? | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2. Distributed Control System (DCS)** | | | |
| | | | |
| Manufacturer, type | - | | |
| Origin of manufacturer | - | | |
| DCS cycle time | msec | <=100 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.1 Application Server** | yes/no | | |
| Redundancy | yes/no | yes | |
| Alarm Annunciation and Sequence of Events Recording system | yes/no | yes | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.2 Historian Server** | yes/no | yes | |
| Redundancy | yes/no | yes | |
| RAID Archiving System available | yes/no | yes | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.3 Engineering and Diagnostic Station** | yes/no | yes | |
| Redundancy | yes/no | yes | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.4 OPC Server** | yes/no | yes | |
| Redundancy | yes/no | yes | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.5 Monitors** | | | |
| Number of control devices (mouse/keyboard) | - | | |
| Screen diagonal size | inch | 24 | |
| Type | - | LED | |
| Resolution | - | min 1024 x 768 | |
| Call time for picture change | s | <=2 | |
| Number of Monitors per Work Station | - | 2 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.6 Large Video Screen per unit/common** | - | | |
| Make and type / Model no. | - | | |
| Technology | - | LED lid DLP cubes | |
| Screen diagonal / Number of screens | inch | min 50 " | |
| Resolution | - | min 1024 x 768 | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Lamp & Display element lifetime | hours | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.7 Graphics** | | | |
| Max number of process graphic displays | - | | |
| Offered number of process graphic displays | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.8 Updating process variables and conditions** | | | |
| Analog inputs | s | <=1 | |
| Digital inputs | s | <=1 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.9 Reaction time from issuing command and monitoring** | | | |
| Up to command execution (switching relay of control actuator) | s | <=1 | |
| Up to execution checkback signal from individual control level to monitor | s | <=1 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.10 Representation of graphs (for trending) on monitor** | | | |
| Max number of curves in per screen | - | | |
| Historian memory capacity | months | 18 | |
| Sequence of Event (SOE) resolution time | ms | <=1 | |
| Time resolution (time stamping) at input modules for reporting of events (SOE) | ms | <=10 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.11 Black & White Laser Printers** | | | |
| Number | - | | |
| Manufacturer / Type | - | | |
| Printing speed | pages/ min | 25 | |
| Resolution (minimum) | dpi | min 300x300 | |
| Noise level | dB(A) | 45 | |
| Format DIN A4 | DIN | A4 | |
| Format DIN A3 | DIN | A3 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.12 Black & White Dot Matrix printers** | | | |
| Number | - | | |
| Manufacturer / Type | - | | |
| Printing speed | pages/ min | 25 | |
| Resolution (minimum) | dpi | min 300x300 | |
| Noise level | dB(A) | 45 | |
| Format DIN A4 | DIN | A4 | |
| Format DIN A3 | DIN | A3 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.13 Color Laser Printers** | | | |
| Number | - | | |
| Manufacturer/Type | - | | |
| Hardcopy image memory (size) | MB | | |
| Processing time | pages/ min | | |
| Resolution | dpi | | |
| Format DIN A4 | DIN | A4 | |
| Format DIN A3 | DIN | A3 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.15 Fibre Optic backbone** | | | |
| Manufacturer | - | | |
| Type | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| "Open" bus as per ISO reference model | yes/no | | |
| Redundancy | yes/no | yes | |
| Transmission rate (useful data rate) | Mbit/s | >=100 | |
| Transmission medium | - | fiber optic | |
| Max. bus length without using repeaters etc. | m | | |
| Max. number of stations that can be connected | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.16 Process station** | | | |
| Number of automation units | - | | |
| Power failure protection for the program | - | | |
| Scanning periods: | | | |
| Data acquisition | | | |
| Analog values | ms | 500 | |
| Binary values | ms | 250 | |
| For binary values (MV/HV systems) | ms | <=1 | |
| Closed-loop control | | | |
| Fast control loops | ms | 250 | |
| Slow control loops | ms | 500 - 1000 | |
| Scanning time for processors | ms | <=100 | |
| Permissible voltage dip to 0V (duration) | ms | | |
| Can status of outputs be defined in the event of a fault? | yes/no | | |
| Is the condition of the I/O modules monitored centrally? | yes/no | | |
| On which data carriers are programs stored? | - | | |
| Can all inputs and outputs be simulated? | yes/no | | |
| Can system conditions and I/O conditions as well as allocations be displayed? | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.17 Distributed Process Controller** | | | |
| Manufacturer | | | |
| Country of origin of manufacture/equipment | | | |
| Model No. | | | |
| CPU type/bits/speed | | | |
| Main memory type/ capacity | | | |
| Non-volatile memory type/capacity | | | |
| Load rate of controller | | | |
| Redundancy of | | | |
| CPU & memory | yes/no | yes | |
| Power supplies | yes/no | yes | |
| I/O bus? | yes/no | yes | |
| If failed, automatic switchover, be alarmed at each OS? | yes/no | yes | |
| Power Supply 24 VDC | yes/no | yes | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.18 Closed-loop (modulating) control modules** | | | |
| Type | - | | |
| Number of control loops per module | - | | |
| Redundant | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.19 Drive control modules** | | | |
| Type | - | | |
| Number of control loops per module | - | | |
| Redundant | yes/no | | |
| Potential separation | - | yes | |
| Monitoring for ambiguity | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| **2.20 Binary input modules** | | | |
| Type | - | | |
| Number of inputs per module | - | | |
| Redundant | yes/no | | |
| Galvanic isolation between input channels | yes/no | yes | |
| Monitoring for ambiguity | yes/no | | |
| Time stamping on module | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.21 Binary output modules** | | | |
| Type | - | | |
| Number of outputs per module | - | | |
| Redundant | yes/no | | |
| Galvanic isolation between output channels | yes/no | yes | |
| Output current at signal "1" max. | mA | | |
| Short-circuit protection | yes/no | | |
| is the DO-Module type available, with dry contact rated at 2A 24VDC? | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.22 Analog input modules** | | | |
| Type | - | | |
| Number of inputs per module | - | | |
| Redundant | yes/no | | |
| Galvanic isolation between input channels | yes/no | | |
| Digital representation of input signal | bit | >= 12 | |
| Fault signal if range exceeded | yes/no | | |
| HART Function in the module, available | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.23 Analog output modules** | | | |
| Type | - | | |
| Number of outputs per module | - | | |
| Redundant | yes/no | | |
| Galvanic isolation between output channels | yes/no | | |
| Output ranges | V, mA | | |
| Digital representation of output | bit | >= 12 | |
| Short-circuit protection | yes/no | | |
| HART Function in the module, available | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.24 Pulse Input** | | | |
| • Model or type | | | |
| • Number of outputs per module | | | |
| • Pulse rate | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **2.25 S.O.E Module (if applicable)** | | | |
| • Model or type | | | |
| • Number of input channels per module | | | |
| • Isolation method | | | |
| • Resolution time | ms | <=1 | |
| • Time synchronisation | - | yes | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **3. Electronic cubicles / RTU** | | | |
| Make, type | - | | |
| Degree of protection to IEC 60529 (for ventilated enclosures installed indoor in air conditioned/ ventilated areas) | IP | 42 (with suitable cannope) | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Degree of protection to IEC 60529 (for non-ventilated enclosures installed indoor in air conditioned/ ventilated areas) | | 22 (with suitable cannope) | |
| Degree of protection to IEC 60529(outdoor) | IP | 65 | |
| Number per unit | - | | |
| Number for common and electrical | - | | |
| Dimensions (H x W x D) | mm | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **4. Marshalling racks /Cabinets** | | | |
| Make/type | - | | |
| Degree of protection to IEC 60529 | IP | | |
| Number | - | | |
| Dimensions (WxHxD) | mm | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **5. Field equipment** | | | |
| Temperature measurement with thermocouples | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter incorporated | yes/no | | |
| Transmitter SMART-type | yes/no | yes | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Temperature transmitter of Pt100 | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Transmitter incorporated | yes/no | | |
| Transmitter SMART-type | yes/no | yes | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Pressure transmitter | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | yes | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Flow meter (water/steam) | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | yes | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Flow meter (fuel oil) | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | yes | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Level transmitter | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Measuring Principle (e.g. US, radar, DP, etc.) | - | | |
| Transmitter SMART-type | yes/no | yes | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Differential pressure transmitter | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | yes | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Flame Detector System | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| (Over)Speed transmitter | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Voltage transducer | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Power transducer | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Power factor transducer | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| $O_2$ analyzer (feedwater) | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| pH-value | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Conductivity | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Turbidity monitoring | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Residual chlorine monitoring | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Silica monitoring | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Sodium monitoring | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Redox monitoring | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Hydrocarbon monitoring | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Sludge level monitoring | | | |
| number of instruments | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **6.1 CEMS - Computer for emission evaluation and data logging** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Interface to DCS System | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| $NO_x$ analyzer (flue gas) | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| $O_2$ analyzer (flue gas) | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| CO analyzer (flue gas) | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| $SO_2$ analyzer (flue gas) | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| $CO_2$ analyzer (flue gas) | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Transmitter SMART-type | yes/no | | |
| Local display | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **6.2 Ambient Air Quality Monitoring System (AAQMS)** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Interface to DCS System | yes/no | | |
| Wind speed sensor make/ type | - | | |
| Wind direction sensor make/ type | - | | |
| Ambient Air sensor make/ type | - | | |
| Relative Humidity sensor make/ type | - | | |
| Solar radiation sensor make/ type | - | | |
| rain gauge make/ type | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **6.3 Potable Water Quality Monitoring System** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Interface to DCS System | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **6.4 Effluent Quality Monitoring System (EQMS)** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Interface to DCS System | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **6.5 Monitoring system for water/steam cycle** | | | |
| Number of racks | No. | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Model or type | - | | |
| Interface to DCS System | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **7. Closed-loop control actuators** | | | |
| **7.1 Control Valves** | | | |
| Noise level of control valves (1m distance) | dB(A) | <= 85 | |
| Time for full stroke for size up to 6" | s | 5 | |
| Time for full stroke for size up to 12" | s | 12 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Electrical actuators | | | |
| Manufacturer | - | | |
| Type | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Electric valve positioner | | | |
| Solid state/contactor | - | | |
| Place of installation: electronic room or incorporated in actuator (compact type) | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Pneumatic actuators | | | |
| Manufacturer | - | | |
| Type | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **7.2 Actuators for open/close operation** | | | |
| Pneumatic actuators | | | |
| Manufacturer | | | |
| Type | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Electric actuators | | | |
| Manufacturer | | | |
| Type | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Solenoid valve | | | |
| Manufacturer | | | |
| Type | | | |
| Power supply 24 VDC | yes/no | | |
| Power supply 240 VAC | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **8.1 Burner  Management System** | | | |
| Integrated in DCS | yes/no | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Degree of protection (cubicle) | IP | | |
| Number of cubicles per Boiler | - | | |
| Design according to NFPA 85 standard | yes/no | yes | |
| Fail-safe system certified according to IEC 61508 | yes/no | yes | |
| SIL classification, if in fail safe technique | SIL | SIL3 | |
| Number of local burner control boxes, if any | - | | |
| Interface to DCS System | yes/no | | |
| Dual or tripple modul redundant? | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **8.2 Boiler Protection System** | | | |
| Integrated in DCS | yes/no | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Degree of protection (cubicle) | IP | | |
| Number of cubicles per Boiler | - | | |
| Design according to NFPA 85 standard | yes/no | yes | |
| Fail-safe system certified according to IEC 61508 | yes/no | yes | |
| SIL classification, if in fail safe technique | SIL | SIL3 | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Interface to DCS System | yes/no | | |
| Dual or tripple modul redundant? | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **8.3 Steam Turbine Protection System** | | | |
| Integrated in DCS | yes/no | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Fail-safe system certified according to IEC 61508 | yes/no | | |
| SIL classification, if in fail safe technique | SIL | SIL3 | |
| Interface to DCS | yes/no | | |
| Dual or tripple modul redundant? | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **9. Plant Performance Analysis, Diagnosis and Optimalization System (PADO)** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Software tools | - | | |
| Interface to DCS System | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **9.1 Vibrating Monitoring System (VMS)** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Software tools | - | | |
| Interface to DCS System | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **9.2 Generator Condition Monitoring System** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Software tools | - | | |
| Interface to DCS System | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **9.3 Boiler Monitoring and Optimization System** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Software tools | - | | |
| Interface to DCS System | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **9.4 Turbine Thermal Stress Evaluation (TSE) System** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Software tools | - | | |
| Interface to DCS System | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **10. HART Management System** | | | |
| Manufacturer | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Origin of Manufacturer | - | | |
| Type | - | | |
| Software tools | - | | |
| Interface to DCS System | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **11. Information Security Management System (ISMS) - Cyber security** | | | |
| Manufacturer | - | | |
| Origin of Manufacturer | - | | |
| Type | - | | |
| Software tools | - | | |
| compliant to international standards like IEC27001 /IEC 62443, ISA99 etc.? | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12. Communication systems** | | | |
| **12.1 Telephone system** | | | |
| IP-PABX | | | |
| Manufacturer | - | | |
| Country of origin of manufacturer/ equipment | - | | |
| Type | - | | |
| Available extension capacity | - | | |
| Equipment spare capacity | - | | |
| Number of subscriber lines | - | | |
| Number of trunk lines | - | | |
| Equipment spare capacity after commissioning | - | | |
| Capacity for additional lines | - | min. 100 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Desk telephone sets | | | |
| Type | - | | |
| Number of desk telephone sets | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| DECT telephone (mobile phone) sets | | | |
| Type | - | | |
| Number of DECT telephone sets | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Wall telephone set | | | |
| Type | - | | |
| Number of wall telephone sets | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Wall telephone sets explosion-proof type | | | |
| Type | - | | |
| Number of wall telephone sets | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12.2 Public address system (IP based)** | | | |
| Manufacturer | - | | |
| Country of origin of manufacturer/ equipment | - | | |
| Type | - | | |
| Number of zones | - | | |
| Max number of zones | - | | |
| Number of loudspeaker lines | - | | |
| Max number of loudspeaker lines (extendable) | - | | |
| Number of master call stations | - | | |
| Max number of indoor and outdoor call stations | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Power amplifier | - | | |
| Number of power amplifier | - | | |
| Power output | W | | |
| Rated output voltage at rated power output | V | | |
| Frequency range | Hz | 300 - 12,500 | |
| Distortion factor at 1,000 Hz | % | 2 or better | |
| Signal-to-noise ratio | dB | 80 or better | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12.3 Intercom system** | | | |
| Manufacturer | - | | |
| Country of origin of manufacturer/ equipment | - | | |
| Type | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12.4 CCTV system (IP based)** | | | |
| Camera | | | |
| Manufacturer | - | | |
| Country of origin of manufacturer/ equipment | - | | |
| Model | - | | |
| Type | - | | |
| Sensor format | inch | 1/2 or 1/3 | |
| Digital remote control | yes/no | yes | |
| Min. resolution | VGA in fps | 640 x 480 | |
| Effective pixels | - | | |
| Number of cameras (min) | - | | |
| Optical zoom | - | 22 | |
| Digital zoom | - | 12 | |
| Compression format | - | | |
| Focus | - | Auto/ Manual | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Housings | | | |
| IP rating outdoor | IP | 66 | |
| IP rating indoor | IP | 42 | |
| Radiant sun temperature | °C | 80 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Pan/Tilt units | | | |
| IP rating | IP | 67 | |
| Pan range | degree | 10 to 345 | |
| Tilt range | degree | +30 to -90 | |
| Panning speed | deg/s | min. 6 | |
| Tilting speed | deg/s | min. 3 | |
| Power source | V | safe AC | |
| Number of units | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Monitors | | | |
| Make | - | | |
| Type | - | non-reflective display | |
| Size, diagonal | inch | 24 | |
| Resolution | - | 1920 x 1200 | |
| Power source | V | | |
| Low radiation emission | yes/no | | |
| Number of monitors | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Network video recorders | | | |
| Power source | V | safe AC | |
| Kind of video storing | - | | |
| Compression format | - | | |
| Internal storage capacity (total) | TB | | |
| Internal storage time per channel | month | 1 | |
| Number of video recording devices | - | 2 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| Furnace flame viewing system | | | |
| Local and remote control from the CCR possible | yes/no | | |
| Type of cooling | air/water | | |
| Housings | IP | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12.5 Clock System** | | | |
| Manufacturer | - | | |
| Country of origin of manufacturer/ equipment | - | | |
| Type | - | | |
| Drift | s/day | | |
| GPS synchronization | yes/no | | |
| Enclosure protection class | IP | | |
| Number of slave clocks | - | | |
| Protocols used for time synchronization | - | NTP and Irig B | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12.6 Access contol system** | | | |
| Manufacturer | - | | |
| Country of origin of manufacturer/ equipment | - | | |
| Type of card reader | - | | |
| Max. number of card readers | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12.7 Office LAN/WAN system** | | | |
| Manufacturer | - | | |
| Country of origin of manufacturer/ equipment | - | | |
| Type of switches - backbone | - | | |
| Type of switches - office area | - | | |
| Type of cables for structured cabling (copper) | - | Cat. 6 | |
| Type of cables for structured cabling (fiber) | - | 24 core multi mode | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **12.8 Portable radio system** | | | |
| Manufacturer | | | |
| Country of origin of manufacturer/ equipment | | | |
| Enclosure protection class of portable transceivers | IP | 54 | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **13. PLC for Local control systems** | | | |
| The Bidder shall provide similar data of above DCS to each of the proposed local control systems and other systems which are not supplied under the DCS. | | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **13.1 Local control systems for $H_2$ Generation** | | | |
| Manufacturer | - | | |
| Controlled by PLC | yes/no | | |
| Brand / type of PLC | - | | |
| Interface to DCS System | - | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| SIL classification, if in fail safe technique | SIL | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **13.2 Local control systems for Gas / Fire Detection and Fire Protection System** | | | |
| Manufacturer | - | | |
| Controlled by PLC | yes/no | | |
| Brand / type of PLC | - | | |
| Interface to DCS System | - | | |
| SIL classification, if in fail safe technique | SIL | | |
| Fire Alarm Panel available? | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14. Plant Information System (PIS)** | | | |
| | | | |
| Manufacturer, type | - | | |
| Origin of manufacturer | - | | |
| DCS cycle time | msec | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.1 Aplication Server** | yes/no | | |
| Redundancy | yes/no | | |
| Alarm Annunciation and Sequence of Events Recording system | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.2 OPC Server** | yes/no | | |
| Redundancy | yes/no | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.3 Monitors** | | | |
| Number of control devices (mouse/keyboard) | - | | |
| Screen diagonal | inch | | |
| Type | - | | |
| Resolution | - | | |
| Call time for picture change | s | | |
| Number of Monitors pro Work Station | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.4 Large Video Screen per unit/common** | - | | |
| Make and type / Model no. | - | | |
| Technology | - | | |
| Screen diagonal / Number of screens | inch | | |
| Resolution | - | | |
| Lamp & Display element lifetime | hours | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.5 Graphics** | | | |
| Max number of process graphic displays | - | | |
| Offered number of process graphic displays | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.6 Updating process variables and conditions** | | | |
| Analog inputs | s | | |
| Digital inputs | s | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.7 Reaction time from issuing command and monitoring** | | | |
| Up to command execution (switching relay of control actuator) | s | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor |
|---|---|---|---|
| Up to execution checkback signal from individual control level to monitor | s | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.8 Representation of graphs (for trending) on monitor** | | | |
| Max number of curves in per screen | - | | |
| Historian memory capacity | months | | |
| Sequence of Event (SOE) resolution time | ms | | |
| Time resolution (time stamping) at input modules for reporting of events (SOE) | ms | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.9 Black & White Laser Printers** | | | |
| Number | - | | |
| Manufacturer / Type | - | | |
| Printing speed | pages/ min | | |
| Resolution (minimum) | dpi | | |
| Noise level | dB(A) | | |
| Format DIN A4 | DIN | | |
| Format DIN A3 | DIN | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.8 Black & White Dot Matrix printers** | | | |
| Number | - | | |
| Manufacturer / Type | - | | |
| Printing speed | pages/ min | | |
| Resolution (minimum) | dpi | | |
| Noise level | dB(A) | | |
| Format DIN A4 | DIN | | |
| Format DIN A3 | DIN | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.9 Color Laser Printers** | | | |
| Number | - | | |
| Manufacturer/Type | - | | |
| Hardcopy image memory (size) | MB | | |
| Processing time | pages/ min | | |
| Resolution | dpi | | |
| Format DIN A4 | DIN | | |
| Format DIN A3 | DIN | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |
| **14.10 Fibre Optic backbone** | | | |
| Manufacturer | - | | |
| Type | - | | |
| "Open" bus as per ISO reference model | yes/no | | |
| Redundancy | yes/no | | |
| Transmission rate (useful data rate) | Mbit/s | | |
| Transmission medium | - | | |
| Max. bus length without using repeaters etc. | m | | |
| Max. number of stations that can be connected | - | | |
| Are the detail product catalogs attached ? | yes/no | | |
| | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | Bidder name | |
| **400 kV Substation** | | | | |
| **General Remarks:** | | | | |
| Unless otherwise noted:<br>• data are per 3-phase unit<br>• data are per initial delivery | | | | |
| | | | | |
| **Ambient conditions** | | | | |
| Altitude above sea level | m | < 30 | | |
| Isoceraunic level (avarage) | days | 80 | | |
| Minimum unified specific creepage distance (USCD) | mm / kV | 53.7 (heavy) | | |
| Other ambient conditions according to Chapter 1 of Section 5 to be followed | - | yes | | |
| | | | | |
| **400 kV Switchgear** | | | | |
| **Type of 400 kV switchgear** | - | Indoor SF6 gas insulated | | |
| Manufacturer | - | | | |
| Applicable standard | | IEC 62271-1 and 203 | | |
| Nominal voltage (phase to phase) | kV(rms) | 400 | | |
| Rated maximum system voltage (phase to phase) | kV(rms) | 420 | | |
| Rated lightning impulse withstand voltage: | | | | |
| • phase-to phase and between phases | kVpeak | 1425 | | |
| • across open switching device and/or across isolating distance | kvpeak | 1425+240 | | |
| Rated short-duration power-frequency withstand voltage: | | | | |
| • phase-to phase and between phases | kVrms | 520 | | |
| • across open switching device and/or across isolating distance | kVrms | 610 | | |
| Rated switching impulse withstand voltage: | | | | |
| • phase-to-earth and across open switching device | kVpeak | 1050 | | |
| • between phases | kVpeak | 1575 | | |
| • across isolating distance | kVpeak | 900+345 | | |
| Rated frequency | Hz | 50 | | |
| Rated short circuit withstand current, 1 s | kA(rms) | 50 | | |
| Rated peak short circuit current | kA(peak) | 125 | | |
| Rated current (busbar) | A | 4000 | | |
| Rated current (diameter) | A | 3150 | | |
| Rated current (generator and line feeders) | A | 3150 | | |
| Rated current (other feeders) | A | 2500 | | |
| Rated line charging breaking current | A | 400 | | |
| Puncturing time, higher than (GIS housings) | ms | 500 | | |
| Protection class of indoor switchgear system (panels, drives/GIS) | - | IP 52/GIS | | |
| Material of encapsulation (GIS housing) | - | | | |
| Busbar material | - | | | |
| Maximum annual gas loss from any gas compartment | % | <0.5 | | |
| Total SF6 gas weight (initial scope) | kg | | | |
| Total weight of the GIS (initial scope) | kg | | | |
| Maximum weight of a transportation unit | kg | | | |
| Bay width | m | | | |
| Indoor foorprint of initial GIS | m x m | | | |
| Indoor footrprint including extension | m x m | | | |
| Applicable standard for SF6 pressurized housings | | EN 50052, 50064, 50068 | | |
| Construction pressure of housings (CB/ others) | MPa | | | |
| Pressure test of casted housings (CB/others) | MPa | | | |
| Pressure test of welded housings | MPa | | | |
| Pressure test for barrier insulators | MPa | | | |
| SF6 gas filling pressure at 20ºC (CB/others) | MPa | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Circuit breaker blocking pressure at 20ºC (Close/Open) | MPa | | | |
| Operating pressure of rupture disc (CB/others) | Mpa | | | |
| Dimensions of the GIS (L x H x D) | m | | | |
| Bay to bay centre line distance | mm | | | |
| Applicable standard for new SF6 gas | - | IEC 60376 | | |
| Volume of largest SF6 gas compartment | $m^3$ | | | |
| Size of maximum transportation unit | m | | | |
| Cross-section of bus bar conductor | $mm^2$ | | | |
| Bus bar material | - | | | |
| Single-phase (1)/three-phase (3) enclosure | - | | | |
| Material of encapsulation | - | | | |
| Diameter of bus bar duct housing | mm | | | |
| Volume of largest bus bar compartment | $m^3$ | | | |
| Cross-section of feeder bus-duct conductor | $mm^2$ | | | |
| Volume of largest feeder compartment | $m^3$ | | | |
| Recommended inspection/maintenance intervals | years | | | |
| | | | | |
| **400 kV circuit breaker** | | integrated | | |
| Applicable standard | | IEC 62271-100 | | |
| Type of quenching medium | | SF6 | | |
| Rated voltage | kV | 420 | | |
| Rated lightning impulse withstand voltage: | | | | |
| • phase-to phase and between phases | kVpeak | 1425 | | |
| • across open switching device | kvpeak | 1425+240 | | |
| Rated short-duration power-frequency withstand voltage: | | | | |
| • phase-to phase and between phases | kVrms | 520 | | |
| • across open switching device | kVrms | 610 | | |
| Rated switching impulse withstand voltage: | kVrms | | | |
| • phase-to-earth and across open switching device | kVpeak | 1050 | | |
| • between phases | kVpeak | 1575 | | |
| First pole-to-clear factor | | 1.5 | | |
| Rated frequency | Hz | 50 | | |
| Number of phases | | 3 | | |
| Rated current (diameter/reactors) | A | 3150/2500 | | |
| Rated short-circuit breaking current, 1s | kA | 50 | | |
| Rated short-circuit making current | kApeak | 125 | | |
| Rated cable charging breaking current | A | | | |
| Maximum capacitive breaking current | A | | | |
| Number of tripping coils | | 2 | | |
| Number of closing coils | | 1 | | |
| Type of operation | | single and three phase | | |
| Rated operating sequence | | 0 • 0.3 s • CO • 3 min • CO | | |
| Rated opening time | ms | < 30 | | |
| Rated breaking time | ms | < 50 | | |
| Rated closing time | ms | < 100 | | |
| Dead time with tolerances | ms | | | |
| Breaking time with tolerances (max) | ms | | | |
| Arcing time with tolerances | ms | | | |
| Number of operation under rated short circuit current | | | | |
| Number of operation at rated circuit current | | | | |
| Drive type | - | | | |
| Motor power | W | | | |
| Number of tripping coils | | 2 | | |
| Number of closing coils | | 1 | | |
| Closing coil | W | | | |
| Tripping coils (2 x ) | W | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Capasitive current switching | - | C2 | | |
| Power supply | V DC | 220 | | |
| Power supply | V AC | 415 | | |
| Rated gas pressure at 20 degr. C | Mpa | | | |
| Minimum operation gas pressure at 20 degr. C | MPa | | | |
| Gas filling pressure at 20 degr. C | MPa | | | |
| Total SF6 gas weight of circuit breaker | kg | | | |
| Total weight of the circuit breaker | kg | | | |
| | | | | |
| **400 kV disconnectors** | | integrated | | |
| Type | | | | |
| Manufacturer | | | | |
| Place of manufacturing | | | | |
| Applicable standard | | IEC 62271-102 | | |
| Type of operation | | single break | | |
| Rated voltage | kV | 420 | | |
| Rated current diameter / GT and OHL feeders | A | 4000/3150 | | |
| Rated current other feeders | A | 2500 | | |
| Rated lightning impulse withstand voltage: | | | | |
| • phase-to phase and between phases | kVpeak | 1425 | | |
| • across isolating distance | kvpeak | 1425+240 | | |
| Rated short-duration power-frequency withstand voltage: | | | | |
| • phase-to phase and between phases | kVrms | 520 | | |
| • across isolating distance | kVrms | 610 | | |
| Rated switching impulse withstand voltage: | | | | |
| • phase-to-earth and across open switching device | kVpeak | 1050 | | |
| • between phases | kVpeak | 1575 | | |
| • across isolating distance | kVpeak | 900+345 | | |
| Rated frequency | Hz | 50 | | |
| Number of phases | | 3 | | |
| Rated short time withstand current (1s) | kA | 50 | | |
| Rated short-circuit peak withstand current | kApeak | 125 | | |
| Number of auxiliary contacts (NO/NC/others) | | | | |
| Power supply | V DC/AC | 220/240 | | |
| | | | | |
| **400 kV current transformers** | | integrated | | |
| Manufacturer | | | | |
| Place of manufacturing | | | | |
| Type | | | | |
| Applicable standard | | IEC 61869, IEC 61869-2 | | |
| Type of CT | | | | |
| Rated voltage | kV | 420 | | |
| Rated short time current (1s) | kA | 50 | | |
| | | | | |
| **Diameter CT core data (CTI, CTIII, CTIV, CTVI)** | | | | |
| Rated primary current | A | 1000-2000-4000 | | |
| Rated secondary current | A | 1/1/1/1 | | |
| Core 1 Class and burden | | 5P20 30 VA | | |
| Core 2 Class and burden | | 5P20 30 VA | | |
| Core 3 Class and burden | | 5P20 30 VA | | |
| Core 4 Class and burden | | 0.2M5 30 VA | | |
| | | | | |
| **Diameter CT core data (CTII, CTV)** | | | | |
| Rated primary current | A | 1000-2000-4000 | | |
| Rated secondary currents | A | 1/1/1 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Core 3 Class and burden | | 5P20 30 VA | | |
| | | | | |
| **Line reactor CT core data (CTVIII)** | | | | |
| Rated primary current | A | 250-500-1000 | | |
| Rated secondary currents | A | 1/1/1 | | |
| C1 Class and burden | | 5P20 30 VA | | |
| C2 Class and burden | | 5P20 30 VA | | |
| C3 Class and burden | | 5P20 30 VA | | |
| | | | | |
| **GT feeder CT core data (CTXIV)** | | | | |
| Rated primary currents for bypass & bus coupler bay | A | 1000-2000-4000 | | |
| Rated secondary currents | A | 1/1 | | |
| Core 1 Tariff metering (Main) | | 0.2 M 5 | | |
| Core 2 Measuring and trafiff metering (Check) | | 0.2 M 5 | | |
| | | | | |
| **In case TPX cores recommended detailled data sheets provided** | | yes / no | | |
| | | | | |
| **400 kV inductive voltage transformer (bus bars)** | | integrated | | |
| Manufacturer | | | | |
| Type | | | | |
| Applicable standard | | IEC 61869, IEC 61869-3 | | |
| Type of VT | | | | |
| Rated primary voltage | kV | 420 | | |
| Rated secondary voltages (W2 measuring/protection) | kV | 0.110/√3 | | |
| Metering winding (W1) | kV | 0.110/√3 | | |
| Open delta winding (WE) | kV | 0.110/3 | | |
| Rated output (W1/W2/WE) | VA | 100/100/100 | | |
| Thermal capacity of the ground fault detection winding | A | 25 | | |
| Accuracy class | | | | |
| • for tariff metering | - | 0.2 | | |
| • for measuring and protection | - | 0.5 / 3P | | |
| • for protection | - | 3P | | |
| Rated voltage factor | - | 1.9/8h | | |
| | | | | |
| **400 kV Maintenance earthing switch** | | integrated | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Applicable standard | - | IEC 62271-102 and 203 | | |
| Drive mechanism | - | motor/manual | | |
| Motor power | W | | | |
| Rated insulation of brought out connection | kV | 10 | | |
| Number of auxiliary contacts (NO/NC/others) | - | | | |
| | | | | |
| **400 kV High speed earthing switch** | | integrated | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Applicable standard | - | IEC 62271-104 and 203 | | |
| Drive mechanism (spring assested) | - | motor/manual | | |
| Motor power | W | | | |
| Rated insulation of brought out connection | kV | 10 | | |
| Number of auxiliary contacts (NO/NC/others) | - | | | |
| | | | | |
| **400 kV Gas insulated line (GIL)** | | | | |
| Applicable standard | - | IEC 62271-203 | | |
| Rated voltages as for 400 kV GIS | - | yes | | |
| Rated current (GT and OHL / others) | A | 3150/2500 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Gas pressure at 20 degr. C (filling/rated/alarm) | MPa | __ / __ / __ | | |
| Capacitance | nF/km | | | |
| Outer diameter | mm | | | |
| Maximum lenght of one tube<br>(max. transport unit) | m | | | |
| Weight per phase | kg/m | | | |
| | | | | |
| **400 kV SF6 air bushing** | | | | |
| Applicable standard | - | IEC 60137 | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Rated switching impulse withstand voltage | kV(peak) | 1050 | | |
| Rated lightning impulse withstand voltage | kV(peak) | 1425 | | |
| Power frequency withstand voltage | kV(rms) | 650 | | |
| Minimum unified specific creepage distance (USCD) | mm/kV | 53.7 | | |
| Current conductor material | - | | | |
| Current conductor dimension | mm | | | |
| Service bending load | N | | | |
| Weight | kg | | | |
| | | | | |
| **Density guard** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Amount of contact | - | | | |
| Scale | Yes/No | Yes | | |
| | | | | |
| **400 kV GIS lightning arrester gapless zinc-oxide type*** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Applicable standard | | IEC 60099-4 | | |
| Type of LA | | GIS | | |
| Rated voltage (Ur) | kV | 390 | | |
| Max. continuous operating voltage (Uc) | kV | | | |
| Rated discharge current | kA | 20 | | |
| Rated frequency | Hz | 50 | | |
| Discharge class | | 4 | | |
| Temporary overvoltage withstand capability for 1 sec. | kV | | | |
| Temporary overvoltage withstand capability for 10 sec. | kV | | | |
| Max. residual voltage at switching impulse 2kA | kV | | | |
| Max. residual voltage at switching impulse 3kA | kV | | | |
| Max. residual voltage at lightning impulse<br>10 kA (8/20) | kV | | | |
| Max. residual voltage at lightning impulse<br>20 kA (8/20) | kV | | | |
| Short circuit strength 0.2 sec. | kA | | | |
| Equipped with counter | Yes/no | yes | | |
| Equipped with leakage current indicator | Yes/no | yes | | |
| | | | | |
| **400 kV lightning arrester discharge counter** | | | | |
| Manufacturer | - | | | |
| Type | - | GIS | | |
| Counter indication | - | digital | | |
| Number per 3 arresters | - | 3 | | |
| *The provided values for 400kV GIS lightning arrester are indicative only. The Contractor shall carry out Insulation Coordination Study according to which the lightning protection equipment shall be sized (subject to Employer's approval) | Yes/no | Yes | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| **400 kV outdoor equipment /material** | | | | |
| **400 kV current transformer** | | | | |
| **Line feeder CT core data (CTVII)** | | | | |
| Manufaturer | | | | |
| Type | | | | |
| Applicable standard | | IEC 61869, IEC 61869-2 | | |
| Rated primary current | A | 1000-2000-4000 | | |
| Rated secondary currents | A | 1/1/1/1/1/1 | | |
| C1 Class and burden | | 5P20 30 VA | | |
| C2 Class and burden | | 5P20 30 VA | | |
| C3 Class and burden | | 5P20 30 VA | | |
| C4 Class and burden | | 5P20 30 VA | | |
| C5 Class and burden | | 0.2 M 5 | | |
| C6 Class and burden | | 0.2 M 5 | | |
| | | | | |
| **400 kV post insulator (if any)** | | | | |
| Applicable standard | - | IEC 60273, IEC 60168 | | |
| Manufacturer | | | | |
| Type | | | | |
| Nominal voltage | kV | 400 | | |
| Rated voltage | kV | 420 | | |
| Rated lightning impulse withstand voltage | kVpeak | 1425 | | |
| Minimum unified specific creepage distance (USCD) | mm/kV | 53.7 | | |
| | | | | |
| **400 kV conductor at Substation** | | | | |
| **Applicable standard** | | EN 50182 | | |
| Manufacturers | - | | | |
| Type (Code number) | - | | | |
| Rated current of GT and OHL bays | A | 3150 | | |
| Rated current of other bays | A | 2500 | | |
| Total cross-section | $mm^2$ | | | |
| Aluminum cross-section | $mm^2$ | | | |
| Conductor design: number of strands x diameter | | | | |
| Aluminum | mm | | | |
| Conductor diameter | mm | | | |
| Conductor weight | kg/m | | | |
| Theoretical breaking force | kN | | | |
| Ohmic resistance at 20°C | ohm/km | | | |
| | | | | |
| **400 kV insulator string** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Insulating body material | - | | | |
| Rated electromechanical or mechanical strength | kN | | | |
| Max. shed diameter | mm | | | |
| Installation height | mm | | | |
| Unified specific creepage distance (USCD) | mm | 53.7 | | |
| Rated short-time withstand current | kA | | | |
| Weight | kg | | | |
| Dead-end and suspension strings | | | | |
| Number of cap insulators per string | | | | |
| Single string | Pcs. | | | |
| Double string | Pcs. | | | |
| | | | | |
| **400 kV clamps/dead-end joints** | | | | |
| Manufacturers | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| | | | | |
| **400 kV OHL connection between GIS and GT** | | | | |
| **OHL conductor** | | | | |
| Applicable standard | - | EN 50182 | | |
| Manufacturer | - | | | |
| Type (Code number) | - | | | |
| Amount of conductors | - | | | |
| Current rating of one conductor | A | | | |
| Total cross-section of one conductor | $mm^2$ | | | |
| Aluminum cross-section of one conductor | $mm^2$ | | | |
| Conductor design: number of strands x diameter | | | | |
| Aluminum | mm | | | |
| Conductor diameter | mm | | | |
| Conductor weight | kg/m | | | |
| Theoretical breaking force | kN | | | |
| Ohmic resistance at 20°C | ohm/km | | | |
| | | | | |
| **400 kV voltage transformers (capacitive)** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Applicable standard | | IEC 61869, IEC 61869-5 | | |
| Rated primary voltage | kV | 420 | | |
| Rated secondary voltages (W2 measuring/protection) | kV | 0.110/√3 | | |
| Metering winding (W1) | kV | 0.110/√3 | | |
| Open delta winding (WE) | kV | 0.110/3 | | |
| Rated output (W1/W2/WE) | VA | 100/100/100 | | |
| Thermal capacity of the ground fault detection winding | A | 25 | | |
| Accuracy class for metering | | 0.2 | | |
| Accuracy class measuring and protection | | 0.5 / 3P | | |
| Accuracy class protection | | 3P | | |
| Minimum rated capacitance | nF | | | |
| Ultimate bending stress at top fitting | kN | | | |
| Protection class of secondaries | - | IP65 | | |
| | | | | |
| **400 kV line traps, capacitors and LMUs*** | | | | |
| Manufacturer | - | | | |
| Type | - | Band Tuned | | |
| Rated continuous current | A | | | |
| Band width | kHz | | | |
| Blocking impedance | Ohm | | | |
| Rated inductance | mH | | | |
| Inserting loss | dB (A) | ≤ 2.0 | | |
| Temperature rise during operation | K | | | |
| Self resonant frequency | Hz | ≥ 600 | | |
| Relative humidity, non-condensing | % | | | |
| *It shall be additionally given the parameters of capacitors (voltage, capacity etc.) and LMU (pass-band) | | | | |
| | | | | |
| **400 kV lightning arrester gapless zinc-oxide type*** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Applicable standard | | IEC 60099-4 | | |
| Type of LA | | outdoor type | | |
| Rated voltage (Ur) | kV | 390 | | |
| Max. continuous operating voltage (Uc) | kV | | | |
| Rated discharge current | kA | 20 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Temporary overvoltage withstand capability for 1 sec. | kV | | | |
| Temporary overvoltage withstand capability for 10 sec. | kV | | | |
| Max. residual voltage at switching impulse 2 kA | kV | | | |
| Max. residual voltage at switching impulse 3 kA | kV | | | |
| Max. residual voltage at lightning impulse 10 kA (8/20) | kV | | | |
| Max. residual voltage at lightning impulse 20 kA (8/20) | kV | | | |
| Short circuit strength 0.2 sec. | kA | | | |
| Equipped with counter | Yes/no | yes | | |
| Equipped with leakage current indicator | Yes/no | yes | | |
| | | | | |
| **400 kV lightning arrester discharge counter** | | | | |
| Manufacturer | - | | | |
| Type | - | outdoor type | | |
| Counter indication | - | digital | | |
| Protection class | - | IP65 | | |
| Number per 3 arresters | - | 3 | | |
| * The provided values for 400 kV GIS lightning arrester are indicative only. The Contractor shall carry out Insulation Coordination Study according to which the lightning protection equipment shall be sized (subject to Employer's approval) | Yes/no | Yes | | |
| | | | | |
| **Firefighting installation** | | | | |
| Manufacturer | | | | |
| Place of Manufacturing | | | | |
| Type | | | | |
| Capacity of the water tank | $m^3$ | | | |
| Outdoor installation | | yes | | |
| Installation for two transformers and three reactors | | yes | | |
| Operation | | automatic/manual | | |
| Corrosion protection | | Galvanized and painted | | |
| Draining time for extinguishing | min. | | | |
| Design temperature | °C | | | |
| Operation pressure | bar | | | |
| Corrosion protection | | | | |
| Water pump capacity | $m^3/h$ | | | |
| Spray nozzles per transformer | nos. | | | |
| Compressed air operation pressure | bar | | | |
| Compressed air supply | $m^3/h$ | | | |
| Type of fire detection | | | | |
| Number of detectors | nos. | | | |
| Type of detectors | | Rate of rise and temperature | | |
| Cabling type | | MICC | | |
| | | | | |
| **Transformer oil testing equipment** | | | | |
| Manufacturer | | | | |
| Place of Manufacturing | | | | |
| Type | | | | |
| | | | | |
| **Shunt reactor (Line reactor / Bus reactor)** | | | | |
| Applicable standard | IEC | 60076-6/ 2007 | | |
| Manufacturer | | | | |
| Type of reactor | - | Outdoor | | |
| Number of phases | # | 3 | | |
| Rated frequency | Hz | 50 | | |
| Rated power (Line reactor / Bus reactor) | MVAr | 63 / 80 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Location of use | | outdoor | | |
| Type of cooling | | ONAN | | |
| | | | | |
| **Temperature ambient** | | | | |
| According to local conditions (see Part B0) | °C | yes | | |
| Service altitude | ml above sea level | < 50 | | |
| **Temperature rise over max. ambient temperature (45°C)** | | | | |
| • top oil | °C | ≤55 | | |
| • average winding | °C | ≤60 | | |
| • hot spot winding | °C | ≤70 | | |
| The temperature rise for winding, core and other parts shall be such as in no case the temperature should reach a value that will injure the winding, core itself, the adjacent parts or materially affect the life of the reactor. | | Yes | | |
| | | | | |
| **Rated power** | | | | |
| HV winding (LR/BR) | MVar | 63 / 80 | | |
| Nominal voltage | kV | 400 | | |
| Highest system voltage | kV | 420 | | |
| Continuous over voltage rating, line to neutral, kV, rms | kV | | | |
| Neutral rated nominal voltage, | kV | | | |
| | rms | | | |
| Rated 2 second over voltage rating, line to neutral, % of nominal rating (500 kV), not less than | % | | | |
| | | | | |
| **Rated power frequency withstand voltage, 1 min dry** | | | | |
| HV winding (phase to earth) | kV | 520 | | |
| | rms | | | |
| Neutral end | kV | | | |
| | rms | | | |
| | | | | |
| **Rated switching impulse withstand voltage** | | | | |
| HV winding (phase to earth/between phases) | kV peak | 1050/1575 | | |
| | | | | |
| **Rated lightning impulse withstand voltage (1.2/50 μs)** | | | | |
| HV winding | $kV_{peak}$ | 1425 | | |
| Neutral end | $kV_{peak}$ | | | |
| Rated nominal current | A | | | |
| Reactance at rated voltage and full loading | Ω | | | |
| Minimum unified specific creepage (USCD) in for insulation (phase to ground) | mm/kV | 53,7 (heavy) | | |
| Audible noise level<br>(according to IEC60076-10) | dB(A) | ≤65 | | |
| | | | | |
| **Load losses at 400kV (LR/BR)** | kW | / | | |
| **Load losses at 1.1 x 400kV (LR/BR)** | kW | / | | |
| The maximum allowable crest value of the third harmonic component of the reactor current shall not exceed by 3% the crest value of the fundamental when the reactor is energized at rated voltage with sinusoidal wavwform | | Yes | | |
| | | | | |
| **Characteristics of HV bushings** | | | | |
| Applicable standard | | | | |
| Manufacturer | | | | |
| Type | | | | |
| Rated current | A | | | |
| Nominal voltage | kV | 400 | | |
| Highest equipment voltage | kV | 420 | | |
| Insulation level | | As for the transformer | | |
| Number of bushings | | 3+N | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| **Reactor bushing current transformers** | | | | |
| Manufacturer | | | | |
| Type | | | | |
| Applicable standard | | IEC 61869, IEC 61869-2 | | |
| **Primary side (CTIX)** | | | | |
| Rated voltage | kV | 420 | | |
| Rated short time current (1s) | kA | 50 | | |
| Rated primary currents | A | 250-500-1000 | | |
| Rated secondary currents | A | 1/1/1/1 | | |
| C1 Class and burden | | 5P20 30 VA | | |
| C2 Class and burden | | 5P20 30 VA | | |
| C3 Class and burden | | 5P20 30 VA | | |
| C4 Class and burden | | 0.2M5 30 VA | | |
| | | | | |
| **NGR side (CTX)** | | | | |
| Rated voltage | kV | | | |
| Rated short time current (1s) | kA | | | |
| Rated primary currents | A | 250-500-1000 | | |
| Rated secondary currents | A | 1/1/1/1 | | |
| C1 Class and burden | | 5P20 30 VA | | |
| C2 Class and burden | | 5P20 30 VA | | |
| C3 Class and burden | | 5P20 30 VA | | |
| C4 Class and burden | | 5P20 30 VA | | |
| | | | | |
| **Main dimensions of the reactor** | | | | |
| Length x width x height | m | | | |
| Gross weight | to | | | |
| Transport weight | to | | | |
| Volume of oil/weight of oil | to/$m^3$ | | | |
| | | | | |
| **Accessories** | | | | |
| Oil conserver with filling and drainage valve | | yes | | |
| Buchholz relay | | yes | | |
| Pressure relieve device | | yes | | |
| Silicagel air dryer | | yes | | |
| Oil level indicator with two contacts | | yes | | |
| Oil thermometer sensor with two contacts | | yes | | |
| Winding thermometer sensors with two contacts | | yes | | |
| | | | | |
| **Auxiliary voltage** | | | | |
| Power supply for heaters | VAC | 400/230 | | |
| Power supply for auxiliary contacts | VDC | 220 | | |
| Set of valves | | yes | | |
| Name plate | | yes | | |
| Connection diagram | | yes | | |
| Designation plate for all devices | | yes | | |
| Control box | | yes | | |
| IP protection for above | IP | 54 | | |
| Fixation on rails via metal wheels | | yes | | |
| | | | | |
| **Test Requirements** | | | | |
| Standard applied | IEC | 60076-1 and 60076-6 | | |
| | | | | |
| **Neutral grounding reactor (NGR)** | | | | |
| Applicable standard | IEC | 60076-6, /2011 | | |
| Manufacturer | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Type of insulating | | Air-core | | |
| Location of use | | outdoor | | |
| Type of cooling | | AN | | |
| Rated voltage | kV | | | |
| Highest system voltage | kV | | | |
| Rated power frequency withstand voltage | kV rms | | | |
| Rated lightning impulse withstand voltage (1.2/50 µs) | kV peak | | | |
| Rated nominal current | A | | | |
| Maximum temperatures as specified | | yes | | |
| | | | | |
| **Tolerances** | | | | |
| For penalty | IEC | 60076-1 | | |
| For rejection | IEC | 60076-1 | | |
| | | | | |
| **Losses** | | | | |
| Losses at ambient temperature and full load | kW | | | |
| Minimum unified specific creepage (USCD) in for insulation (phase to ground) | mm/kV | 53,7 (heavy) | | |
| | | | | |
| **Main dimensions** | | | | |
| Length x width x height | m | | | |
| Gross weight | to | | | |
| Transport weight | to | | | |
| | | | | |
| **Accessories** | | | | |
| Name plate | | yes | | |
| Connection diagram | | yes | | |
| Designation plate for all devices | | yes | | |
| Fixation | | To be proposed by the Bidder | | |
| **Painting** | | | | |
| Painting cycle (according to ISO12944 • 2 Paints and varnishes – Corrosion protection of steel structures by protective paint systems • Part 2 Classification of environment) | | C5 M | | |
| Durability | | High | | |
| | | | | |
| **Test Requirements** | | | | |
| Standard applied | IEC | 60076-1 | | |
| Temperature rise test according to IEC 60076-2 | | yes | | |
| Noise level according to IEC 60076-10 | | yes | | |
| | | | | |
| **Disconnectors for NGR** | | | | |
| Applicable standard | IEC | 62271-102 | | |
| Manufacturer | | | | |
| Type | | outdoor | | |
| Type of operation | | Single break | | |
| Nominal voltage | kV | | | |
| Rated voltage | kV | | | |
| Rated nominal current | A | | | |
| Rated short time current, 3s | kA | | | |
| Rated short circuit current | kA | | | |
| Rated Power frequency withstand voltage | kV rms | | | |
| Rated lightning impulse withstand voltage | kV peak | | | |
| Rated frequency | Hz | 50 | | |
| Minimum unified specific creepage (USCD) in for insulation (phase to ground) | mm/kV | 53.7 | | |
| Protection class | - | IP 54 | | |
| Type of drive | - | Electric motor | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Power supply for heater | VAC | 415/230 | | |
| Manual operating facility | yes/no | yes | | |
| | | | | |
| **Current transfromer on NGR ground side (CTXI)** | | | | |
| Manufacturer | | | | |
| Type | | | | |
| Applicable standard | | IEC 61869, IEC 61869-2 | | |
| Rated voltage | kV | | | |
| Rated short time current (1s) | kA | | | |
| Rated primary currents | A | | | |
| Rated secondary currents | A | 1/1 | | |
| C1 Class and burden | | 5P20 30 VA | | |
| C2 Class and burden | | 5P20 30 VA | | |
| | | | | |
| **Protection System** | | | | |
| **Relays (general)** | - | Digital | | |
| • standard | - | IEC 60255 | | |
| • maximum ambient temperature for rated accuracy | oC | 40 | | |
| • maximum temperature by storage | oC | 60 | | |
| • maximum humidity | % | 80 | | |
| • electromagnetic compatibility tests | - | EN 50081 EN 50082-1 IEC 60255-6 | | |
| • insulation tests | - | IEC 60255-5 IEC 60870-2-1 | | |
| • mechanical tests (vibration and shock stress) | - | IEC 60255-2-1 IEC 60068-2 | | |
| • other: all other Norms as specified on technical document | - | IEC | | |
| Contact rating | | | | |
| • make and carry for 0.2 s | VA | | | |
| • break | | | | |
| • operation indicator | | | | |
| • manufacturer references | year | 3 | | |
| | | | | |
| **Panels** | | | | |
| • standard | - | IEC 60529 | | |
| • protection class | - | IP 52 | | |
| • pre-wired | - | Yes | | |
| • floor-mounted | - | Yes | | |
| • steel sheet thickness | mm | > 2 | | |
| • maximum height | mm | 2000 | | |
| • maximum width | mm | 800 | | |
| • maximum depth | mm | 600 | | |
| • front-door material | - | Glass | | |
| • coloring | - | RAL 7035 | | |
| | | | | |
| **Line differential protection (ANSI: 87L)** | | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Place of manufacture | - | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase current | A | 1 | | |
| • DC voltage | V | 220 | | |
| • communication | | | | |
| | | | | |
| **Settings** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| • ranges of times | sec | 0.00 – 30.00 | | |
| • trip mode | - | 1-/3 pole | | |
| • minimum number of auto-reclose cycles (AR-cycles) | - | 3 | | |
| • fault locator and event (disturbance) recorder | - | Yes | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Phase comparison protection (ANSI: 87PC)** | | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Place of manufacture | - | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase current | A | 1 or 5 | | |
| • DC voltage | V | 220 | | |
| • communication | | | | |
| Settings | | | | |
| • phase comparison | degree | 0 – 60 | | |
| • ranges of values of phase overcurrent | I>/In | 2.00 – 20.00 | | |
| • ranges of values of earth fault overcurrent | IN>/In | 2.00 – 20.00 | | |
| • ranges of negative sequence overcurrent | I2P>/In | 0.08 – 1.00 | | |
| • minimum number of auto-reclose cycles (AR-cycles) | - | 3 | | |
| • fault locator and event (disturbance) recorder | - | Yes | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Distance protection (ANSI: 21)** | | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Place of manufacture | - | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase current | A | 1 or 5 | | |
| • phase to phase voltage | V | 100 | | |
| • DC voltage | V | 220 | | |
| Settings | | | | |
| • ranges of values | Ohm | 0.050 – 600 | | |
| • ranges of times | sec | 0.00 – 30.00 | | |
| • minimum number of independent impedance zones | - | 4 | | |
| • type of characteristic of teleprotection | - | PUTT, POTT | | |
| • trip mode | - | 1-/3 pole | | |
| • minimum number of auto-reclose cy+A1240cles (AR-cycles) | - | 3 | | |
| • fault locator and event (disturbance) recorder | - | Yes | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Back-up directional overcurrent protection (ANSI: 67&67N)** | | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Place of manufacture | - | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| • DC voltage | V | 220 | | |
| Settings | | | | |
| • ranges of current values | A | 0.10 – 35.00 | | |
| • ranges of voltage values | V | 0.10 – 120 | | |
| • ranges of times | sec | 0.00 – 30.00 | | |
| • minimum number of DTL stages for 67 | - | 2 | | |
| • minimum number of IDMT stages for 67 | - | 2 | | |
| • minimum number of DTL stages for 67N | - | 2 | | |
| • trip mode | - | 1-/3 pole | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Overload protection (ANSI: 49)** | | | | |
| • k-factor | | 0.1 – 4.0 | | |
| • time constant | min | 1.0 – 999.0 | | |
| | | | | |
| **Transformer differential protection (87T)** | | | | |
| Type | | | | |
| Manufacturer | | | | |
| Operating principle | | | | |
| Rated values | | | | |
| • phase current | A | 1 and 5 | | |
| • frequency | Hz | 50 | | |
| • DC voltage | V | 220 | | |
| Current settings | | | | |
| • ranges of values of restricted protection | I/InO | 0.05 – 2.00 | | |
| • ranges of values of unrestricted protection | I/InO | 0.5 – 35.00 | | |
| • ranges of times | sec | 0.00 – 30.00 | | |
| Integrated functions | | | | |
| • back-up overcurrent (eventual directional) | | | | |
| • back-up earth fault (eventual directional) | | | | |
| • breaker-failure | | | | |
| • others | | | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Transformer restricted earth fault protection (87N)** | | | | |
| Type | | | | |
| Manufacturer | | | | |
| Operating principle | | | | |
| Rated values | | | | |
| • phase current | A | 1 and 5 | | |
| • frequency | Hz | 50 | | |
| • DC voltage | V | 220 | | |
| Current settings | | | | |
| • ranges of values of restrained protection | I/InO | 0.05 – 2.00 | | |
| • ranges of values of unrestrained protection | I/InO | 0.5 – 35.00 | | |
| • ranges of times | sec | 0.00 – 30.00 | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Busbar (Bus Arrangement) differential protection (ANSI: 87BB)** | | | | |
| Type | - | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase current | A | 1 and 5 | | |
| • DC voltage | V | 220 | | |
| Settings | | | | |
| • ranges of values of restricted protection | I/InO | 0.05 – 2.00 | | |
| • ranges of values of unrestricted protection | I/InO | 0.5 – 35.00 | | |
| • ranges of times | sec | 0.00 – 30.00 | | |
| CT supervision | | | | |
| Operating time | ms | | | |
| DC burden | W | | | |
| AC burden | Ohm | | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Back-up overcurrent protection (ANSI: 50/51&50N/51N)** | | | | |
| Type | - | | | |
| Manufacturer | - | | | |
| Place of manufacture | - | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase current | A | 1 or 5 | | |
| • DC voltage | V | 220 | | |
| Settings | | | | |
| • ranges of current values | A | 0.10 – 35.00 | | |
| • ranges of times | sec | 0.00 – 30.00 | | |
| • minimum number of DTL stages for 50/51 | - | 2 | | |
| • minimum number of IDMT stages for 50/51 | - | 2 | | |
| • minimum number of DTL stages for 50N/51N | - | 2 | | |
| • minimum number of IDMT stages for 50N/51N | - | 2 | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Load unbalance protection (ANSI: 46)** | | | | |
| Manufacturer | - | | | |
| Place of manufacture | - | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase current | A | 5 | | |
| Settings | | | | |
| • setting range current stage 1 | A | 0.10 – 35.00 | | |
| • setting range current stage 2 | A | 0.10 • 35.00 | | |
| • setting range time delay stage 1 | sec | 0.00 – 30.00 | | |
| • setting range time delay stage 2 | sec | 0.00 – 30.00 | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Undervoltage protection (ANSI: 27)** | | | | |
| Manufacturer | | | | |
| Place of manufacture | | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase to phase voltage | V | 100 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| • setting range undervoltage stage 2 | V | 0.05 • 100 | | |
| • setting range time delay stage 1 | sec | 0.00 • 30.00 | | |
| • setting range time delay stage 2 | sec | 0.00 • 30.00 | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Overvoltage protection (ANSI: 59)** | | | | |
| Manufacturer | | | | |
| Place of manufacture | | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase to phase voltage | V | 100 | | |
| Settings | | | | |
| • setting range undervoltage stage 1 | V | 0.5 • 200 | | |
| • setting range undervoltage stage 2 | V | 0.5 • 200 | | |
| • setting range time delay stage 1 | sec | 0.00 • 30.00 | | |
| • setting range time delay stage 2 | sec | 0.00 • 30.00 | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **Breaker failure protection (ANSI: 50BF)** | | | | |
| Manufacturer | | | | |
| Place of manufacture | | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase current | A | 1 or 5 | | |
| • DC voltage | V | 220 | | |
| Settings | | | | |
| • ranges of current flow monitoring | A | 0.05 – 20.00 | | |
| | | or | | |
| | | 0.25 • 100 | | |
| • ranges of times | sec | 0.00 – 30.00 | | |
| | | | | |
| **Automatic Reclosure (79)** | | | | |
| Manufacturer | | | | |
| Place of manufacture | | | | |
| Type | | 1-pole, 3-pole or 1-/3-pole | | |
| Settings | | | | |
| • ranges of times | sec | 0.01 – 30.00 | | |
| | | | | |
| **Synchrocheck Relay (25)** | | | | |
| Manufacturer | | | | |
| Place of manufacture | | | | |
| Rated values | | | | |
| • frequency | Hz | 50 | | |
| • phase to phase voltage | V | 100 | | |
| Settings | | | | |
| • ΔU measurement | V | 1-60 | | |
| • Δφ measurement | degree | 2-80 | | |
| Remote communication | | | | |
| • protocol | - | IEC 61850 | | |
| • transmission rate | Baud | 9600 | | |
| | | | | |
| **11/0.415 kV distribution transformers** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Type: | | | | |
| Rated power (i.e. continuous rating at site | kVA | 630 | | |
| Vector group | - | Dyn5 | | |
| Normal ratio of transformation at off load | kV | 11 / 0,415 | | |
| Type of cooling | - | ONAN | | |
| Voltage to earth for which transformer neutral will be insulated | kV | | | |
| Total range of variation of transformation ratio expressed as percentage of high voltage with low voltage constant: | | | | |
| • Increasing ratio | % | 2 x 2,5 | | |
| • Decreasing ratio | % | 2 x 2,5 | | |
| Size of steps | % | 4 | | |
| Position of tappings | | At HV Winding | | |
| Impedance voltage | % | 4 | | |
| Maximum noise level | dB (A) | 46 | | |
| Primary terminals | | Cable box | | |
| Secondary terminals | | Cable box | | |
| Winding temp. measurement | | yes | | |
| No-load losses | kW | | | |
| Load losses at full load | kW | | | |
| Ratings (winding) | | | | |
| • Rated nominal voltage | | | | |
| • HV winding | kVrms | 11 | | |
| • LV winding | kVrms | 0.415 | | |
| • Rated highest voltage for equipment | | | | |
| • HV winding | kVrms | 12 | | |
| • LV winding | kVrms | 1 | | |
| • Insulation levels | | | | |
| • Rated lightning impulse withstand voltage | | | | |
| • HV winding | kVpeak | 75 | | |
| • LV winding | kVpeak | | | |
| • Neutral | kVpeak | | | |
| • Rated short duration power frequency withstand voltage | | | | |
| • HV winding | kVrms | 28 | | |
| • LV winding | kVrms | 3 | | |
| • Neutral end of winding | kVrms | | | |
| • Short circuit withstand capability for 2s (HV and LV) | | | | |
| Ratings (bushings) | | | | |
| • Current rating | | | | |
| • HV | Arms | | | |
| • LV | Arms | | | |
| • Neutral | Arms | | | |
| • Unified specific creepage distance (USCD) | mm/kV | 53.7 | | |
| | | | | |
| **AC/DC Installation** | | | | |
| 380 V AC Distributions | | | | |
| Manufacturer: | | | | |
| Type | - | fix mounted components | | |
| Rated voltage | V | 415 | | |
| Number of phases | - | 3 | | |
| Frequency | Hz | 50 | | |
| Rated short-circuit current | kA | 25 | | |
| Test voltage | V | 2500 | | |
| Type of load-break switch | - | hand-operated | | |
| Protection class | - | IP52 | | |
| Type of switching | - | | | |
| Plug-in units | - | yes/no | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Max. asymmetric 3-phase short circuit withstand current | kApeak | 25 | | |
| Short-time current (1 s) | kA | 25 | | |
| Busbar cross-section (Cu) | $mm^2$ | | | |
| | | | | |
| **DC Distributions 220 V and 48 V** | | | | |
| Manufacturer: | | | | |
| Type | | fix mounted components | | |
| Metal cabinets with single busbar system and fixed equipment | - | | | |
| Rated current | A | 250 (100) | | |
| Short-time withstand current, 1 s | A | | | |
| Busbar cross-section (Cu) | $mm^2$ | | | |
| Busbars | P and N | insulated | | |
| Rated voltage DC | V | 220 (48) | | |
| Test voltage | V | 1500 (1000) | | |
| Type of load break switch | - | hand-operated | | |
| Protection class | - | IP52 | | |
| | | | | |
| **Load switch** | | | | |
| Type | - | | | |
| Rated current DC | A | | | |
| | | | | |
| **Fuse** | | | | |
| Type | - | | | |
| Rated current DC | A | | | |
| Rated breaking current DC | A | | | |
| Rated breaking time | ms | | | |
| | | | | |
| **Main dimensions:** | | | | |
| Height x width x depth of single cabinet | mm | | | |
| Weight of cabinet | kg | | | |
| Number of cabinets | - | | | |
| | | | | |
| **220 V batteries** | | | | |
| Manufacturer: | | | | |
| Type | - | NiCd Low Performance Pocket plate or Lead Acid | | |
| Rated voltage | V | 220 | | |
| Type of operation | | stand-by / parallel | | |
| No. of cells | | | | |
| Rated capacity (for 10 hours discharge time) | Ah | | | |
| Electrical characteristics | | | | |
| Voltage range | ± V | | | |
| Rated capacity for: | | | | |
| 10 hours | Ah | | | |
| 5 hours | Ah | | | |
| 1 hour | Ah | | | |
| Rated discharge current: | | | | |
| 10 hours | A | | | |
| 5 hours | A | | | |
| 1 hours | A | | | |
| Charging current | A | | | |
| Short-circuit current | A | | | |
| Number of cells | - | | | |
| Operating voltage per cell | V | | | |
| Time to charge complete battery from total discharge to 90 % charge capacity | h | | | |
| | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Total weight | kg | | | |
| | | | | |
| **220 V battery charger** | | | | |
| Manufacturer: | | | | |
| Type | - | Thyristor controlled | | |
| Input voltage | V | 3ph 415 ± 10% | | |
| Frequency | Hz | 50 ± 10% | | |
| Rated DC voltage | V | 220 | | |
| Maximum DC voltage | V | 250 | | |
| Rated current DC | A | | | |
| Trickle charging voltage per cell | V | 1,45 ± 1% | | |
| Boost charging voltage per cell | V | Less than 1,65 ± 1% | | |
| Residual ripple | % | Less than 2 | | |
| Main cells / End cells (yes / no) | | | | |
| Rated capacity | kVA | | | |
| Rated input voltage | V | | | |
| Rated current consumption | A | | | |
| Efficiency | % | | | |
| Charging characteristics | - | | | |
| Constant voltage range from – to | V | | | |
| Number of battery cells | - | | | |
| Manual regulation mode stepwise/continuous | - | | | |
| Noise level (1 m) | dB(A) | | | |
| | | | | |
| **Contactor** | | | | |
| Type | - | | | |
| Rated current | A | | | |
| Tripping thermal current range | A | | | |
| | | | | |
| **Load switch** | | | | |
| Type | - | | | |
| Rated current | A | | | |
| | | | | |
| **Main dimensions** | | | | |
| Height x width x depth per panel | mm | | | |
| weight per panel | kg | | | |
| Number of panels | - | | | |
| Type of cooling | - | Self Ventilating | | |
| Protection class of cubicle | - | IP52 | | |
| | | | | |
| **48 V Batteries** | | | | |
| Electrical characteristics | | | | |
| Manufacturer | - | | | |
| Type | - | NiCd or Lead Acid | | |
| Rated voltage | V | | | |
| Voltage range | ± V | | | |
| Rated capacity for: | | | | |
| 10 hours | Ah | | | |
| 5 hours | Ah | | | |
| 1 hour | Ah | | | |
| Rated discharge current: | | | | |
| 10 hours | A | | | |
| 5 hours | A | | | |
| 1 hours | A | | | |
| Charging current | A | | | |
| Short-circuit current | A | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Time to charge complete battery from total discharge to 90 % charge capacity | | | | |
| | | | | |
| **Main dimensions (single cell)** | | | | |
| Length x width x height | mm | | | |
| Total weight | kg | | | |
| Total dimensions of assembled battery (length x width x height) | mm | | | |
| | | | | |
| **48 V battery charger** | | | | |
| Manufacturer | | | | |
| Type | - | Thyristor controlled | | |
| Input voltage | V | 3ph 415±10% | | |
| Frequency | Hz | 50 +/• 10% | | |
| Rated DC voltage | V | 48 | | |
| Maximum DC voltage | V | | | |
| Residual ripple | - | 5 | | |
| Type of cooling | - | Natural | | |
| | | circulation | | |
| Rated voltage DC | V | | | |
| Rated current DC | A | | | |
| Rated capacity | kVA | | | |
| Rated current consumption | A | | | |
| Constant voltage range from • to | V | | | |
| Protection class of cubicle | - | IP52 | | |
| | | | | |
| **LV Cables** | | | | |
| **0.415 kV L.V. power cables, single-core** | | | | |
| Applied standard | IEC | 60502-1 | | |
| Manufacturer | - | | | |
| Cable type | - | | | |
| Rated voltage Uo/U | kV | 0.6/1 | | |
| Test voltage | kV | | | |
| Conductor material | - | | | |
| Insulation material | - | | | |
| | | | | |
| **0.415 kV L.V. power cables, four-core** | | | | |
| Applied standard | IEC | 60502-1 | | |
| Manufacturer | - | | | |
| Cable type | - | | | |
| Rated voltage Uo/U | kV | 0.6/1 | | |
| Test voltage | kV | | | |
| Conductor material | - | | | |
| Insulation material | - | | | |
| | | | | |
| **DC cables** | | | | |
| Applied standard | IEC | 60502-1 | | |
| Manufacturer | - | | | |
| Cable type | - | | | |
| Rated voltage | kV | | | |
| Test voltage | kV | | | |
| Conductor material | - | | | |
| Insulation material | - | | | |
| | | | | |
| **Control cables** | | | | |
| Applied standard | IEC | 60502-1 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Insulation material | | PVC | | |
| Rated voltage Uo/U | kV | 0.6/1 | | |
| Highest voltage | kV | 1.2 | | |
| Category of cable | | B | | |
| Maximum conductor temperature normal operation | °C | 70 | | |
| Maximum conductor temperature after short circuit | °C | 160 | | |
| Conductor material | | copper | | |
| Nominal thickness of insulation at rated voltage | mm | | | |
| Weight | Kg/m | | | |
| | | | | |
| **Accessories** | | | | |
| Cable termination | | | | |
| Standard applied | IEC | 60502-1 | | |
| Type | | | | |
| Insulation material | | | | |
| | | | | |
| **Fibre optical cables** | | | | |
| Manufacturer | | | | |
| Type of fibers | | | | |
| Number of fibers | | minimum 12 | | |
| Mono-mode (graded index) glass fiber | | | | |
| Core/cladding diameter | | 10/125 micrometer | | |
| Attenuation | | < 0.3 dB/km at 1550 nm | | |
| | | | | |
| **Cranes for GIS Halls (400 kV)** | | | | |
| Manufacturer: | | | | |
| Type: | | | | |
| Test load for the crane and lifting gears in % of the nominal carrying capacity | % | 125 | | |
| Carrying capacity, approx. (to be adapted by the Bidder, according to the heaviest part to be lifted) | t | / | | |
| Lifting height, approx. | m | / | | |
| Operation mode | | remote and cable | | |
| Hoisting speed, fast/creep approx. | m/min | 4/0.4 | | |
| Crab traversing speed, fast/creep approx. | m/min | / | | |
| Crane bridge travelling speed | m/min | / | | |
| Fast/creep approx. | | / | | |
| Span approx. | m | / | | |
| Length of runway approx. | m | / | | |
| Design and calculation of the crane according to standard | | | | |
| Manufacturer | | | | |
| Test load for the crane and lifting gears in % of the nominal carrying capacity | % | / | | |
| Carrying capacity | t | / | | |
| Hoisting speed, fast/creep | m/min | / | | |
| Crab traversing speed, fast/creep | m/min | / | | |
| Crane bridge traveling speed fast/creep | m/min | / | | |
| Heaviest part to be lifted | - | / | | |
| Weight | t | / | | |
| | | | | |
| **General Guarantees** | | | | |
| The Contractor shall guarantee the following values and characteristics of the crane. | | | | |
| Faultless operation of the crane installation | | | | |
| Travel and lifting speeds including the inching speed with a tolerance of each nominal speed at nominal load. | % | ± 15 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| The lifting capacity with a permitted overload capacity (test load) of at least nominal lifting capacity. | % | 25 | | |
| Max. deflecting of the crane bridge of span at nominal load | - | 1/800 | | |
| | | | | |
| **Special Guarantees** | | | | |
| Lifting capacity | t | | | |
| Deflecting of crane girder at nominal load and with crab in centre position | mm | | | |
| Traveling speeds fast/creep | m/min | | | |
| Hoisting speeds fast/creep | m/min | | | |
| Max. power demand | kW | | | |
| Reference Standards | | DIN 15018, 4132, 18800 and 9837 | | |
| | | | | |
| **Digital Substation Control and Monitoring System** | | | | |
| **General** | | | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| System availability | % | > 99.95 | | |
| MTBF (Mean Time Between Failure) | h | > 8750 | | |
| Time resolution events | ms | < 10 | | |
| Data integrity class | | I3 | | |
| Information error probability | | ≤10 exp. -14 | | |
| Automatic time synchronization at all nodes of the network | | Yes | | |
| Time resolution events | ms | < 10 | | |
| Fault indication LEDs on modules | - | Yes | | |
| Spare function capacity | % | 35 | | |
| Spare parts | % | 20 | | |
| | | | | |
| **Station bus** | | | | |
| Protocol | | IEC 61850-8-1 | | |
| Transmission medium | | FOC | | |
| Transmission rate | MBit/s | 100 | | |
| | | | | |
| **Ethernet switches** | | | | |
| Number of ethernet switches | - | | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Power supply from station battery | V DC | 220 | | |
| Management | | Port Monitoring; RMON; SNMP | | |
| Alarm indication | - | Diagnostics LEDs | | |
| Security | - | Disabling of Ports; Authentification (IEEE802.1x) | | |
| Number of optical ports | - | ≥ 10 | | |
| Minimal distance covered | m | > 100 m | | |
| Clock system | - | | | |
| Number of clock systems | - | 1 | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Synchronization source | - | GPS or Radio | | |
| Synchronization interval | ms | ≤ 1 | | |
| Maximum time Deviation by Running without radio reception | msec/Day | ≤ 50msec/Day | | |
| Alarm LED | - | Yes | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| **Station computer** | | | | |
| Number of station computers | - | 2 | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Power supply from station battery | V DC | 220 | | |
| | | | | |
| **Common bay unit** | | | | |
| Number of common bay units | - | 1 | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Power supply from station battery | V DC | 220 | | |
| | | | | |
| **Interfaces to remote control centers** | | | | |
| Number of remote control centers to be interfaced simultaneously | - | > 2 | | |
| Serial interface | - | IEC 60870-5-101/104 | | |
| Transmission medium | - | FOC | | |
| Minimum data transmission rate | MBit/s | 100 | | |
| Other serial interface | - | | | |
| Transmission medium | - | | | |
| Data transmission rate | - | | | |
| | | | | |
| **Operator workstation (OWS)** | | | | |
| Number of operator workstations | - | 1 | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Power supply from UPS | V AC | 230 | | |
| CPU | | | | |
| Working memory | MB | ≥ 2048 MB | | |
| Hard disk | - | | | |
| Type | - | | | |
| Capacity | GB | ≥ 320 GB | | |
| RAID-System | - | Yes | | |
| External memory | - | DVD or Disk array | | |
| Operating system | - | | | |
| Screens | | | | |
| Type | - | TFT | | |
| Number of Screens | - | 2 | | |
| Screen size | inch | 20 | | |
| Pixels | - | 1280 x 1024 | | |
| TCO standards | - | 5.0 | | |
| Noise | dB(A) | <70 dB(A) | | |
| Mouse Type | - | Optical Mouse | | |
| Desk | - | 1 | | |
| Chair | - | 1 | | |
| | | | | |
| **Engineering Workstation (EWS)** | | | | |
| Number of operator workstations | - | 1 | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Power supply from UPS | V AC | 230 | | |
| CPU | | | | |
| Working memory | MB | ≥ 2048 MB | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Capacity | GB | ≥ 320 GB | | |
| RAID-System | - | Yes | | |
| External memory | - | DVD or Disk array | | |
| Operating system | - | | | |
| Screens | | | | |
| Type | - | TFT | | |
| Number of Screens | - | 2 | | |
| Screen size | inch | 20 | | |
| Pixels | - | 1280 x 1024 | | |
| TCO standards | - | 5.0 | | |
| Noise | dB(A) | <70 dB(A) | | |
| Mouse Type | - | Optical Mouse | | |
| Desk | - | 1 | | |
| Chair | - | 1 | | |
| | | | | |
| **OPC Server/Client** | | | | |
| Server | | | | |
| Number of servers | - | 2 | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Operating system | - | | | |
| Screens | | | | |
| Type | - | TFT | | |
| Number of Screens | - | 1 | | |
| Screen size | inch | 20 | | |
| Pixels | - | 1280 x 1024 | | |
| TCO standards | - | 5.0 | | |
| Noise | dB(A) | <70 dB(A) | | |
| Mouse Type | - | Optical Mouse | | |
| Client | | | | |
| Number of servers | - | 1 | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Operating system | - | | | |
| Screens | | | | |
| Type | - | TFT | | |
| Number of Screens | - | 2 | | |
| Screen size | inch | 20 | | |
| Pixels | - | 1280 x 1024 | | |
| TCO standards | - | 5.0 | | |
| Noise | dB(A) | <70 dB(A) | | |
| Mouse Type | - | Optical Mouse | | |
| | | | | |
| **MMI-Software** | | | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| | | | | |
| **System Performance** | | | | |
| Exchange of display (first reaction) | Sec. | < 1 | | |
| Presentation of a binary change in the process display | Sec. | < 0.5 | | |
| Presentation of an analogue change in the process display | Sec. | < 1 | | |
| From order to process output | Sec. | < 0.5 | | |
| From order to updating the display | Sec. | < 1.5 | | |
| | | | | |
| **Hardcopy printer** | | | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
|---|---|---|---|---|
| Format | DIN | A3 | | |
| Color | - | Yes | | |
| Pages / min. | - | > 12 | | |
| Noise | dB(A) | ≤ 55dB(A) | | |
| | | | | |
| **Event and Record printer** | | | | |
| Number of Event and record printers | - | 1 | | |
| Power supply from UPS | V AC | 230 | | |
| Format | DIN | A4 | | |
| Color | - | Black-white | | |
| Pages / min | - | > 15 | | |
| Noise | dB(A) | ≤ 55dB(A) | | |
| | | | | |
| **Service and Analysis System** | | | | |
| Hardware | - | | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Power supply from UPS | V AC | 230 | | |
| CPU | - | | | |
| Working memory | MB | ≥ 2048 MB | | |
| Hard disk | - | | | |
| External memory | - | DVD | | |
| Operating system | - | | | |
| Screens | 1 | TFT | | |
| Screen size | Inch | 20 | | |
| Pixels | - | 1280 x 1024 | | |
| Mouse type | - | Optical mouse | | |
| Desk | 1 | | | |
| Chair | 1 | | | |
| | | | | |
| **Service and Analysis Software** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| | | | | |
| **Service unit** | | | | |
| Hardware | - | Laptop | | |
| Manufacturer | - | | | |
| Type | - | | | |
| Power supply from UPS | V AC | 230 | | |
| CPU | - | | | |
| Working memory | - | | | |
| Hard disk | GB | ≥ 160GB | | |
| Operating system | - | | | |
| External memory | - | DVD | | |
| Screen size | inch | 14 | | |
| Pixels | - | 1280 x 1024 | | |
| | | | | |
| **Service Software** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| | | | | |
| **Station Control Cubicles** | | | | |
| Pre-wired | - | Yes | | |
| Floor-mounted | - | Yes | | |
| Steel sheet thickness | mm | > 2 | | |

| Description | Unit | Specified Data | Data by Bidder/Contractor | Remarks |
| --- | --- | --- | --- | --- |
| Maximum width | mm | | | |
| Maximum depth | mm | | | |
| Front-door material | - | glass | | |
| Coloring | - | RAL 7035 | | |
| | | | | |
| **Bay Control Cubicles** | | | | |
| Pre-wired | - | Yes | | |
| Floor-mounted | - | Yes | | |
| Steel sheet thickness | mm | > 2 | | |
| Protection class | - | IP 52 | | |
| Maximum height | mm | | | |
| Maximum width | mm | | | |
| Maximum depth | mm | | | |
| Front-door material | - | | | |
| Coloring | - | RAL 7035 | | |
| | | | | |
| **Bay control units (IEDs)** | | | | |
| for high voltage application | - | | | |
| Number of bay control units | - | | | |
| Manufacturer | - | | | |
| Location of manufacturing site | - | | | |
| Type | - | | | |
| Power supply from station battery | V DC | 220 | | |
| Protocol | | IEC 61850 | | |
| | | | | |
| **W-meter** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| size | mm x mm | | | |
| accuracy class | | 0.2 | | |
| | | | | |
| **VAr-meter** | | | | |
| Manufacturer | - | | | |
| Type | - | | | |
| size | mm x mm | | | |
| accuracy class | | 0.2 | | |

# SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT A2 – SPARE PART LIST

# CONTENTS

# A2. SPARE PART LIST

Table A2-1 List “A”: 2-Year Maintenance Spares indicative list covering predominantly the power island

A2-1.A STEAM GENERATOR

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| | **MISC BOILER VALVES** | |
| 1 | Packing Sets - Sixteen Types of Valves - 1 each | 16 |
| | **SOOT BLOWERS** | |
| 2 | Housing Assembly Limit Switch | 6 |
| | **POPPET VALVE:** | |
| 3 | Poppet Valve Assembly | 6 |
| 4 | Air Relief Valve | 6 |
| 5 | Packing Ring Set | 6 |
| 6 | Lever Assembly | 3 |
| 7 | Valve Latch Assembly | 3 |
| | **LOWER HOUSING ASSEMBLY:** | |
| 8 | Packing Bushing | 12 |
| 9 | Packing Set | 12 |
| 10 | Cam Pin | 8 |
| 11 | Lock Plate | 8 |
| 12 | Side Roller Assembly | 8 |
| | **MISCELLANEOUS:** | |
| 13 | Companion Flange Gasket | 1 |
| | **TOOLS:** | |
| 14 | Poppet Valve Pressure Gage Kit | 1 |
| | **VS WALL BLOWER:** | |
| | **MAIN ASSEMBLY:** | |
| 15 | Gasket for Feed Tube | 10 |
| 16 | Poppet Cam | 4 |
| 17 | Feed Tube Packing | 16 |
| 18 | Flange, Packing Follower | 2 |
| 19 | Packing Follower | 2 |
| 20 | Feed Tube | 4 |
| 21 | Nozzle Assembly | 4 |
| 22 | Limit Switch | 4 |
| 23 | Limit switch Arm | 4 |
| | **POPPET VALVE:** | |
| 24 | Companion Flange Gasket | 4 |
| 25 | Poppet Valve Pressure Gage Kit | 1 |
| | **USB SOOT BLOWER:** | |
| | **HOUSING ASSEMBLY:** | |
| 26 | Feed Tube Gasket | 12 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 27 | Lance Tube Gasket | 12 |
| 28 | Limit Switch | 6 |
| | **POPPET VALVE:** | |
| 29 | Poppet Valve Assembly | 6 |
| 30 | Air Relief Valve | 6 |
| 31 | Packing Ring Set | 6 |
| 32 | Lever Assembly | 3 |
| 33 | Valve Latch Assembly | 3 |
| | **LOWER HOUSING ASSEMBLY:** | |
| 34 | Lower Housing Assembly : | 4 |
| 35 | Packing Bushing | 12 |
| 36 | Packing Set | 4 |
| 37 | Seal Pack Assembly | 8 |
| 38 | Cam Pin | 8 |
| 39 | Lock Plate | 8 |
| 40 | Side Roller Assembly | 4 |
| 41 | Auto Packing Tightener | 160 |
| 42 | Spring Washer | 4 |
| 43 | Chain Tightener Assembly | 4 |
| 44 | Chain Assembly | 4 |
| 45 | Companion Flange Gasket | 18 |
| 46 | Gear Rack Spray | 4 |
| 47 | Poppet Valve Pressure Gage Kit | 1 |
| | **ECONOMIZER VALVE** | |
| 48 | Inner Ring | 3 |
| 49 | Pressure Seal Gasket | 2 |
| 50 | Outer Ring | 1 |
| | **SAFETY VALVES** | |
| | **SH SAFETY VALVE ASSEMBLY:** | |
| 51 | Disc | 2 |
| 52 | Upper Adj Ring Pin | 2 |
| 53 | Lower Adj Ring Pin | 2 |
| | **RH Safety Valve Assembly:** | |
| 54 | Disc | 12 |
| 55 | Upper Adj Ring Pin | 12 |
| 56 | Lower Adj Ring Pin | 12 |
| | **ERV Safety Valve Assembly:** | |
| 57 | Disc | 4 |
| 58 | Upper Adj Ring Pin | 4 |
| 59 | Lower Adj Ring Pin | 4 |
| | **CIRCULATION MOTOR OPER. SHUT-OFF VALVE** | |
| 60 | Packing Kits - 14 Types | 27 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 61 | PS Gasket Assemblies- 8 Types | 8 |
| | **DAMPERS for MILL / PULVERIZER AIR** | |
| | **BUTTERFLY SHUT OFF VLV at FEEDER - MILL SAS,** | |
| 62 | Packing Nut | 2 |
| 63 | Packing | 4 |
| 64 | Bearing | 4 |
| | **BUTTERFLY SHUT OFF VLV at FAN - MILL SAS** | |
| 65 | Packing Gland | 2 |
| 66 | Bearing | 2 |
| 67 | Packing | 2 |
| | **BUTTERFLY S.O. VLV at MILL - SAS** | |
| 68 | Packing Nut | 2 |
| 69 | Packing | 4 |
| 70 | Bearing | 4 |
| | **PULVERIZER AIR FILTER BLEED OFF VLV** | |
| 71 | Packing Nut | 1 |
| 72 | Packing | 2 |
| 73 | Bearing | 2 |
| | **FD AXIAL FAN:** | |
| 74 | Tightening Tube | 8 |
| 75 | Teflon Ring, O-Rings | 67 |
| 76 | Bushings | 32 |
| 77 | Retaining Ring | 16 |
| 78 | Gasket Copper | 1 |
| 79 | Steel Bellows Hose | 3 |
| 80 | Gasket & Lock Washer Kit | 1 |
| | **ID RADIAL FAN:** | |
| 81 | Filter core for forced oil station | 2 |
| 82 | Filter core for lubrication oil station | 4 |
| | **PA AXIAL FAN:** | |
| 83 | Tightening Tube | |
| 84 | Teflon Ring, O-Rings | |
| 85 | Bushings | |
| 86 | Retaining Ring | |
| 87 | Gasket Copper | |
| 88 | Steel Bellows Hose | |
| 89 | Gasket & Lock Washer Kit | |
| | **PULVERIZER HOT AIR DAMPER** | |
| 90 | Packing Rings | 144 |
| 91 | Limit switch | 2 |
| | **PULVERIZER COLD AIR DAMPER** | |
| 92 | Packing Rings | 96 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 93 | Limit Switch | 2 |
| | **PULVERIZER AIR INLET SLIDE GATE** | |
| 94 | Seals | 2 |
| 95 | Backup Leaf Seal | 2 |
| 96 | Seal Retainer | 2 |
| 97 | Re-Entry Seals | 4 |
| 98 | Limit Switch | 4 |
| | **PULVERIZER LUBE OIL SYSTEM** | |
| 99 | Filter Cartridge | 8 |
| | **DAMPERS - CONTROL, GATE, SHUT-OFF** | |
| 100 | Sq Packing 7 Sizes | 7 |
| 101 | Complete Set Of Flexible Seat | 1 |
| | **AIR HEATER (2)** | |
| 102 | Filter For Air Motor | 1 |
| 103 | Limit Switch | 2 |
| 104 | Rotary Limit Switch | 1 |
| 105 | Hi Temp. Limit Switch | 4 |
| 106 | Limit Switch | 1 |
| 107 | Input Module | 1 |
| 108 | Output Card | 1 |
| 109 | Circuit Breaker 1 Pole | 1 |
| 110 | Circuit Breaker 2 Pole | 1 |
| 111 | Relay 3 Pole | 1 |
| 112 | 2 Amp Fuse | 2 |
| 113 | Phase Loss Monitor Relay | 1 |
| 114 | Aux. Contacts | 1 |
| | **COAL FEEDER** | |
| 115 | Belt | 1 |
| 116 | Speed Sensor | 1 |
| 117 | Link Assy-Chain Kit | 4 |
| 118 | Gasket | 1 |
| 119 | Retaining Ring | 1 |
| 120 | Blade-Rubber Scraper | 2 |
| 121 | Load Cell Assy | 2 |
| 122 | O-ring | 2 |
| 123 | Gasket | 8 |
| 124 | Card Assy-Feedrate/Feedback | 2 |
| 125 | Card Assy-Signal Converter | 1 |
| 126 | Board Assy-Power Supply | 1 |
| | **SHUT OFF GATE AT BURNER** | |
| 127 | Packing Kit | 2 |
| 128 | Limit Switch | 2 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 129 | Limit Switch | 2 |
| | **PULVERIZER MILL** | |
| 130 | Scraper Assembly 3 Types - 8 each | 24 |
| | **TT & SOFA WINDBOX WITH COAL NOZZLES, OIL GUNS** | |
| | **NOZZLE TIPS** | |
| 131 | Oil Nozzle Tips | 2 |
| 132 | CFS Air Nozzle Tip | 2 |
| 133 | CFS II Air Nozzle Tip | 4 |
| 134 | Straight Air Nozzle Tip | 4 |
| | **COAL COMPARTMENT** | |
| 135 | Coal Nozzle Tip | 4 |
| 136 | Cast Coal Nozzle | 4 |
| 137 | Nozzle Tip Pivot Bracket (W/Pin) | 8 |
| | **TILTS** | |
| 138 | Shear Pin | 20 |
| 139 | Quick Release Pin | 20 |
| 140 | Pin | 8 |
| 141 | Noz. Tip Conn. Bar | 2 |
| 142 | Noz. Tip Pivot Pin | 16 |
| 143 | Noz. Tip Pivot Pin Assy. | 16 |
| 144 | Deflector Plate Assy | 1 |
| 145 | Flame Scanner Guide Pipe | 1 |
| 146 | Hose | 48 |
| 147 | Hose Clamp Assy | 4 |
| 148 | Gasket Tape =100 ft | 1 |
| | **DAMPERS** | |
| 149 | Bearing Assembly | 8 |
| 150 | Spring Seal | 8 |
| 151 | Keyless Bushing | 8 |
| 152 | Gasket | 8 |
| | **FIRING EQUIPMENT** | |
| 153 | Igniter Guide Pipe | 1 |
| 154 | Retract Mechanism | 2 |
| 155 | Light Oil & Atomizing Valve Packing Kits 8 each | 16 |
| | **HEAT IGNITER & FLAME SCANNER** | |
| | **HEAT IGNITER** | |
| 156 | Proximity Switch (set) | 2 |
| 157 | Packing | 2 |
| 158 | HEI Exciter | 1 |
| 159 | Flexible Spark Rod | 3 |
| 160 | Igniter Tip | 5 |
| 161 | Air Cylinder | 2 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 162 | Solenoid Valve and Coil | 2 |
| | **FLAME SCANNER** | |
| | **Scanner Head** | 2 |
| 163 | Signal Analyzer | 1 |
| 164 | Power Supply | 1 |
| 165 | Spool Piece w/ Cable | 1 |
| 166 | Light Guide | 1 |
| 167 | Lens Barrel | 1 |
| 168 | Collimator and Lens Barrel | 2 |
| 169 | Socket Head Cap Screws | 6 |
| 170 | Pull Pins ( sets, 1 of each ) | 2 |
| 171 | 10' Pigtail | 2 |
| | **SH DESUPERHEAT SPRAY BLOCK VALVE** | |
| | **Valve** | |
| 172 | Packing | 1 |
| 173 | Body/Bonnet Gasket | 1 |
| 174 | Trim Gasket | 2 |
| 175 | Piston Ring | 2 |
| 176 | Stem Guide Bushing | 1 |
| 177 | Packing | 5 |
| 178 | Body/Bonnet Gasket | 5 |
| 179 | Trim Gasket | 10 |
| 180 | Piston Ring | 10 |
| 181 | Stem Guide Bushing | 5 |
| 182 | Diaphragm | 5 |
| 183 | Actuator Gasket | 5 |
| 184 | Actuator U Cup Seal | 5 |
| 185 | Actuator O-Ring | 10 |
| | **ISOLATION VALVE - SH & RH DESH SPRAY** | |
| 186 | SH Valve Packing Set | 4 |
| 187 | RH Valve Packing Set | 2 |
| 188 | SB Valve Packing Set | 3 |
| | **START UP CONTROL VALVES HWL 1 & 2** | |
| 189 | Packing Set For Type 1 Valve 2 Each | 2 |
| 190 | Pressure Seal Set For Type 1 Valve, 2 Each | 2 |
| 191 | Packing Set For Type 2 Valve 1 Each | 1 |
| 192 | Pressure Seal For Type 2, | 1 |
| 193 | Key, Parallel | 1 |
| 194 | Threaded Bushing | 1 |
| 195 | Oil Seal Ring | 1 |
| 196 | Ball Bearing | 1 |
| 197 | O-Ring | 1 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 198 | Annular Spring | 1 |
| 199 | Filter, Hydraulic Unit | 1 |
| | **WARM KEEPING CONTROL VALVE** | |
| 200 | Packing | 1 |
| 201 | Body/Bonnet Gasket | 1 |
| 202 | Trim Gasket | 1 |
| 203 | Stem Guide Bushing | 1 |
| 204 | Actuator Diaphragm | 1 |
| 205 | Actuator Gasket | 1 |
| 206 | Actuator U Cup Seal | 1 |
| 207 | Actuator O-Ring | 2 |
| | **ECONOMIZER , BACK PRESSURE CONTROL VALVE** | |
| | **Valve 1** | |
| 208 | Packing | 1 |
| 209 | Body/Bonnet Gasket | 1 |
| 210 | Trim Gasket | 2 |
| 211 | Piston Ring | 2 |
| 212 | Stem Guide Bushing | 1 |
| | **Valve 2** | |
| 213 | Packing | 1 |
| 214 | Body/Bonnet Gasket | 1 |
| 215 | Trim Gasket | 2 |
| 216 | Piston Ring | 2 |
| 217 | Stem Guide Bushing | 1 |
| | **FUEL OIL CONTROL VALVE** | |
| 218 | Packing | 1 |
| 219 | Body/Bonnet Gasket | 1 |
| 220 | Trim Gasket | 2 |
| 221 | Trim Gasket | 2 |
| 222 | Vary-Seal | 1 |
| 223 | Stem Guide Bushing | 1 |
| 224 | Diaphragm | 1 |
| 225 | Actuator Gasket | 1 |
| 226 | Actuator U Seal Cup | 1 |
| 227 | Actuator O-Ring | 2 |
| | **TILT DRIVE, TT WINDBOX** | |
| 228 | Limit Switch Assy, CW/CCW | 1 |
| 229 | Limit Switch Assy, S1/S2 | 1 |
| 230 | Fuse for DCM, 5 pk | 1 |
| 231 | Gasket Repl. Kit | 1 |
| 232 | Resistor | 1 |
| 233 | Capacitor | 1 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| | **OVERFIRE AIR TILT DRIVE CCW AND CW :** | |
| 234 | Gasket Kit | 1 |
| 235 | Resistor | 1 |
| 236 | Capacitor | 1 |
| | **CONTROL & BLOCK VALVE - PULVERIZER STEAM INERT** | |
| | **Valve 1 & 2** | |
| 237 | Packing | 2 |
| 238 | Body / Bonnet Gasket | 2 |
| 239 | Trim Gasket | 4 |
| 240 | Piston Ring | 4 |
| 241 | Stem Guide Bushing | 2 |
| | **Valve 3** | |
| 242 | Packing | 1 |
| 243 | Body / Bonnet Gasket | 1 |
| 244 | Trim Gasket | 2 |
| 245 | Piston Ring | 2 |
| 246 | Stem Guide Bushing | 1 |
| 247 | Diaphragm | 1 |
| 248 | Actuator Gasket | 1 |
| 249 | Seal for Actuator U Cup | 1 |
| 250 | O-Ring Actuator | 2 |
| | **SAFETY MONITORING CABINET** | |
| 251 | Circuit Breakers | 2 |
| 252 | Circuit Breakers | 2 |
| 253 | Relays | 2 |
| 254 | Relay Sockets | 15 |
| | **OXYGEN ANALYZER** | |
| 255 | Cell Assembly | 1 |
| | **SLIDE GATE for (4) ECON OUTLET HOPPERS** | |
| 256 | Packing Set | 4 |
| | **SLIDE GATE FOR AIRHEATER ASH HOPPER** | |
| 267 | Packing Set | 4 |
| | **VALVES - MILL FIRE PRTECTION** | |
| 268 | Repair Kit - Ball Valve | 1 |
| 269 | Repair Kit - Pneumatic Actuator | 2 |
| 270 | Solenoid Valve - Complete Assy | 1 |
| 271 | Regulator - Complete Assy | 2 |
| 272 | Repair Kit - 2nd Ball Valve | 1 |
| 273 | Repair Kit - Pneumatic Actuator | 1 |
| | **CONTROLS INSTRUMENTATION** | |
| 274 | Pressure Transmitter Kits | 6 |
| 275 | Flow Adequate Switch Gaskets | 8 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| | **ELEVATOR** | |
| 276 | Closer,Reel | 4 |
| 277 | Door Contact | 2 |
| 278 | Contact Bridge, | 2 |
| 279 | Hanger Roller, Assy, Amd, | 6 |
| 280 | Counter Roller, Upthrus, Amd | 2 |
| 281 | Pattern, Beam Door Electronic F.S. | 1 |
| 282 | Actuator, Magnetic, Schmersal, Ecosystem | 2 |
| 283 | Battery, Lead Acid | 2 |
| 284 | Lamp For Emerg Light | 10 |
| 285 | Led Lamp | 10 |
| 286 | Contactor Unit | 1 |
| 287 | Cartridge Fuse | 6 |
| 288 | Fuse, Dual Element | 6 |
| 289 | Fuse | 12 |
| 290 | Cartridge Fuse | 6 |
| 291 | Fuse | 6 |
| 292 | Light ,Indicating, Grn Lens | 10 |
| 293 | Lantern Assy, Arrow, W/Cable, Green | 1 |
| 294 | Lantern Assy, Arrow, W/Cable, Red | 1 |
| 295 | Lantern Assy,Arrow,Led,24V,Red,W/Cble | 2 |
| 296 | Lantern Assy,Arrow,Led,24V,Grn,W/Cble | 2 |
| 297 | Emergency Light Assy | 1 |
| 298 | Magnets, Plastoferrite Strip | 2 |
| 299 | Pc Brd, Arrival Lantern | 1 |
| 300 | Relay, Plug-In | 1 |
| 301 | Relay, Control | 1 |
| 302 | Sliding Guide Shoe | 4 |
| 303 | Micro Switch | 1 |
| 304 | Magnet Switch | 1 |
| | **INSTRUMENTATION - BALANCE OF PLANT** | |
| | **LEVEL GAUGE** | |
| 305 | Gasket Repair Kit - 2 Types | 2 |
| | **SAFETY VALVES for B.O.P.: CCSys, NBSys, FOSys** | |
| 306 | Gaskets | 3 |
| 307 | Disc | 1 |
| 308 | Repair Kit - 6 Sizes Ball Valve | 31 |
| | **CONTROL VALVE FOR BOP AUX STEAM** | |
| 309 | Gasket Set | 1 |
| 310 | Stem For Plug | 1 |
| 311 | Pin, Groove, Flat End | 1 |
| 312 | Ring, Back-Up | 1 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 313 | Seal Ring | 1 |
| 314 | O-Ring | 1 |
| 315 | O-Ring | 1 |
| 316 | Pin, Groove, Type F | 1 |
| 317 | Diaphragm For Actuator | 3 |
| 318 | Gauge, Pressure,1 Inch | 2 |
| 319 | Pot Bushing Assembly | 1 |
| 320 | Relay Assembly | 1 |
| 321 | O-Ring | 1 |
| 322 | Kit, Elastomer | 1 |
| 323 | Kit, Misc Small Hdwre | 1 |
| 324 | Repair Kits 2 Types | 2 |
| | **CONTROL VALVE FOR BOP CLOSE CYC COOLING WTR** | |
| 325 | Gasket Set | 1 |
| 326 | Seal Ring / Spr, Radial | 1 |
| 327 | Ring, Back-Up | 1 |
| 328 | Ring, Retaining, Ext | 1 |
| 329 | Seat Ring | 1 |
| 330 | Bushing, Seal | 1 |
| 331 | Diaphragm, Seal | 1 |
| 332 | Pin, Cotter | 1 |
| 333 | Gauge, Pressure, 2 Inch | 1 |
| 334 | Orifice, Bleed | 1 |
| 335 | Repair Kits 3 Types | 3 |
| | **FLASH TANK DRAIN TANK PUMPS** | |
| 336 | Oil Ring | 2 |
| 337 | Locknut Brg | 1 |
| 338 | Bearing, Ball | 1 |
| 339 | Impeller Key | 1 |
| 340 | Gasket | |
| 341 | Lockwasher, Brg | 1 |
| 342 | Seal-Type 1 | 1 |
| 343 | Seal-Type 2 | 1 |
| 344 | Key | |
| 345 | Bearing | 1 |
| | **PYRITES SYSTEM** | |
| 346 | Pressure Switch | 2 |
| 347 | Full Face Gasket | 8 |
| 348 | Orifice Plate | 8 |
| 349 | 4"-150# Full Face Gasket, 1/8" Thk, Rubber | 98 |
| 350 | Limit Switch | 2 |
| 351 | Limit Switch Arm | 2 |

| ITEM NO. | DESCRIPTION | QTY |
|---|---|---|
| 352 | Temperature Switch | 1 |
| 353 | Level Switch | 1 |
| 354 | Flight Bar | 80 |
| 355 | Conveyor Chain Strand 100mm, Type 1 | 22 |
| 356 | Conveyor Chain Strand 100mm, Type 2 | 2 |
| 357 | Flat Coupling | 24 |
| 358 | (Set) Tooth Segments Only | 2 |
| | **SUBMERGED IDLER WHEEL ASSEMBLIES** | |
| 359 | Submerged Idler Wheel Bearing (Cylindrical Roller Bearing) | 2 |
| 360 | Submerged Bearing Seal Plate Gasket | 4 |
| 361 | Submerged Bearing Inner Seal | 8 |
| | **TAKE-UP SECTION ASSEMBLIES** | |
| 362 | Take-Up Idler Wheel Bearing (Cylindrical Roller Bearing) | 2 |
| 363 | Bearing Seal Plate Gasket | 2 |
| 364 | Seal, Shaft | 2 |
| | **RETURN IDLER SHAFT ASSEMBLIES** | |
| 365 | Bearing Assembly, Exp | 2 |
| 366 | Bearing Assembly, Fixed | 2 |
| | **HYDRAULIC DRIVE COMPONENTS** | |
| 367 | Coupling Assembly | 1 |
| 368 | Pressure Filter Element | 4 |
| 369 | Return Line Filter Element | 24 |
| 370 | Level/Temp Switch | 1 |
| 371 | Spray Nozzles | 2 |
| 372 | Hydraulic Cylinder Rod Cartridge Kit | 2 |
| 373 | Hydraulic Cylinder Piston & Tube Kit | 2 |
| | **TUBING FOR PRESSURE PARTS** | |
| 374 | SA-210C 50 feet of each size | 7 |
| 375 | SA-213 T12 50 feet of each size | 10 |
| 376 | SA-213 T22 50 feet of each size | 5 |
| 377 | SA-213 T23 50 feet of each size | 1 |
| 378 | SA-213 T91 50 feet of each size | 8 |
| 379 | SA-213 T92 50 feet of each size | 3 |
| 380 | SA-213 TP304H 50 feet of each size | 6 |

A2-1.B STEAM TURBINE & GENERATOR

| No | Quantity | Unit | Description |
|---|---|---|---|
| | | | **Turbine** |
| | | | **FRONT BEARING PEDESTAL** |
| 1 | 12 | M | PROFILE BRASS |
| | | | **THRUST AND JOURNAL BEARING PEDESTAL** |
| 2 | 12 | M | PROFILE BRASS |
| | | | **INTERMEDIATE BEARING PEDESTAL** |
| 3 | 18 | M | SEALING PROFILE |
| | | | **BEARING PEDESTAL** |
| 4 | 18 | M | SEALING PROFILE |
| | | | **GENERATOR BEARING PEDESTAL** |
| 5 | 15 | M | SEALING PROFILE |
| 6 | 8 | Pcs | EARTHING COPPER STRIP |
| | | | **GENERATOR BEARING PEDESTAL** |
| 7 | 12 | M | SEALING PROFILE |
| | | | **EXITER BEARING PEDESTAL** |
| 8 | 12 | M | SEALING PROFILE |
| | | | **LP-TURBINE** |
| 9 | 2 | Pcs | RUPTURE DISC |
| | | | **Turbine Systems** |
| | | | **TWO-STAGE FILTER FOR LUBE OIL** |
| 10 | 12 | Pcs | FILTER ELEMENT |
| 11 | 2 | Set | GASKET SET |
| | | | **TWO-STAGE FILTER FOR HYDRAULIC OIL** |
| 12 | 4 | Pcs | FILTER ELEMENT |
| 13 | 2 | Set | GASKET SET |
| | | | **EMERGENCY OIL PUMP** |
| 14 | 1 | Pcs | GASKET |
| | | | **AUXILIARY OIL PUMP** |
| 15 | 1 | Pcs | GASKET |
| | | | **GLAND STEAM CONDENSER** |
| 16 | 1 | Pcs | SET OF SEALINGS |
| 17 | 4 | Pcs | LUBRICATION GREASE |
| 18 | 1 | Pcs | GREASE PRESS |
| 19 | 2 | Pcs | MAINTENANCE SET 24 MON. |
| | | | **GLAND STEAM ADMISSION VALVE** |
| 20 | 1 | Pcs | COVER GASKET |
| 21 | 1 | Pcs | PACKING SET |
| 22 | 1 | Pcs | GASKET |
| 23 | 1 | Set | ACTUATOR SEAL KIT |
| 24 | 1 | Pcs | COVER GASKET |

| No | Quantity | Unit | Description |
|---|---|---|---|
| 25 | 1 | Pcs | PACKING SET |
| 26 | 1 | Pcs | GASKET |
| 27 | 1 | Set | ACTUATOR SEAL KIT |
| 28 | 1 | Pcs | COVER GASKET |
| 29 | 1 | Pcs | PACKING SET |
| 30 | 1 | Pcs | BODY SEAL RING |
| 31 | 1 | Set | ACTUATOR SEAL KIT |
| | | | **WATER DRAIN VALVES** |
| 32 | 2 | Set | PACKING SET |
| 33 | 2 | Set | SET OF GASKETS |
| 34 | 2 | Set | PACKING SET |
| 35 | 2 | Set | SET OF GASKETS |
| 36 | 2 | Pcs | GASKET |
| 37 | 2 | Set | PACKING SET |
| 38 | 2 | Set | SET OF GASKETS |
| | | | **LP WATER INJECTION VALVE** |
| 39 | 1 | Pcs | GASKET |
| 40 | 1 | Set | PACKING |
| 41 | 1 | Set | SET OF GASKETS |
| | | | **Turbine Control** |
| | | | **TURBINE SUPERVISION/ PROTECTION/CONTROL MODULES** |
| 42 | 1 | Pcs | CPU FOR COMMUNICATION CONTROLLER |
| 43 | 1 | Pcs | INTERFACE CARD |
| 44 | 1 | Pcs | MODULE POWER SUPPLY |
| 45 | 1 | Pcs | CENTAL PROCESSING UNIT / USDE FOR OLC IO CONTROLLERS |
| 46 | 2 | Pcs | CENTAL PROCESSING UNIT / USED FOR ALL CONTROLLERS |
| 47 | 2 | Pcs | MODULE COMMUNICATION FIB BUS |
| 48 | 1 | Pcs | I/O MODULE 8ANA OUTPUT |
| 49 | 1 | Pcs | I/O MODULE 16ANA INPUT |
| 50 | 1 | Pcs | I/O MODULE 32LOG INPUT |
| 51 | 1 | Pcs | I/O MODULE 32LOG OUTPUT |
| 52 | 1 | Pcs | I/O MODULE 32 OUTPUT RELAY |
| 53 | 1 | Pcs | MODULE OVERSPEED DETECTION |
| 54 | 1 | Pcs | MODULE SPEED ACQUISITION |
| 55 | 1 | Pcs | MODULE COIL CURRENT SUPERVISION |
| 56 | 3 | Pcs | ANALOGIO INSULATION TERMINAL BOARD |
| 57 | 1 | Pcs | SLAVE MODBUS INTERFACE MODULE |
| 58 | 1 | Pcs | MASTER MODBUS INTERFACE MODULE |
| | | | **Generator** |
| | | | **STATOR** |
| 59 | 50 | M | SEALING PROFILE |

| No | Quantity | Unit | Description |
|---|---|---|---|
| | | | **BRUSH GEAR** |
| 60 | 1792 | Pcs | CARBON BRUSH |
| 61 | 72 | Pcs | PRE FILTER |
| 62 | 72 | Pcs | FINE FILTER |
| 63 | 16 | Pcs | BRUSH |
| **Generator Systems** | | | |
| | | | **Seal oil system** |
| 64 | 1 | Set | Spare for Seal oil system |
| | | | **Gas cooling system** |
| 65 | 1 | Set | Spare for Gas cooling system |
| | | | **Consumables** |
| 66 | 8 | Pcs | Filter inlet for gel drying fan |
| | | | **Liquid cooling system for stator winding** |
| 67 | 1 | Set | Liquid cooling system for stator winding |
| | | | **Consumables** |
| 68 | 100 | Ltr | Ion exchanger filling (shelf life 12 month) |

A2-1.C MECHANICAL POWER BLOCK

| No | ITEM | QTY operating spares |
|---|---|---|
| | | |
| **ES B01 - WATER COOLED CONDENSERS** | | |
| | **FOR CONDENSERS** | |
| 1 | WATER BOX GASKET | 1 |
| 2 | MANHOLE GASKET (WATER SIDE) | 4 |
| 3 | MANHOLE GASKET (STEAM SIDE) | 2 |
| 4 | MANHOLE GASKET (BY-PASS TANK SIDE) | 1 |
| 5 | MISCELLANEOUS GASKET OF EACH TYPE | 1 |
| 6 | TUBE PLUGS | 100 |
| | | |
| **ES B15 - VACUUM PUMPS OF CONDENSER** | | |
| | **MAIN PUMPS** | |
| 1 | SET OF PACKINGS AND GASKETS OF ONE PUMP | 1 |
| 2 | SHAFT SLEEVE | 1 |
| 3 | BEARINGS OF ONE MOTO - PUMP | 1 |
| 4 | COUPLING WEAR PARTS | 1 |
| **ES B16 - WATER BOX PRIMING EQUIPMENT** | | |

| No | ITEM | QTY operating spares |
|---|---|---|
| 1 | SET OF MECHANICAL SEAL WEAR PARTS AND GASKETS OF ONE PUMP | 1 |
| 2 | SET OF BEARINGS OF ONE PUMP AND MOTOR | 1 |
| 3 | WEAR RING, | 1 |
| | | |
| **ES B20 - CONDENSATE PUMPS** | | |
| 1 | SET OF GASKETS AND PACKINGS ( IF ANY ) OF ONE PUMP | 1 |
| 2 | BALL BEARING | 1 |
| 3 | THRUST ROLLER BEARING | 1 |
| 4 | SET OF JOURNAL BEARING OF ONE PUMP | 1 |
| 5 | SET OF MECHANICAL SEALS OF ONE PUMP | 1 |
| 6 | SET OF SLEEVES OF ONE PUMP ( UNDER MECHANICAL SEAL IF ANY AND JOURNAL BEARINGS ) | 1 |
| | | |
| **ES B25 - FEED HEATING PLANTS** | | |
| | **LP HEATERS** | |
| 1 | INTERNAL MANHOLE GASKET FOR EACH TYPE OF LP HEATERS | 1 |
| 2 | MANHOLE GASKET FOR EACH TYPE OF LP HEATER | 1 |
| 3 | GASKETS OF EACH TYPE ( MANHOLE GASKET EXCEPTED ) | 1 |
| 4 | TUBE PLUG | 40 |
| | **FEED- WATER TANK** | |
| 5 | MANHOLE GASKET | 1 |
| 6 | GASKETS OF EACH TYPE ( MANHOLE GASKET EXCEPTED ) | 1 |
| | **HP HEATERS** | |
| 7 | INTERNAL MANHOLE GASKET FOR EACH TYPE OF HP HEATER | 1 |
| 8 | MANHOLE GASKET FOR EACH TYPE OF HP HEATER | 1 |
| 9 | GASKETS OF EACH TYPE ( MANHOLE GASKET EXCEPTED ) | 1 |
| 10 | TUBE PLUG | 30 |
| | | |
| **ES B30 - MOTOR DRIVEN FEED WATER PUMP** | | |
| | **BOOSTER PUMP** | |
| 1 | SET OF GASKETS OF ONE BOOSTER PUMP | 2 |
| 2 | SET OF WEAR PARTS OF MECHANICAL SEALS OF ONE PUMP | 2 |
| 3 | SET OF BALL BEARINGS OF ONE PUMP | 1 |
| 4 | FLEXIBLE FOR COUPLING BETWEEN MOTOR & BOOSTER PUMP | 1 |
| | **MAIN PUMP** | |
| 5 | SET OF GASKETS OF ONE PUMP | 2 |

| No | ITEM | QTY operating spares |
|---|---|---|
| 6 | SET OF WEAR PARTS OF MECHANICAL SEALS OF ONE PUMP | 2 |
| 7 | FILTER CARTRIDGE OF MECHANICAL SEAL | 2 |
| 8 | SET OF JOURNAL BEARINGS OF ONE PUMPS | 1 |
| 9 | SET OF THRUST BEARING WEAR PARTS OF ONE PUMP ( IF ANY ) | 1 |
| 10 | BALANCE DRUM | 1 |
| 11 | BALANCE DRUM LINER | 1 |
| 12 | FLEXIBLE FOR COUPLING BETWEEN PUMP / H.S.C . | 1 |
| | **HYDRAULIC SPEED COUPLING** | |
| 13 | SET OF 2 OIL FILTER CARTRIDGES | 2 |
| 14 | SET OF FUSE PLUGS OF ONE COUPLING | 2 |
| 15 | FLEXIBLE FOR COUPLING BETWEEN MOTOR / H.S.C . | 1 |
| | **FILTER** | |
| 16 | GASKETS OF ONE FILTER | 2 |
| | **MINIMUM FLOW VALVE** | |
| 17 | SET OF GASKETS AND PACKINGS OF ONE VALVE | 2 |
| | **OUTLET CHECK - VALVE** | |
| 18 | SET OF GASKETS OF ONE CHECK - VALVE | 2 |
| | | |
| **ES B30 - TURBINE DRIVEN FEED WATER PUMPS** | | |
| | **BOOSTER PUMPS** | |
| 19 | SET OF GASKETS OF ONE BOOSTER PUMP | 1 |
| 20 | SET OF WEAR PARTS OF MECHANICAL SEALS OF ONE PUMP | 1 |
| 21 | SET OF BEARINGS OF ONE PUMP | 1 |
| 22 | FLEXIBLE FOR COUPLING BETWEEN GEAR BOX & BOOSTER PUMP | 1 |
| | **MAIN PUMPS** | |
| 23 | SET OF GASKETS OF ONE PUMP | 2 |
| 24 | SET OF WEAR PARTS OF MECHANICAL SEALS OF ONE PUMP | 2 |
| 25 | FILTER CARTRIDGE OF MECHANICAL SEAL | 2 |
| 26 | SET OF JOURNAL BEARINGS OF ONE PUMPS | 1 |
| 27 | SET OF THRUST BEARING WEAR PARTS OF ONE PUMP (IF ANY) | 1 |
| | **BOOSTER GEAR BOXES** | |
| 31 | SET OF OIL SEALS § DEFLECTORS OF ONE GEAR BOX | 1 |
| 32 | SIGHT GLASS | 1 |
| 33 | FLEXIBLE FOR COUPLING BETWEEN GEAR BOX / TURBINE | 1 |
| | **FILTERS** | |
| 34 | GASKETS OF ONE FILTER | 1 |
| | **MINIMUM FLOW VALVE** | |
| 35 | SET OF GASKETS AND PACKINGS OF ONE VALVE | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | | |
| **ES B35 - M. V. MOTORS** | | |
| | **FEED WATER PUMPS MOTOR** | |
| 1 | THERMO-COUPLE | 1 |
| 2 | HEATING RESISTANCE | 1 |
| 3 | OIL SIGHT GAUGE (IF ANY) | 1 |
| 4 | SET OF OUTSIDE LABYRINTHS | 1 |
| 5 | SET OF BEARINGS OF ONE MOTOR | 1 |
| 6 | PROBE FOR WATER LEAKS DETECTION ( IF ANY ) | 1 |
| 7 | SET OF GASKETS | 1 |
| | | |
| | **CONDENSATE PUMPS MOTORS** | |
| 8 | THERMO-COUPLE | 1 |
| 9 | HEATING RESISTANCE | 1 |
| 10 | SET OF OUTSIDE LABYRINTHS | 1 |
| 11 | SET OF BEARINGS OF ONE MOTOR | 1 |
| 12 | SET OF GASKETS | 1 |
| | | |
| | **CLOSED COOLING WATER CIRCUIT PUMPS MOTORS** | |
| 13 | THERMO-COUPLE | 1 |
| 14 | HEATING RESISTANCE | 1 |
| 15 | SET OF OUTSIDE LABYRINTHS | 1 |
| 16 | SET OF BEARINGS OF ONE MOTOR | 1 |
| 17 | SET OF GASKETS | 1 |
| | | |
| **ES B41 - HEATER DRAINS RECOVERY MOTO-PUMPS** | | |
| 1 | SET OF GASKETS OF ONE PUMP | 1 |
| 2 | MECHANICAL SEAL | 1 |
| 3 | SLEEVE OF MECHANICAL SEAL | 1 |
| 4 | SET OF BEARINGS OF ONE PUMP + MOTOR | 1 |
| 5 | SET OF 2 SLEEVES UNDER BALL BEARING ( IF ANY ) | 1 |
| 6 | COUPLING FLEXIBLE | 1 |
| | | |
| **ES B50 - CHEMICAL INJECTIONS** | | |
| | **FOR TANKS** | |
| 1 | GLASS FOR LEVEL INDICATOR | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | **FOR STIRRERS** | |
| 2 | BEARING AND GASKETS OF ONE STRIRRER FOR EACH TYPE | |
| | **FOR EACH TYPE OF PUMPS** | |
| 3 | SET OF GASKETS OF ONE PUMP | 1 |
| 4 | LIP SEAL OF EACH TYPE | 1 |
| 5 | SET OF PACKINGS OF ONE PUMP | 1 |
| 6 | DIAPHRAGM OF EACH TYPE | 1 |
| 7 | SET OF BEARINGS OF EACH TYPE | 1 |
| 8 | SEAL FOR CHECK-VALVE | 1 |
| 9 | SUCTION / DISCHARGE CHECK VALVE BALL | 2 |
| 10 | SUCTION / DISCHARGE CHECK VALVE | 1 |
| | **FOR EACH TYPE OF MOTORS** | |
| 11 | SET OF BEARINGS | |
| | **FOR ELECTRICAL CUBICLE** | |
| 12 | SET OF 5 FUSES OF EACH TYPE | 1 |
| 13 | SET OF 3 LAMPS OF EACH TYPE | 1 |
| | | |
| **ES B55 -STEAM AND WATER SAMPLING PLANT** | | |
| | **PH METERS** | |
| 1 | MEASUREMENT ELECTRODE | 2 |
| 2 | REFERENCE ELECTRODE | 2 |
| 3 | MEASUREMENT CABLE | 1 |
| 4 | REFERENCE CABLE | 1 |
| 5 | SET OF ELECTRODES GASKETS | 2 |
| 6 | MEASUREMENT BOWL GASKETS | 2 |
| 7 | TEMPERATURE COMPENSATOR | 1 |
| 8 | PYREX BOWL | 1 |
| 9 | RELAY | 1 |
| 10 | KIT OF 10 FUSES | 1 |
| | **CONDUCTIVIMETERS** | |
| 11 | SET OF GASKETS FOR PROBE | 4 |
| 12 | NTC 10 KOHM | 4 |
| 13 | RELAY | 1 |
| 14 | KIT OF 10 FUSES | 2 |
| 15 | CONDUCTIVITY PROBE | 1 |
| | **OXYGENMETER** | |
| 16 | SET OF 10 FUSES | 1 |
| 17 | SET OF GASKETS | 1 |
| 18 | CELL | 1 |
| 19 | AMPLIFIER | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | **FOR SAMPLING EQUIPMENT** | |
| 20 | OVERFLOW POT | 1 |
| 21 | THERMOMETER | 1 |
| 22 | KIT FOR PRESSURE REDUCING VALVE | 2 |
| 23 | CATIONIC COLUMN WITH RESIN LOAD | 1 |
| 24 | 48 L CATIONIC RESINS | 1 |
| 25 | COMPLETE THERMOSTAT | 1 |
| 26 | COIL FOR HP SOLENOID VALVE | 1 |
| 27 | COIL FOR HP SOLENOID VALVE | 1 |
| 28 | HP SOLENOID VALVE | 1 |
| 29 | LP SOLENOID VALVE | 1 |
| 30 | PACKINGS FOR LP VALVE | 2 |
| 31 | PACKINGS FOR HP VALVE | 2 |
| 32 | BULB FOR THERMOSTATIC VALVE | 1 |
| 33 | KIT OF EACH TYPE FOR THERMOSTATIC VALVE | 1 |
| 34 | FILTER CARTRIDGE | 2 |
| 35 | GASKETS SET FOR FILTER | 3 |
| 36 | RELAY | 1 |
| 37 | BULB | 10 |
| | | |
| **ES B60 - POLISHING PLANT** | | |
| 1 | GASKET (FOR MIXED BED MANHOLE) | 10 |
| 2 | GASKET (FOR REGENERATION TANK MANHOLE) | 10 |
| 3 | SEAT (FOR BUTTERFLY VALVES) | 1 |
| 4 | NOZZLES FOR MIXBED | 40 |
| 5 | SEAL FOR RECIRCULATION PUMP | 1 |
| 6 | SEAL FOR DEMINERALIZED WATER PUMP | 1 |
| 7 | DIGITAL INPUT MODULE | 1 |
| 8 | DIGITAL OUTPUT MODULE | 1 |
| 9 | ANALOGUE INPUT MODULE | 1 |
| 10 | ANALOGUE OUTPUT MODULE | 1 |
| 11 | MICRON CARTRIDGES | 5 |
| | | |
| **ES C04 - CONTINUOUS CLEANING SYSTEMS** | | |
| | **FOR PUMPS** | |
| 1 | SET OF PACKINGS AND GASKETS OF ONE PUMP | 1 |
| 2 | SET OF BEARINGS OF ONE PUMP AND MOTOR | 1 |
| 3 | SHAFT SLEEVE ( IF ANY ) | 1 |
| 4 | WEAR RING | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | **FOR OTHERS DEVICES** | |
| 5 | SET OF 1000 BALLS | 15 |
| 6 | GASKETS AND GLASS FOR BALL COLLECTOR | 1 |
| 7 | SEALINGS FOR SCREENS | 2 |
| 8 | GASKETS OF ONE ACTUATOR | 2 |
| 9 | GASKETS AND PACKINGS OF THE PUMP OUTLET VALVE | 1 |
| | **FOR C & I** | |
| 10 | FUSE | 10 |
| 11 | BULB | 10 |
| 12 | CYCLE PROGRAMER | 1 |
| 13 | WEEKLY CLOCK | 1 |
| 14 | CONTACTOR | 1 |
| | | |
| **ES C05 - DEBRIS FILTERS** | | |
| | **FOR FILTERING ELEMENT** | |
| 1 | SET OF GASKETS OF ONE ROTOR | 1 |
| 2 | ROTOR BEARING | 1 |
| | **FOR SLEEVE** | |
| 3 | INTERNAL LINING REPAIR KIT ( IF CONVENIENT ) | 1 |
| | **FOR DEBRIS DISCHARGE VALVE** | |
| 4 | SET OF GASKETS | 1 |
| | **FOR CONTROL PANEL** | |
| 5 | SET OF 10 FUSES | 1 |
| 6 | SET OF 10 BULBS | 1 |
| 7 | PUSH BUTTON | 1 |
| 8 | CONTACTOR | 1 |
| | | |
| **ES C20 - CLOSE COOLING WATER PLATE WATER COOLERS** | | |
| 1 | INLET / OUTLET END PLATE GASKET | 2 |
| 2 | BOTTOM PLATE GASKET | 2 |
| 3 | STANDARD GASKET | 6 |
| | | |
| **ES E05 - FIXED FIRE EXTINGUISHING SYSTEM** | | |
| | **FOR WATER** | |
| 1 | GASKETS FOR EACH TYPE OF DELUGE VALVES | 1 |
| 2 | SOLENOID MONITORING UNIT FOR DELUGE VALVE | 1 |
| 3 | SPRINKLER QUARTZOID BULB | 10 |
| 4 | PRESSURE INDICATOR | 1 |
| 5 | PRESSURE SWITCH | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | **FOR FOAM** | |
| 6 | SPARES KIT OF ONE AUTOMATIC VALVE (COIL, DIAPHRAGM,PACKINGS ) | 1 |
| 7 | SPARES KIT FOR PROPORTIONER ( BALL, DIAPHRAGM,CONTROL PLUG, | 1 |
| 8 | SPARES KIT FOR FOAM GENERATOR (GLASS OBTURATOR ) | 1 |
| 9 | LITER OF FLUOROPROTEINIC EMULSER | 300 |
| | | |
| **ES E10 - FIRE FIGHTING DETECTION** | | |
| 1 | IONIC DETECTOR | 4 |
| 2 | THERMOVELOCIMETRIC DETECTOR | 2 |
| 3 | ALARM PUSH BUTTON | 1 |
| 4 | GLASS FOR ALARM PUSH BUTTON | 2 |
| 5 | AUDIBLE SIGNAL | 1 |
| 6 | VISUAL SIGNAL | 1 |
| 7 | DETECTION ZONE CARD | 1 |
| 8 | EXTINCTION ZONE CARD | 1 |
| 9 | CHARGER CARD | 1 |
| 10 | SURVEILLANCE CARD | 1 |
| 11 | SET OF 10 DIODS | 1 |
| | | |
| **ES G01 - MAIN TURBINE HALL CRANE** | | |
| | **1 - FOR CRANE:** | |
| 1 | COIL FOR EACH TYPE OF BRAKES | 1 |
| 2 | SET OF BRAKE SPRINGS OF EACH TYPE | 1 |
| 3 | LINING FOR EACH TYPE OF BRAKES | 1 |
| 4 | SET OF BRUSHES OF EACH TYPE FOR MOTORS | 1 |
| 5 | SET OF GASKETS FOR EACH TYPE OF REDUCERS | 1 |
| 6 | SET OF 2 BEARINGS FOR LONG TRAVEL | 1 |
| 7 | SET OF 2 BEARINGS FOR LATERAL TRAVEL | 1 |
| 8 | SET OF 2 BEARINGS FOR GEAR BOXES | 1 |
| 9 | SET OF 2 BEARINGS FOR PULLEY BLOCKS | 1 |
| | **2 - C & I** | |
| 10 | SET OF FUSES | 1 |
| 11 | LIMIT SWITCH OF EACH TYPE | 1 |
| 12 | SET OF EACH TYPE OF COILS FOR CONTACTORS | 1 |
| 13 | OVERLOAD RELAY FOR EACH TYPE OF MOTORS | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | | |
| **ES G05 - AUXILIARY CRANES ( based on 2 types )** | | |
| | **1 - FOR EACH TYPE OF CRANES :** | |
| 1 | COIL FOR EACH TYPE OF BRAKES | 1 |
| 2 | SET OF BRAKE SPRINGS OF EACH TYPE | 1 |
| 3 | LINING FOR EACH TYPE OF BRAKES | 1 |
| 4 | SET OF BRUSHES | 1 |
| 5 | SET OF GASKETS FOR EACH TYPE OF REDUCERS | 1 |
| 6 | SET OF 2 BEARINGS FOR LONG TRAVEL | 1 |
| 7 | SET OF 2 BEARINGS FOR LATERAL TRAVEL | 1 |
| 8 | SET OF 2 BEARINGS FOR GEAR BOXES | 1 |
| 9 | SET OF 2 BEARINGS FOR PULLEY BLOCKS | 1 |
| | **2 - C & I** | |
| 10 | SET OF FUSES | 1 |
| 11 | LIMIT SWITCH OF EACH TYPE | 1 |
| 12 | SET OF EACH TYPE OF COILS FOR CONTACTORS | 1 |
| 13 | OVERLOAD RELAY FOR EACH TYPE OF MOTORS | 1 |
| | | |
| **ES H20 - GAS STORAGE PLANT** | | |
| 1 | SUPPLE CONNECTION | 1 |
| | | |
| **ES J15 - MISCELLANEOUS CENTRIFUGAL PUMPS** | | |
| | **FOR EACH TYPE OF PUMPS :** | |
| 1 | SET OF PACKINGS ( or mech. seal wear parts ) OF ONE PUMP | 1 |
| 2 | SET OF GASKETS OF ONE PUMP | 1 |
| 3 | FLEXIBLE FOR COUPLING | 1 |
| | | |
| **ES J35 - MISCELLANEOUS SUMP OR SUBMERSIBLE PUMPS** | | |
| | **FOR EACH TYPE OF PUMPS :** | |
| 1 | MECHANICAL SEAL | 1 |
| 2 | SET OF GASKETS OF ONE PUMP | 1 |
| 3 | WEAR RING | 1 |
| | | |
| **ES J55 - MOTORS LV** | | |
| | **FOR EACH TYPE OF MOTORS (EXCEPTED IF ALREADY QUOTED IN OTHER PARAGRAPHS )** | |
| 1 | SET OF BEARINGS | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | | |
| **ES M01 - ASSISTED CHECK VALVES** | | |
| | **FOR EACH TYPE OF CHECK VALVES:** | |
| 1 | GASKETS OF ONE JACK | 1 |
| 2 | LATERAL GASKET | 1 |
| 3 | COVER GASKET | 1 |
| 4 | STUFFING BOX PACKING | 1 |
| 5 | NUT-PIN | 1 |
| 6 | STUD-BOLT AND NUT | 1 |
| 7 | BEARING | 2 |
| 8 | THRUST | 1 |
| 9 | WASHER | 1 |
| | **FOR CHECK - VALVES** | |
| 10 | LIMIT SWITCH | 1 |
| | | |
| **ES M05 - LP BY-PASS VALVES** | | |
| 1 | SEALS AND PACKINGS SET OF ONE MAIN VALVE | 1 |
| 2 | SET OF MISCELLANEOUS PARTS OF ONE MAIN VALVE (bolts, washers, spacer ) | 1 |
| 3 | PACKING AND SEALS OF ONE ACTUATOR | 1 |
| 4 | PACKING AND SEALS OF ONE SERVOVALVE | 1 |
| 5 | FILTER INSERT FOR SERVOVALVE | 1 |
| 6 | PACKING AND SEALS OF ONE BLOCKING ELEMENT | 1 |
| 7 | SET OF GASKETS § O - RINGS OF ONE SAFETY DEVICE | 1 |
| 8 | FILTER ELEMENTS FOR OIL SUPPLY UNIT | 1 |
| 9 | SET OF SEALS FOR OIL SUPPLY UNIT | 1 |
| 10 | FLEXIBLE CONNECTION FOR OIL SUPPLY UNIT | 1 |
| 11 | SET OF 5 ELECTRONIC CARDS | 1 |
| | | |
| **ES M10 - CONTROL VALVES** | | |
| | **FOR EACH TYPE OF VALVE :** | |
| 1 | GASKETS OF BODY, SEAT AND O - RINGS OF ONE VALVE | 1 |
| 2 | STUFFING BOX PACKING | 1 |
| 3 | MEMBRANE OF ONE PNEUMATIC ACTUATUOR | 1 |
| 4 | PRESSUE REDUCING FILTER | 1 |
| | | |
| **ES M15 - BUTTERFLY VALVES > or = 800mm** | | |
| | **FOR EACH TYPE OF VALVES** | |

| No | ITEM | QTY operating spares |
|---|---|---|
| 1 | GASKETS | 1 |
| 2 | LIMIT SWITCH | 1 |
| 3 | FLITER CARTRIDGE | 1 |
| 4 | CONNECTION HOSE | 1 |
| | | |
| **ES M24 - HP HEATERS BY-PASS VALVES** | | |
| | **FOR INLET AND OUTLET VALVES** | |
| 1 | STEM PACKINGS | 1 |
| 2 | SET OF GASKETS | 1 |
| 3 | UPPER RING OF PACKINGS | 1 |
| 4 | BOTTOM RING OF PACKINGS | 1 |
| 5 | PACKING OF PRESSURE SEAL | 1 |
| 6 | RING IN TWO PARTS | 1 |
| 7 | CYLINDER SEGMENT | 1 |
| 8 | PISTON RING | 1 |
| 9 | LIMIT SWITCH | 1 |
| | **FOR DRIVE VALVE** | |
| 10 | SET OF GASKETS AND PACKINGS | 1 |
| 11 | INTERNALS | 1 |
| 12 | SOLENOID | 1 |
| | **FOR PRESSURE RELEASE VALVE** | |
| 13 | SET OF GASKETS AND PACKINGS | 1 |
| 14 | INTERNALS | 1 |
| 15 | SOLENOID | 1 |
| | **FOR EACH TYPE OF OTHER VALVES** | |
| 16 | SET OF GASKETS AND PACKINGS | 1 |
| | | |
| **ES M25 - LARGE BORE HP OR ALLOYED STEEL VALVES > 50** | | |
| | **FOR EACH TYPE OF VALVES** | |
| 1 | GASKET AND PACKING OF ONE VALVE | 1 |
| | **FOR EACH TYPE OF ACTUATORS** | |
| 2 | SET OF GASKETS OF ONE ACTUATOR | 1 |
| | **FOR ACTUATORS** | |
| 3 | LIMIT SWITCH | 1 |
| | | |
| **ES M26 - LARGE BORE VALVES > 50** | | |
| | ( Slide valves, globe - valves, check - valves ) | |
| | **FOR EACH TYPE OF VALVES** | |
| 1 | GASKET AND PACKINGS OF ONE VALVE | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | **FOR EACH TYPE OF ACTUATORS** | |
| 2 | SET OF GASKETS OF ONE ACTUATOR | 1 |
| | **FOR ACTUATORS** | |
| 3 | LIMIT SWITCH | 2 |
| | | |
| **ES M35 - SAFETY VALVES** | | |
| | **FOR EACH TYPE OF VALVES** | |
| 1 | GASKETS OF ONE VALVE | 1 |
| | **SAFETY PARTS** | |
| | **FOR EACH TYPE OF VALVES** | |
| 2 | NOZZLE, STEM, OBTURATOR, SPRING § WASHER - SPRING OF ONE VALVE | 1 |
| | | |
| **ES M40 - BALL VALVES** | | |
| | **FOR EACH TYPE OF VALVES** | |
| 1 | GASKETS § PACKINGS OF ONE VALVE | 1 |
| | | |
| **ES M45 - BUTTERFLY VALVES < 800** | | |
| | **FOR EACH TYPE OF VALVES** | |
| 1 | SYNTHETIC CASING SLEEVE OR GASKETS OF ONE VALVE | 1 |
| | **FOR EACH TYPE OF ACTUATORS** | |
| 2 | SET OF GASKETS OF ONE ACTUATOR | 1 |
| | **FOR ACTUATORS** | |
| 3 | LIMIT SWITCH | 1 |
| | | |
| **ES M50 - DUAL CHECK - VALVES** | | |
| | **FOR EACH TYPE OF VALVES :** | |
| 1 | GASKETS OF ONE VALVE | 1 |
| | | |
| **ES M65 - HP VALVES < or = 50mm** | | |
| | **FOR EACH TYPE OF VALVES :** | |
| 1 | GASKET AND PACKING OF EACH TYPE | 1 |
| | **FOR EACH TYPE OF ACTUATORS** | |
| 2 | SET OF GASKETS OF ONE ACTUATOR | 1 |
| | **FOR ACTUATORS** | |
| 3 | LIMIT SWITCH | 1 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | | |
| **ES M66 - VALVES < or = 50mm** | | |
| | **FOR EACH TYPE OF VALVES :** | |
| 1 | GASKET AND PACKING | 1 |
| | | |
| **ES N01 - ELECTRONIC CONTROL § MEASUREMENT LOOPS** | | |
| 1 | SET OF 40 MODULES | 1 |
| 2 | KIT OF 1 SET POINT ADJUSTING HEAD § 1 DRIVE HEAD | 1 |
| | | |
| | **N10 - TRANSMITTERS** | |
| | **TRANSMITTERS OF RELATIVE PRESSURE** | |
| 1 | ELECTRONIC PRINTED CIRCUIT CARD | 3 |
| | **TRANSMITTERS OF ABSOLUTE PRESSURE** | |
| 2 | ELECTRONIC PRINTED CIRCUIT CARD | 1 |
| | **TRANSMITTERS OF DIFFERENTIAL PRESSURE** | |
| 3 | ELECTRONIC PRINTED CIRCUIT CARD | 2 |
| | **LEVEL TRANSMITTERS ( TORSION TUBE )** | |
| 4 | SET OF GASKETS | 2 |
| 5 | AMPLIFIER | 2 |
| | | |
| | **N15 -PRESSURE AND TEMPERATURE GAUGES** | |
| | **FOR PRESSURE AND TEMPERATURE GAUGES** | |
| 1 | GLASS DIAM. 100 WITH GASKETS | 2 |
| 2 | GLASS DIAM. 150 WITH GASKETS | 3 |
| 3 | CAN OF 5 LITERS OF DAMPER LIQUID | 1 |
| | | |
| | **N25 - PRESSURE AND TEMPERATURE SWITCHES** | |
| | **PRESSURE SWITCHES** | |
| 1 | SWITCH | 2 |
| 2 | SENSITIVE ELEMENT | 2 |
| | **DIFFERENTIAL PRESSURE SWITCHES** | |
| 3 | SWITCH | 1 |
| 4 | SENSITIVE ELEMENT | 1 |
| | **TEMPERATURE SWITCHES** | |
| 5 | SWITCH | 2 |
| 6 | SENSITIVE ELEMENT | 2 |

| No | ITEM | QTY operating spares |
|---|---|---|
| | | |
| | **N30 - RESISTANCE PROBES AND THERMOCOUPLES** | |
| | **RESISTANCE PROBES ( 2 types )** | |
| 1 | RESISTANCE PROBE FOR THERMOWELL 250 mm | 1 |
| 2 | RESISTANCE PROBE FOR THERMOWELL 200 mm | 1 |
| | **THERMOCOUPLES ( 2 types )** | |
| 3 | THERMOCOUPLE | 1 |
| 4 | THERMOCOUPLE | 2 |
| | | |
| | **N40 - FLOW GAUGES WITH SWITCHES** | |
| 1 | SWITCH | 1 |
| | | |
| | **N45 - VISUAL LEVEL GAUGES** | |
| 1 | FLOAT in Titanium | 1 |
| 2 | FLOAT in stainless steel | 1 |
| 3 | SET OF 6 GLASS TUBES + INDEX + GASKETS | 1 |
| | | |
| **ES S10 AND S20 -AIR CONDITIONING AND VENTILATION** | | |
| 1 | SET OF WEAR PARTS | 1 |
| | | |

A2-1.D ELECTRICAL POWER BLOCK

| | Name of Spare Parts | Unit | Quantity |
|---|---|---|---|
| **Isolated Phase busduct** | | | |
| 1 | Supporting insulators | piece | 20 |
| 2 | Gasket for inspection window | piece | 20 |
| 3 | Seal-off bushing for main bus | piece | 3 |
| 4 | Ethylene Propylene Bellows for main bus | piece | 3 |
| 5 | Ethylene Propylene Bellows for Tap bus | piece | 6 |
| 6 | Copper braids | piece | 10 |
| **MV switchgear** | | | |
| 1 | Display | set | 4 |
| 2 | Space Heater | piece | 4 |
| 3 | Air switch | piece | 4 |
| 4 | Selective switch | piece | 4 |
| 5 | PT fuse | piece | 3 |
| **LV switchgear** | | | |
| 1 | ACB - 800 A | piece | 2 |
| 2 | ACB - 1000 A | piece | 1 |
| 3 | ACB - 1600 A | piece | 1 |
| 4 | ACB - 2500 A | piece | 2 |
| 5 | MCCB - 6 A | | 22 |
| 6 | MCCB - 16 A | | 9 |
| 7 | MCCB - 25 A | | 4 |
| 8 | MCCB - 32 A | piece | 4 |
| 9 | MCCB - 50 A | piece | 1 |
| 10 | MCCB - 80 A | piece | 39 |
| 11 | MCCB - 100 A | | 3 |
| 12 | MCCB - 125 A | | 4 |
| 13 | MCCB - 160 A | piece | 32 |
| 14 | MCCB - 200 A | | 1 |
| 15 | MCCB - 250 A | piece | 1 |
| 16 | MCCB - 400 A | piece | 2 |
| 17 | Contactor - 12 A | piece | 22 |
| 18 | Contactor - 25A | piece | 9 |
| 19 | Contactor - 32A | piece | 4 |
| 20 | Contactor - 40 A | piece | 3 |
| 21 | Contactor - 80A | piece | 7 |
| 22 | Contactor - 160 A | piece | 4 |
| 23 | Contactor - 185 A | piece | 2 |
| 24 | Contactor - 300 A | piece | 1 |
| 25 | Contactor - 400 A | piece | 1 |
| 26 | Terminals | piece | 60 |

| | | | |
|---|---|---|---|
| **Emergency diesel generator** | | | |
| 1 | Fuel filter / Every 500 hours | unit | 2 |
| 2 | Air filter / Every 3000 hours | unit | 4 |
| 3 | Oil filter / Every 250 hours | unit | 50 |
| **Battery- Charger - UPS** | | | |
| | 24 VDC CONVERTERS | | |
| 1 | kit for 5 years | set | 1 |
| | 220 and 110 VDC CHARGERS - UPS | | |
| 2 | Set of electronic protections | set | 1 |
| 3 | Charger protection | set | 3 |
| 4 | Set of printed circuit boards | set | 1 |
| 5 | Thyristors | set | 3 |
| 6 | Diode | set | 1 |
| 7 | Bridge fan | set | 1 |
| 8 | Cubicle fan | set | 2 |
| | BATTERIES | set | |
| 9 | Dry battery cells (220 and 110 VDC system) | set | 5 |
| 10 | Dry battery cells (UPS) | set | 5 |
| 11 | Set of accessories | set | 1 |

A2-1.E DCS

| | ITEM DESCRIPTION | | QTY |
|---|---|---|---|
| **COMMUNICATION ACCESSORIES** | | | |
| 1 | ETHERNET SWITCH FOR ENTERPRISE BUS | | 1 |
| 2 | ETHERNET FIREWALL | | 1 |
| 3 | ETHERNET SWITCH FOR PROCESS BUS | | 4 |
| 4 | POWER SUPPLY FOR ETHERNET SWITCHES | | 4 |
| 5 | ETHERNET HUB FOR FIELD BUS | | 4 |
| 6 | LINK SELECTOR FOR FIELD BUS | | 2 |
| 7 | SWITCH 4TX/1FX MULTIMODE SC (FOR MODBUS TCP LINK) | | 1 |
| 8 | MODBUS TCP/SERIAL CONVERTER | | 1 |
| **CONTROLLERS AND I/O CARDS** | | | |
| 1 | PROCESSING UNIT | | 8 |
| 2 | POWER SUPPLY | | 3 |
| 3 | 8 HIGH LEVEL ANALOG INPUTS MODULE (mA OR VDC HART) | | 8 |
| 4 | 8 ANALOG OUTPUT MODULE (24 V DC) | | 4 |
| 5 | 16 LOGIC OUTPUT MODULE WITH POLARISED CONTACT (48VDC) | | 5 |
| 6 | 16 LOGIC OUTPUT MODULE WITH UN-POLARISED CONTACT (24 / 48 V DC) | | 1 |
| 7 | 16 LOGIC OUTPUT MODULE WITH UN-POLARISED CONTACT (125 V DC) | | 0 |
| 8 | 16 LOGIC INPUT MODULE (48VDC) | | 8 |
| 9 | 16 LOGIC INPUT MODULE (110VDC) | | 0 |
| 10 | 2X4 SLOTS 230V REDUNDANT WITH SYNCHRONIZATION CONVERTER | | 2 |
| **TRUSTED SAFETY CONTROLLER** | | | |
| 1 | PROCESSOR CARD | | 1 |
| 2 | COMMUNICATION INTERFACE CARD (ETHERNET COUPLER) | | 1 |
| 3 | EXPANDER INTERFACE CARD (MAIN RACK) | | 1 |
| 4 | EXPANDER PROCESSOR CARD (EXPANDER RACK) | | 1 |
| 5 | 40 ANALOGUE INPUT MODULE | | 1 |
| 6 | 40 LOGIC INPUT MODULE | | 2 |
| 7 | 40 DIGITAL OUTPUTS MODULE | | 1 |
| 8 | 32 DIGITAL OUTPUTS MODULE (120VDC) | | 1 |
| **HMI** | | | |
| 1 | BI-PROCESSOR PC WITH TFT 24" SCREEN | | 1 |
| 2 | HMI PC WITH min TFT 24" SCREEN | | 2 |
| 3 | HMI PC BI-PROCESSOR WITH min TFT 24" SCREEN | | 1 |

| | ITEM DESCRIPTION | | QTY |
|---|---|---|---|
| 4 | SERVER BI-PROCESSOR | | 1 |
| 5 | LASER PRINTER A4 COLOR 230VAC | | 1 |
| 6 | LASER PRINTER A3/ A4 COLOR 230VAC | | 1 |
| **Large Screen Display** | | | |
| 1 | ETHERNET SWITCH FOR LARGE SCREEN DISPLAY | | 1 |
| 2 | LAMP 100W/120W | | 4 |
| 3 | AIR FILTER | | 4 |
| 4 | POWER SUPPPLY MODULE | | 1 |
| 5 | LAMP BALLAST | | 1 |
| 6 | COLOUR WHEEL REPLACEMENT | | 1 |
| 7 | ELECTRONICS INPUT MODULE (INTEGRATED) | | 1 |
| 8 | OPTICAL ENGINE DUAL WITH SWITCHER RP - NO LAMP | | 1 |
| 9 | NTP TIME SERVER SYNCHRONIZED BY GPS | | 1 |
| 10 | DIPLEXER FOR SYNCHRONISATION SYSTEM | | 1 |
| 11 | DUAL OPTICAL PULSE TRANCEIVER FO-ST/CU/FO-ST | | 2 |

A2-1.F AIR QUALITY CONTROL SYSTEMS

| NO. | ITEM DESCRIPTION | Qty |
|---|---|---|
| **FGD** | | |
| | **BOOSTER FAN** | |
| 1 | MAIN BEARING | 1 |
| | **AERATION FAN** | |
| 2 | OIL SEALING | 3 |
| | **DAMPER** | |
| 3 | BLADE / FRAME SEAL | 1 |
| 4 | O-RING KIT | 3 |
| 5 | SOLENOID VALVES | 2 |
| | **ABSORBER PUMP** | |
| 6 | GASKET & O-RING | 1 |
| 7 | PACKING | 1 |
| 8 | SLEEVE | 1 |
| 9 | LINE BEARING | 1 |
| **Electrostatic Precipitator (ESP)** | | |
| 1 | Support Insulator | 10% |
| 2 | Shaft insulator | 10% |
| 3 | Emitting electrodes | |

| NO. | ITEM DESCRIPTION | Qty |
|---|---|---|
| | | |
| | a) Helical wire type | 10% |
| | i) Wire pipe in rigid | 3% |
| | ii) Mast type | 0.5% |
| 4 | Collecting electrode | 0.5% |
| 5 | Inner arm assembly | 10 Nos. for collecting and emitting system |
| 6 | Outer arm for rapping system collecting & emitting system | 5 Nos. for each type and size |
| 7 | Plain bearing | 5 Nos. for each type and size |
| 8 | Shock bar / anvil | 5 Nos. for each type and size |
| 9 | **Rappers** | |
| | a) For electric rappers | |
| | 1. Assembled rappers / drop rods | 10 Nos. for each type and size |
| | 2. Coil assembly along | 4 Nos |
| | 3. Casing | 4 Nos |
| | 4. Gasket and packing | 5 set |
| | b) For tumbling rappers | |
| | 1. Hammers | 5% of each type |
| | 2. Bearing components | 4 Nos. |
| | 3. Shafts | 4 Nos. |
| | 4.Gear motors | 4 Nos. |
| 10 | **TR sets** | |
| | a) Complete set | 2 Nos. |
| | b) HV insulators | 10 Nos. |
| 11 | Switches & Gaskets | 1 set |
| 12 | **Control system** | |
| | a) Transformer - rectifier set controllers | 10% |
| | b) Transformer - rectifier set intermittent charge controller complete | 10% |
| | c) Rapper controller complete | 10% |
| | d) Communication controller complete | 10% |
| | e) Electronic cards | |

| NO. | ITEM DESCRIPTION | Qty |
|---|---|---|
| | 1. For rapper controller & EP management system | 1 set |
| | 2. For transformer rectifier controller | 1 set |
| | f) Display Unit | 1 Nos. of each type |
| | g) Key board | 1 Nos. of each type |
| | h) Push buttons<br>1. TR set controller | 1 set |
| | 2. Others | 1 set |
| | i) Indicator lamps | 10% of each type |
| | j) Control fuse | 10% of each type |
| | k) Power fuse | 10% of each type |
| | l) Thyristor fuse | 10% of each type |
| | m) Thyristor of transformer rectifier controller | 10% of each type |
| 13 | **MCC of TR controller** | |
| | a) Air Break switches | 2 set |
| | b) Power contacts | 2 set |
| | c) Auxiliary Relay | 2 set |
| | d) Over load Relay | 2 set |
| | e) Power fuse | 4 set |
| | f) Contract fuse | 4 set |
| | g) Control terminal block | 1 set |

Table A2-2 List “B”: 2-Years Maintenance Spare Parts indicative list covering predominantly the rest of plant outside of the power island

| | No. | Items | Specification | Unit | Quantity |
|---|---|---|---|---|---|
| **Fly Ash Handling System** | 1. | Insert Seal | DN200 | Set | 24 |
| | 2. | Insert Seal | DN150 | Set | 8 |
| | 3. | Insert Seal | DN125 | Set | 4 |
| | 4. | Insert Seal | DN50 | Set | 12 |
| | 5. | Cylinder Repair Part | DN200 | Set | 24 |
| | 6. | Cylinder Repair Part | DN150 | Set | 8 |
| | 7. | Cylinder Repair Part | DN125 | Set | 4 |
| | 8. | Cylinder Repair Part | DN50 | Set | 12 |
| | 9. | “O” Seal for Dome Valve | DN200 | Set | 24 |
| | 10. | “O” Seal for Dome Valve | DN150 | Set | 8 |
| | 11. | “O” Seal for Dome Valve | DN125 | Set | 4 |
| | 12. | “O” Seal for Dome Valve | DN50 | Set | 12 |
| | 13. | Gasket for Inlet Valve | DN200 | Set | 16 |
| | 14. | Gasket for Outlet Valve | DN150 | Set | 3 |
| | 15. | Gasket for Outlet Valve | DN125 | Set | 3 |
| | 16. | Gasket for Outlet Valve | DN50 | Set | 8 |
| | 17. | Flexible Tie-In | DN200 | Set | 6 |
| **Cycle Makeup** | 1. | Seals of Demineralized water pump | | set | 2 |
| | 2. | Seals of Filtered water pump | | set | 2 |
| | 3. | Seals of Regeneration pump | | set | 2 |
| | 4. | Seals of Wastewater pump | | set | 2 |
| | 5. | Seals of Decarbonated water pump | | set | 2 |
| **Wastewater Treatment** | 1. | Dosing pump (for each dosing pump) | | | |

| | No. | Items | Specification | Unit | Quantity |
|---|---|---|---|---|---|
| | | Spare part package | | set | 1 |
| | 2. | Centrifugal pump ( for each pump ) | | | |
| | | Bearing | | set | 1 |
| | | Set of gasket | | set | 1 |
| | | Mechanical seal assembly | | pc | 1 |
| | | Mechanical seal non-metallic faces, o-ring, gasket, spring | | set | 1 |
| | | Wearing ring | | set | 1 |
| | 3. | Air Blower ( for each Blower ) | | | |
| | | Bearing | | set | 1 |
| | | Set of gasket | | set | 1 |
| | | Wearing ring | | set | 1 |
| | | Shaft sleeve | | pc | 1 |
| | | Shaft | | pc | 1 |
| **ID FAN** | 1. | Filter core for forced oil station | | EA | 1 |
| | 2. | Filter core for lubrication oil station | | EA | 1 |
| **CW Pump** | 1. | Shaft sleeve | | EA | 1 |
| | 2. | Pump guide bearing | | EA | A |
| | 3. | Wear ring | | EA | 1 |
| **Coal Handling System** | 1. | Conveyor System | | | |
| | 1.1 | Belt B=1800mm | | M | 100 |
| | | Belt B=1400mm | | M | 100 |
| | 1.2 | Carrying Idler (Roller) | | EA | 100 |
| | | Impact Idler (Roller) | | EA | 50 |
| | | Return Idler (Roller) | | EA | 50 |
| | 1.3 | Bearings of Drive Pulley Diameter 1000 | | EA | 8 |
| | | Bearings of Drive Pulley Diameter 800 | | EA | 8 |
| | | Bearings of Drive Pulley Diameter 630 | | EA | 4 |
| | | Bearings of Tail Pulley Diameter 500 | | EA | 4 |
| | | Bearings of Pulley Diameter 400 | | EA | 4 |
| | 1.4 | Resilient Driving Plate of Coupling | | EA | 30 |
| | | Fusible Plugs of Fluid Coupling | | EA | 18 |

| | No. | Items | Specification | Unit | Quantity |
|---|---|---|---|---|---|
| | 1.5 | Liners of Brakes | | EA | 24 |
| | 1.6 | Tips of Primary Cleaner | | EA | 24 |
| | | Rubber Tip of V Plough Belt Cleaner | | EA | 24 |
| | 1.7 | Conveyor Electrical Safety Device | | | |
| | | Misalignment switch | | LOT | 4 |
| | | Pull Cord Switch | | LOT | 4 |
| | | Zero Speed Switch | | LOT | 4 |
| | | Temperature Sensor for Pulley | | LOT | 4 |
| | | Position Switches for Take Up Unit | | LOT | 4 |
| | | Emergency Switch for Fluid Coupling | | LOT | 4 |
| | 2 | Vibrating Screen | | | |
| | | Motor | | EA | 1 |
| | 3 | Stacker/reclaimer | | | |
| | 3.1 | Motor-Gear Unit of the Driving System | | LOT | 1 |
| | | Bearing of Driving Wheel | | EA | 4 |
| | 3.2 | Bucket Wheel Complete | | LOT | 6 |
| | | Bucket Wheel Bearing House | | LOT | 2 |
| | | Liners of Bucket Wheel | | EA | 6 |
| | 3.3 | Pressure relief valve of Hydraulic System | | LOT | 2 |
| | | Solenoid valve | | LOT | 2 |
| | 3.4 | Nozzle of water system | | EA | 10 |
| | | Solenoid Valve | | EA | 4 |
| | 3.5 | Distributor of Lubrication System | | LOT | 10 |
| | | Connector | | EA | 20 |
| | 3.6 | Liner of Hopper | | EA | 12 |
| | 3.7 | Hydraulic Seals, connector | | LOT | 1 |
| | 3.8 | Coupling of cable drum | | LOT | 2 |
| | 4 | PROGRAMMABLE LOGIC CONTROLLER (PLC) | | | |
| | 4.1 | Control Relay | | EA | 5 |
| | 5 | MISCELLANEOUS SPARES FOR PROCESS EQUIPMENT | | | |
| | 5.1 | Electric heater | | LOT | 1 |
| | 5.2 | Anti-condensation heater | | LOT | 2 |

| | No. | Items | Specification | Unit | Quantity |
|---|---|---|---|---|---|
| | | for HV switchgears | | | |
| | 6 | MISCELLANEOUS SPARES FOR PROCESS EQUIPMENT | | | |
| | 6.1 | Electric heater | | LOT | 1 |
| | 6.2 | Anti-condensation heater for HV switchgears | | LOT | 2 |
| | 7 | Control System of Stacker & Reclaimer | | | |
| | 7.1 | High pressure sodium lamp | | EA | 2 |
| | 7.2 | AC Contactor | | EA | 1 |
| | 7.3 | Breaker | | EA | 1 |
| | 7.4 | Indicator Lamp | | EA | 16 |
| | 7.5 | Push Button | | EA | 16 |
| | 7.6 | Limit Switch | | EA | 4 |
| | 7.7 | Proximity switch | | EA | 4 |
| | 7.8 | Frequency Converter | | LOT | 1 |
| **GSU** | | Silica gel breather | | PCS | 1 |
| | | Rubber bag | | PCS | 1 |
| | | Winding temperature indicator | | PCS | 1 |
| | | Pressure relief device | | PCS | 1 |
| | | Oil temperature indicator | | PCS | 1 |
| | | Gas relay | | PCS | 1 |
| | | Motor fan | | PCS | 1 |
| | | Complete gaskets | | PCS | 1 |
| | | LV bushing | | PCS | 1 |
| | | HV bushing | | PCS | 1 |
| | | HV neutral bushing | | PCS | 1 |
| **UAT** | | Silica gel breather | | PCS | 1 |
| | | Rubber bag | | PCS | 1 |
| | | Winding temperature indicator | | PCS | 1 |
| | | Pressure relief device | | PCS | 1 |
| | | Oil temperature indicator | | PCS | 1 |
| | | Gas relay | | PCS | 1 |
| | | Cooler | | PCS | 1 |
| | | Complete gaskets | | PCS | 1 |
| | | LV bushing | | PCS | 1 |
| | | HV bushing | | PCS | 1 |
| | | HV neutral bushing | | PCS | 1 |
| **Electrical** | 1 | 3.3KV SWITCHGEAR | | | |

| | No. | Items | Specification | Unit | Quantity |
|---|---|---|---|---|---|
| | 1.1 | Circuit breaker (VCB) | | LOT | 1 |
| | 1.2 | Potential transformer | | LOT | 1 |
| | 1.3 | PT fuses-100A | | LOT | 1 |
| | 1.4 | Busbar insulator (Complete set for one cubicle) | | LOT | 1 |
| | 1.5 | Closing coil | | LOT | 2 |
| | 1.6 | Tripping coil | | LOT | 2 |
| | 1.7 | Main fixed and moveable contacts of each rating | | LOT | 1 |
| | 1.8 | Auxiliary relays | | LOT | 4 |
| | 1.9 | Protection relays | | LOT | 2 |
| | 1.1 | Breaker position | | LOT | 10 |
| | 1.11 | Current Transducer | | LOT | 4 |
| | 1.12 | Control fuses | | LOT | 4 |
| | 1.13 | Control Switches | | LOT | 5 |
| | 1.14 | Control breaker | | LOT | 4 |
| | 1.15 | Indication Lamps | | LOT | 4 |
| | 1.16 | Cable Current Transformer | | LOT | 1 |
| | 1.17 | Current transformer | | LOT | 1 |
| | 1.18 | Surge arrestor for 3.3KV | | LOT | 1 |
| | 1.2 | Micro switches | | LOT | 1 |
| | 1.21 | Any special switches in breaker | | LOT | 1 |
| | 2 | TRANSFORMER | | | |
| | 2.1 | High voltage bushing | | EA | 2 |
| | 2.2 | Low voltage bushing | | EA | 2 |
| | 2.3 | Gasket for various joints | | LOT | 2 |
| | 2.4 | Silica gel breather | | EA | 2 |
| | 3 | 415VOLTS SWITCHGEAR, MCC AND POWER / CONTROL PANELS | | | |
| | 3.1 | Air circuit breaker | | LOT | 10 |
| | 3.2 | Main circuit breaker | | LOT | 2 |
| | 3.3 | Magnetic contactor | | LOT | 20 |
| | 3.4 | Control circuit breakers | | LOT | 20 |
| | 3.5 | Thermal / electronic overload relay | | LOT | 20 |
| | 3.6 | Auxiliary relays | | LOT | 10 |
| | 3.7 | Fixed and moving contacts for draw-out type | | LOT | 20 |
| | 3.8 | Control circuit fuses | | LOT | 30 |
| | 3.9 | Transducer | | LOT | 2 |

| | No. | Items | Specification | Unit | Quantity |
|---|---|---|---|---|---|
| | 3.10 | Control switches | | LOT | 5 |
| | 3.11 | Push Button | | LOT | 20 |
| | 3.12 | Indication lights | | LOT | 100 |
| | 3.13 | Lamps for indication lights | | LOT | 100 |
| **Air Compressor** | 1 | Air filter | | EA | 20 |
| | 2 | Oil filter | | EA | 30 |
| | 3 | Oil separator core | | EA | 5 |
| | 4 | Lube oil | | EA | 5 |
| | 5 | 8000hrs maintenance package | | EA | 5 |
| **400KV Substation** | 1 | SF6 Air Bushing | | PCS | 1 |
| | 2 | SF6 Circuit breaker | | PCS | 2 |
| | 3 | Circuit Breaker trip coil | | LOT | 1 |
| | 4 | Circuit Breaker close coil | | LOT | 1 |
| | 5 | Disconnector switch moving contact | | LOT | 1 |
| | 6 | Disconnector switch fixed contact | | LOT | 1 |
| | 7 | ACSR conductor | | METER | 30 |
| | 8 | PT fuses | | LOT | 1 |
| | 9 | Clamps | | LOT | 1 |
| | 10 | Insulators Disc | | LOT | 1 |
| | 11 | Post insulator | | PCS | 1 |
| | 12 | String insulator | | LOT | 1 |
| | 13 | Line trap | | PCS | 1 |
| | 14 | Shunt reactor | | PCS | 1 |
| | 15 | Surge monitor | | PCS | 1 |
| | 16 | SF6 Density monitor | | PCS | 1 |
| | 17 | Battery | | LOT | 1 |
| | 18 | Battery cell monitor | | LOT | 1 |
| | 19 | Battery hydrometer | | PCS | 1 |
| | 20 | Contactors (Each rating one no) | | LOT | 1 |
| | 21 | Indication lamps | | LOT | 1 |
| | 22 | Control switches | | LOT | 1 |
| | 23 | Control fuses (Each rating one no) | | LOT | 1 |
| | 24 | Auxiliary relays ( Each type one no) | | LOT | 1 |
| | 25 | Protective relays(Each type one no) | | LOT | 1 |

# SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT A3 - SCHEDULE OF TECHNICAL GUARANTEES

# (I) SCHEDULE OF PERFORMANCE GUARANTEES

# CONTENTS

# 1. PERFORMANCE GUARANTEES CONDITIONS

Performance Guarantees shall be based on the following conditions and parameters:

**Table 1.12.1-1**
**Performance Guarantees Conditions**

| Parameters (Basic for Performance Guarantees) | Value |
|---|---|
| Ambient Dry-Bulb Temperature, ºC | 30.7 |
| Ambient Relative Humidity,% | 88% |
| Ambient Pressure, kPa (a) | 99.84 |
| Guarantee Fuel | Performance Test Coal (Attachment B3, Section 5) |
| Power Factor at GSU High Side Terminals | 0.85 lagging |
| Raw Water Temperature | 32.2 |
| Plant Operating Loads | 100% MCR, 75% MCR and 50% MCR |
| Make-up for output guarantee | 0 percent of steam flow (no correction allowed) |
| Make-up for heat rate guarantee | 0 percent of steam flow (no correction allowed) |
| Metering Point | HV side Of GSU transformer |

In the event that conditions are not described above, mutually agreed corrections shall be applied to the test results in accordance with the applicable ASME PTC codes.

The test coal shall be as close as possible to the Performance Test coal value indicated into Attachment B3, Section 5 of the ER in composition and characteristics such that a reasonable comparison to guaranteed performance can be made. During the boiler efficiency determination, the heating value and constituents of the test coal (including volatile matter and fixed carbon) shall be within a +/- 5% (relative) band of the Performance test coal analysis for ASME Code test corrections to apply. If the Performance Test coal provided doest not meet criteria, mutually agreed corrections shall be determined and will apply.

# 2. DETAILS OF PERFORMANCE GUARANTEES

The Performance Test shall be carried out in accordance with sub-clause 38.3.4 of Chapter 38 Section 5 of the Employer's Requirements.

No tolerances shall be applied when deriving and comparing the results and/or Calculation for Dependable Capacity, Weighted Plant Net Heat Rate, the Emission Test and the Guaranteed Dependable Capacity, Guaranteed Heat Rate and other Guaranteed Criteria respectively.

The correction curves as referred to in sub-clause 38.3.6.2 of Chapter 38, Section 5 [Adjustment of Performance Test results to Guaranteed Basis] shall be applied in the Performance Test. The correction curves shall apply within the range of 5% below to 5% above the values prescribed in the Table 1.12.1-1 (Performance Guarantee Conditions). These correction curves include but not limited to the following:

a) Generator efficiency vs power factor;
b) Generator losses vs power factor; and
c) Gross electrical output and gross heat rate (HHV) vs cooling water temperature.

The Bidder to furnish curves to be used for the determination of the allowable degradation Factors for ageing as referred to in Section 38.3.6.2 [Correction for Ageing].

The type of coal(s) as specified in the Employer's Requirements to be used during the Performance Test will be determined by the Engineer.

The Bidder to provide the followings:

| No. | Item | Unit | 100% MCR | 75% MCR | 50% MCR | Remarks |
|---|---|---|---|---|---|---|
| A | Electrical Output (Gross) | MW | | | | Based on firing the Performance Test Coal indicated in Attachment B3 of Section 5 of the ER |
| B | Guaranteed Dependable Capacity | MW | | | | |
| C | Turbine Heat Rate (Gross) | kJ/kWh | | | | |
| D | Guaranteed Plant Heat Rate (Net) | kJ/kWh | | | | |
| E | Auxiliary Power Consumption | MW | | | | |
| F | Super-heated steam flow at BMCR | Tons / Hour | | | | |
| G | Limestone Consumption at MCR | Tons / Hour | | | | |
| H | Minimum load for continuous Stable operation Reactive capability (both lagging and leading) | MW | | | | The Power Station is capable to run at 30% MCR without auxiliary fuel support under guarantee conditions. |
| I | Spinning reserve capability | % | | | | |
| | Specified governor droop | % | | | | |
| J | Minimum time to synchronize the generating unit (start) from boiler lighting up: | | | | | |
| | (i) Cold start | Min | | | | Shall be < 720 mins |
| | (ii) Warm start | Min | | | | Shall be < 240 mins |
| | (iii) Hot start | Min | | | | Shall be < 180 mins |

| No. | Item | Unit | 100% MCR | 75% MCR | 50% MCR | Remarks |
|---|---|---|---|---|---|---|
| K | Minimum time to minimum stable generation from boiler lighting up: | | | | | |
| | (i) Cold start (plant shutdown) | Min | | | | |
| | (ii) Warm start | Min | | | | |
| | (iii) Hot start | Min | | | | |
| L | Block load Synchronizing | | | | | |
| | (i) Cold start | MW | | | | |
| | (ii) Warm start | MW | | | | |
| | (iii) Hot start | MW | | | | |
| M | Maximum Loading Rate | | | | | |
| | (i) Cold start | MW/min | | | | |
| | (ii) Warm start | MW/min | | | | |
| | (iii) Hot start | MW/min | | | | |
| N | House load operation | % | The Power Station can run at ____ load to meet house-load needed by auxiliaries | | | |

## 3. AUXILIARY POWER CONSUMPTION

During the performance Test, the Contractor shall measure the auxiliary power consumption in accordance with sub-clause 38.3.4.1 of Chapter 38, Section 5 of the Employer’s Requirements.

Table 3-1-defines the list of Auxiliary Equipment in Service in continuous operation and considered during Performance Tests.

Table 3-2-defines the list of Auxiliary Equipment in Service not in continuous operation nor considered during Performance Tests.

The Bidder is required to fill-in the indicative power consumption for the auxiliaries listed in Table 3-1 an Table 3-2.

Table 3-1

| No. | Item | | Auxiliary Power Consumptions (kW) | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | 100% MCR | | 75% MCR | | 50% MCR | | |
| | | | Nos. in service during testing | **Total kW** | Nos. in service during testing | **Total kW** | Nos. in service during testing | **Total kW** | |
| **(A) BOILER ISLAND** | | | | | | | | | |
| 1 | Primary fan | | 2 | | 2 | | 2 | | |

| No. | Item | | Auxiliary Power Consumptions (kW) | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | 100% MCR | | 75% MCR | | 50% MCR | | |
| | | | Nos. in service during testing | **Total kW** | Nos. in service during testing | **Total kW** | Nos. in service during testing | **Total kW** | |
| 2 | Forced draught fan | | 2 | | 2 | | 2 | | |
| 3 | Coal Pulverizer | | 7 | | 5 | | 4 | | |
| 4 | Pulverizer lube oil pump | | 7 | | 5 | | 4 | | |
| 5 | Coal Pulverizer dynamic classifier | | 7 | | 5 | | 4 | | |
| 6 | Coal Feeder | | 7 | | 5 | | 4 | | |
| 7 | Scanner air fan | | 1 | | 1 | | 1 | | |
| 8 | Seal air fan | | 1 | | 1 | | 1 | | |
| 9 | Tri-sector heater drive | | 2 | | 2 | | 2 | | |
| 10 | Air Pre-heater lube pumps | | 2 | | 2 | | 2 | | |
| 11 | Submerged Scrapper conveyor SSC Auxiliaries | | 1 | | 1 | | 1 | | |
| 12 | Ash recirculation pump | | 1 | | 1 | | 1 | | |
| 13 | Other continuous electrical load | | 1 lot | | 1 lot | | 1 lot | | |
| **(B) TURBINE GENERATION AND AUXILIARIES** | | | | | | | | | |
| 1 | Oil vapor exhauster for lube oil | | 1 | | 1 | | 1 | | |
| 2 | Oil purification with coalesce filter | | 1 | | 1 | | 1 | | |
| 3 | Control oil pump for turbine | | 1 | | 1 | | 1 | | |
| 4 | Gland steam condenser exhauster fan | | 1 | | 1 | | 1 | | |
| 5 | Oil heater to coalesce filter | | 1 | | 1 | | 1 | | |
| 6 | Exhaust blower | | 1 | | 1 | | 1 | | |
| 7 | Seal oil pump | | 1 | | 1 | | 1 | | |
| 8 | Cubicles, converters, valves | | 1 | | 1 | | 1 | | |
| 9 | Stator water pump | | 1 | | 1 | | 1 | | |
| 10 | Air moister | | 1 | | 1 | | 1 | | |
| 11 | Gel drying fan | | 1 | | 1 | | 1 | | |
| 12 | Condensate extraction pumps | | 2 | | 2 | | 2 | | |
| 13 | Condenser vacuum water pumps | | 2 | | 2 | | 2 | | |

| No. | Item | | Auxiliary Power Consumptions (kW) | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | 100% MCR | | 75% MCR | | 50% MCR | | |
| | | | Nos. in service during testing | **Total kW** | Nos. in service during testing | **Total kW** | Nos. in service during testing | **Total kW** | |
| 14 | LP3 drain recovery pump | | 1 | | 1 | | 1 | | |
| 15 | Condenser water box vacuum | | 1 | | 1 | | 1 | | |
| 16 | Sampling system | | 1 | | 1 | | 1 | | |
| 17 | ST Driven (FWP) lube oil pump | | 2 | | 2 | | 1 | | |
| 18 | ST Driven (FWP hydraulic oil | | 2 | | 2 | | 1 | | |
| 19 | Closed cooling water pump | | 1 | | 2 | | 1 | | |
| 20 | Booster pump for CCW | | 1 | | 1 | | 1 | | |
| 21 | CCW debris filter | | 4 | | 4 | | 4 | | |
| 22 | Dosing pumps (Ammonia,O2 scavenger) for WS and CCW | | 1 | | 1 | | 1 | | |
| 23 | Polishing plant | | 1 | | 1 | | 1 | | |
| **(C) BALANCE OF PLANT** | | | | | | | | | |
| | **ESP, Flue Gas Treatment. Ash Handling System** | | | | | | | | |
| 1 | Induced draught fan | | 2 | | 2 | | 2 | | |
| 2 | ESP | | 2 | | 2 | | 2 | | |
| 3 | Fly Ash Handling system | | 1 | | 1 | | 1 | | |
| 4 | Continuous emission monitoring system | | 1 | | 1 | | 1 | | |
| | **FGD** | | | | | | | | |
| 5 | Absorber pumps | | 1 | | 1 | | 1 | | |
| 6 | Gas/Gas heat exchangers(soot-blowing not in service) | | 1 | | 1 | | 1 | | |
| 7 | Aeration fans | | 1 | | 1 | | 1 | | |
| 8 | ID Booster fans for SWFGD | | 1 | | 1 | | 1 | | |
| 9 | Other continuous electrical Loads | | 1 lot | | 1 lot | | 1 lot | | |
| | **CW pump and others** | | | | | | | | |
| 10 | Circulating water Pumps | | 3 | | 3 | | 3 | | |

| No. | Item | | Auxiliary Power Consumptions (kW) | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | 100% MCR | | 75% MCR | | 50% MCR | | |
| | | | Nos. in service during testing | Total kW | Nos. in service during testing | Total kW | Nos. in service during testing | Total kW | |
| | **Ash plant** | | | | | | | | |
| 11 | Bottom ash system before conveyors | | 1 | | 1 | | 1 | | |
| | **Air Compressors** | | | | | | | | |
| 12 | Air compressors and dryer | | 4 | | 3 | | 3 | | |
| | **Miscellaneous** | | | | | | | | |
| 13 | HVAC | | 1 | | 1 | | 1 | | |
| 14 | HVAC turbine hall and boiler electrical building | | 1 | | 1 | | 1 | | |
| 15 | Miscellaneous Coal handling (including I&C, HVAC, Lighting) | | 1lot | | 1lot | | 1lot | | |
| **(D) TRANSFORMER LOSSES AND OTHER LOSSES (IF ANY)** | | | | | | | | | |
| 1 | Generator transformer losses | | 1 | | 1 | | 1 | | |
| 2 | Unit transformer losses | | 2 | | 2 | | 2 | | |
| 3 | MV LV transformer losses | | 1 lot | | 1 lot | | 1 lot | | |
| 4 | MV cable losses | | 1 lot | | 1 lot | | 1 lot | | |
| 5 | LV cable losses | | 1 lot | | 1 lot | | 1 lot | | |
| 6 | Lighting and communication | | 1 lot | | 1 lot | | 1 lot | | |
| 7 | Electrical auxiliary systems | | 1 lot | | 1 lot | | 1 lot | | |
| **(E) TOTAL** | | | | | | | | | |

Table 3-2

| No. | Items | Number in Service | Auxiliary Power (kW) | Remarks |
|---|---|---|---|---|
| 1 | Water treatment plant | 1 | | |
| 2 | Waste water treatment | 1 | | |
| 3 | Bottom / Fly ash conveyors | 1 | | |
| 4 | Coal receiving system | 1x Conveyors | | |
| 5 | Coal forwarding system | 1x Conveyors | | |
| 6 | Fire water pump | 1 | | |

| No. | Items | Number in Service | Auxiliary Power (kW) | Remarks |
|---|---|---|---|---|
| 7 | Service water pump | 1 | | |
| 8 | Potable water pump | 1 | | |
| 9 | Demineralized water transfer pump for normal | 1 | | |
| 10 | Demineralized water transfer pump for startup backup | 1 | | |
| 11 | Fuel oil unloading pump | 1 | | |
| 12 | Fuel oil forwarding pump | 1 | | |
| 13 | AH wash pump | 2 | | |
| 14 | Misc.aux.power consumers | | | |
| 15 | Turbine system / Air Heater | | | |
| 16 | Condenser tube cleaning | | | |
| 17 | Polishing regeneration plant | | | |
| 18 | Normal condensate make-up pump | | | |

## SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT A3 - SCHEDULE OF TECHNICAL GUARANTEES

# (II) SCHEDULE OF OTHER GUARANTEED CRITERIA

# CONTENTS

# 1. EMISSION LIMITS

The Bidder shall provide the following emission guarantees:

| Emissions | Units | Bidder's Guarantees |
|---|---|---|
| Particulate Matters | $mg/Nm^3$ | |
| Sulphur Dioxide | $mg/Nm^3$ | |
| Nitrogen Oxide | $mg/Nm^3$ | |
| Hydrogen Chloride | $mg/Nm^3$ | |
| Hydrogen Fluoride | $mg/Nm^3$ | |
| Mercury | $mg/Nm^3$ | |
| Carbon Monoxide | $mg/Nm^3$ | |
| Polychlorinated dibenzo-dioxins (PCDDs) or Polychlorinated dibenzo-furans (PCDF) | Nanogram TEQ (Toxicity Equivalent Quantity)/$m^3$ | |

# 2. IN-PLANT NOISE EMISSION

The Bidder shall provide the following guarantees:

**Far Field Noise**

The equivalent continuous A-weighted sound pressure level emitted by the Power Station during continuous base load operations, excluding the background noise level caused by other external sources, during night-time and daytime when measured at the Site perimeter and at a height of 1.5 meter above the ground level.

**Near Field Noise**

During the continuous base load operation of the Power Station, the A-weighted surface sound pressure level averaged over the measurement surface according to ISO 3746 at a distance of 1 meter from the equipment or its acoustical enclosure, and 1.5 meters above ground level or personal platforms.

The average A-weighted sound pressure level inside Central Control Room (CCR) (excluding printer, computer and alarm noise, phones and office equipment).

**Guarantees Exclusions**

The Bidder to specify any exclusion from the above noise guarantees (if any).

# 3. EFFULENT DISCHARGE

The Bidder shall provide the following guarantees:

| Item | Unit | Bidder's Guarantees |
|---|---|---|
| Water Temperature | $^{o}C$ | ......... (Summer) |
| | | ......... (Winter) |
| pH | - | ......... |
| DO | mg/l | ......... |
| SS | mg/l | ......... |
| Oil | mg/l | ......... |
| BOD | mg/l | ......... ( at 20 $^{o}C$) |
| As (Arsenic) | mg/l | ......... |
| Pb (Lead) | mg/l | ......... |
| Fe (Iron) | mg/l | ......... |

# SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT A4 – CONTRACTOR'S OBLIGATIONS WITH RESPECT TO PPA

# CONTENTS

# A4 CONTRACTOR'S OBLIGATIONS WITH RESPECT TO PPA

## A4.1 TESTING AND CAPACITY RATINGS

### A4.1.1 TESTING OF THE FACILITY PRIOR TO THE OPERATIONAL ACCEPTANCE

#### A4.1.1.1 NOTIFICATION AND SCHEDULING

a) The Contractor shall at his best efforts to provide the Employer on an ongoing basis with relevant information regarding the program for testing. Not less than thirty (30) Days prior to testing, the Contractor shall deliver to the Employer in writing the final program for testing, including the expected duration of the testing program and a tentative schedule for conducting all relevant tests required by Appendix to Attachment A4. The Contractor shall advise the Employer in writing of the final schedule for the testing program not less than seven (7) Days prior to the commencement of the tests required by Clause 1 of Appendix to Attachment A4. If the schedule for any test required by Appendix to Attachment A4 is adjusted after the Contractor has provided the Employer with the final testing program schedule, the Contractor shall advise the Employer not less than twenty-four (24) hours prior to the commencement of any such test. On each Day beginning with the Day on which testing commences, the Contractor shall provide the Employer with a schedule of the tests to be conducted on the following Day or Days if such test will continue for more than one (1) Day. All testing of the Plant shall satisfy the applicable requirements provided in Appendix to Attachment A4.

b) If the Employer is unable to accommodate the schedule for such test or tests as provided by the Contractor in the final schedule for the program of tests pursuant to the foregoing sub-clause A4.1.1.1(a) (whether by reason of the Grid's failure to deliver electrical energy to or receive Net Energy Output from the Plant, or otherwise), the Employer will give the Contractor notice within forty-eight (48) hours of its receipt of the final schedule for testing of its requirements regarding deferral of any test or tests and mutually agree on a date for any deferral test or program of tests.

#### A4.1.1.2 TEST ON COMPLETION

a) The Contractor shall be entitled to attempt as many Tests on Completion as are necessary to satisfy the minimum criteria (as set out in Appendix to Attachment A4) for achieving the Operational Acceptance. The Contractor shall give the Employer not less than forty-eight (48) hours' notice of each additional Tests on Completion he desires to attempt.

## A4.1.2 NOTICE OF AND COMPLIANCE WITH TESTING PROCEDURES

The Contractor shall carry out commissioning of the Plant and testing of the Dependable Capacity of the Plant in accordance with sub-clause A4.1.1 and Appendix to Attachment A4. The Employer shall use its reasonable efforts to comply promptly with all reasonable requests by the Contractor for assistance carrying out such testing and commissioning. The Employer shall be given prior written notice of the testing or commissioning procedure in accordance with sub-clause A4.1.1 and his representative shall be entitled to be present and observe any such testing and commissioning.

# SECTION 5 – EMPLOYER’S REQUIREMENTS

# APPENDIX TO ATTACHMENT A4
# COMMISSIONING AND TESTING

# CONTENTS

# 1 COMMISSIONING AND TESTING

"Test on Completion" means the tests referred to in sub-clause 1.1 and 1.2 of Appendix to Attachment A4.

"Dependable Capacity Test" means the test scheduled pursuant to Attachment A4 to determine the Dependable Capacity of the Plant by measuring at the HV side of the Generator Step up Transformer, the average Net Energy Output, corrected to Reference Site Conditions using relevant correction factors. The test shall comply with the ASME or ISO standards. Throughout the test period, the NLDC shall dispatch the Plant at the maximum generating capability of the Plant.

## 1.1 TESTS PRIOR TO SYCHRONISATION

The Contractor shall carry out the following tests prior to synchronisation of each generating unit of the Plant:

a) automatic voltage regulator setting and adjusting in stand-still condition and with the generator running at no load;

b) turbine governor control checks, including a steam governor overspeed test; This test may be performed after a specified period of running of the Unit on load as per the manufacturer's recommendation;

c) open circuit and short circuit tests on the generator;

d) functional testing and timing of high voltage switchgear in the sub-station of the Plant;

e) The Employer shall verify that the protection level settings for substation protection equipment;

f) Voltage phasing checks will be carried out between the Grid System and the Plant; and

g) All inter-tripping circuits between the Plant and the Grid equipment will be proved.

## 1.2 COMMISSIONING TESTS

The following tests shall be carried out by the Contractor for commissioning of each generating unit of the Plant after completing the tests set out in sub-clause 1.1 of Appendix to Attachment A4 insofar as these tests can be accommodated within the Grid System:

a) Dependable Capacity Test

The Dependable Capacity Test shall be carried out to determine the Dependable Capacity. This test shall comply with ASME or ISO standards and shall be carried out as part of the Reliability Run. For the purpose of achieving the Operational Acceptance, the Dependable Capacity shall be equal or greater than the Threshold Capacity.

b) Reliability Run
As a minimum requirement to demonstrate the reliability of the Plant, the Contractor shall carry out a reliability run in which time the Plant shall operate continuously (without interruption) for seventy-two (72) continuous hours at then demonstrated Dependable Capacity. The output during the remaining hours of the test will be as requested by the NLDC.

c) Automatic Voltage Regulator (“AVR”) Droop Test
The AVR will be demonstrated to control the steam turbine generator voltage over its entire set range.

d) Steam Turbine Governor Operation Test
The operation of the steam turbine speed governor will be demonstrated.

e) Reactive Capacity Test
This test will demonstrate the capability of the Plant to operate at rated voltage and frequency at power factors and under reactive conditions in accordance with the manufacturer’s generator rating curves to be provided by the Contractor, insofar as these tests can be accommodated within the Grid System.

f) Minimum Load Capability Test
This test will demonstrate the capability of the Plant to be operated at thirty percent (30%) of the Dependable Capacity while the Steam Turbine and auxiliaries remain in a stable and controlled condition. This test will demonstrate the Plant’s automatic control capabilities from Dependable Capacity to sixty (30%) of Dependable Capacity.

# SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT B1 – PROCUREMENT, FABRICATION, INSPECTION, TESTING AND DOCUMENTATION REQUIREMENTS FOR GRADE 91 (9Cr-1Mo-V) AND GRADE 92 (9Cr-2W) MATERIALS

# B1 GENERAL

Attachment B1 defines the requirements for the procurement, fabrication, inspection, testing, and documentation of ASTM A335 or ASME SA-335 Grade P91 and P92 piping and Grade 91 (9Cr-1Mo-V) and 92 (9Cr-2W) nominal compositions piping components. These materials are subsequently and most commonly referred to herein as Grade 91 and Grade 92, respectively.

The ASME Section IX, 2009 Addenda re-categorized Grade 91 materials from P-No. 5B Group 2 to P-No. 15E Group 1.

ASME Sections I and VIII, Division 1, Code Case 2179 (revision approved by Employer) and ASME B31.1 Code Case 183 provide requirements and the basis for the use of Grade 92 materials.

The requirements herein do not address all requirements of the ASME Boiler Pressure and Vessel Code, ASME B31.1, other applicable ASME codes, or the Malaysian Factories and Machinery Act 1967 (Act 1391 and Regulations. The Contractor shall be responsible for meeting any additional requirements specified by the codes when applicable.

Any conflict identified between the requirements of this document and the provisions of any applicable industry standard, code, regulation, specification, directive, or purchasing document contractually required for a given application shall be referred to Employer for resolution prior to the start of welding.

Where requirements of a referenced code or standard or contract specification differ from this document, the more stringent or restrictive requirements shall apply.

Any request for deviation from specified requirements shall be submitted in writing and shall include the proposed deviation, rationale for the deviation, any technical data supporting the deviation, and historical experience supporting the deviation.

Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard Is not jurisdictionally mandated, then the current edition and addenda in effect at the time of (contract or specification) approval shall govern.

This attachment is comprised of the following articles:

- B1.1 Material Procurement and Testing Requirements
- B1.2 Requirements for Seamless Pipeand Tube Cold and Hot Bends

## B1.1 MATERIAL PROCUREMENT AND TESTING REQUIREMENTS

### B1.1.1 GENERAL

This article provides base material procurement and testing requirements for Grade 91 and 92 materials for pressure-retaining boiler proper, boiler external and nonboiler external components.

All pipes shall be in accordance with the applicable codes and standards except as further limited herein. Except as otherwise specified, schedule numbers, sizes, and dimensions of piping shall conform to the applicable standards specified. Pipe weight variations shall be as specified herein.

Pipe and tube shall be ungalvanized seamless type.

For special wall pipe, the nominal weight per linear foot shall be as follows:

W = C (D-t) t

Where

C = 0.0246615,
W = weight, kg/m,
D = specified nominal outside diameter, mm, and
T = the nominal wall thickness, mm where the nominal wall thickness is the specified minimum wall thickness on inspection divided by 0.875.

The actual weight of any pipe length NPS 300 mm and under in size shall not vary more than 10 percent over nor 3.5 percent under the nominal weight as specified above. For sizes over NPS 300 mm, the actual weight shall not vary more than 10 percent over nor 5 percent under the nominal weight as specified above. These requirements shall apply to all standard wall pipes and all special wall pipes and are in addition to applicable industry standards.

Substitution of minimum wall piping in lieu of specified schedule wall piping shall not be acceptable unless approved in writing by the Employer.

Material substitutions shall not be made without the written consent of the Employer.

The chemical composition for the elements nickel and manganese (Ni and Mn) for Grades 91 and 92 pipes shall each be within the range of 0.3 to 1.01 weight percent inclusive based on either the actual product or heat analysis.

## B1.1.2 GRADE 91 AND 92 MATERIAL COMPOSITION AND HEAT TREATMENT REQUIREMENTS

The nitrogen to aluminum ratio, based on either the actual product or heat analysis, shall be 2 or greater (N:Al ≥ 2) for Grades 91 and 92 pipes and fittings.

Mill-supplied Grades 91 and 92 piping components shall be supplied in the normalized and tempered condition as follows:

> <u>Normalization cycle:</u> 1,040°C to 1,080°C, held at temperature for a time sufficient to ensure that the entire component thickness is within the required normalization temperature range. After the appropriate soak temperature and time have been completed, the component shall be promptly removed from the furnace to allow the component to cool to less than 95°C in still air at ambient temperature. Accelerated cooling may be necessary for thicknesses greater than 75 mm to help ensure transformation to martensite during cooling.
>
> <u>Tempering cycle</u>: 745°C to 780°C, held at temperature for a time sufficient to ensure that the entire component thickness is within the required tempering temperature range. Recommended hold times, based on the furnace temperature or thermocouples attached to the exterior surface of the component, are as follows: 1 hour per 25 mm of thickness, with 2 hours plus 15 minutes per 25 mm additional time for thicknesses over 50 mm, 30 minutes minimum, 3 hours maximum. The holding time may be increased by 40 percent for holding temperatures 745° C to 760°C.

Mill-supplied pipe and pressure-retaining piping components shall meet 180 BHN minimum hardness unless the material will be subsequently normalized and tempered. Note: Even though the minimum hardness tests stated above is 180 BHN, It is recommended that a minimum hardness test be targeted at 200 BHN to provide additional margin when multiple post weld heat treatments of the piping are required.

In the final fabricated condition, hardness test results for Grade 91 and 92 piping and pressure-retaining piping components shall not be less than 180 BHN, and the maximum BHN shall not exceed the maximum permitted by the applicable base metal material specification. In the absence of any material specification hardness requirements, pressure-retaining piping components shall not exceed 250 BHN. Weld metal hardness test results for pressure-retaining welds for Grade 91 and Grade 92 shall not be less than 180 BHN, and the maximum shall not exceed 280 BHN.

In the event there is evidence of components being inter-critically heat treated (i.e., heated to a temperature at or above the material's lower critical temperature) during fabrication or stress relieving (e.g., from flame impingement) ASME B&PVC Section I, Table PW-39 Note (4) shall apply.

Certified material test reports (CMTRs) are required for all Grade 91 and 92 pressure-retaining and nonpressure-retaining piping components. The CMTR shall report the actual temperatures and times used for both the normalizing and tempering heat treatment cycles. CMTRs shall also provide a statement indicating that "normalizing and tempering was performed subsequent to (after) all hot bending or forming operations”.

### B1.1.3 REQUIREMENTS FOR FITTINGS

Fittings over 500 mm nominal diameter, except wye or lateral machined fittings, shall be seamless or shall be of welded fabrication with joints fully radiographed. Wye or lateral fittings and fittings 500 mm nominal size and smaller shall be seamless.

Flanges, fittings, and valves manufactured in the People's Republic of China shall meet following requirements:

- Manufacturer's quality system shall be in accordance with ISO 9001 and the manufacturer shall hold a valid ISO 9001 certificate issued by the certified ISO 9000 certification organization.

- Manufacturer shall hold a manufacturer's license issued by the China Special Equipment Inspection & Research Center (CSE1) under General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (AQSIQ).

- Products shall have markings as required by ASME B16.1, ASME B16.5, ASME B16.9, ASME B16.10, ASME B16.11, ASME B16.25, or ASME B16.34 as applicable.

- The final quality certificate and quality inspection documents shall bear the official stamp of CSEI or AQSIQ or its branches.

Individual parts shall be manufactured to standard sizes and gauges so that repair parts furnished at any time can be installed in the field. Like parts of duplicate units shall be interchangeable.

### B1.1.4 ADDITIONAL REQUIREMENTS FOR VALVES

Positive Material Identification (PMI) of valve bodies and all external welded pressure retaining components and weld deposits is required. For Grade 91, analysis shall be performed for chromium (Cr), molybdenum (Mo), and vanadium (V). For Grade 92, analysis shall be performed for chromium (Cr), tungsten (W), molybdenum (Mo), and vanadium (V) The acceptance criteria for each required element is the range specified by the applicable material or welding consumable manufacturing standard.

PMI should preferably be performed prior to post weld heat treatment (PWHT). When preparing the surface for PMI testing, care shall be taken not to violate minimum wall thickness requirements. Any area abrasively cleaned for PMI testing shall be smoothly blended, without rough grinding marks or gouges.

A report identifying the valve, components and weld deposits shall be provided with the valve.

## B1.2 REQUIREMENTS FOR SEAMLESS PIPE AND TUBE COLD AND HOT BENDS

### B1.2.1 GENERAL

The restrictions specified herein apply to cold and hot bending requirements for ASTM A335 / A213 or ASME SA-335 / A213 Grade 91 and 92 pipes and tubes.

Pipe bending will be permitted as specified herein, and the following requirements. Bending methods, equipment, and post bending controls including heat treatment shall be subject to review by the Employer.

Cold bending will be permitted in accordance with section B1.2.2.1. The Contractor's cold bending procedures shall be submitted to the Employer prior to bending.

Bend surfaces shall be free of cracks. Limits on buckling pipe shall be in accordance with PFI Standard ES-24. Allowable flattening, as defined by ASME B31.1, shall not be greater than 10 percent of the average measured outside diameter of the straight pipe before bending, unless specified otherwise on the Employer's drawings. The final pipe bend diameter, completed pipe ovality calculations, and measurements for each end of each bend shall be documented and shall be provided to the Employer when requested.

The Contractor shall provide allowance for outside of bend thinning and inside of bend thickening of pipe wall, in accordance with the requirements of ASME B31.1, to ensure that the actual wall thickness after bending is not less than the minimum wall thickness required by the Code for extrados, intrados, and straight pipe locations, plus the Employer's required additional thickness ("A" value). If the wall thickness specified Is a schedule wall thickness, the Contractor may take credit for the manufacturing tolerance applicable to the material specified, less the Employer's additional thickness allowance requirement ("A" value), to achieve the minimum wall thicknesses of the straight pipe, intrados, and extrados, which must be maintained in the completed fabrication.

### B1.2.2 BENDING OF SEAMLESS PIPE AND TUBE, GENERAL REQUIREMENTS

Cold bending of Grade 91 and 92 materials, as defined herein, refers to any forming operation that is performed at a temperature 700°C and lower.

The Contractor's cold bending procedures shall be submitted to the Employer prior to bending.

Hot bending of Grade 91 and 92 materials, as defined herein, refers to the applied temperature during any forming operation that exceeds 700°C.

Pipe larger than 100 mm NPS shall be bent by hot bending using the Induction heating (incremental) bending method only. Other bending methods shall not be permitted above this size. All other piping materials may be bent by other methods if approved by the Employer.

A complete record of the pipe temperature during fabrication of each hot bending operation shall be made by means of a recording pyrometer.

No girth welds shall be located in the bend radius location.

Before the pipe is loaded into the machine, it shall be visually examined for cracks, gouges, nicks, abrasions, or other defects. Inside and outside surfaces shall be cleaned and free of foreign materials that might be detrimental to the material during bending.

The pipe to be bent shall be identified by the machine operator as to the material specification, type or grade, size, schedule, and heat number to ensure that it matches the material specified on the design drawing.

The pipe should be loaded into the machine so that the thickest quadrant will lie in the extrados (i.e., outside of bend).

When supplementary heating is used during bending, the maximum allowable temperature during heating and bending shall be verified using a calibrated optical pyrometer, temperature indicating crayons, or other Employer-approved measurement method. Heating shall be uniform throughout the circumference of the pipe.
Silica-bearing till media is prohibited, and all proposed fill materials shall be proven silica-free by ultimate analysis test. The use of fill material is subject to prior written approval by Employer.

A detailed procedure used to control each hot bending or cold bending method and post bending heat treatment shall be submitted to the Employer for review prior to performing bending operations. The bending procedure shall also include precautions for preparation and handling of Grade 91 and 92 piping materials after hot bending and during transfer of bends to the furnace for performing the normalizing and tempering heat treatments. The piping shall be positioned or protected in the furnace to preclude any direct flame impingement or temperature hot spots on the piping materials.

A detailed report of bending results shall be submitted for each bend used to qualify a bending procedure. As a minimum, the qualification reports shall include intrados and extrados bend UT wall thickness verification at 10 degree intervals plus 75 mm of straight tangent pipe on each side of the bend.

### B1.2.2.1 REQUIREMENTS FOR COLD BENDS

The minimum bend radius for pipe shall be in accordance with the requirements of Table B1.2.2.1-1. The minimum bend radius is defined as the centerline bend radius and is expressed in terms of the quantity of diameters of the nominal pipe size.

| **Table B1.2.2.1-1** | | |
|---|---|---|
| **Applicable Pipe Materials, Sizes, and Minimum Bend Radius** | | |
| **ASME P-No. or Equivalent / (Grade)** | **Nominal Pipe Size** | **Minimum Bend Radius** |
| Grades 91 and 92 | ≤100 mm | 3D |

All cold bending shall be performed by the rotary draw bending method utilizing an internal mandrel as necessary to maintain the tolerances defined.

The temperature while bending shall be more than 100°C below the material lower critical temperature, as specified in Table B1.2.2.1-2. If necessary, the pipe shall be preheated to ensure that it is above the ductile-brittle transition temperature range to prevent brittle fracture during the bending process.

Table B1.2.2.1.2

| Grade | Approximate Lower Critical Temperature | Maximum Temperature (during heating and bending) (Note 1) |
|---|---|---|
| Grade 91 and 92 | 800°C | 700°C |

Notes:

1. When supplementary heating is used during bending, the maximum allowable temperature during heating and bending shall be verified using a calibrated optical pyrometer, temperature indicating crayons, or other Employer-approved measurement method. Heating shall be uniform throughout the circumference of the pipe.

## B1.2.2.2 REQUIREMENTS FOR HOT BENDS

A complete record of the pipe temperature during forming of each hot bend shall be made by means of a recording pyrometer.

To minimize the potential for micro fissuring, the maximum material temperature during bending should not exceed 900°C at the extrados and 1,100°C at the intrados.

## B1.2.2.3 POST BEND HEAT TREATMENT REQUIREMENTS

Contractor shall implement written practices to ensure that each specific component receives the required post bend heat treatment (PBHT) (as applicable). Full traceability, including PBHT of each component, is required. The practice shall include proper identification of components prior to and after heat treatment (e.g. maintaining heat treatment traceability to each specific component). Contractor shall submit the written practice to Employer for review.

### B1.2.2.3.1 Practices for Post Bend Heat Treatment

The components shall be positioned or protected in the furnace to preclude any direct flame impingement or temperature hot spots on the piping materials.

Prior to the post bending heat treatment, the bend shall be sufficiently supported to prevent overstressing the bend if the bend is to be moved or otherwise loaded. Post bending heat treatment of Grade 91 and 92 piping materials should be accomplished within 7 days of post bending completion. Bends that are awaiting a post bending heat treatment shall be stored in a dry location or otherwise protected to avoid exposure to moisture until the post bend heat treatment is performed. Cold bending of these materials is not permitted under any circumstance.

Prior to the post bending heat treatment, thermocouple wire shall be temporarily attached directly to the piping using the capacitor discharge method of welding. Thermocouple wire shall be attached at various locations on the piping bends to ensure uniform recording of the normalizing and tempering heat treatments. One thermocouple wire shall be attached to the pipe in a location nearest to the closest furnace burner.

With prior approval of Employer, PWHT may alternatively be performed without attached thermocouples, in a furnace where the furnace work zone has been surveyed for temperature uniformity within the last 6 months. When this option is permitted by Employer, a minimum of two thermocouples are required at opposite ends of the furnace, and all components being heat treated shall be loaded entirely within the previously surveyed furnace work zone.

A time-temperature recording chart/record traceable to the post bending heat treatment hot bend for Grade 91 and 92 piping materials shall be made for all post bending heat treatments and shall be made available to the Employer when requested.

### B1.2.2.3.2 Post Bend Heat Treatment Requirements of Grade 91 and 92 Cold Bends

PBHT of cold bends shall be performed in accordance with the requirements in Table B1.2-1.

**Table B1.2-1**

| Forming Strain | Operating Temperature | PBHT |
|---|---|---|
| ≤5% | All | Not required |
| >5%, ≤20% | All | Yes, Stress in accordance with Note A.1 |
| >20%, ≤35% | ≤ 600°C | Yes, Stress in accordance with Note A.1 |
| >20% | > 600° C | Yes, normalized and tempered (N&T) in accordance with Note A.2 |
| >35% | ≤ 600°C | Yes, N&T in accordance with Note A.2 |
| All cold swages and upsets | All | Yes, N&T in accordance with Note A.2 |

Forming strain (percent) of pipe bends is calculated based on the following formula:

$$\frac{r}{R} \text{x100}$$

Where:
r is the nominal outside radius of the pipe.
R is the nominal bending radius to the center line of the pipe.

Note: Bend radius is specified by the product of a specific number of nominal pipe diameters (e.g., bend radius of three diameters for 50 mm pipe = 3 x 50 = 150 mm).

A.1 PBHT by stress relieving the cold strained area or entire component: 750°C to 770°C, 30 minutes minimum. Alternatively, when welds are included with the bend piping spool, the PBHT/PWHT may be performed in accordance with PWHT requirements specified in Article 131.4.5.5. In lieu of stress relief, the vendor has the option to normalize and temper in accordance with Note A.2.

A.2 After bending (or forming of swages or upsets) is complete, the entire component shall be normalized (followed by air cooling) to a temperature less than 95°C and then tempered at a temperature not to exceed 780°C. Normalizing requires heating the component within the temperature range of 1,040°C to 1,080°C, holding at temperature for an appropriate time, followed by prompt removal from the furnace to allow the component to cool in still air at ambient temperature. The Contractor shall perform the normalizing and tempering heat treatment of bends in accordance with the applicable option provided below:

Option 1: The normalizing and tempering heat treatment shall be performed using the same temperature and hold time as specified on the CMTR for the material, except that the tempering heat treatment temperature shall not exceed 780°C.
Option 2: The bends shall be normalized within the temperature range of 1,040°C to 1,080°C, and held at temperature 1 hour per inch of thickness (30 minutes minimum, 2 hours maximum), followed by prompt removal from the furnace to allow the component to cool to less than 95° F in still air at ambient temperature. Tempering shall be performed at 760°C ±15°C, and held at temperature 1 hour per 25 mm of thickness (30 minutes minimum, 2 hours maximum).

Option 3: The Contractor may submit its proposed normalizing and tempering heat treatment procedure to the Employer for review prior to performing the post bend heat treatment.

Normalization requires cooling at a rate equivalent to removing the component from the furnace and allowing the component to cool in air at ambient temperature. The component shall be allowed to cool to less than 100°C prior to tempering.

A time-temperature recording chart/record that is traceable to the PBHT for all furnace runs and bends is required and shall be made available to Employer when requested (refer to Article B1.2.2.3).

**B1.2.2.3.3 Post-Bend heat treatment requirements for Grade 91 and 92 hot bends**

The entire component shall be normalized and tempered utilizing the same heat treatment parameters specified in Table B1.2-1, Note A.2, for cold bends.

Comment: For the cooling step during the normalization cycle, materials with wall thicknesses exceeding 75 mm may require accelerated cooling to obtain a fully martensitic microstructure as part of the normalization process. The use of accelerated cooling methods besides air shall require prior written approval by Employer.

Prior to PBHT, the bend shall be sufficiently supported to prevent overstressing the bend if the bend is to be moved or otherwise loaded. PBHT should be accomplished within 7 days of post bending completion. Bends that are awaiting a PBHT shall be stored in a dry location or otherwise protected to avoid exposure to moisture until PBHT is performed. Cold bending of these materials is not permitted under any circumstance.

## B1.2.3 EXAMINATION AND TESTING

All examination and testing shall be performed in accordance with the methods specified in the referenced code and any supplemental examination and testing specified herein.

All required examinations and tests shall be performed and documented.

All rejects shall be repaired or replaced as necessary. Replaced product shall be identified and controlled to prevent its unintended use or delivery. Records of the nature of nonconformities and any subsequent actions taken, including concessions obtained, shall be maintained

Table B1.2-2

Summary of Testing Requirements and Frequency for Pipe

| **Test** | **B1.2 Article** | **Examination Frequency and Notes, Grades 91, 92** |
|---|---|---|
| Visual | B1.2.3.5 | All |
| Thickest quadrant wall check and weld seam before bending | B1.2.2 | Note 1 |
| Wall thickness before bending | B1.2.2 | All |
| Wall thickness after bending | B1.2.3.4 | All |

| | | |
|---|---|---|
| Ovality | B1.2.1 | All |
| WFMP | B1.2.3.2, B1.2.3.3 | All |
| Miscellaneous tolerances | B1.2.1 | 5 |
| Hardness | B1.2.3.1 | All, Note 4 |

Notes:
1. All completed pipe bends shall be checked, but data is not required to be recorded.
2. Not used.
3. Not used.
4. Hardness testing is required only if elevated temperatures are used during the bending operation or if bends have been post bend heat treated.
5. Miscellaneous tolerances identified in Article B1.2.1 shall be checked, but data is not required to be recorded.

### B1.2.3.1 HARDNESS TESTING OF BENDS AFTER HEAT TREATMENT

To verify that satisfactory post bending heat treatment of bends has been accomplished for Grade 91 and 92 piping materials, the Contractor/Installer shall perform Brinell Hardness Tests or an acceptable equivalent hardness test (e.g., Krautkramer, MIC 10, or MIC 20) on completed hot bends as specified below. Hardness testing shall be performed in accordance with a written procedure. The written procedure for performing the hardness testing shall be submitted for review by the Employer prior to use. The test preparation and hardness tests shall not reduce the section pipe wall thickness below the minimum required by design. Refer to the following:

Hardness Test for Hot Bends: Hardness tests shall be performed at both tangent areas at the end of the bend and at the mid-bend area. A total of four locations, one test at each 90 degree Increment around the pipe bend, shall be hardness tested and shall include the intrados and extrados at each test area. A total of four hardness tests shall be performed at each of the three different areas (12 tests total). For hardness test acceptance, all of the resulting hardness tests shall be within the range of 180 BHN to 250 BHN Any hardness test that is not acceptable may be retested. A retest shall consist of three additional areas selected as close as practical to the location that was not acceptable. For hardness test retest acceptance, all of the resulting hardness tests shall be within the range of 180 BHN to 250 BHN. If the results of the hardness retests are unacceptable, it is Contractor's obligation to show by calculation or other methods that the material is still acceptable for the intended Service Life., otherwise a nonconformance report documenting the hardness test failure location, bend configuration, post bending heat treatment for the bend, test results, and proposed disposition shall be submitted to the Employer for review.

Hardness Test for Hot Bend Field Weld End Preparation(s).: Hardness tests shall be performed on the piping field weld end preparation for all hot bend end preparations that are required to be field welded. At a location approximately 1 inch from the face of the weld end preparation, a total of four locations shall be tested at each 90 degree increment around the pipe. A total of four hardness tests shall be performed. For hardness test acceptance, all of the resulting hardness tests shall be within the range of 180 BHN to 250 BHN. Any hardness test that is not acceptable may be retested. A retest shall consist of three additional areas selected as close as practical to the location that was not acceptable. For hardness test retest acceptance, all of the resulting hardness tests shall be within the range of 180 BHN to 250 BHN. If the results of the hardness tests are unacceptable, a nonconformance report documenting the hardness test failure location, test results, and proposed disposition shall be submitted to the Employer for review.

Note: Even though the minimum hardness tests stated above are 180 BHN, It Is recommended that a minimum hardness test be targeted at 200 BHN to provide additional margin when multiple post weld heat treatments of the piping are required.

Surface hardness measurements of bends are only required if external heat is applied at any time during bending or if bends have been post bend heat treated. Hardness testing shall be conducted with a telebrineller, MIC 10/20 UCI, or other Employer-approved device. A test bar of approximate hardness of the specimen to be tested shall be used.

As required in Section B1.2.2.1, hardness testing shall be performed on completed bends at each of the following three locations: at the midpoint of the intrados, the extrados, and the neutral axis. The acceptance criteria for various material grades are specified In Section B1.2.2.1. For completed bends that have hardness readings outside of the specified range (Table B1.2.2.1-1), a nonconformance report (NCR) and proposed disposition shall be submitted to Employer for review and approval. Bends shall be re-hardness tested alter any subsequent heat treating.

### B1.2.3.2 SURFACE EXAMINATION

For Grade 91 and 92 materials, the wet fluorescent magnetic particle (WFMP) examination method shall be performed for all required surface examinations specified herein.

WFMP shall be performed in accordance with the ASME B&PVC, Section V, Article 7.
WFMP examination shall be performed at all locations where defects have been repaired.

An additional WFMP examination shall be performed after heat treatment on any completed bends that have required such heat treatment because of excessive hardness, as defined in Article B1.2.3.1.

#### B1.2.3.3 WET FLUORESCENT MAGNETIC PARTICLE EXAMINATION

The Contractor shall perform WFMP examination of the extrados of Grade 91 and Grade 92 pipe bends after the post bending heat treatment as follows.

A band width of not less than the pipe diameter x 0.4, but not to exceed 300 mm, and a minimum bend arc length of 45 degrees shall be examined. The examination area shall be approximately centered on the pipe extrados and the band length, approximately centered at the mid-bend location. A minimum of two pipe bends shall be examined for every essential variable change Essential variables are defined as a change in any of the following: pipe diameter, wall thickness, bend radius, material type and heat number, and bending process parameter change including temperature, force, speed, and cooling method. The examined area is determined acceptable if it is free from cracks, micro fissures (micro cracks), and laps. If any pipe bend has unacceptable discontinuities, then all pipe bends having the same essential variables shall be subject to 100 percent examination comprising the entire bend extrados, and a nonconformance report documenting the test results and the proposed disposition shall be submitted to the Employer for review. The results of the WFMP shall be documented and shall be provided to the Employer when requested.

#### B1.2.3.4 ULTRASONIC EXAMINATION

The Contractor shall perform an ultrasonic examination (UT) minimum wall thickness measurement on all completed Grade 91 and Grade 92 pipe bends. The UT minimum wall thickness measurements shall be performed on the intrados and extrados at both tangent areas at the end of the bend and at the mid-bend area. A total of three areas on the intrados and a total of three areas on the extrados shall be examined. The results of the UT minimum wall thickness measurements shall be documented and shall be provided to the Employer when requested.

#### B1.2.3.5 VISUAL EXAMINATION

All completed bends shall be visually examined and shall be free of cracks, laps, and gouges.

All completed bends shall be visually examined to ensure that they are smooth, without buckles, and truly circular. All bends shall be "substantially free" of buckling irregularities such as wrinkles, bulges, and kinks, as defined herein.

### B1.2.4 RECORDS

Records of all inspections, nondestructive examination (NDE), hardness testing, heat treatment charts or records, base material test reports, deviation requests including resolution documentation, NCRs, and other records shall be retained by Contractor for 5 years after completion of the work, Records shall be submitted to Employer, if requested.

Quality records, including applicable Data Report Forms generated by a manufacturer or assembler in accordance with an approved Quality Control System and applicable Certificates of Authorization from the fabrication code shall be provided in accordance with the approved contract or purchase order. Quality records shall be legible, appropriately completed, and sufficiently detailed to permit traceability to the item or activity involved.

## B1.3 GENERAL FABRICATION REQUIREMENTS

### B1.3.1 GENERAL

The requirements herein apply to similar and dissimilar material combinations of Grade 91 and 92 materials. Article B1.3 shall be used in conjunction with the other articles herein.

### B1.3.2 WELDING PROCESSES REFER TO ARTICLE B1.4.2

### B1.3.3 WELDING PROCEDURE QUALIFICATION

Welding procedures shall be prepared and qualified in accordance with ASME Section IX. Unless otherwise specified, each manufacturer or contractor is responsible for conducting the tests required by the referenced code to qualify the Welding Procedure Specification (WPS).

WPSs and applicable Procedure Qualification Records (PQRs) shall be submitted for review by Employer prior to start of fabrication. Submittal of welding procedures and applicable PQRs shall apply to all contractors and subcontractors. Contractors shall review the documents in accordance with the applicable code and specification requirements and shall accept all of their subcontractors' welding procedures and applicable PQRs prior to submitting accepted documents to Employer.

### B1.3.4 WELDER/WELDING OPERATOR PERFORMANCE QUALIFICATION

Welders and welding operators shall be qualified In accordance with the referenced code. The welder and welding operator qualification records shall be available at the shop facility or construction site and shall be made available for review when requested.

Field personnel not qualified and certified as welders or welding operators are prohibited from performing any welding activities such as tack welds, temporary welds, permanent welds, manufacturing aids, tools, fixtures, or other welded items. The only field personnel not qualified or certified as welders or welding operators who are permitted to perform welding are personnel completing welding training or performing welding performance qualification testing required by the applicable referenced code or specification.

Shop personnel not qualified and certified as welders or welding operators are prohibited from performing any welding activity on materials designated for permanent or temporary installation by the contract, such as tack welds or temporary welds.

Welders and welding operators qualified for GMAW short-circuit arc transfer using a CV power supply shall not qualify a welder or welding operator for GMAW using a controlled variation of short-circuit arc transfer by a power supply other than CV or vice versa.

Each manufacturer or contractor is responsible for the qualification of welders or welding operators. Welder or welding operator performance qualification testing shall be performed under the full supervision and control of the manufacturer or contractor.

## B1.3.5 FILLER MATERIALS

### B1.3.5.1 FILLER MATERIAL CONTROL

Storage, handling, and drying of SMAW electrodes and SAW flux shall, as a minimum, be in accordance with the manufacturers' recommendations. In addition, SMAW low-hydrogen type electrodes shall be stored in ovens at 120°C minimum after the hermetically sealed or vacuum packed container is opened. Bare rod in straight lengths shall be individually flag tagged, stamped, or otherwise identified with the product classification. Each spool of solid or cored rod shall be tagged, labeled, or otherwise identified with the product classification. SMAW low-hydrogen type covered electrodes shall only be reconditioned one time. Any SMAW electrodes that have been wet or have damaged coatings shall not be used. Any welding filler metals or fluxes not readily identifiable shall not be used.

SAW fluxes shall be baked prior to use. This requirement does not apply for fluxes used within the same work shift after removal from a hermetically sealed package or container. Flux that is exposed to an atmospheric exposure limit exceeding one work shift shall be baked prior to use, unless the flux is placed in a heated container within 10 hours of issuance. After baking, fluxes should be stored in hermetically sealed containers or (preferably) stored in a heated container until issuance. Storage in a heated container or baking shall be in accordance with the flux manufacturer's directions.

A written procedure for storing, handling, issuing, and reconditioning electrodes, wires, and fluxes shall be submitted for review by Employer.

## B1.3.6 FABRICATION CONTROLS

Fabrication, assembly, and erection shall be in accordance with the construction code for the design of the item and the design documents.

### B1.3.6.1 NOT USED

### B1.3.6.2 POST WELD HEAT TREATMENT, PWHT SHALL BE IN CONFORMANCE WITH THE REQUIREMENTS OF ARTICLE B1.4

### B1.3.6.3 MISCELLANEOUS FABRICATION CONTROL REQUIREMENTS

Welding shall not be performed when surfaces of the parts to be welded are wet. The parts to be welded shall be protected from deleterious contamination and from rain, snow, and excessive wind during welding.

Prior to welding, the weld preparation and adjacent base material surfaces shall be cleaned and kept free from paint, oil, grease, dirt, scale, rust, and other foreign materials.

The weld end preparation on materials that will be stored for extended periods of time may consist of coating with deoxaluminate or an equivalent protective material. This coating may be welded through if applied within the manufacturer's maximum weldable limit of 1.25 mils. Complete removal of the coating is neither required nor prohibited, unless signs of rust or other foreign materials such as oil, grease, dirt, or excessive coating are apparent, in which case these areas shall be cleaned.

Acceptable cleaning solvents include new or redistilled acetone (acetone reclaimed by other methods shall not be used) alcohol (ethyl, methanol, or isopropanol), methyl ethyl ketone, or toluene (toluol). Halogenated cleaning solvents shall not be used for cleaning or degreasing.
All groove butt Joints shall be complete joint penetration unless specified otherwise by design documents or the applicable code. Partial penetration weld joints not specified by design shall require written approval by design engineering.

Tack welds that are to remain in the completed weld shall have their stopping and starting ends prepared by grinding or other suitable means for satisfactory incorporation Into the completed weld. Tack welds that are to become part of the completed weld shall be visually examined; defective tack welds, including cracked tack welds, shall be removed.

Complete penetration joints welded from both sides shall have the root of the first layer or pass chipped, gouged, ground, or machined to sound metal prior to welding from the second side. This requirement is not intended to apply to automated line processes, where the welding from the second side is controlled to provide adequate penetration and ensure full fusion without back gouging.

Welded joints shall be made by completing each weld layer before succeeding weld layers are deposited. Partial fill passes are permitted to correct localized underfill conditions and for the purpose of maintaining alignment. Block welding is prohibited.

As-welded surfaces are permitted; however, the surfaces of welds shall be uniform in width and size throughout their full length. The cover pass shall be free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys. The surface condition of the finished welds shall be suitable for the proper interpretation of nondestructive examination. If the surface of the weld requires grinding to meet the above criteria, care shall be taken to avoid reducing the weld or base material below the minimum required thickness.

All pressure retaining fillet weld joints other than socket welded joints that require a fillet weld size greater than 6 mm shall require a minimum of two weld layers, except for those fillet weld joints welded with a mechanized or automatic welding process.

Socket welds shall meet the following requirements within the welding process restrictions and limitations specified in the applicable Welding Technical Supplemental Specification section:

- A minimum of two weld layers is required for pipe or tube over 5 mm nominal wall thickness.
- For pipe or tube 13 mm or less in nominal pipe size, the GTAW process shall be used.

Welding slag and spatter shall be removed from all welds.

A gas or gas mixture used for shielding shall be welding grade or shall meet Specification SFA-5.32 and have a dew point of -40° C or lower.

Shop fabricators and Contractors shall check for residual magnetism at each end of the machined field pipe weld bevels. Weld bevels containing residual magnetism greater than 5 gauss shall be demagnetized.

Arc strikes outside of the area of permanent welds should be avoided on any base metal. Cracks or blemishes caused by arc strikes shall be ground to a smooth contour and checked to ensure soundness.

Peening is prohibited. The use of power tools for slag removal is not considered peening.

The application of heat to correct weld distortion and dimensional deviation without prior written approval from Employer is prohibited.

Complete Joint penetration welds welded from one side without backing, weld repairs welded from one side without backing, or weld repairs in which the base metal remaining after excavation is less than 5 mm from being through wall, which are fabricated from materials with an ASME P-number of 5B or higher or unassigned metals with similar chemical compositions, shall have the root side of the weld purged with an argon backing gas prior to welding. Unless otherwise specified, backing gas (purge) shall only be argon. The argon backing gas shall be classified as welding grade argon or shall meet Specification SFA-5.32, AWS Classification SG-A. The backing gas (purge) shall be maintained until a minimum of two layers of weld metal have been deposited.

A written procedure for root side purging shall be described in detail and shall be submitted concurrently with the welding procedures for review by Employer.

Temporary attachments to pressure boundary components outside the weld bevel groove area should be avoided and only used when absolutely necessary. When required, clamps, welded clips, tack welds, or other appropriate means shall be used to properly align the joint for welding. Welded attachments used for fit-up shall be compatible with the base material and shall be welded with a qualified welding procedure. Attachments shall not be knocked off base material. The attachments shall be removed by suitable methods, such as grinding, machining, or sawing, followed by grinding flush with the base material. When thermal cutting is used to remove attachments, approximately 7 mm of material shall be left for final removal by grinding. The ground area shall then be visually examined for defects. The area from which attachments have been removed shall be examined as required by the governing code or specification. Any defects found shall be repaired.

All defects in welds or base materials shall be removed and repaired in accordance with the referenced code.

Welding machine ground leads and clamps shall be located to avoid passing welding current through equipment, snubbers, bearings, or any other items where transfer of electrical current may result in damage to equipment.

A complete repair procedure for repairs that are documented as the basis of a nonconformance report shall be submitted to Employer for review and approval in writing prior to performing the repair. If repair by welding is required, the applicable WPSs and supporting PQRs shall be submitted with the repair procedure. All nonconformance report dispositions shall comply with applicable code requirements.

## B1.3.7 NONDESTRUCTIVE EXAMINATION

All NDE shall be performed in accordance with the methods specified in the referenced code.

Except for final visual examination, which is required for all welds, the responsible Contractor's Certified Welding Inspector (CWI) shall perform in-process visual inspections at suitable intervals during the fabrication and erection process to ensure the applicable requirements of the referenced code, design specification, and WPS are met. Such inspections, on a sampling basis, shall be performed prior to assembly, during assembly, and during welding.

NDE shall be performed in accordance with written procedures that are prepared in accordance with the referenced code and as specified herein. NDE procedures other than for visual examination shall be approved by a qualified and certified NDE Level III. The NDE Level Ill approval shall be shown on the

### B1.3.7.1 NDE PROCEDURE

NDE procedures shall be submitted for review by Employer prior to their use.

NDE personnel performing NDE other than visual shall be qualified and certified for the applicable NDE method. Personnel shall meet written practice ASNT SNT-TC-1A, unless permitted otherwise by the referencing code or prior written approval from Employer is obtained. NDE personnel qualification records shall be made available for review when requested.

Personnel performing or supervising the visual examination of welds, including ASME Boiler and Pressure Vessel components, shall be qualified as a CWI in accordance with the American Welding Society AWS QC 1 or previously approved equivalent program as determined by Employer. Visual inspectors' qualifications and certificates shall be submitted for review and verification.

All welds shall receive 100 percent visual examination. Visual Inspection of welds shall be performed prior to any painting, coating, or galvanizing. Visual weld examination acceptance criteria and other NDE acceptance criteria shall be in accordance with applicable referenced codes and design documents.

Records of these examinations shall be documented.

The NDE results shall be provided in a NDE Report that is evaluated, interpreted, and accepted by a Level II or Level III NDE personnel.

Contractor shall obtain and pay for the services of an independent testing laboratory to provide the required field nondestructive examination. Any defective weld shall be removed, repaired, and retested at the Contractor's expense.

Employer may order NDE by an independent laboratory in addition to any examinations specified herein. The NDE type, extent, and method shall be the same as that required for the original weld. If the weld is defective, the laboratory costs shall be paid by the Contractor. If the weld is not defective, the laboratory costs will be paid by Employer. Repair of defective welds and reexamination shall be at the Contractor's expense. Weld acceptance standards shall be in accordance with applicable codes and design specifications. If an individual Interpretation is in question, the final authority shall be the responsibility of Employer.

### B1.3.8 RECORDS

Records of inspections, NDE, impact testing, hardness testing, PWHT charts or records, base material test reports, filler material test reports, radiographic film with applicable reader sheets, deviation requests including resolution documentation, nonconformance reports, and other records, as required, shall be retained by the Contractor for 5 years after completion of the work. Records shall be submitted, if requested.

Quality records, including applicable Data Report Forms generated by a manufacturer or assembler in accordance with an approved Quality Control System and applicable Certificates of Authorization from the ASME Boiler & Pressure Vessel Code, shall be provided in accordance with the approved contract or purchase order. Quality records shall be legible, appropriately completed, and sufficiently detailed to permit traceability to the item or activity involved.

## B1.4 MISCELLANEOUS REQUIREMENTS FOR FABRICATION INCLUDING WELDING RESTRICTIONS, POST WELD HEAT TREATMENT, AND TESTING

### B1.4.1 GENERAL

This article provides miscellaneous fabrication requirements for welding Grade 91 and Grade 92 materials. This article shall be used in conjunction with Articles B1.3, B1.5, and B1.6 of this document, as applicable.

## B1.4.2 WELDING PROCESSES

Permitted welding processes shall be as specified and shall include the additional restrictions and limitations as specified herein.

### B1.4.2.1 WELDING PROCESS RESTRICTIONS AND LIMITATIONS

The Gas Metal Arc Welding (GMAW) process shall not be used.

The weld progression for manual or semiautomatic vertical position welds shall be uphill. The Flux Cored Arc Welding (FCAW) process shall only be used with shielding gas.

The FCAW process shall not be used for root pass applications in single welded complete penetration weld joints without backing or without back gouging and back welding.

The Shielded Metal Arc Welding (SMAW) process shall not be used for root pass applications in single welded complete penetration weld joints without backing or without back gouging and back welding, unless approved by Employer.

Welding procedure qualification with the Submerged Arc Welding (SAW) process is restricted to that flux used in the welding procedure qualification test. Any change in the flux trade name or designation shall require a new welding procedure qualification.

## B1.4.3 FILLER MATERIAL

### B1.4.3.1 FILLER MATERIAL FOR WELDING GRADE 91 AND GRADE 92

Welding filler metal shall comply with the requirements of the referenced code and any modified requirements specified herein. The filler metal shall be as specified in the applicable WPS.

Unless otherwise specified, the welding filler metal for welding similar base metal types shall have a chemical composition as similar as possible to the base materials to be welded. The finished weld as deposited, or after post weld heat treatment (PWHT) when required, shall be at least equal to the base metal's minimum specified properties or characteristics as they pertain to strength, ductility, notch toughness, corrosion-erosion resistance, or other physical or thermal properties.

Unless otherwise approved in writing, the GTAW or PAW process shall require the addition of filler metal.

Unless otherwise specified or permitted by an approved deviation request, the use of the — G electrode/wire classification is prohibited. When permitted, welding procedures specifying "G" classification consumables shall be restricted to the same manufacturer and brand-name consumable used to weld the procedure qualification test coupon. The manufacturer and brand name shall be listed on the WPS and PQR. The manufacturer's standard, including the mechanical properties and chemical analysis, along with the request for using non-AWS classification or "G" classification consumables shall be submitted to Employer prior to fabrication.

When using the SAW process, the flux listed in the WPS Is restricted to the specific brand-name flux used in the welding procedure qualification test. Any change in the flux brand name or designation shall require a new welding procedure qualification. For SAW welding using nickel-based alloy consumables, only those fluxes specified by the flux manufacturer as suitable for the particular type of high alloy electrode to be used are permitted.

The SAW process shall not use recrushed slag.

SMAW low-hydrogen type electrodes, including stainless steel and nickel and nickel alloy electrodes, shall be purchased in hermetically sealed or vacuum packed containers only.

Welding filler metal shall comply with the requirements of the referenced code and any modified requirements specified herein. The filler metal shall be as specified in the applicable Welding Procedure Specification (WPS).

### B1.4.3.2 FILLER MATERIAL FOR WELDING GRADE 91 AND 92

For welding of Grade 91 material to itself, the filler metal and applicable welding process to be used shall be in accordance with the following:

| ASME Specification | Filler Metal Classification | Welding Process |
|---|---|---|
| SFA-5.28 | ER90S-B9 | Gas Tungsten Arc Welding (GTAW) |
| SFA-5.23 | E89 | SAW |
| SFA-5.5 | E9015.69 | SMAW |
| SFA-5.29 | E91T1-B9M<br>Only manufacturers: Metrode, Bohler Welding Group, ESAB, and Midalloy are permitted | FCAW |

Filler materials for welding Grade 91 materials shall be purchased with a Certified Material Test Report (CMTR), Certified Report of Test, or equivalent Material Test Report that provides the actual test results for the following required tests. All tests and their acceptance shall be performed in accordance with the applicable SFA specification. The CMTR, Certified Report of Test, or equivalent Material Test Report shall be submitted for review by Employer and shall be available for review at the shop facility or construction site when requested The required tests and post weld heat treatment (PWHT) for the subject filler metals shall include the following:

| Filler Metal Test Requirements | GTAW Process (1) | SMAW Process (2) | SAW Process (1) | FCAW Process (3) |
|---|---|---|---|---|
| Report Chemical Analysis | Required | Required | Required | Required |
| Report Tensile/Yield Strength | Not Required | Required | Not Required | Required |
| Report PWHT at 760° C ±15° C | Not Required | Required | Not Required | Required |
| Report Soundness Test | Not Required | Not Required | Not Required | Required |
| Report Mn + Ni, wt % | <1.5 | <1.5 | <1.5 | <1.5 |
| Diffusible Hydrogen Designator | Not Required | H4 Required | Not Required | H8 Required |

Notes:

1. The actual test results shall be documented in the CMTR for each heat number for filler materials used with the GTAW or SAW process.

Chemical analysis shall meet the SFA Specification. In addition to meeting the chemical composition requirements of the SFA Specification, the Mn + Ni shall be <1.5 weight percent.

8. The actual test results shall be documented in the CMTR of each electrode size and lot number for filler materials used with the SMAW process.

For the SMAW process, in lieu of or in addition to the 'Table 5 Required Tests' specified in the SFA Specification, testing shall be conducted in accordance with the SFA Specification to determine the chemical analysis and tensile/yield strength. The chemical analysis and tensile/yield strength shall meet the SFA Specification. In addition to meeting the chemical composition requirements of the SFA Specification, the Mn + Ni shall be <1.5 weight percent.

PWHT shall be performed in accordance with the parameters specified below. The PWHT temperature and holding requirements below shall be shown in the CMTR.

PWHT shall be performed as follows:

PWHT Temperature: 7600 C ±15°C.
Holding Time: 2 hours minimum.

8. Only classification (E91T1-B9M) manufactured by Metrode, Bohler Welding Group, ESAB, or Midalloy and supplied in accordance with this specification is permitted.

The actual test results shall be documented in the CMTR of each electrode size and lot number for filler material used with the FCAW process.

For the FCAW process, testing shall be conducted in accordance with SFA Specification to determine the chemical analysis, tensile/yield strength, and soundness. The chemical analysis, tensile/yield strength, and soundness shall meet the requirements of the SFA Specification. In addition to meeting the chemical composition requirements, the Mn + Ni shall be <1.5 weight percent.

The welding parameters to be used for the weld test assembly shall be as follows

Current/Polarity: DCRP.
Shielding Gas: 75-80%, Ar/bal $CO_2$.

PWHT shall be performed in accordance with the parameters specified below. The PWHT temperature and holding requirements below shall be shown in the CMTR:

PWHT Temperature: 760° C ±15° C.
Holding Time: 2 hours minimum.

### B1.4.3.3 FILLER MATERIAL FOR WELDING GRADE 92

For welding of Grade 92 material to itself or to P-No. 5B or Grade 91 material, the filler metal and applicable welding process to be used shall be In accordance with the following:

Note: Only the following Manufacturers and Trade Names may be used for the process specified. The following filler metals are classified with the General ("G") designation In the applicable SFA Specification.

| ASME Specification | Filler Metal Classification | Welding Process |
|---|---|---|
| SFA-5.28 | ER90S-G<br>Manufacturer: Bohler Welding Group<br>Trade Name: Thermanit MTS 616 or<br>Manufacturer: Metrode<br>Trade Name: 9CrWV | GTAW |
| SFA-5.23 | EG<br>Manufacturer: Bohler Welding Group<br>Trade Name: Thermanit MTS 616 with Thyssen Marathon 543 flux or<br>Manufacturer: Metrode<br>Trade Name: 9CrWV with Bavaria Schweisstechnik W P-380 flux | SAW |
| SFA-5.5 | E9015-G<br>Manufacturer: Bohler Welding Group<br>Trade Name: Thermanit MTS 616 or<br>Manufacturer: Metrode<br>Trade Name: Chromet 92 | SMAW |
| SFA-5.29 | E91T1-G<br>Manufacturer: Metrode<br>Trade Name: Supercore F92 | FCAW |

Filler materials for welding Grade 92 material shall be purchased with a CMTR, Certified Report o Test, or equivalent Material Test Report that provides the actual test results for the following required tests. All tests and their acceptance shall be performed in accordance with the applicable SFA Specification and the Manufacturers Trade Name Standard, where specific requirements are not provided for the "G" classification. The CMTR, Certified Report of Test, or equivalent Material Test Report shall be submitted for review by Employer and shall be available for review at the shop facility or construction site when requested.

The required tests and PWHT for the subject filler metals shall include the following:

| **Filler Metal Test Requirements** | **GTAW Process (1)** | **SMAW Process (2)** | **SAW Process (1)** | **FCAW Process (3)** |
|---|---|---|---|---|
| Report Chemical Analysis | Required | Required | Required | Required |
| Report Tensile/Yield Strength | Not Required | Required | Not Required | Required |
| Report PWHT at 760°C ±15° C | Not Required | Required | Not Required | Required |
| Report Soundness Test | Not Required | Not Required | Not Required | Required |
| Report Mn + Ni, wt % | <1.5 | <1.5 | <1.5 | <1.5 |
| Diffusible Hydrogen Designator | Not Required | H4 Required | Not Required | H8 Required |

Notes:

1. The actual test results shall be documented in the CMTR for each heat number for filler materials used with the GTAW or SAW process.

   Chemical analysis shall meet the Manufacturers Trade Name Standard. In addition to meeting the chemical composition requirements, the Mn + Ni shall be <1.5 weight percent.

   8. The actual test results shall be documented in the CMTR of each electrode size and lot number for filler materials used with the SMAW process.

   For the SMAW process, testing shall be conducted in accordance with SFA-5.5 to determine the chemical analysis and tensile/yield strength. The chemical analysis shall meet the Manufacturers Trade Name Standard and the tensile/yield strength shall meet the SFA Specification. In addition to meeting the chemical composition requirements, the Mn + Ni shall be <1.5.

   PWHT shall be performed in accordance with the parameters specified below. The PWHT temperature and holding requirements below shall be shown in the CMTR.
   PWHT shall be performed as follows:
   PWHT Temperature: 760°C ±15° C.
   Holding Time: 2 hours minimum.

   8. Only Metrode Supercore F92 (E91T1-G) manufactured and supplied In accordance with this specification is permitted.

   The actual test results shall be documented in the CMTR of each electrode size and lot number for filler material used with the FCAW process.

   For the FCAW process, testing shall be conducted in accordance with SFA-5.29 to determine the chemical analysis, tensile/yield strength, and soundness. The chemical analysis shall meet the Manufacturers Trade Name Standard, and the tensile/yield strength and soundness shall meet the requirements of SFA-5.29. In addition to meeting the chemical composition requirements, the Mn + Ni shall be <1.5 weight percent.

   The welding parameters to be used for the weld test assembly shall be as follows:
   Current/Polarity: DCRP.
   Shielding Gas: 75-80%, Ar/bal CO2.

   PWHT shall be performed in accordance with the parameters specified below. The PWHT temperature and holding requirements below shall be shown in the CMTR:
   PWHT Temperature: 760° C ±15° C.
   Holding Time: 2 hours minimum.

### B1.4.3.4 FILLER MATERIALS OTHER THAN THOSE SPECIFIED HEREIN

Filler materials other than those specified herein shall be subject to the approval of Employer.

## B1.4.4 NOT USED

## B1.4.5 FABRICATION CONTROL

Fabrication, assembly, and erection shall be in accordance with the construction code and the design documents.

### B1.4.5.1 WELDING PREHEAT, INTERPASS TEMPERATURE, AND HEAT TREATMENT

The preheat and interpass temperature requirements are mandatory values and shall be in accordance with the referenced code and as specified herein. The W PS for the material being welded shall specify the minimum preheat and maximum interpass temperature requirements. The thickness used to determine preheat requirements shall be the thickness of the thickest part at the point of welding.

The minimum preheat temperature shall be obtained prior to any welding. This shall include tack welding or temporary tack welding.

Preheating shall provide uniform heating over the complete weld or thermal removal process area.

Preheat and interpass temperatures shall be monitored and checked by temperature indicating crayons, thermocouples (TCs), surface contact pyrometers or thermometers, or other suitable methods.

### B1.4.5.2 WELDING PREHEAT, INTERPASS TEMPERATURE, AND HEAT TREATMENT FOR GRADE 91 AND GRADE 92 MATERIALS

Preheat shall be 200°C minimum to 425°C maximum in all areas in which preheating is applied.

The maximum interpass temperature shall be 315° C. Welding shall only be performed within the temperature range of 200°C minimum to 315°C maximum.

#### B1.4.5.2.1 Preheating Method Limitations

The method of preheating shall be limited to the applications defined as follows:

> Preheating prior to tack welding may be performed using electrical resistance, induction heating, or gas flame heating methods for all components.
>
> If the electrical resistance or induction heating method is used, attachment of thermocouples (TCs) to the component by the capacitor discharge method is required to control the temperature for all electric resistance and induction heating preheating sources. The control thermocouple (CTC) connections shall be located underneath or within 25 mm of the ceramic pad heating element(s) or Induction heating coil(s). In no case shall the preheating temperature exceed 425°C.

After tack welding, preheating shall only be performed by electrical resistance or induction heating methods for the following defined components:

Piping/tubing components >50 mm NPS, including all pressure-retaining connections or non pressure-retaining attachments welded to piping/tubing components >50 mm NPS.

After tack welding, preheating may be performed using either the gas flame heating method or the electrical resistance or Induction heating methods for the following defined components. If the gas flame preheating method is used, the gas shall be propane-air, propylene-air, MAPP-air, or natural gas-air.

Piping/tubing components ≤50 mm NPS, Including all pressure-retaining connections or nonpressure-retaining attachments welded to piping/tubing components ≤50 mm NPS.

Precautionary Note: Oxyfuel heating sources that introduce oxygen gas are prohibited for preheating applications due to the increased potential of localized overheating, which can "over temper" (over soften) localized areas. Over tempering may possibly reduce the service life of the piping system. When using any flame heating method from a gas heating source, craft personnel shall be instructed not to use excessive flame velocities/intensities and to closely monitor the preheat temperature to avoid excessive localized hot spots.

### B1.4.5.3 PREHEATING PROCEDURE REQUIREMENTS

A detailed procedure for preheating using gas flame heating methods shall be submitted for review by Employer prior to any gas flame preheating operation. As a minimum, the preheating procedure shall provide the following information in sufficient detail to ensure that controls are established to assure that the base materials will not be adversely affected by gas flame preheating:

The base metal (SM) temperature prior to any welding shall be at or above the specified minimum preheat temperature in all directions from the point of welding for a distance of 75 mm, or three times the BM thickness of the thickest part at the point of welding, whichever is greater.

The gas flame preheating fuel gases permitted in production shall be specified.

Instructions shall be provided for fuel gas flow rate control and adjustment to avoid excessive flame velocities/intensities that can lead to localized overheating.

The gas flame preheating equipment for the method selected shall be identified to ensure the proper torch head selection and the application of regulators and settings, as applicable.

The approximate stand-off distance range of the torch head from the BM shall be specified.

Instructions for continuous movement of the torch head to preclude any localized overheating shall be specified.

To preclude development of any localized overheating, instructions shall be provided for verifying the minimum and maximum preheat temperatures using temperature indicating devices such as temperature indicating crayons, thermocouple pyrometers, or other suitable methods to ensure that the required minimum and maximum preheat temperatures are verified. When temperature indicating crayons are used, they shall be applied to avoid direct contact with the surface to be welded.

All personnel who are permitted to apply gas flame preheating methods or who are supervising preheating operations shall be trained in the flame preheating method and procedure. Training records shall be generated and maintained for all personnel completing gas flame preheating training

Training instructors shall provide the rationale for avoiding localized overheating. The following statement is provided to aid the instructor:

> "It has been established that the improper application of gas flame preheating can result in localized hot spots that can alter the base metal properties and microstructure, reducing its design capabilities. When localized hot spots occur, conditions that lead to possible failures may also occur and the service life of the piping system may be degraded. To ensure personnel and plant safety, it is essential that personnel understand the importance of controlling gas flame preheating to ensure that localized hot spots are avoided through the preheat controls established In this procedure."

The preheating procedure shall provide a Preheating Checklist Record to be used by Quality Control personnel to verify compliance with the preheating procedure. Quality Control personnel shall perform surveillances during every work shift to verify compliance with this procedure.

Nonconformance reports shall be used to document deviations from this procedure.

## B1.4.5.4 INTERMEDIATE HEAT TREATMENT

Prior to welding or tack welding, a minimum preheat temperature of 200°C shall be obtained. Tack welds or temporary tack welds shall be preheated as specified; however, the preheat temperature is not required to be maintained and the intermediate heat treatment conditions specified below are not required. Temporary tack welds must be removed by mechanical means and shall not be incorporated in the completed weld.

The preheat temperature may be reduced to 95° C minimum for the purpose of root examination without performing an intermediate heat treatment, unless prohibited by the applicable construction code.

Intermediate heat treatment shall only be performed using electrical resistance or induction heating methods. Gas flame heating methods are prohibited.

The weld and BM temperature for intermediate heat treatment shall be at or above the specified minimum intermediate heat treatment temperature in all directions from the point of welding for a distance of 150 mm, or three times the BM thickness of the thickest part at the point of welding, whichever is greater.

Attachment of TCs to the component by the capacitor discharge method is required to control the temperature for all electric resistance and induction heating sources. The CTC connections shall be located underneath or within 25 mm of the ceramic pad heating element(s) or induction heating coil(s). In no case shall the intermediate heat treatment temperature exceed 425°C.

The preferred sequence for welding these materials is to weld without Interruption once welding commences. However, when interruption is necessary or after weld completion and prior to PWHT, special conditions shall apply as follows. Condition 1 applies from the time welding commences through weld completion. Condition 2 applies after weld completion and prior to PWHT. The weld shall not progress from weld completion through PWHT completion without meeting Condition 2 below. The following conditions shall be satisfied:

Condition 1 If necessary, welding may be Interrupted provided a minimum of at least 10 mm thickness of weld is deposited or 25 percent of the welding groove is filled, whichever is less. The weldment shall be sufficiently supported to prevent overstressing the weld if the weldment is to be moved or otherwise loaded. If welding is interrupted, the weld shall be insulated immediately and subjected to an intermediate heat treatment with a controlled rate of cooling detailed as follows:

- For weld deposit thickness s50 mm, the weld shall be held at 260° C to 315°C for 1 hour minimum and allowed to slow cool.
- For weld deposit thickness >50 mm, the weld shall be held at 260°C to 315° C for 2 hours minimum and allowed to slow cool.

Condition 2. After weld completion, the weld shall be insulated immediately and subjected to an intermediate heat treatment with a controlled rate of cooling detailed as follows:

- For nominal material thickness 550 mm, the weld shall be held at 260°C to 315°C for 1 hour minimum and allowed to slow cool to <95°C.
- For nominal material thickness >50 mm, the weld shall be held at 260°C to 315°C for 2 hours minimum and allowed to slow cool to <95° C.

Alternatives to Conditions 1 and 2 are as follows:

When the weld thickness and BM thickness is less than 13 mm and welding is performed by the GTAW process only, after completion of welding, the weld shall be wrapped with insulation immediately and allowed to slow cool to <95°C.

When the piping/tubing components are S50 mm NPS, including all pressure-retaining connections or nonpressure-retaining attachments welded to piping/tubing components 52 inches (50 mm) NPS, after completion of welding, the weld shall be wrapped with insulation immediately and allowed to slow cool to <95° C.

## B1.4.5.5 POST WELD HEAT TREATMENT

PWHT shall be performed in accordance with the referenced code and any modified requirements specified herein. PWHT of material combinations other than those specified in the table on the following page shall be submitted to Employer for review and approval prior to performance of any PWHT.

### B1.4.5.5.1 Local PWHT Requirements, Grade 91 and 92 Welds

This article specifies requirements for local PWHT of Grade 91 and Grade 92 welds using the electrical resistance heating method. Other methods of local PWHT shall require review and approval by Employer.

The weld and adjacent region required by code to be heat treated is specified as the soak band (SB) and is defined in the applicable code of construction (e.g., ASME B31.1, 132.7, ASME Section I, PW 39.3, etc.).

Guidance for the placement of TCs on circumferential butt welds and other type welds is provided in AWS D10.10, "Recommended Practices for Local Heating in Pipe and Tubes: Sections 5, 6, and 8. Special consideration shall be given to the placement of TCs when heating welds adjacent to large heat sinks such as valves, flanges, special fittings, or when joining parts of differing thicknesses, to ensure that no portion of the materials subject to the heat source exceeds the lower critical temperature of the material. Particular care must be considered when the PWHT temperature is close to the material's lower critical temperature, such as for Grade 91 and Grade 92 materials.

Since the construction code does not define the terms "control zone," "heated band," and "gradient control band," the latest edition of AWS 010.10 and the requirements specified herein shall be used to determine the minimum heated band (HB) width and the gradient control (insulation) band (GCB) width critical for achieving the required temperature through the weld SB thickness within the SB region. When the dimensions for the AWS 010.10 HB or GCB cannot be achieved because of configuration, space limitations, component manufacturer restrictions, field conditions, or other valid limitations, the documentation package shall provide an explanation for the deviation.

For each weld joint that Is post weld heat treated, a sketch showing the TC attachment location(s), SB width, HB width, GCB width, and heating pad sizes and locations, and a heat treatment time-temperature record or chart recording all TC data (including temperature data log sheets denoting the time and temperature of all TCs at any given time during the PWHT) is required in the documentation package and shall be provided to Employer when requested. All of the required information shall be traceable to the PWHT weld joint.

| Base Material Welded Combination (Notes 1, 2, 3, 5, 6, and 7) | | Post Weld Heat Treatment (Notes 1, 3, 4, 5, 6, 7, 8, and 9) | | |
|---|---|---|---|---|
| First Base Material | Welded to Base Material | Furnace and Local Holding Temperature Set Point, °C (Note 1 for Performance) | Based on Weld/Nominal Thickness, mm | Holding Time (Minimum and Maximum) (Note 6) |
| Grade 91 | Grade 91 | 760 +15/-0 Local<br>745 +15/-0 Furnace (Note 8, 9) | <19 | 1 hr/in. 30 minutes minimum |
| | | | ≥19-50 | 2 hours |
| | | | >50-100 | 4 hours (Note 4) |
| Grade 91 | P-No. 5B Grp.1 (5Cr-0.5Mo) or P-No. 5A (2.25Cr-1Mo) (Note 3) | 760 +15/-0 Local<br>745 +15/-0 Furnace (Note 8, 9) | <19 | 1 hr/in. 30 minutes minimum |
| | | | ≥19-50 | 2 hours |
| | | | >50-100 | 4 hours (Note 4) |
| Grade 92 | Grade 92 or Grade 91 | 760 +15/-0 Local<br>745 +15/-0 Furnace (Note 8, 9) | <19 | 1 hr/in. 30 minutes minimum |
| | | | ≥19-50 | 2 hours |
| | | | >50-100 | 4 hours (Note 4) |
| Grade 92 | P-No. 5B Grp.1 (5Cr-0.5Mo) or P-No. 5A (2.25Cr-1Mo) (Note 3) | 760 +15/-0 Local<br>745 +15/-0 Furnace (Note 8, 9) | <19 | 1 hr/in. 30 minutes minimum |
| | | | ≥19-50 | 2 hours |
| | | | >50-100 | 4 hours (Note 4) |

Notes:

1. The holding temperature set point is for PWHT performed in a furnace or locally. Because local PWHT is typically applied from the outer surface of the weld, specific PWHT temperatures must be set at the outer surface to achieve the required minimum PWHT temperature at the internal surface of complete penetration welds. For local PWHT, when the internal surface is accessible for monitoring temperature, the minimum PWHT temperature is 730° C. For example, the holding temperature set point specified is the temperature specified as 760° C or 745° C in the table above. This means that the local PWHT equipment shall be programmed or set to achieve 760° C or 745° C minimum as specified above with a tolerance of +15° C/-0. The local PWHT holding temperature set point is the temperature the heating source and weld must achieve at the outer surface of a complete penetration weld in the soak band region.

2. In addition to the base material P-numbers listed, other base materials may include S-numbers, unassigned BMs with the same nominal chemical analysis, and mechanical property limits as defined in ASME Section IX, QW-420, QW-424, ASME B31.1, and ASME Code Cases, as applicable.

   For the purpose of PWHT, Grade 92 base material is considered P-No. 5B Group 2 or 15E as defined by ASME Section I and ASME Section VIII, Division 1, Code Case 2179 (revision approved by Employer) and ASME B31.1 Code Case 183.

   For the purpose of PWHT, SA-217 C12A (9Cr-1Mo-V) type casting base material is considered P-No. 5B Group 2 or 15E as defined by ASME Section I Code Case 2192 (revision approved by Employer).

   For the purpose of PWHT, (2.25Cr-1.6W-V-Cb) Grade 23 base material is considered P-No. 5A as defined by ASME Section I Code Case 2199 (revision approved by Employer).

3. When the filler metal has a chromium content <3.0 percent or is nickel-base, the PWHT shall be performed at 745° C +15°/-0°. When the filler metal is nominal 9Cr for welding Grade 91 or 92 materials, the PWHT shall be performed at 760° C +15°/-0°.

4. The weld/nominal thickness shall be as defined by the governing code. When weld/nominal thickness is >100 mm, the holding time shall be held for a minimum of 1 hour for each additional inch >100 mm.

5. Grade 91 and 92 (9 Cr) base materials and weld deposits as well as 5 Cr materials contain alloying elements that make them air harden and exhibit very little ductility in the as-welded condition. Extreme care must be observed during the fabrication process to avoid applying bending stresses or loading to welds that have not been post weld heat treated.

6. PWHT of P-No. 5B or 15E (9Cr-1Mo-V) and (9Cr-2W) welds, including dissimilar welds, should be accomplished within 7 days of weld completion. It is preferable to complete the PWHT as soon as possible after weld completion and cooling to <95° C. During welding and while awaiting PWHT of the completed weld joint, the weld joint shall be stored or maintained in a dry location or otherwise protected to avoid exposure to moisture until PWHT is performed. Any weld exposed to moisture shall be identified to Employer for disposition.

7. To minimize the risk of over tempering during a single furnace or local PWHT, the maximum time allowed above 700° C for any TC attached to the component(s) being heat treated shall not exceed 2 hours beyond the minimum required PWHT holding time. When a PWHT is performed on a variety of weld joints with differing nominal thicknesses, the minimum and maximum PWHT holding time shall be based on the greatest nominal thickness being post weld heat treated. It is the responsibility of the PWHT Responsible Supervisor to ensure that proper furnace and local heat treatment equipment setup, TC attachment, TC locations, furnace loading practices (as applicable), and operational practices will achieve the holding set point PWHT temperature and the minimum and maximum PWHT holding times as specified herein. Any exception to this requirement shall require the approval of Employer.

8. For local PWHT, when the weld nominal thickness of a complete penetration weld exceeds 50 mm, the local PWHT holding temperature set point shall be increased from 760° C to 768° C +6° C/-0.

   For local PWHT, when the pipe size and nominal thickness is ≤100mm NPS and ≤13 mm, the local PWHT holding temperature set point shall be decreased from 760° C to 745° C +15° C /-0.

9. The PWHT holding temperature range for acceptance of the PWHT is 760° C +15/-30° C for welds completed with 9Cr filler metals and 745° C ± 15° C for welds completed with <3.0 percent chromium or nickel-base filler metals. The furnace and local PWHT set point temperatures are established to ensure that these PWHT holding temperature ranges are met for the through thickness volume of metal heated.

The minimum number of TC locations required for performing a local PWHT shall be in accordance with the following table.

| **Pipe Size NPS (mm) or Equivalent Pipe Outside Diameter (OD)** | **Minimum Number of Thermocouple Locations and Control Zones (Notes 1, 2)** | | |
|---|---|---|---|
| | **On Weld (Note 3)** | **At Each Outer Edge of the Soak Band (Note 3)** | **Additional TC Locations** |
| Up to ≤100 | 1 | None Required | Notes 4, 5 |
| >100 to ≤300 | 2 | None Required | |
| >300<br>For joints composed of similar nominal thickness materials <50 mm thick | 4 | None Required | |
| >300<br>For dissimilar thickness weld joints (defined in Article 0110.6.5.1.1) and for weld joints of similar nominal thickness materials >50 mm thick | 4 | 4 | |

Notes:

1. TCs shall be placed at the location of the highest expected temperature to minimize the possibility of exceeding the maximum allowed temperature.
2. A control zone consists of a grouping of one or more heating pads that are controlled (turned off and on) based upon input from a CTC. The TC that controls the heating pads is a CTC. One or more control zones may be present in the circumferential and/or axial directions.
3. Example: A 500mm NPS weld requires four weld metal TCs and four TCs at each of the four outer edges of the soak band (12 total).
   The TCs designated for "On weld" are primarily for complete penetration welds such as, butt joints and branch connections. TCs shall be attached at the approximate weld center line for all complete penetration welds. TCs shall be attached adjacent to the weld toe for welds other than complete penetration welds. CTCs should be located at approximate equal distances apart to affect temperature uniformity.
4. One TC shall be placed under each heating pad. At least one IC per band of heating pads shall be attached under the anticipated highest temperature location of each band of heating pads. These requirements may require additional TCs than are required by Note 1 to ensure that the anticipated highest temperature location of each band of heating pads is controlled.
5. Overlap of electrical resistance heating pads is prohibited unless the heating pad overlap covers the complete component surface uniformly. Any partial overlap of heating pads is prohibited. Overlap of heaters controlled by separate TCs is prohibited

### 1.4.5.5.1.1 LOCAL PWHT OF GRADE 91 OR GRADE 92 DISSIMILAR THICKNESS WELDS

To ensure temperature uniformity, multiple heating control zones shall be considered for sections with significantly varying thickness across the soak band width. The additional use of blocking-heat control zone(s) should be considered for the thicker side of the weld joint to minimize the thermal gradient.

For each dissimilar thickness butt weld joint greater than NPS 300 mm or the equivalent pipe OD to be post weld heat treated, a sketch showing the TC attachment location(s), (both CTCs and monitoring thermocouples (MTCs), SB width, FIB width, GCB width, heating pad sizes and locations, and the wall thickness across the soak band shall be submitted to Employer for review (prior to PWHT). All the sketch information shall be traceable to the PWHT weld joint.

Dissimilar thickness is defined as when the base material thickness varies by more than 10 mm or more than 30 percent** across the soak band width. Refer to the following:

** Thickness variation = $[(T_{tk} - T_{tn}) / (T_{tn})] \times 100$

where

$T_{tk}$ = Base material thickness on the thick side of the weld joint at the outer edges of the soak band.

$T_{tn}$ = Base material thickness on the thin side of the weld joint at the outer edges of the soak band.

### B1.4.5.6 ABORTING A LOCAL PWHT FOR GRADE 91 OR GRADE 92 WELDS

If the specified upper tolerance of the specified PWHT temperature (indicated by any TC) is exceeded by more than 8° C and there is no means to promptly correct the deviation, the PWHT operation shall be aborted. Refer to the following example:

> Example: 760°C specified set point with a +14° c specified allowable tolerance: Abort the PWHT operation If the temperature exceeds 782°C [760 $^{o}$C +14°C (upper tolerance) + (8°C allowable tolerance)].

After aborting a PWHT, if possible, the weld shall be allowed to cool at a cooling rate not to exceed the applicable construction code requirements. All sketches and the heat treatment time-temperature record or chart recording of aborted PWHT attempts shall be submitted to Employer for review prior to any subsequent attempt to perform another PWHT.

### B1.4.5.7 WELD END PREPARATION

When weld joint details are specified by the design documents, they shall be prepared in accordance with the design documents.

Weld end preparations should preferably be prepared by machining.

### B1.4.5.8 HARDNESS TESTING OF GRADE 91 AND GRADE 92 WELDMENTS

To verify that satisfactory PWHT and fabrication processes have been performed on base material and welds joining Grade 91 and 92 materials to themselves or each other, the Contractor/installer shall perform Brinell Hardness Tests or an acceptable equivalent hardness test on completed production piping pressure welds or welds to pressure-retaining components as listed below. Hardness testing shall be performed in accordance with a written procedure that meets the requirements of the applicable ASTM standard for the method of testing used. Hardness tests shall be performed using the Telebrinell, Ultrasonic Contact Impedance (UCI) method, Pin Brinell, Equi-tip, or other equivalent testing methods... Hardness testing equipment shall be capable of producing consistent results accurate to within ± 5 percent. The written procedure for performing the hardness testing shall be submitted for review by Employer prior to use. The test preparation and hardness tests shall not reduce the required weld size or section wall thickness below the minimum required by design. In the event an individual point is found to be < 180 Brinell it is Contractor's obligation to show by calculation or other methods that the material Is still acceptable for the intended Service Life.

For areas where unacceptable low hardness readings are obtained, additional material removal is permitted provided that the material removal does not reduce the weld size or section wall thickness below the minimum required by design. Experience has shown that additional material removal of approximately 0.4 to 0.8 mm is sufficient to ensure a reliable hardness retest. The material removal may be necessary to ensure that hardness testing is performed below a possible decarburized surface layer.

After PWHT and prior to hardness testing, the piping shall be permitted to cool to ambient temperature.

Unless otherwise directed by Employer, the area to be hardness tested may be selected at random. Hardness tests shall be judged acceptable If all the resulting hardness tests are in the Brinell Hardness Number (BHN) range as specified in the following: In the event an individual point is found to be < 180 Brinell it is Contractor's obligation to show by calculation or other methods that the material is still acceptable for the intended Service Life

For Grade 91 base metal or unassigned base metals with the same nominal chemical analysis and mechanical property limits, the minimum hardness shall not be less than 180 BHN and the maximum BHN shall not exceed the maximum permitted by the applicable base metal material specification. In the absence of any base metal material specification hardness requirements, pressure-retaining components shall not exceed 250 BHN.

For Grade 92 base metal or unassigned base metals with the same nominal chemical analysis and mechanical property limits, the minimum hardness shall not be less than 1800 BHN and the maximum BHN shall not exceed the maximum permitted by the applicable base metal material specification. In the absence of any base metal material specification hardness requirements, pressure-retaining components shall not exceed 250 BHN.

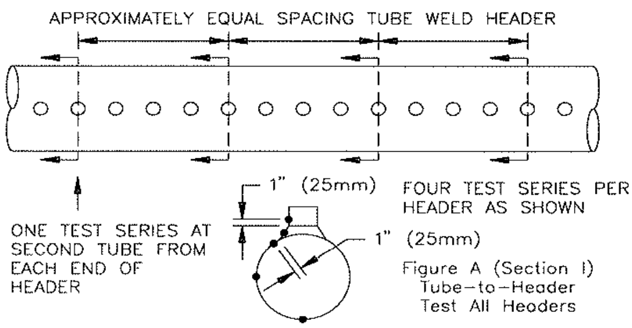
Weld metal resulting from welding base metals Grade 91, Grade 92, and Grade 91 to Grade 92 shall not be less than 180 BHN and the maximum shall not exceed 280 BHN.

In the event there is evidence of components being intercritically heat treated (i.e., heated to a temperature at or above the material's lower critical temperature) during fabrication or stress relieving (e.g., from flame impingement) ASME B&PVC Section i, Table PW-39 Note (4) shall apply.

The scope of welds and base material requiring hardness testing is defined as follows. Employer shall be notified of any piping pressure-retaining welds or welds to pressure-retaining components not specifically defined below. When notified, Employer will define the hardness testing requirements:

**B1.4.5.8.1 Hardness Test Requirements for ASME Section I Components**

Pipe/Tube-to-Header Welds (ASME Sect. I). 100 percent of pipe/tube-to-header sections shall be tested as follows: One series of hardness tests will be performed at four locations on each header section. Each series will consist of five readings (in a plane radial to the header): (1) One test on the tube approximately 25 mm from the weld toe; (2) One weld metal MM) test; (3) One test on the header approximately 25 mm from the weld toe; and (4 and 5) One test on the header at 90 degrees and also at 180 degrees from the tube. The four locations for each series shall be selected as follows: First and second locations—Second tube from each end of header. Third and fourth locations—Approximate equal spacing between all test locations. All four series will result in the performance of 20 (total) hardness tests on each header section. Refer to Figure A.




Note: When the header contains more than one row of tubes, only a single row is required to be tested as defined above.

Header End Plate Welds (ASME Sect. I). A minimum of 50 percent of header end plates shall be tested per header section as follows: One series of hardness tests shall be performed on one end plate weld per header assembly. The hardness tests shall consist of five (total) hardness tests. The end plate weld metal shall be hardness tested in three circumferential locations approximately equally spaced around the weld. The end plate base metal shall be checked in one location at the approximate center. The header base metal shall be checked approximately 25 mm from the end plate weld on the header OD. Refer to

Figure A1.

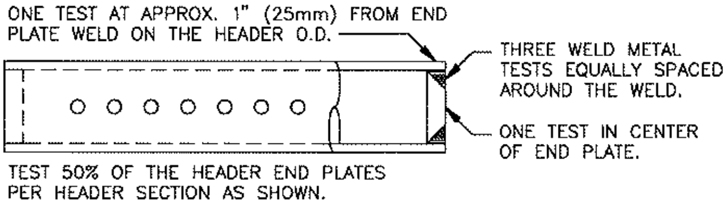


Figure A1 (Section I)
Header End Plate Welds

Branch Connections (ASME Sect. I). A minimum of 25 percent of branch connections shall be tested per header or pipe section as follows: (1) One test on the branch fitting; (2) One WM test; and (3) Three tests on the pipe or header, with each test spaced at least 90 degrees around the branch fitting approximately 25 mm from the weld toe. Testing will result in the performance of 5 (total) hardness tests for each branch connection requiring testing. Refer to Figure B

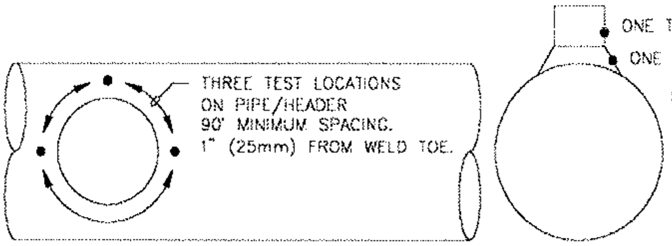


Figure B (Section I)
Branch Connections
Test 25% minimum
per pipe/header section.

Socket Welds (ASME Sect. I ). A minimum of 10 percent of socket welds per header or pipe section shall be tested as follows: (1) One test on the tube or pipe approximately 25 mm from the weld toe; (2) One WM test; and (3) One test on the socket weld fining. Refer to Figure C.

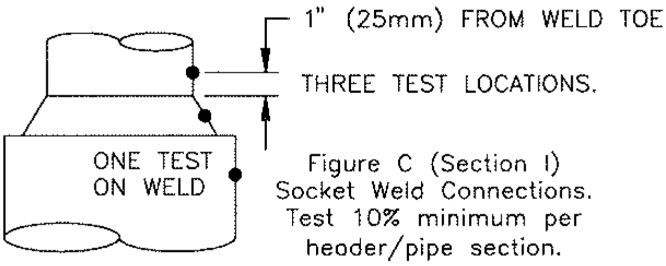


Figure C (Section I)
Socket Weld Connections.
Test 10% minimum per
header/pipe section.

Circumferential Butt Welds (ASME Sect, I nine or tube NPS 150 mm or less): A minimum of 5 percent of butt joints for each pipe or tube size, per each header or pipe section, shall be tested. One traverse consisting of three (total) hardness tests in a line shall be tested as follows: (1) One test on each side of the weld approximately 25 mm from the weld toe; and (2) One WM test. Refer to Figure D

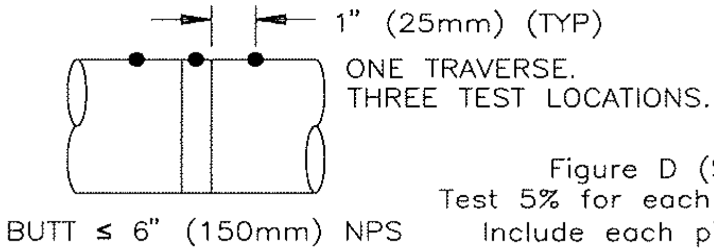



Figure D (Section I)
Test 5% for each header or pipe.
Include each pipe/tube size.

Circumferential Butt Welds (ASME Sect. I pipe > NPS 150 mm and greater). A minimum of 50 percent of butt joints per header or pipe section shall be tested as follows: Three traverses consisting of three readings per traverse are required (9 readings total). Each traverse shall be comprised of the following: (1) One test on each side of the weld approximately 25 mm from the weld toe; and (2) One WM test. Each traverse shall be spaced at least 90 degrees from each of the other traverses. Refer to Figure DI

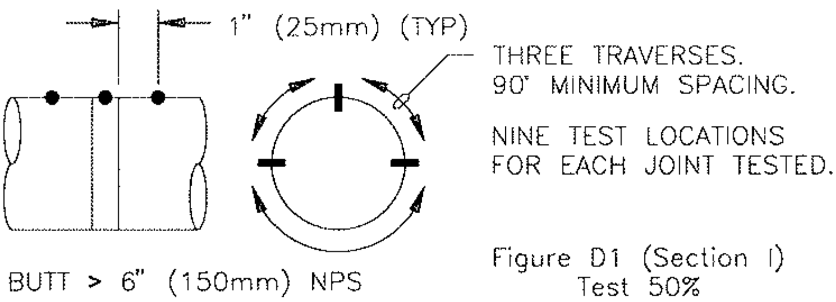



Figure D1 (Section I)
Test 50%

Round Non pressure Attachments, em. stanchions and trunions (ASME Sect. I I. One attachment per header or pipe section shall be tested as follows: Three tests on the pipe or header, with each test spaced at least 90 degrees around the attachment approximately 25 mm from the weld toe. Refer to Figure E.

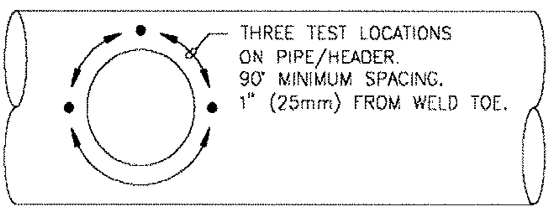
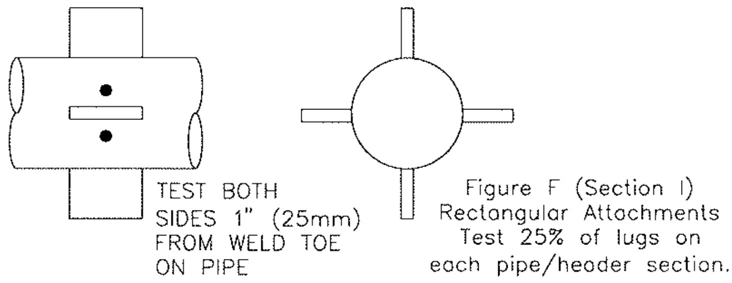



Figure E (Section I)
Round Non-Pressure Attachments
Test one attachment
per pipe/header section.

Rectangular Nonpressure Attachments em. support lugs (ASME Sect. I ). A minimum of 25 percent of rectangular nonpressure attachments shall be tested per header section or pipe as follows: One test shall be performed on the header or pipe (on each of the major sides of the lug), with the hardness test located approximately centered and approximately 25 mm from the weld toe. Refer to Figure F

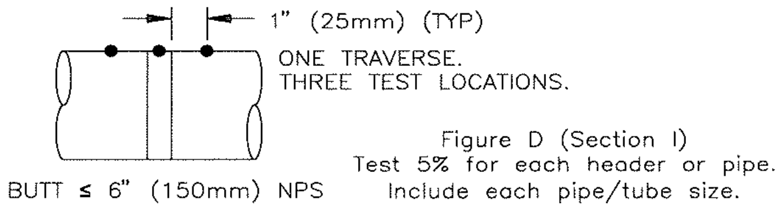



<u>General Note (ASME Sect. I Components).</u> In instances of extreme handling difficulties or inaccessibility issues, performing all the required hardness tests may not be practical. In those specific instances, the test reports must indicate the reason for not hardness testing those areas.

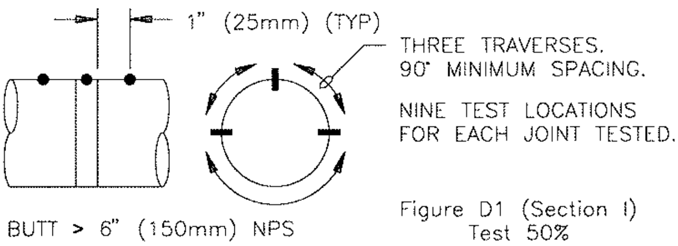
**B1.4.5.8.2 Hardness Testing Requirements for ASME B31.1 Components**

(Note: Includes Boiler External Piping and Non-Boiler External Piping (BEP and NBEP.)

<u>Circumferential Butt Welds (ASME B31.1 pipe or tube NPS 150 mm or less).</u> A minimum of 5 percent of butt joints for each pipe or tube size, per each header or pipe section, shall be tested. One traverse consisting of three (total) hardness tests in a line shall be tested as follows: (1) One test on each side of the weld approximately 25 mm from the weld toe; and (2) One WM test. Refer to Figure




<u>Circumferential Butt Welds (ASME B31 1 pipe > NPS 150 mm and less).</u> A minimum of 50 percent of butt joints per header or pipe section shall be tested as follows: Three traverses consisting of three readings per traverse are required (9 readings total). Each traverse shall be comprised of the following: (1) One test on each side of the weld approximately 25 mm from the weld toe; and (2) One WM test. Each traverse shall be spaced at least 90 degrees from each of the other traverses. Refer to Figure Dl.



Branch Connections and Thermowell Connection (Stub-in) Welds (ASME Sect. B31.1). A minimum of 25 percent of branch connections shall be tested per header or pipe section as follows: (1) One test on the branch fitting; (2) One WM test; and (3) Three tests on the pipe or header, with each test spaced at least 90 degrees around the branch fitting approximately 25 mm from the weld toe. Testing will result in the performance of 5 (total) hardness tests for each branch connection requiring testing. Refer to Figure B.

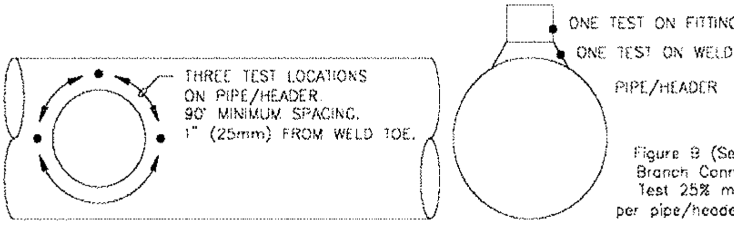



Figure B (Section I)
Branch Connections
Test 25% minimum
per pipe/header section.

Socket Welds (ASME Sect. B31.1). A minimum of 10 percent of socket welds per header or pipe section shall be tested as follows: (1) One test on the tube or pipe approximately 25 mm from the weld toe; (2) One WM test; and (3) One test on the socket weld fitting. Refer to Figure C

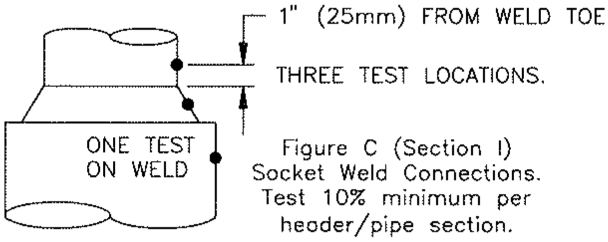



Figure C (Section I)
Socket Weld Connections.
Test 10% minimum per
header/pipe section.

Round Nonpressure Attachments. e.g. stanchions and trunions (ASME Sect. B31.1) One attachment per header or pipe section shall be tested as follows: Three tests on the pipe or header, with each test spaced at least 90 degrees around the attachment approximately 25 mm from the weld toe. Refer to Figure E.

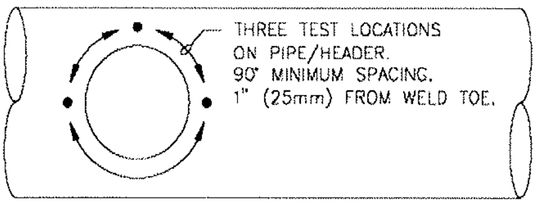



Figure E (Section I)
Round Non-Pressure Attachments
Test one attachment
per pipe/header section.

Rectangular Nonpressure Attachment e.g. support lugs (ASME B31.1 and B31.1). A minimum of 25 percent of rectangular nonpressure attachments shall be tested per header section or pipe as follows: One test shall be performed on the header or pipe (on each of the major sides of the lug), with the hardness test located approximately centered and approximately 25 mm from the weld toe.
Refer to Figure F

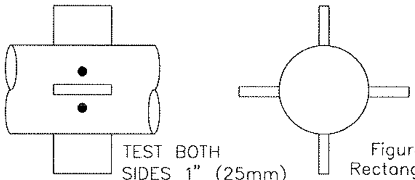



Figure F (Section I)
Rectangular Attachments
Test 25% of lugs on
each pipe/header section.

Rectangular Nonpressure Attachment Welds Designed for Alignment/Fit-up (ASME B31.1). Alignment attachments are used to aid fit-up of the piping and are associated with an adjacent circumferential butt weld. Temporary attachments are exempt from this testing. A minimum of 25 percent of rectangular nonpressure attachments shall be tested per header section or pipe as follows: One test shall be performed on the header or pipe (on each of the major sides of the lug), with the hardness test located approximately centered and approximately 25 mm from the weld toe.

Seal/Partial Penetration Welds for Gamma Ray Plugs (ASME B31.1) One series of hardness tests shall be completed on 100 percent of the gamma ray plug seal/partial penetration welds. One hardness test shall be performed on the WM, and one hardness test shall be taken adjacent to the seal weld on the pipe BM within approximately 25 mm from the toe of the weld. Additionally, one hardness test shall be performed (In the same radial plane as the gamma ray plug seal/partial penetration weld around the pipe) at each 90 degree increment (three total) from the gamma ray plug seal/partial penetration weld. All series of hardness tests will result in the performance of five (total) hardness tests. Refer to Figure M

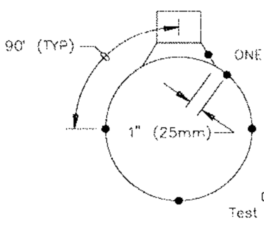



Figure M (B31.1)
Gamma Ray Plug Seal Welds.
Test 100% of every gamma ray plug.

General Note (ASME B31.1 Components). In instances of extreme handling difficulties or inaccessibility issues, performing all the required hardness tests may not be practical. In those specific instances, the test reports must indicate the reason for not hardness testing those areas.

#### B1.4.5.8.3 Hardness test retests

Hardness test retests shall be performed as follows:

If any hardness test is unacceptable, three retests are required and shall be performed in the same area as close as practical to the failed test. If the average of the retests is within the allowable hardness test range, no additional testing is required.

If the results of the hardness retests are unacceptable, it is Contractor's obligation to show by calculation or other methods that the material is still acceptable for the intended Service Life, otherwise a NCR documenting the BM, filler metal, location, weld configuration, test results, and proposed disposition shall be submitted to Employer for review.

## B1.4.6 NONDESTRUCTIVE EXAMINATION

All NDE shall be performed in accordance with the methods specified in the fabrication code and any supplemental NDE specified within this document.

### B1.4.6.1 POSITIVE MATERIAL IDENTIFICATION (PM)

Positive Material Identification (PMI) shall be performed on all shop fabricated ASME B31.1, BEP and NBEP piping spool pressure-retaining components and pressure-retaining welds; a report identifying the piping spool number, location, and PMI results shall be submitted to Employer in the documentation package. Employer shall be notified if the PMI results fall outside the following ranges.

#### B1.4.6.1.1 Grade 91—Allowable PMI Ranges

| | |
|---|---|
| Chromium (Cr) | 8.0 to 10.5 percent |
| Molybdenum (Mo) | 0.8 to 1.2 percent |
| Vanadium (V) | 0.15 to 0.30 percent |

#### B1.4.6.1.2 Grade 92—Allowable PMI Ranges

| | |
|---|---|
| Chromium (Cr) | 8.0 to 10.5 percent |
| Molybdenum (Mo) | 0.25 to 0.75 percent |
| Vanadium (V) | 0.1 to 0.30 percent |
| Tungsten (W) | 1.3 to 2.2 percent |

## B1.4.7 RECORDS

In addition to the requirements specified for records as defined in Article B1.3, the following pipe spool documentation submittal requirements shall be provided as specified.

### B1.4.7.1 PIPING (ASME 631.1) SHOP FABRICATED PIPING SPOOLS

ASME B31.1 shop fabricated piping spool documentation records for Grade 91 and 92 materials shall be submitted to Employer for review prior to shipment or as otherwise approved by Employer. The documentation records shall be organized into documentation packages that clearly identify the contents and enable Employer's review to be performed for each piping spool, with traceability to Employer's isometric drawings. The document package shall contain all relevant documents to enable Employer to confirm compliance with the governing code and design specification requirements.

#### B1.4.7.1.1 Grade 91 and 92 Pipe Spool Documentation Submittal Requirements

The documentation package, as applicable for each spool, shall be assembled in the order stated below:

Documentation Record: The P91/P92 Documentation Record (Record Number XXX; refer to Attachment I for a sample record form) shall be completed for each piping spool and shall be reviewed and accepted by the shop fabricators QA/QC representative prior to submittal to Employer.

Weld Map: The fabricator shall supply, as a part of the documentation package, a legible weld map of each spool that accurately identifies each weld and bend location and assigns each weld and bend an identifying number.

Nonconformance Reports (NCRs) and Quality Action Requests (OARs): All NCRs and QARs applicable to the piping spool shall be Included in the documentation package and must be closed prior to release for shipment.

Normalizing and Tempering Heat Treatment Records. A copy of the heat treatment charts applicable to the piping spool shall be included in the documentation package. Each chart shall clearly identify the spool number and bend or component number represented by the heat cycle and the date that the heat treatment was performed.

Bend Data. Code calculations for minimum wall thickness of induction bends, as well as NDE results from fabrication monitoring or as required by engineering specifications, shall be included in the piping documentation package.

Post Weld Heat Treatment (PWHT) Records. A copy of the heat treatment charts applicable to the piping spool shall be included in the documentation package. Each chart shall clearly identify the PWHT method used (Local or Furnace), the PWHT procedure number used, the spool or component number, and the date the PWHT was performed. If local PWHT Is used, the spool and weld number must be documented.

Magnetic Particle/Penetrant Test (MT/PT) Reports. All MT/PT reports applicable to the piping spool shall be included in the piping documentation package and shall meet the requirements of ASME Section V and the applicable code and specification requirements.

Radiographic/Ultrasonlc Test (RT/UT) Reports. All RT/UT reports applicable to the piping spool shall be included in the piping documentation package and shall meet the requirements of ASME Section V and the applicable code and specification requirements.

Hardness Testing Results. A copy of the Hardness Testing Records applicable to the piping spool shall be Included in the documentation package. Each record shall clearly identify the person performing the testing, the procedure and testing equipment used, the spool number, weld number or bend/component number represented by the Hardness Testing data, and the date that the Hardness Testing was performed.

Certified Material Test Reports (GMT% All piping components and welding filler materials used in the fabrication of P91/P92 piping are required to be supported by a CMTR showing compliance with the applicable code, material specifications, and engineering specifications. All CMTRs shall be submitted to Employer for review and should be submitted as early in the fabrication process as is possible. Unless otherwise required, CMTRs should not be required to be resubmitted with each piping documentation package.

Positive Material Identification (PMI) Reports. PMI reports shall be traceable to the pipe spool and specific locations of the inspection.

Traveler Package. The Traveler Package shall be as applicable to the work activity and traceable to the pipe spool welds. Note: Traveler Package is defined as the set of documents that provide work activity process information/instructions to craft personnel and provide space for documentation of welding, NDE, PWHT, or other activities. The Traveler Package serves as a permanent record of the work activity and is typically associated with the documentation of ASME code stamped welds.

If the shop fabricator feels that its normal method of documentation will meet all of the requirements listed above, the fabricator may submit a sample package to Employer for review and approval.

## B1.5 FABRICATION OF BOILER EXTERNAL AND NON-BOILER EXTERNAL PRESSURE PIPING COMPONENTS

### B1.5.1 GENERAL

This article provides requirements for the fabrication and welding of Grade 91 and Grade 92 boiler external and non-boiler external piping and shall be used in conjunction with Articles B1.3 and B1.4 of this document. Bending of pipe and tube shall be In accordance with the requirements of Article B1.2. Material requirements shall be in accordance with the requirements of Article B1.1.

This article does not apply to ASME BPVC (boiler proper components).

### B1.5.2 WELDING PROCESSES

Permitted welding processes and restrictions shall be as specified in Articles B1.3 and B1.4 and shall include the restrictions and limitations applicable to those processes as specified herein.

### B1.5.3 BACKING RINGS AND RETAINERS

Backing rings and retainers shall not be used.

### B1.5.4 PREHEAT AND POST WELD HEAT TREATMENT

Preheat and post weld heat treatment shall be in accordance with the WPS, the code of fabrication, Article B1.4, and the design documents.

### B1.5.5 INTERRUPTION OF WELDING

The conditions for interruption of welding shall be provided in the WPS or other work control document to ensure that the minimum preheat temperature is maintained as required.

### B1.5.6 SAFE END PIPE CONNECTIONS

Equipment connections such as turbine connections, fabricated from unassigned materials or materials not referenced by the code of fabrication shall have a safe end attached by Contractor on each equipment connection to be attached to Employer's piping. The safe end shall comprise a pipe stub of the same material specification and type as the adjoining Employer's piping, including mechanical and chemical properties, dimensional size, and weld end preparation. Material certifications shall be supplied for all safe end pipe stubs. The safe end stub length shall be as follows:\

300 mm for material 150 mm inside diameter or less.
400 mm for material 150 mm through 350 mm inside diameter.
600 mm for material over 350 mm inside diameter.

If the use of safe ends is not feasible, and if acceptable to Employer, then Contractor shall furnish weld test coupons for Employer's welding procedure qualifications in lieu of safe ends in accordance with the following requirements:

Material certifications shall be supplied with all material used for weld test coupons.

The weld test coupon material shall be of the same material, chemical composition, and mechanical properties, type, and/or grade as the equipment connection, such as the valve or nozzle that it represents.

The material quantity shall be sufficient to complete the required test for the welding procedure qualification prescribed by the governing code and/or standard. As a minimum, the weld test coupon material product form shall be of adequate size and thickness to permit removal of the required test specimens and to qualify the joint thickness required for the production weld.

The weld test coupon material shall be delivered in adequate time to support the welding procedure qualification and production schedules as defined by Employer.

### B1.5.7 WELD END PREPARATION

Preparation of butt welding ends of piping components for shop welds shall be in accordance with the fabricator's standard end preparation details and the WPS. Preparation of pipe butt welding ends for field welds shall be in accordance with contract design documents.

The difference between major and minor diameters for a distance of 75 mm from the ends of the pipe shall not exceed 3 mm or 1 percent of the nominal diameter, whichever is less

To ensure satisfactory fit-up for circumferential butt welds in piping systems fabricated of rolled and welded plate, the following procedures shall be followed:

Concentricity. If weld metal is used to obtain concentricity, the weld deposit shall be free from porosity or other defects, and the inside surface shall be ground smooth and blended smoothly into the pipe wall.

NDE. Additional NDEs specified herein shall be evaluated in accordance with the code of fabrication.

Radiographic Inspection. Upon completion of the weld buildup and finishing procedures, the area shall be radiographed in accordance with the code of fabrication prior to shop welding to other sections or prior to shipment, The radiographs shall be submitted to Employer to permit complete analysis of the Joint after field radiography.

Pipe ends for socket-weld connections shall be reamed to full inside diameter to remove all burrs and obstructions and to ensure proper assembly.

## B1.5.8 STAMPING OF LOW ALLOY STEEL PIPE

Information may be stamped directly on low alloy piping with "low stress" die stamps such as interrupted dot or round nose types.

Carbon steel stamps shall not be used on stainless steel or nickel base alloy materials.
Stamping shall not damage material or reduce the wall thickness to less than design requirements.

## B1.5.9 NONDESTRUCTIVE EXAMINATION

NDE of weld shall be performed in accordance with the code of fabrication.

### B1.5.9.1 NDE OF TEMPORARY ATTACHMENT REMOVAL AREAS.

Surface NDE of pressure boundary component temporary attachment weld removal areas outside the weld bevel area shall be performed as follows:

Visual examination (VT) and magnetic particle examination (MT) are required for temporary attachment removal areas on Grade 91 and 92 piping systems

## B1.6 FABRICATION OF GRADE 91 AND GRADE 92 BOILER COMPONENTS

## B1.6.1 GENERAL

This article provides requirements for the fabrication and welding of Grade 91 and Grade 92 boiler components, including parts and appurtenances, as applicable, and shall be used in conjunction with Articles B1.3 and B1.4. Bending of pipe and tube shall be in accordance with the requirements of Article B1.2. Material requirements shall be in accordance with the requirements of Article B1.1.

### B1.6.2 WELDING PROCESSES

Permitted welding processes shall be as specified in Article B1:3, and shall include the restrictions and limitations applicable to those processes as specified herein and in Articles B1.3 and B1.4.

### B1.6.3 FABRICATION CONTROL

Fabrication, assembly, and erection shall be in. accordance with the code of fabrication and the design documents

## Attachment 1
## Grade 91/Grade 92 Documentation Record (SAMPLE)

Spool No.___________

| DRAWING NO. | QUALITY ACTION REQUESTS APPLICABLE | NONCONFORMANCE REPORTS APPLICABLE |
|---|---|---|
| SKETCH NO. | | |
| BASE MATERIAL | | |

| WELD NO. OR BEND NO. | JOINT TYPE/SIZE | | NORM. AND TEMP CHART NO./DATE | | BEND DATA ACC. OR REJ./DATE | | PWHT CHART NO./DATE | | MT/PT ACC. OR REJ./DATE | | RT/UT ACC. OR REJ./DATE | | HARDNESS ACC. OR REJ./DATE | | PMI COMPLETE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |
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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GTAW HT NUMBERS USED | | | | | | | |
| SMAW HT NUMBERS USED | | | | | | | |
| FCAW HT NUMBERS USED | | | | | | | |
| SAW HT NUMBERS USED | | | | | | | |
| MATERIAL HT NUMBERS USED | | | | | | | |

COMMENTS:

QA/QC ACCEPTANCE DATE QC ACCEPTANCE DATE

Pipe ends for socket weld connections shall be reamed to full inside diameter to remove all burrs and obstructions to ensure proper assembly.

#### B1.6.3.1 BACKING AND RETAINERS

Backing strips and retainers shall not be used.

#### B1.6.3.2 PREHEAT AND POST WELD HEAT TREATMENT

Preheat shall be performed in accordance with the WPS applicable to the materials being welded, the code of fabrication, and Article B1.4.

Post weld heat treatment shall be in accordance with the code of fabrication and Article B1.4

#### B1.6.3.3 WELD END PREPARATION

Joint design and weld end preparation for boiler components shall be in accordance with the fabricator's standard end preparation details and the WPS, and shall be as specified by the design documents.

Preparation of piping butt welding ends for field welds shall be in accordance with the contract design documents.

### B1.6.4 NONDESTRUCTIVE EXAMINATION

NDE of welds shall be performed in accordance with the code of fabrication and as specified by the design documents.

### B1.6.5 HARDNESS TESTING

Hardness testing shall be performed in accordance with Article B1.4.

# SECTION 5 – EMPLOYER’S REQUIREMENTS

# ATTACHMENT B2 – COATING SYSTEM

# CONTENTS

# 1. COATING SYSTEM

| CLASSFICATION OF CORROSIVE ENVIRONMENTS | |
|---|---|
| **Atmospheric Service[a]** | **Page 1 of 1** |

| Paragraph Number | Item | Classification |
|---|---|---|
| 1.0 | **Structural Steel** | |
| 1.1 | Structural Steel, Outdoor | C4 |
| 1.2 | Structural Steel, Indoor | |
| 1.2.1 | Auxiliary Bay | C3 |
| 1.2.2 | Baghouse | C3 |
| 1.2.3 | Boiler Bay | C4 |
| 1.2.4 | Turbine Hall | C3 |
| 2.0 | **Conveyors/Transfer Towers** | C4 |
| 3.0 | **Tanks, Drums, Columns, Vessels, Reactors, and Shell and Tube Heat Exchangers, Shop Fabricated** | C4 |
| 4.0 | **Pipe and Pipe Supports** | C4 |
| 5.0 | **Pumps, Compressors, and Rotating Equipment** | C4 |
| 6.0 | **Bulk Valves and Fittings** | C4 |
| 7.0 | **Electric Motors and Equipment** | C4 |
| 8.0 | **Instruments and Control Panels** | C4 |
| 9.0 | **Tanks, Silos, and Spheres, Field Erected** | C4 |
| 10.0 | **Furnaces, Stacks, Ducts, and Boilers** | C4 |
| **All Outdoor Items in a Marine[b] Atmosphere Are Classified Corrosive Environment C5-M** | | |

Notes:

[a]Atmospheric Service categories C3, C4 and C5-M are defined by ISO 12944 as follows:

C3 represents > 1 to 2 mils (>25 to 50 um) thickness loss for carbon steel
or >0.03 to 0.08 mils (>0.7 to 2.1 um) thickness loss for zinc.
C4 represents > 1 to 2 mils (>25 to 50 um) thickness loss for carbon steel
or >0.08 to 0.17 mils (>2.1 to 4.2 um) thickness loss for zinc.
C5-M represents > 3.1 to 8 mils (>80 to 200 um) thickness loss for carbon steel
or >0.17 to 0.33 mils (>4.2 to 8.4 um) thickness loss for zinc.

[b]Less than 2 miles from a body of salt water.

| CLASSFICATION OF CORROSIVE ENVIRONMENTS | |
|---|---|
| **Wetted, immersion, and Buried Service** | **Page 1 of 3** |

| Paragraph Number | Environment | Operating Temp °F (°C) | Fluid Quality | Carbon Steel Surface Coating System Number | Carbon Steel Surface Codes[1] | Typical Structures |
|---|---|---|---|---|---|---|
| **1.0** | **AIR** | | | | | |
| 1.1 | Air | ≤300° F (149° C) | | 1401 | IZ | Air receivers |
| **2.0** | **CHEMICAL** | | | | | |
| 2.1 | Acid | | pH≤3 | | | HCL, $HNO_3$, or $H_2SO_4$ storage |
| 2.2 | Ammonia | | | | | Ammonia storage |
| 2.3 | Caustic | ≤120° F (49° C) | pH≥11 | 2313 | EPP/EPP | 50% NaOH or KOH storage |
| 2.4 | Glycol | | | | | |
| **3.0** | **CONDENSATE** | | | | | |
| 3.1 | Condensate | ≤250° F (121° C) | 9.2≤pH≤9.6 | 2312 | EPP/EPP | Tanks and polisher vessels |
| **4.0** | **GAS** | | | | | |
| 4.1 | Flue Gas, Inlet | ≤130° F (54° C) | pH≤3 | | SPC/SPC | Jet bubbling reacter (JBR) inlet ductwork, internal surfaces |
| 4.2 | Flue Gas, Outlet | ≤130° F (54° C) | pH≤3 | | SPC/SPC | Jet bubbling reacter (JBR) outlet ductwork, internal surfaces |
| **5.0** | **OIL** | | | | | |
| 5.1 | Oil, Fuel | ≤120° F (49° C) | | 1401 | IZ | Tank vapor space |

| CLASSFICATION OF CORROSIVE ENVIRONMENTS | |
|---|---|
| Wetted, immersion, and Buried Service | Page 2 of 3 |

| Paragraph Number | Environment | Operating Temp °F (°C) | Fluid Quality | Carbon Steel Surface Coating System Number | Codes[1] | Typical Structures |
|---|---|---|---|---|---|---|
| 5.2 | Oil, Fuel | ≤120° F (49° C) | | 2314 | EPT/EPT | Tank inside bottom and 3 feet up side |
| 5.3 | Oil, Lube | | | Project Specific | | |
| **6.0** | **SOIL** | | | | | |
| 6.1 | Underground | ≤120° F (49° C) | | 3311 | EPT/EPT | Buried tanks and piles |
| 6.2 | Underground | ≤120° F (49° C) | | 3301 | EPB | Buried pipes (carbon steel and stainless steel) |
| 6.3 | Underground | ≤230° F (110° C) | | 3312 | EPB/EPB | Buried pipes (carbon steel and stainless steel) |
| 6.4 | Underground | ≤120° F (49° C) | | 3011 | SPC/SPC | Buried pipe fittings (carbon steel and stainless steel) |
| 6.5 | Underground | ≤230° F (110° C) | | 3012 | SPC/SPC | Buried pipe fittings (carbon steel and stainless steel) |
| **7.0** | **WATER** | | | | | |
| 7.1 | Water, Abrasive or Oily | ≤120° F (49° C) | 6≤pH≤8 | 2311 | EPA/EPA | Process water tanks, solids contact units |
| 7.2 | Water, Boiler Blowdown | ≤300° F (149° C) | 9.2≤pH≤9.6 | 1401 | IZ | Boiler or HRSG blowdown tank |
| 7.3 | Water, Brackish | ≤120° F (49° C) | 1,000≤$Cl^-$ ≤18,000 ppm | 2314 | EPT/EPT | Circulating water piping/equipment |

| CLASSFICATION OF CORROSIVE ENVIRONMENTS | |
|---|---|
| **Wetted, immersion, and Buried Service** | **Page 3 of 3** |

| Paragraph Number | Environment | Operating Temp °F (°C) | Fluid Quality | Carbon Steel Surface Coating System Number | Codes[1] | Typical Structures |
|---|---|---|---|---|---|---|
| 7.4 | Water, Demineralized | ≤120° F (49° C) | 6.5≤pH≤8, $O_2$≥20 ppb, TDS≥0.025 ppb | 2313 | EPP/EPP | Storage tanks for steam cycle turbines |
| 7.5 | Water, Fresh | ≤120° F (49° C) | $Cl^-$<1,000 ppm | 2314 | EPT/EPT | Circulating water piping/equipment |
| 7.6 | Water, Potable | ≤120° F (49° C) | 6≤pH≤8 | 2315 | EPX/EPX | |
| 7.7 | Water, Salt or Brine | ≤120° F (49° C) | $Cl^-$>18,000 ppm | 2314 | EPT/EPT | Circulating water piping/equipment |
| 7.8 | Water, Lime or Gypsum Slurry | ≤160° F (71° C) | 4≤pH≤6.5, 5≤TSS≤15% | 2011 | SPC/SPC | Flue gas desulfurization, tanks |
| 7.9 | Water, Lime or Gypsum Slurry | ≤160° F (71° C) | 4≤pH≤6.5, TSS>15% | 2012 | SPC/SPC | Flue gas desulfurization, tanks, tank floor, lower 3 feet of shell and baffle |
| 7.10 | Water, Lime or Gypsum Slurry | ≤160° F (71° C) | 4≤pH≤6.5, TSS>15% | 2011 | SPC/SPC | Flue gas desulfurization, tanks, balance of tank |

1. EPA - Epoxy amine
EPB - Epoxy fusion bonded
EPP - Epoxy phenolic
EPT - Epoxy coal tar
EPX - Epoxy polyamide
IZ - Inorganic zinc
SPC - No assigned family

| COATING SELECTION | |
|---|---|
| Atmospheric Corrosivity Category C3<br>Moderate Environment | Page 1 of 3 |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| 1.0 | **Structural Steel** | | | | | |
| 1.1 | Outdoor columns, beams, girders, trusses, channels, and other structural members | ≤200 (≤93) | 1401<br>or<br>1301 | IZ<br>or<br>EPZ | ☐ Shop | |
| 1.2 | Ladders, cages, platforms, stairways, walkways, handrail assemblies, and grating | ≤200 (≤93) | | Galvanized | ☐ Shop | |
| | | | **Refer to the Following for Touchup only:** | | | |
| | | | 1302 | EPZ | ☐ Shop<br>☐ Field | |
| 1.3 | Indoor columns, beams, girders, trusses, channels, and other structural members | ≤200 (≤93) | 1401<br>or<br>1301 | IZ<br>or<br>EPZ | ☐ Shop | |
| 2.0 | **Conveyor/Transfer Tower Steel** | | | | | |
| 2.1 | Columns, beams, girders, trusses, channels, and other structural members | | N/A | N/A | | |
| 3.0 | **Tanks, Drums, Columns, Vessels, Reactors, and Shell and Tube Heat Exchangers, Shop Fabricated** | | | | | |
| 3.1 | **Carbon Steel** | | | | | |
| 3.1.1 | Uninsulated | ≤200 (≤93) | 1111 | EPZ/ACW | ☐ Shop | ☐ Shop<br>☐ Field |
| 3.1.2 | Uninsulated | >200 (>93)<br>≤750 (≤399) | 1611 | IZ/SLH | ☐ Shop | ☐ Shop<br>☐ Field |
| 3.1.3 | Uninsulated | >750 (>399)<br>≤1,000 (≤538) | 1612 | SLH/SLH | ☐ Shop | ☐ Shop<br>☐ Field |

| COATING SELECTION | |
|---|---|
| Atmospheric Corrosivity Category C3<br>Moderate Environment | PAGE 2 OF 3 |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| 3.1.4 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1313 | EPP/EPP | Shop | Shop<br>Field |
| 3.1.5 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | 1304 | EPX | Shop | |
| 3.2 | Stainless Steel | | | | | |
| 3.2.1 | Uninsulated | All | | No coating | | |
| 3.2.2 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1303 | EPP | Shop | |
| 3.2.3 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No coating | | |
| **4.0** | **Pipe and Pipe Supports** | | | | | |
| 4.1 | Carbon Steel | | | | | |
| 4.1.1 | Uninsulated | ≤200 (≤93) | 1112 | EPX/ACW | Shop | Shop<br>Field |
| 4.1.2 | Uninsulated | >200 (>93)<br>≤750 (≤399) | 1611 | IZ/SLH | Shop | Shop<br>Field |
| 4.1.3 | Uninsulated | >750 (>399)<br>≤1,000 (≤538) | 1612 | SLH/SLH | Shop | Shop<br>Field |
| 4.1.4 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1313 | EPP/EPP | Shop | Shop<br>Field |
| 4.1.5 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No coating | | |
| 4.2 | Stainless Steel | | | | | |
| 4.2.1 | Uninsulated | All | | No coating | | |
| 4.2.2 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1303 | EPP | Shop | |
| 4.2.3 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No coating | | |
| **5.0** | **Pumps, Compressors, and Rotating Equipment** | All | | Manufacturer's Standard Coating | | |

| COATING SELECTION | |
|---|---|
| **Atmospheric Corrosivity Category C3 Moderate Environment** | **PAGE 3 OF 3** |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| 6.0 | **Bulk Valves and Fittings** | All | | Manufacturer's Standard Coating | | |
| 7.0 | **Electric Motors and Equipment** | All | | Manufacturer's Standard Coating | | |
| 8.0 | **Instruments and Control Panels** | All | | Manufacturer's Standard Coating | | |
| 9.0 | **Tanks , Silos, and Spheres, Field Erected** | | | | | |
| 9.1 | **Carbon Steel** | | | | | |
| 9.1.1 | Uninsulated | ≤200 (≤93) | 1111 | EPZ/ACW | ☐ Shop | ☐ Shop ☐ Field |
| 9.1.2 | Insulated | >-50 (>-46) ≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop ☐ Field |
| 9.1.3 | Insulated | ≤-50 (≤-46) >300 (>149) | 1304 | EPX | ☐ Shop | |
| 9.2 | **Stainless Steel** | | | | | |
| 9.2.1 | Uninsulated | All | | No coating | | |
| 9.2.2 | Insulated | >-50 (>-46) ≤300 (≤149) | 1303 | EPP | ☐ Shop | |
| 9.2.3 | Insulated | ≤-50 (≤-46) >300 (>149) | | No coating | | |
| 10.0 | **Furnaces, Stacks, Ducts, and Boilers** | | | | | |
| 10.1 | Uninsulated | ≤300 (≤149) | 1401 | IZ | ☐ Shop | |
| 10.2 | Uninsulated | >300 (>149) ≤750 (≤399) | 1402 | IZ | ☐ Shop | |
| 10.3 | Uninsulated | >750 (>399) ≤1,000 (≤538) | 1612 | SLH/SLH | ☐ Shop | ☐ Shop ☐ Field |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| 10.4 | Insulated | >-50 (>-46) ≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop ☐ Field |
| 10.5 | Insulated | ≤-50 (≤-46) >300 (>149) | | No coating | | |

1. ACW - Acrylic waterborne
EPA - Epoxy amine
EPP - Epoxy phenolic
EPX - Epoxy polyamide
EPZ - Epoxy zinc
IZ - Inorganic zinc
SLH - Silicon heat cured
URA - Polyurethane

| COATING SELECTION CRITERIA | |
|---|---|
| **Atmospheric Corrosivity Category C4 Industrial Environment** | **PAGE 1 OF 4** |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| **1.0** | **Structural Steel** | | | | | |
| 1.1 | Outdoor columns, beams, girders, trusses, channels, and other structural members | ≤200 (≤93) | 1712 | EPZ/URA | ☐ Shop | ☐ Shop<br>☐ Field |
| 1.2 | Ladders, cages, platforms, stairways, walk-ways, handrail assemblies, and grating | ≤200 (≤93) | | Galvanized | ☐ Shop | |
| | | | **Refer to the Following for Touchup only:** | | | |
| | | | 1302 | EPZ | ☐ Shop<br>☐ Field | |
| 1.3 | Indoor columns, beams, girders, trusses, channels, and other structural members | ≤200 (≤93) | 1311 | EPZ/EPX | ☐ Shop | ☐ Shop<br>☐ Field |
| **2.0** | **Conveyor/Transfer Tower Steel** | | | | | |
| 2.1 | Columns, beams, girders, trusses, channels, and other structural members | ≤200 (≤93) | 1312 | EPZ/EPF | ☐ Shop | ☐ Shop<br>☐ Field |
| **3.0** | **Tanks, Drums, Columns, Vessels, Reactors, and Shell and Tube Heat Exchangers, Shop Fabricated** | | | | | |
| 3.1 | **Carbon Steel** | | | | | |
| 3.1.1 | Uninsulated | ≤200 (≤93) | 1712 | EPZ/URA | ☐ Shop | ☐ Shop<br>☐ Field |
| 3.1.2 | Uninsulated | >200 (>93)<br>≤750 (≤399) | 1611 | IZ/SLH | ☐ Shop | ☐ Shop<br>☐ Field |
| 3.1.3 | Uninsulated | >750 (>399)<br>≤1,000 (≤538) | 1612 | SLH/SLH | ☐ Shop | ☐ Shop<br>☐ Field |

| COATING SELECTION CRITERIA | |
|---|---|
| **Atmospheric Corrosivity Category C4<br>Industrial Environment** | **PAGE 2 OF 4** |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| 3.1.4 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop<br>☐ Field |
| 3.1.5 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | 1304 | EPX | ☐ Shop | |
| 3.2 | **Stainless Steel** | | | | | |
| 3.2.1 | Uninsulated | All | | No coating | | |
| 3.2.2 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1303 | EPP | ☐ Shop | |
| 3.2.3 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No coating | | |
| **4.0** | **Pipe and Pipe Supports** | | | | | |
| 4.1 | **Carbon Steel** | | | | | |
| 4.1.1 | Uninsulated | ≤200 (≤93) | 1112 | EPX/ACW | ☐ Shop | ☐ Shop<br>☐ Field |
| 4.1.2 | Uninsulated | >200 (>93)<br>≤750 (≤399) | 1611 | IZ/SLH | ☐ Shop | ☐ Shop<br>☐ Field |
| 4.1.3 | Uninsulated | >750 (>399)<br>≤1,000 (≤538) | 1612 | SLH/SLH | ☐ Shop | ☐ Shop<br>☐ Field |
| 4.1.4 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop<br>☐ Field |
| 4.1.5 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No Coating | | |
| 4.2 | **Stainless Steel** | | | | | |
| 4.2.1 | Uninsulated | All | | No coating | | |
| 4.2.2 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1303 | EPP | ☐ Shop | |
| 4.2.3 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No coating | | |
| **5.0** | **Pumps, Compressors, and Rotating Equipment** | All | | Manufacturer's Standard Coating | | |

| COATING SELECTION CRITERIA | |
|---|---|
| **Atmospheric Corrosivity Category C4 Industrial Environment** | **PAGE 3 OF 4** |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| **6.0** | **Bulk Valves and Fittings** | All | | Manufacturer's Standard Coating | | |
| **7.0** | **Electric Motors and Equipment** | All | | Manufacturer's Standard Coating | | |
| **8.0** | **Instruments and Control Panels** | All | | Manufacturer's Standard Coating | | |
| **9.0** | **Tanks, Silos, and Spheres, Field Erected** | | | | | |
| 9.1 | **Carbon Steel** | | | | | |
| 9.1.1 | Uninsulated | ≤200 (≤93) | 1712 | EPZ/URA | ☐ Shop | ☐ Shop ☐ Field |
| 9.1.2 | Insulated | >-50 (>-46) ≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop ☐ Field |
| 9.1.3 | Insulated | ≤-50 (≤-46) >300 (>149) | 1304 | EPX | ☐ Shop | |
| 9.2 | **Stainless Steel** | | | | | |
| 9.2.1 | Uninsulated | All | | No coating | | |
| 9.2.2 | Insulated | >-50 (>-46) ≤300 (≤149) | 1303 | EPP | ☐ Shop | |
| 9.2.3 | Insulated | ≤-50 (≤-46) >300 (>149) | | No coating | | |
| **10.0** | **Furnaces, Stacks, Ducts, and Boilers** | | | | | |
| 10.1 | Uninsulated | ≤300 (≤149) | 1401 | IZ | ☐ Shop | |
| 10.2 | Uninsulated | >300 (>149) ≤750 (≤399) | 1402 | IZ | ☐ Shop | |
| 10.3 | Uninsulated | >750 (>399) ≤1,000 (≤538) | 1612 | SLH/SLH | ☐ Shop | ☐ Shop ☐ Field |
| 10.4 | Insulated | >-50 (>-46) ≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop ☐ Field |
| 10.5 | Insulated | ≤-50 (≤-46) >300 (>149) | | No coating | | |

1. ACW - Acrylic waterborne
   EPA - Epoxy amine
   EPF - Epoxy flake filled
   EPP - Epoxy phenolic
   EPX - Epoxy polyamide
   EPZ - Epoxy zinc
   IZ - Inorganic zinc
   SLH - Silicone heat cured
   URA - Polyurethane

| COATING SELECTION | |
|---|---|
| **Atmospheric Corrosivity Category C5-M Marine Environment** | **PAGE 1 OF 4** |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| **1.0** | **Structural Steel** | | | | | |
| 1.1 | Outdoor columns, beams, girders, trusses, channels, and other structural members | ≤200 (≤93) | 1511 | EPZ/PSX | ☐ Shop | ☐ Shop<br>☐ Field |
| 1.2 | Ladders, cages, platforms, stairways, walkways, handrail assemblies, and grating | ≤200 (≤93) | | Galvanized | ☐ Shop | |
| | | | **Refer to the Following for Touchup only:** | | | |
| | | | 1302 | EPZ | ☐ Shop<br>☐ Field | |
| 1.3 | Indoor columns, beams, girders, trusses, channels, and other structural members | | Use Category C4 recom-mendation. | N/A | | |
| **2.0** | **Conveyor/Transfer Tower Steel** | | | | | |
| 2.1 | Columns, beams, girders, trusses, channels, and other structural members | ≤200 (≤93) | 1312 | EPZ/EPF | ☐ Shop | ☐ Shop<br>☐ Field |
| **3.0** | **Tanks, Drums, Columns, Vessels, Reactors, and Shell and Tube Heat Exchangers, Shop Fabricated** | | | | | |
| 3.1 | | | **Carbon Steel** | | | |
| 3.1.1 | Uninsulated | ≤200 (≤93) | 1511 | EPZ/PSX | ☐ Shop | ☐ Shop<br>☐ Field |
| 3.1.2 | Uninsulated | >200 (>93)<br>≤750 (≤399) | 1611 | IZ/SLH | ☐ Shop | ☐ Shop<br>☐ Field |
| 3.1.3 | Uninsulated | >750 (>399)<br>≤1,000 (≤538) | 1612 | SLH/SLH | ☐ Shop | ☐ Shop<br>☐ Field |

| COATING SELECTION | |
|---|---|
| Atmospheric Corrosivity Category C5-M Marine Environment | PAGE 2 OF 4 |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| 3.1.4 | Insulated | >-50 (>-46) ≤300 (≤149) | 1313 | EPP/EPP | Shop | Shop Field |
| 3.1.5 | Insulated | ≤-50 (≤-46) >300 (>149) | 1304 | EPX | Shop | |
| 3.2 | Stainless Steel | | | | | |
| 3.2.1 | Uninsulated | All | | No coating | | |
| 3.2.2 | Insulated | >-50 (>-46) ≤300 (≤149) | 1303 | EPP | Shop | |
| 3.2.3 | Insulated | ≤-50 (≤-46) >300 (>149) | | No coating | | |
| **4.0** | **Pipe and Pipe Supports** | | | | | |
| 4.1 | Carbon Steel | | | | | |
| 4.1.1 | Uninsulated | ≤200 (≤93) | 1711 | EPX/URA | Shop | Shop Field |
| 4.1.2 | Uninsulated | >200 (>93) ≤750 (≤399) | 1611 | IZ/SLH | Shop | Shop Field |
| 4.1.3 | Uninsulated | >750 (>399) ≤1,000 (≤538) | 1612 | SLH/SLH | Shop | Shop Field |
| 4.1.4 | Insulated | >-50 (>-46) ≤300 (≤149) | 1313 | EPP/EPP | Shop | Shop Field |
| 4.1.5 | Insulated | ≤-50 (≤-46) >300 (>149) | | No Coating | | |
| 4.2 | Stainless Steel | | | | | |
| 4.2.1 | Uninsulated | All | | No coating | | |
| 4.2.2 | Insulated | >-50 (>-46) ≤300 (≤149) | 1303 | EPP | Shop | |
| 4.2.3 | Insulated | ≤-50 (≤-46) >300 (>149) | | No coating | | |
| **5.0** | **Pumps, Compressors, and Rotating Equipment** | All | | Manu-facturer's Standard Coating | | |

| COATING SELECTION | |
|---|---|
| **Atmospheric Corrosivity Category C5-M Marine Environment** | **PAGE 3 OF 4** |

| Paragraph Number | Items | Operating Temp °F (°C) | Coating System Number | Codes[1] | First Coat | Second Coat |
|---|---|---|---|---|---|---|
| **6.0** | **Bulk Valves and Fittings** | All | | Manu-facturer's Standard Coating | | |
| **7.0** | **Electric Motors and Equipment** | All | | Manu-facturer's Standard Coating | | |
| **8.0** | **Instruments and Control Panels** | All | | Manu-facturer's Standard Coating | | |
| **9.0** | **Tanks, Silos, and Spheres, Field Erected** | | | | | |
| 9.1 | **Carbon Steel** | | | | | |
| 9.1.1 | Uninsulated | ≤200 (≤93) | 1511 | EPZ/PSX | ☐ Shop | ☐ Shop<br>☐ Field |
| 9.1.2 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop<br>☐ Field |
| 9.1.3 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | 1304 | EPX | ☐ Shop | |
| 9.2 | **Stainless Steel** | | | | | |
| 9.2.1 | Uninsulated | All | | No coating | | |
| 9.2.2 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1303 | EPP | ☐ Shop | |
| 9.2.3 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No coating | | |
| **10.0** | **Furnaces, Stacks, Ducts, and Boilers** | | | | | |
| 10.1 | Uninsulated | ≤300 (≤149) | 1401 | IZ | ☐ Shop | |
| 10.2 | Uninsulated | >300 (>149)<br>≤750 (≤399) | 1402 | IZ | ☐ Shop | |
| 10.3 | Uninsulated | >750 (>399)<br>≤1,000<br>(≤538) | 1612 | SLH/SLH | ☐ Shop | ☐ Shop<br>☐ Field |
| 10.4 | Insulated | >-50 (>-46)<br>≤300 (≤149) | 1313 | EPP/EPP | ☐ Shop | ☐ Shop<br>☐ Field |
| 10.5 | Insulated | ≤-50 (≤-46)<br>>300 (>149) | | No coating | | |

1. EPA - Epoxy amine
   EPF - Epoxy flake filled
   EPP - Epoxy phenolic
   EPX - Epoxy polyamide
   EPZ - Epoxy zinc
   IZ - Inorganic zinc
   PSX - Polysiloxane
   SLH - Silicon heat cured
   URA - Polyurethane

| Epoxy Zinc (EPZ)/Acrylic Waterborne (ACW) | Coating System 1111 |
|---|---|

| | |
|---|---|
| **Description** | Organic zinc primer with acrylic finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPZ | 3 mils (75 µm) | 4 mils (100 µm) | S | Class B slip coefficient. |
| **Touchup** | EPZ | 3 mils (75 µm) | 4 mils (100 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | ACW | 2 mils (50 µm) | 3 mils (75 µm) | S, F | |
| **Completed System** | | 5 mils (125 µm) | 7 mils (175 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| **Polyamide Epoxy (EPX)/Acrylic Waterborne (ACW)** | **Coating System 1112** |
|---|---|

| | |
|---|---|
| **Description** | Polyamide epoxy primer with acrylic finish |
| **Surfaces** | Carbon steel |

| | **First Coat** | **Touchup** | **Second Coat** |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 μm to 50 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | **Generic Coating Type** | **Minimum DFT** | **Maximum DFT** | **Shop (S) or Field (F) Applied** | **Remarks** |
|---|---|---|---|---|---|
| **First Coat** | EPX | 4 mils (100 μm) | 6 mils (150 μm) | S | |
| **Touchup** | EPX | 4 mils (100 μm) | 6 mils (150 μm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | ACW | 2 mils (50 μm) | 3 mils (75 μm) | S, F | |
| **Completed System** | | 6 mils (150 μm) | 9 mils (225 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| **Epoxy Zinc** | **Coating System 1301** |
|---|---|

| | |
|---|---|
| **Description** | Organic zinc |
| **Surfaces** | Carbon steel |

| | **First Coat** | **Touchup** | **Second Coat** |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 μm to 50 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | **Generic Coating Type** | **Minimum DFT** | **Maximum DFT** | **Shop (S) or Field (F) Applied** | **Remarks** |
|---|---|---|---|---|---|
| **First Coat** | EPZ | 3 mils (75 μm) | 4 mils (100 μm) | S | Class B slip coefficient. |
| **Touchup** | EPZ | 3 mils (75 μm) | 4 mils (100 μm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | | | | | |
| **Completed System** | | 3 mils (75 μm) | 4 mils (100 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy Zinc (EPZ) | Coating System 1302 |
|---|---|

| | |
|---|---|
| **Description** | Organic zinc cold galvanizing compound in aerosol container |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | Galvanizing exists | 4.17 lb/gal (500 g/L) | |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP3 Power Tool Cleaning |
| **Remarks** | Complies with ASTM A780 or Mil-P-21035A |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | Hot-Dip Galvanizing | | | | Galvanizing exists. |
| **Touchup** | EPZ | 2 mils (50 μm) | 3 mils (75 μm) | S, F | Touchup for hot-dip galvanizing. |
| **Second Coat** | | | | | |
| **Completed System** | | 2 mils (50 μm) | 3 mils (75 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy Phenolic (EPP) | Coating System 1303 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy phenolic |
| **Surfaces** | Stainless steel under insulation |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) | |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPP | 6 mils (150 µm) | 8 mils (200 µm) | S | DFT as noted. |
| **Touchup** | EPP | 6 mils (150 µm) | 8 mils (200 µm) | S, F | DFT as noted. |
| **Second Coat** | | | | | |
| **Completed System** | | 6 mils (150 µm) | 8 mils (200 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Polyamide Epoxy (EPX) | Coating System 1304 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy polyamide primer |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) | |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP3 Power Tool Cleaning |
| **Remarks** | |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPX | 4 mils (100 μm) | 6 mils (150 μm) | S | |
| **Touchup** | EPX | 4 mils (100 μm) | 6 mils (150 μm) | S, F | |
| **Second Coat** | | | | | |
| **Completed System** | | 4 mils (100 μm) | 6 mils (150 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy Zinc (EPZ)/Polyamide Epoxy (EPX) | Coating System 1311 |
|---|---|

| | |
|---|---|
| **Description** | Organic zinc primer with polyamide epoxy finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPZ | 3 mils (75 µm) | 4 mils (100 µm) | S | Class B slip coefficient. |
| **Touchup** | EPZ | 3 mils (75 µm) | 4 mils (100 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | EPX | 4 mils (100 µm) | 6 mils (150 µm) | S, F | |
| **Completed System** | | 7 mils (175 µm) | 10 mils (250 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy Zinc (EPZ)/Epoxy Flake Filled (EPF) | Coating System 1312 |
|---|---|

| | |
|---|---|
| **Description** | Organic zinc primer with flake filled epoxy finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 μm to 50 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPZ | 3 mils (75 μm) | 4 mils (100 μm) | S | Class B slip coefficient. |
| **Touchup** | EPZ | 3 mils (75 μm) | 4 mils (100 μm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | EPF | 10 mils (250 μm) | 15 mils (375 μm) | S, F | |
| **Completed System** | | 13 mils (325 μm) | 19 mils (475 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy Phenolic (EPP)/ Epoxy Phenolic (EPP) | Coating System 1313 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy phenolic primer with epoxy phenolic finish |
| **Surfaces** | Carbon steel under insulation |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPP | 6 mils (150 µm) | 8 mils (200 µm) | S | DFT as noted (typical). |
| **Touchup** | EPP | 6 mils (150 µm) | 8 mils (200 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | EPP | 6 mils (150 µm) | 8 mils (200 µm) | S, F | |
| **Completed System** | | 12 mils (300 µm) | 16 mils (400 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Inorganic Zinc (IZ) | Coating System 1401 |
|---|---|

| | |
|---|---|
| **Description** | Inorganic zinc with organic zinc touchup |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

| Dry Film Thickness (DFT) | | | | | |
|---|---|---|---|---|---|
| | **Generic Coating Type** | **Minimum DFT** | **Maximum DFT** | **Shop (S) or Field (F) Applied** | **Remarks** |
| **First Coat** | IZ | 3 mils (75 µm) | 4 mils (100 µm) | S | Class B slip coefficient. |
| **Touchup** | EPZ | 3 mils (75 µm) | 4 mils (100 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | | | | | |
| **Completed System** | | 3 mils (75 µm) | 4 mils (100 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Inorganic Zinc (IZ) | Coating System 1402 |
|---|---|

| | |
|---|---|
| **Description** | Inorganic zinc with inorganic zinc touchup |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E" profile. |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | IZ | 3 mils (75 µm) | 4 mils (100 µm) | S | |
| **Touchup** | IZ | 3 mils (75 µm) | 4 mils (100 µm) | S, F | SSPC-SP11 Power Tool Cleaning to Bare Metal. |
| **Second Coat** | | | | | |
| **Completed System** | | 3 mils (75 µm) | 4 mils (100 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy Zinc (EPZ)/Polysiloxane (PSX) | Coating System 1511 |
|---|---|

| | |
|---|---|
| **Description** | Organic zinc primer with polysiloxane finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPZ | 3 mils (75 µm) | 4 mils (100 µm) | S | Class B slip coefficient. |
| **Touchup** | EPZ | 3 mils (75 µm) | 4 mils (100 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | PSX | 3 mils (75 µm) | 7 mils (175 µm) | S, F | |
| **Completed System** | | 6 mils (150 µm) | 11 mils (275 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Inorganic Zinc (IZ)/Silicone Heat Cured (SLH) | Coating System 1611 |
|---|---|

| | |
|---|---|
| **Description** | Inorganic zinc primer with heat cured silicone finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | 3.52 lb/gal (420 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 0.5 to 1 mil (13 µm to 25 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | IZ | 2 mils (50 µm) | 3 mils (75 µm) | S | |
| **Touchup** | IZ | 2 mils (50 µm) | 3 mils (75 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | SLH | 1 mil (25 µm) | 2 mils (50 µm) | S, F | |
| **Completed System** | | 3 mils (75 µm) | 5 mils (125 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Silicone Heat Cured (SLH)/ Silicone Heat Cured (SLH) | Coating System 1612 |
|---|---|

| | |
|---|---|
| **Description** | Heat cured silicone primer with silicone heat cured finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 3.52 lb/gal (420 g/L) | 3.52 lb/gal (420 g/L) | 3.52 lb/gal (420 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 0.3 to 0.8 mil (8 µm to 20 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | SLH | 0.5 mil (13 µm) | 2 mils (50 µm) | S | Shop coat(s) shall be heat cured before shipment. |
| **Touchup** | SLH | 0.5 mil (13 µm) | 2 mils (50 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | SLH | 0.5 mil (13 µm) | 2 mils (50 µm) | S, F | |
| **Completed System** | | 1 mil (25 µm) | 4 mils (100 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Polyamide Epoxy (EPX)/ Polyurethane (URA) | Coating System 1711 |
|---|---|

| | |
|---|---|
| **Description** | Polyamide epoxy primer with polyurethane finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPX | 4 mils (100 µm) | 6 mils (150 µm) | S | |
| **Touchup** | EPX | 4 mils (100 µm) | 6 mils (150 µm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | URA | 3 mils (75 µm) | 5 mils (125 µm) | S, F | |
| **Completed System** | | 7 mils (175 µm) | 11 mils (275 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy Zinc (EPZ)/Polyurethane (URA) | Coating System 1712 |
|---|---|

| | |
|---|---|
| **Description** | Organic zinc primer with high-build polyurethane finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 4.17 lb/gal (500 g/L) | 4.17 lb/gal (500 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 1 to 2 mils (25 μm to 50 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPZ | 3 mils (75 μm) | 4 mils (100 μm) | S | Class B slip coefficient. |
| **Touchup** | EPZ | 3 mils (75 μm) | 4 mils (100 μm) | S, F | SSPC-SP3 Power Tool Cleaning. |
| **Second Coat** | URA | 3 mils (75 μm) | 5 mils (125 μm) | S, F | |
| **Completed System** | | 6 mils (150 μm) | 9 mils (225 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Vinyl Ester (SPC)/ Vinyl Ester Flake Filled (SPC) | Coating System 2011 |
|---|---|

| | |
|---|---|
| **Description** | Vinyl ester primer with vinyl ester flake filled finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP 5/NACE No. 1 White Metal<br>Profile depth 3 to 5 mils (75 μm to 125 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>1/4" radius all corners and edges.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "C."<br>Second coat Taber abrasion test result shall be less than or equal to 20 mg loss per 1,000 cycles with 1,000g and CS-17 wheel when tested in accordance with ASTM D4060.<br>Second coat moisture permeability shall be less than or equal to 0.0010 perm-inch when measured in accordance with ASTM E96. |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | SPC | 4 mils (100 μm) | 6 mils (150 μm) | F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | SPC | 55 mils (1,375 μm) | 65 mils (1,625 μm) | F | DFT as noted. Apply in successive applications of 15 to 20 mils (375 to 500 μm) each as recommended by the manufacturer. |
| **Completed System** | | 59 mils (1,475 μm) | 71 mils (1,775 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. Holiday testing shall be performed in accordance with NACE RP0188 and coating manufacturer's instructions. |

| Vinyl Ester (SPC)/ Vinyl Ester Reinforced (SPC)/ Vinyl Ester Filled (SPC) | Coating System 2012 |
|---|---|

| | |
|---|---|
| **Description** | Vinyl ester primer with fiberglass reinforced second coat and vinyl ester filled finish |
| **Surfaces** | Carbon steel |

| | First Coat | Second Coat | Third Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP 5/NACE No. 1 White Metal Blast Cleaning<br>Profile depth 3 to 5 mils (75 µm to 125 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "C."<br>Second and third coat Taber abrasion test result(s) shall be less than or equal to 15 mg loss per 1,000 cycles with 1,000g and CS-17 wheel when tested in accordance with ASTM D4060.<br>Second and third coat moisture permeability shall be less than or equal to 0.0010 perm-inch when measured in accordance with ASTM E96. |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | SPC | 4 mils (100 µm) | 6 mils (150 µm) | F | |
| **Second Coat** | SPC | 60 mils (1,500 µm) | 65 mils (1,625 µm) | F | DFT as noted. |
| **Third Coat** | SPC | 60 mils (1,500 µm) | 65 mils (1,625 µm) | F | DFT as noted. |
| **Completed System** | | 124 mils (3,100 µm) | 136 mils (3,400 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2.<br>Holiday testing shall be performed in accordance with NACE RP0188 and coating manufacturer's instructions. |

| Epoxy Amine (EPA)/Epoxy Amine (EPA) | Coating System 2311 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy amine primer with epoxy amine finish |
| **Surfaces** | Carbon Steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP5/NACE No. 1 White Metal Blast Cleaning<br>Profile depth 2 to 3 mils (50 µm to 75 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "D." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPA | 6 mils (150 µm) | 8 mils (200 µm) | S, F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | EPA | 6 mils (150 µm) | 8 mils (200 µm) | S, F | |
| **Completed System** | | 12 mils (300 µm) | 16 mils (400 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2.<br>Holiday testing required in accordance with NACE RP0188 and coating manufacturer's instructions. |

| Epoxy Phenolic (EPP)/ Epoxy Phenolic (EPP) | Coating System 2312 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy phenolic primer with epoxy phenolic finish |
| **Surfaces** | Carbon Steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP5/NACE No. 1 White Metal Blast Cleaning<br>Profile depth 2 to 3 mils (50 μm to 75 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "C." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPP | 5 mils (125 μm) | 6 mils (150 μm) | S, F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | EPP | 5 mils (125 μm) | 6 mils (150 μm) | S, F | |
| **Completed System** | | 10 mils (250 μm) | 12 mils (300 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2.<br>Holiday testing required in accordance with NACE RP0188 and coating manufacturer's instructions. |

| Epoxy Phenolic (EPP)/ Epoxy Phenolic (EPP) | Coating System 2313 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy phenolic primer with epoxy phenolic finish |
| **Surfaces** | Carbon Steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP5/NACE No. 1 White Metal Blast Cleaning<br>Profile depth 2 to 3 mils (50 μm to 75 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "C" profile. |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPP | 5 mils (125 μm) | 7 mils (175 μm) | S, F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | EPP | 5 mils (125 μm) | 7 mils (175 μm) | S, F | |
| **Completed System** | | 10 mils (250 μm) | 14 mils (350 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2.<br>Holiday testing required in accordance with NACE RP0188 and coating manufacturer's instructions. |

| Epoxy Coal Tar (EPT)/ Epoxy Coal Tar (EPT) | Coating System 2314 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy coal tar primer with epoxy coal tar finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP5/NACE No. 1 White Metal Blast Cleaning<br>Profile depth 2 to 4 mils (50 µm to 100 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "C." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPT | 8 mils (200 µm) | 12 mils (300 µm) | S, F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | EPT | 8 mils (200 µm) | 12 mils (300 µm) | S, F | |
| **Completed System** | | 16 mils (400 µm) | 24 mils (600 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2.<br>Holiday testing required in accordance with NACE RP0188 and coating manufacturer's instructions. |

| Epoxy Polyamide (EPX)/ Epoxy Polyamide (EPX) | Coating System 2315 |
|---|---|

| | |
|---|---|
| **Description** | NSF certified epoxy polyamide primer with epoxy polyamide finish |
| **Surfaces** | Carbon Steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP5/NACE No. 1 White Metal Blast Cleaning<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "C." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPX | 4 mils (100 µm) | 6 mils (150 µm) | S, F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | EPX | 4 mils (100 µm) | 6 mils (150 µm) | S, F | |
| **Completed System** | | 8 mils (200 µm) | 12 mils (300 µm) | | Dry film thickness to be verified in accordance with SSPC-PA2.<br>Holiday testing shall be performed in accordance with NACE RP0188 and coating manufacturer's instructions. |

| Adhesive Primer (SPC)/ Cold Applied Tape (SPC) | Coating System 3011 |
|---|---|

| | |
|---|---|
| **Description** | Adhesive primer with AWWA C209 Type II cold applied tape finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 1.66 lb/gal (200 g/L) | N/A | N/A |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP3 Power Tool Cleaning |
| **Remarks** | Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E". |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | SPC | 1 mil (25 μm) | 2 mils (50 μm) | S, F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | SPC | 56 mils (1,400 μm) | 70 mils (1,750 μm) | S, F | 50 percent overlap. |
| **Completed System** | | 57 mils (1,425 μm) | 72 mils (1,800 μm) | | |

| Adhesive Primer (SPC)/ Cold Applied Tape (SPC) | Coating System 3012 |
|---|---|

| | |
|---|---|
| **Description** | Adhesive primer with AWWA C209 Type II cold applied tape finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 1.66 lb/gal (200 g/L) | N/A | N/A |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Clean<br>Profile depth 1 to 2 mils (25 µm to 50 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Designation "E." |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | SPC | 6 mils (150 µm) | 10 mils (250 µm) | S, F | |
| **Touchup** | | N/A | N/A | | |
| **Second Coat** | SPC | 38 mils (950 µm) | 42 mils (1,050 µm) | S, F | Add moldable sealant to fill voids. 50 percent overlap. |
| **Completed System** | | 82 mils (2,050 µm) | 94 mils (2,350 µm) | | |

| Epoxy, Fusion Bonded (EPB) | Coating System 3301 |
|---|---|

| | |
|---|---|
| **Description** | Fusion bonded epoxy |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | N/A | N/A |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP10/NACE No. 2 Near White Blast Cleaning<br>Profile depth 2 to 4 mils (50 μm to 100 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E". |

| Dry Film Thickness (DFT) | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPB | 14 mils (350 μm) | 20 mils (500 μm) | S | |
| **Touchup** | SPC | 25 mils (625 μm) | 28 mils (700 μm) | S, F | SSPC-SP11 Power Tool Cleaning. |
| **Second Coat** | | N/A | | | |
| **Completed System** | | 14 mils (350 μm) | 28 mils (700 μm) | | Dry film thickness to be verified in accordance with NACE RP0394.<br>Holiday testing required in accordance with NACE RP0490. |

| Epoxy Coal Tar (EPT)/Epoxy Coal Tar (EPT) | Coating System 3311 |
|---|---|

| | |
|---|---|
| **Description** | Epoxy coal tar primer with epoxy coal tar finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | 2.83 lb/gal (340 g/L) | | 2.83 lb/gal (340 g/L) |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP6/NACE No. 3 Commercial Blast Cleaning<br>Profile depth 2 to 4 mils (50 μm to 100 μm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E". |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| **First Coat** | EPT | 8 mils (200 μm) | 12 mils (300 μm) | S | |
| **Touchup** | | N/A | | | |
| **Second Coat** | EPT | 8 mils (200 μm) | 12 mils (300 μm) | S | |
| **Completed System** | | 16 mils (400 μm) | 24 mils (600 μm) | | Dry film thickness to be verified in accordance with SSPC-PA2. |

| Epoxy, Fusion Bonded (EPB)/ Epoxy, Fusion Bonded (EPB) | Coating System 3312 |
|---|---|

| | |
|---|---|
| **Description** | Fusion bonded epoxy primer with fusion bonded epoxy finish |
| **Surfaces** | Carbon steel |

| | First Coat | Touchup | Second Coat |
|---|---|---|---|
| **VOC Limits** | N/A | N/A | N/A |

| | |
|---|---|
| **Surface Preparation** | SSPC-SP10/NACE No. 2 Near White Blast Cleaning<br>Profile depth 2 to 4 mils (50 µm to 100 µm) |
| **Remarks** | Profile to be verified by Contractor using ASTM D4417 Method C.<br>Welds to be prepared in accordance with NACE RP0178, Appendix C, Replica "E". |

**Dry Film Thickness (DFT)**

| | Generic Coating Type | Minimum DFT | Maximum DFT | Shop (S) or Field (F) Applied | Remarks |
|---|---|---|---|---|---|
| First Coat | EPB | 10 mils (250 µm) | 12 mils (300 µm) | S | |
| Touchup | | N/A | N/A | | |
| Second Coat | EPB | 20 mils (500 µm) | 24 mils (600 µm) | S | |
| Completed System | | 30 mils (750 µm) | 36 mils (900 µm) | | Dry film thickness to be verified in accordance with NACE RP0394.<br>Holiday testing required in accordance with NACE RP0490. |

## SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT B3 – REFERENCE COAL LIST

# CONTENTS

# 1. REFERENCE COAL LIST

Table B3-1 Coal quality analysis

| Item | Symbol | Unit | Design Coal | Worst Coal |
|---|---|---|---|---|
| **1. Coal type** | | | indo 12 | indo 6 |
| **2. Element analysis** | | | | |
| Base carbon as received | Car | % | 54.34 | 46.59 |
| Base hydrogen as received | Har | % | 3.72 | 3.49 |
| Base oxygen as received | Oar | % | 11.93 | 14.43 |
| Base nitrogen as received | Nar | % | 1.14 | 0.84 |
| Base total sulfur as received | St, ar | % | 0.37 | 0.47 |
| Base ash content as received | A, ar | % | 6 | 4.68 |
| Total moisture as received | M, ar | % | 22.5 | 29.50 |
| Total | | % | 100 | 100 |
| **3. Technical analysis** | | | | |
| Air-dried base moisture content | Mad | % | 16 | 13.57 |
| Air-dried base volatile constituent | Vda | % | 38 | 38.63 |
| **4. Base low heat value as received** | LHV,ar | MJ/kg | 19.949 | 17.408 |
| **5. Hardgrove grindability index** | HGI | | 42 | 48 |
| **6. Ash fusion temperature** | | | | |
| Deformation temperature | DT | ℃ | 1130 | 1210 |
| Softening temperature | ST | ℃ | 1180 | 1310 |
| Flowing temperature | FT | ℃ | 1210 | 1330 |
| **7. Ash component analysis** | | | | |
| $SiO_2$ | | % | 40 | 43 |
| $Al_2O_3$ | | % | 13.9 | 23.1 |
| $Fe_2O_3$ | | % | 14.8 | 9 |
| CaO | | % | 10.5 | 9.5 |
| MgO | | % | 7.5 | 3.58 |
| $Na_2O$ | | % | 0.7 | 0.44 |
| $K_2O$ | | % | 1.7 | 1.48 |
| $TiO_2$ | | % | 0.8 | 0.96 |
| $Mn_3O_4$ | | % | - | 0.12 |
| $SO_3$ | | % | 9.9 | 7.95 |
| $P_2O_5$ | | % | 0.2 | 0.86 |

| | | | | |
|---|---|---|---|---|
| Other | | % | - | 0.01 |
| BaO | | % | - | - |

# SECTION 5 – EMPLOYER’S REQUIREMENTS

# ATTACHMENT B4 – REFERENCE DRAWINGS

## LIST OF DRAWINGS

| No. | DRAWING TITLE | DRAWING NO. |
|---|---|---|
| | MECHANICAL DRAWING | |
| 1 | LIST OF DRAWINGS | 10-PM-PAY-00 |
| 2 | GENERAL LAYOUT (ENLARGE VIEW) | 10-PM-PAY-01 |
| 3 | GENERAL LAYOUT (OVERALL) | 10-PM-PAY-02 |
| 4 | PRINCIPLE THERMAL POWER SYSTEM DRAWING | 10-PM-PAY-03 |
| 5 | PRINCIPLE COMBUSTION SYSTEM DRAWING | 10-PM-PAY-04 |
| 6 | GROUND PLAN OF MAIN POWER BUILDING | 10-PM-PAY-05 |
| 7 | CROSS-SECTION OF MAIN POWER BUILDING | 10-PM-PAY-06 |
| 8 | FLUE GAS DESULPHURIZATION SYSTEM DIAGRAM | 10-PM-PAY-07 |
| 9 | SLAG DISPOSAL SYSTEM DIAGRAM | 10-PM-PAY-08 |
| 10 | FLY ASH HANDLING SYSTEM DIAGRAM | 10-PM-PAY-09 |
| 11 | BOILER MAKE-UP WATER TREATMENT SYSTEM | 10-PM-PAY-10 |
| 12 | CONDENSATE WATER POLISHING TREATMENT SYSTEM | 10-PM-PAY-11 |
| 13 | WATER BALANCE DIAGRAM WITHIN THE PLANT | 10-PM-PAY-12 |
| 14 | WATER BALANCE DIAGRAM OF COOLING WATER | 10-PM-PAY-13 |
| 15 | DIAGRAM OF FRESH WATER SUPPLY SYSTEM | 10-PM-PAY-14 |
| 16 | DIAGRAM OF COOLING WATER SUPPLY SYSTEM | 10-PM-PAY-15 |
| 17 | COMPRESSED AIR SYSTEM | 10-PM-PAY-16 |
| 18 | PLOT DRAWING OF MAKE UP WATER PUMP HOUSE | 10-PM-PAY-17 |
| 19 | SECTION DRAWING OF ASH YARD EMBANKMENT | 10-PM-PAY-18 |
| 20 | COAL HANDLING PLANT | 10-PM-PAY-19 |
| 21 | SECTION DRAWING PF MAKE UP WATER PUMP HOUSE | 10-PM-PAY-20 |

## LIST OF DRAWINGS

| No. | DRAWING TITLE | DRAWING NO. |
|---|---|---|
| | CIVIL DRAWING | |
| 22 | PLAN DRAWING OF CW HOUSE | 10-PC-PAY-01 |
| 23 | SECTION DRAWING OF CW HOUSE | 10-PC-PAY-02 |
| 24 | COAL YARD STORAGE AREA PLAN | 10-PC-PAY-03 |
| 25 | COAL STACK-DOME GENERAL ARRANGEMENT DRAWING | 10-PC-PAY-04 |
| 26 | EXECUTIVE GUEST HOUSE | 10-PC-PAY-05 |
| 27 | VVIP RESTHOUSES | 10-PC-PAY-06 |
| 28 | CLINIC | 10-PC-PAY-07 |
| 29 | EMPLOYERS & ENGINEERS SITE OFFICE | 10-PC-PAY-08 |
| 30 | ADMIN BUILDING GROUND FLOOR PLAN | 10-PC-PAY-09 |
| 31 | ADMIN BUILDING FIRST FLOOR PLAN | 10-PC-PAY-10 |
| 32 | ADMIN BUILDING SECOND FLOOR PLAN | 10-PC-PAY-11 |
| 33 | MINI FIRE STATION | 10-PC-PAY-12 |
| 34 | WHARF STRUCTURE PLAN & ELEVATION DRAWING | 10-PC-PAY-13 |
| 35 | WHARF STRUCTURE CROSS-SECTIONAL DRAWING | 10-PC-PAY-14 |
| 36 | TRESTLE STRUCTURE CROSS-SECTIONAL DRAWING | 10-PC-PAY-15 |
| | | |
| | ELECTRICAL DRAWING | |
| 37 | ELECTRICAL MAIN WIRE CONNECTION DIAGRAM | 10-PE-PAY-01 |
| 38 | 6.6kV WIRE CONNECTION DIAGRAM | 10-PE-PAY-02 |
| 39 | PLANT CONTROL SYSTEM CONFIQURATION DIAGRAM | 10-PE-PAY-03 |

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| Rev. | Date | Coord. | Checked | Details of revision |
|---|---|---|---|---|
| 00 | Sept 2015 | Dharma | Bala | First Issue |

EMPLOYER :
BANGLADESH-CHINA POWER COMPANY (PVT) LIMITED
A JOINT VENTURE OF NORTH WEST POWER GENERATION CO. LIMITED
AND CHINA NATIONAL MACHINERY IMPORT & EXPORT CORPORATION

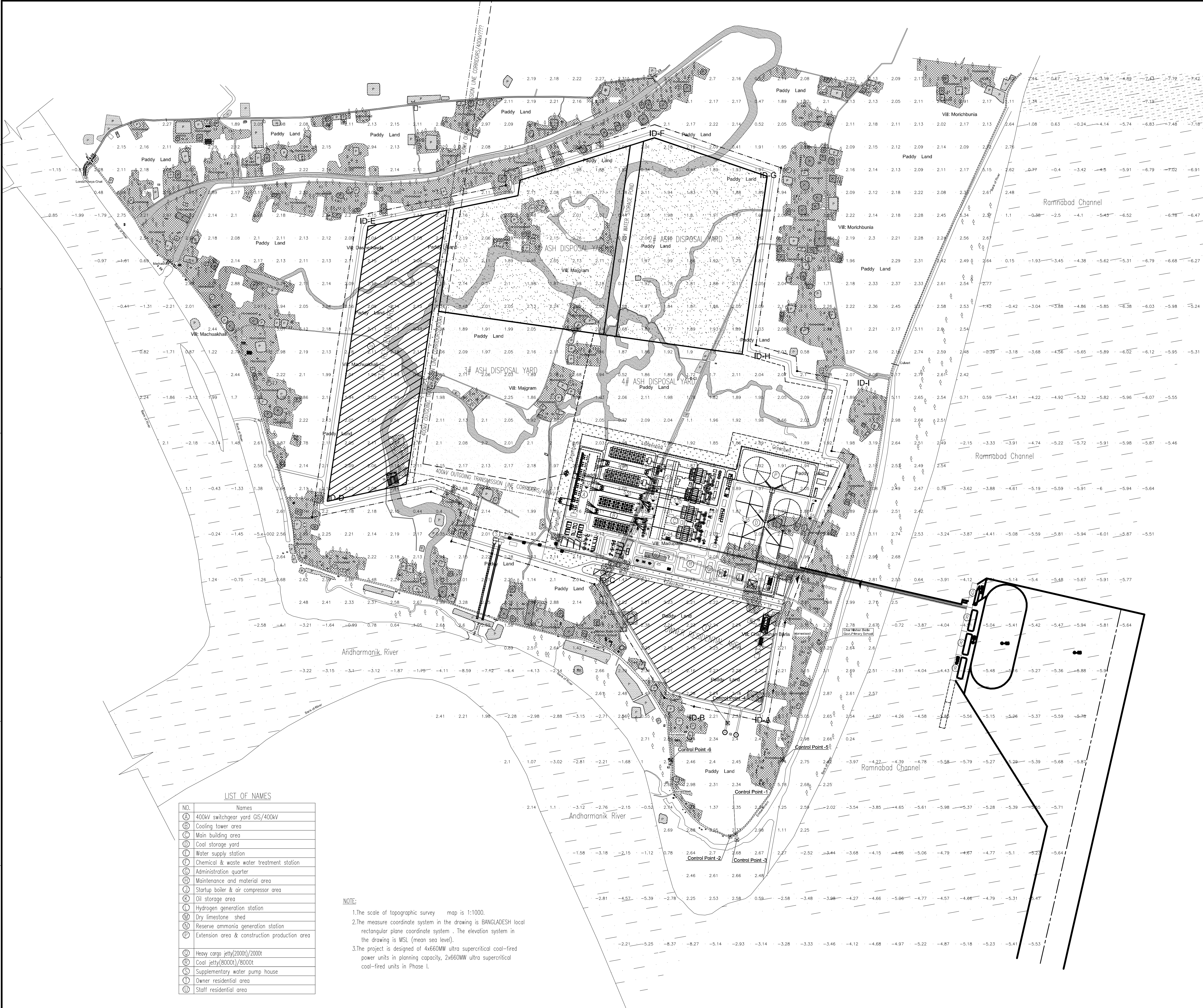
ENGINEER :
MINCONSULT SDN. BHD.

DRAWN BY : - | CERTIFIED BY : - | DATE : SEPT 2015

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
LIST OF DRAWINGS

SCALE : NTS | DRAWING NO : 10-PM-PAY-00 | SHEETS: 1/1




## TABLE FOR ECONOMIC AND TECHNICAL INDICES OF PLANT SITE

| NO. | Items | Units | Index Phase I | Index Planning | Remarks |
|---|---|---|---|---|---|
| 1 | Total land area of plant site | $hm^2$ | 148.35 | 264.75 | |
| 1.1 | Plant area | $hm^2$ | 41.10 | 58.80 | |
| 1.2 | Land area of external roads | $hm^2$ | | | |
| 1.3 | Land area of ash disposal yard | $hm^2$ | 98.80 | 195.00 | |
| 1.4 | Land area of pipelines outside plant | $hm^2$ | 0.25 | 0.55 | Supplementary water pipe |
| 1.5 | Land area of jetty | $hm^2$ | 7.70 | 9.40 | Interconnecting waters exclusion |
| 1.6 | Land area of freshwater source | $hm^2$ | 0.50 | 1.00 | Supplementary water pump house |
| 1.7 | Others | $hm^2$ | | | |
| 2 | Length of external road | | | | |
| 2.1 | Length of main access road | m | | | Incorporated in the plant road |
| 2.2 | Length of secondary access road | m | | | |
| 2.3 | Length of ash road | m | | | |
| 3 | Length of supplementary water pipe outside plant | m | 350 | 725 | Path length |

## LIST OF NAMES

| NO. | Names |
|---|---|
| A | 400kV switchgear yard GIS/400kV |
| B | Cooling tower area |
| C | Main building area |
| D | Coal storage yard |
| E | Water supply station |
| F | Chemical & waste water treatment station |
| G | Administration quarter |
| H | Maintenance and material area |
| J | Startup boiler & air compressor area |
| K | Oil storage area |
| L | Hydrogen generation station |
| M | Dry limestone shed |
| N | Reserve ammonia generation station |
| P | Extension area & construction production area |
| Q | Heavy cargo jetty(2000t)/2000t |
| R | Coal jetty(8000t)/8000t |
| S | Supplementary water pump house |
| T | Owner residential area |
| U | Staff residential area |

NOTE:

1. The scale of topographic survey map is 1:1000.
2. The measure coordinate system in the drawing is BANGLADESH local rectangular plane coordinate system . The elevation system in the drawing is MSL (mean sea level).
3. The project is designed of 4x660MW ultra supercritical coal–fired power units in planning capacity, 2x660MW ultra supercritical coal–fired units in Phase I.

**FOR BIDDING PURPOSES ONLY**

| Rev. | Date | Coord. | Checked | Details of revision |
|---|---|---|---|---|
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EMPLOYER :

BANGLADESH-CHINA POWER COMPANY (PVT) LIMITED
A JOINT VENTURE OF NORTH WEST POWER GENERATION CO. LIMITED
AND CHINA NATIONAL MACHINERY IMPORT & EXPORT CORPORATION

ENGINEER :

MINCONSULT SDN. BHD.

DRAWN BY : –
CERTIFIED BY : –
DATE : SEPT 2015

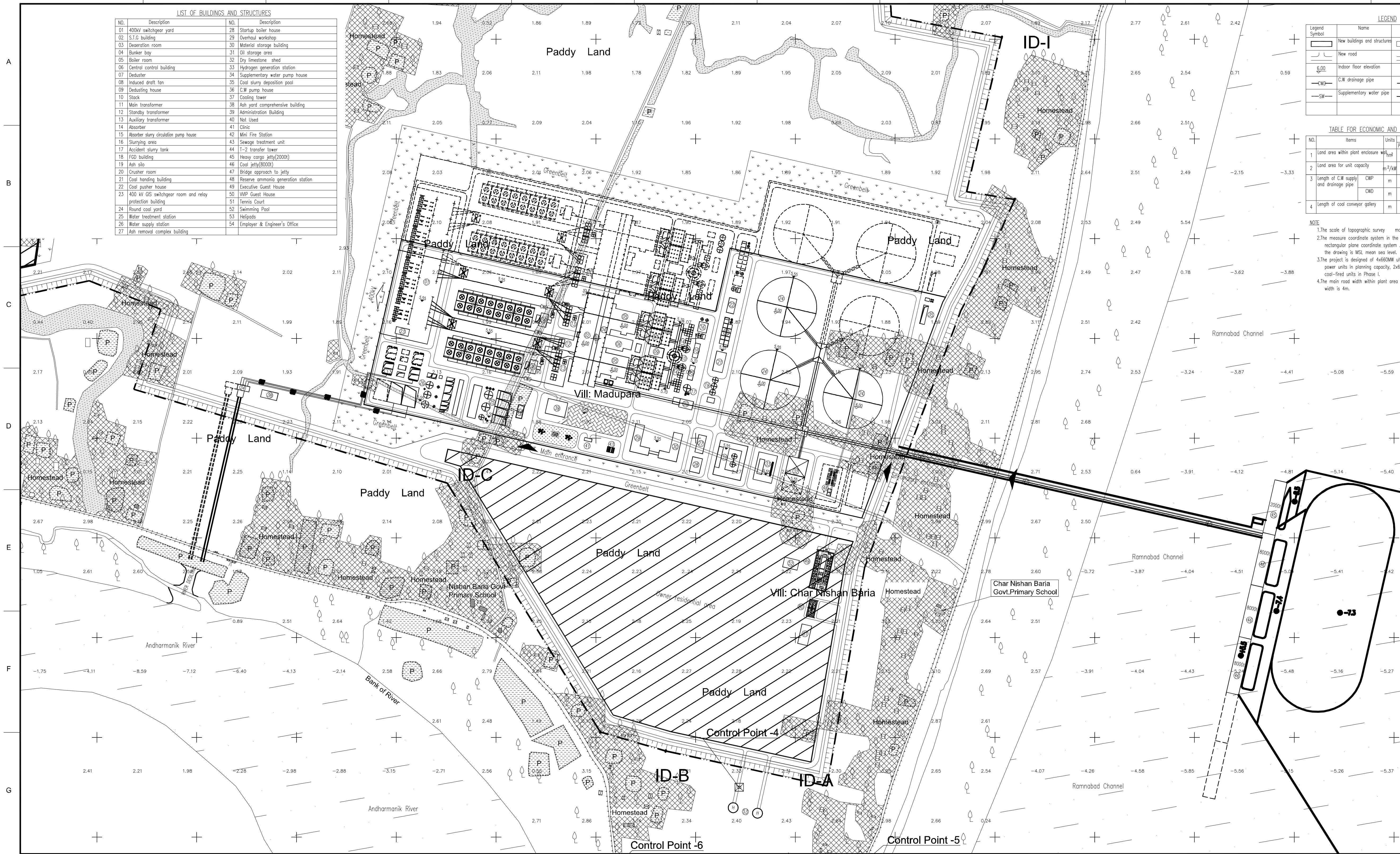
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

GENERAL LAYOUT (ENLARGE VIEW)

SCALE : NTS
DRAWING NO : 10–PM–PAY–01
SHEETS: 1/1




## LIST OF BUILDINGS AND STRUCTURES

| NO. | Description | NO. | Description |
|---|---|---|---|
| 01 | 400kV switchgear yard | 28 | Startup boiler house |
| 02 | S.T.G building | 29 | Overhaul workshop |
| 03 | Deaeration room | 30 | Material storage building |
| 04 | Bunker bay | 31 | Oil storage area |
| 05 | Boiler room | 32 | Dry limestone shed |
| 06 | Central control building | 33 | Hydrogen generation station |
| 07 | Deduster | 34 | Supplementary water pump house |
| 08 | Induced draft fan | 35 | Coal slurry deposition pool |
| 09 | Dedusting house | 36 | C.W pump house |
| 10 | Stack | 37 | Cooling tower |
| 11 | Main transformer | 38 | Ash yard comprehensive building |
| 12 | Standby transformer | 39 | Administration Building |
| 13 | Auxiliary transformer | 40 | Not Used |
| 14 | Absorber | 41 | Clinic |
| 15 | Absorber slurry circulation pump house | 42 | Mini Fire Station |
| 16 | Slurrying area | 43 | Sewage treatment unit |
| 17 | Accident slurry tank | 44 | T-2 transfer tower |
| 18 | FGD building | 45 | Heavy cargo jetty(2000t) |
| 19 | Ash silo | 46 | Coal jetty(8000t) |
| 20 | Crusher room | 47 | Bridge approach to jetty |
| 21 | Coal handing building | 48 | Reserve ammonia generation station |
| 22 | Coal pusher house | 49 | Executive Guest House |
| 23 | 400 kV GIS switchgear room and relay protection building | 50 | VVIP Guest House |
| | | 51 | Tennis Court |
| 24 | Round coal yard | 52 | Swimming Pool |
| 25 | Water treatment station | 53 | Helipads |
| 26 | Water supply station | 54 | Employer & Engineer's Office |
| 27 | Ash removal complex building | | |

## LEGEND

| Legend Symbol | Name | | Name |
|---|---|---|---|
| | New buildings and structures | | Extension buildings and structures |
| | New road | | Extension road |
| 6.00 | Indoor floor elevation | 5.55 | Outdoor ground elevation |
| —CWD— | C.W drainage pipe | —CWP— | C.W supply pipe |
| —SW— | Supplementary water pipe | | Land range |

## TABLE FOR ECONOMIC AND TECHNICAL INDEXEX

| NO. | Items | | Units | Index Phase I | Index Planning | Remarks |
|---|---|---|---|---|---|---|
| 1 | Land area within plant enclosure wall | | hm² | 41.10 | 58.80 | |
| 2 | Land area for unit capacity | | m²/kW | 0.311 | 0.223 | |
| 3 | Length of C.W supply and drainage pipe | CWP | m | 240 | 390 | |
| | | CWD | m | 1150 | 2250 | |
| 4 | Length of coal conveyor gallery | | m | 1530 | 1680 | From jetty to bunker |

NOTE

1. The scale of topographic survey map is 1:1000.
2. The measure coordinate system in the drawing is BANGLADESH local rectangular plane coordinate system . The elevation system in the drawing is MSL mean sea level.
3. The project is designed of 4x660MW ultra supercritical coal-fired power units in planning capacity, 2x660MW ultra supercritical coal-fired units in Phase I.
4. The main road width within plant area is 7m, the secondary road width is 4m.

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| Rev. | Date | Coord. | Checked | Details of revision |
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EMPLOYER :
BANGLADESH-CHINA POWER COMPANY (PVT) LIMITED
A JOINT VENTURE OF NORTH WEST POWER GENERATION CO. LIMITED
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ENGINEER :
MINCONSULT SDN. BHD.

| DRAWN BY : | CERTIFIED BY : | DATE : |
|---|---|---|
| - | - | SEPT 2015 |

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

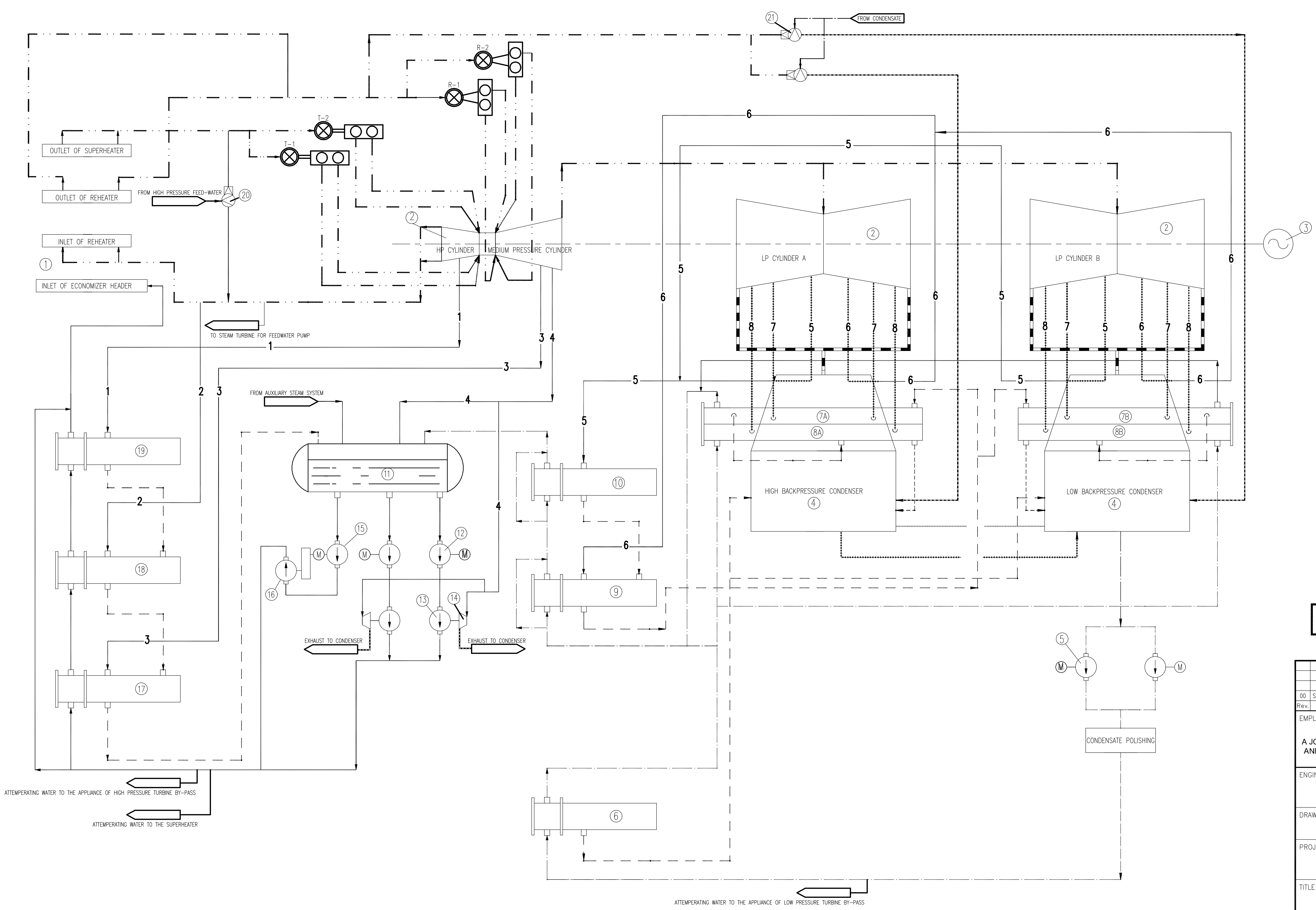
TITLE :
GENERAL LAYOUT (OVERALL)

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-02 | 1/1 |

| Symbol | Name | Symbol | Name |
|---|---|---|---|
| | Feed water Pipe | | Exhaust Steam Pipe |
| | Other Steam water Pipe | | Drain Pipe |
| —N— | N Stage Extraction Steam Pipe | | Circulating Water Pipe |
| | Steam Main and Reheater Steam Pipe | | Condensate Pipe |

Legend and Symbol

Note:
1. Two units will be installed in this phase.The Thermal Powers System in this list is for one unit.




| No. | Name | Remarks |
|---|---|---|
| 21 | Pressure Turbine By-pass | |
| 20 | Appliance of High Pressure Turbine By-pass | |
| 19 | 1# HP Heater | |
| 18 | 2# HP Heater | |
| 17 | 3# HP Heater | |
| 16 | ~~Electric Feed Water Pump~~ | |
| 15 | Booster Pump of Electric Feed Water Pump | |
| 14 | Driving Turbine of Feed Water Pump | |
| 13 | Turbo-feed Pump | |
| 12 | Booster Pump of turbo-feed Pump | |
| 11 | Deaerator Storage tank and Deaerator | |
| 10 | 5# LP Heater | |
| 9 | 6# LP Heater | |
| 8B | 8B# LP Heater | |
| 8A | 8A# LP Heater | |
| 7B | 7B# LP Heater | |
| 7A | 7A# LP Heater | |
| 6 | Gland Steam Condenser | |
| 5 | Condensate Pump | |
| 4 | Condenser | |
| 3 | Generator | |
| 2 | Steam Turbine | |
| 1 | Boiler | |

Equipments list

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|---|---|---|---|---|
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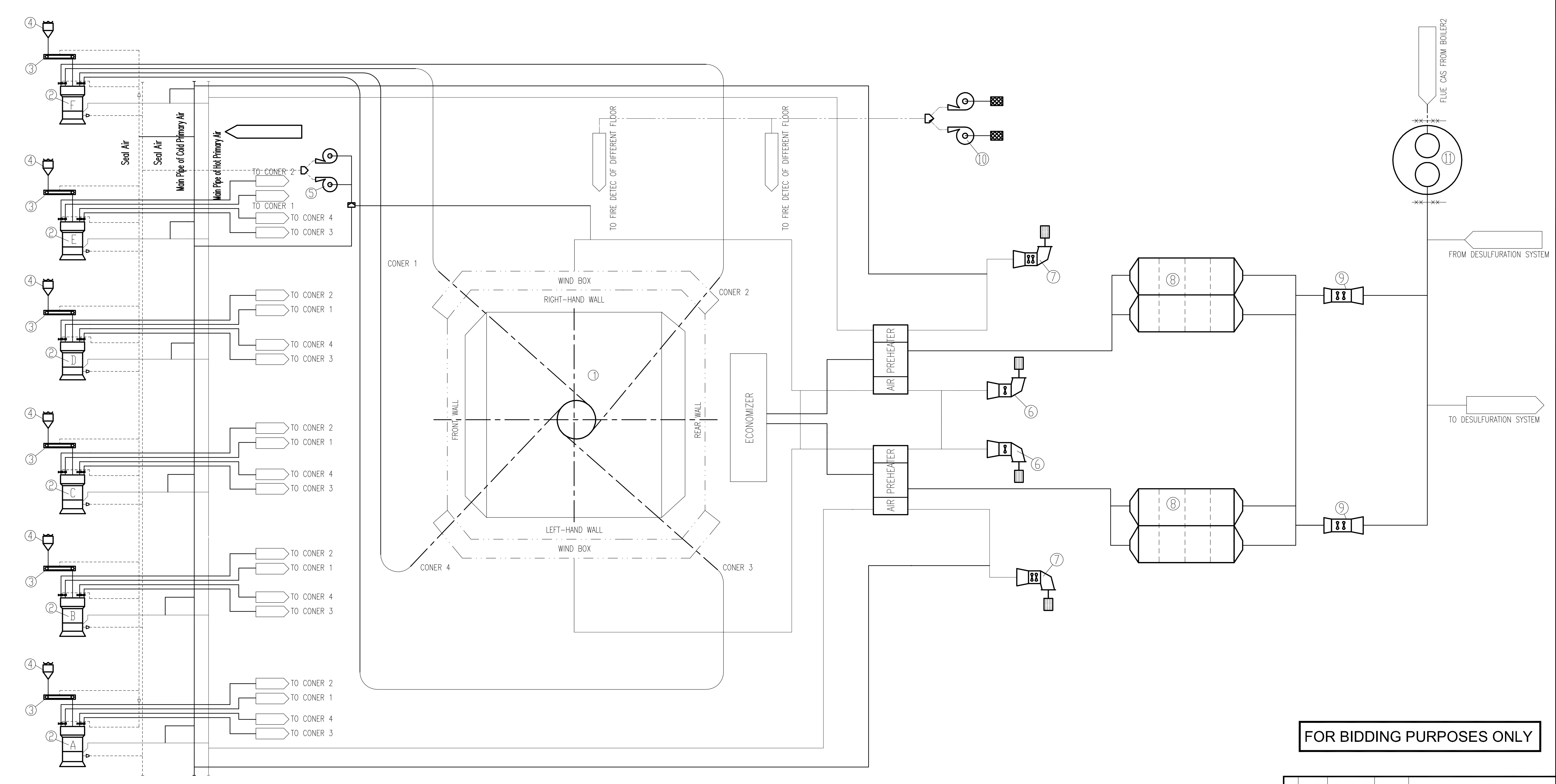
ENGINEER :
MINCONSULT SDN. BHD.

DRAWN BY : -
CERTIFIED BY : -
DATE : SEPT 2015

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
PRINCIPLE THERMAL POWER SYSTEM DRAWING

SCALE : NTS
DRAWING NO : 10-PM-PAY-03
SHEETS: 1/1

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| No. | Name | Note |
|---|---|---|
| 11. | Stack | Public stack of boiler 1 and boiler 2 |
| 10. | Cool Fan of Fire Detect | |
| 9. | Suction Fan | |
| 8. | Electro-static Precipitator | |

List of Equipments

| No. | Name | Note |
|---|---|---|
| 7. | Primary Air Fan | |
| 6. | Forced Draft Fan | |
| 5. | Seal Air Fan | |
| 4. | coal bunker | |
| 3. | Coal Feeder | |
| 2. | Medium Speed Pulverizer | |
| 1. | Once-through Boiler | |

List of Equipments

Notes:

1. Two units will be installed in this Phase.
2. The System of Unit-1 is shown in this drawing.The System in Unit-2 is same as Unit-1.
3. Types of Fan indicated are for reference only.

| Rev. | Date | Coord. | Checked | Details of revision |
|---|---|---|---|---|
| 00 | Sept 2015 | Dharma | Bala | First Issue |

EMPLOYER :

BANGLADESH-CHINA POWER COMPANY (PVT) LIMITED
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ENGINEER :

MINCONSULT SDN. BHD.

| DRAWN BY : | CERTIFIED BY : | DATE : |
|---|---|---|
| - | - | SEPT 2015 |

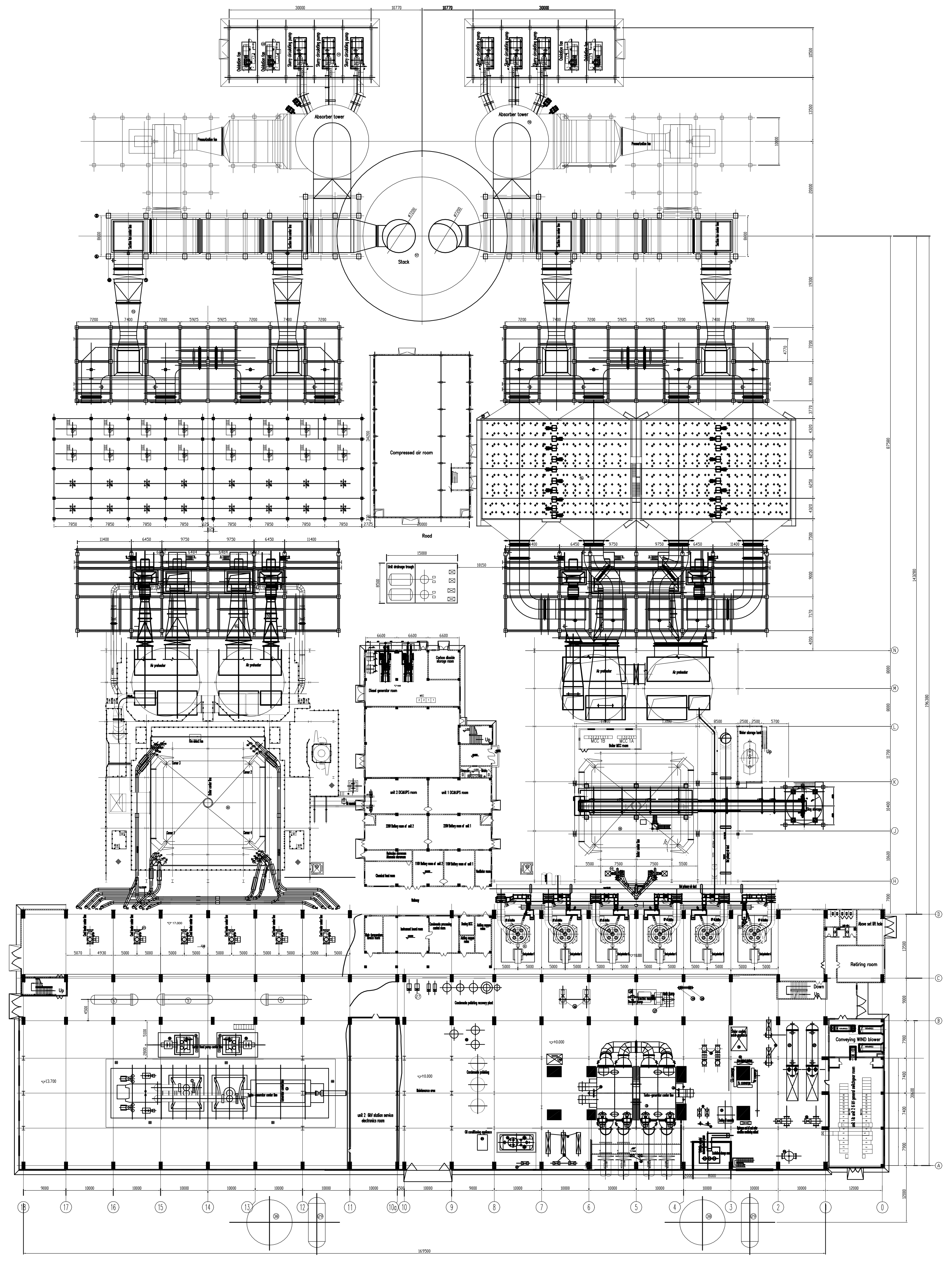
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

PRINCIPLE COMBUSTION SYSTEM DRAWING

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-04 | 1/1 |

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EMPLOYER :
BANGLADESH-CHINA POWER COMPANY (PVT) LIMITED
A JOINT VENTURE OF NORTH WEST POWER GENERATION CO. LIMITED
AND CHINA NATIONAL MACHINERY IMPORT & EXPORT CORPORATION

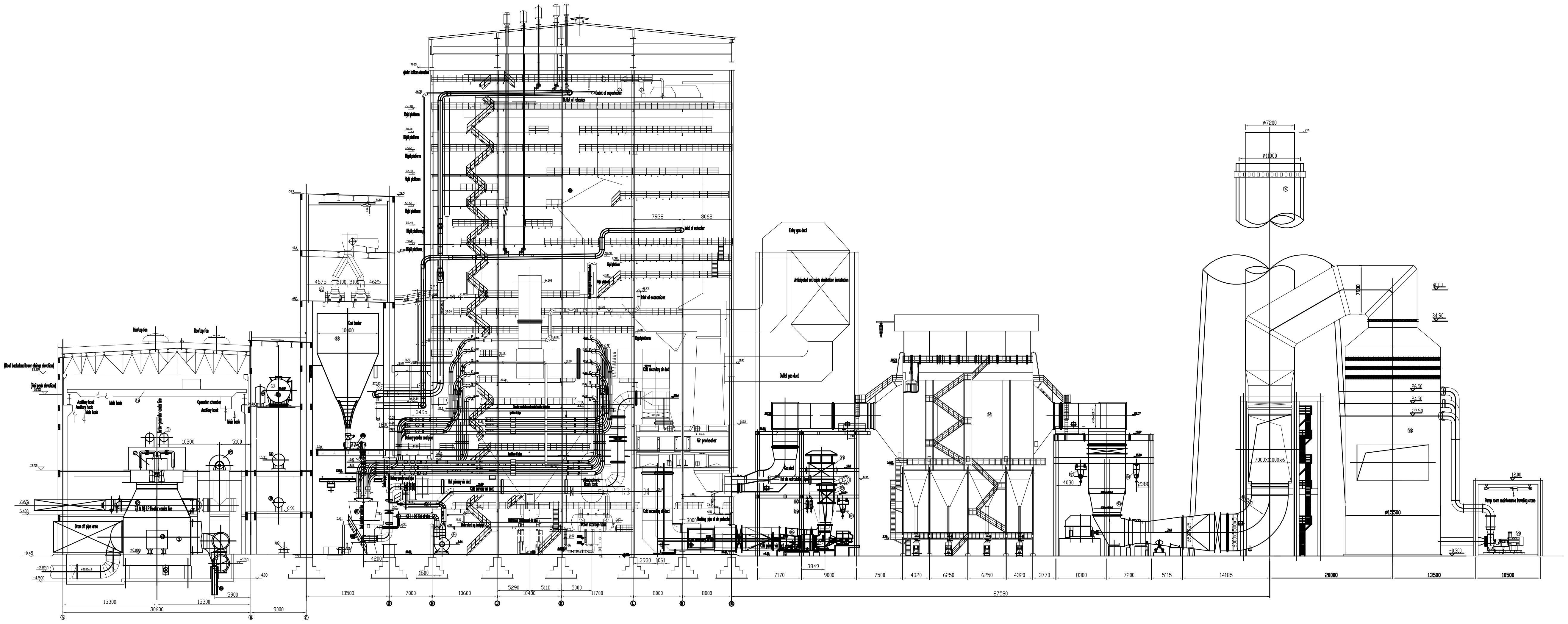
ENGINEER :
MINCONSULT SDN. BHD.

DRAWN BY : –
CERTIFIED BY : –
DATE : SEPT 2015

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
GROUND PLAN OF MAIN POWER BUILDING

SCALE : NTS
DRAWING NO : 10–PM–PAY–05
SHEETS: 1/1



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ENGINEER :

MINCONSULT SDN. BHD.

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| – | – | SEPT 2015 |

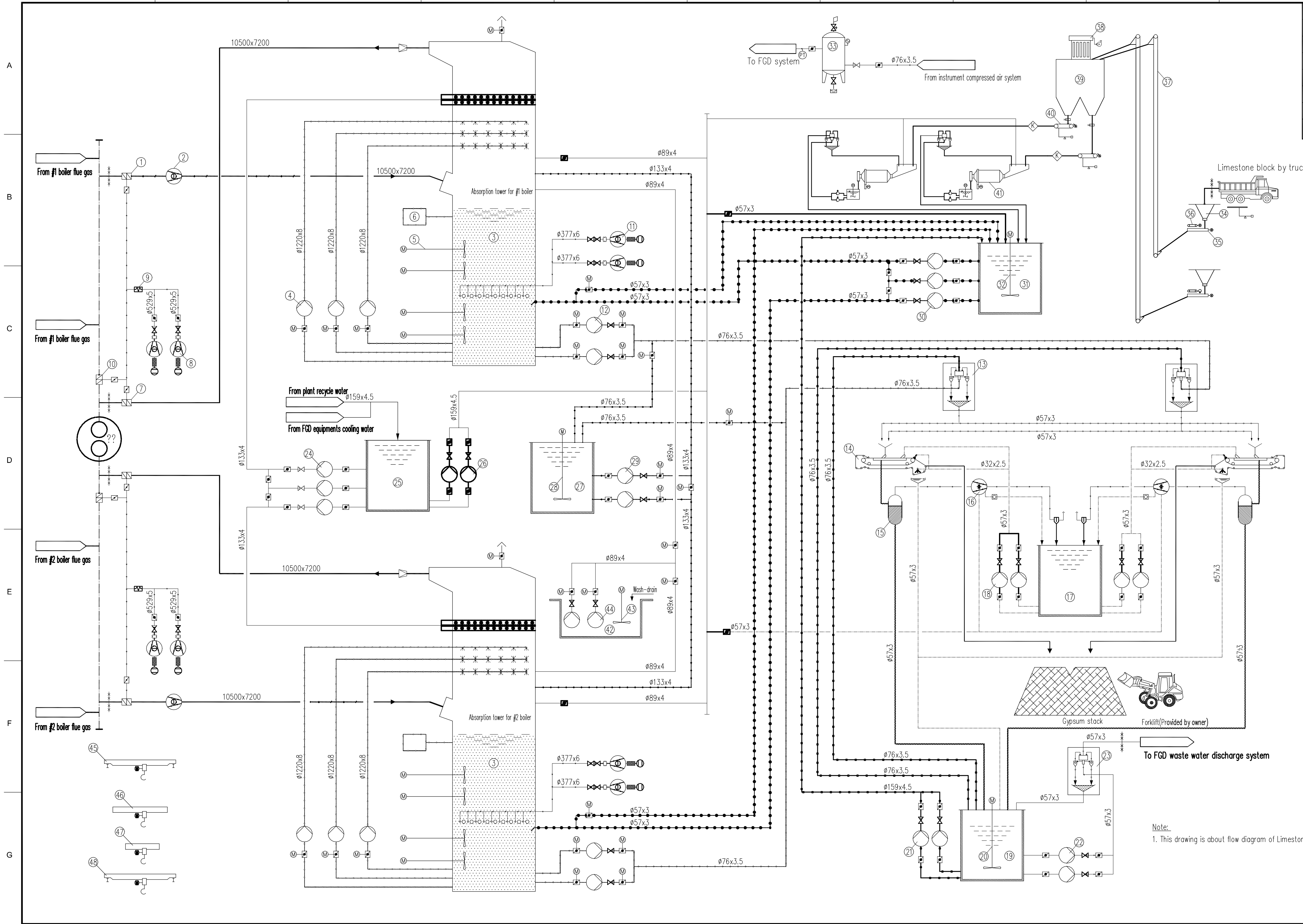
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

CROSS-SECTION OF MAIN POWER BUILDING

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-06 | 1/1 |




| Symbol | Name | Symbol | Name | Symbol | Name |
|---|---|---|---|---|---|
| | Plug | | Filter cloth wash pipe | | Pneumatic slide gate |
| | Reducer | | Filter water pipe | | Manual slide gate |
| | Design line | | Gypsum pipe | | Stop valve |
| | Reflux pipe | | Water pipe | | Ball valve |
| | Flue pipe | | Pneumatic operator | | Check valve |
| | Slurry pipe | | Electric operator | | Butterfly valve |

LEGEND

| No. | Name |
|---|---|
| 48 | Mill room electical single beam suspension crane |
| 47 | Absorption tower maintenace electric hoist |
| 46 | Dewatering building maintenace electric hoist |
| 45 | Slurry pump and oxidation fan room electical single beam suspension crane |
| 44 | FGD sump sewage pump |
| 43 | FGD sump agitator |
| 42 | FGD sump |
| 41 | Limestone wet mill |
| 40 | Belt weigh feeder |
| 39 | Limestone block bin |
| 38 | Bag filter |
| 37 | Bucket elevator |
| 36 | Metal separator |
| 35 | Limestone feeder |
| 34 | Unload hopper |
| 33 | FGD air tank |
| 32 | Limestone slurry tank agitator |
| 31 | Limestone slurry tank |
| 30 | Slurry feed pump |
| 29 | Slurry return pump |
| 28 | Emergency slurry tank agitator |
| 27 | Emergency slurry tank |
| 26 | Process water pump |
| 25 | Process water tank |
| 24 | Demister washing pump |
| 23 | Waste water cyclone |
| 22 | Feed pump |
| 21 | Reflux pump |
| 20 | Reflux tank agitator |
| 19 | Reflux tank |
| 18 | Filter cloth washing pump |
| 17 | Filter cloth washing tank |
| 16 | Vacuum pump |
| 15 | Gas/water separator |
| 14 | Vacuum gypsum dewaterer |
| 13 | Gypsum slurry cyclone |
| 12 | Gypsum discharge pumps |
| 11 | Oxidation fan |
| 10 | Bypass flue gas damper |
| 9 | Seal air electric heater |
| 8 | Seal fan |
| 7 | Clean gas damper |
| 6 | Absorption tower analysis measurement system |
| 5 | Absorption tower slurry agitator |
| 4 | Slurry circulating pump |
| 3 | Absorption tower |
| 2 | Blower fan |
| 1 | Raw gas damper |

Equ. List

FOR BIDDING PURPOSES ONLY

Note:

1. This drawing is about flow diagram of Limestone handling system for 2x660MW.

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ENGINEER :

MINCONSULT SDN. BHD.

DRAWN BY : – | CERTIFIED BY : – | DATE : SEPT 2015

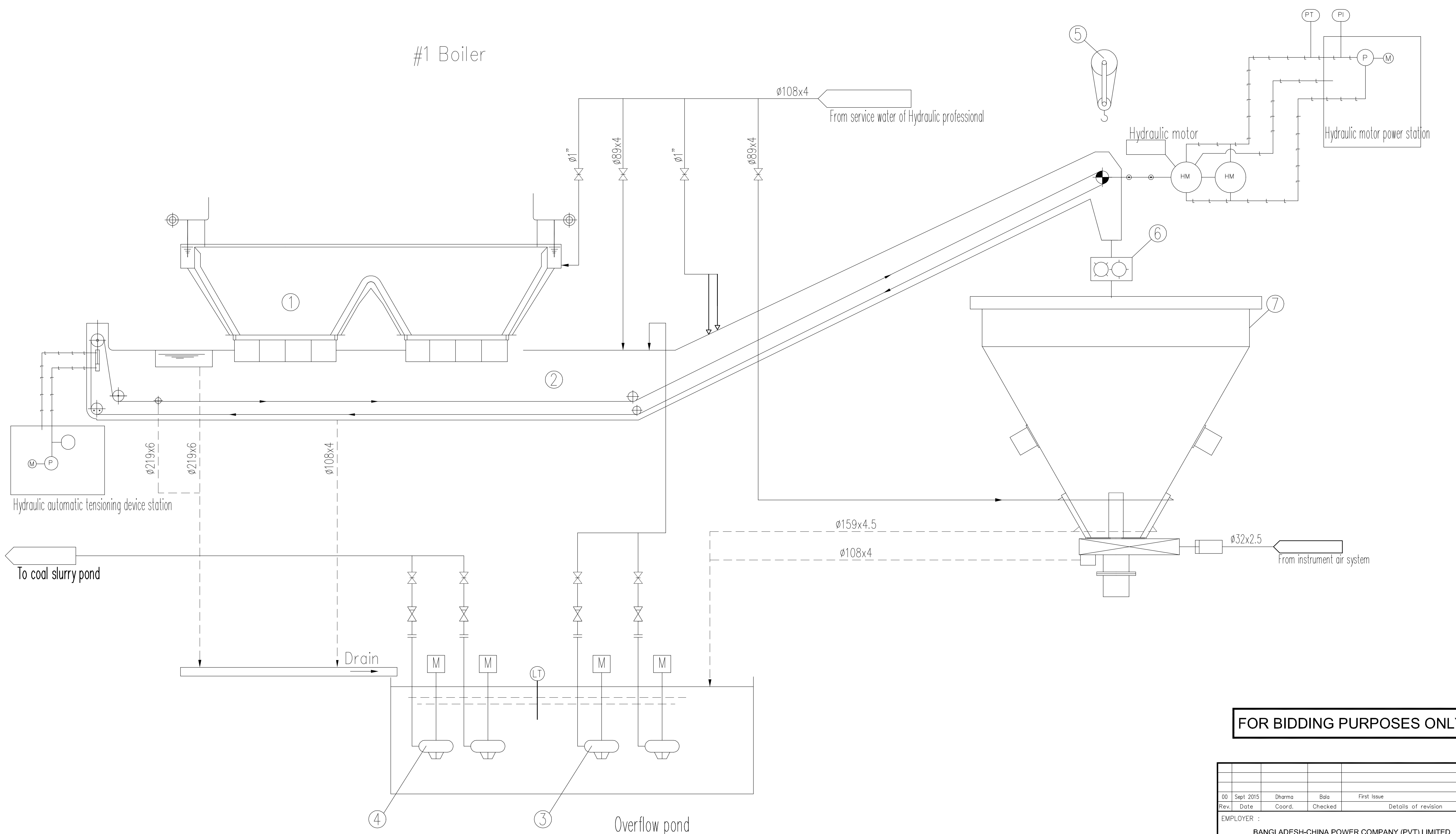
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

FLUE GAS DESULPHURIZATION SYSTEM DIAGRAM

SCALE : NTS | DRAWING NO : 10-PM-PAY-07 | SHEETS: 1/1




FOR BIDDING PURPOSES ONLY

Note:
1. The slag disposal system shown is for 1x660MW. Unit-2 arrangement is similar to Unit-1.

| Symbol | Name | Symbol | Name |
|---|---|---|---|
| | Pneumatic operator | | Electric operator |
| | Nozzle | | Plug |
| | Gate valve | | Overflow pipe |
| | Stop valve | | Water pipe |

LEGEND

| No. | Name |
|---|---|
| 7 | Slag silo |
| 6 | Crusher |
| 5 | Electric hoist |
| 4 | Overflow pump |
| 3 | Slag circulating pump |
| 2 | Scraper slag conveyor |
| 1 | Slag pit |

Equ. List

| Rev. | Date | Coord. | Checked | Details of revision |
|---|---|---|---|---|
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|---|---|---|
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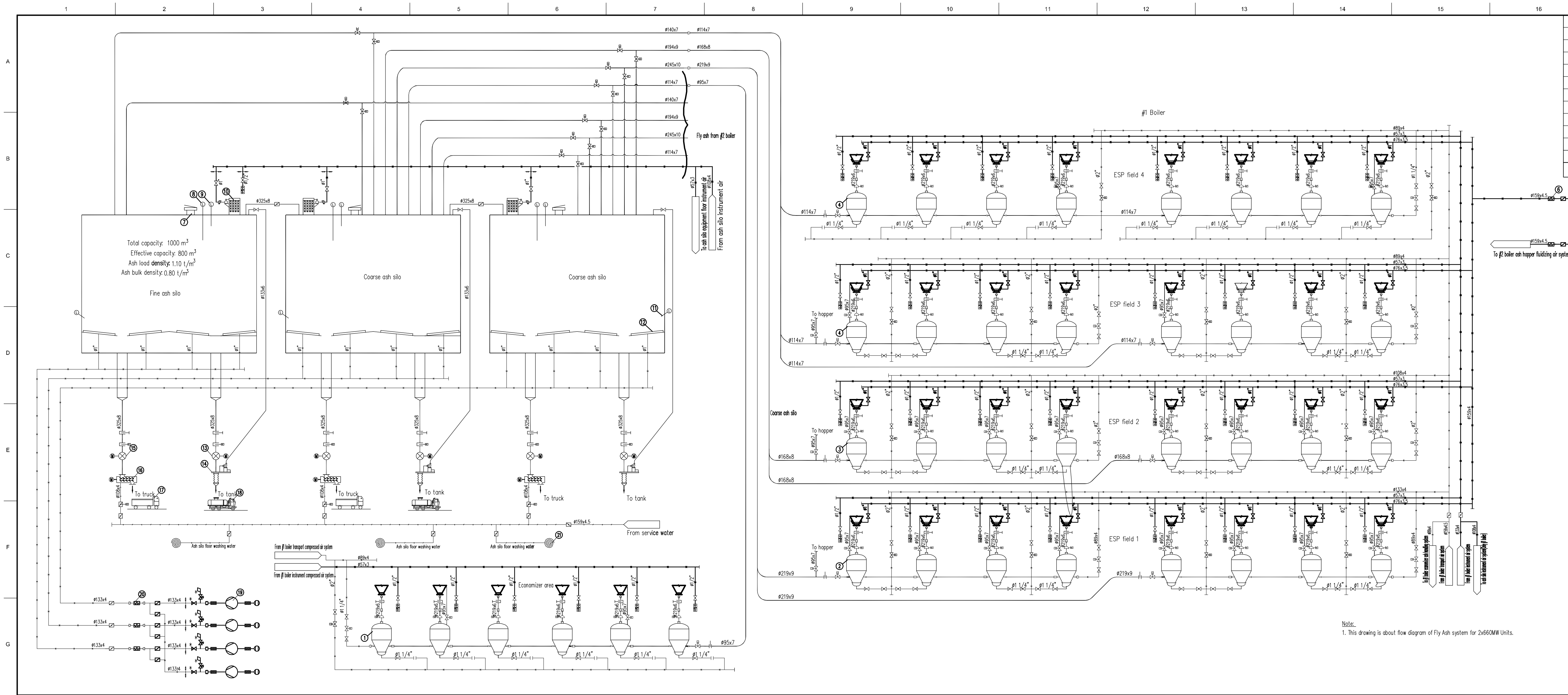
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
SLAG DISPOSAL SYSTEM DIAGRAM

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-08 | 1/1 |




| Symbol | Name | Symbol | Name |
|---|---|---|---|
| | Level | | |
| | Pressure gage | | Flexible connector |
| | Electric operator | | Orifice |
| | Design divide | | Pneumatic operator |
| | Silencer | | Slide gate |
| | Wear expansion joint | | Stop valve |
| | Plug | | Safe valve |
| | Reducer | | Ball valve |
| | Service water pipe | | Check valve |
| | Compressed air pipe | | Butterfly valve |
| | Filter | | Dome valve |

LEGEND

| No. | Name |
|---|---|
| 21 | Washing box |
| 20 | Ash silo electric heater |
| 19 | Ash silo fluidizing blower |
| 18 | Tank |
| 17 | Truck |
| 16 | dual-axle mixer |
| 15 | Electric feeder |
| 14 | Dry ash unloader |
| 13 | Electric feeder |
| 12 | Ash silo fluidizing groove |
| 11 | Ash silo low level |
| 10 | Ash silo bag filter |
| 9 | Ash silo high level |
| 8 | Ash silo continuation level |
| 7 | Pressure/vacuum valve |
| 6 | Ash hopper electric heater |
| 5 | Ash hopper fluidizing blower |
| 4 | Vessel transporter for three/four electric field |
| 3 | Vessel transporter for two electric field |
| 2 | Vessel transporter for one electric field |
| 1 | Vessel transporter for economizer |

Equ. List

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Note:
1. This drawing is about flow diagram of Fly Ash system for 2x660MW Units.

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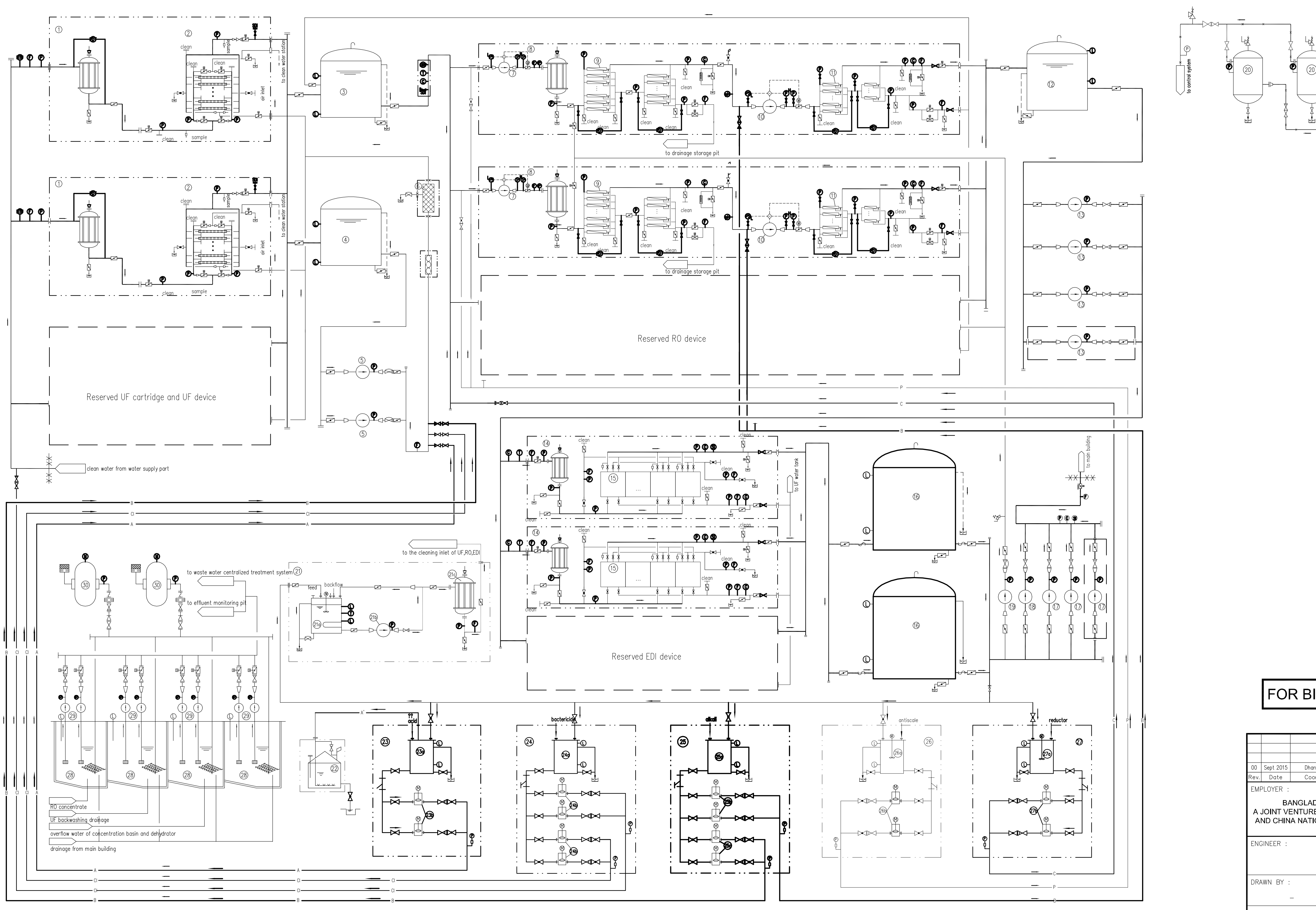
DRAWN BY : – | CERTIFIED BY : – | DATE : SEPT 2015

PROJECT : PAYRA THERMAL POWER PLANT (2x660MW)

TITLE : FLY ASH HANDLING SYSTEM DIAGRAM

SCALE : NTS | DRAWING NO : 10-PM-PAY-09 | SHEETS: 1/1




| Symbols | Name |
| --- | --- |
| | equipment NO. |
| | rubber pipe |
| P | pressure gage |
| T | thermometer |
| L | level signal |
| NTU | turbimeter |
| F | flow meter |
| Cl | residual chlorine meter |
| ORP | ORP meter |
| pH | PHmeter |
| Si | silicon meter |
| C | conductivity meter |
| | drainage canal |
| | sampling funnel |
| | flexible connector |
| | strainer |
| | $CO_2$ respirator |
| | Y type filter |
| | pipe mixer |
| | sampling valve |
| | to atmosphere |
| | reducer |
| | angle spring safety valve |
| | pneumatic open rubber lined diaphgram valve |
| | electric check valve |
| | pneumatic rubber butterfly valve |
| | manual rubber lined butterfly valve |
| | rubber lined diaphgram valve |
| | rubber lined check valve |
| | check valve |
| | stop valve |
| —CL— | bacteriacide pipe |
| —C— | reductant pipe |
| —P— | scale inhibitor pipe |
| —B— | alkali pipe |
| —A— | acid pipe |
| —x— | compressed air pipe |

Symbols table

| No. | Name |
| --- | --- |
| 30 | blower |
| 29 | drainage transfer pump |
| 28 | drainage storage pit |
| 27b | reductor metering pump |
| 27a | reductor solution tank |
| 27 | reductor dosing unit |
| 26b | antiscale metering pump |
| 26a | antiscale solution tank |
| 26 | antiscale dosing unit |
| 25c | RO alkali metering pump |
| 25b | alkali metering pump |
| 25a | alkali solution tank |
| 25 | alkali dosing unit |
| 24b | bactericide metering pump |
| 24a | bactericide solution tank |
| 24 | bactericide dosing unit |
| 23b | acid metering pump |
| 23a | acid solution tank |
| 23 | acid dosing unit |
| 22 | acid mist absorber |
| 21c | cleaning filter |
| 21b | cleaning pump |
| 21a | cleaning tank |
| 21 | chemical cleaning unit |
| 20 | air storage tank |
| 19 | RO flushing pump |
| 18 | DM water pump |
| 17 | DM water pump |
| 16 | DM water tank |
| 15 | EDI device |
| 14 | cartridge filter |
| 13 | EDI booster pump |
| 12 | fresh water tank |
| 11 | 2nd RO device |
| 10 | 2nd HP pump |
| 9 | 1st RO device |
| 8 | cartridge filter |
| 7 | 1st HP pump |
| 6 | cartridge filter |
| 5 | backwashing pump |
| 4 | backwashing tank |
| 3 | UF water tank |
| 2 | UF device |
| 1 | cartridge filter |

Equipments list

FOR BIDDING PURPOSES ONLY

Note:

1. The capacity of Boiler make-up water treatment system is 2x60 t/hr. Another 1x60 t/hr Boiler make-up water treatment system is reserved forward.
2. Equipment inside Dot Dash Lime shall be supplied as a Whole.

| Rev. | Date | Coord. | Checked | Details of revision |
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| --- | --- | --- |
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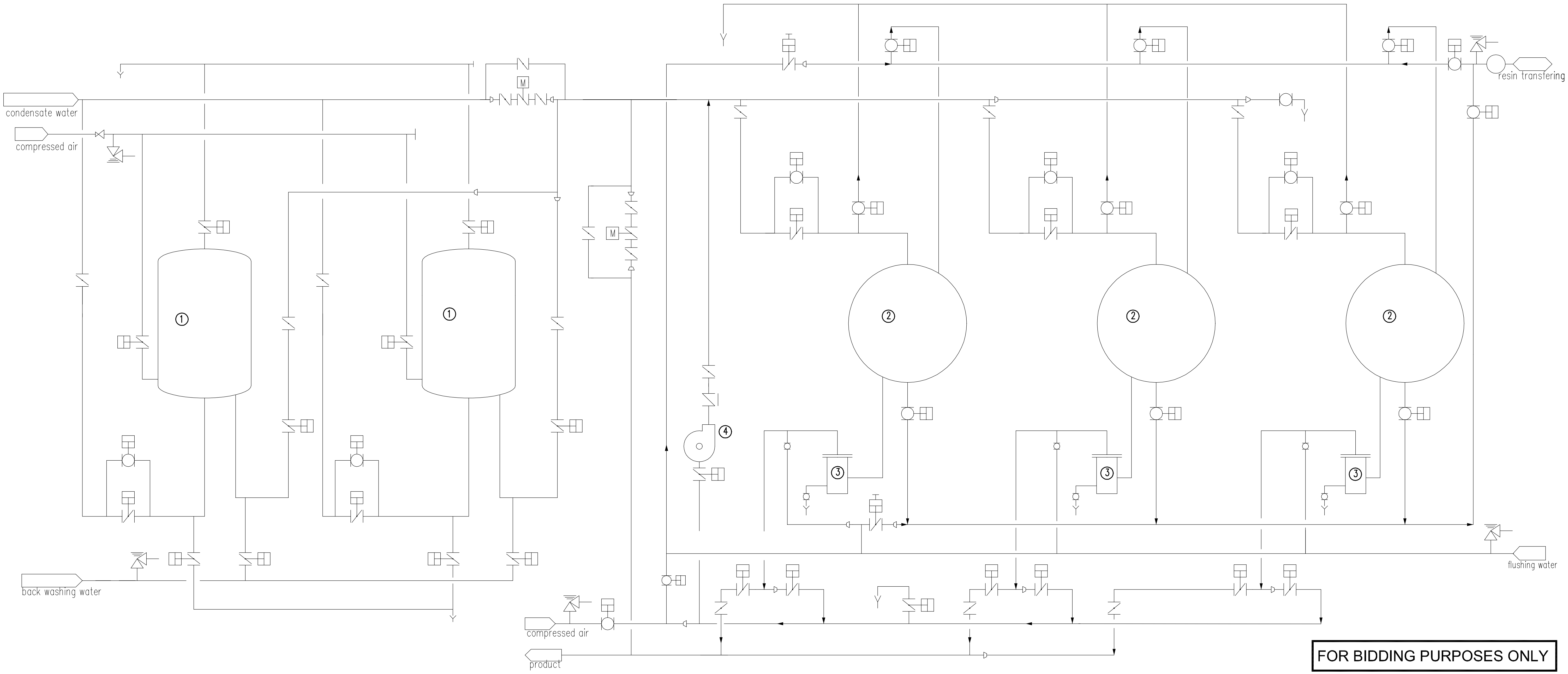
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

BOILER MAKE-UP WATER TREATMENT SYSTEM

| SCALE : | DRAWING NO : | SHEETS: |
| --- | --- | --- |
| NTS | 10-PM-PAY-10 | 1/1 |




**FOR BIDDING PURPOSES ONLY**

Note:
1. The System shown here is for 1x660MW.

| No. | Name | Remarks |
|---|---|---|
| 4 | recycle pump | |
| 3 | resin trapper | |
| 2 | mixed bed | |
| 1 | prefilter | |

Equipments list

| Symbols | Name | Symbols | Name | Symbols | Name | Symbols | Name |
|---|---|---|---|---|---|---|---|
| | pneumatic butterfly valve | | manual ball valve | | pneumatic butterfly valve | | manual butterfly valve |
| | safety valve | | electric butterfly valve | | pneumatic ball valve | TE | temperature |
| Y | drainage canal | | reducer | | pneumatic ball valve | | needle valve |

Symbols list

| Rev. | Date | Coord. | Checked | Details of revision |
|---|---|---|---|---|
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ENGINEER :

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|---|---|---|
| – | – | SEPT 2015 |

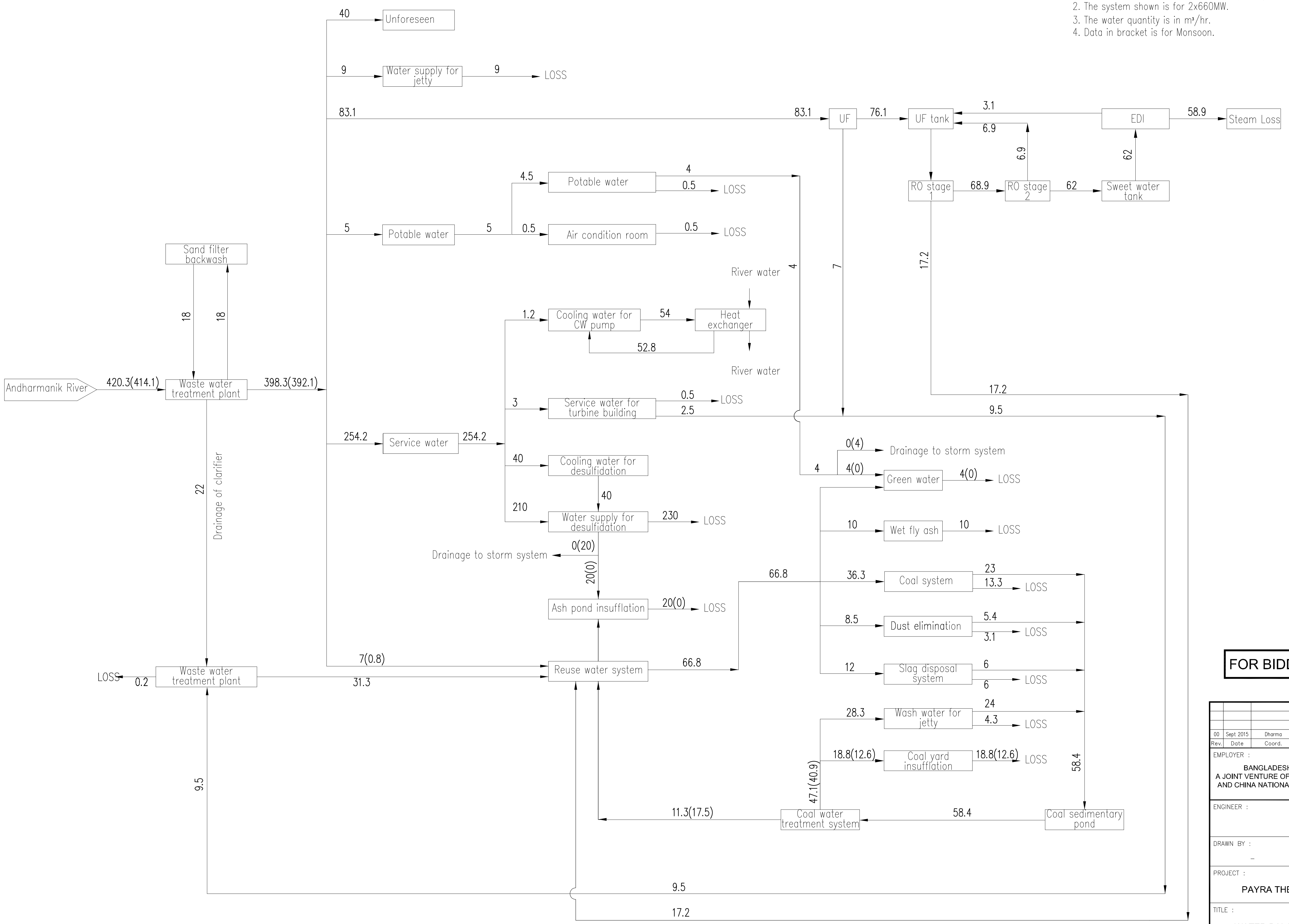
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

CONDENSATE WATER POLISHING TREATMENT SYSTEM

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10–PM–PAY–11 | 1/1 |




Note:

1. Provided values are tentative, exact quantity to be given by Bidder.
2. The system shown is for 2x660MW.
3. The water quantity is in m³/hr.
4. Data in bracket is for Monsoon.

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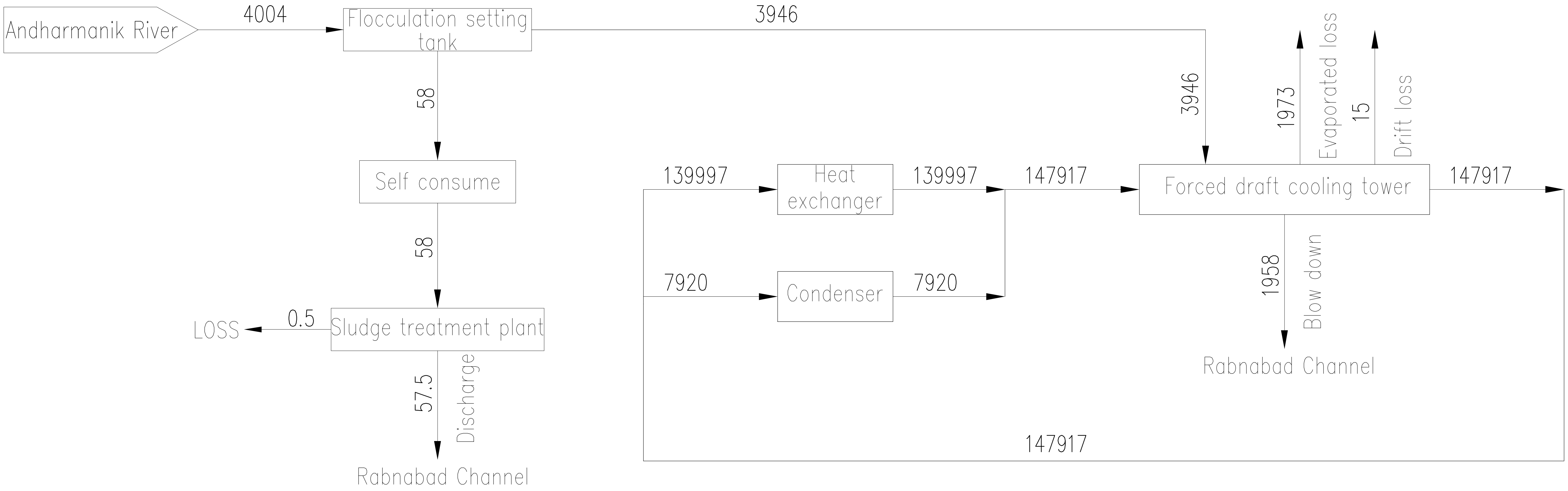
ENGINEER :
MINCONSULT SDN. BHD.

DRAWN BY : –
CERTIFIED BY : –
DATE : SEPT 2015

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
WATER BALANCE DIAGRAM WITHIN THE PLANT

SCALE : NTS
DRAWING NO : 10–PM–PAY–12
SHEETS: 1/1




Note:

1. Provided values are tentative, exact quantity to be given by Bidder.
2. The water balance diagram is for 2x660MW.
3. The water quantity is in $m^3/hr$.

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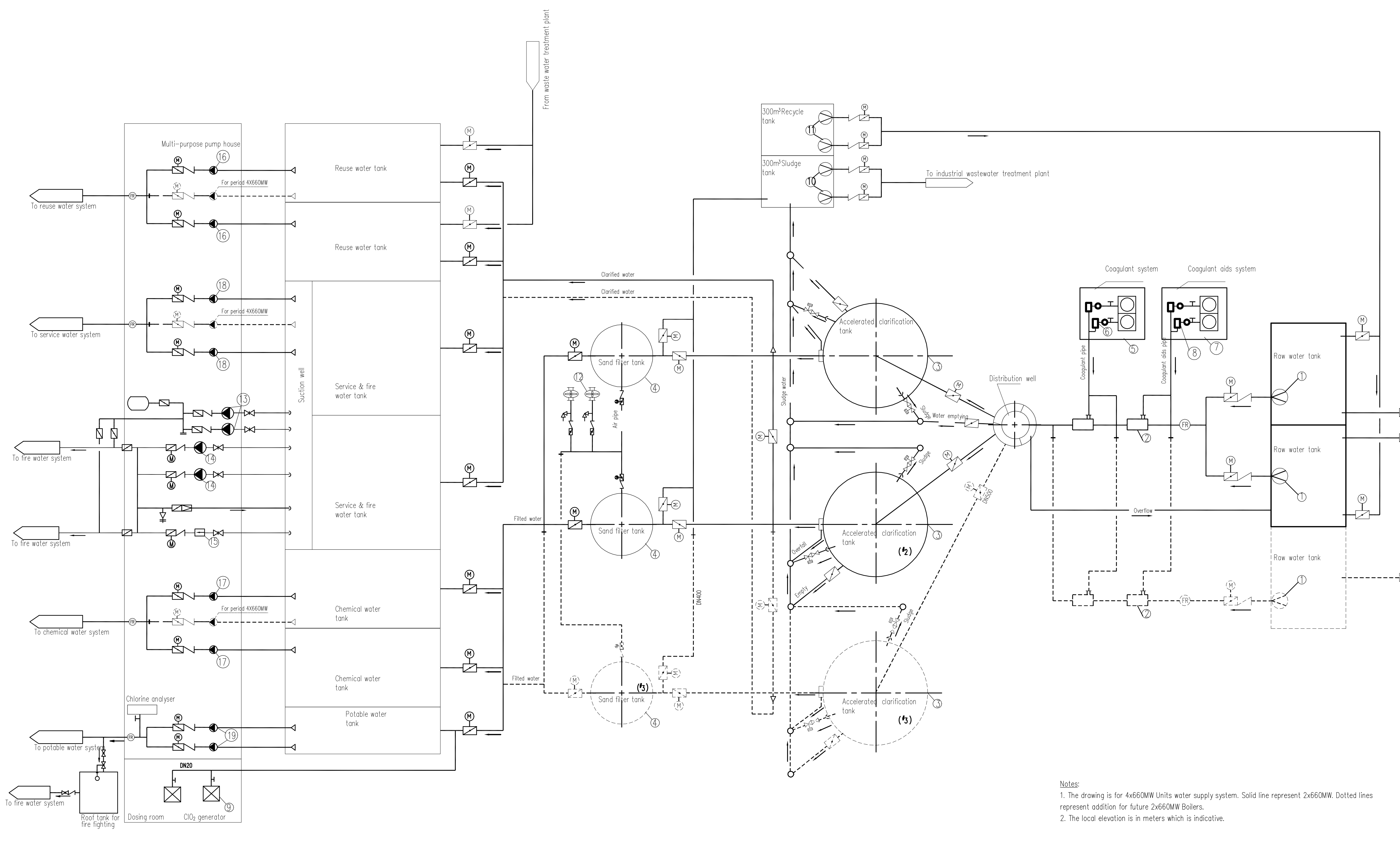
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
WATER BALANCE DIAGRAM OF COOLING WATER

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-13 | 1/1 |




Legend

| | |
|---|---|
| | Roots blower |
| | Safety valve |
| | Hydralic control valve |
| | Electromagnetic valve |
| | Pressure reducing valve |
| | Pressure relief valve |
| | Electric butterfly valve |
| | Butterfly valve |
| | Check valve |
| | Cut-off valve |
| | Horizontal pump |
| | Under-water pump |
| | Air tank |
| | Flowmeter |
| | Diesel engine pump |
| | Dosing pump |
| | Gate valve |
| | Mixer |
| | Pressure reducing valve |
| | Inspector |
| | Gate valve |

| | |
|---|---|
| 21 | Suspension crane for dosing room |
| 20 | Suspension crane for pump house |
| 19 | Potable water pump |
| 18 | Service water pump |
| 17 | Chemical water pump |
| 16 | Reuse water pump |
| 15 | Diesel engine fire pump |
| 14 | Electrical fire pump |
| 13 | Jockey pump |
| 12 | Roots blower |
| 11 | Recycle water pump |
| 10 | Sludge water pump |
| 9 | $ClO_2$ generator |
| 8 | Coagulant aids dosing pump |
| 7 | Coagulant aids dosing facility |
| 6 | Coagulant dosing pump |
| 5 | Coagulant dosing facility |
| 4 | Sand filter |
| 3 | Mechanical agitating clarifier |
| 2 | Mixer |
| 1 | Class II raw water pump |
| No | Item |

Equipments & facilities list

FOR BIDDING PURPOSES ONLY

Notes:
1. The drawing is for 4x660MW Units water supply system. Solid line represent 2x660MW. Dotted lines represent addition for future 2x660MW Boilers.
2. The local elevation is in meters which is indicative.

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ENGINEER :
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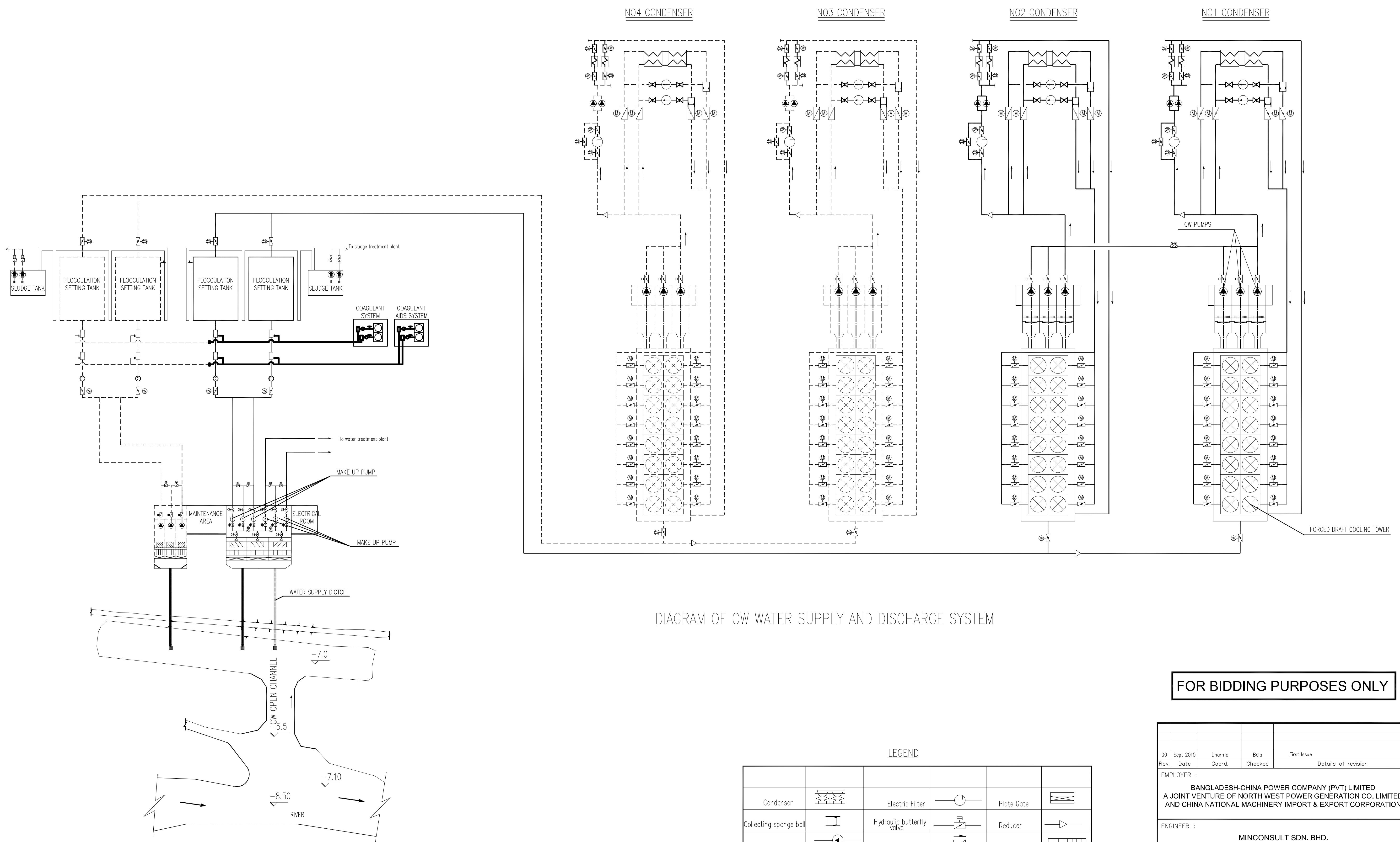
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
DIAGRAM OF FRESH WATER SUPPLY SYSTEM

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-14 | 1/1 |




# DIAGRAM OF CW WATER SUPPLY AND DISCHARGE SYSTEM

FOR BIDDING PURPOSES ONLY

## LEGEND

| | | | | | |
|---|---|---|---|---|---|
| Condenser | | Electric Filter | | Plate Gate | |
| Collecting sponge ball | | Hydraulic butterfly valve | | Reducer | |
| Pump | | Check valve | | Trash rack | |
| gate valve | | Electric gate valve | | Vacuum breaker valve | |
| Electric butterfly valve | | Travelling screen | | Release valve | |
| CCCW heat exchanger | | Interface Line | | Vacuum pump cooler | |
| Sponge ball room | | Mixer | | Flowmeter | |
| Forced draf cooling tower | | | | | |

Notes:

1. This drawing is for 4x660MW Units water supply system. Solid line represent 2x660MW. Dotted line represent addition for future 2x660MW by Boilers.
2. The elevation is local elevation in meters, which is indicative.

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ENGINEER :
MINCONSULT SDN. BHD.

DRAWN BY : – | CERTIFIED BY : – | DATE : SEPT 2015

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
DIAGRAM OF COOLING WATER SUPPLY SYSTEM

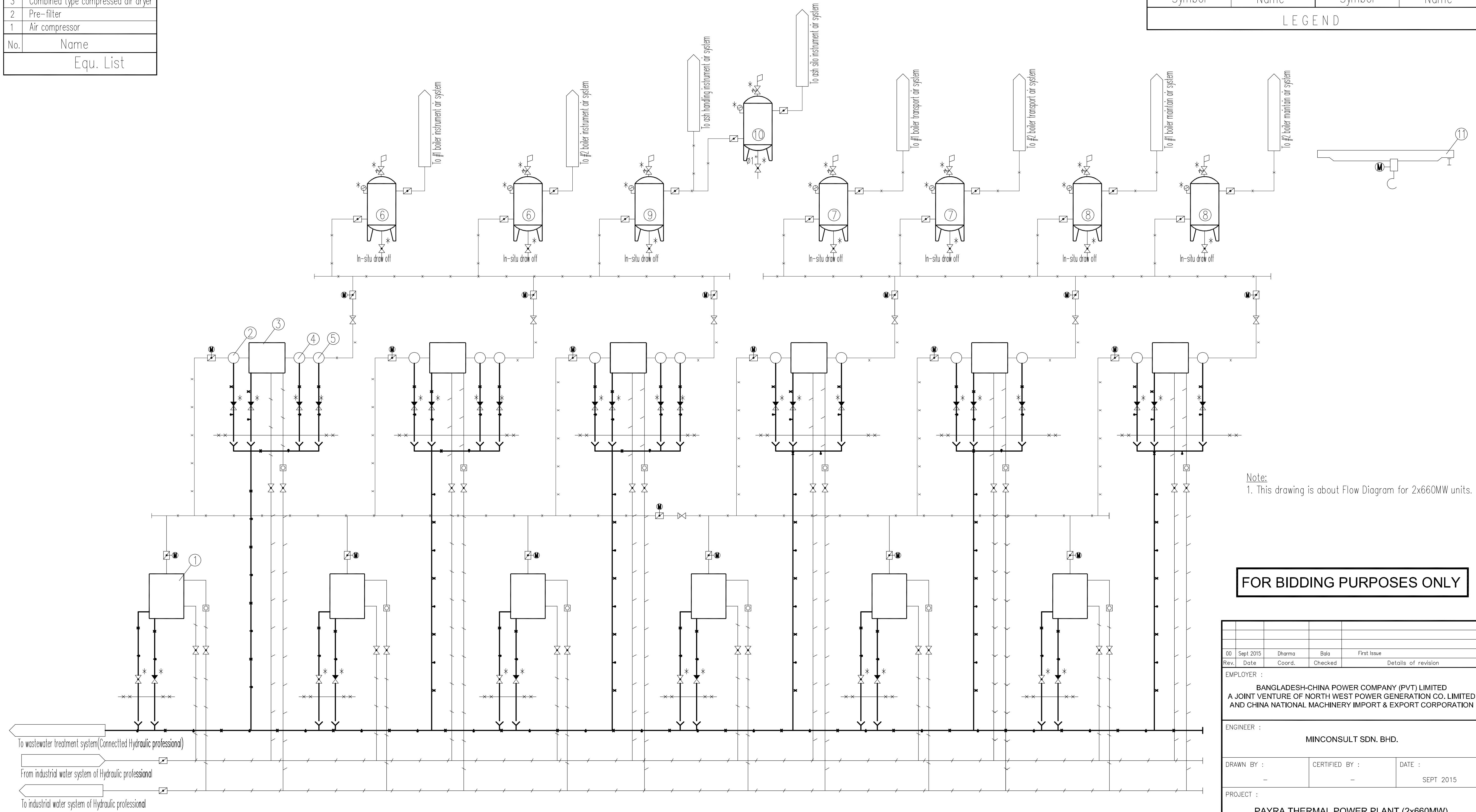
SCALE : NTS | DRAWING NO : 10-PM-PAY-15 | SHEETS: 1/1

## Equ. List

| No. | Name |
|---|---|
| 11 | Electrical single beam crane |
| 10 | Ash silo instrument air receiver |
| 9 | Ash handling instrument air receiver |
| 8 | Maintain air receiver |
| 7 | Ash handling transport air receiver |
| 6 | Instrument air receiver |
| 5 | Precise filter |
| 4 | After filter |
| 3 | Combined type compressed air dryer |
| 2 | Pre-filter |
| 1 | Air compressor |

## LEGEND

| Symbol | Name | Symbol | Name |
|---|---|---|---|
| | Exhaust air | | Flow indicator |
| | Safe valve | | Electric operator |
| | Stop valve | | Reducer |
| | Stop valve(normal closed) | | Plug |
| | Check valve | | Oil-water drainage pipe |
| | Butterfly valve | | Cooling water pipe |
| | Local pressure gauge | | Compressed air pipe |




Note:
1. This drawing is about Flow Diagram for 2x660MW units.

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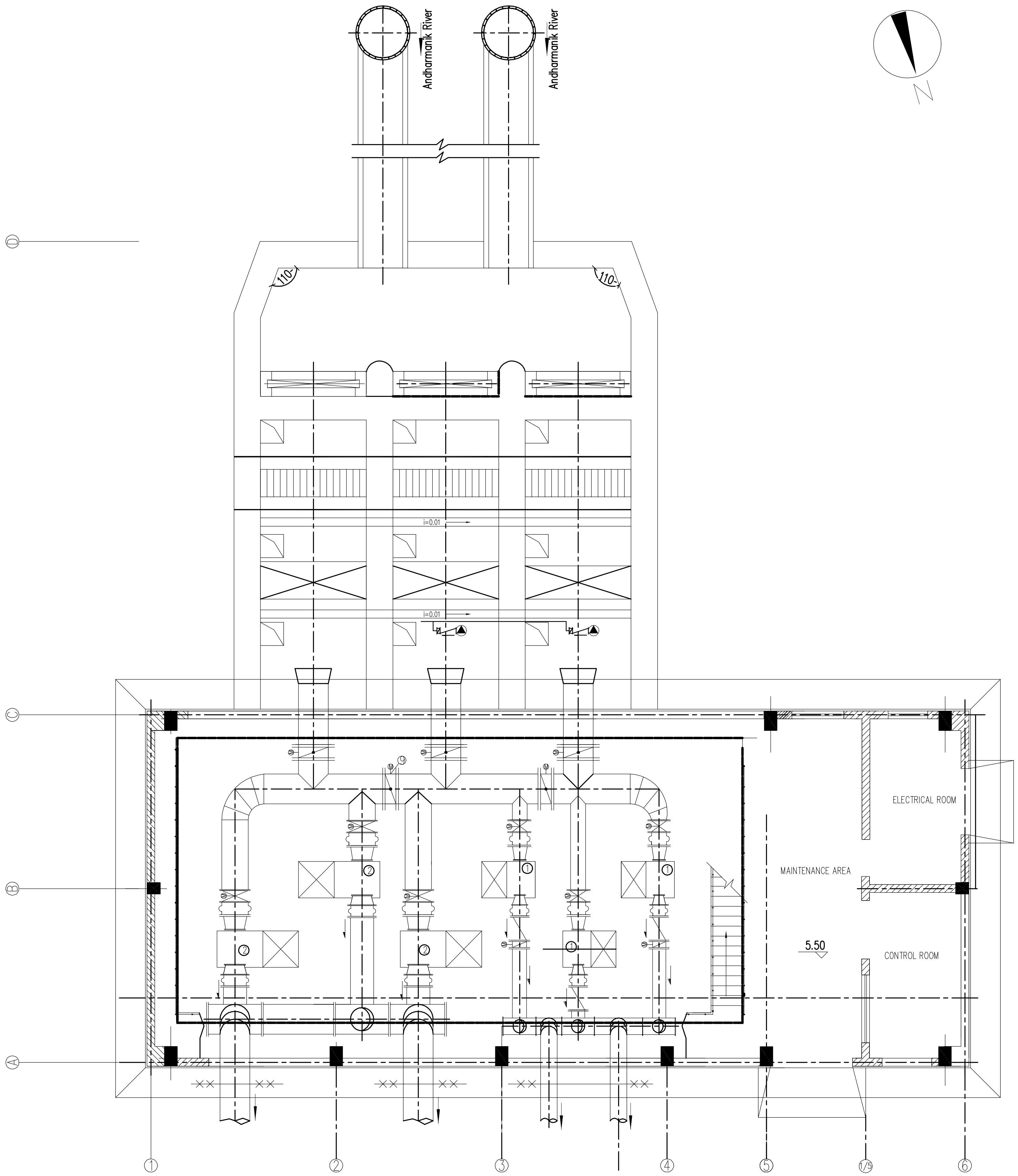
DRAWN BY : - | CERTIFIED BY : - | DATE : SEPT 2015

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
COMPRESSED AIR SYSTEM

SCALE : NTS | DRAWING NO : 10-PM-PAY-16 | SHEETS: 1/1




Plan drawing of make up water pump house
1:100

## MAIN EQUIPMENT LIST

| NO. | NAME | REMARKS |
|---|---|---|
| 1 | Make Up Pump For Fresh Water System | 2W1S |
| 2 | Make Up Pump For CW System | 2W1S |
| 3 | Sluice Gate | |
| 4 | Bar Screen | |
| 5 | Traveling Screen | |
| 6 | E.O.T Crane | |
| 7 | E.O.T Crane | |
| 8 | Motor Driven butterfly valve | |
| 9 | Motor Driven Gate valve | |
| 10 | Motor Driven butterfly valve | |
| 11 | Check valve | |
| 12 | Motor Driven Gate valve | |
| 13 | Motor Driven butterfly valve | |
| 14 | Check valve | |
| 15 | Portable Pit Pump | |
| 16 | | |
| 17 | Pit Pump | |

Note:
1. The system indicated is for 2x660MW.

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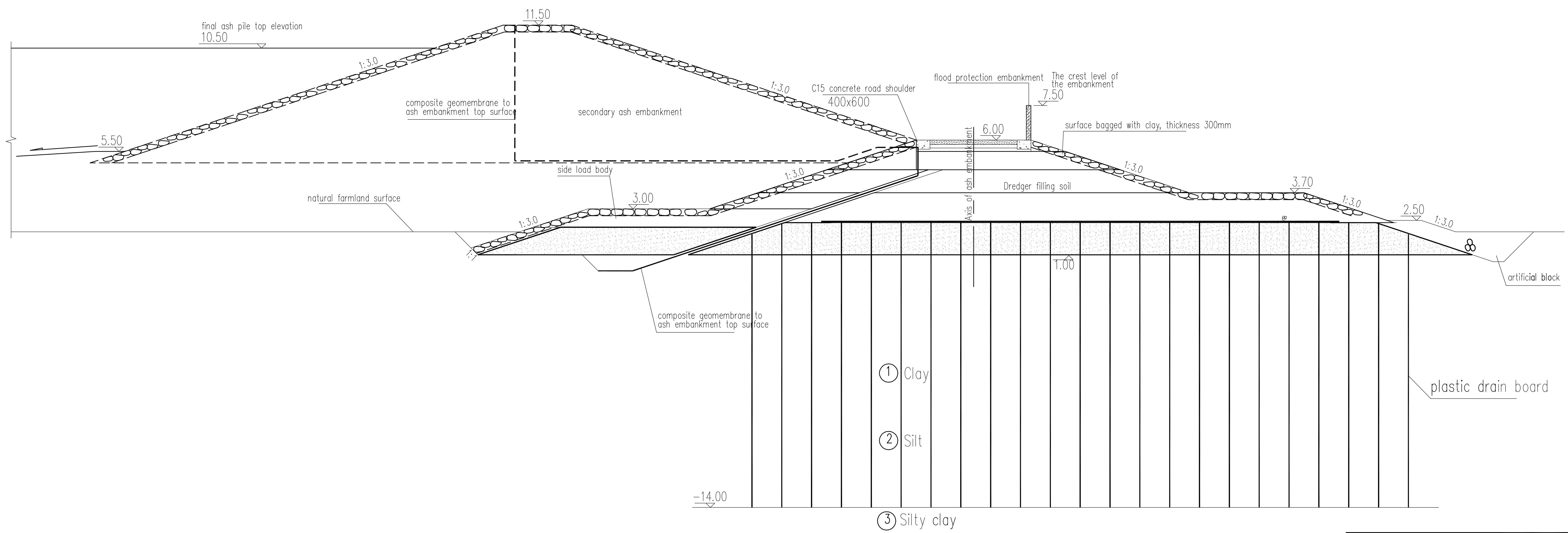
DATE : SEPT 2015

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
PLOT DRAWING OF MAKE UP WATER PUMP HOUSE

SCALE : NTS
DRAWING NO : 10-PM-PAY-17
SHEETS: 1/1




FOR BIDDING PURPOSES ONLY

Section drawing of ash yard embankment

NOTES:
1. The elevation system in the drawing is MSL (mean sea level).
2. All levels are noted in meters.

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EMPLOYER :
BANGLADESH-CHINA POWER COMPANY (PVT) LIMITED
A JOINT VENTURE OF NORTH WEST POWER GENERATION CO. LIMITED
AND CHINA NATIONAL MACHINERY IMPORT & EXPORT CORPORATION

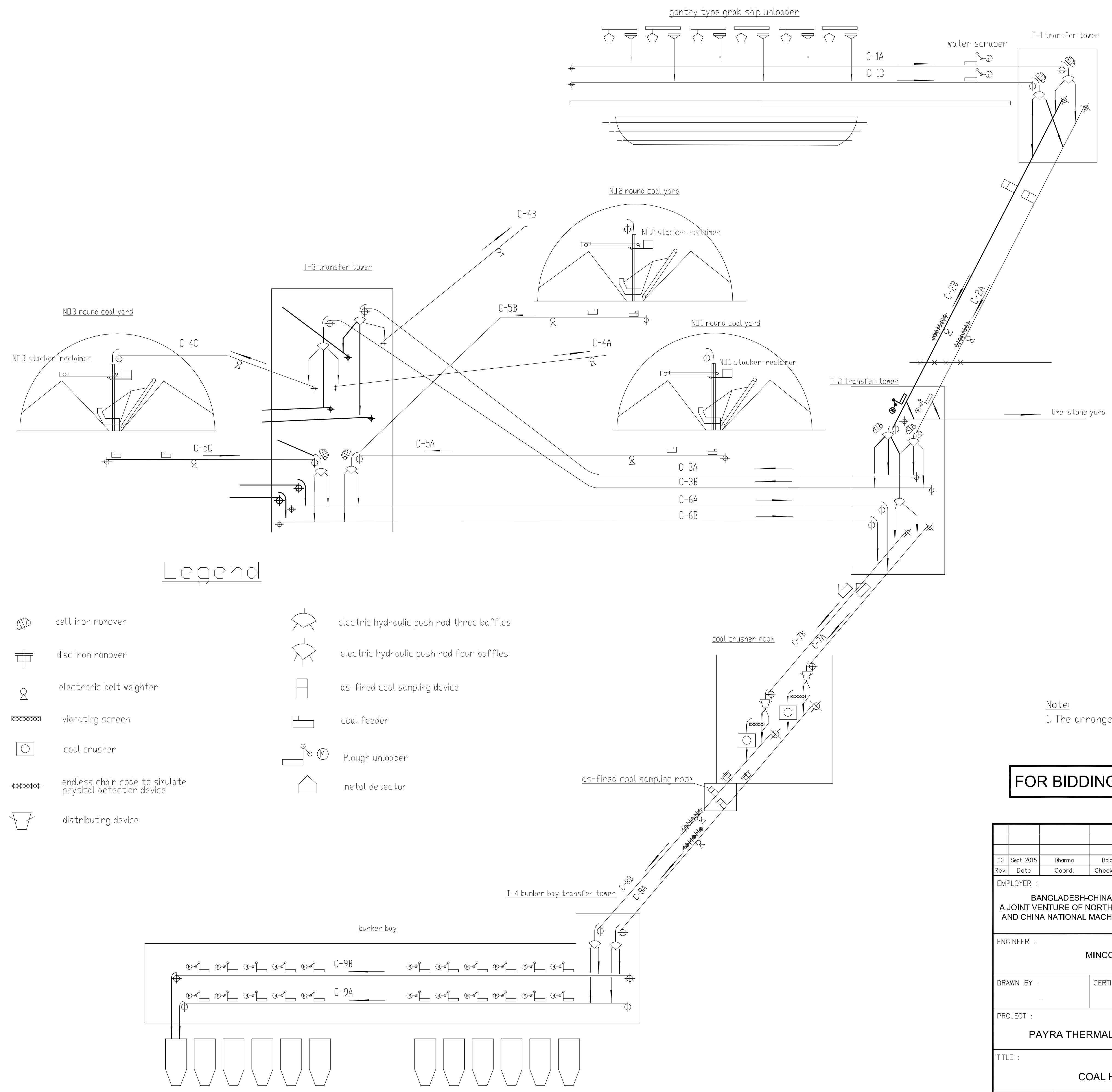
ENGINEER :
MINCONSULT SDN. BHD.

| DRAWN BY : | CERTIFIED BY : | DATE : |
|---|---|---|
| - | - | SEPT 2015 |

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
SECTION DRAWING OF ASH YARD EMBANKMENT

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-18 | 1/1 |




Note:
1. The arrangement shown is for 2x660mw.

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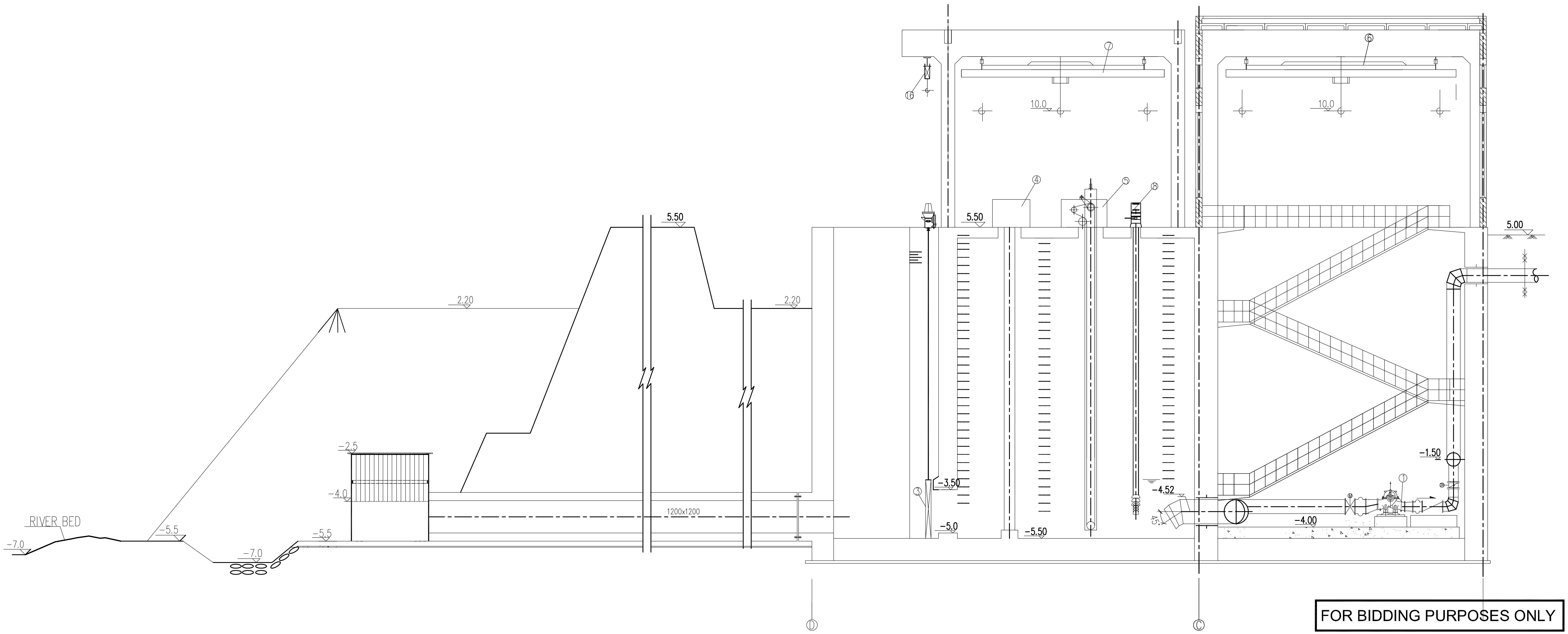
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

COAL HANDLING PLANT

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-19 | 1/1 |




Section drawing of make up water pump house

1:100

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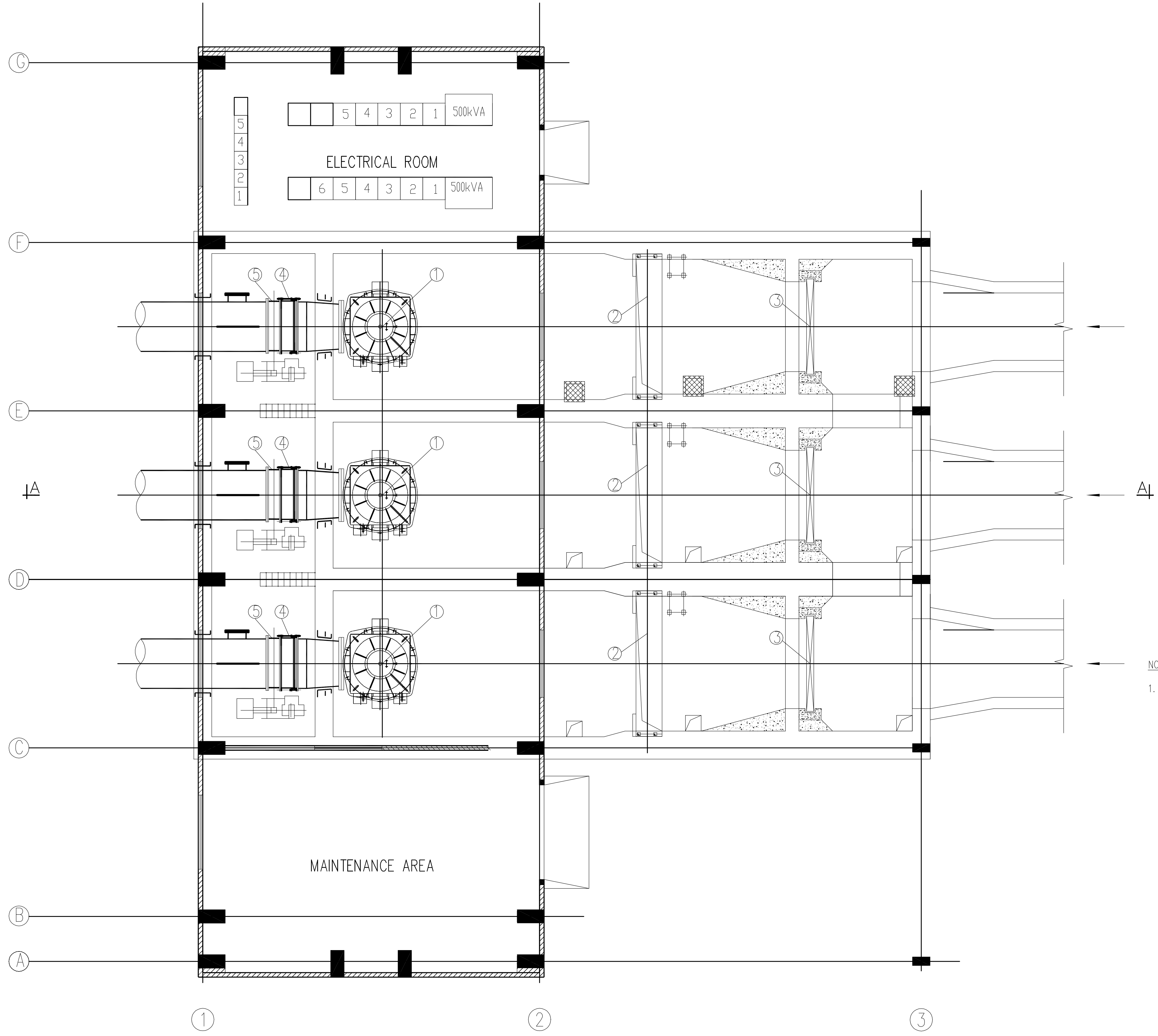
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

SECTION DRAWING PF MAKE UP WATER PUMP HOUSE

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PM-PAY-20 | 1/1 |




NOTE:

1. The system indicated is for 1x660MW.

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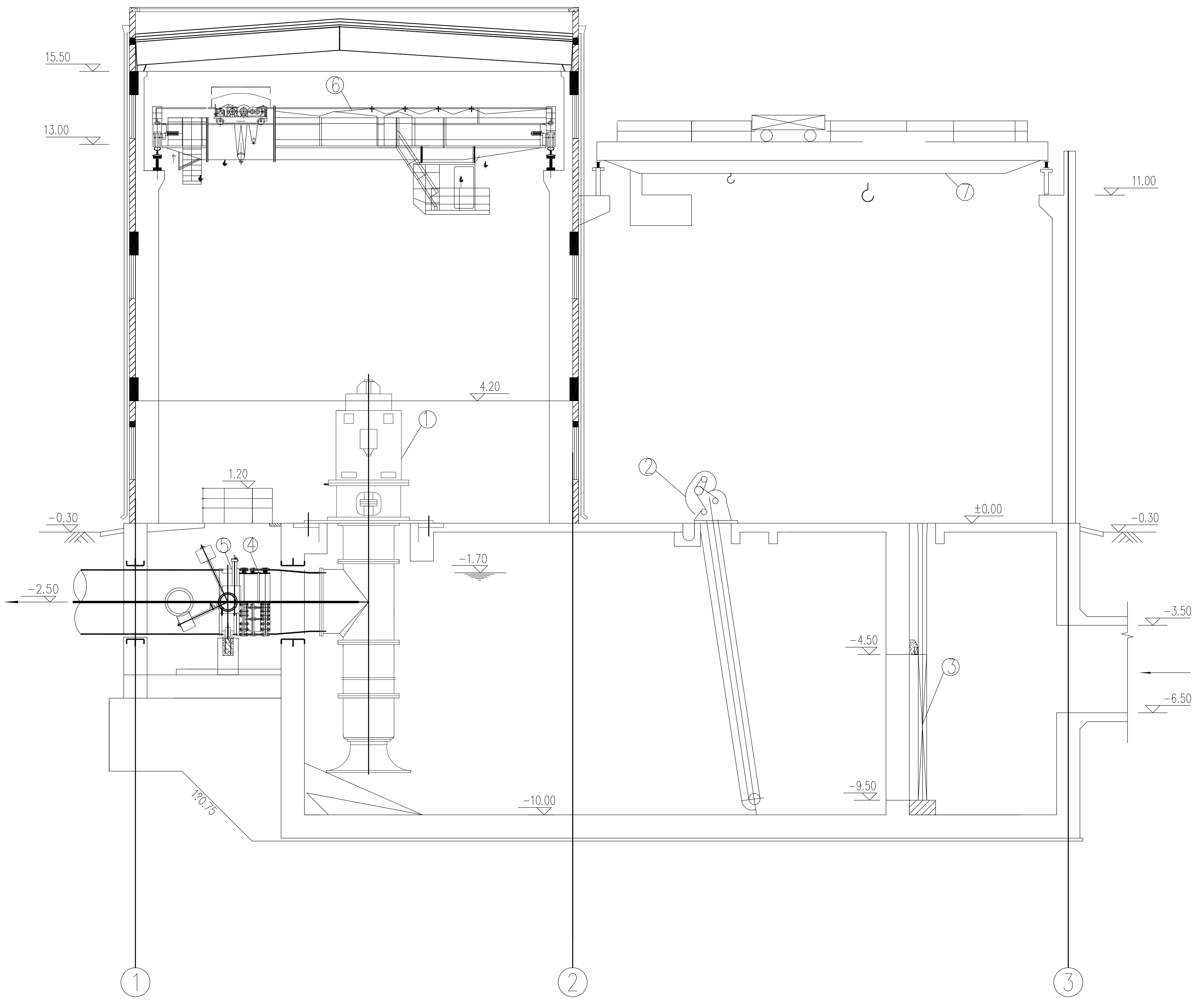
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

PLAN DRAWING OF CW HOUSE

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PC-PAY-01 | 1/1 |




A-A

## MAIN EQUIPMENT LIST

| NO. | Item and specification |
|---|---|
| 1 | CW Pump |
| 2 | Motor |
| 3 | 80°Trash Racks & Rake |
| 4 | Sluice Gate |
| 5 | Flexible Rubber Joint |
| 6 | Hydraulic driven butterfly valve |
| 7 | E.O.T. Crane with Hook |
| 8 | E.O.T. Crane with Hook |
| 9 | Pit Pump |
| 10 | Portable Pit Pump |
| | |

NOTE:

1. All levels are in meters and are indicative.

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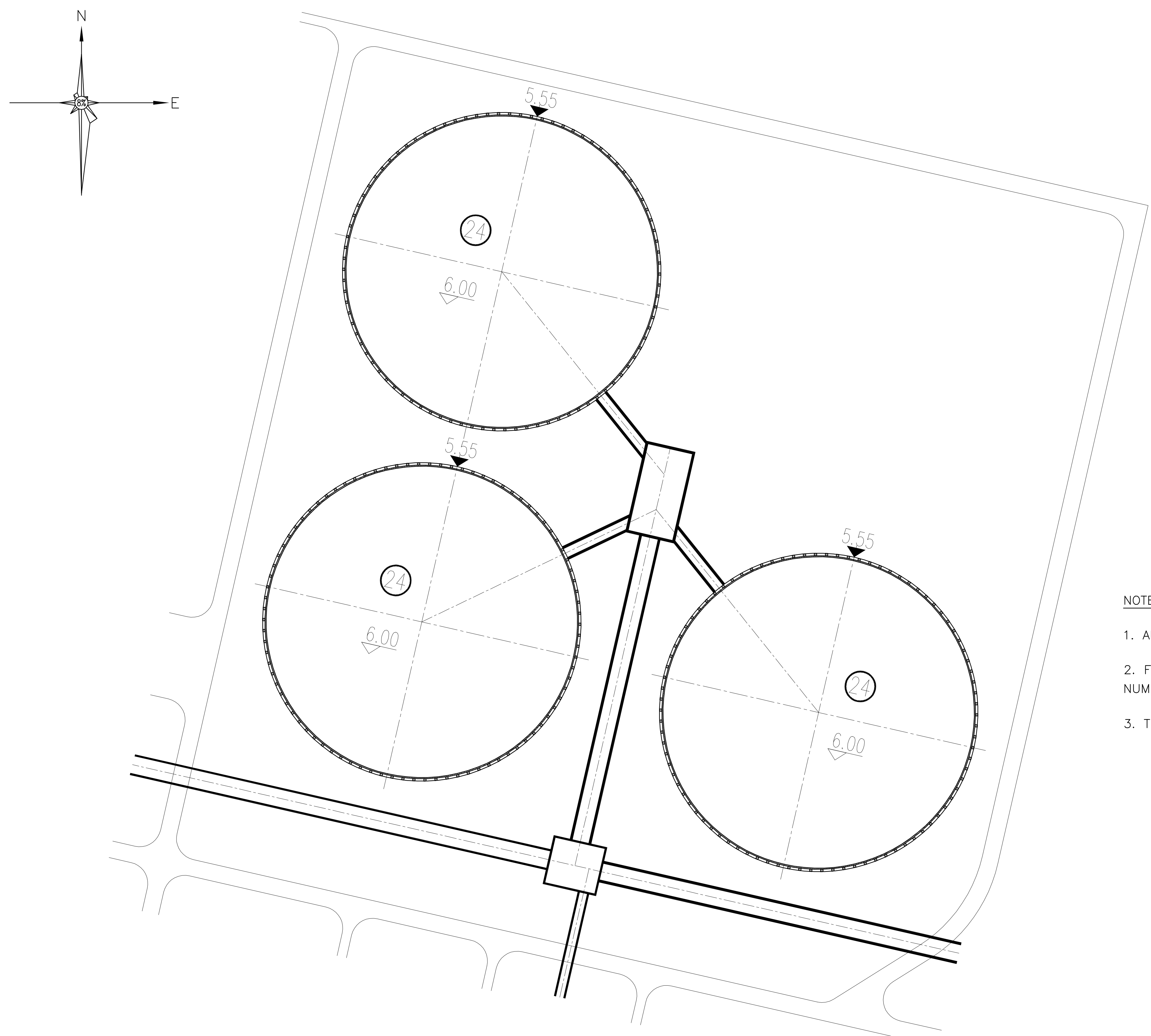
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

SECTION DRAWING OF CW HOUSE

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PC-PAY-02 | 1/1 |




COAL YARD STORAGE AREA–PLAN
SCALE 1:1000

NOTES:–

1. ALL DIMENSIONS ARE IN MILLIMETERS AND LEVELS ARE IN METRES.

2. FOR LOCATION OF ITEM 24 IN PLANT LAYOUT REFER DRAWING NUMBER 10–PM–PAY–02 GENERAL LAYOUT (OVERALL)

3. THE ARRANGEMENT IS FOR 2x660MW.

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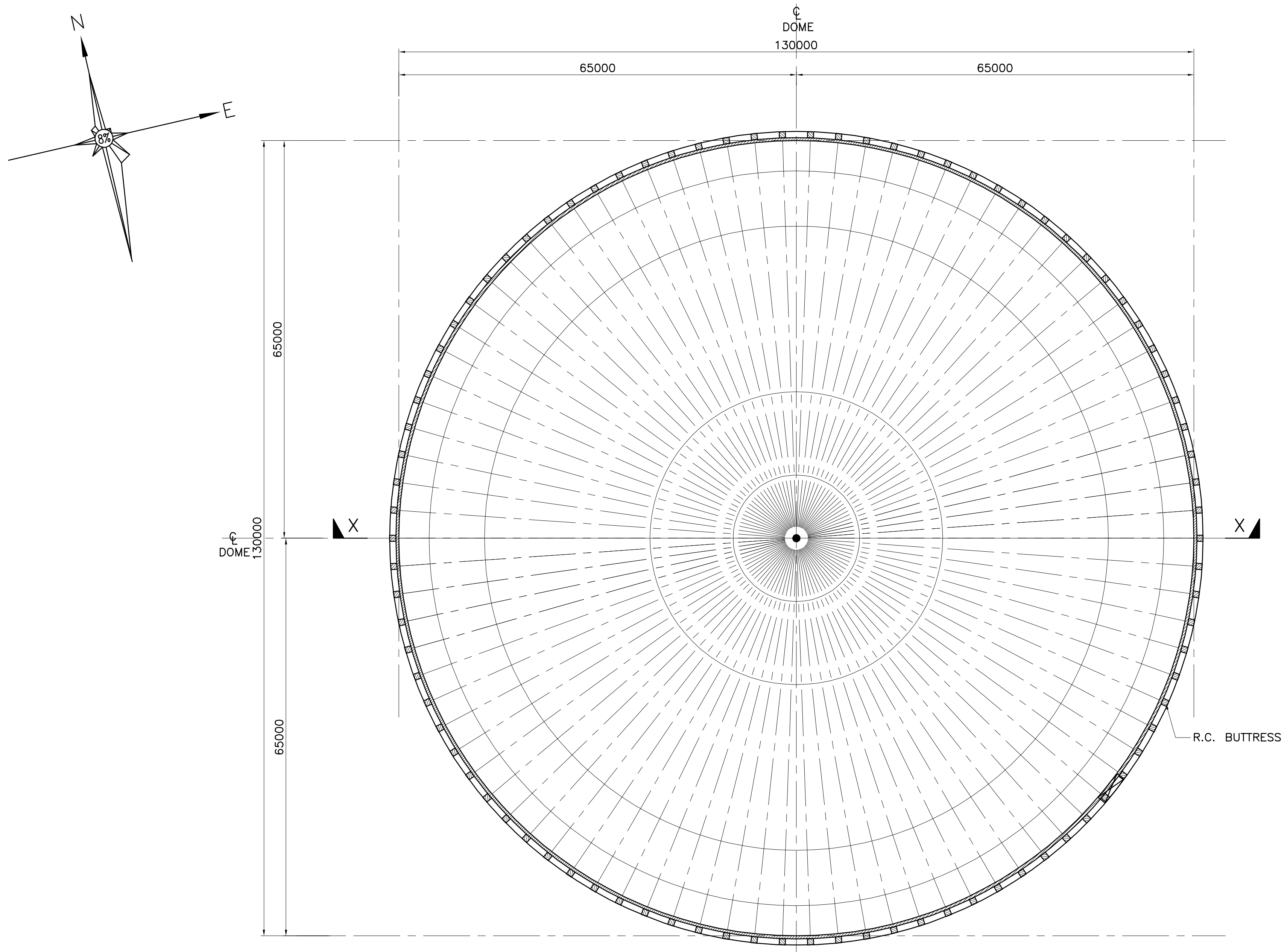
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

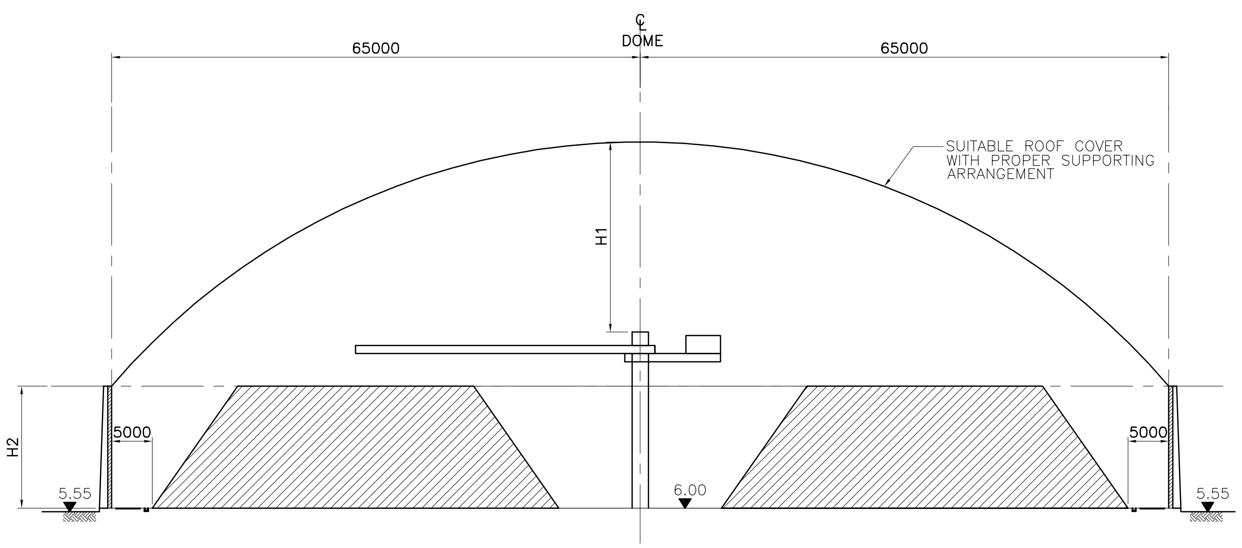
TITLE :
COAL YARD STORAGE AREA-PLAN

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10–PC–PAY–03 | 1/1 |




COAL YARD STORAGE DOME–PLAN

SCALE 1:500




SECTION X–X

SCALE 1:500

NOTES:–

1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES.
2. HEIGHT H1 AND H2 SHALL BE DECIDED BASED ON THE BASIS OF REQUIREMENT OF COAL STACK AND STACKER/RECLAINMER EQUIPMENT.
3. PROPER VENTILATION & DRAINAGE SYSTEM INSIDE THE DOOM SHALL BE CONSIDERED.
4. DUST SUPPRESSION SYSTEM FOR THE COAL STACK SHALL BE PROVIDED.
5. PROPER FIRE DETECTION & FIRE FIGHTING SYSTEM SHALL BE PROVIDED.
6. ACCESS TO THE STORAGE YARD BY BULLDOZER AND OTHER MAINTENANCE VEHICLE SHALL BE PROVIDED.
7. SUITABLE OPENNING ARRANGEMENT ON TOP AND BOTTOM FOR COAL CONVEYOR ENTRY AND OUT RESPECTIVELY SHALL BE PROVIDED.

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PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

COAL STACK-DOME
GENERAL ARRANGEMENT DRAWING

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10–PC–PAY–04 | 1/1 |


**LAYOUT PLAN**
SCALE 1:150

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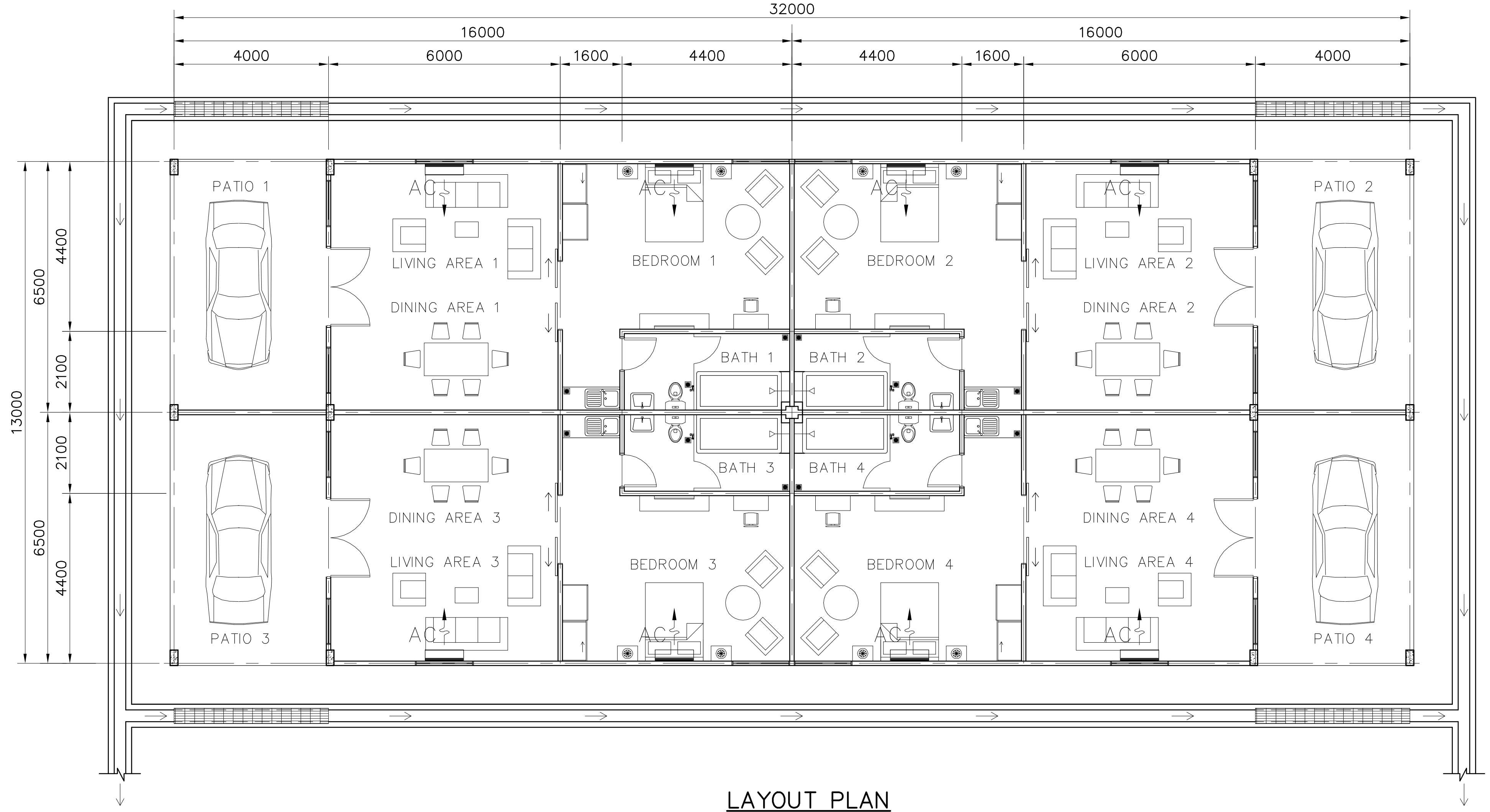
| SABRI | T.ROY | SEPT 2015 |

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
EXECUTIVE GUEST HOUSE

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| 1:150 | 10-PC-PAY-05 | 1/1 |




## LAYOUT PLAN

SCALE 1:75

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ENGINEER :

MINCONSULT SDN. BHD.

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|---|---|---|
| AISYAH | T.ROY | SEPT 2015 |

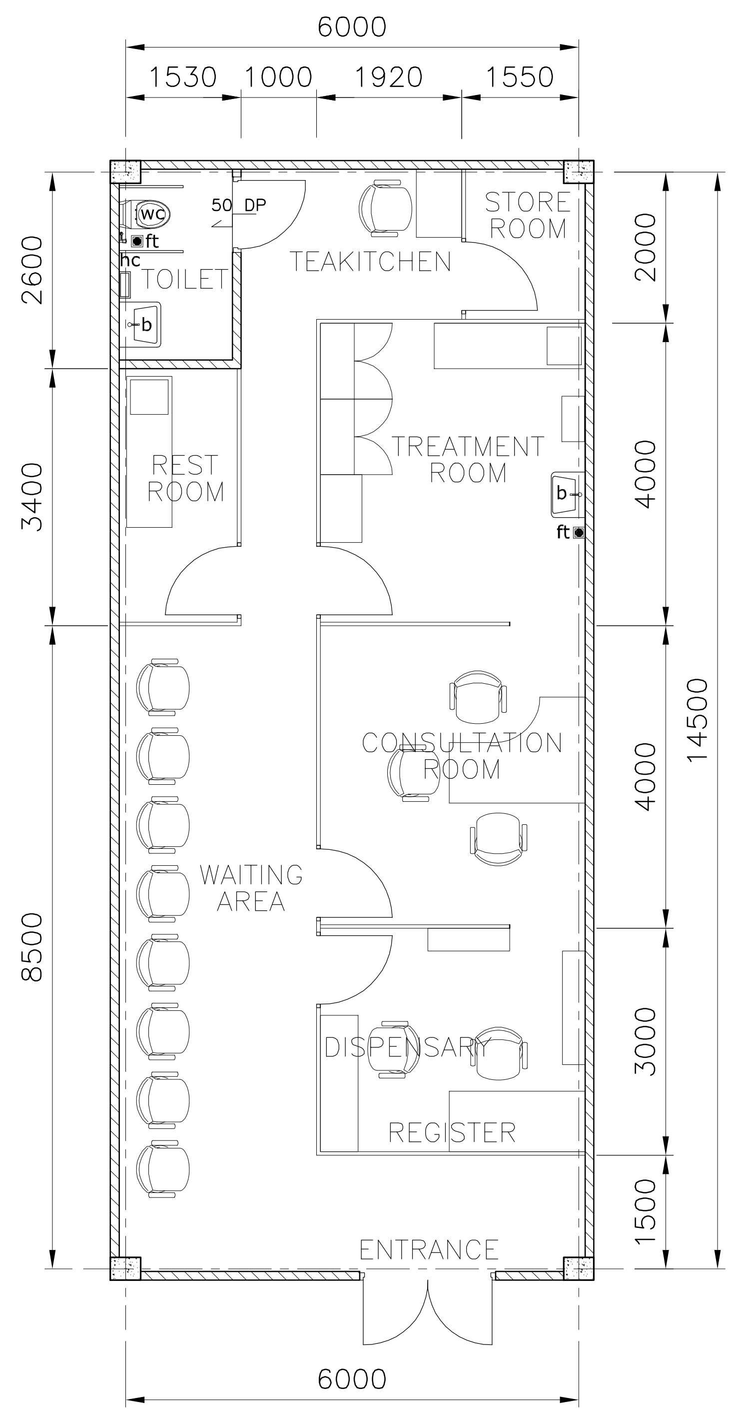
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

VVIP RESTHOUSES

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| 1:75 | 10-PC-PAY-06 | 1/1 |




## LAYOUT PLAN

SCALE 1:50

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ENGINEER :

MINCONSULT SDN. BHD.

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|---|---|---|
| SABRI | T.ROY | SEPT 2015 |

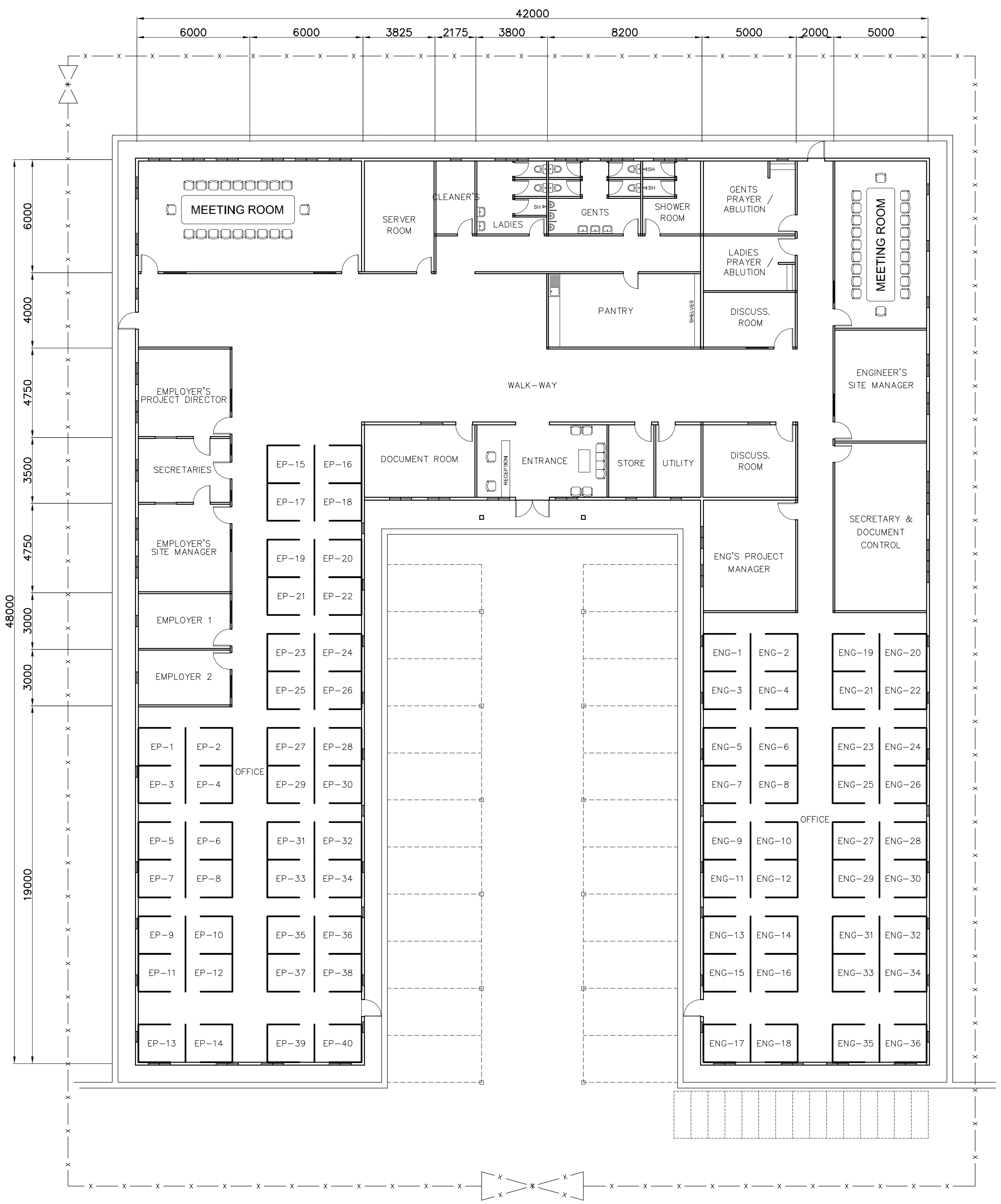
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

CLINIC

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| 1:50 | 10-PC-PAY-07 | 1/1 |




**LAYOUT PLAN**
SCALE 1:150

**FOR BIDDING PURPOSES ONLY**

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AND CHINA NATIONAL MACHINERY IMPORT & EXPORT CORPORATION

ENGINEER :
MINCONSULT SDN. BHD.

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| AISYAH | T.ROY | SEPT 2015 |

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
EMPLOYER'S & ENGINEER'S
SITE OFFICE

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| 1:150 | 10-PC-PAY-08 | 1/1 |


GROUND FLOOR PLAN
SCALE 1:100

FOR BIDDING PURPOSES ONLY

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EMPLOYER :
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ENGINEER :
MINCONSULT SDN. BHD.

| DRAWN BY : | CERTIFIED BY : | DATE : |
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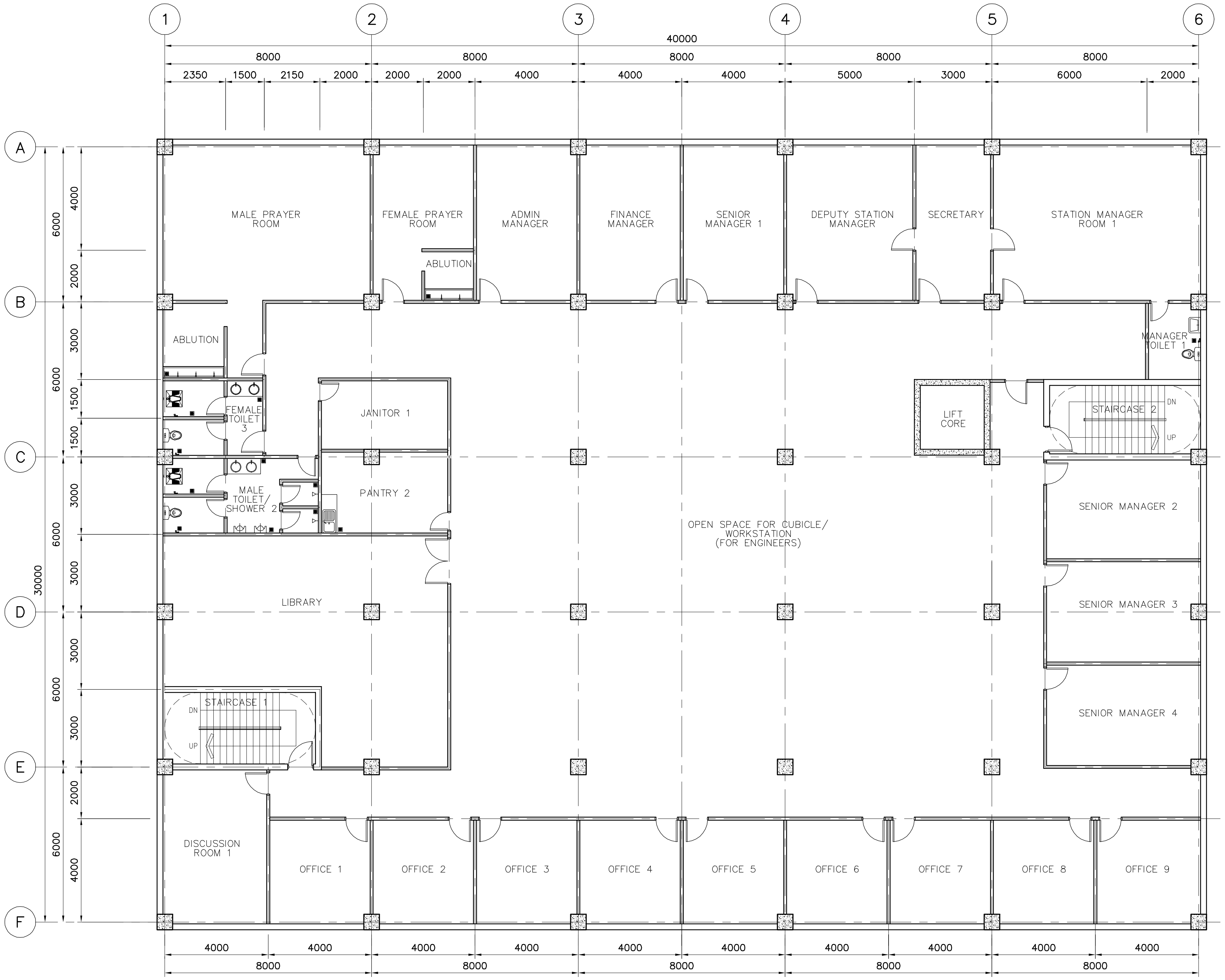
| SABRI | T.ROY | SEPT 2015 |

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
ADMIN BUILDING
GROUND FLOOR PLAN

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| 1:100 | 10-PC-PAY-09 | 1/1 |




FIRST FLOOR PLAN
SCALE 1:100

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ENGINEER :
MINCONSULT SDN. BHD.

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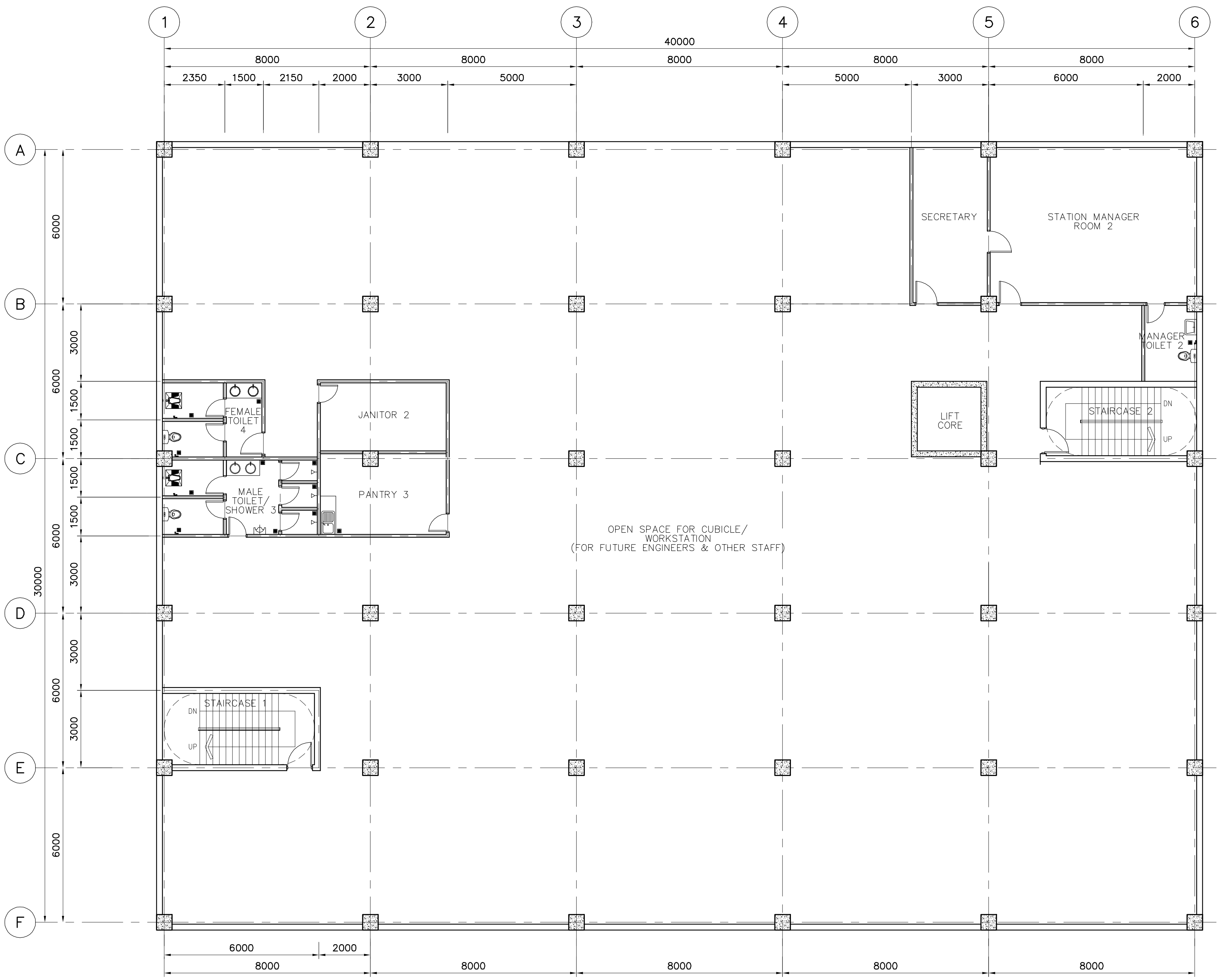
| SABRI | T.ROY | SEPT 2015 |

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
ADMIN BUILDING
FIRST FLOOR PLAN

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| 1:100 | 10-PC-PAY-10 | 1/1 |




SECOND FLOOR PLAN
SCALE 1:100

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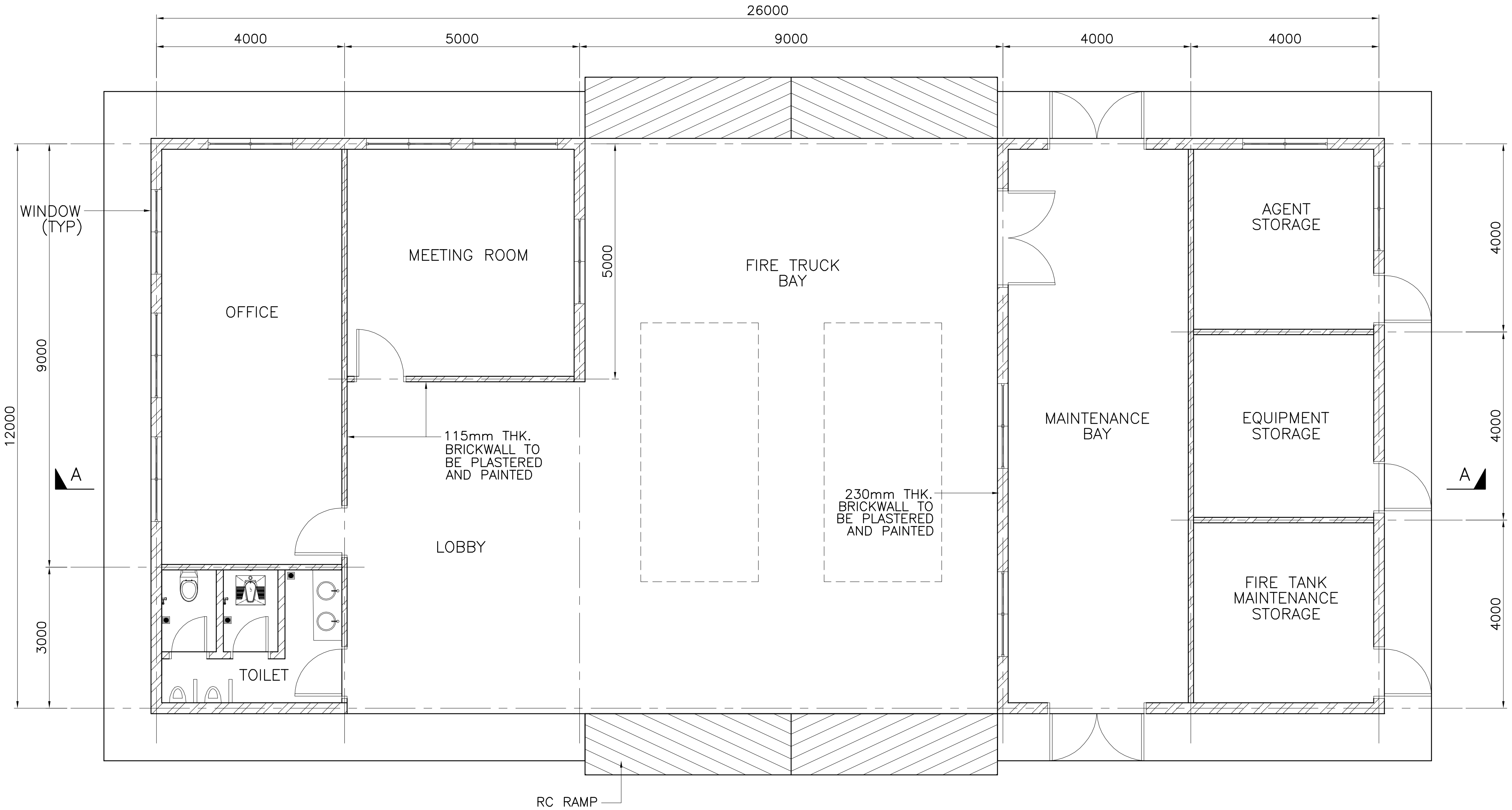
ENGINEER :
MINCONSULT SDN. BHD.

DRAWN BY : SABRI | CERTIFIED BY : T.ROY | DATE : SEPT 2015

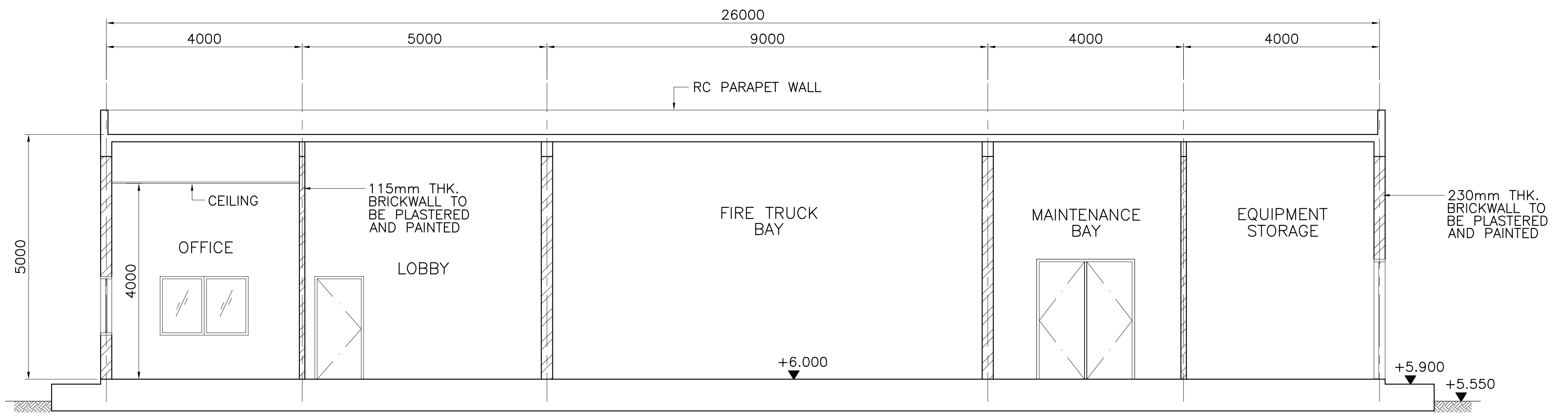
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
ADMIN BUILDING
SECOND FLOOR PLAN

SCALE : 1:100 | DRAWING NO : 10-PC-PAY-11 | SHEETS: 1/1




MINI FIRE STATION—PLAN
SCALE 1:75




SRCTION A—A
SCALE 1:75

NOTES:—
1. ALL DIMENSIONS ARE IN MILLIMETRES AND LEVELS ARE IN METRES.

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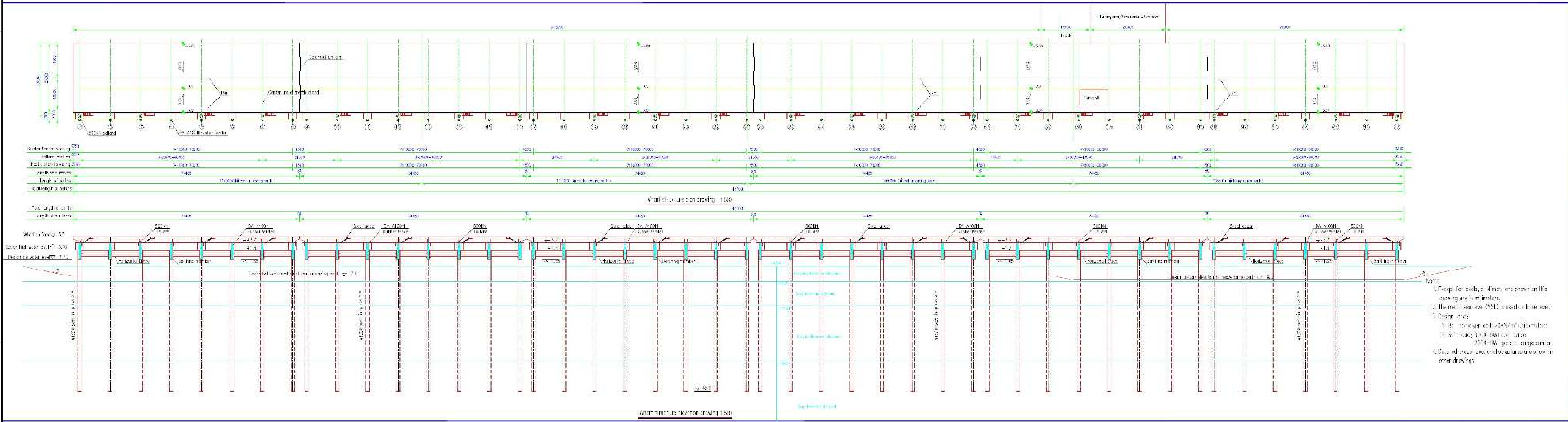
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
GENERAL ARRANGEMENT DRAWING
MINI FIRE STATION-PLAN

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| 1:500 | 10-PC-PAY-12 | 1/1 |



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MINCONSULT SDN. BHD.

DRAWN BY : -
CERTIFIED BY : -
DATE : SEPT 2015

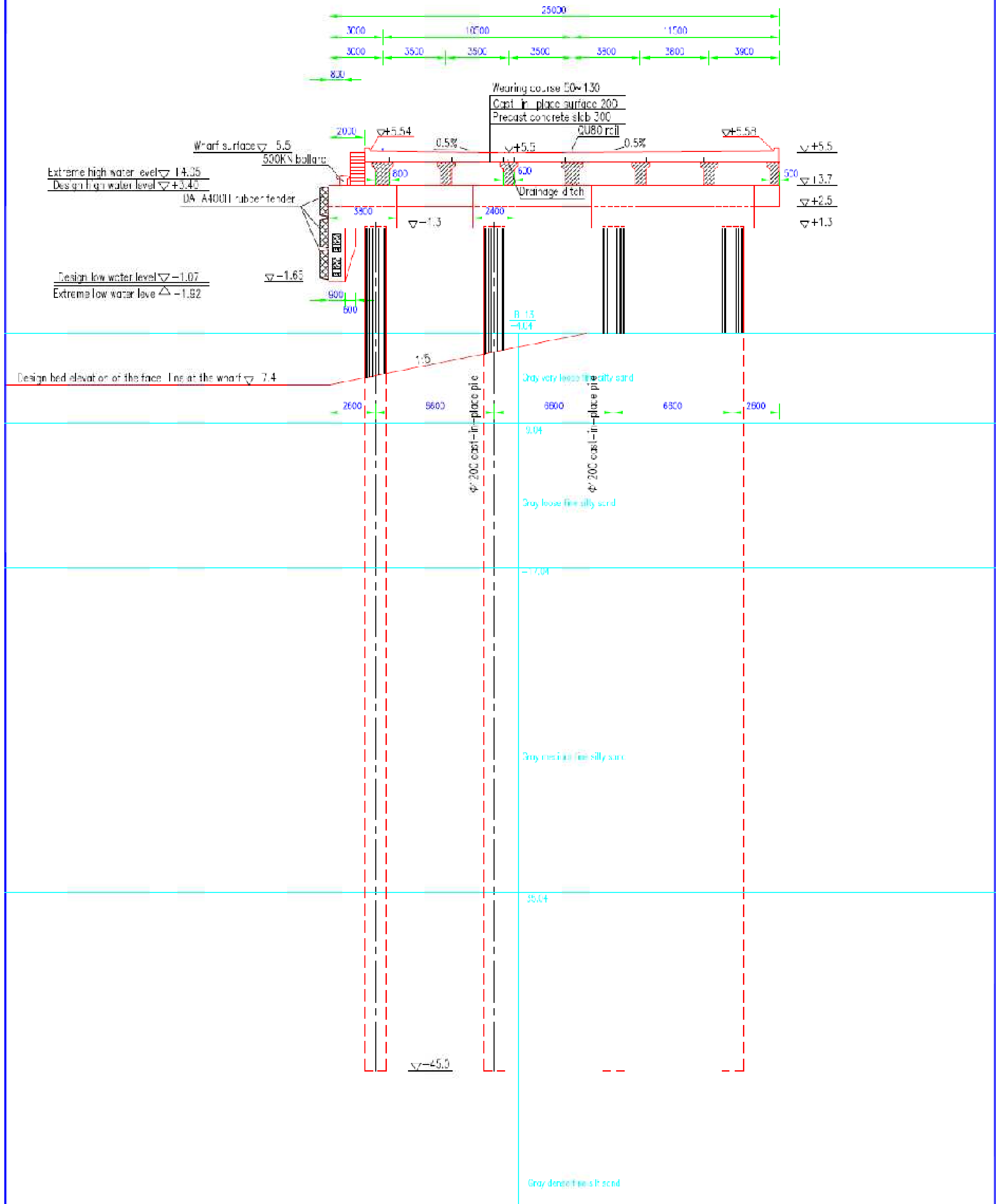
PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

WHARF STRUCTURE PLAN & ELEVATION DRAWING

SCALE : NTS
DRAWING NO : 10-PC-PAY-13
SHEETS: 1/1




Wharf structure cross-sectional drawing

Notes:

1. Except for levels, all dimentions shown on this drawing are in millimeters.
2. The mean sea level (MSL) is used as base level.
3. In this project, the trestle stand spacing is 10m. And Φ1200 cast-in-place pile is applied in the pile foundation.

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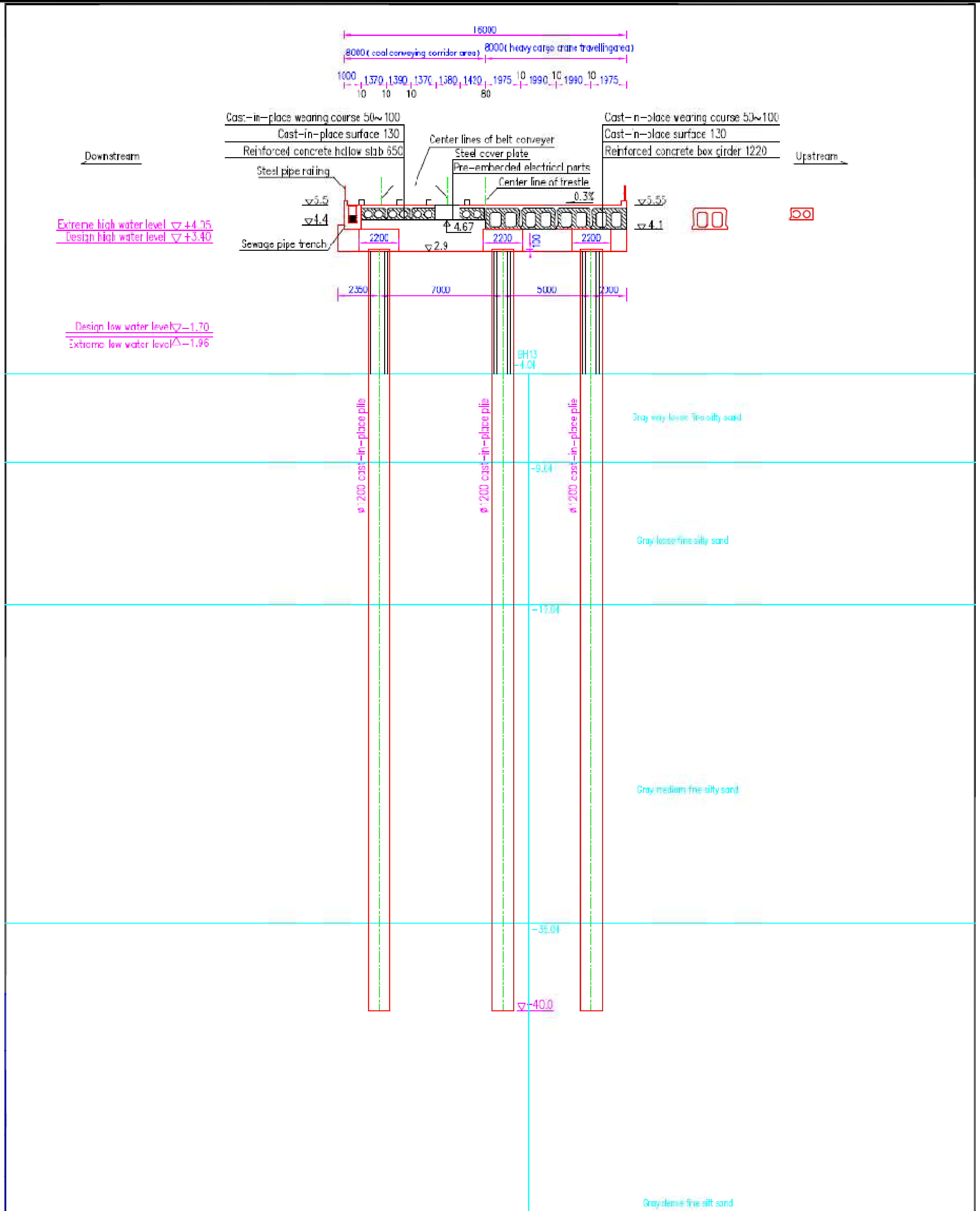
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
WHARF STRUCTURE CROSS-SECTIONAL DRAWING

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PC-PAY-14 | 1/1 |




Notes:

1. Except for levels, all dimensions shown on this drawing are in millimeters. The mean sea level (MSL) is used as base level.
2. The trestle stand spacing of the trestle is 12m. And Φ1200 cast–in–place pile is applied in the pile foundation.
3. The pile–toe supporting course is a compacted fine silty layer.

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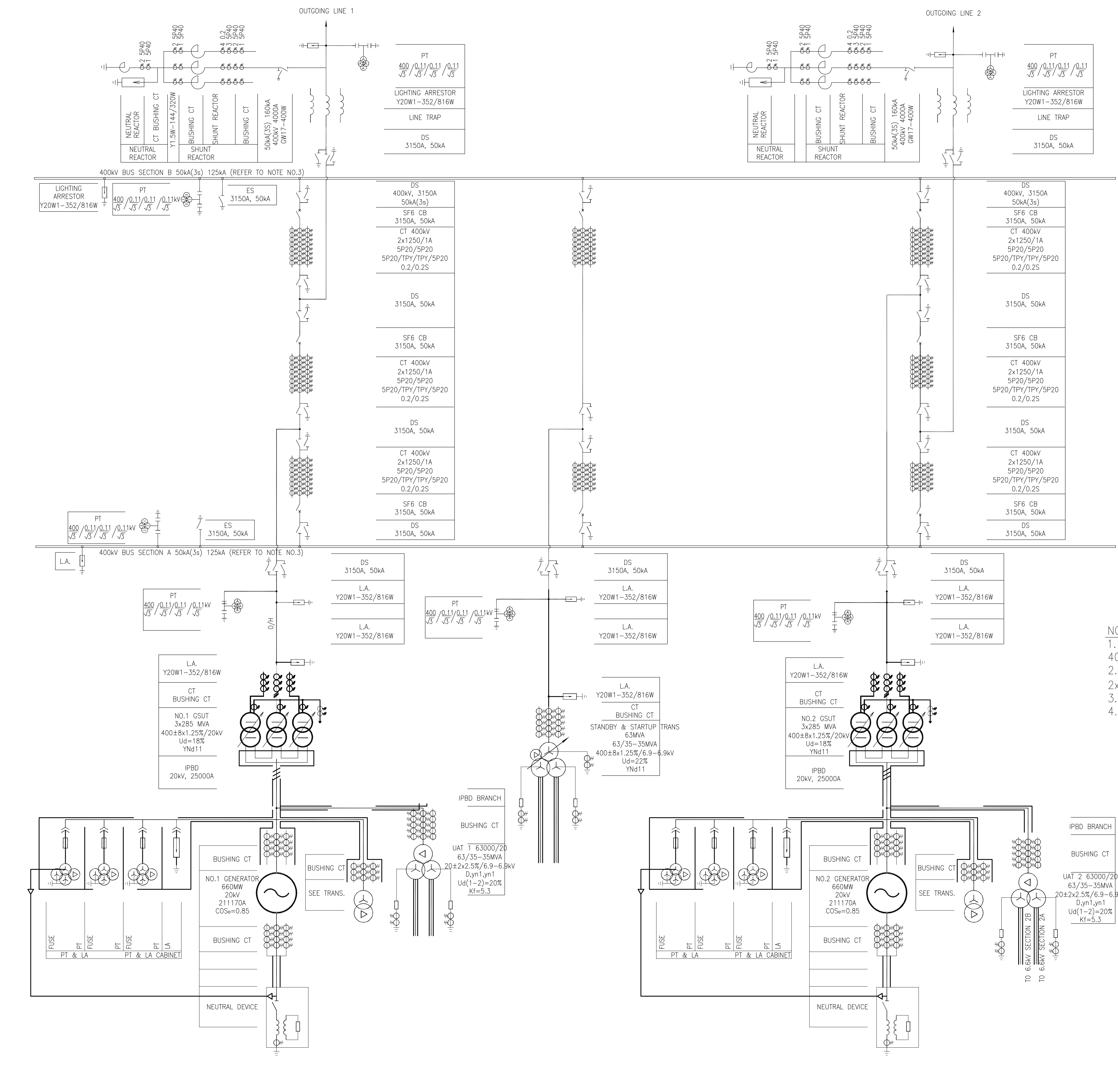
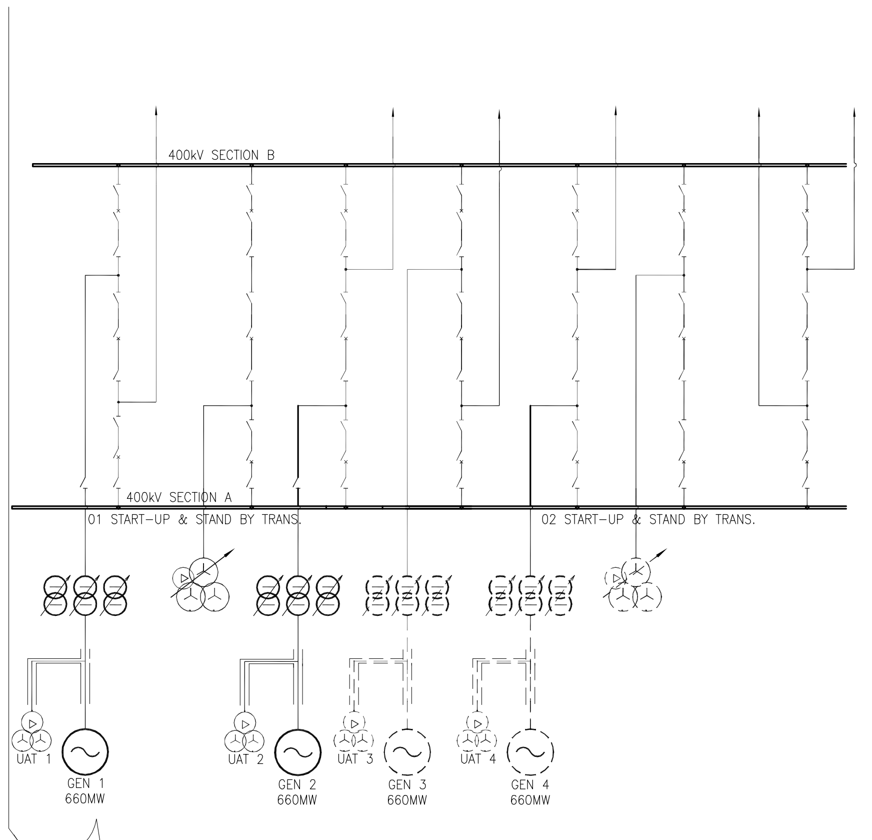
PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
TRESTLE STRUCTURE CROSS-SECTIONAL DRAWING

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10–PC–PAY–15 | 1/1 |




SLD IN FUTURE

NOTE:

a) THE EQUIPMENTS DESCRIBED BY DOTTED LINE ARE FUTURE SCOPE.

NOTE:

1. WHEN THE UNIT AREA STARTING UP, THE 6.6kV AUXILIARY SYSTEM ARE POWERED BY 400kV SYSTEM THROUGH THE 400kV START UP AND STANDBY TRANSFORMER.
2. BUS SECTION RATING SHALL BE SIZED CONSIDERING THE FUTURE PROVISION OF 2x660MW (PHASE II PROJECT).
3. THE PGCB CONTROL BUILDING SHALL BE BUILT IN THE SWITCHYARD AREA.
4. ALL RATINGS ARE MINIMUM -BIDDER TO PROPOSE.

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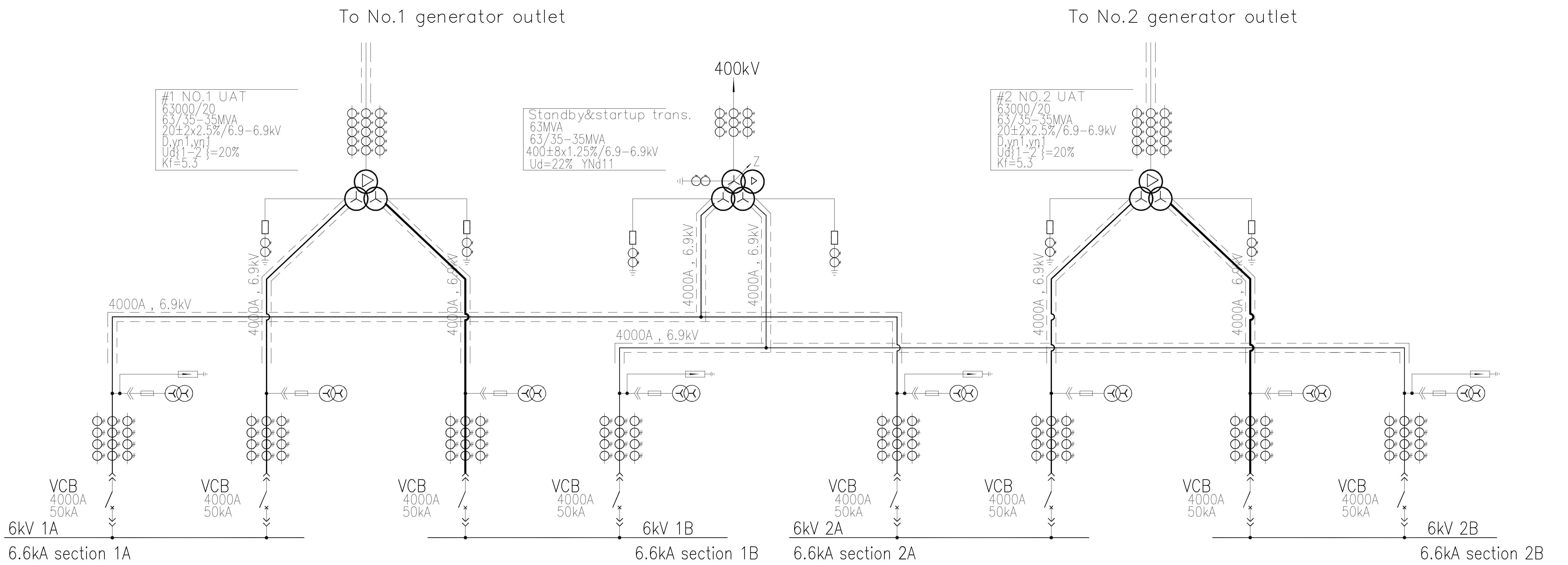
PROJECT : PAYRA THERMAL POWER PLANT (2x660MW)

TITLE : ELECTRICAL MAIN WIRE CONNECTION DIAGRAM

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PE-PAY-01 | 1/1 |




NOTE:
1. ALL RATINGS ARE MINIMUM. BIDDER TO PROPOSE.

**FOR BIDDING PURPOSES ONLY**

| Rev. | Date | Coord. | Checked | Details of revision |
|---|---|---|---|---|
| 00 | Sept 2015 | Dharma | Bala | First Issue |

EMPLOYER :
BANGLADESH-CHINA POWER COMPANY (PVT) LIMITED
A JOINT VENTURE OF NORTH WEST POWER GENERATION CO. LIMITED
AND CHINA NATIONAL MACHINERY IMPORT & EXPORT CORPORATION

ENGINEER :
MINCONSULT SDN. BHD.

| DRAWN BY : | CERTIFIED BY : | DATE : |
|---|---|---|
| - | - | SEPT 2015 |

PROJECT :
PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :
6.6kV WIRE CONNECTION DIAGRAM

| SCALE : | DRAWING NO : | SHEETS: |
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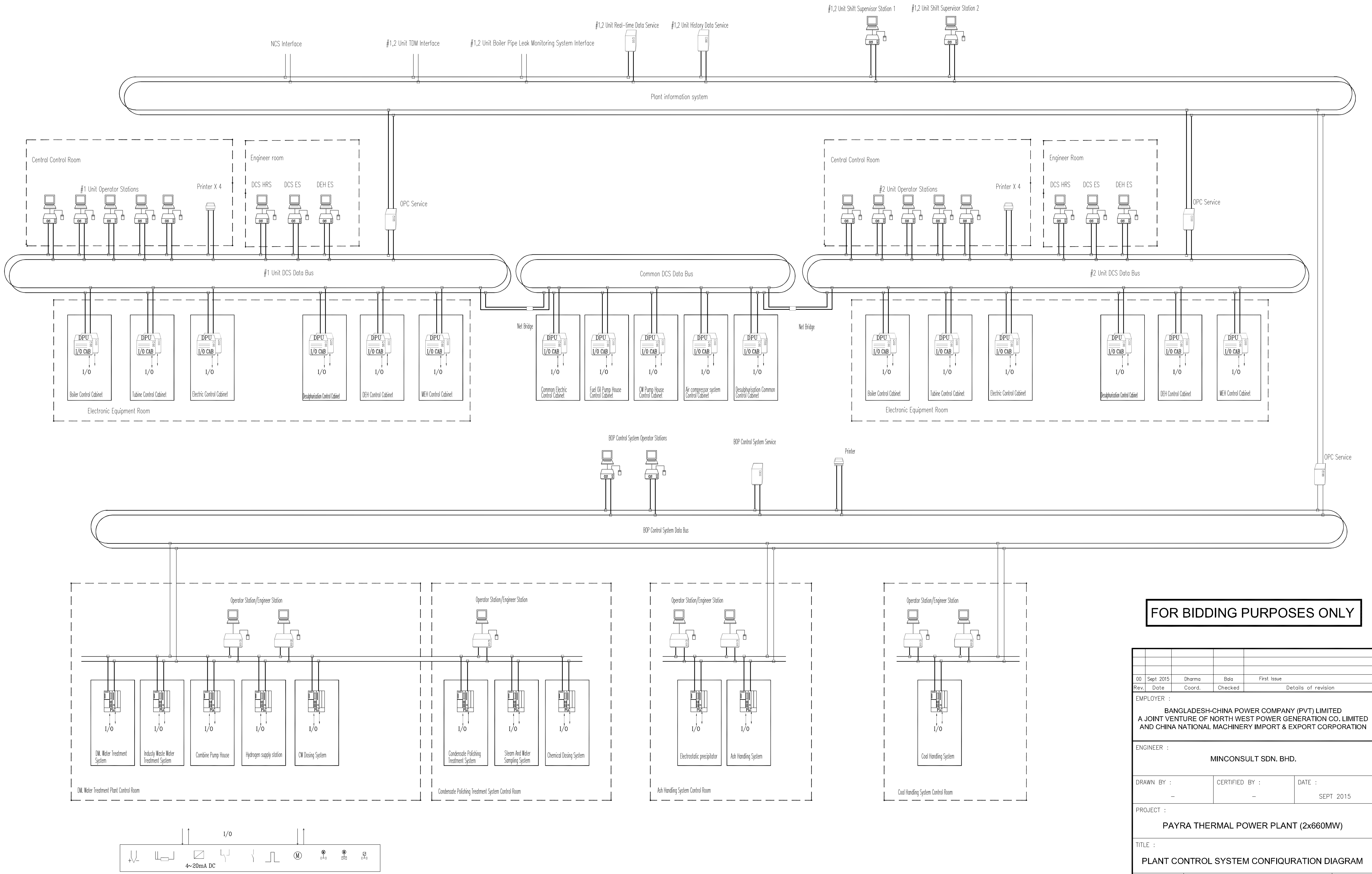
| NTS | 10-PE-PAY-02 | 1/1 |

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| DRAWN BY : | CERTIFIED BY : | DATE : |
|---|---|---|
| - | - | SEPT 2015 |

PROJECT :

PAYRA THERMAL POWER PLANT (2x660MW)

TITLE :

PLANT CONTROL SYSTEM CONFIQURATION DIAGRAM

| SCALE : | DRAWING NO : | SHEETS: |
|---|---|---|
| NTS | 10-PE-PAY-03 | 1/1 |

# SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT C – SYSTEM DEFINITIONS

| Document | Title |
|---|---|
| APB | Lighting & Small Power |
| APC | LV Switchgear |
| APF | MV Switchgear |
| APH | DC System |
| APK | Emergency Diesel Generator |
| ASA | Bottom Ash |
| ASB | Fly Ash |
| ASF | Combustion Waste Disposal Handling |
| CAA | Station Air |
| CAB | Control Air |
| CCA | Chimney |
| CCB | Particulate Removal |
| CCC | Flue Gas Desufurization |
| CCE | Induced Draft |
| CGA | Hydrogen Storage |
| CGB | Carbon Dioxide Storage |
| CHA | Coal Receiving and Stockout |
| CHB | Coal Reclaim and Mill Bunker Fill |
| COA | DCS |
| COC | Unit Protection |
| ECA | Auxiliary Cooling Water |
| ECB | Closed Cycle Cooling Water |
| EEB | Earthing & Lightning Protection |
| EEC | Cabling and Racking |
| EMV | MV Motors |
| EXCT | Generator Excititation System |
| FOA | Fuel Gil Unloading Storage and Supply |
| FPA | Generation Building Fire Protection System |
| FWA | Boiler Feed |
| FWC | Condensate |
| FWD | Condensate Polishing |
| FWE | Cycle Chemical Feed |
| FWF | Cycle Makeup and Storage |
| GTA | Generator |
| GTB | GSU, UAT, and SST |
| GTD | Earthing Transformers & Resistors |
| GTE | Generator Breaker & Earth Switch |
| HRA | Condensing |
| HRB | Condenser Air Extraction |
| HRC | Circulating Water |
| HRE | Electrochlorination |
| PPH | Metering & Measurements |
| PSA | Auxiliary Steam Supply |
| SAA | Continuous Emissions Monitoring |
| SAC | Steam Cycle Sampling Analysis |
| SGA | Boiler |
| SGF | Boiler Vents and Drains |
| SGG | Main Steam |
| SGI | Soot Blowing |
| SGJ | Hot Reheat Steam |
| SGK | d Reheat Steam |
| STG | Site Fire Protection |
| TEA | HP Extraction Steam |
| TEB | LP Extraction Steam |
| TEC | Extraction Drains |
| TED | HP Heater Drains |
| TEE | LP Heater Drains |
| TGA | Steam Turbine |
| TGB | Generator |
| TGC | Turbine Seals and Drains |
| TGD | Turbine Lube Gil |
| TGE | Generator Cooling and Purge |
| WSC | Service Water |
| WSD | Potable Water |
| WSE | Fire Protection Water Supply |
| WTD | Demineralized Water Treatment |
| WWA | Chemical Waste Collection and Treatment |
| WWB | Sanitary Drainage and Treatment |
| WWC | Wastewater Collection & Treatment |

# 1 LIGHTING & SMALL POWER

## 1.1 SYSTEM IDENTIFICATION

- System Name Lighting and Small Power
- KKS Code BLA

The lighting and small power system shall include the distribution boards, single and multi-core cables, conduits, wiring, luminaire brackets, luminaires, switch socket outlets and welding plugs.

## 1.2 CONSTRAINTS AND ASSUMPTIONS

The lights shall be fixed, self-contained or seal-beam type units.

Small power circuits shall be protected with earth leakage and over current protection circuit breakers. Small power circuits shall be fed from circuit breakers, which are connected to the normal supply distribution board.

Maintenance power circuits consist of earth leakage and over current protection circuit breakers, and shall be fed from the normal supply.

The lighting and small power installation shall be in accordance with standards listed in 1.7, below. The lighting is designed with personnel safety and functionality as the main criteria, and shall provide adequate lighting to allow employees to perform their work safely and efficiently.

Self-contained battery back-up emergency lights shall be provided in outside plant areas where unit or station essential service Vac is not readily available.

## 1.3 PERFORMANCE

The illumination level shall be designed to the applicable nominal illumination levels as stated in IES. Degradation and environment shall be considered, along with maintenance in accordance with the supplier recommended maintenance plan.

## 1.4 TECHNICAL REQUIREMENTS

The lighting installation shall be suitable for the area of application, readily accessible for maintenance, and standardized as much as possible, to keep the luminaires and lamp spares to a minimum.

Small power panel boards shall be placed throughout the plant to reduce the extent of low voltage wiring for lighting and small power needs.

The lighting system shall be evenly distributed and minimize "black spots" and stroboscopic effect.

### 1.4.1 BOILER HOUSE

The luminaires used shall be broad beam floodlights with a low glare light distribution. Special care is necessary in the design of the lighting in the boiler area to minimize glare and harsh shadows. Luminaires shall be mounted at a height of approximately 2.2 meters off the floor level, access platform, or stairway to aid in maintenance. Luminaires shall have a minimum protective class rating of IP 55.

### 1.4.2 TURBINE HOUSE

The light sources for this area shall be the same as for the boilers, with the addition of the self-cleaning high bay types for the turbine hall.

### 1.4.3 ELECTRICAL ROOMS, OFFICES, SUBSTATIONS AND WORKSHOPS

Recessed or surface mounted low glare fluorescent luminaires shall be used in electrical rooms, offices, and areas of similar environment.

### 1.4.4 CONTROL ROOMS

The control rooms require special consideration. Down lights on dimmer switches shall be used for the general area lighting. Low glare fluorescent luminaires shall be installed to light the mimic panel. Uniform light distribution is necessary. DC luminaires shall be installed at the doors and above the control desk for emergency use if the normal and essential power supplies fail.

### 1.4.5 OUTSIDE AREAS

For large areas that require area lighting, 20 m light masts with 8 or 12 x 400 W high pressure sodium or 6 x 940 W xenon high pressure sodium floodlights shall be used. The lighting shall be controlled by a photo electric cell (preferred) or timer and contactor, and has an override switch.

### 1.4.6 CHIMNEY

Because of the height of the structures the installation requires Aircraft Warning Lights (AWL). These shall be located on three levels equally spaced around the outside wind shield. Long life incandescent lamps shall be used. The AWLs shall be controlled with a daylight switch and a bypass switch for maintenance. An alarm to the station control room is installed to indicate lamp failure. The staircase shall only be for emergency use and lighted accordingly, a 100 lux light level is adequate. Bulkheads with a long lamp life and a robust structure shall be provided.

### 1.4.7 COAL STOCK YARD

Lighting masts up to a 40 meter height with 8 x 940 Watt xenon high pressure sodium floodlights shall be used for area lighting. The lighting shall be controlled by a photo electric cell and contactor, and has an override switch.

### 1.4.8 SECURITY FENCE

The security fence shall be 150 Watt high pressure sodium floodlights mounted on 3 meter poles. Mini-substations situated around the fenced area shall supply the different sections of the fence lighting. Adjacent luminaires shall be fed from alternative mini-substations to ensure that there is still lighting when one mini-substation fails.

## 1.5 MAINTAINABILITY

Installation shall be done in a manner to help facilitate maintenance.

## 1.6 OPERABILITY

Switching shall be provided in offices, general rooms, workshops, substations, electrical rooms, substations, chimneys and transformer bays.

Daylight switches shall be installed on outside areas and high masts to ensure lights are only switched on when required. The boiler and turbine houses installations run continuously, and are unswitched.

## 1.7 APPLICABLE STANDARDS

- IEC 60309
- IEC 60598
- IEC 60669
- IEC 60730
- IEC 60906
- IEC 60998

# 2 LV SWITCHGEAR

## 2.1 SYSTEM IDENTIFICATION

- System Name Low Voltage Switchgear and Control gear
- KKS Code BHA

This document describes the Low Voltage (LV) switchgear and control gear serving the LV loads, such as motors, small power and lighting, and DC systems.

## 2.2 CONSTRAINTS AND ASSUMPTIONS

The design shall include the following constraints and assumptions:

- Loading Requirements
- Type of Loads Served
- Fault Levels
- Environmental factors such as ambient temperature, dust, seawater environment, and airborne debris.
- The Power Station life will be at least 30 years
- The best switchgear technology currently available in the market will be used.
- Switchgear will be installed in safe and secure manner; within spaces not exceeding the maximum temperature rating of equipment.

## 2.3 PERFORMANCE

The power supply distribution system shall be arranged in such a way that a reasonable approach to redundancy is applied to maintain the availability of the plant.

Failure of equipment in the common plant power supply system shall not force a shutdown of the station. Power supply to the auxiliary equipment of the unit should be carefully selected and placed to enable unit operation at a minimum of half load in case of an electrical board failure. A double ended LV arrangement shall be applied in the common plant to enable maintenance of the electrical equipment while the common plant services to the units are not interrupted. The layout shall be designed to accommodate routine and breakdown maintenance of the electrical equipment. Routine maintenance on the unit electrical equipment shall only be performed when the unit is not running.

## 2.4 TECHNICAL REQUIREMENTS

### 2.4.1 POWER SUPPLY

Auxiliary transformers shall transform the medium voltage supply to LV as required. The transformers will have HV winding delta connected, and the LV winding wye connected. The neutral of each transformer shall be grounded to provide a 3-phase, 4-wire system, with current carrying neutral for single phase loads. The transformers shall be 3-phase, 2-winding transformers. Each transformer will be sized for 100 % capacity of the connected bus. Indoor unit substation transformers shall be of the air-cooled, cast coil dry type provided without cooling fans. Outdoor unit transformer shall be either oil-filled type with naturally cooled ratings or dry type, similar to indoor type.

Supply for the Vdc boards shall be from the unit boards and station boards through chargers/rectifiers.

### 2.4.2 SWITCHBOARD RATINGS

Components of the switchgear shall have properties that enable the system to operate normally, without any de-rating or reduced life expectancy, and within the design margins recommended for the equipment electrical parameters. The partial list of critical parameters and their recommended design redundancy limits are as follows:

| Electrical Parameter | Design Margin |
|---|---|
| Lightning impulse voltage withstand | ≥IEC specified level |
| Power frequency impulse voltage withstand | ≥IEC specified level |
| Operating voltage | ±10 % |
| Thermal load (current) | ≥10 % |

### 2.4.3 DESIGN

The switchboard shall be factory built free standing type, front-operated assemblies, with front/rear-access for cabling. The boards consist of the multi-cubicle type with a combination of withdrawable and fixed trays, as required.

Incoming feeders, motor starters and drives less than 75 kW shall be of the fully withdrawable type. Incoming feeders, motor starters and drives 75 kW and larger shall be of the fixed type. Circuit breakers and switching devices shall be rated for the system voltage, current, and fault levels of each switchboard.

The control circuits shall be 110V DC or 240V AC control.

## 2.5 MAINTAINABILITY

The switchgear design shall be performed, and the material selected such that they ensure low maintenance. The switchgear supplier shall provide a maintenance plan for the switchgear life expectancy of 30 years. The equipment should have the same rating and be interchangeable to decrease spares inventory and shorten down times.

The supplier shall provide any special maintenance tools and equipment.

## 2.6 OPERABILITY

The operability will be defined by the Station LV switchgear philosophy.

## 2.7 OPERABILITY

- IEC 60269
- IEC 60439
- IEC 60947

# 3 MV SWITCHGEAR

## 3.1 SYSTEM IDENTIFICATION

- System Name MV Switchgear
- KKS Code BBA

The Power Station electrical auxiliary system provides power to the general loads and to the unit load. The common plant includes various switchboards for areas such as coal handling, ash handling, and water treatment.

A cross-tie will be provided for the Future Unit, as specified in Chapter 2 of Section 5 Employer's Requirements.

## 3.2 CONSTRAINTS AND ASSUMPTIONS

The design should include the following constraints and assumptions:

- Loading requirements.
- Type of load served
- Fault levels.
- Environmental factors such as ambient temperature, dust, seawater and airborne debris.
- The Power Station life will be at least 25 years.
- The best switchgear technology currently available in the market will be used.

## 3.3 PERFORMANCE

The power supply distribution system shall be arranged in such a way that a reasonable approach to the redundancy principle is applied to maintain the availability of the plant.

Failure of equipment in the common plant power supply system shall have limited impact on overall operation of the plant. Power supply to the auxiliary equipment of the unit shall be carefully selected and placed to enable unit operation at a minimum of half load in case of an electrical board failure.

The redundancy principle shall be applied in the common plant to enable maintenance of the electrical equipment while the common plant services to the units are not interrupted. The layout shall be designed to accommodate routine and breakdown maintenance of the electrical equipment. Routine maintenance on the unit electrical equipment shall only be performed when the unit is not running.

## 3.4 TECHNICAL REQUIREMENTS

The MV switchgear shall comply with the following design requirements:

Components of the switchgear shall have properties that enable the system to operate normally, without any de-rating or reduced life expectancy, and within the design margins recommended for the equipment electrical parameters. The list of critical parameters and their recommended design redundancy limits are as follows:

### 3.4.1 SWITCHBOARDS RATINGS

Components of the switchgear shall have properties that enable the system to operate normally, without any de-rating or reduced life expectancy, and within the design margins recommended for the equipment electrical parameters. The list of critical parameters and their recommended design redundancy limits are as follows:

| Electrical Parameter | Design Margins |
|---|---|
| Lightning impulse voltage withstand | ≥IEC specified level |
| Power frequency impulse voltage withstand | ≥IEC specified level |
| Operating voltage | ±10 % |
| Thermal load (current) | ≥10 % |

### 3.4.2 PANELS CONSTRUCTION

The switchgear shall be of the metal-clad, single tier design. Switchgear shall include:

- Circuit breakers and motor switching devices.
- Main bus bars.
- Auxiliary bus bars and bus-wiring.
- Control circuit and protection relays.
- Steel barrier isolation between primary circuits.
- Isolated low voltage compartments.
- Power cables termination.
- Voltage and current transformers.
- Cable live indicators.
- Motor heater power supply.
- Earthing switches.
- Fast transfer, as required.
- Exhausting ducts, as required.
- Ammeters and Volt meters

The control panel shall be located in the front and at the top of the switchgear panel with the protection relays, indication and control facilities accessible (visible) with the door closed.

Access doors and covers to live compartments shall be bolted in position and have adequate marking with warning signs to warn of live parts behind them.

Circuit breakers and switching devices shall be vacuum or SF6 interrupter type; rated for the system voltage, current, and fault levels of each switchboard.

The design will allow for the cable support structures, fixing bolts, clamping devices and cable lug fixing holes, with provisions for terminating MV cables using dry type terminations.

The MV switchboards shall be equipped with microprocessor numerical relays, including an internal arc protection scheme. The protection relays shall be microprocessor based intelligent, integrated modules offering protection, signaling, measuring, automation, and communication functions.

## 3.5 MAINTAINABILITY

The switchgear design shall be performed, and the material selected such that they ensure low maintenance. The switchgear supplier shall provide a maintenance plan for the switchgear life expectancy of 30 years. The equipment shall have the same rating and be interchangeable to decrease spares inventory and shorten down times.

The protection maintenance is as important as the power circuitry. Due to the nature of electronic and electrical equipment failures, mostly hidden type failures, it is essential to perform routine type maintenance to ensure that it is possible to find defects, and repair them before developing into a flashover. Self diagnostic protection equipment shall be provided.

For Standardization of Operation, Performance, facilities and spares requirements the main protective relays and control system (SAS) including complete panels to be supplied under this project shall comprise Alstom (France/UK), ABB (Switzerland/Sweden) and Siemens (Germany) make manufacture

## 3.6 OPERABILITY

The configuration of the medium voltage networks shall incorporate electrical interlocking and functional switching arrangements through the DCS system to ensure that no paralleling operation permitted between any of the supply points to the system. Therefore, system shall be constrained to run as single radial transformer supply so that fault levels applied to the MV system are held well within the switchgear short circuit ratings.

Each circuit shall have local and remote control capability. The remote control shall be through the DCS and automation system.

## 3.7 APPLICABLE STANDARDS

- IEC 62271-100
- IEC 62271-102
- IEC 62271-200:2003
- IEC 60265-1
- IEC 60470
- IEC 60694

# 4 DC SYSTEM

## 4.1 SYSTEM IDENTIFICATION

- System Name DC System
- KKS Code

The DC system shall consists of battery chargers, station batteries, DC switchboard, and DC converters.

The battery chargers are required to supply DC power to the DC switchboards and at the same time charge the station batteries.

Station batteries shall be either valve-regulated types lead acid batteries or nickel cadmium (NiCd) batteries.

The primary function of the converter is to transform one DC power source to a lower DC output format. The converter may also serve to improve the quality of the power source by keeping its own output within the specified characteristics.

## 4.2 CONSTRAINTS AND ASSUMPTIONS

- The electrical system requires separate DC for power and control, and each unit shall have its own stand alone battery system.
- The DC voltage for power shall be 220V. The unit shall have two group batteries and two 100% capability battery chargers.
- The DC voltage for control shall be 110V. The unit shall have two group batteries and two 100% capability battery charges.
- The equipment shall be installed in conditioned space with the batteries.
- The electrical configuration requirements for the Control and Instrumentation (C&I) system shall be such that it consumes power from the DC system supply via DC-DC converters and shall not have separate batteries.

## 4.3 PERFORMANCE

The battery chargers shall be robust, reliable and suitable for battery charging applications in power stations.

The valve-regulated type lead acid batteries shall be capable of sustaining short periods of intermittent heavy discharges and limited duration discharges until the prescribed end• voltage is reached.

The NiCd batteries shall be suitable for reliability and a service life of 30 years.

In order to ensure that the converter units are reliable, semiconductor devices, power transformers, chokes and other components forming part of the converter equipment shall be suitable for the particular application with respect to their rated voltages, rated currents, temperature rise, and service life.

## 4.4 TECHNICAL REQUIREMENTS

Battery chargers shall be self-regulating, solid-state, silicon controlled, full wave rectifier type suitable for parallel operation. If automatic load sharing operation is specified, the features of the battery chargers shall include cross compensation providing for equal sharing of the charger loads.

The battery charger(s) shall maintain output voltage within plus or minus 1% from no load to full load with an input power supply deviation in voltage level as specified and an input power supply deviation in frequency of plus or minus 5%.

Solid-state electronic circuits shall have ac and de transient voltage protection and shall be designed to recharge a totally discharged battery without overloading and without interrupting operation of ac or de circuit breakers.

There shall be charge mode indications and alarms with all alarms locally displayed, and potential free change-over contacts wired to terminals for remote indication.

The batteries shall support their associated switchboard duty cycle loading during loss of AC power for the full duration requiring safe shutdown of the connected system. During the duty cycle, the batteries shall continue to supply the required load until the end of their duty cycle. Upon supply from either emergency diesel generator power, or normal ac power, the batteries shall start to recharge.

The battery stands shall be positioned so that the positive and negative cell pillars of the battery are nearest to a wall or cable entry opening provided that a safe distance is maintained between the stand and wall or opening. Each pole of a battery shall be provided with a cable terminating device mounted on the wall or stand nearest to its cell pillar. If a wall mounted terminating device is used, the conductor shall have a solid copper section.

Converters shall be connected to a DC supply source and the output from the converter shall be connected to a load busbar off which the critical load is fed. The converter shall produce a constant voltage level.

Each converter unit shall make provisions for dedicated local and remote alarms with electronic monitoring and shut-down of a converter configuration or any part of it under fault conditions.

The Contractor shall design plant battery systems suitable for supplying to all the auxiliaries DC essential loads for the safe coast-down/run-down of the plant in the event of the loss of the plant AC supply.

### 4.5 MAINTAINABILITY

Battery stands with a total height of a single tier stand plus battery shall be limited to provide ease of maintenance. There shall be an acceptable clearance between the lower struts and the floor shall to enable easy cleaning.

### 4.6 OPERABILITY

The battery chargers simultaneously charge their associated batteries and supply power to both their associated switchboard loads and their redundant (adjacent) switchboard loads.

The minimum acceptable level of reliability in the electrical system is that the batteries should meet the full operational requirements of a safe shutdown of the unit in the event of a total loss of AC supply. This shall be supported by automatically switching to emergency diesel generator supplies.

The converter shall maintain the output to the load without any disturbance exceeding the specified tolerances appearing on the converter output. The battery shall be continuously connected to the DC bus and not only connected when there is an AC input power failure. The converter shall automatically compensate for the fluctuation in DC voltage to keep its DC output within the required limits. The converter shall automatically switch off when the input voltage is outside the limits.

When the AC input power returns to within the tolerances specified, the rectifier shall automatically recharge the battery while at the same time providing full power to the converter for conversion into the DC load supply. This shall occur whether the return of the AC input power occurs before or after the battery voltage has reached the rated end-point discharge level. If it occurs before this point the converter shall continue supplying the load power without disturbance. If it occurs after this time the converter shall automatically switch on again and resume supply to the load.

If the converter should fail, it shall automatically shut-down. It shall be possible to isolate the faulty converter for repair. Upon reconnection of its output, the converter shall resume normal duty supply. Back feed of current into the output of a converter that has shut-down shall not be possible.

## 4.7 APPLICABLE STANDARDS

- IEC 61056
- IEC 61951
- IEC 60146

# 5 EMERGENCY DIESEL GENERATOR

## 5.1 SYSTEM IDENTIFICATION

- System Name Emergency Diesel Generator
- KKS Code BRV

## 5.2 CONSTRAINTS AND ASSUMPTIONS

The diesel generator provides emergency power supply during power grid instability and can also supply emergency power for unit shut down.

The unit shall have an independent emergency diesel generator and emergency power system.

## 5.3 PERFORMANCE

The starting period of the generating set from either automatic or manual switching until the taking over of the generating set of load of at least 50% of its rated output shall not exceed 15 seconds.

## 5.4 TECHNICAL REQUIREMENTS

The diesel generator set shall consist of a diesel engine directly coupled to a generator and shall have a unit control panel. The equipment shall be mounted on a common steel base and housed in a weatherproof acoustical enclosure. The unit shall be furnished with all auxiliary equipment required to locally operate it. All transformers, motor starters, and electrical control equipment required for operation of the unit shall be furnished and mounted within the confines of the steel base.

The unit shall be capable of being started, synchronized to the system, and loaded to the full rating of the unit without dependence upon ac auxiliary power for a minimum of 5 minutes. The voltage and frequency variations shall remain within the code allowed tolerances.

A complete fuel supply system including a fuel oil day tank, valves and piping, and all fuel control devices shall be furnished. The day tank shall be sized to operate the diesel generator at full load for a minimum of 8 hours.

Loading and synchronizing of the diesel generator shall be Digital Synchronizer and Load Control (DSLC) module. The control system shall be designed for black start of the diesel generator.

Electrical control and metering equipment for the diesel generator shall be furnished, mounted, and wired on the unit control panel. If mounted on the diesel generator steel base, the local unit control panel shall be mounted with resilient mounts. The local unit control panel shall be completely enclosed at the front, rear, top, and both sides. A hinged front panel shall be provided to allow for maintenance of the controls and instruments. All operator interface command functions, except screen paging, shall be designed for two-step operation. The operator shall be required to make one touch screen action to select the function to be performed and a touch screen action to execute the function.

## 5.5 MAINTAINABILITY

The enclosure shall be provided with removable panels or doors to allow complete access to the engine and generator as well as auxiliary equipment located on the common skid.

## 5.6 OPERABILITY

The minimum acceptable level of reliability is that the diesel generator should meet the full operational requirements of a safe shutdown of the unit in the event of a total loss of AC supply.

## 5.7 APPLICABLE STANDARDS

- IEC 60034
- ISO 8528

# 6 BOTTOM ASH

## 6.1 SYSTEM IDENTIFICATION

- System Name Bottom Ash
- KKS Code

## 6.2 FUNCTION

The Bottom Ash System collects and removes bottom ash from the bottom of the Boiler furnace through the use of a submerged scraper conveyor (SSC). From the silo, the ash will be sold for beneficial uses or if sales are unavailable, deposited in the ash yard.

## 6.3 PROCESS DESCRIPTION

### 6.3.1 SUBMERGED SCRAPER CONVEYOR (SSC) SYSTEM

A process flow diagram of the Bottom Ash Handling System for each unit is shown in drawing 10-PM-PAY-08.

The Bottom Ash System will include the following major equipment and components:

- One submerged scraper conveyor (SSC) with rollout capability, outboard bearings, automatic lubrication system and chain washing system.
- One SSC diverting discharge chute
- One self-cleaning grizzly
- One SSC agitation water pump and piping.
- Two full capacity (one operating, one standby) SSC water recirculation pumps.
- Two full capacity (one operating, one standby) slurry/sludge return pumps.
- Two full capacity (one operating, one standby) heat exchangers.
- One recirculation system settling tank with integral surge tank.
- One storage silo for each boiler.
- Coal pulverizer rejects hoppers (one for each supplied coal pulverizer).
- Coal pulverizer rejects jet pumps (one for each rejects hopper), abrasion resistant piping, fittings and valves.
- Two full capacity (one operating, one standby) pyrites sluice water supply pumps.
- Economizer ash hopper isolation gates, automatic gates and expansion joints (one for each supplied ash collection hopper).
- Mechanical sealing arrangement.
- Bottom ash storage silo
- Telescoping discharge chute
- Redundant ash conditioners

A mechanical system for collection, removal, dewatering and transport of bottom ash will be provided.

Bottom ash produced in the steam generator furnace will fall into the water-filled upper trough of the SSC. Boiler seal plates, which extend below the SSC upper trough water level, will provide a pressure seal for the boiler. Bottom ash in the upper trough of the SSC will be conveyed up a dewatering slope by the SSC and discharged on to a belt conveyor via a clinker grinder which conveys the material to the bottom ash storage silo. Means for emergency dumping ash on the ground will be available at the discharge of the SSC.

The primary ash disposal method will be dry discharge to ash transport trucks for offsite beneficial use or transport to the ash yard.

Water in the SSC upper trough will be maintained at a temperature of 60°C or below. Water for controlling temperature and level in the SSC will be provided by one of two 100% capacity water recirculation pumps. The cooling system will be of a closed loop design. Water overflowing the SSC will be collected in a settling/surge tank. The SSC water recirculation pumps will pump the hot overflow water through one of two 100% capacity heat exchangers before directing the water back to the upper trough of the SSC. The heat exchangers will be designed to use closed cooling water as the cooling fluid. To account for system water losses (due to evaporation, water retained in the ash, or system leaks), a service water makeup primary connection will be provided at the settling/surge tank with a secondary connection to the upper trough of the SSC.

Sludge that collects in the settling/surge tank will be periodically pumped to the upper trough of the SSC via redundant sludge return pumps.

Piping and spray nozzles for water to clean the chains before contact with the drive sprockets will be provided.

Continuous removal of ash from the hoppers will prevent sintering of ash in the hot gas stream which could result in a hopper plug. The system will consist of collection conveyors and a transfer conveyor. Collection conveyors will dump onto the transfer conveyor. The transfer conveyor will transport the material through a water seal box to the upper trough of the SSC.

The SSC will be equipped with a rollout feature which will enable boiler and conveyor access during boiler outages or SSC repairs.

Two methods will be provided to discharge the ash from the bottom ash silo, a motor-operated telescoping discharge chute and ash conditioners. One dry telescoping bottom ash load out station will be provided as the primary means of saleable ash unloading from the silo. The spout will consist of silo isolation gates, ash metering valves, telescopic chute assemblies, vent fan, vent return valves, piping and pendant control accessories.

Ash conditioning equipment will be provided as a secondary means of unloading non-saleable ash from the silo. Two ash conditioners (one operating, one standby) will be provided on the unloading floor under the silo. Manual and air cylinder operated gates will be provided to isolate the unloading equipment from the silo. An ash metering device (either automatic valve with positioner and feedback loop or rotary vane feeder) will control the flow of bottom ash into the conditioner. Service water will be used for conditioning the bottom ash. A pressure regulating valve and flow meter will be provided to control the flow of water into the conditioner. The conditioners will discharge via a lined chute and skirt on open bed truck for transport to the ash yard.

## 6.4 BASIS FOR DESIGN

### 6.4.1 SIZING CRITERIA

- The speed and resultant conveying capacity of the SSC will be designed with an adjustable speed adjustment drive which will provide for continuous removal under minimum and maximum load conditions, as well as for intermittent removal and backlog recovery under minimum and maximum load conditions. The maximum chain speed of the conveyor shall not exceed 2.5 m/min.
- The submerged scraper conveyor will also be designed with sufficient capacity to continuously remove all of the bottom ash plus an additional 20 percent margin, when operating at BMCR condition and burning fuel (from the selected design fuels) which results in the worst case (maximum) ash production.
- The SSC wear surfaces shall be lined with Abrasion Resistant plate and the SSC hardened steel drag chain shall have a Brinell hardness number of at least 710.
- The return trough of the SSC will be an arrangement to reduce scraper wear and resistance.
- Submerged scraper conveyors will be designed so that the spilling of hot water or the ejection of the steam cannot endanger personnel.
- The SSC will be designed with sufficient capacity to permit complete backlog recovery within 4 hours of operation, following an 8 hour conveyor shut down, while the boiler is operating at BMCR conditions and burning fuel (from the selected design fuels) which results in the worst case (maximum) ash production. Facilities will be provided for an automated closed loop water agitation process for backlog recovery conditions and start ups. Agitation will be controlled by pressure on the hydraulic drives. The capacity of the upper water trough will be adequate to contain the displaced water volume during the backlog storage (i.e. no water shall overflow during this operation).
- The SSC will be retractable during boiler outages or when emergency repair to the SSC is required. The height attained by the ash in the hopper will not impede the removal of the SSC after a controlled shutdown of the boiler, commenced after the three (3) hour backlog period has expired.
- All sprocket wheel bearings will be split type roller bearings suitably sized for an operating life without maintenance of 100,000 hours. Outboard bearing arrangements for all sprocket shafts will be provided. An automatic lubrication system shall be provided for all outboard bearings on the SSC.
- The hydraulic drive unit will enable speed adjustment which will be infinitely variable from zero and maximum. The reduction gear connected by a flexible coupling will have an integrated overload trip to de-energize the motion in the event of any blockage to prevent overload damage to the drag link system and drive unit.

- The tension take-up sprocket wheels will be located outside of the water filled hopper. A hydraulic chain tensioning device will be used to tension the chain and will not drift after tensioning of the chain. A mechanical or hydraulic position-locking device will ensure that drift does not occur.
- Facilities for chain washing will be provided on the dewatering slope.
- The SSC will be designed for a design life of 200,000 hours.
- The bin vent filter shall have a minimum efficiency of 99 percent.
- The bottom ash silo will be sized to store 40 hours of bottom ash, economizer ash and pyrites produced by the boiler when operating at BMCR condition and burning the worst case fuel or 100m3 effective storage capacity whichever is larger.

# 7 FLY ASH

## 7.1 SYSTEM IDENTIFICATION

- System Name Fly Ash
- KKS Code

## 7.2 FUNCTION

The Fly Ash Handling System removes fly ash from air heater and electro slag precipitator (ESP) hoppers and transfers it to the fly ash storage silo via a dense-phase pneumatic pressure conveying system. Ash from the silo will be either dry loaded into closed ash hauling (pneumatic) trucks via a vented telescoping spout for disposal in the ash yard or the wet type unloading device makes the dry ash into ash wetting then to be transported outward by wetted dust dumper to ash yard.

## 7.3 PROCESS DESCRIPTION

A process flow diagram of the Fly Ash Handling System is shown on drawing 10-PM-PAY-09.

The Fly Ash Handling System will include the following major equipment and components:

- Three (3) fly ash transport compressor assemblies (two operating, one standby).
- Conveying pipe, fittings, and valves. All fly ash transport straight pipes shall be carbon steel. All elbows and all the pipes after the last elbows into the fly ash silo shall be lined internally using the fused cast basalt material to prevent erosion.
- Compressor air pipe, fittings, and valves.
- Airlock vessel assemblies under each ash collection hopper.
- ESP fluidizing system including fluidizer assemblies, fluidizing blowers, heaters, and weld-in nozzles for installation on the ESP hoppers
- Fly Ash Storage Silo
- Fly Ash Storage Silo fluidizing system, including two full capacity fluidizing air blowers, heating system, valves and all required in-line devices.
- Fly Ash Storage Silo dry unloading system, complete with telescopic chute, vent fan, feed and vent piping, valves and control accessories.
- Fly Ash Storage Silo ash conditioning system, complete with two pugmill type unloaders (one operating; one standby), ash and water metering devices, isolation valves, instrumentation and control accessories.
- Silo accessories including bin vents, instrumentation, and pressure vacuum relief hatches.

### 7.3.1 PNEUMATIC CONVEYING SYSTEM

The positive pressure pneumatic conveying system is preferred for the fly ash delivery system of this project, which is briefly described below:

An ash transporting and storage pump is installed under each economizer hopper and electric precipitator ash hopper of each boiler. The storage pump has the necessary instruments such as pneumatic feed valve, air inlet component, air inlet control mechanism, charge level indicator and pressure transmitter. The manual slide plate gate is equipped between the ash hopper outlet and the inlet valve of the storage pump for storage pump repair. In order to improve the ash flow in the ash hopper, a set of electric precipitator ash hopper fluidizing blower is equipped, which includes fluidizing blower, electric heater, fluidizing plate, etc. The fluidizing blower is arranged in the compressor room. A coarse ash delivery pipe is equipped for economizer and No. 1 and No. 2 electric fields of the electric precipitator of each boiler to deliver the fly ash to the coarse ash silo for storage; a fine ash delivery pipe is shared by the fly ash of the storage pump under the ash buckets of No. 3 and No. 4 electric fields to deliver the ash to the fine ash silo. And meanwhile, the pneumatic pipe changeover valve is equipped at the ash delivery pipe at the top of the ash silo, through which, the coarse ash in the coarse ash delivery pipe could be changed over to any coarse ash silo or the fine ash in the fine ash delivery pipe could be changed over between the coarse and fine ash silos.

### 7.3.2 FLY ASH STORAGE SILO

The fly ash storage system is planned temporarily to include three reinforced concrete structure ash silos with the storage capacity of $1000m^3$, two for coarse ash and one for fine ash, each of which has the effective storage capacity of $800m^3$. The two coarse ash silos could contain the ash discharge of the design coal combustion for 48 hours of the two boilers at the working condition of BMCR. A pressure vacuum relief valve and a pulse bag filter are equipped at the top of each ash silo, the air delivering the ash discharged directly into the atmosphere after filtration in the pulse bag filter. Each ash silo has one continuous level indicator, one low level indicator and one high level indicator. The ash silo is equipped with the areation system, which includes the devices and accessories such as ash silo fluidizing blower, electric air heater, fluidizing groove at the bottom of the ash silo. The hot air supplied by the fluidizing blower and electric heater enters the fluidizing groove and fluidize the ash in the silo to improve the ash flow for easy discharge. Two discharge outlets, one set of dry ash unloading device with the output of 100t/h and one set of wet type unloading device with the output of 100t/h are equipped at the bottom of each ash silo. The dry ash unloading device is used for the dry ash tank car to load and transport outward the dry ash for comprehensive utilization; the wet type unloading device makes the dry ash into ash wetting then to be transported outward by wetted dust dumper for comprehensive utilization or to the ash yard for storage.

Ash conditioning equipment will be provided as a secondary means of unloading non-saleable ash from the silo. Two ash conditioners (one operating, one standby) will be provided on the unloading floor under the silo. Manual and air cylinder operated gates will be provided to isolate the unloading equipment from the silo. An ash metering device (either automatic valve with positioner and feedback loop or rotary vane feeder) will control the flow of bottom ash into the conditioner. Service water will be used for conditioning the fly ash. A pressure regulating valve and flow meter will be provided to control the flow of water into the conditioner. The conditioners will discharge via a lined chute and skirt to open bed truck for transport to ash pond.

## 7.4 BASIS FOR DESIGN

### 7.4.1 SIZING CRITERIA

- The ESP hoppers will provide for the storage of eight (8) hours of ash production and will be equipped with hopper heaters and insulation.
- The design capacity of the system will be based on a minimum of 200 percent of the maximum ash collection rate at each hopper.
- Small quantities of air from the pressure vessels below the ESP hoppers will be vented back into the hoppers through abrasion resistant vent lines
- Fabric filter hopper elevation will provide a minimum clearance of 4 meters to the bottom of the ash transport pipe.
- The ash from each boiler unit will be pneumatically conveyed to a fly ash storage silo. Each fly ash storage silo will have a storage capacity of $1000m^3$. The system will be designed to convey the ash to the silos in a reliable and efficient manner. Equipment sizing and material velocities must be selected to minimize material wear and turbulence in the conveying system.
- The conveying lines will be piped so fly ash from either unit ESP can be conveyed into either silo to provide operational backup during periods of silo maintenance. Bin vents will be sized to handle conveying air from both unit conveying systems simultaneously in addition to the airflows noted below.
- The silo venting system will accommodate all volumes of conveying air plus that used for silo fluidization. The filter inlet from the silo and dust return to the silo will be positioned far enough apart to minimize any dust re-entrainment.
- All maintenance parts subject to abrasion and/or in contact with the fly ash will be designed to minimize wear in order to achieve a service life of at least five years continuous operation.
- If the noise expected from the operating exhauster is predicted to exceed 85 dBA additional measures shall be provided to reduce noise to this level.
- The plant will be of weatherproof construction, suitable for outdoors operation in climatic conditions prevailing at site, without undue maintenance and deterioration.
- Equipment in the entire plant i.e. mechanical, electrical, control and instrumentation, etc. will be designed to be cleaned by water washing at a pressure of up to 10 bar, without impairing the performance of any component. All components shall be designed for operation in a dusty environment.
- The ash conditioners will include all necessary equipment to minimize internal solids build-up and provide a homogeneous mixture of material at the discharge.
- The bin vent filter shall have a minimum efficiency of 99 percent.

# 8 STATION AIR

## 8.1 SYSTEM IDENTIFICATION

- System Name Station Air
- KKS Code QC

## 8.2 FUNCTION

The Station Air System supplies compressed air for the following simultaneous uses as a minimum. Some of these loads will be intermittent

- Flame scanner cooling air
- Burner fuel oil (ignitor) atomization
- Air heater
- Boiler building (distribution system on each floor)
- FGD area
- ESP area
- Steam turbine building (distribution system on each floor)
- Circulating water pump area
- Warehouse
- Water treatment plant and Wastewater treatment plant.

## 8.3 PROCESS DESCRIPTION

A process flow diagram of the Station Air System is shown on drawing 10-PM-PAY16.

The Station Air System will serve the entire station to the above mention system and will supply compressed air to the Control Air System as a back-up. The station air system shall be located in a common compressor house and will consist of the following major equipment:

- Electric motor driven centrifugal air compressors. Quantity as required by detail design and shall comply with redundancy requirement
- Station air receivers.

Additional station air receivers may be required for intermittent high demand users in remote areas. Consideration will be given to smaller individual systems installed in outlying areas instead of installing a long header from the power block area if the usage rate is relatively small.

Compressed air from the air compressors will be cooled by passing through an after cooler and moisture separator before entering the station air receiver tanks. Air will then be filtered and dried by refrigerant type dryers.

The Station Air System header in the compressor house shall be provided with a valved connection for a portable air compressor to be connected for temporary use during initial startup or maintenance.

A station air header shall be provided around the turbine areas with hose connections located on the ground floor, mezzanine level, turbine deck, and other equipment areas for maintenance. Station air headers shall also be provided in the Boiler Buildings, Air Quality Control System (AQCS) areas, workshops, water treatment plant, and wastewater treatment plant with risers and connections at each floor elevation and supply piping distributed around each floor to convenient connection locations.

The Compressed air supply for the ESP and fly ash transport shall be provided by a separate system from the Station Air System.

## 8.4 BASIS FOR DESIGN

The station air compressors shall be oil free, water cooled design and shall use the closed cooling water system as the cooling water source. The quantity of station air compressors shall be determined during detail design and shall include at least two spare air compressors. All air compressors shall be of the same design and capacity.

Each station air receiver shall be a shop fabricated, carbon steel, vertical, cylindrical vessel designed and constructed in accordance with ASME Codes. Each receiver shall be equipped with a relief valve for overpressure protection and an automatic trap for removal of condensate.

The station air dryers shall be refrigerant type dryers.

Station air supply headers shall be carbon steel. Miscellaneous air supply piping from air supply headers to services requiring clean air (including air heater drive motors, thermoprobe cooling, etc.) shall be carbon steel with air filter devices installed at each clean air user. Isolation valves shall be provided at each structure and at each elevation within the structure to allow a part of the system to be isolated for maintenance while the rest of the system remains in service. Isolation valves shall also be provided in the distribution headers in any given area to allow part of the system to be taken out of service while the balance of the system continues to operate. Isolation valves shall be provided at each station air user.

The system shall be design such that it is possible to isolate any piece of equipment from the system while the balance of the equipment remains in service.

# 9 CONTROL AIR

## 9.1 SYSTEM IDENTIFICATION

- System Name Control Air
- KKS Code QF

## 9.2 FUNCTION

The Control Air System will supply clean, dry, oil free air at adequate pressure and capacity for transmitters, instruments and other users requiring control quality air supply.

## 9.3 PROCESS DESCRIPTION

A process flow diagram of the Control Air System is shown on drawing 10-PM-PAY16.

The Control Air System consists of a plant piping system, which delivers clean, dried, oil free, compressed air to instruments and transmitters which require a control air supply.

The Control Air System will include the following major components and will serve the entire station. Set of compressors will provide compressed air for control air equipment and will consist of the following major equipment:

- Electric motor driven centrifugal air compressors. Quantity as required by detail design and shall comply with redundancy requirement
- Control air receivers.
- Dual tower heatless type desiccant air dryers, with coalescing pre.-filters and after filters.
- Additional control air receivers for high demand intermittent users, as determined during detailed design.

Compressed air will be piped to the control air receivers and then to the inlet of the air dryers and discharged to the supply piping distribution system.

Control air shall be provided to the following areas as a minimum:

- Coal yard area/conveyors
- FGD area
- FD and PA fan area
- ID fan area
- ESP Area
- Boiler building (distribution system on each floor)
- Steam turbine building (distribution system on each floor)
- Condensate polishing area
- Water treatment area
- Wastewater treatment area

- Electrochlorination Building

Consideration will be given to smaller individual systems installed in outlying areas instead of installing a long header from the power block area if the usage rate is relatively small. The use of smaller individual systems will be determined during detailed design.

## 9.4 BASIS FOR DESIGN

The control air equipment shall be located in a common compressor house with the station air equipment. A back-up compressed air to Control Air system from Station Air system shall be provided upstream of control air dryers. Back up maybe provided via a common header. Each control air receiver shall be a shop fabricated, carbon steel, vertical, cylindrical vessel designed and constructed in accordance with ASME Codes. Each receiver shall be equipped with a relief valve for overpressure protection and an automatic trap for removal of condensate.

The desiccant air dryers shall dry control air to a pressure dew point, as measured at the dryer outlet, of at least -40°C in accordance with ANSI/ISA - 7.0.01 (1996). The desiccant air dryers shall be automatically controlled. Desiccant air dryers shall be dual tower, heatless, fully automatic reactivation cycle type. Each dryer will have two absorbing desiccant towers which will alternate, one in service while the other is reactivating, to provide sufficient capacity of dried air, based on the volume of air entering under the service conditions specified. Two full capacity parallel coalescing prefilters and after filters shall be furnished with each air dryer.

Control air supply headers shall be stainless steel pipe. Miscellaneous air supply piping or tubing from air supply headers to users shall be copper pipe, stainless steel pipe, or stainless steel tubing. Tubing connections to individual users shall be stainless steel only. Piping upstream of the desiccant air dryers shall be carbon steel. Isolation valves shall be provided at each structure and at each elevation within the structure to allow a part of the system to be isolated for maintenance while the rest of the system remains in service. Isolation valves shall also be provided in the distribution headers in any given area to allow part of the system to be taken out of service while the balance of the system continues to operate. Isolation valves shall be provided at each control air user.

The system shall be design such that it is possible to isolate any piece of equipment from the system while the balance of the equipment remains in service.

# 10 CHIMNEY

## 10.1 SYSTEM IDENTIFICATION

- System Name Chimney
- KKS Code HN

## 10.2 FUNCTION

The function of the Chimney is to discharge combustion gas to the atmosphere at a sufficient elevation to provide adequate dispersion as required by the air permit.

## 10.3 DESCRIPTION

The Chimney will consist of a reinforced concrete outer shell surrounding, protecting, and supporting inner flue carrying flue gas for atmospheric dispersal. It consists of the following major components:

- Foundation and piles.
- Reinforced concrete outer shell.
- Two (2) steel inner flue.
- Corrosion Resistant Liner.
- Insulation.
- Aviation obstruction lighting.
- Lightning protection.
- Access-Provide means of ingress and egress and allow for access to the contained systems through doors, elevator, ladders, and platforms.

One chimney shall be provided for 2 boilers. It shall be founded on a reinforced concrete foundation supported on piles. The gas path shall consist of a carbon steel inner flue with borosilicate glass block or a lining material more superior than borosilicate for the purpose intended and the external surface be suitably insulated, if necessary.

An expansion joint shall separate the upstream ductwork from the breeching penetrating the shell. The base of inner flue shall be elevated to match the ductwork elevation. A barrel concrete shell will surround and support the inner flue. The concrete shell shall be designed to carry all exterior loads as well as supporting the inner flues and breechings for this unit.

The Chimney shall be provided with aviation obstruction lighting in accordance with local aviation requirements and protection lightning. The concrete shell shall contain a construction opening and a personnel door. Interior steel and grating platforms shall be provided near the midpoint and at the top of the chimney for access and operation of continuous emissions monitoring equipment and service of obstruction lighting. A ladder and rack-and-pinion vertical lift service car shall be provided for access to the platforms. The base of inner flue shall contain a drain and a piping system leading to a drain in the Chimney foundation for removal of collected rainwater to the plant wastewater system. Inner flue will contain an ash cleanout port at its base.

To meet the requirement of one boiler working and the other for chimney and desulfuration flue repair and maintenance, a reinforced concrete outer cylinder with double cylinder with steel inner casing is advised to be shared by the two boilers of the project, the steel inner core of chimney of φ7.2m in (min) diameter and (min) 275m in height. However, the Bidder to meet the local environmental norms.

As the chimney uses wet desulfurization process and does not operate under GGH, the discharged flue gas is strongly corrosive. The internal cylinder is suggested to use Pennguard block lining system to resistant corrosion of flue gas.

This project has desulfurization bypass for the flue gas. When the desulfurization system breaks down, the flue gas is discharged directly through the chimney but not the absorption tower.

# 11 INDUCED DRAFT

## 11.1 SYSTEM IDENTIFICATION

- System Name Induced Draft
- KKS HN

## 11.2 FUNCTION

The Induced Draft System in conjunction with the Boiler System provides the static pressure required to induce the flow of combustion gases from the Boiler furnace through the ESP and Flue Gas Desulfurization System (FGD) to the chimney. The system will include the capability of controlling the flue gas flow rate to maintain furnace draft over the load range. The system operates and is controlled in conjunction with the boiler combustion air system.

## 11.3 PROCESS DESCRIPTION

A process flow diagram of the Induced Draft System is shown in drawing 10-PM-PAY-05.

The Induced Draft System will include the following major equipment and components for each unit:

- Two 50 percent capacity induced draft (ID) Radial fans with motors, each complete with:
  - One forced lubrication unit with integral oil/water cooler and fan.
- Two ID fan inlet and two outlet tandem louver isolation dampers and drives.
- Two 50 percent capacity booster ID axial flow fans (if required) with motors,
  - each complete with:
  - One forced lubrication unit with integral oil/water cooler and fan.
  - One hydraulic oil fan blade pitch control unit with integral oil/water
  - cooler and fan.
- Two FGD inlet and outlet tandem louver isolation dampers and drives. FGD bypass tandem louver dampers and pneumatic operator.
- Damper seal air fans with drives.
- Associated ductwork and expansion joints.
- Associated piping, valves, instruments, controls, and accessories.

The Chimney, ESP and FGD systems are detailed in separate system definitions for the Chimney; Particulate Removal ; and Flue Gas Desulfurization.

Combustion flue gas will flow from the boiler air heaters through the ESP to the inlet duct of each ID fan. Each Induced Draft fan will exhaust into a Booster fan (if required) and then to the FGD systems and then will rejoin at a common header to the stack. FGD bypass ductwork and bypass damper will be installed in case of an emergency. The flue gas can go to the stack directly through FGD bypass. ductwork. The ID fans/booster fans are also used in Boiler and ductwork purging cycle prior to firing fuel in the furnace or after the steam generator shut down.

These radial fans shall have damper control that will be used for exhaust gas flow control over the unit operating load range. Each of these fans will be designed for direct connection to a single speed motor. The control system will control the fans to maintain the furnace pressure at a predetermined value.

Leak proof expansion joints shall be provided in the ductwork where required to accommodate movements due to thermal expansion and contraction. Inlet and outlet isolation dampers and a forced lubrication oil unit shall be provided with each ID fan and each booster fan. The ID fan and booster fan sound level shall be attenuated by the use of insulation and lagging of the ID fan casings.

## 11.4 BASIS FOR DESIGN

The Induced Draft System shall be designed and constructed in accordance with NFPA Codes and Standards, ASME Codes and Standards.

The tandem louver isolation dampers on each ID Fan inlet and outlet and each booster fan inlet and outlet shall be provided with a seal air system to prevent flue gas leakage.

The continuous design pressure ratings of the ductwork and equipment flue gas path pressure boundaries shall be no less than the equipment operating pressures during unit full load operation with fans operating at the test block flow and pressure conditions. All ducting shall be designed in accordance with the requirements of NFPA 85 and designed to withstand a transient pressure of not less than a) 1.5 times static head in the relevant section (positive/negative as applicable) at maximum fan operating conditions, or b) maximum transient pressure resulting from failure analysis of combustion system in the relevant section (positive/negative as applicable), whichever is the larger. Component stress levels during operation at the transient design operating pressure shall not exceed 95 percent of the material yield strength.

ID fans and booster fans shall be capable of continuous operation at Boiler MCR (BMCR) while firing any fuel within the range of specified fuels. The fans shall have a 40% margin on BMCR flow rate including a 14°C temperature margin and 50% margin on pressure.

The ductwork shall be gastight and composed of structural plate steel with stiffeners and circular pipe internal bracing. All ducts shall be insulated and lagged for personnel protection, corrosion control and to reduce sound levels from the ductwork.

Connections shall be provided on the ductwork into and out of each air heater and from each fabric filter for sampling and testing of the flue gas.

During a severe transient event, such as loss of fuel, the system shall respond to the commands from the DCS to minimize the negative furnace pressure transient.

# 12 COAL RECEIVING AND STOCK OUT

## 12.1 SYSTEM IDENTIFICATION

- System Name Coal Receiving and Stock Out
- KKS Code EA

## 12.2 FUNCTION

The function of the Coal Receiving and Stockout System is to receive coal from the three Transfer Tower and transport it to the coal yard via a fully redundant belt conveyor system.

Traveling stacker/reclaimers will stack the unloaded coal into piles in the three enclosed round coal storage yard. The same machines will reclaim the coal from coal storage piles and deliver it via yard belt conveyors to the collecting conveyors.

After receiving the coal in the coal yard, the stockout equipment will prepare three live stock coal yard for 40 days requirement of 2x660MW.

The Coal Receiving and Stockout system will be designed so that coal from the ships can be stacked on the live stockpiles/emergency pile or can feed directly to the coal silos located in the boiler houses.

## 12.3 PROCESS DESCRIPTION

A process flow diagram of the Coal Handling System is shown on drawing 10-PM-PAY-19

The Coal Receiving and Stockout System will include the following major equipment and components:

- Three stacker/reclaimers (S/Rs)
- Three transfer towers
- conveyors

The coal will be unloaded from bulk carriers by the ship unloaders. The ship unloaders and unloading system shall be capable of unloading all typical bulk vessels/ barges with capacities between 2000 and 8000 DWT.

The ship unloaders are travelling along a set of rails, with a rail gauge of 20 meters, mounted on top of the wharf. The unloaders transfer the unloaded coal by means of shuttle belt feeders onto two dock conveyors. Each dock conveyor has a capacity of 1750 t/h, sufficient to handle the combined cream digging rate of the ship unloaders. The dock conveyors' lengths provide sufficient ship unloaders travel to unload two vessels, berthed bow to stern along the pier.

Before the coal is transported to Tower T1 on the dock conveyors, all ferrous materials will be removed by magnetic separators, then the coal is scanned by Metal Detectors for non-ferrous materials, weighed by commercial accuracy belt scales, and then sampled by a sampling system.

The coal will be transferred in T-1 from the two dock conveyors to a redundant system of conveyors. The conveyors will transfer the unloaded coal to the connecting conveyors in T-2 on land. From T-2 the coal is moved by connecting conveyors to T-3

The connecting conveyors and all receiving downstream conveyors will be sized for 1750 t/h capacity, able to handle the combined cream digging rate of the existing ship unloaders.

Elevated belt conveyors C-2A/B along with other elevated belt conveyors and transfer tower(s) will be transferring the coal to the first junction at the coal yard, T-3.

Distribution conveyors C-3A/B will move the coal to Transfer Tower T-3. Here, as part of the main plant operation, the coal may be directed by means of two- position diverter gates to transfer conveyor C-4A, 4B and 4C, which supplies the coal to stacker/reclaimer.

During normal operation one of the set of belt conveyors will receive coal from one of the existing coal unloading jetty conveyors and deliver it to all stacker/reclaimers in the coal yard. The coal may also bypass the stacker/reclaimers to be delivered directly to the boiler coal storage silos.

Normal operation will be to deliver the coal to the stacker/reclaimer for distribution to the live stockpile. The stacker/reclaimer will reclaim the coal from the live stockpile and deliver it to the boiler storage silos.

An emergency stockout pile is provided to allow the ship unloading to continue in the event the stacker/reclaimers are out of service or by-passing coal to the boiler storage silos is not permissible.

## 12.4 BASIS FOR DESIGN

Redundant belt conveyors shall be provided from the interface point to the coal yard transfer towers.

All belt conveyors to be in enclosed galleries except conveyor between T1 and T2. Emergency stacking conveyor and receiving conveyor shall be of the 3/4 type cover, allowing operators to observe conditions along the conveyor from the walkway, but protecting the conveyor belt area from rain. A full floor, checkered plate, shall be installed under the receiving conveyors to collect the coal dust. By using besom, the coal spillage material can be pushed towards the collection chute located at every 30~40 meters to dump all spillover dust to the bins, further manual removal of the ground spillage may be required. A vacuum cleaning method is also provided: the vacuum cleaning flexible hoses with a length of about 15 meters are to be installed every 30 meters where a fixed pipe will be installed with one end connecting to the hose and the other end located close to the ground level with a quick release connection for connecting to the vacuum vehicle (provided by the

Contractor). The routine vacuum cleaning can be performed typically once a week, depending on the operating conditions. Drainage of rain water shall be provided for.

The coal yard shall have a 40 day storage capacity at BMCR conditions for two unit when burning the design basis coal. The balance of the coal yard storage capacity can be made up of inactive piles developed by mobile equipment.

The S/Rs shall be controlled by an operator during the operations with certain functions of machines controlled by a Programmable Logic Controller (PLC) located on each unit.

Coal can be delivered from the ship directly to the coal yard stockpile, or boiler storage silos.

It shall be possible to unload a ship and send the coal to one stacker/reclaimer while the other stacker/reclaimer is reclaiming coal from another pile for distribution to the boiler storage silos.

# 13 DCS

## 13.1 SYSTEM IDENTIFICATION

- System Name Distributed Control System
- KKS Code CR

## 13.2 FUNCTION

The Distributed Control System (DCS) will provide the means to manually and automatically control all the plant equipment both individually and as a coordinated system within the project scope. It will perform the following functions of, among others;

- monitoring
- indicating alarms
- protection and interlock
- performance monitoring
- historical data archiving
- data trending
- GPS clock synchronization
- diagnostics etc

The DCS will facilitate the functional, operational reliable, safe and consistent control over all the plant equipment and processes, at each and every level.

The DCS will facilitate the Plant Information System (PIS) for the overall plant.

The operator interface to the unit and Balance of Plant (BOP) equipment and process control and information will be either directly or indirectly through the DCS workstations, installed on control consoles located in the main plant Central Control Room (CCR).

The DCS will include the following major components:

- Input/Output (I/O) modules.
- Redundant logic processors.
- Redundant DCS processor and I/O module power supplies.
- Redundant system communications modules and switches.
- I/O module, logic processor and communications module processing cabinets.
- Operator consoles.
- Operator workstations.
- Supervisor workstations.
- Large overhead VDUs.
- Engineering workstation.
- Optimization software workstation.
- Plant Management System
- Historian server/workstation.

- Alarm, log and utility printers.
- Unit Protection.
- GPS Clock.
- Data highway backbone.

All specialized and/or specific equipment packages will be interfaced to the DCS for supervisory level control and monitoring, which is required for the dedicated control and monitoring functionality of the DCS.

Datalink communications are expected to be provided between the DCS and such sub-systems for the overall power plant control.

The following systems, among others, shall be controlled and monitored by the DCS;

- Steam Turbine and Auxiliary Control System (STG/EHC).
- Heating Ventilation and Air Conditioning system (HVAC).
- Compressed Air System (Station Air & Control Air systems)
- Ash Handling System.
- Water Treatment Plant.
- Electro-chlorination Plant.
- Wastewater Treatment Plant.
- Coal handling equipment.
- Continuous Emissions Monitoring System (CEMS).
- Condensate polishing system.
- ESP.

Hardwired interfaces are expected between the DCS and the following dedicated systems, among others:

- Steam Turbine Trip System (ETS).
- Diesel generator control and synchronization.
- Generator Protection System.
- Fire Protection and Detection System.

All remaining plant equipment and systems will not require being DCS controlled and monitored or will be operationally sufficient to be in manual mode.

The DCS system communication will consist of the following levels:

- Plant Information System LAN (PIS LAN),
- Plant Management System (PMS),
- Unit DCS Control Bus,
- IO Bus and external device interfaces.

The PIS LAN will be a dual data highway of the plant and be capable of incorporating all plant systems into one seamless system for information, maintenance and management.

The DCS real time control bus will be connected to the PIS through the DCS gateway. The plant information system brings all operational data into a single system that can deliver it to operators at all levels of the power plant. The system shall keep all the critical operating and information data online and available in a specialized time-series database so it can be recalled when required. The system shall be an independent system connected to DCS with security protection to avoid unauthorized usage. Communication shall be one way and shall not affect any of the DCS functions.

An integrated Plant Information System (PIS) shall be provided for the overall administration and maintenance of the plant. The system shall be provided with all necessary hardware, software, firmware and interfaces. The PIS shall provide information related to;

- Environmental information
- Operation information
- Equipment status

In addition, an OPC server shall be provided as a gateway for connection to the Owners data network. It shall access data points plant wide from the PIS using client/server technologies and shall provide capability to retrieve, display and store the information from the historian systems. The system shall be furnished with security protection to avoid unauthorized usage.

## 13.3 PROCESS DESCRIPTION

### 13.3.1 DCS DESCRIPTION

The main principle is to integrate the control of all systems into the DCS. All information from stand alone controllers shall be interfaced with the DCS.

The configuration of the DCS will take into account redundancy and functional distribution of I/O wherever a failure or loss of a component could cause a plant upset or loss of generation capacity in order to meet the power plant availability and reliability specifications. The DCS will utilize redundant control processors throughout its architecture and redundant I/O for critical measurements and all protection systems.

DCS equipment, with hardware configured as per the latest NFPA requirements, will be dedicated to the Burner Management System (BMS). The control logic will be configured in the standard programming language of the selected DCS vendor.

DCS I/O remote/distributed architecture is the preferred approach for implementing DCS I/O within the plant. These I/O cabinets/systems shall be located in protected and environmentally controlled areas of the plant in close proximity to the physical location of the plant equipment to be controlled and monitored.

All turbine instrumentation will be wired directly to the turbine control system for dedicated control, monitoring, and protection of the steam turbine generator. A redundant data link and hardwired interface will be provided between the turbine control system and the DCS for control and monitoring of the steam turbine generator via the DCS operator workstations in the CCR. Through these interfaces the DCS will also archive and provide steam turbine generator alarm signaling.

The DCS will be interfaced to other dedicated microprocessor based control systems via datalinks and/or other hardwired interfaces such that the DCS will have the capability to remotely monitor and provide supervisory level control for these dedicated microprocessor based systems.

The DCS will have the capability to trend process parameters, develop operating logs, and display sequence of event alarm logs when required. As part of the PIS, a redundant historian server will be included to allow retrieval of historic plant data and to develop specialized displays and reports of plant information. The operator graphics will be developed based upon plant systems to be controlled and displayed in a hierarchical format.

The DCS will be capable of handling its functions with minimal communication or processor lags. It is expected that the processor execution times will be less than 1 second for each processor pair. The time of build-up of VDU display including dynamic values and status shall not exceed 1 sec under all operating conditioned measured from initiating the display by the keyboard until completion the display on the VDU. The VDU display update rate shall not be more than one (1) second, under and all power plant conditions.

Scan time for closed loops (i.e. cycle time taken by controller to read and process the inputs, perform control calculations and update control outputs for all configured loops) and open loops (i.e. cycle time taken by controller to read and process the inputs and perform computation of all the configured loops) shall not be more than 500 milliseconds. However, the scan time should be configurable down to 200 milliseconds. Sequence of events (SOE) alarming will be provided with 1 millisecond resolution for critical parameters.

Each electrical gear lineup, MCCs, SUSs, and Switchgear, will be connected to the DCS via hardwired I/O or external/foreign device interfaces. For the medium voltage metal-clad switchgear and low voltage power centers, protective relay trip and relay block close functions will be hardwired.

### 13.3.2 HMI DESCRIPTION

The following is a typical HMI system description; the final detail design should take modern ergonomic design practice, the operator cognitive loading and the optimization of operating and maintenance processes into consideration.

Modular, ergonomically designed, sit down type operator consoles will be located in the main plant CCR. The CCR will have dedicated operator workstations for monitoring and control of Unit and balance of plant auxiliary system. The operator workstations will consist of six workstation processors, six keyboards, and six trackballs or mouse pointing devices. Each operator workstation shall have identical capabilities so that each shall be able to perform the tasks of any other operator workstation e.g. steam turbine control and boiler control. It is preferred to have STG/EHC control and monitoring system to be part of the main DCS workstation in CCR.

A four-panel multi-screen display on a high-visibility 4 x 50 inch Digital Light Processing (DLP) large-screen will be furnished to be part of control and monitoring system. The large displays will capable to provide overview, plant trend and alarm displays in the CCR.

Two engineering workstations will be furnished for the DCS, each having one VDU of the latest technology, one keyboard, and one trackball or mouse pointing device. Engineering workstations shall be capable of all operator workstation functions, and in addition shall be used for system programming, maintenance, troubleshooting, and other engineering functions such as performance calculations. The engineering workstations will be located in the Control Equipment Room with the control consoles.

One optimization software workstation shall be furnished for DCS comprising of one workstation processor, one VDU of the latest technology, one keyboard, and one trackball or mouse pointing device. The optimization software shall be capable of on-line performance and optimization calculation. The optimization software workstation will be located in the CCR with the control consoles.

Supervisory workstation with a printer will also be provided in the CCR. The workstation will consist of one workstation processor, one VDU of the latest technology, one keyboard, and one trackball or mouse pointing device. The supervisory workstation shall be capable of displaying any screen and carry out any operator or engineering operations, such as parameter settings changes, alarm acknowledgement, control mode selection, or operator control of equipment devices.

Redundant data historian servers and one historian workstation with a printer will be provided for plant historical data storage and report generation. The workstation will consist of one VDU, one keyboard, and one trackball or mouse pointing device. This equipment will be located in the Station Computer Room.

One plant information server (PIS) will be located in the Station Computer Room, which consists of one VDU of the latest technology, one keyboard, and one trackball or mouse pointing device. Five PMS clients workstation will be provided by the Contractor in the administration building.

The CCR will have four printers for the DCS. The CCR will have a black & white printer for purpose of printing logs and reports on demand, one black & white printer for purpose of printing alarm and two A3 sized color laser printers for printing of trends, charts and graphic. These A3 sized color printers also shall be able to print A4 size paper.

The DCS will communicate between processors and the operator workstations by means of redundant data highways.

### 13.3.3 UNIT PROTECTION SYSTEM

The unit protection system as part of the DCS will include redundant control processors, communication modules, I/O and master trip relays. Inputs to the unit protection logic will consist of dedicated hardwired field devices and dedicated I/O transmitted from DCS control processors. The unit protection logic will be set up as fail-safe in the event of the loss of a critical input or redundant processor pair and shall be designed in accordance with IEC 61508 and IEC 61511.

The unit protection system hardware and logic will be designed in accordance with National Fire Protection Association, NFPA 85 - Boiler and Combustion Systems Hazards Code.

### 13.3.4 BURNER MANAGEMENT SYSTEM

#### 13.3.4.1 PURGE INTERLOCKS

The purge interlock in the Burner Controls shall be designed in accordance with NFPA 85. The purge interlocks shall be designed to assure that all sources of fuel are positively interrupted, all air and gas passages capable of trapping fuel-air mixtures are open for ventilation, and that an adequate flow of ventilating air has been maintained in the gas and air passages for a sufficient period of time to assure complete removal of all combustible gases. Gas path equipment such as the regenerative air heaters should be operated during the purge period to assure ventilation of the complete flue gas and combustion air system. Coal pulverizers shall not be operated during this period.

#### 13.3.4.2 FUEL SAFETY INTERLOCK

This interlock is designed to interrupt the fuel supply under possibly hazardous conditions. The monitored operating conditions include those relating to fuel safety (e.g., excessive furnace pressure, partial loss of flame, and fuel pressure out of limits) and also those relating to plant operation (e.g., loss of air fan(s), loss of boiler control power, and loss of feedwater). These interlocks are part of the steam generator control in the distributed control system logic.

### 13.3.5 UNIT TRIP RELAY

Unit trip functions shall coordinate the trip of the boiler, turbine, auxiliary electric, and generator systems. The unit trip conditions will be monitored by triple redundant instrumentation and shall be designed in accordance with NFPA 85.

#### 13.3.5.1 TRIP SIGNALS IN THE 2-OUT-OF-3 TRIP GROUP

The trip signals in the 2-out-of-3 trip group include the following as a minimum:

- Igniter fuel pressure low.
- Furnace pressure high.

- Furnace pressure low.
- Deaerator level high.
- Air heater exit gas temperature high, trip after time delay.
- Secondary air duct pressure low.

#### 13.3.5.2 TRIP SIGNALS IN THE 2-OUT-OF-3 TRIP GROUP

Components in this group include the following as a minimum:

- Fuel safety supervisory system.
- Loss of all FD fans.
- Loss of all ID fans.
- Loss of all primary air fans (with any pulverizer running).
- Interruption of turbine steam flow after steam flow through turbine is established
- Output of 2-out-of-3 sensing systems.
- Turbine tripped.
- Generator lockout relays.
- Emergency trip push buttons.
- Loss of control system power and safety supervising system power.
- Furnace airflow low.
- AQCS system trip
- Loss of unit protection.

#### 13.3.5.3 UNIT TRIP RELAY OUTPUT

Dedicated highly reliable unit trip relays shall be provided. Actuation of the unit trip relays by either the 2-out-of-3 or 1-out-of-2 trip groups will result in actions including those in the following list, subject to certain additions or deletions based on unit design features. The unit trip relay contacts will be arranged in a 1-out-of-2 tripping scheme, so that actuation of either unit trip relay will cause the desired action:

- Annunciation (blocked for normal shutdown) including an interface to the public address system so that all personnel will be aware of unit trips.
- Turbine trip.
- Burner and pulverizer control trip.
- Coordinated control system trip.
- Soot blowing system trip.
- Trip fuel supply equipment (e.g., pulverizers, primary air fans, coal feeders, fuel oil safety shutoff valve, igniter oil valves).
- Initiate turbine water induction protection.
- Fabric filter cleaning equipment trip.
- Flue gas desulfurization equipment trip.

# 14 UNIT PROTECTION

## 14.1 SYSTEM IDENTIFICATION

- System Name Unit Protection
- KKS Code MKY

## 14.2 CONSTRAINTS AND ASSUMPTIONS

None.

## 14.3 PERFORMANCE

The generating unit protection shall protect the generating units against damage caused by insulation failure, abnormal electrical conditions and abnormal mechanical conditions. This shall be achieved by tripping the EHV breaker, the unit board breakers, the excitation, ESVs, stator coolant, cooling fans and pumps as appropriate.

The synchroniser shall adjust the generator voltage and frequency to match the system conditions and shall close the relevant breaker when voltages and frequencies are close enough.

The fault recorder shall record details of events.

The generating units shall consist of the generator, excitation system, busbars, surge arrestors, earth switches, CTs, VTs, earthing transformer, earthing resistor, generator breaker, generator transformer, EHV breaker and unit transformers.

The protection functions for the generating unit shall consist of Main 1 and Main 2 protection groups. These shall be independent of each other and shall be redundant as far as possible.

Protection multi-trip latched relays shall be provided for each of Main 1 and Main 2 Schemes which shall provide trip signals to the following equipment:

- Boiler Protection System.
- Turbine Protection System.
- Excitation control system.
- Generator field circuit breaker.
- Burner management system.
- Unit Auxiliary Transformer MV circuit breakers.
- 400 kV switchyard intertrips.
- Generator fault recorder trigger.

## 14.4 TECHNICAL REQUIREMENTS

The generator protection shall consist of dual redundant protection equipment, dual channel automatic synchronizer and fault recorder.

The protection design shall protect against the following:

Insulation failure for:

- Single phase to earth fault.
- Phase to phase fault.
- Phase to phase to earth fault.
- Three phase fault.
- Single rotor earth fault.
- Double rotor earth fault.

Abnormal electrical conditions, such as:

- Undervoltage.
- Overvoltage.
- Under frequency.
- Overfrequency.
- Overfluxing.
- Negative phase sequence.
- Reverse power.
- Low forward power.
- Loss of field.
- Pole slipping.
- Switch onto standstill.

Abnormal mechanical conditions:

- Boiler trip.
- Turbine trip.
- Stator coolant flow.
- Emergency pushbuttons.
- Transformer Buchholz.
- Transformer pressure relief device.
- Oil temperature.
- Winding temperature.
- Pole discrepancy.

Tripping principles are base on the following:

- Faults in the EHV system cause the tripping of the EHV breaker.
- Faults in the generator transformer or unit transformers cause a unit shutdown.

- Faults that could be in the EHV system are initially assumed to be in the EHV system and the EHV breaker is tripped. If the fault persists, then the unit is shut down after a time delay.
- Protection against insulation failure is usually fast to prevent harm to personnel and excessive damage to equipment.

Setting principles are based on the following:

- Protection against insulation failure shall be sensitive to prevent harm to personnel and excessive damage to equipment.
- Protection against abnormal electrical conditions shall be set to the capability of the primary equipment to ensure maximum plant availability.
- Protection against abnormal mechanical conditions shall be set according to the severity of the condition. This could require an alarm, an immediate trip or a delayed trip.

The Generator Synchroniser shall be used to connect the Generator onto the system. Three phase synchronising shall be required across the generator breaker. Compensation for different breaker operating times shall be required.

Main 1 and Main 2 protections shall be located in separate panels. The fault recorder and auxiliary equipment shall be located in separate panels.

## 14.5 MAINTAINABILITY

Modern microprocessor based equipment shall be self monitoring. Testing shall be done by computer and can be done during unit outages. All equipment shall be readily accessible for inspection and maintenance.

## 14.6 OPERABILITY

There is no operating required except for the synchroniser which receives signals from the DCS.

There shall be continuous self monitoring of the hardware and software of the relay and providing remote alarm when a component failure is detected.

## 14.7 APPLICABLE STANDARDS

- IEC 60255
- IEC 61800
- IEC 61850

# 15 AUXILIARY COOLING WATER

## 15.1 SYSTEM IDENTIFICATION

- System Name Auxiliary Cooling Water
- KKS Code PA

## 15.2 FUNCTION

The Auxiliary Cooling Water System provides cooling water for cooling the Closed Cycle Cooling Water System.

## 15.3 PROCESS DESCRIPTION

A process flow diagram of the Auxiliary Cooling Water System is shown on drawing 10-PM-Pay-13

The Auxiliary Cooling Water System will include the following major equipment and components:

- Two self cleaning debris filters.
- Auxiliary cooling water piping, valves, and expansion joints
- 3 x 50 % booster pumps

The cooling water will be provided from the Circulating Water System and transported by the auxiliary cooling water piping to the closed cycle heat exchangers. Heated water from the closed cycle cooling water heat exchangers will be discharged to the circulating water discharge pipe from the condenser to be returned to the sea via the circulating water effluent channel.

## 15.4 BASIS FOR DESIGN

The Auxiliary Cooling Water System shall be designed and fabricated in accordance with ASME Codes and Standards.

The pressure drop through the auxiliary cooling water side of the dosed cycle cooling water heat exchanger, including booster pump, debris filter, heat exchangers and associated piping and valves, shall not be greater than the pressure drop through the condenser (including tube cleaning system device and associated piping and valves].

Booster pumps shall be installed in the auxiliary cooling water side with a minimum head of 10 m for hydraulic reasons.

# 16 CLOSED CYCLE COOLING WATER

## 16.1 SYSTEM IDENTIFICATION

- System Name Closed Cycle Cooling Water
- KKS Code PC

## 16.2 FUNCTION

The Closed Cycle Cooling Water System transfers heat rejected by various plant equipment heat exchangers to the Auxiliary Cooling Water System.

## 16.3 PROCESS DESCRIPTION

The Closed Cycle Cooling Water System for each unit shall include major equipment and components as per drawing no. 10-PM-PAY-013 and 10-PM-PAY-014.

The Closed Cycle Cooling Water System will supply inhibited demineralized quality cooling water to plant equipment heat exchangers. The closed cycle cooling water heat exchangers will transfer heat from the Closed Cycle Cooling Water System to the Auxiliary Cooling Water System. The closed cycle cooling water pumps will circulate the cooling water through the closed cycle cooling water heat exchangers and the various plant equipment heat exchangers. An elevated closed cycle cooling water head tank will provide liquid expansion capacity, a location for system makeup and venting, and will maintain a system static head. To minimize corrosion, a corrosion inhibitor solution is added to the Closed Cycle Cooling Water System through a chemical pot feeder.

The various plant equipment heat exchangers will receive cooling water from a common supply header. The plant equipment heat exchangers will return the heated closed cooling water to a common return header. Makeup water will be provided from the Cycle Makeup and Storage System to the closed cycle cooling water head tank.

## 16.4 BASIS FOR DESIGN

The heat exchangers will be sized to reject the design heat load to the Auxiliary Cooling Water System, with one heat exchanger out of service. The design heat load is the heat load at Boiler BMCR during the design hot ambient day. The pressure drop through the auxiliary cooling water side of the closed cooling water heat exchanger, including booster pump, debris filter, heat exchangers and associated piping and valves, shall not be greater than the pressure drop through the condenser (including tube cleaning system device and associated piping and valves).

The closed cycle cooling water pumps will be of the horizontal split case, single stage, double-suction volute type with mechanical seals. Each pump will be sized for the maximum required cooling water flow determined during detailed design. The total design capacity will be as required to supply equipment cooling requirements with the unit operating at BMCR during the design hot ambient day.

The pressure drop across plant equipment heat exchangers shall be designed for between 50 kPa and 100 kPa

The equilibrium of the system shall be performed with diaphragm devices adjusted through DeltaP measurement.

The closed cycle cooling water head tank shall be sized to handle the liquid expansion of the system from a cold start at normal water level without overflowing.

Butterfly valves shall be used in piping 80 mm nominal size and larger. Butterfly valves may be carbon steel, cast iron or ductile iron. Gate, globe, or ball valves shall be used in piping 50 mm nominal size and smaller. Piping shall be constructed of carbon steel materials.

The Closed Cycle Cooling Water System shall be designed and fabricated in accordance with ASME Codes and Standards.

# 17 EARTHING & LIGHTNING PROTECTION

## 17.1 SYSTEM IDENTIFICATION

- System Name Earthing & Lightning Protection
- KKS Code BAW

## 17.2 DESCRIPTION

### 17.2.1 GENERAL

The power station earthing is based on the power station layout and has a main earth mat for the power block area with connections to the other earthing systems, such as HV substation, water treatment plant, coal yard, and other ancillary buildings. The auxiliary plant and ancillary buildings have earth mat systems in accordance with their location, size and function.

The main earth mat has earthing tails protruding from the earth mat and concrete reinforcing that is then connected to the equipment with copper conductors. The size of the equipment conductors is based on their respective fault levels.

The earthing design starts with the determination of the high level earthing philosophy and associated fault currents that can be experienced in the different power distribution systems. The conductor sizing for each of these systems is then determined based on the conductor temperature rise limitation. The details of the earthing system is then finalized by sizing the conductors of each of the subsystems.

### 17.2.2 EARTHING SYSTEM PHILOSOPHY

An earthing system is provided to perform the following functions:

- Safety protection of staff;
- Provide earth fault current path that enables electrical protection to prevent or mitigate plant damage;
- Protect plant against lightning effects;
- Protect electrical components against incoming surges;
- Provide a path for dissipation of electrostatic discharge; and
- Provide a reference point for electrical signals.

The earthing system consists of earth networks and earth electrodes, and the aim is to achieve a low impedance path to earth.

### 17.2.3 ELECTROMAGNETIC COMPATIBILITY PHILOSOPHY

To ensure Electromagnetic Compatibility (EMC), electrical and electronic subsystems and components are required to have proper immunity and emission levels, compatible with the plant environment. In addition to the basic design of earthing electrodes and the earthing network, constraints are placed on the design and installation of cabling, cable racking, cable entries into buildings and metal enclosures.

The sources of electromagnetic interference are current-carrying components, switching devices and lightning.

### 17.2.4 EARTHING OF GENERATORS AND TRANSFORMERS

The concrete reinforcing of the building is used as part of the earth mat, to which all electrical equipment will be connected. The reinforcing of the building is not used as a replacement of the total or parts of the earthing system but is used to complement the earthing system. Should the building reinforcing be used to complement the earthing system, then it is ensured that the reinforcing is properly bonded to the earth electrode at ground level of the building. Bonding to the reinforcing is done with a Crosby clamp or is welded. Earth networks are not bonded to the building reinforcing in the case where these networks are used to carry fault currents of electrical equipment.

The following list gives the type of earthing used for the power equipment:

- The generator transformer star winding neutral is solidly earthed.
- Generator terminals point earthed via earthing transformer, limited to less than 2A, primary.
- Neutral earthing resistor to limit earth fault currents to between 50 and 300 A at MV.
- The diesel generator star points are earthed via a contactor that is closed only when the transformer earthing is not active.
- Low voltage winding of secondary transformer neutral is solid earthing.
- Switchgear panels and equipment are connected directly to the earth bonding terminals supplied in each equipment room.

## 17.3 PERFORMANCE

The power station earthing system shall limit the touch and step potentials on structures and equipment and provide low impedance return path to limit the damage to equipment or danger to human life by fault currents during abnormal system conditions. The maximum step and touch potentials for the completed earth mat system of about 165 V is considered safe in accordance with IEEE Std. 142 and Std. 80.

The earthing system also protects the installation against lightning strikes by conducting the strike via a preferred path to earth.

The grounding of electrical equipment ensures personnel safety under all circumstances and facilitates interference-free operation of electronics by establishing equipotential areas on all structural levels. This method provides that building floors, equipment enclosures and circuit boards are constructed using local ground planes on each level. The ground planes can also be mesh structures.

Continuity measurements between any two points are less than 10-ohms and are measured with a four lead micro-ohmmeter.

## 17.4 TECHNICAL REQUIREMENTS

### 17.4.1 MATERIAL TYPE

The materials used for earth mats and conductors are copper rod for earth mats, interconnections and the earthing of equipment.

### 17.4.2 SIZING

The conductor sizing is determined by the conductor temperature rise limitation that is based on the fault currents that can be experienced in the different power distribution systems.

### 17.4.3 MAIN EARTH MAT

The power station earth mat consists of copper rod except in the transformer bays where two copper rods run in parallel, laid at a depth of one meter. The rods under the main buildings and the transformer bays are arranged to provide a matrix.

The earthing tails that are connected to the earth mat have earthing tails of at least 500 mm protruding from the concrete or on terrace ground level. The earth tails are then connected to the equipment with copper conductors.

The earth mats of all auxiliary plant and buildings are connected to the main station earth mat by at least two connections of copper bar. These shall not run side by side and where possible shall connect to diagonally opposite portions of the earth mat system.

Joints are made using exothermic weld techniques such as copper oxide and aluminum powder in a graphite mould. No crimping bonds shall be made on round bars. Bonding to round copper bars is by means of exothermic welding.

### 17.4.4 EARTHING WITH CABLE RACKING

Earthing conductors are installed on all the cable racks at the power station. The cable racks serve an excellent medium of ensuring continuity in the plant. It serves as a secondary earth mat (surface equipotential bonding system) connected to the station and local earth mats whenever possible. Even if copper is not installed on the rack, it links equipment. The metal is conducting and helps to lower the resistance between equipment therefore improving continuity. Cable racks shall be bolted together to ensure continuity.

### 17.4.5 STRUCTURAL STEELWORK

The steelwork structures in the transformer bays shall be connected to the earth mat. The boiler and turbine house main building columns shall be connected to the earth mat. The main structural steelwork of all ancillary buildings shall be connected to their relevant earth mats.

Steel columns supporting equipment such as the air quality control equipment, inclined conveyors, etc. shall be connected to the station earth mat with at least one copper rod.

### 17.4.6 METAL ROOFS AND CLADDING

Metal roofs or steel trusses not in direct contact with building steelwork is connected to the earth mat at diagonally opposite points of the building. Structures having metal roofs do not require air terminals, but must be earthed by down conductors. Un-insulated cladding not in direct contact with building steelwork shall be bonded to the building steelwork. Where cladding is fully insulated (e.g., sheets covered with a bitumastic compound, and fully insulated from one another) the sheets do not require earthing.

### 17.4.7 FIRE PROTECTION

Fire protection piping shall be earthed in the region of the transformers to reduce the touch potential. The piping shall also be earthed at various points.

### 17.4.8 ANCILLARY BUILDINGS

These buildings include the electrical substations, water treatment plant, auxiliary cooling system, workshop, fuel oil plant, administration buildings, etc. Each building is provided with its own earth mat or earthed with earth rods, depending on the size of the building, location and application. The building earthing system is connected to the main station earth mat to ensure continuity. All major apparatus in the building is connected to a main earth strap and is connected to the earth mat.

The individual building or area earth mats shall be bonded to the main station earth mat by at least two connections of copper rod, each linking in to separate meshes of the main station earth mat where possible. Individual earth mats for buildings or area earth mats shall be large enough to provide a resistance to earth of not more than 0.2 ohm.

### 17.4.9 CHIMNEY

The chimney shall be provided with a lightning protection system comprising an air terminal, down conductors and an earth mat. Air terminal components are bonded to the chimney down conductors at intervals of a maximum of 15 m. Chimney down conductors are spaced at intervals of a maximum of 15 m and are securely bonded to the reinforcement steel at intervals of a maximum of 15 m. Down conductors shall be cast into the concrete. The combined rated area of chimney down conductors shall be not less than 700 mm2. The earth mat electrode of copper rod that surrounds the chimney shall be provided with inspection pits located at evenly spaced intervals. The aircraft warning lights shall be connected to the earthing system.

### 17.4.10 FLUE-DUCTS AND SUPPORT STRUCTURES

Earth rods shall be buried along both sides of the support structures for the flue gas ducts. These rods are connected to the earth mat surrounding the chimneys and to the earth mat of the gas cleaning plant. All steel structures supporting the flue gas ducts are connected to these earth rods. Where Teflon or other insulating "slide bearings" are installed between supports and ductwork, these shall be bridged by flexible copper connections; either braided tinned copper or yellow/green insulated wire of 70 $mm^2$.

## 17.5 MAINTAINABILITY

The earthing system shall be designed and installed to allow inspections and continuity tests.

## 17.6 OPERABILITY

The earthing system is a passive system and there are therefore no operating requirements.

## 17.7 APPLICABLE STANDARDS

- IEC 61000
- IEC 60037
- IEC 61024
- IEEE 80
- IEEE 665

# 18 CABLING AND RACKING

## 18.1 SYSTEM IDENTIFICATION

- System Name Cabling and Racking
- KKS Code N/A

## 18.2 CONSTRAINTS AND ASSUMPTIONS

### 18.2.1 GENERAL

Outdoor and indoor MV and LV cables shall be of the XLPE (Crosslinked polyethylene) or EPR (Ethylene-Propylene Rubber insulated) insulated cables. The control cables will be PVC insulated cables.

Cables shall at all times be fully supported on, and strapped to, supporting steelwork in the form of ladder rack, cable trays and angle iron. Directly buried cables shall be armoured.

### 18.2.2 RATING

Electrical cables shall be suitably rated not to exceed the maximum allowable voltage drop at the load terminals under full load conditions.

The cross-sectional areas for cables connected to circuit-breakers between distribution boards shall be selected to withstand a three-phase ac or dc through-fault without damage for the total operating time of the protection plus circuit-breaker fault clearing time.

Where the feeder circuit breaker is fitted with instantaneous over current protection, the cable shall be rated for continuous full-load current or a short circuit fault current for 0.2 s, whichever is the greater.

### 18.2.3 CABLE TYPES AND INSTALLATION

All cables shall be flame retardant (FR) cables. Power cables shall be XPLE or EPR insulated single-core or multi-core copper conductor, and the control cable shall be PVC insulated multi-core copper conduct. Cables installed in protected runs (i.e., cable trays and conduits) do not require armouring. Halogen free cables may not buried directly in ground as they have no long term resistance to immersion in water. Cables for direct buried service and those where mechanical damage is possible shall be steel armoured and PVC insulated with FR PVC.

### 18.2.4 CABLE DOCUMENTATION

Cable schedules shall be used that show from, to, and routing of the interconnected equipment and the cables installed. Each cable shall be numbered and coded.

The cable numbering and coding shall be in accordance with the Code system of numbering. Cable schedules detailing each cable, its number, type, length, origin and destination are compiled and used for the initial cable installation and thereafter it shall be kept for maintenance purposes.

#### 18.2.5 FIRE PROTECTION FOR CABLES

Cable penetrations through walls and into the different building areas shall be adequately fire sealed using approved materials, with a 2 hour fire retardant rating.

All cable and cable tray penetrations through walls and floors as well as any other types of cableways or conduits shall have fire stops installed.

### 18.3 PERFORMANCE

#### 18.3.1 CURRENT RATINGS

The current ratings of the cabling shall be based on recommendations from the cable manufacturers.

#### 18.3.2 FAULT RATINGS

The cables that are connected to circuit breakers shall be rated to withstand a three-phase or DC through fault without damage for the total operating time of the protection and circuit breaker. Where the circuit breaker is fitted with instantaneous over current protection, the cable shall be rated for carrying full load (continuously) or short circuit current for 200ms, whichever requires the larger cable. Cables protected by fuses are fault protected if selected to carry full load current continuously. The minimum duration considered in calculating the maximum short circuit rating is 200ms.

#### 18.3.3 VOLTAGE DROP

Maximum voltage drops for different consumers are as follows:

- 1.5 percent - Used for cables for critical drives like standby jacking oil pumps or turbine barring gear, though only operating during start up and shut down of the unit.
- 3 percent - For all drives and other consumers operating continuously under normal operating conditions. This is also applicable for a one out of two situation as for belt drives, and up to a four out of five situation as for example coal mills.
- 5 percent - For all drives and other consumers operating intermittently under normal operating conditions. This can include drives like actuators, valve drives, and soot blowers.
- 5 percent - For all drives operating continuously only for a number of hours during start up and shut down of a unit and for motor space heaters.
- 5 percent - For all DC operated solenoid circuits with the full continuous solenoid operating current flowing.

### 18.3.4 SAFETY CONSIDERATIONS

The types of cable and insulation used are flame retardant FR-PVC, FR-XLPE and halogen free (HF) cables. The aim is the reduction of hydrogen chloride (HCL) gas in combination with other toxic gasses that are produced from the burning of PVC cables which present a hazard to plant personnel and are also responsible for the corrosion to steel reinforcement of concrete, steel structures and electronic equipment printed circuit boards.

All cables installed above ground shall also be fire retardant to prevent the spreading of fire to other areas.

## 18.4 TECHNICAL REQUIREMENTS

The cable racking allow for easy cable approaches accommodating cable bending radii as required and the supplier recommendations.

Cable racks shall ensure that every cable is adequately supported throughout its run.

Armoured and unarmoured multi-core cables are supported every 400 mm in the horizontal position where racks are provided. Where cables leave the racks or descend or ascend vertically, they are clamped every 750 mm.

Where practical, cable racks are routed away from fire exposure or hazards or are protected from such exposures. Where cable racks are subject to oil spills, they shall be designed to prevent the spread of oil fires. Under floor and concealed cable spreading areas which have a height of more than 800mm and total floor area exceeding $300m^2$ shall have a fire detection system.

Where cables are direct buried, these runs shall be protected by concrete slabs and cable route markers provided above ground. The cable route markers are provided to mark all cable servitudes and the general location of buried cables. The cable route markers shall be located at 50 m intervals and wherever a route changes direction, to mark buried joints and where cables cross roads, railways or any other servitude.

Once the cabling work is complete, cable entries leading from inside buildings directly into the ground or to cable tunnels/trenches shall be sealed with fire proofing and then made watertight.

## 18.5 MAINTAINABILITY

No routine maintenance is required other than a visual inspection.

Cable racks shall be installed to prevent dust accumulation, such that maintenance access to equipment is possible and with no exposure to physical cable damage such as by personnel, overheating, sharp edges, immersed in water, or exposure to direct sunlight.

## 18.6 OPERABILITY

There are no operating related requirements.

## 18.7 APPLICABLE STANDARDS

- IEC 60502
- IEC 60183
- IEC 60228
- IEC 61084
- IEC 61238
- IEC 61386

# 19 MV MOTORS

## 19.1 SYSTEM IDENTIFICATION

- System Name MV Motors
- KKS Code N/A

## 19.2 CONSTRAINTS AND ASSUMPTIONS

- Motor design shall be for high reliability; over efficiency or power factor.
- The motors shall be operated in accordance with a base load-operating regime for at least the 30 years of life.
- Motor manufacturer shall take into consideration relevant characteristics and operating conditions pertaining to the driven machine and the motor environment.
- Motors shall be suitable for variable speed drive application, where drives shall be used.

## 19.3 PERFORMANCE

This system covers three-phase medium voltage (MV) induction motors.

The motors shall be capable of at least 3,000 hot starts, 750 warm starts, and 300 cold starts. Design life should be 200,000 hours.

The motors shall be designed and constructed to operate within the vibration limits. The vibration limits shall be based on equipment manufacturer's recommendation.

Motors shall be suitable for direct-on-line starting and, unless otherwise specified, shall be designed for at least three consecutive starts per hour when cold and two consecutive starts per hour when hot.

## 19.4 TECHNICAL REQUIREMENTS

Windings shall be insulated with either Class F or Class H insulating materials. Approved measures against corona shall be applied to the slot portion of all coils for motors of 3,300 V and above.

The kilowatt rating of each motor shall not be less than the maximum design loading of the driven machine.

Motors shall operate within their rated temperature rise limits.

## 19.5 MAINTENANCE

Corresponding parts of all motors of the same type and size shall be interchangeable.

## 19.6 APPLICABLE STANDARDS

- IEC 60034

# 20 GENERATOR EXCITATION SYSTEM

## 20.1 SYSTEM IDENTIFICATION

- System Name Generator Excitation System
- KKS Code MKC

## 20.2 CONSTRAINTS AND ASSUMPTIONS

- Excitation shall be designed and supplied in coordination with the generator.
- The system shall be of full static design with shunt excitation.
- The system shall interface with the protection via hard wiring.
- The system shall interface with the measurement panel via hard wiring.
- The interface to the DCS shall be a combination of hardwiring and software protocol using either fibre optic (preferred) or copper.
- The system shall allow for its internal clock to be updated from a central GPS type master clock on a minute/hour pulse or string that contains all relevant information. The system shall be able to time adjust any of these signals to compensate for transmission time and data interpretation to allow the best possible accuracy to be obtained in a power station configuration.

## 20.3 PERFORMANCE

The design is for such a nature that the maximum plant availability shall be guaranteed. In broad terms it must be able to perform the following:

- Regulate the voltage to within 0.5 percent of rated voltage.
- It must have a power system stabiliser (PSS) which is one of the formats described in IEC 60034-16-2.
- As secondary functionality and performance it shall have the following limiters.
  - Over fluxing limiters.
  - Load angle or under excitation limiter but excluding a stator current limiter.
  - Over excitation limiter based on the $\int I^2t$ of the rotor current.

The excitation transformer and associated power electronics shall be dimensioned such that 200 percent of rated field voltage can be supplied to the rotor even with a terminal voltage depressed to 80 percent of nominal value.

## 20.4 TECHNICAL REQUIREMENTS

Figure 1 shows a concept design of the excitation control system.

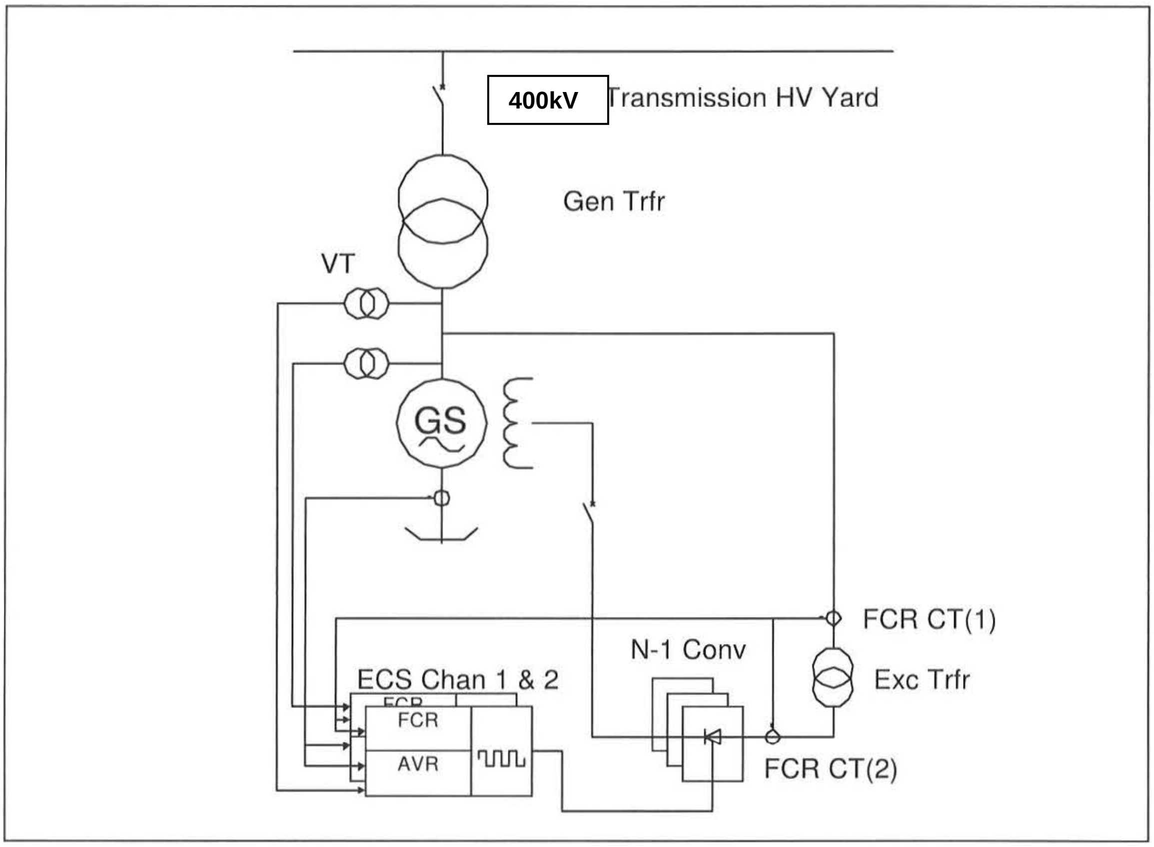


Figure 1: Excitation Single Line Diagram

The system should fulfill the Grid Code requirements and must comply with the Generators own demands. The concept presented in Figure 1 has been derived from the methodology presented below.

## 20.5 MAINTAINABILITY

It is important that limited online maintenance can be performed without endangering personnel or equipment. For a high degree of maintainability the system shall be redundant, as the plant will be inoperable if the system needs to be isolated even for a short period of time.

For the control electronics it is envisaged to have a completely redundant scheme, which shall include separate and redundant power supplies, I/O cards (digital and analogue) as well as a very reliable online monitoring system to enable engineers to pinpoint faults before isolation is required.

On the converter side the redundancy shall be at least N+1 and converters shall need to be effectively isolated from each other so that online maintenance can be carried out. This might require separate converter compartments with bushing for the interconnected busbars.

Five-way isolating mechanisms shall be required to allow proper electrical isolation before any repair work could be carried out on-line.

## 20.6 OPERABILITY

The operator interface shall have all required switching operations clearly marked. An alarm response chart shall be compiled either as part of an on-line help function or in a printed format and be readily available to operators of the system.

## 20.7 APPLICABLE STANDARDS

- IEC 60034-16
- IEC 60146

# 21 FUEL OIL UNLOADING, STORAGE AND SUPPLY

## 21.1 SYSTEM IDENTIFICATION

- System Name Fuel Oil Unloading, Storage, and Supply
- KKS Code EG

## 21.2 FUNCTION

The Fuel Oil Unloading, Storage, and Supply System provides the capability to use fuel oil and deliver it for use at the required pressure to the boiler igniter oil control packages, for use in boiler startup and shutdown. The emergency diesel generators, diesel driven fire water pumps and diesel driven fire water booster pump will use the fuel oil as well.

The HSD fuel oil specification is contained in Chapter 1 of Section 5.

## 21.3 PROCESS DESCRIPTION

A process flow diagram of the Fuel Oil Unloading, Storage, and Supply System is stated in Chapter 9 of Section 5.

The Fuel Oil Unloading, Storage, and Supply System will include the following major equipment and components:

- Truck unloading pad with spill collection.
- Fuel oil unloading pump.
- One fuel oil storage tank with containment.
- Fuel oil unloading and supply meter.
- Two (2) 100% fuel oil transfer pumps
- Associated piping, valves, instruments, controls, and accessories.

The fuel oil transfer pumps shall deliver fuel oil to the boiler igniter oil control packages located at the boiler and emergency diesel generators area via a common header serving all equipment. Unused fuel oil shall be recirculated back to the Fuel Oil tank.

## 21.4 BASIS FOR DESIGN

The storage tank shall be located at appropriate place, preferably near the Auxiliary Boiler. The Contractor shall provide suitably sized and locate branches together with manual isolating valves on the boiler supply and return lines. As part of the scope of work the Contractor shall also provide a piping system including oil transfer pumps and associated valves and controls to deliver the fuel oil to the various users associated with the Plant.

The Fuel Oil Supply System shall be designed and fabricated in accordance with API, NFPA, ASME Codes and Standards.

# 22 GENERATION BUILDING FIRE PROTECTION

## 22.1 SYSTEM IDENTIFICATION

- System Name Building Fire Protection
- KKS Code SG

## 22.2 FUNCTION

The Building Fire Protection System will provide water under pressure to fixed fire suppression systems and standpipes for the building listed in Table 1-1. In addition to these systems, the Building Fire Protection System will also include independent fire detection systems and portable fire extinguishers. Fire water supply is described in the Fire Protection Water Supply (WSE) System Definition. Site fire protection is described in the Site Fire Protection (STG) System Definition. It is not the intent of this document to specifically call out all of the necessary fire protection systems, but rather to clarify the minimum requirements. The system design must meet NFPA, Building by-Laws and local fire code requirements (BOMBA).

## 22.3 PROCESS DESCRIPTION

The Building Fire Protection System will be capable of delivering fire water required to meet the demand from fixed fire suppression systems and fire hose streams in the Turbine and Boiler Buildings.

At the higher elevations in the Boiler Building, such as the silo fill gallery and upper section of the coal conveyors feeding coal to the boiler, fire water booster pumps may be required to boost the pressure of the required water demand due to the loss of pressure from the increased elevation of these areas. If required, high-pressure lines will supply fire water to standpipes and fixed water suppression systems located in the upper elevation areas of the Boiler Building.

Various types of fixed water suppression and detection systems are provided throughout the units. These systems operate in response to fire signatures such as excessive heat, temperature rate-of-rise, or products of combustion. See Table 1-1 for minimum recommended systems protecting the areas or hazards throughout the Boiler Building and Turbine Building.

Standpipe and fire hose stations are strategically located at various locations for buildings and structures as required by the building code. See Table 1-2 for minimum recommended standpipe and hose connections information.

Portable hand-held fire extinguishers are provided at key locations in accordance with the requirements of NFPA 10 or local regulations, whichever is more conservative. The extinguishing agent will be selected based on the fire hazards in the immediate area.

## 22.4 BASIS FOR DESIGN

**Table 1-1**
**Minimum Recommended Fire Suppression and Detection Systems**

| Area or Hazard | System Suppression Type | Actuation | Detection Types | Density (mm/min) | Coverage Area |
|---|---|---|---|---|---|
| **BOILER AREA** | | | | | |
| Coal Pulverizers | Water Spray (open head) | Manual | Heat (thermocouples) | 10 | Entire area |
| Coal Silos | F-500 and $00_2$ inerting system | Manual | Carbon monoxide (CO) and methane | N/A | Entire silo |
| Primary Air Fan and Forced Draft Lube Oil Systems | Deluge (Dry Pilot) or Wet, Pipe | Automatic | Heat | 10 | Entire area or most remote 232 square meters |
| Air Heaters | Deluge | Manual | Heat (thermocouples) | 24 (for horizontal rotor/stator) | Entire area |
| Silo. Fill Conveyors | Wet pipe | Automatic | Heat | 10 | Most remote 18.6 square meters (top and bottom) |
| Silo Fill Gallery | Dry pipe sprinkler | Automatic | None | **10** | Most remote 232 square meters |
| Dust Collectors | Preaction Water Spray | Automatic | Heat | 8 | Entire collector |
| Ail Electrical Rooms | None. | N/A | Smoke | N/A | Entire room |
| All Buildings | Fire Extinguishers | Manual | N/A | Per NFPA 10 | All Buildings |
| Exit Doors | N/A | Manual | Pull Stations | N/A | Per NFPA 72 |
| | | | | | |
| **TURBINE AREA** | | | | | |
| Turbine Underfloor (Ground Floor) | Wet Pipe Sprinkler | Automatic | Heat | 12 | Most remote 465 square meters |

Table 1-1 (Cont'd)

**Minimum Recommended Fire Suppression and Detection Systems**

| Area or Hazard | System Suppression Type | Actuation | Detection Types | Density (mm/min) | Coverage Area |
|---|---|---|---|---|---|
| MCC/SUS Rooms | | N/A | Smoke | N/A | Entire room |
| Turbine Underfloor (Mezzanine Floor) | Wet Pipe Sprinkler | Automatic | Heat | 12 | Most remote square meters |
| Steam Turbine Bearings | Preaction | Automatic | Spot Heat | 10 | Entire Area |
| Lube Oil Reservoir | Deluge (Dry Pilot) | Automatic | Heat | 12 | Entire reservoir surface area |
| Boiler Feed Pump | Preaction | Automatic | Spot Heat | 12 | Entire area |
| Electrical and Control Equipment Rooms | None | N/A | Smoke | N/A | Entire room |
| Battery Room | None | N/A | Smoke | N/A | Entire room |
| Main Control Room | None | N/A | Smoke | N/A | Entire room |
| Switchgear Room | None | N/A | Smoke | N/A | Entire room |
| HVAC | None | N/A | Smoke Detection per NFPA 90A | N/A | N/A |
| All Buildings | Fire Extinguishers | Manual | N/A | Per NFPA 10 | All Buildings |
| Exit Doors | N/A | Manual | Pull Stations | N/A | Per NFPA 72 |

Note:

SPRINKLER:

Wet Pipe--The piping is filled with water under pressure that is immediately discharged when the sprinkler actuates. Water will discharge only from those sprinklers which are fused.

Dry Pipe--Dry pipe systems are used in buildings or building areas that are unheated and where any water in piping might freeze. The piping contains air under pressure that holds back the water at a dry pipe valve in a heated location. When a sprinkler operates and releases air, the drop in air pressure automatically opens the dry pipe valve and admits water to the system. Water will discharge only from those sprinklers which are fused.

SPRAY:

Preaction--The automatic preaction spray system is somewhat similar to a dry pipe sprinkler system. The important difference is that a system of heat or smoke detectors is installed throughout the protected area. When a detection device is actuated, an automatic water control valve automatically operates to admit water through the spray piping. The spray nozzles are closed as on a dry pipe system and discharge when their fusible elements operate. The system is used where an alarm in advance of suppression operation is desired and where it is particularly important to prevent the accidental discharge of water. Supervisory air pressure in the piping Is also maintained; should the pressure drop, a trouble alarm will sound. However, pressure loss does not cause the preaction valve to operate.

Deluge-- The automatic deluge system, which has open spray nozzles, is used where it is desirable to deliver water through all spray nozzles simultaneously and to wet down the entire protected area. The water supply is held back from the spray piping by a deluge valve automatically actuated by operation of a heat detection system installed throughout the protected area.

Manual deluge systems consist of open nozzles located over the hazard.. System actuation is performed by manually opening two valves in series. The two valves are installed in series to mitigate water leakage.

Systems will meet Employer's insurance requirements, National and local codes, and Authority Having Jurisdiction (AHJ) requirements.

Table 1-2

Standpipes and Hose Connections

| Building or Structure | Class and Type of Standpipe |
|---|---|
| Boiler Area | Class III — Automatic Wet Standpipe * |
| Turbine Area | Class III — Automatic Wet Standpipe * |

All standpipe systems are Class III with 40 and 65 mm hose connections.
The 40 mm connection is for trained personnel on-site and the 65 connection is for use by the responding fire department.

Wet `Standpipe

Standpipe is constantly full of pressurized water up to the hose connection valve. .

Dry Standpipe

A dry standpipe system is similar to a dry pipe sprinkler system. The pipe is dry with pressurized air that holds the valve closed. The valve is located in a heated enclosure. When a hose connection valve is opened, air pressure •drops allowing the dry pipe valve to open and water fills the pipe and supplies the opened hose connection.

*Systems will meet Employer's insurance requirements, National and local codes, and Authority Having Jurisdiction AHJ requirements.

# 23 BOILER FEED

## 23.1 SYSTEM IDENTIFICATION

- System Name Boiler Feed
- KKS Code LA

## 23.2 FUNCTION

The Boiler Feed System will provide a flow path for feedwater from the deaerator storage tank to the economizer inlet, will raise the feedwater temperature through heating in the feedwater heaters using extraction steam, and will provide the flow path for spray water to the main steam bypass steam conditioning valves and boiler reheat desuperheater.

## 23.3 PROCESS DESCRIPTION

A process flow diagram of the Boiler Feed System is shown on drawing 10-PM-Pay-03

The Boiler Feed System will include the following major equipment and components, for each generating unit:

- Two 50% nominal capacity boiler feedwater pump sets. Each boiler feedwater pump set is comprised of:
  - One booster pump inlet strainer.
  - One booster pump.
  - One cross.-over pipe between booster pump discharge and main pump suction with strainer.
  - One balancing pipe between booster pump discharge and main pump.
  - One main boiler feedwater pump.
  - One main feedwater pump drive turbine ,
  - Minimum flow recirculation line returning back to the deaerator
  - Self contained lubricating oil system.
  - Drive end and non-drive end bearing housing vibration accelerometers for vibration protection installed in the vertical and horizontal positions
- One 25% capacity motor driven startup and back-up boiler feedwater pump skid comprising:
  - One booster pump inlet strainer.
  - One booster pump.
  - One cross.-over pipe between booster pump discharge and main pump suction with strainer. One main boiler feedwater pump
  - One main feedwater pump drive motor
  - One variable speed coupling between MV motor and main pump, including a complete lubricating system.
  - Minimum flow recirculation line returning back to the deaerator
  - Drive end and non-drive end bearing housing vibration accelerometers for vibration protection installed in the vertical and horizontal positions

- Three high pressure feedwater heaters
- One normal operation motor operated feedwater valve (open/close).
- One feedwater control valve for startup/shutdown service.
- Associated piping, valves, instruments, controls, and accessories.

Feedwater for the boiler feedwater pump set will be provided by the deaerator. Each boiler feedwater pump shall have its own suction line to the deaerator. The boiler feedwater pumps supply the feedwater pressure necessary to overcome friction losses in the high-pressure feedwater heaters, feedwater piping, boiler internal tubes, and to provide the pressure required at the steam turbine throttle valves.

During normal operation 2 x 50% turbine driven boiler feedwater pump sets will be in operation while the third motor driven pump serves as a startup and back-up set. At normal loads the flow to the boiler will be regulated by the speed of the main boiler feedwater pumps by using the variable speed steam turbine drive.

A normal operation motor operated feedwater valve (open/close) and one feedwater control valve sized for startup service shall be provided in parallel upstream of the feedwater heaters. The startup feedwater control valve shall provide increased system resistance at low loads which supports the attemperator spray water requirements. The startup feedwater control valve shall be closed during normal operation. The normal operation motor operated feedwater valve shall be open during normal plant load conditions and closed during startup.

The feedwater will flow through three stages of feedwater heating before entering the boiler economizer.

The final stage of feedwater heating receives extraction steam from the high pressure section of the steam turbine.

A common bypass shall be provided for all three high pressure heaters in each 50% capacity train.

## 23.4 BASIS FOR DESIGN

Design for this system shall be coordinated with the High Pressure Extraction Steam System and the High Pressure Heater Drains System so that the recommendations of ASME TOP-1 for turbine water induction protection and the steam turbine manufacturer’s recommendations are fully met.

The best efficiency point shall be at TMCR (the guarantee point).

The Boiler Feed System shall be arranged so that the net positive suction head (NPSH) available to the boiler feed pumps for normal steady operation up to BMCR not less than 180% of the required NPSH based on a 3% first-stage head reduction under steady-state operation. The minimum transient NPSH shall be 1.3 times the required pump.

NPSH based on a 3% first stage head reduction under steady state operation. The pump suction piping from the deaerator should have the maximum continuous falling gradient toward the pump. The declivity of any section of the suction piping should not be less than 10 degrees.

Each boiler feed pump shall be provided with a low pump NPSH alarm as part of the automated alarm protection equipment.

Each boiler feed pump shall be provided with individual flow measurement for accurate control of the pump speed and pump minimum flow control.

Shaft monitoring equipment for vibration of the main pump in operation shall be provided. Both the drive end and the non-drive end bearing housings must be equipped with vertical and horizontal vibration accelerometers for vibration monitoring and protection purposes.

The high pressure feedwater heaters shall be shell and tube-type feedwater heaters and configured in 2 x 50% capacity trains. Feedwater shall flow through the heater tubes and high-pressure extraction steam shall flow through the heater shell. An integral drain cooler section and desuperheating zone shall be provided with the feedwater heaters. All feedwater heaters shall be of the horizontal shell design and shall be equipped with vents. Startup and operating vents shall be provided to remove non condensable gases from the feedwater heaters during startup and normal operation. Startup vents shall have double isolation using manual valves. Operating vents shall also have double isolation, but shall be equipped with one motor operated valve and one manual valve.

The hydrostatic test pressure of the heaters shall be in accordance with ASME Codes and Standards and the Malaysian Factories and Machinery Act 1967 (Act 139) and Regulations as a minimum requirement.

Carbon steel material used in the boiler feed system with fluid temperatures less than 260$^{o}$C and greater than 90$^{o}$C shall have a chromium equivalent of 0.16% or greater to resist the effects of flow accelerated corrosion (FAG). Chromium equivalent is defined as follows: CrEq = Cr + 0.19Mo + 0.4Cu where CrEq is chromium equivalent, Cr is percent chromium, Mo is percent molybdenum, and Cu is percent copper. The chromium content shall be a minimum of 0.1% where a chrome equivalent of 0.16% is required. Material/Mill test certificates, including chromium content, shall be provided for all carbon steel components that require minimum amounts of certain constituents to mitigate FAG-related failure risk and to meet the chromium equivalent of 0.16%. In addition, a corrosion allowance of 0.0625 inch shall be provided for carbon steel piping operating where FAG is a concern.

For Heating Plant equipment material of shell for HP heater is in SA 204 Gr C excepted for HP6 bis where the shell is in SA 387 Gr 12 C12. Water boxes for HP are in SA 508 Gr3 CII. The deaerator shell is in SA 204 and feed water tank shell is in SA 516 Gr 70.

For Piping: as per ASME code, piping will have less than 0.30/o Cr. Minimum is not required by the Code.

A welded-in feedwater flow nozzle shall be used for a higher level of accuracy. To ensure the higher accuracy levels, the flow nozzle shall be shop installed into a piping section. The flow nozzle shall be constructed of 304 stainless steel and welded into the feedwater system piping downstream of the feedwater heaters.

The feedwater piping shall be designed in accordance with ASME Codes and Standards.

# 24 CONDENSATE

## 24.1 SYSTEM IDENTIFICATION

- System Name Fuel Oil Unloading, Storage, and Supply
- KKS Code EG

## 24.2 FUNCTION

The Condensate System provides a flow path for condensate from the condensate regulating valve to the deaerator. The system includes the low'-pressure feedwater heaters and the deaerator which raise the condensate temperature. The condensate system will also provide water to various desuperheaters, seal water to equipment and makeup water to miscellaneous systems as required by system operating

## 24.3 PROCESS DESCRIPTION

A process flow diagram of the Condensate System is shown on drawing 10-PM-PAY-03.

The Condensate System includes the following major equipment and components:

- Drain cooler
- Three horizontal U.-tube type low pressure feedwater heaters
- Deaerator.
- One 100 % capacity and one startup condensate regulating valves~
- One on-off maintenance valve.
- Associated piping, valves, instruments, controls, and accessories.

The Condensate System receives condensate from the Condensing System at the inlet of the condensate regulating valves. The condensate then flows through the low pressure feedwater heaters into the deaerator.

Condensate flow control will be provided by the condensate regulating valves.

Feedwater heating will be provided by one drain cooler, four stages of low pressure, closed feedwater heaters and the deaerator. The deaerator will function as an open direct contact feedwater heater.

The feedwater heaters and deaerator shall be equipped with vents. Startup and operating vents shall be provided to remove non-condensable gases during startup and normal operation. Startup vents shall have double isolation using manual valves. Operating vents shall also have double isolation, but will be equipped with one motor operated valve and one manual valve.

The heaters are furnished with emergency drain valves that shall open upon high drains level in the feedwater heaters to dump high level drains to the condenser or to the drain flash tank. In addition, the previous feedwater heater cascading drains valve shall close to a feedwater heater with high drains level and shall also open its emergency drain valve to direct drains flow to the condenser or to the drain flash tank.

The extraction piping steam stop check valves and motor-operated isolation valves shall also close upon high drains level in the associated feedwater heater to stop further inflow of extraction steam and block the flow path between the feedwater heater to the turbine to prevent drains level from rising and entering the steam turbine.

## 24.4 BASIS FOR DESIGN

Design for this system shall be coordinated with the Low Pressure Extraction Steam System and the Low Pressure Heater Drains System so that the recommendations of ASME TDP-1 for turbine water induction protection and the steam turbine(s) manufacturer requirements are fully met.

The condensate piping shall be designed in accordance with ASME Codes and Standards.

The feedwater heaters shall be designed for use with extraction steam in condensate service. An integral drain cooler section shall be provided on feed water heater LP4. All feedwater heaters shall be of the horizontal shell design and equipped with vents.

Low pressure feedwater heater tubes shall be Type 304 stainless steel.

The deaerator shall be a direct contact, spray-type design. The deaerator shall consist of a single horizontal cylindrical deaerator tank containing a pre-deaeration spraying device in the steam space with steam injection in the water space. The deaerator storage tank elevation and capacity shall be selected to provide sufficient NPSH for the boiler feed pumps at all normal and transient operating conditions.

The storage tank shall be sized to provide at least 5 minutes of full load boiler feed pump flow with the deaerator water elevation at the low water level at the beginning of the 5 minute period

Condensate piping and valve bodies shall be constructed of carbon steel materials. The hydrostatic test pressure of the heaters, Gland Steam Condenser and Deaerator shall be in accordance with ASME Codes and Standards.

Extraction steam shall be supplied directly to the deaerator from an intermediate or low pressure turbine extraction connection, with no pressure reducing valve for normal operation. Pegging steam for startup and transients shall be provided from the either the Auxiliary Steam System or Cold Reheat System.

Motor-operated bypass and motor-operated isolation valves shall be provided around the feedwater heaters. The bypass valve shall open and the motor-operated isolation valves shall automatically close in the event of high-high water level in the associated feedwater heater.

The Contractor shall ensure that equipment specification and system configuration shall be in accordance with the requirement of the plant/system offered.

# 25 CYCLE CHEMICAL FEED

## 25.1 SYSTEM IDENTIFICATION

- System Name Cycle Chemical Feed
- KKS Code LF

## 25.2 FUNCTION

The function of the Cycle Chemical Feed System is to chemically condition the condensate and feedwater to minimize corrosion and scale formation throughout the condensate-feedwater-steam cycle. The Cycle Chemical Feed System shall be designed to provide a conditioning program based on an oxygenated treatment (OT) approach.

## 25.3 PROCESS DESCRIPTION

A Process Flow Diagram of the Cycle Chemical Feed System is shown on drawing 10-PM-PAY-14

The Cycle Chemical Feed System shall include the following major equipment and components.

- Oxygen feed system consisting of two subsystems:
- Oxygen supply and storage equipment consisting of oxygen cylinders and oxygen manifold.
- Oxygen feed equipment consisting of pressure regulators, rotameters, control valves, relief valves, check valves, shutoff valves, and back pressure valves.
- Ammonia feed system consists of the following major components:
- One ammonia drum pump.
- One stainless steel ammonia solution tank and tank mixer with measuring pot.
- Two full capacity ammonia dosing pumps.
- Associated system piping, valves, instrumentation, and controls.

Oxygen shall be supplied using a manifold of replaceable cylinders

Contractor will perform oxygen injections downstream the condensate polishing plant (one injection point, on common line) and at the suction of each feedwater pump (3 injection points). Back pressure valves shall be installed at the discharge points. These back pressure valves compensate for any changes in the discharge pressure from the oxygen feed system and provide for a more constant feed rate.

Ammonia solution shall be fed to the downstream side of the condensate polishers. The ammonia feed equipment shall consist of two full capacity feed pumps and a solution tank with mixer and measuring pot. The system shall feed from the ammonia solution tank.

## 25.4 BASIS FOR DESIGN

The Cycle Chemical Feed System shall consist of two subsystems that operate independently of each other, an oxygen feed subsystem and an ammonia feed subsystem. Both the oxygen and ammonia feed subsystems shall be designed for operation with the condensate and boiler feed water to minimize corrosion and corrosion product transport,

Oxygen shall be used as a part of oxygenated treatment (OT) to minimize corrosion and corrosion product transport. Oxygen shall be fed in proportion to condensate flow and biased by dissolved oxygen residual in the economizer inlet sample to achieve the selected oxygen concentration (typically 30 to 150 ppb). The oxygen feed system shall be interlocked to shut off oxygen feed at high condensate cation conductivity levels and also at low unit load.

Ammonia solution shall be fed to downstream of the condensate polishers. The solution shall be added as required to maintain a condensate pH within the selected range (typically 8.0 to 9.0) at full condensate flow. Ammonia feed shall be controlled in proportion to condensate flow, biased by the condensate specific conductivity as monitored by the Steam Cycle Sampling and Analysis (SAC) system. During normal operating conditions, only one pump will be required; for exceptional conditions, such as wet conservation, two pumps could be used in the same time.

The ammonia dosing pumps shall be positive displacement, hydraulically actuated diaphragm metering pumps furnished with automatic stroke controllers and/or variable frequency drive motors. The ammonia solution tank shall be sized for 7 days of normal operation.

# 26 CYCLE MAKEUP AND STORAGE

## 26.1 SYSTEM IDENTIFICATION

- System Name Cycle Makeup and Storage
- KKS Code LC

## 26.2 FUNCTION

The Cycle Makeup and Storage System provides high purity water for the main cycle fill and makeup, chemical cleaning, and various startup operations. The system will also provide water for other systems requiring high purity water and will provide active storage capacity for condensate makeup and dump.

## 26.3 PROCESS DESCRIPTION

A process flow diagram of the Cycle Makeup and Storage System is shown on drawing 10-PM-PAAY-10

The Cycle Makeup and Storage System will consist of the following major components:

- Three 50 % capacity demineralized water transfer pumps.
- Two stainless steel, or coated Carbon steel, demineralized water storage tanks.
- One stainless steel, or coated Carbon steel, condensate storage tank
- Two 100 % capacity condensate makeup pumps
- Associated piping, valves, instruments, controls and accessories.
- One stainless steel, or coated Carbon steel, condensate storage tank
- Associated piping, valves, instruments, controls and accessories.

The system will receive demineralized water from the Cycle Makeup Treatment System Demineralized water will be pumped from the demineralized water storage tanks to the condensate storage tanks to maintain normal operating level by use of the demineralized water transfer pumps.

The makeup to the condenser to ensure that sufficient makeup will be introduced to prevent low level in the condenser hotwell and will be extracted from the condensate makeup storage tank by the vacuum drag in the condenser during normal operation. Before the startup of unit, the condensate makeup pump will be provided for the condenser and deaerator storage tank.

The demineralized water pumps will take suction from the demineralized water tanks and convey them to the condensate makeup storage tank for each unit respectively. The purpose of condensate makeup storage tank is to supply the cycle make-up to the condenser and receive the condenser dumping excess condensate in the event of high condenser hotwell level.

## 26.4 BASIS FOR DESIGN

The pumps shall have sufficient head to overcome piping friction losses and to provide the pressure requirements based on the worst case tank levels. Each demineralized water transfer pump shall be sized to provide the miscellaneous demineralized water requirements simultaneously.

The design flow capacity of each condensate makeup pump shall be the capacity required to fill the condenser and maintain normal level. Using the two makeup pumps at the same time the condensate pumps shall be capable to fill either HP part or LP part of the boiler for hydrostatic testing in a 2 hour time period. Design head of the condensate makeup pump shall be that required to overcome piping system friction losses at the pump design capacity and the static head to the highest elevation condensate user.

Buried piping shall be high density polyethylene. Above ground piping and valves shall be stainless steel.

Demineralized water storage and condensate storage tanks shall be fabricated of stainless steel components or coated carbon steel and shall be welded construction. Demineralized water storage tanks and condensate storage tanks shall have a minimum combined capacity equivalent to 72 hours of cycle makeup based on annual average cycle makeup water requirements for the unit.

The condensate storage tank capacity shall also be sized to contain the volume required to drain the boiler, condenser hotwell, and all condensate piping.

The Cycle Make-up and Storage System shall be designed and fabricated in accordance with ASME Codes and Standards and the Malaysian Factories and Machinery Act 1967 (Act 139) and Regulations. The Demineralized water storage and condensate storage tanks shall be designed and fabricated in accordance with AWWA 0100 or API 650.

# 27 GENERATOR ISOLATED PHASE BUS

## 27.1 SYSTEM IDENTIFICATION

- System Name Generator Isolated Phase Bus
- KKS Code BAA

## 27.2 CONSTRAINTS AND ASSUMPTIONS

The isolated phase bus system must comply with the following:

- Cater for penetration depth due to the skin effect of alternating current.
- Be self-cooled by natural convection and radiation cooling for a rating of 15 percent above the maximum continuous current rating of the power generator
- Limit temperature rise
- Maintain minimum insulation levels when filled with atmospheric air as per site specific environmental conditions.
- On-line temperature monitoring and alarming facility to monitor the temperature of all bolted connections is provided. Facility for local and remote indication is included.
- Dust and moisture ingress is limited by a busbar pressurisation system. The air volume in the enclosure is slightly pressurized with a positive pressure. The air consumption is monitored as an indication of sealing arrangement condition. The busbar system is protected from being over-pressurized. The source of air is control air.
- Air tight inspection doors provided for access to all bolted connections and fitted close to all sharp bends in the busbar system to provide adequate access for maintenance requirements.
- Busbar support insulators shall have a self centring facility reducing forces during fault conditions.
- Particular care needs to be paid in the design to avoid common defects that could lead to phase-to-phase faults such as water ingress into more than one duct, gas spreading during faults, incorrectly designed CT and generator terminal cubicles.

## 27.3 PERFORMANCE

The generator isolated phase bus interconnects the generator output terminals with the generator breaker, tap to unit transformers, and terminals of the generator transformer.

The main objectives of the busbar system design are:

- Prevent inadvertent contact with hazardous parts
- Ensure a safe human environment
- Eliminate phase-to-phase faults
- Limit electromagnetic field under normal operating conditions

The main busbar conductor shall be capable of carrying the rated generator output current and withstand a maximum phase-to-phase short circuit. The secondary connections to the unit transformers, voltage transformers, and the surge arrestors shall have respective ratings in line with the connected equipment.

## 27.4 TECHNICAL REQUIREMENTS

### 27.4.1 CONDUCTOR

The conductor consists of an aluminium alloy tube. The enclosure housing of the conductor is a circular aluminium duct. The conductors have flexible joints which allows for expansion and contraction. The conductor expansion joint consists of aluminium laminated flexible connectors welded between two sections of the conductor. Each laminated flexible connector is made from layers of aluminium foil. Laminated copper flexible connectors are used for the busbar-to-equipment connections.

The busbar conductor insulators, made of symmetrical shed porcelain or epoxy resin, support the conductor at the centre of the enclosure and insulate it electrically from the enclosure. The insulators carry the weight of the conductor and withstand the phase-to-phase short circuit forces.

### 27.4.2 ENCLOSURE AND SUPPORTS

The respective ends of the three enclosures are short circuited with each other by means of aluminium shorting plates, and earthed to the station mat at only one earthing point to prevent circulating currents and consequent overheating of the busbar enclosure.

The enclosures are anchored but allowed to slide on insulating pads to accommodate expansion and contraction. The insulating feet support the busbar enclosures and ensure electrical insulation between the enclosures and supporting steel to maintain a single connection to earth. The support structures are built to maintain the enclosure position under normal and fault current conditions.

The enclosures are fitted with ethylene-propylene flexible bellows at each interface. The bellows form an effective dust and air seal, and are rated for the required creepage distance for the electrical installation voltage.

Seals are used at wall penetrations, which consist of a sectional aluminium frame bolted to the turbine house wall. The wall seal is earthed at one end to prevent circulating currents and consequential over heating of the wall seal plate.

The busbar enclosures on the outside of the turbine house are fitted with canopies, as required, reflecting the sunlight from the enclosure to reduce the busbar temperature rise.

### 27.4.3 BUSKER PRESSURISATION SYSTEM

The busbar interior is pressurized with control air to maintain the pressure above atmospheric to prevent the ingress of dust. Over pressure protection shall be provided. The pressurization system is not intended to be used for cooling the bus bars.

### 27.4.4 GENERATOR VOLTAGE TRANSFORMER CUBICLES

The voltage transformer cubicles for protection, synchronising, metering, and control are situated on the level just below that of the main busbars and segregated from each phase to ensure a phase isolated busbar system.

### 27.4.5 SURGE ARRESTER AND CAPACITOR CUBICLES

The surge arresters and capacitors ensure that the maximum surge voltage does not exceed the generator transformer winding impulse level. The cubicles are situated on the level just below the main busbars and segregated. The interconnections for the surge arresters and capacitors are with small copper busbars that are connected to the main generator busbar conductor by means of flexible connections.

### 27.4.6 CURRENT TRANSFORMER CUBICLE AND NEUTRAL ENCLOSURE

The cubicles just below the terminal enclosure are phase segregated on the line and star point side with ring type current transformers installed just above the star connection.

## 27.5 MAINTAINABILITY

Current transformers shall be arranged to permit occasional removal of individual units for testing and calibration.

## 27.6 OPERABILITY

The CT cubicle cooling fans shall be equipped with differential pressure switches that are positioned over the intake and outlet of the respective fan filters in order to provide an alarm in the unit control room of a blocked filter.

A thermometer shall be installed on the generator phase side CT cubicle in order to measure the temperature of the circulating air inside the enclosure of the middle phase. The thermometer shall provide a high temperature alarm in the DCS.

## 27.7 APPLICABLE STANDARDS

- IEEE C37.23

# 28 GSU, UAT AND STANDBY & STARTUP TRANSFORMERS

## 28.1 SYSTEM IDENTIFICATION

- System Name: Generator Step Up (GSU) transformer, Unit Auxiliary Transformer (UT) and Standby & Startup transformer
- KKS Code: BAT/BBT

## 28.2 CONSTRAINTS AND ASSUMPTIONS

- Transformers shall be designed in compliance with the latest revision of IEC 60076.
- All transformers and switchboards capacity shall be adequately sized and rated to supply the connected loads
- All transformers, switchboards and load feeders shall be complete with adequate protection system in accordance with good engineering practice of prudent power utility.

## 28.3 PERFORMANCE

Selection of the HV and LV insulation level shall be based on IEC standards for the appropriate voltage class.

The thermal rating of transformers shall have a safety margin above IEC standard for normal craft paper by utilizing thermally upgraded paper.

The high voltage winding rating shall be such that there is optimization of system performance.

## 28.4 TECHNICAL REQUIREMENTS

### 28.4.1 GENERATOR STEP UP TRANSFORMER (GSU) 20/400KV

Reference to the Electrical Main Wiring Diagram drawing number 10-PE-PAY-01.

The generator step up transformer (GSU) configuration is a star connection on the high voltage side and a delta connection on the low voltage, or generator side. Three single phase GSUs shall be provided for each unit. One spare GSU shall be provided for the station to serve as backup for any GSU transformer.

The generator transformers shall have forced oil, forced air design, OFAF and shall have redundant oil pumps. The voltage on the LV side of the generator transformer shall be determined from the voltage rating of the plant generator. The voltage on the HV side shall be 400kV.

The MVA, voltage, and impedance rating of the transformer shall be capable of allowing the generator to provide VAR support to the Grid, in accordance with the Bangladesh Grid Code and also be capable of providing voltage support for motor starting.

The generator transformers shall be fitted with no-load tap changers. The tap selection shall be based on power grid voltage variation. The remote control motor drive switch shall be equipped for operation of off circuit tap changer. The voltage-regulating shall only apply when the HV breaker and generator circuit breaker is opened. During normal operation, when exporting power, regulation shall be by the generator automatic voltage regulator.

### 28.4.2 UNIT AUXILIARY TRANSFORMER (UAT)

Two (2) Unit Auxiliary Transformers (“UATs”) of two-windings (20/6.6kV) shall be provided. Each transformer shall be sized to provide the auxiliary power requirements of the Plant without exceeding a 55°C temperature rise. The Contractor shall provide a load flow study for the auxiliary power system. The study shall include system voltage regulation when starting the largest motor on each medium voltage system and the 415/240 V system. The UATs shall be equipped with off load tap changers with the tap range selected based on the load flow study. Connection between UATs and 6.6kV switchgear shall be by Segregated Phase Bus Duct. The cooling system for the UATs shall be ONAN/ONAF. A n+1 fan system will be provided (one additional installed fan will be provided). ONAN power rating will be 60% of ONAF rating.

The UAT shall be fully rated for supplying power to the entire Plant electrical load. The high voltage sides of the transformers are bus bar connected to the generator isolated phase bus duct; and the low voltage winding connected to 6.6kV switchboards through non-segregated phase bus duct.

The UATs shall be equipped with de-energized tap changers (DETC). The DETC shall be motor driven and configured for remote controlled by the DCS. A Local/Remote selector shall be provided to allow the DETC to be operated locally. The tap changer shall have a range of +10 to -10 with 17 steps.

### 28.4.3 STANDBY/STARTUP TRANSFORMER

The Standby/Startup Transformer shall comprise as follows:

- One (1) Standby/Start-up Transformer of two-windings (400/6.6kV) shall be provided. The Standby/Start-up Transformer shall be equipped with power source from the 400kV power distribution unit as the startup/standby power for the Plant.
- Connection between the Standby/Start-up Transformer to the 6.6kV Switchgear shall be of non-segregated phase bus duct.

### 28.4.4 6.6KV UNIT BOARDS

6.6kV unit switchboards shall be fed from two numbers of 20 / 6.6kV double split winding high voltage Unit Auxiliary Transformers and one number of 400 / 6.6kV double split winding

Standby/Startup transformer. The 6.6kV common switchboards shall be interconnected with 6.6kV unit switchboards to enhance reliability. The 6.6kV switchboards shall also supply to the 415V switchboards through auxiliary transformers.

### 28.4.5 CONTROL AND INSTRUMENTATION

The control cabinet contains the power supplies and control circuitry for the fan motors and pumps.

The tap change control cabinet shall include the power supply, motor drive unit, position indicator and control circuit.

The oil and winding temperature instruments shall have provision for a 4-20 mA two-wire facility to enable remote analogue indications. The cooler oil temperature shall be measured at the inlet and outlet of each of cooling unit. These 4-20 mA signals are terminated in the terminal cabinet for the connection of remote temperature monitoring in the DCS.

## 28.5 MAINTAINABILITY

Sufficient space shall be provided around the transformers to allow for maintenance. The layout and construction shall allow convenient access for cranes, trucks, and heavy haul equipment to remove the transformers from their foundation for repair or replacement. The layout of the transformer foundations and fire walls shall allow for the installation of rails to slide the transformer off the foundation to a more convenient location to be lifted by jacking equipment or crane for installation and removal.

## 28.6 OPERABILITY

If one of the transformer cooling systems fails, an alarm is activated in the electrical control room. The standby cooling system shall automatically start. An alarm shall also be activated if the oil flow is less than the pre-calculated minimum value in each of the generator transformer cooler banks.

When power is removed from the transformer, the cooling system shall keep operating until the oil temperature drops below the predetermined temperature.

## 28.7 APPLICABLE STANDARDS

- IEC 60076, all parts
- IEC 60137
- IEC 60354
- IEC 61558

# 29 EARTHING TRANSFORMERS & RESISTORS

## 29.1 SYSTEM IDENTIFICATION

- System Name: Earthing Transformer and Resistor
- KKS Code BAY

## 29.2 CONSTRAINTS AND ASSUMPTIONS

The sizes and rating of the earthing transformers and resistors is dependant on the fault level study that shall be performed as part of the detail design process.

## 29.3 PERFORMANCE

The generator earthing transformer and resistor shall be located at the generator terminals. This, in conjunction with the unit transformer earthing transformers and resistors, limits the earth fault currents. The earth fault current shall be limited to a value determined by the system capacitance.

Earthing transformers and resistors shall be required for the earthing systems for following equipment:

- Generator
- Generator export system
- Generator transformer
- Unit transformer

The equipment shall be able perform their function during normal and abnormal power supply conditions as well as during fault conditions.

## 29.4 TECHNICAL REQUIREMENTS

### 29.4.1 GENERATOR EARTHING

The generator earthing system shall facilitate the protection of the stator winding. During fault conditions this protection limits the magnitude of the earth fault current and the subsequent core damage by the arc that burns the core and welds the laminations together which can lead to overheating due to excessive eddy currents. Using high impedance protection also provides a means for detecting ground faults within the generator.

The generator earthing system shall utilize single phase earthing transformer, with the primary connected to the generator neutral point, and the secondary windings connected to a resistor. The single-phase earthing transformer and resistor rating determination shall be by calculation using generator and system information. For safety, the resistor installation shall be in a proper cabinet.

### 29.4.2 GENERATOR TRANSFORMER EARTHING

The function of earthing the generator transformer neutral shall be as follows:

- The earth fault protection system is simple, as the fault currents are usually high.

- Arcing ground faults cannot occur, as the short circuit current is much larger compared to the capacitive charging developed between the line connection, transformer windings and ground, which is even greater when the system is resistively earthed, thus eliminating its influence. This charge is developed due to the capacitance reactance of the windings and the line connection with reference to ground. If the system was resistively earthed the capacitance charge due to the line connection and the transformer windings during such a fault creates large over voltage spikes on the healthy phases, which is not desirable.

- Over voltages during earth faults is minimized, i.e., less than 0.8 times the phase-to-phase voltages, since with solid earthing the voltage on the healthy phases will only increase towards the phase-to-neutral magnitude, whereas with resistive earthing the voltage here tends towards the phase-to-phase magnitude.

### 29.4.3 UNIT AUXILIARY TRANSFORMER (UAT) EARTHING

On the LV side of the UAT an earthing resistor shall be connected between the star point and earth to limit any resulting phase to earth fault current to a desired limit.

## 29.5 APPLICABLE STANDARDS

- IEC 60037
- IEEE 80

# 30 GENERATOR BREAKER & EARTH SWITCH

## 30.1 SYSTEM IDENTIFICATION

- System Name: Generator Breaker & Earth Switch
- KKS Code BAC

## 30.2 CONSTRAINTS AND ASSUMPTIONS

Generator circuit breakers shall comply with the provisions of IEC 62271-100 and subsequent amendments, with the following additions:

Capable of carrying 115 percent of maximum continuous current rating of the power-generating unit.

- Shall be self cooled by natural convection and radiant.
- Auxiliary cooling or compressed air is not required for the generator circuit breaker operation.

Earthing switches comply with the provisions of IEC 62271-102, in addition:

- An arcing contact will provide the ability to enable the earthing switch to safely interrupt the residual current of the associated generator, with the generator on barring.
- Include facilities for direct visual observation of the main contact open and close positions without possibility of exposure to any live parts.

## 30.3 PERFORMANCE

The function of the breaker is to protect the generator in case of an electrical fault, connect and disconnect the generator from the transmission power system during unit start-ups, and unit shutdowns, and conduct the normal load current without exceeding the temperature rise values permitted by the standards.

The earthing switch acts as an earth connection when maintenance is required on the generator or generator export system.

### 30.3.1 CIRCUIT BREAKER

The generator circuit breaker shall:

- Have voltage ratings greater than generator.
- Interrupt phase-to-phase faults without exceeding short circuit capability
- Close on phase-to-phase or phase-to-earth faults without damage.
- Withstand ground and across gap impulse and power frequency voltages per IEC standards.

The earthing switch shall:

- Have a current and voltage rating equal to the generator circuit breaker.
- Be capable of closing onto the requisite peak short circuit phase-to-phase current.
- Interrupt the residual current of the generator when it is on barring.
- Be capable of carrying the through fault currents as specified for the generator circuit breaker.

## 30.4 TECHNICAL REQUIREMENTS

### 30.4.1 CIRCUIT BREAKERS

The $SF_6$ type generator circuit breakers shall comply with the provisions of IEC 62271-100. Circuit breaker shall be suitable for connection on each side to isolated phase busduct that has a slight positive internal pressure. The circuit breaker phases shall be isolated such that the only possible faults are phase to earth faults. Connection between circuit breakers and isolated phase busduct is by means of laminated copper flexible straps, for both the main conductor and the enclosure.

### 30.4.2 EARTHING SWITCH

Earthing switches shall comply with the provisions of IEC 62271-102. Earthing switches shall be an integral part of the generator side of the circuit breaker and shall be arranged for sequential single pole operation to minimize the possibility of a multi-phase short circuit.

The earthing switch shall be provided with the ability to be manually operated in case of power failure. Earthing switches shall be provided with a local control cubicle. Switches shall have positive locking facilities by means of padlocks to lock the earthing switch in the open or closed position.

### 30.4.3 INTERLOCKING

Interlocking shall be provided to prevent closing of the breaker after a short circuit before the required resting time has lapsed. The interlocking is a function of the actual short circuit current and resting time.

Earthing switches shall be provided with electrical interlocks to prevent closing of the earthing switch if the breaker is closed. Interlocks are also provided to prevent the breaker from closing if any earthing switch is closed. Provision shall be made for remote indication of earthing switch position. A positive mechanical moans shall be provided for immobilizing the earthing switch in both the open and closed position that are capable of resisting the full force of the motor drive.

## 30.5 MAINTAINABILITY

The generator circuit breaker shall have separate, series disconnect switches to facilitate generator maintenance while the other side of the generator bus duct is energized. Disconnect switches shall comply with the provisions of IEC 62271-102. Circuit breakers shall be designed for minimum maintenance. Components requiring frequent maintenance shall be easily accessible and removable.

## 30.6 OPERABILITY

The station operator is able to check such things as pressure gauges and main contact positions from the mounting plinth level without opening doors or covers.

## 30.7 APPLICABLE STANDARDS

- IEC 62271 applicable parts and subsequent amendments
- IEC 60529
- IEC 61271-100
- IEC 61271-102
- IEEE C37.013
- ISO 2437
- IEC 60037
- IEC 60044
- IEC 60071

# 31 CONDENSING

## 31.1 SYSTEM IDENTIFICATION

- System Name: Condensing
- KKS Code MAG

## 31.2 FUNCTION

The Condensing System condenses main turbine exhaust steam and other reclaimable steam. In addition, the system serves as a collection point for certain cycle drains which are reclaimable as condensate. The system returns condensate to the Condensate System and also provides short-term condensate storage.

## 31.3 PROCESS DESCRIPTION

Process flow diagrams of the Condensing System are shown on drawings 10-PM-PAY-03.

The Condensing System includes the following major components:

- double shell, double pass, and double pressure surface type condenser including all auxiliary equipment necessary.
- Two (2) 100 % capacity condensate pumps including all auxiliary equipment necessary
- One gland steam condenser
- Two (2) condensate pump suction strainers with differential pressure measurement
- Minimum flow (leak off valve) protection device including isolating valve actuators and back pressure regulator. Minimum flow of Condensate Extraction system consisting of a Control Valve associated with multi orifice diaphragm.[zl]
- Power Operated Vacuum breakers on the condenser.
- Piping, valves, fittings, and other accessories.

The Condensing System condenses main cycle exhaust steam and other reclaimable steam and serves as a collection point for certain cycle drains that are reclaimable as condensate. The system provides short'-term storage and a means to supply condensate to the deaerator at startup and throughout the operating load range of the unit.

The LP turbine exhausts steam through the turbine exhaust into the condenser. The steam is condensed in the condenser. Air and other non-condensable gases are removed by the Condenser Air Extraction System.

The condensate will be taken from the condenser hot well to the suction of the condensate pumps. The condenser hot well will provide surge capacity to allow continued operation through load changes and upset conditions. A simplex strainer shall be installed in the suction line of each condensate pump to remove any debris during commissioning and normal operation.

A recirculation line from a point downstream of the gland steam condenser to the main condenser shall be provided to maintain minimum required pump flowrate. The recirculation line shall also ensure minimum flow through the gland steam condenser during startup and low load operation.

The condenser hot well level will be maintained within a suitable operating range to assure that water is always available to the condensate pumps and to assure that flooding of the condenser shells will not occur Makeup water will be provided to the condenser during normal and low level operation through makeup control valves. The makeup system will include a normal makeup control valve and an alternate makeup valve. Both valves take suction from a local (unit specific) condensate storage tank which will be filled by the Cycle Makeup and Storage System. The spray and seal water will be supplied between the gland steam condenser and the condensate regulating valves.

The Condensing System includes supply and return connections for the Condensate Polishing System. A motorized valve ON/OFF shall be provided on the bypass line.[z2] Detailed information for the condensate polishing can be found in the Condensate Polishing (LD) system description.

Detailed information for the oxygen and ammonia feed can be found in the Chemical Feed (LF) system description.

## 31.4 BASIS FOR DESIGN

The condenser hot well storage working capacity between Normal Working Level and Low Low Working Level shall be at least 3 minutes (retention time) when operating at TMCR conditions.

An alarm shall be provided at low level and the condensate pumps shall trip at low low level.

Power operated vacuum breakers shall be provided to reduce the roll-down time of the steam turbine after trip by allowing air to be vented into the Condensing System. The vacuum breaker valves shall operate in only two positions: fully closed or fully open. The design, control and operation of the vacuum breaker valves shall be based on the turbine manufacturer’s recommendations. A water seal shall be provided on each of the power operated vacuum breaker valves to prevent the admission of air and other non.-condensable gases into the Condensing System during normal operation. Condensate shall be used for the seal water.

Condenser air extraction piping, condensate piping, and vacuum breaker valve material shall be carbon steel.

The optimum condensate extraction pump efficiency should be obtained at the Turbine MCR duty point. The zero flow head at the design speed shall be at least 125 % of the duty point head. The two 100% condensate extraction pumps shall be able to run in parallel during abnormal condenser and deaerator levels. This abnormal operating condition shall be accounted for in the control of the Condensing System.

A common minimum flow or leak-off system shall be provided to protect the condensate pumps against overheating at low flow conditions.

The Condensing System shall be designed and fabricated in accordance with ASME Codes and Standards

# 32 CONDENSER AIR EXTRACTION

## 32.1 SYSTEM IDENTIFICATION

- System Name: Condenser Air Extraction
- KKS Code MAJ

## 32.2 FUNCTION

The Condenser Air Extraction system removes the non-.condensable gases from the Condensing System during operation and rapidly reduces the condenser pressure before unit startup.

## 32.3 PROCESS DESCRIPTION

The Condenser Air Extraction System will include the following major equipment and components:

- Three 50% capacity water ring vacuum pumps
- Interconnecting piping between the condenser and the vacuum pump

Removal of non-condensable gases from the condenser steam space reduces condenser pressure and prevents blanketing of condenser tubes, thus improving heat transfer and main turbine generator performance. The non-condensable gases will be drawn through piping from the surface condenser to the vacuum pumps. The vacuum pumps will compress the non-condensable gases and discharge them to a separator at a pressure slightly above that of atmospheric pressure. Any entrained moisture discharged from the vacuum pump will be collected in the separator and reused as seal water in the condenser exhauster or sent to drain. The "dry" non-condensable flow from the separator will be vented to the atmosphere at an exterior location

Three vacuum pumps are used during startup to rapidly reduce the condenser pressure below atmospheric pressure. This "hogging" process is done to allow the admission of steam to the condenser.

## 32.4 BASIS FOR DESIGN

The time required to reduce the condenser from atmospheric pressure to a pressure suitable to start bypassing steam to the condenser shall be 30 minutes or less. The maximum allowable condenser pressure to bypass steam shall be defined by the steam turbine supplier.

Condenser air extraction piping and vacuum breaker valve material shall be carbon steel.

For liquid ring type rotary pumps, sealing water shall be from the condensate quality water. Heat exchanger cooling water may be by seawater. The controls shall be designed to allow each vacuum pump to be operated independently in manual or automatic mode. When in automatic mode, the pump operation shall be interlocked with the vacuum switch.

The Condenser Air Extraction system shall be designed and fabricated in accordance with ASME Codes.

# 33 METERING & MEASUREMENTS

## 33.1 SYSTEM IDENTIFICATION

- System Name: Metering and Measurements
- KKS Code AQA

## 33.2 CONSTRAINTS AND ASSUMPTIONS

The following key areas require metering systems to evaluate and monitor the economics of power supply and sales:

- Generator
- Auxiliary power
- Generator transformer
- Loop supply
- Diesel generators

An overall measurement accuracy of ±0.2 % for active energy and 1% for reactive energy is required for the generator.

The three phase four wire method of measurement shall be employed for all metering installations.

A single hardware or software failure in the measurements system shall not result in a critical unit trip.

Component failures shall not propagate throughout the measurement system, increasing the scope of repair and loss of function.

## 33.3 PERFORMANCE

MW parameter shall require redundancy for security and reliability of the generator load.

The auxiliary supply to the equipment shall be DC power. The measurement equipment shall have multi-functionality.

The accuracy of measurement for the generator and unit transformer circuits shall be tariff quality.

The manufacturer shall perform calibration of the measurement equipment and issue a calibration certificate for the installed and tested measurement equipment including, CTs and VTs.

The information gathered shall be accumulated into an Energy Management Data Acquisition System (EMDAS). The information shall be correct and compatible with the measurement data and equipment used for the transmission interface.

## 33.4 TECHNICAL REQUIREMENTS

Tariff energy meters shall be provided for the accurate measurement of the generated MWh and MVarh.

Signals for Automatic Generation Control (AGC) purposes shall be interfaced to the Automatic Generation Control Remote Terminal Unit (AGC RTU). All real time signals (for a generator and unit transformers) to National control for Network operation shall be via the AGC RTU.

The unit auxiliary transformers shall be measured on the HV side for the correct electrical parameters required for operational and monitoring purposes.

Redundancy is required for operational purposes. High accuracy (class 0.2S) precision user configurable energy meters shall be used for main and check metering purposes.

Two completely independent sets of metering equipment for the generator entitled revenue and back-up metering shall be provided using high accuracy equipment. Main and back-up metering shall have independent CT cores respectively. The VT winding shall be also independent for both sets of meters.

Both sets of meters shall have latest technology type recorders with high accuracy and communication interface.

Specification for import / export metering both at GSUT and Start-up/Stand-By Transformer specification must comply with PGCB requirements including specification for IVT / CT class, etc.

For accurate measurement of four-quadrant energy exported or imported (kWh, kVAh), dedicated CTs and VTs, shall be installed on the HV side of the generator transformers.

The auxiliary supply shall be metered at the Unit level as well as on the Station board level. Metering equipment redundancy is not required at these levels.

MV switchboard measurement shall be provided for each incoming and outgoing feeder, and each motor circuit.

For LV switchboards, measurement shall be provided for each incoming and outgoing feeders, and on motor circuits above 75kW.

An EMDAS shall be installed and used for the acquisition and processing of energy data. The system shall also automatically transfer data to the various users of the data as well as make data available on demand.

All equipment shall be installed in air conditioned environments.

## 33.5 MAINTAINABILITY

All equipment shall be easily accessible for maintenance purposes.

## 33.6 OPERABILITY

The operating philosophy of the station shall determine the way in which the energy data is to be used and reported on. This shall be automatic with no manual interference or manipulation allowed.

## 33.7 APPLICABLE STANDARDS

- IEC 60051
- IEC 60060-2
- IEC 60688
- IEC 62053-11, -21, -22, -23
- IEC 60297
- IEC 60044-2
- IEC 60044-1

# 34 AUXILIARY STEAM SUPPLY

## 34.1 SYSTEM IDENTIFICATION

- System Name: Auxiliary Steam System
- KKS Code LBG

## 34.2 FUNCTION

The Auxiliary Steam System provides auxiliary steam during startup and normal station operation.

## 34.3 PROCESS DESCRIPTION

The Auxiliary Steam System will continuously supply the auxiliary steam requirements for the unit during normal operation, startup, and shutdown.

During start up of the Plant, the auxiliary steam header shall be supplied with steam from Auxiliary Boiler during start-up and auxiliary steam shall be supplied from Cold Reheat line when the Boiler steam becomes available at sufficient pressure and temperature. Cold reheat steam will be attemperated to match the service conditions required by the equipment.

The Contractor shall condition the steam entering the auxiliary steam header (pressure reduction and attemperation) to match the service conditions required by the equipment.

- Auxiliary steam users will include the following:
- Atomizing medium for the HSD fuel burners
- Deaerator Prewarming and Pegging. Auxiliary steam will be provided to elevate the temperature of the water stored in the deaerator while maintaining operating pressure in the deaerator.
- Turbine and BFP Turbine Seal Steam. Auxiliary steam will be provided for the seals of the steam turbine and steam driven BFP turbine at startup until the turbine becomes self sealing.
- Steam Air Heater if required. Auxiliary steam will be provided to the air preheat coils if required for regenerative air heater corrosion protection during startup and low load operation if required.
- Sootblower system for the Air heater
- Sootblower system for the Boiler

## 34.4 BASIS FOR DESIGN

The Auxiliary Steam System shall be designed and constructed in accordance with the ASME Codes and Standards

The Auxiliary Steam System shall be designed for auxiliary steam header pressures and temperatures consistent with the worst case needs of the users being served. Auxiliary steam piping and valves shall be constructed in ASME materials in accordance with ASME Codes.

During plant startup the auxiliary steam shall be supplied from the Auxiliary Boiler

A manually operated bypass valve shall be installed in parallel with the isolating valve to allow warming up of the interconnection line and the auxiliary steam header on the plant. The contractor shall install a temperature sensor on the auxiliary steam header to provide a permissive to open the isolation valve once the header and the connecting piping is warmed up. Contractor shall arrange the piping to ensure drainage of accumulated condensate and install steam traps at strategic locations to ensure the condensate is removed. The discharge from the steam traps shall be collected and transported in accordance with the DOE requirements.

Once the cold reheat steam is available, it will enable the interconnection line to the existing facility auxiliary boiler to be isolated. The piping systems downstream of the header can then be warmed up and used as required. Pressure and temperature of the steam provided from the Cold Reheat Steam System shall be conditioned to match the auxiliary steam header conditions.

# 35 CONTINUOUS EMISSIONS MONITORING

## 35.1 SYSTEM IDENTIFICATION

- System Name: Continuous Emissions Monitoring
- KKS Code ST

## 35.2 FUNCTION

The function of the Continuous Emissions Monitoring System is to measure the combustion gases to determine constituent concentrations for emissions monitoring and reporting.

## 35.3 PROCESS DESCRIPTION

The Continuous Emissions Monitoring System (CEMS) will be used to regulate and control the boiler combustion process and provide documentation for compliance with regulatory emission requirements via continuous emission monitoring (CEM) equipment. The CEMS will be designed to comply with the requirements of the Environmental Protection Agency as stated in 40 CFR Part 60, or equivalent International Standards and Department of Environment of Bangladesh. The CEMS will fulfill the applicable requirements for emissions monitoring and will be in accordance with national and local regulations.

The Continuous Emissions Monitoring System will measure the following flue gas constituents and characteristics at the following locations for each unit:

- Stack:
  - Oxygen ($O_2$)
  - Carbon Dioxide ($CO_2$)
  - Sulfur Dioxide ($SO_2$).
  - Oxides of Nitrogen ($NO_x$)
  - Carbon Monoxide (CO)
  - Volumetric flow rate.
  - Flue gas temperature.
  - Flue gas pressure.
- ESP Outlet:
  - Opacity.
- Other
  - Atmosphere pressure (if required).

The above analog measurements will have a 4 - 20 mA signal hardwired to the DCS for monitoring, trending, and display. A data acquisition and handling system (DAHS) shall be provided for data logging, alarming, and reporting. In addition to the hardwired inputs to the DCS an open protocol datalink shall be provided to communicate additional information from the CEMS to the DCS for condition monitoring of the CEMS controller and gas analyzers. An open protocol datalink interface shall be reserved for connection to regulatory agencies (if required).

The CEM equipment will be a highly reliable extractive type system. The CEM cabinets shall be installed in a walk-in fully enclosed and temperature controlled shelter and the CEM sampling points will be located in stack. The shelter shall have redundant HVAG systems. The gas samples will be extracted through a probe and transported in its original state to the analyzers. Design of the system will be such that the sample lines will be heat traced. Opacity will be measured directly in accordance with 40 GFR Part 60.

A controller will be provided for the CEMS to control all sampling, calibration, and back-purging functions of the emissions monitoring system, and provide initial signal conditioning. The CEMS controller will transfer the signal conditioned data to the DAHS from which the DAHS will be used to generate the reports as required by applicable regulatory agencies and plant operations.

The CEMS System data|ink to the DCS will allow the operator access to actual analyzer measurements for monitoring, trending, display and alarm of selected measurement, alarm data and data storage.

## 35.4 BASIS FOR DESIGN

Systems selected are to be compatible and complimentary to each other to provide an emission’s sampling, monitoring, and calibrating arrangement acceptable to all local and national agencies for emissions reporting.

# 36 STEAM CYCLE SAMPLING AND ANALYSIS

## 36.1 SYSTEM IDENTIFICATION

- System Name: Steam Cycle Sampling and Analysis
- KKS Code QU

## 36.2 FUNCTION

The function of the Steam Cycle Sampling and Analysis System is to monitor the water/steam purity and chemical performance and operation of the steam-condensate-feedwater cycle. The system provides sufficient data to operating personnel for detection of any deviations from control limits so corrective action can be taken.

## 36.3 PROCESS DESCRIPTION

The Steam Cycle Sampling and Analysis System shall include the following major equipment and components:

- One sample panel with integral wet (sample conditioning) and dry (analyzer) sections.
- One secondary sample chiller.
- Interconnecting piping, tubing, and valves.
- As a minimum, the analyzers noted in Table 1

The sample system receives and provides analysis for samples as listed in Table 1.
Note - Sampling and analysis components for local samples for the auxiliary boiler, the Demineralized Water Treatment System, and the Flue Gas Desulfurization System are considered a part of those systems.

The wet side (sample conditioning) of the sample panel shall provide the following functions:

- Receive samples.
- Provide primary cooling of each sample with a design temperature above 49°C.
- Provide for blowdown to waste of each sample.
- Provide final controlled cooling to 25°C +/- 2.0°C for each sample sent to automatic analyzers.
- Regulate flow of each sample.
- Provide safety relief for overpressure protection of all downstream equipment for each sample.
- Provide automatic thermal shutoff valves for high temperature protection of all downstream equipment for each high temperature sample.
- Provide pressure control and indication for each sample.

- Provide temperature indication after primary and secondary cooling for each sample.
- Provide measurement of pH, specific conductivity, cation conductivity, sodium, silica, and dissolved oxygen of selected sample streams.
- Provide control and indication of sample flow rates to analyzers.
- Provide grab samples for each sample stream.
- Provide cooling water safety relief for protection of each sample cooler.
- Provide drainage to waste for all sample streams and discharges from analyzers.

The dry side (analyzer) shall provide the following functions:

- Receive conditioned samples for routing to the various analyzers.
- Provide selector equipment for automatic switching of multiple sample streams to shared analyzers.
- Indicate locally each measurement signals of pH, specific conductivity, cation conductivity, sodium, silica, and dissolved oxygen from the analyzers.
- Transmit each measurement signal to the plant Distributed Control System (DCS).
- House all electrical and control components associated with the Sampling System.

## 36.4 BASIS FOR DESIGN

The sample panels shall be designed to condition the samples before analysis. The samples flow through the tube side of the coolers, where heat removal occurs. Secondary sample coolers shall be used in conjunction with the Closed Temperature Control Unit (Secondary Sample Chiller) to achieve a controlled temperature of 25$^{o}$C +/- 2.0$^{o}$C. The final temperature of each sample shall be 25$^{o}$C +/- 2.0$^{o}$C. Each sample pressure shall be reduced to approximately 140 kPa. Conditioned samples shall be continuously monitored for parameters as indicated in Table 1. Flow to each analyzer branch shall be controlled via pressure controller and indicated on the flow indicators. Flow indicators should be set to maintain approximately 500 to 1,500 ml/min, sufficient to supply in-line instrumentation and grab samples. Flow adjustment occurs by adjusting the appropriate pressure control valve. Grab samples can be taken at any time for laboratory analysis.

Sample lines from the sample points to the sampling equipment shall be Type 316 stainless steel tubing, sized for the maximum sample flow with consideration for reducing sample lag as much as possible. Samples where temperatures exceed 535°C require Type 316 stainless steel with minimum 0.04 percent carbon content. Where sample conditions (temperature and pressure) preclude the use of tubing, suitable sample piping shall be required.

The sample panels shall be located in a conditioned space within the Steam Turbine Building.

**Table 1**
**Sample Points with Associated Analyzers**

| Sample Point | pH | Specific Conductivity | Cation Conductivity | Degassed Cation Conductivity | Dissolved Oxygen | Sodium | Silica |
|---|---|---|---|---|---|---|---|
| Demineralized water plant outlet | | X | | | | X | X |
| Cycle Makeup | | X | | | | | |
| Condensate Pump Discharge | | X | X | X | X | X | |
| Condensate Polisher A Effluent (only Local Polisher Panel) | | | X | | | X | X |
| Condensate Polisher B Effluent (only Local Polisher Panel) | | | X | | | X | X |
| Condensate Polisher C Effluent (only Local Polisher Panel) | | | X | | | X | X |
| Condensate Polisher Common Effluent | | X | X | | X | X | X |
| Deaerator Effluent | | | | | X | | |
| Economizer Inlet | X | X | X | | X | | |
| Main Steam | | X | X | X | X | X | X |
| Hot Reheat Steam | | X | X | X | X | X | X |

# 37 BOILER

## 37.1 SYSTEM IDENTIFICATION

- System Name: Boiler
- KKS Code HA

## 37.2 FUNCTION

The Boiler System provides for the transfer of heat released during the combustion of the fuel to the feedwater and steam. This heat transfer produces main steam at an ultra-supercritical or supercritical pressure and temperature required by the high-pressure steam turbine. Heat transfer also takes place in the reheater to increase the temperature of the cold reheat steam to that required by the intermediate-pressure steam turbine. The Boiler will receive a coal-air mixture from the pulverizers from the Coal Handling System (CHB), ignitor oil from the Fuel Oil Unloading, Storage and Supply System, feedwater from the Boiler Feed System, reheat steam from the Cold Reheat Steam System, and combustion air. The Boiler will be a once-through supercritical, variable pressure, top supported, welded wall, balanced draft, single reheat, field erected unit direct fired with pulverized bituminous coal. The Boiler will include low NOx burners and overtire air systems to reduce NOx emissions to meet the emissions guarantees.

## 37.3 PROCESS DESCRIPTION

The Boiler shall include the following major equipment and components:

- Feedwater/steam cooled furnace.
- Steam separator.
- Boiler recirculation pump start up system.
- Water walls, roof panel tubes.
- Superheater tube sections.
- Reheater tube sections.
- Economizer tube sections.
- Steam temperature control (desuperheaters).
- Boiler Safety Valves
- Tilting burners
- Ignitor oil packages (as required by manufacturer).
- Coal silos.
- Coal feeders.
- Coal pulverizers.
- Wind box and low NOx burners.
- Flame scanners.
- Regenerative air preheater.
- Forced Draft (FD) fans.
- Primary Air (PA) fans.

- Ductwork, breeching, and expansion joints.
- Soot blowers for on-line convective surface cleaning
- Steam wall blowers for furnace wall tube cleaning
- Associated piping, valves, instruments, and accessories.

Combustion of pulverized coal fuel with air, releases radiant and convective heat energy in the boiler furnace. The Boiler System also receives feedwater from the boiler feed pumps described in the Boiler Feed System (FWA), and cold reheat steam from the high-pressure steam turbine exhaust as described in the Cold Reheat Steam System (SGK). The boiler will use these sources to produce steam at the required operating conditions for main steam flow to the high-pressure steam turbine and for hot reheat steam flow to the intermediate-pressure steam turbine.

Boiler feedwater enters the economizer section of the boiler, located at the lowest temperature stage of the convection pass heat recovery area. Exhaust gas will flow across the economizer tubes in a direction opposite to the feedwater flow.

The furnace section of the boiler will be a gas-tight construction of welded membrane carbon steel tubes. The furnace tubes will be in vertical arrangement to minimize localized hot spots and minimize thermal stresses. The furnace tube construction is dependent on the manufacturer's specific design. The furnace will consist of a combustion zone that is to be conservatively sized in order to minimize slagging, fouling, and erosion risks based on the design coals.

The boiler will consist of feedwater and steam cooled furnace walls, convection pass walls, convection pass screen tubes, primary superheat tubes, finishing secondary superheater tubes, reheater tube sections and steam separator and water collector vessels. The bottom of the furnace will slope down and toward the center of the furnace from the water walls to form a long sloping ash discharge interface leading into the bottom ash submerged scraper chain conveyor.

The steam temperature leaving the final superheater will be controlled with firing rate and feedwater flow control. Attemperators (desuperheaters) may also be used for emergency control. The attemperator spray water will be supplied from the Boiler Feed System (FWA). The boiler water recirculation pump is used during startup and up to the minimum once through load (between 35 and 40% BMCR) to maintain a minimum circulation in the boiler wall tubes cooled by feedwater and steam.

The reheater section of the boiler will consist of convective heat recovery surface and radiant surface as designed by the boiler supplier. Steam from the Cold Reheat Steam System (SGK) enters the reheater inlet header section at the low temperature end of the flue gas path and then flows counter to the flue gas stream. Reheated steam leaves through the outlet header located external to the flue gas stream.

The boiler will be a two-pass boiler design. The boiler will combust pulverized coal in suspension within the furnace and exhaust the flue gas to the air heater. The furnace will be tangential burner configuration. The method of steam temperature control for tangentially fired boilers is by the use of tilting burners in the furnace to move the fireball higher or lower in the furnace that enable greater or less heat transfer from the flue gas to the furnace walls before the gas enters the convection pass area of the boiler.

The reheater steam outlet temperature shall be provided with means of emergency temperature control by a boiler reheat desuperheater located between reheaters 1 and 2. Spray water for the boiler reheat desuperheater will be provided from the Boiler Feed System (FWA).

The method of steam temperature control will be determined by the Supplier. In any case, spray attemperators shall be provided as part of the steam temperature controls for fast desuperheating response for any temperature excursions.

The boiler will be top supported with thermal growth downward. Connections to the boiler shall be designed to accommodate this expansion without excessive stress.

Low NOx burners and an overtire air system shall be installed in order to accurately stage combustion and minimize the formation of NOx during the combustion process in order to meet the emissions guarantees.

## 37.4 BASIS FOR DESIGN

The following regulatory requirements and design Codes and Standards are applicable to the Boiler System:

- ASME 831.1
- ASME Boiler & Pressure Vessel Code
- Other Applicable ASME standards
- Applicable NFPA standards.

The Boiler System shall be suitable for continuous safe and reliable operation at all loads from startup to the Boiler Maximum Continuous Rating (BMCR) condition and include:

- Base load operation is defined as 100% MCR. Turbine MCR is defined as 103% MCR. Boiler MCR is defined as 105% MCR.
- The operation of the boiler will initially be base load operation but it will have the ability to load follow in normal automatic control (from 30 percent MCR to 100 percent BMCR) and two-shift daily cycling operation.
- The boiler shall be designed to operate in the sliding pressure mode in normal automatic control over the range 30 percent to 100 percent Maximum Continuous Rating (MCR) as well as Valves Wide Open (VWO) operating mode (103% MCR). The boiler shall be capable of operating at BMCR (105% MCR) with the worst-case coal.
- The boiler shall be designed to meet the steam requirements listed in the heat balances.
- Continuous operation at minimum load.

- Daily load swings from minimum load to MCR.
- Operation under minimum load change ramp rate of ±3 percent of TMCR per minute (increasing or decreasing) under variable pressure operation or constant pressure operation in normal automatic control is required from a minimum of Once-through load. This rate will be reduced to 1% per minute when increasing load between 90% and 100% BMCR.
- Four cold starts per year, where a cold start is defined as a startup after a 48 hour (or greater) shutdown.
- Twelve warm starts per year, where a warm start is defined as a startup after an 8 to 48 hour shutdown.
- Forty Eighty hot starts per year, where a hot start is defined as a startup after less than an 8 hour shutdown.
- The Boiler System shall be capable of stable firing without the use of fuel oil ignitors or warm-up guns to stabilize the coal flame from 30 percent MCR to 100 percent BMCR.
- The minimum stable load (30% MCR) shall be achieved with two adjacent coal elevations (i.e. two pulverizers) in service without the use of distillate fuel.

The functional constraints on the Boiler System will be as follows:

- The maximum reheater pressure drop shall be designed such that the combined pressure losses of the cold reheat piping, reheater, and hot reheat piping do not exceed 8 percent of the high-pressure turbine exhaust pressure during turbine operation at the rated valves wide open (VWO) condition at design steam turbine throttle pressure and temperature. The reheater outlet pressure at the VWO conditions shall correspond to the required IP turbine inlet pressure plus the pressure drop through the hot reheat piping.
- The boiler furnace, ductwork, breeching, and expansion joints shall be designed to withstand the transient internal operating pressures without permanent deformation of any support member. The furnace shall have a transient design pressure of no less than 8.7 kPag in accordance with the provisions of NFPA 85.
- The Boiler System shall be designed to operate at BMCR without unscheduled maintenance, slagging, or other operating constraints when fired with any of the specified coals.
- Maximum flue gas temperature entering the convective zone shall not exceed 1010°C. The entrance to the convective zone is located at the water\all hangers.
- Maximum flue gas velocity shall not exceed 18 meters/second.
- Burner heat input per plan area shall not exceed 5.04 MW/m$^2$ at MGR.
- Water chemistry of the boiler feedwater will be controlled within limits prescribed by the boiler manufacturer and steam turbine manufacturer so that steam produced by the boiler will be of sufficient purity in order to meet the manufacturers steam purity requirements to prevent corrosion, erosion, and solid deposits occurring in the boiler, steam piping, and steam turbine.

- The maximum pressure drop through the boiler from the feedwater inlet connection to the main steam outlet shall be no more than 58 bar.
- The pressure drop in the safety valve inlet piping shall not exceed 50 percent of the expected blowdown of the valve.
- Safety valve quantity and capacity shall be in accordance with the ASME Boiler & Pressure Vessel Code Section 1.

Physical constraints on the Boiler System are as follows:

- The piping shall be routed to provide the shortest length consistent with a flexibility analysis designed to limit forces and moments on the boiler and turbine-generator connections.
- All valves, dampers, and motor operators shall be accessible from permanent platforms for maintenance and operation.
- The equipment, piping, and electrical conduit and cable tray shall be routed to allow a minimum of 2 meters of headroom above normal personnel access ways and shall not be routed in egress pathways.
- Insulation shall be designed to limit the surface temperature of the lagging to <66$^{o}$C where pipe or lagging may be accessible to personnel.
- Isolation valves shall be provided as required in ASME Boiler & Pressure Vessel Code. Isolating valves in the boiler outlet steam pipe shall be located downstream of the boiler safety valves, such that they cannot impede pressure relief during an overpressure event.
- The boiler shall be top supported to allow downward thermal expansion and guided to control movement.
- The combined capacity of the coal silos shall be sufficient to store coal for a duration of 12 hours when the boiler is operating at BMCR based on the worst case coal conditions.
- Inspection / peep holes shall be located at appropriate angle and floor to view combustion flame.

### 37.4.1 CONTROLS

Control of the Boiler System is a function of the Distributed Control System (DCS).

Control items directly or indirectly affecting the Boiler System include the following:

- Control of coal flow, transport air flow and temperature, and combustion air flow.
- Superheat steam temperature control by boiler feed water flow control, and spray water desuperheating.
- Reheat steam temperature control by tilting burners and/or spray water desuperheating.
- Furnace draft control by the induced draft fan operation.
- Furnace wall protection and separator bottle level control by flow recirculation

- Gas path safety controls.

The Boiler System shall contain the necessary instruments for safe and reliable control and monitoring of the boiler and its auxiliaries; as a minimum, all instruments and associated devices required by the applicable ASME 831.1 and Boiler & Pressure Vessel Code, Malaysia Factories and Machinery Regulations, and NFPA codes.

### 37.4.2 BOILER TRIP SIGNALS

The protective trips associated with boiler subsystems are provided in part by the Burner Management System and in part by the Unit Protection System of the DCS.

Boiler safety interlocks are intended to prevent the accumulation and ignition of an appreciable volume of fuel-air mixture within the furnace gas passages or air passages. Positive interlocks are to be used to prevent hazardous operating procedures. Protection must be provided against fuel leakage into the furnace during an idle period and against fuel accumulations or potentially unsafe furnace conditions while operating.

# 38 BOILER VENTS AND DRAINS

## 38.1 SYSTEM IDENTIFICATION

- System Name: Boiler Vents and Drains
- KKS Code HA

## 38.2 FUNCTION

The Boiler Vents and Drains System will provide vents and drains for the steam generator and related systems and equipment. Boiler vent piping will provide a flow path from steam generator vent connections to a location for safe discharge to the atmosphere. Boiler drain piping will collect steam generator component drains and other related drains in the Startup System Flash Tank to separate flashing steam from condensate at atmospheric pressure, allowing much of the boiler drain water to be reclaimed.

## 38.3 PROCESS DESCRIPTION

The Boiler Vents and Drains System will include the following major equipment and components:

- Start up System Flash Tank
- Main steam, cold reheat steam and hot reheat steam safety valve vents and drains, as required.
- Boiler waterside maintenance drains.
- Superheater and economizer vents and drains.
- Associated piping, valves, instruments, controls, and accessories.

The purpose of the Startup System Flash Tank is to receive high energy drains and separate the water and steam components so that the water can be reclaimed. A loop seal is provided and sized to ensure sufficient height to prevent the water from being blown out by the normal operating pressure in the tank (slightly above atmospheric). The Startup System Flash Tank shall be sized to prevent excessive carryover of water droplets from the vent, or producing severe noise problems.

Power operated valves shall be provided for use during unit start-up for venting and warming of boiler components.

Drains will be collected in piping headers, segregated by operating pressure, prior to entering the Start up System Flash Tank In the Startup System Flash Tank , flashing steam will be separated from water and vented to the atmosphere. The water from the Start up System Flash Tank shall be routed to the Condenser.

## 38.4 BASIS FOR DESIGN

The Boiler Vents and Drains System shall be designed and constructed in accordance with the ASME Codes and Standards

Operating vents and drains, normally used during startup and shutdown shall be power operated, controlled from the control room through the Distributed Control System (DCS), and shall be used in combination with an upstream manual globe or ball valve for maintenance and to meet boiler code requirements. Maintenance drains, such as economizer drains and other equipment drains will be manually operated.

Steam vents, including startup vents and safety valves shall be equipped with silencers if necessary to meet the project noise requirements. Vent piping shall be routed to locations away from personnel, arranged to minimize exposure of personnel to noise, as well as provided with personnel protection thermal insulation or barriers in locations where personnel may come into contact with hot vent piping. Safety valves, vent valves, and connecting piping shall have drain piping to remove condensate and accumulated rain water from these areas, thereby preventing the possibility of vents being blocked or damaged by slugs of accumulated water. Drains shall be routed to the Start up System Flash Tank.

Vent piping shall be adequately sized to prevent excessive backpressure from interfering with the function or capacity of the venting device. Vents and drains shall be routed separately as individual piping runs. In locations where vents or drains must be connected together, such as drain headers, the drains shall be grouped by upstream pressure, and the piping header shall be conservatively sized to prevent the accumulation of excessive backpressure at maximum flow. Drain headers and Start up System Flash Tank sizing shall be based on the maximum possible coincident flow rates during a cold startup.

Alloy piping shall be used downstream from the last isolation valve for high temperature boiler drain piping to the Start up System Flash Tank. This will ensure that localized high temperatures caused by valve leakage, or by a drain valve left open, will not compromise the piping system integrity or cause failure due to erosion from high fluid velocities.

# 39 MAIN STEAM

## 39.1 SYSTEM IDENTIFICATION

- System Name: Main Steam
- KKS Code HA

## 39.2 FUNCTION

The Main Steam System conveys superheated steam from the Boiler superheater outlet to the turbine stop valves of the high pressure (HP) steam turbine.

## 39.3 PROCESS DESCRIPTION

A process flow diagram of the Main Steam System is shown on drawing 10-PM-PAY-03.

The Main Steam System will include the associated alloy steam piping, valves, instruments, controls, and accessories required to convey steam from the steam generator to the HP steam turbine.

Main steam will be heated in the Boiler and will flow from two separate superheater outlet headers to the turbine stop valves and HP steam turbine. A balancing line shall be placed upstream of the turbine stop valves to maintain equilibrium in the steam lines. Provisions shall be included to facilitate warming of the main steam lines prior to unit startup. During startup condensate collected shall be collected and returned to the condenser.

A connection to bypass main steam around the HP turbine to cold reheat steam shall be provided. The bypass system shall be sufficient to allow startup from cold, warm, and hot conditions as well as not lift safety valves in the event of a steam turbine trip when operating at 100% TMCR conditions. The bypass system shall also be designed to support steam turbine operation on house load after full load rejection for an extended period of time. Attemperator water is provided from the Boiler Feed System. A warming line shall be routed to the Cold Reheat Steam System to reduce the potential of thermal shock when extracting steam from the HP turbine during startup.

Drain lines shall be provided for water removal from the main steam lines. These drain lines shall be located at low points in horizontal runs and also as near as practical to the turbine stop valves.

## 39.4 BASIS FOR DESIGN

The Main Steam System shall be designed and constructed in accordance with ASME or EN Codes and Standards

Instrumentation isolation, vents, and drains shall be installed using double valves.

Piping design shall meet ASME TOP-1 and the turbine manufacturer's requirements for turbine water induction prevention.

Main steam piping shall be seamless P92 or P91 chrome-moly piping material.

The Main Steam System shall be designed to deliver steam to the HP steam turbine at all steaming rates from start-up conditions to the steaming rate which corresponds to that required for turbine operation at the valves wide open boiler maximum continuous rating (BMCR) condition.

# 40 SOOT BLOWING

## 40.1 SYSTEM IDENTIFICATION

- System Name: Soot Blowing
- KKS Code HC

## 40.2 FUNCTION

The Soot Blowing System removes ash deposits from the heat transfer surfaces of the boiler, air heater, and gas-to-gas reheater to maintain steam generator efficiency, prevent ash pluggage and maintain normal operating temperatures.

## 40.3 PROCESS DESCRIPTION - BOILER

The Soot Blowing System will generally include the following major equipment and components. The number, type, and location of soot blowing equipment will vary among steam generator manufacturers.

- Retractable and rotary steam soot blowers.
- Steam furnace wall blowers
- Associated piping, valves, instruments, controls, and accessories.
- Steam sootblowers for each air heater and each gas-to-gas heater

The furnace soot blowers, convection pass soot blowers, air heater soot blowers and will receive steam from the primary superheater by way of pressure reducing valve stations. Each steam source will be provided with a full-capacity pressure control valve station, one motor-operated isolation valve, one manual isolation valve and one safety relief valve. This steam will be directed as jets onto the convective heat transfer surfaces of the boiler and the air heater to blow off ash deposits. During the initial phases of startup, the air heater soot blowers will receive superheated steam from the auxiliary steam system and when adequate steam pressure is available, from the normal steam generator source.

The steam supply for normal operation of the air heater soot blowers will be provided from one of the convection pass soot blower steam supply headers, if the steam conditions satisfy the air heater Otherwise, the steam for air heater soot blowing will be supplied from the auxiliary steam system through a valve station containing a full-capacity pressure control valve, one motor-operated isolation valve, one manual isolation valve and one safety relief valve. During startup, the steam supply for the air heater soot blowers will be provided at the steam conditions developed for the Auxiliary Steam Supply System.

The pressure reducing valve stations will maintain a steam flow through the system to provide the correct blower steam pressure while the system is in service. An automatic thermal drain valve shall be provided at the termination of each supply header to keep the entire system warm. The thermal drain valves will allow draining of condensate from the soot blowing piping. The thermal drain valves will be provided with two bypasses, one with manual globe valve, and the other with a steam trap. The bypasses allow for removal of the thermal drain valves from service for maintenance, and for cleaning and warming the steam lines during startup.

Steam soot blowers will clean the heating surfaces of the superheater, reheater, convection pass heat recovery area, regenerative air heater. The superheater, convection pass, soot blowers will receive steam from the interstage superheater outlet. An adequate number of soot blowers shall be provided to keep the superheater and reheater surfaces and economizer surface clean. Long-retractable (full) and/or part-retractable (half) soot blowers shall be provided. The retractable type soot blower will be supplied to clean radiant and convective heating surface. These retractable soot blowers normally use two 180 degree opposed cleaning nozzles at the tip of moving lance which emit a high-velocity jet of superheated steam perpendicular to the lance. While the lance traverses the boiler, it rotates, forming a helical blowing pattern which effectively cleans both sides of superheat platens and space between the tubes in pendant superheater and reheater sections. The effective range of retractable soot blowers depends upon the gas temperature in the area to be cleaned and the ash characteristics of the fuel fired.

Furnace wall steam blowers will be provided. Adequate number of sootblowers shall be provided to keep the furnace water walls clean.

The air heater will have a dedicated fire water deluge system for the purpose of fire suppression. A dedicated service water connection is provided for off line washing.

## 40.4 BASIS FOR DESIGN - BOILER

The Soot Blowing System shall be designed and constructed in accordance with ASME Codes and Standards

The sootblowing system shall be designed to adequately remove slag and fouling deposits from the heat transfer surfaces while the boiler is firing any of the design coals within the design range. The system shall be designed for full coverage to remove slag and ash deposits from all heat transfer surfaces, taking into account the locations of platens and other tube surface protrusions into the furnace.

Retractable sootblowers shall be equipped with an emergency manual retract feature. System design and installation shall make arrangement provision of at 10% margin for sootblowers to cater for future coal with higher ash content..

The Soot Blowing System controls will be a complete, automatic, selective sequential type with variable group, electric control. Operator interfacing will be from the main control room via the DCS. The soot blowing controller will be integral to the DCS such that DCS control will initiate programmed blowing sequences. Control operations from the main control room will include the following:

- Starting and stopping each individual soot blower.
- Initiating and terminating programmed soot blowing sequences.

- Monitoring status of the Soot Blowing System

Operation of the motor-operated drain valves will be coordinated with the Soot Blowing System controls. Each drain valve will be interlocked through the Soot Blowing System controls to open when the respective soot blowing steam supply header is pressurized, and to close when no soot blowers are in service.

## 40.5 PROCESS DESCRIPTION

During operation, some dust deposits on the heating elements is expected. The dust deposits are normally removed by soot blowing of the heating elements. Steam is blown through lances that are traversing over the surface of the rotor.

The soot blowing sequence should be initiated automatically by a timing device every 8 hours. The intervals may be adjusted based on operating experience. The soot blowing can also be started manually from the control room by the Operators.

Steam to the system shall be supplied from the Unit auxiliary steam header / Auxiliary Boiler

High-pressure washing shall be initiated when the pressure drop exceeds a certain level. Both the lances above and below the rotor will be operated simultaneously. High-pressure washing is performed with the FGD plant in operation.

Water for the water washing system shall be supplied from the service water system.

# 41 HOT REHEAT STEAM

## 41.1 SYSTEM IDENTIFICATION

- System Name: Hot Reheat Steam
- KKS Code LB

## 41.2 FUNCTION

The Hot Reheat Steam System provides a flow path from two separate steam generator reheater outlets to the turbine stop valves of the intermediate pressure (IP) steam turbine.

## 41.3 PROCESS DESCRIPTION

A process flow diagram of the Hot Reheat Steam System is shown on drawing 10-PM-PAY-03.

The Hot Reheat Steam System will include the associated alloy steam piping, valves, instruments, controls, and accessories required to convey hot reheat steam from the steam generator reheater outlet connections to the turbine stop valves of the (IP) steam turbine

Hot reheat steam piping will include drip legs located at low points in a horizontal run of each branch line as necessary and also as near as practical to the IP steam turbine stop valves. Water will be removed from the drip legs using pneumatic valves and will be collected and returned to the condenser. Safety valves for the hot reheat line will be provided for system overpressure protection. A balancing line will be provided in order to maintain system equilibrium.

Connections for miscellaneous turbine valve drains and leakoffs will be provided on the hot reheat lines as required by the turbine manufacturer.

Primary control of reheat steam temperature will be accomplished in the Boiler using tilting burners or reheat desuperheating. The boiler reheat desuperheater will be located inside the Boiler between reheaters 1 and 2. A connection to bypass hot reheat steam around the IP turbine to the condenser will be provided on each header. The bypass steam will be attemperated with water from the Condensing System before entering the condenser. The bypass system shall be sufficient to allow startup from cold, warm, and hot conditions as well as not lift safety valves in the event of a steam turbine trip when operating at 100% TMCR conditions. The bypass system shall also be designed to support steam turbine operation on house load after full load rejection for an extended period of time.

## 41.4 BASIS FOR DESIGN

The Hot Reheat Steam System shall be designed and constructed in accordance with ASME or EN Codes and Standards

The design and arrangement of piping used for the Hot Reheat Steam System shall meet the recommendations of ASME TOP-1 and the turbine manufacturers requirements for turbine water induction protection.

The hot reheat steam piping will be sized such that the combined pressure losses of the cold reheat piping, steam generator reheater, and hot reheat piping do not exceed 8 percent of the high-pressure turbine exhaust pressure during turbine operation at the rated valves wide open (VWO) condition at design steam turbine throttle pressure and temperature.

Instrumentation isolation, vents, and drains shall be installed using double valves for personnel safety.

Pipe material for the hot reheat piping will be seamless P92 or P91 chrome-moly.

The Hot Reheat Steam System will be designed to deliver superheated steam to the IP steam turbine at a rate which corresponds to that required for turbine operation at the valves wide open boiler maximum continuous rating (BMCR) condition.

# 42 COLD REHEAT STEAM

## 42.1 SYSTEM IDENTIFICATION

- System Name: Cold Reheat Steam
- KKS Code LB

## 42.2 FUNCTION

The Cold Reheat Steam System provides a flow path for cold reheat steam from the high-pressure (HP) steam turbine exhaust to the steam generator reheater inlet.

## 42.3 PROCESS DESCRIPTION

A process flow diagram of the Cold Reheat Steam System is shown on drawing 10-PM-PAY-03.

The Cold Reheat Steam System will include the associated piping, valves, instruments, controls, and accessories to convey cold reheat steam from the HP steam turbine exhaust to the steam generator reheater inlet connection.

Cold reheat steam will exhaust from the HP steam turbine into two cold reheat branch lines. A balancing line will be provided in order to maintain system equilibrium. Drip legs will be provided near the HP steam turbine exhaust and as necessary at low points in the piping for water removal from the cold reheat piping. Warming lines routed from the Main Steam System will be provided to reduce the potential of thermal shock during startup.

Cold reheat steam will be extracted from the balancing line and supplied to the Auxiliary Steam System. Connections for miscellaneous turbine valve drains and leakoffs shall be provided on the cold reheat lines where required by the turbine manufacturer.

## 42.4 BASIS FOR DESIGN

The Cold Reheat Steam System shall be designed and constructed in accordance with ASME

The cold reheat steam piping system shall also be designed to meet ASME TOP-1 recommendations and the turbine manufacturers requirements for turbine water induction prevention.

Instrumentation isolation, vents, and drains shall be installed using double valves for personnel safety.

The cold reheat steam piping shall be sized such that the combined pressure losses of the cold reheat piping, Boiler reheater, and hot reheat piping do not exceed 8 percent of the high-pressure turbine exhaust pressure during turbine operation at the rated valves wide open (VWO) condition at design steam turbine throttle pressure and temperature.

Cold reheat steam piping materials shall be designed and constructed in accordance with ASME Codes and Standards

The Cold Reheat Steam System shall be designed to deliver superheated steam to the steam generator reheater inlet at a rate which corresponds to that required for turbine operation at the valves wide open boiler maximum continuous rating (BMCR) condition.

# 43 SITE FIRE PROTECTION

## 43.1 SYSTEM IDENTIFICATION

- System Name: Site Fire Protection
- KKS Code SG

## 43.2 FUNCTION

The function of the Site Fire Protection System is to provide fire hydrants, fixed suppression systems, fire extinguishers, and independent fire detection systems to protect the site buildings and equipment in the event of fire. Fire water supply is described in the Fire Protection Water Supply System Definition. Turbine and Boiler building fire protection is described in the Generation Building Fire Protection System Definition. It is not the intent of this document to specifically call out all of the necessary fire protection systems, but rather to clarify the minimum requirements. The system design must meet NFPA and local fire code requirements.

## 43.3 PROCESS DESCRIPTION

The Site Fire Protection System will include the following major components:

- Underground Fire Main.
- Yard Fire Hydrants.
- Fire Hose Racks.
- Fire Department Connections.
- Fire Main Segmenting Valves (Post Indicating Valve - PIV).
- Fixed Sprinkler and Spray Suppression Systems.
- Local Control Fire Panels.

The minimum recommendations for the areas and equipment protected by various types of detection and suppression systems are listed in Table 1-1. These systems operate in response to fire signatures such as excessive heat or products of combustion. The basic operation of each type of system is described below. In addition, requirements for standpipes and hose connections are provided in Table 1-2.

### 43.3.1 SYSTEM TYPES

Wet-pipe sprinkler systems employ thermally sensitive sprinkler heads attached to piping connected to the fire protection water loop. The piping is filled with water under pressure. System activation occurs whenever a sprinkler head opens due to excessive heat and water flow is only from the activated sprinkler head or spray nozzle.

The automatic preaction sprinkler systems utilize a detection system installed throughout the protected area. In the automatic preaction sprinkler system, when a detector is activated, a solenoid valve is energized and opens the preaction valve to admit water to the system piping. The sprinklers/spray nozzles are closed and will discharge water only when individual head(s) operate. The systems are used where an alarm in advance of sprinkler/spray nozzle operation is desired and where it is particularly important to prevent the accidental discharge of water. On systems of more than 20 sprinklers, the system must be supervised Where air pressure is used for pipe supervision, air pressure loss does not cause the valve to operate; it will only sound a trouble alarm.

Deluge sprinkler systems employ dry pilot heat detection which utilizes thermally sensitive pilot sprinkler heads attached to a piping system containing air under pressure (a pilot line). System actuation occurs whenever a pilot sprinkler head opens due to excessive heat. The opening of a pilot sprinkler head causes the air pressure to be released; which permits the deluge valve to open. The water then flows into the main piping system and out all open sprinklers/spray nozzles at the same time.

Dry-pipe sprinkler systems use closed sprinkler heads attached to a piping system connected to the fire protection water loop. The piping system is pressurized with air to hold back the water at the dry-pipe valve. The dry-pipe valve is a differential pressure latch valve which depends on air pressure in the system to keep it closed against the water supply pressure. The valve has a trip ratio of approximately 6:1 and opens when the air pressure in the dry-pipe system is less than approximately one-sixth that of the water supply pressure. When a sprinkler is fused (opened due to fire), system air pressure is relieved through the open sprinkler. The water supply pressure then forces the dry-pipe valve open, and water flows into the piping system and discharges through the open (fused) sprinkler head(s). A supervisory air pressure switch is provided on the air side of the dry-pipe valve to provide an alarm in the event that pressure decays.

Fire detection equipment consists of heat or smoke detectors. Heat detectors include fixed temperature, rate-of-rise, linear, or rate compensated. Smoke detectors consist of ionization or photoelectric detectors which respond to products of combustion.

### 43.3.2 ALARMS, SIGNALING, CONTROL PANELS AND INSTRUMENTATION

Manual pull stations are provided as required by the building code in the site buildings for actuation of building fire alarms. The fire protection systems are monitored at local control panels and at a main fire alarm panel provided in the station main control room.

A fire protection signaling system is provided to monitor the various fixed fire protection and detection systems throughout the new facilities and annunciates to each units control room. The system includes local control panels throughout the plant. Fire alarm, supervisory, and trouble signals are annunciated at the local control panels in the protected areas and at the main fire alarm panel in each unit's respective control room. Fire protection system inputs to the DCS may be provided but are limited to the general trouble signal, general supervisory signal, and a general fire alarm. The DCS is not used as the fire alarm panel.

Local control panels are provided to monitor equipment status. The main fire alarm panel located in the control room indicates the status of all fire protection subsystems. The main fire alarm panel and system will be a proprietary supervising system. All fire signals will be annunciated at the main fire alarm panel.

Each local control panel will be located in proximity to the hazard areas they supervise and will alarm to a main fire alarm panel located in each the control room. The local control panels or the main fire alarm panel must be consulted to identify the zone in which a fire signature has been detected.

All control panels located in unoccupied areas will have a smoke detector located above the panel.

### 43.3.3 WATER SUPPLY

An underground yard distribution system is provided to supply fire water throughout the plant area. The yard distribution piping includes a loop around the plant to supply water to fire hydrants and fixed water suppression systems installed in buildings and other plant structures. Additional fire protection yard piping is provided to outlying areas and structures such as coal handling. Multiple flow paths are provided in the loop piping so that if one path fails, other piping paths can supply sufficient fire water to other outlets. Valves (post indicator type for underground lines or a valve box for hydrant isolation) are provided where appropriate to sectionalize the yard piping and for each fixed water suppression system. These valves enable isolation of any failed piping section. Water is supplied to the yard piping from the Fire Protection Water Supply System.

Fire hydrants are spaced at intervals not exceeding 90 meters around the loop piping in the main plant area and 150 meters in remote areas such as the coal yard, or be accordance with local requirement. Every hydrant will have an underground isolation valve. Hose, fire hydrant, hose rack connections, and local fire department connections will all be identical thread type without the use of special adapters.

Upon actuation of a fixed water suppression system, water is supplied from the Fire Protection Water Supply System to the building or structure via the fire main distribution piping.

### 43.3.4 NORMAL OPERATION

The following subsections describe the normal operation of each type of suppression/ detection system.

#### 43.3.4.1 WET-PIPE SPRINKLERS

Wet-pipe sprinklers are fully automatic. To prime the equipment, the associated manually operated gate valve should be fully opened, filling the sprinkler piping with water and equalizing the pressure upstream and downstream of the alarm check valve.

Heat produced by a fire causes a sprinkler head to actuate, allowing fire water to discharge from the sprinkler. The drop in pressure downstream of the alarm check valve will also allow water to flow into the retarding chamber upstream of the pressure switch alarm and water operated alarm bell. The retarding chamber allows a time lag before the pressure switch alarm and alarm bell are activated. This precludes false alarms due to pressure fluctuations upstream of the alarm check valve, which will cause short duration flow through the check valve until upstream and downstream pressures equalize. After the fire has been completely extinguished, the flow of water is stopped by manually closing the isolating gate valve. Any fused sprinkler heads must be replaced and the sprinkler piping again filled with water, vented, and pressurized.

### 43.3.4.2 DELUGE SPRINKLER/SPRAY SYSTEMS

Automatic deluge systems are either of the sprinkler type or spray type.

The automatic deluge sprinkler and spray equipment are fully automatic utilizing open heads to fully spray the protected area. To prime the equipment, the isolation gate valve upstream of the deluge valve will be placed in the closed position. The system air supply will be isolated and system piping drained. All vent and drain valves will be in the closed position and the alarm control valve and the position will be closed. The clapper will be reset and the valve primed via the priming valve in accordance with the deluge valve manufacturer's instructions. The isolation gate valve will be opened; then the alarm control valve will be opened; and "System Normal" will be verified at the local control panel.

Heat produced by the fire causes a sprinkler head on the dry-pilot or wet-pilot heat detection piping to actuate allowing air or water to escape and the line pressure to drop. The drop in pressure in the pilot line allows the deluge valve to open pneumatically (dry-pilot) or hydraulically (wet-pilot). Water is allowed to discharge from all open sprinkler heads/spray nozzles connected to that system. The alarm line fills at a faster rate than it can be drained by the drain restriction. This action applies the water supply pressure to the water flow pressure switch. The water flow pressure switch trips and actuates a "Fire" alarm at the local panel and in the Control Room.

The fire alarm can be silenced at the local control panel. After the fire has been completely extinguished, the flow of water is stopped by closing the isolation gate valve upstream of the deluge valve. The system piping is then drained.

### 43.3.4.3 PREACTION SPRINKLER/SPRAY SYSTEMS

Automatic preaction systems are either of the sprinkler type or spray type.

The sprinkler/spray equipment is fully automatic. To prime the equipment, the isolation gate valve upstream of the preaction valve will be placed in the closed position. The supervisory air supply will be isolated and the system drained. The alarm control valve, alarm test valve, solenoid valve, and manual control station will be verified closed. The preaction valve will be reset. The isolation gate valve will then be opened. All vents and drains will be verified closed and the system pressurized with supervisory air.

Loss of supervisory air pressure in the system does not cause the preaction valve to operate; it will only sound a trouble alarm. The automatic preaction sprinkler system may utilize a smoke or heat detection system installed in each room. For a cross-zoned fire detection system, actuation of both zones of fire detection (heat and smoke) in a given room alerts personnel and opens the preaction valve, allowing water to discharge from any open sprinklers.

Heat produced by a fire causes a thermally sensitive sprinkler head to open, allowing fire water to discharge from the sprinkler for the preaction sprinkler system.

The fire alarm can be silenced at the local control panel. After the fire has been completely extinguished, the flow of water is stopped by closing the isolation gate valve upstream of the preaction valve. The supervisory air supply is shut off and any fused sprinkler heads/spray nozzles are replaced. The system piping is then drained.

#### 43.3.4.4 DRY-PIPE SPRINKLER SYSTEMS

To prime the equipment, the isolation gate valve upstream of the dry-pipe valve is placed in the closed position. The system air supply is isolated and the system piping drained. All the vent and drain valves, primary water valve, alarm control valve, and alarm test valve are closed. The clapper assembly in the dry'-pipe valve is then reset in accordance with the valve manufacturer’s instructions. The air supply valve is then opened to establish the desired system pressure and the isolation gate valve is reopened. The "System Normal" status is verified at the local control panel.

Dry-pipe sprinkler systems use closed sprinkler heads attached to a piping system connected to the fire protection main. The piping system is pressurized with air to hold back the water at the dry-pipe valve. The dry-pipe valve is a differential pressure latch valve which depends on air pressure in the system to keep it closed against the water supply pressure. The valve has a trip ratio of approximately 6:1 and opens when the air pressure in the dry-pipe system is less than approximately one-sixth that of the water supply pressure. When a sprinkler is fused (opened due to fire), system air pressure is relieved through the open sprinkler. The water supply pressure then forces the dry-pipe valve open, and water flows into the piping system and discharges through the open (fused) sprinkler head. A supervisory air pressure switch is provided on the air side of the dry-pipe valve to provide an alarm in the event that pressure decays.

### 43.3.5 ABNORMAL OPERATION

Sectionalizing valves are provided in the looped header so that portions of the header can be isolated for maintenance operations or to isolate leaks without shutting down the entire system.

### 43.3.6 INTEGRATED UNIT OPERATION

The Fire Protection Water Supply System must be in operation before the Generation Building Fire Protection System or the Site Fire Protection System can be put into operation.

The Generation Building Fire Protection System and Site Fire Protection System must be in operation prior to first fire and initial transformer back energization and must remain in service during all shutdowns.

### 43.3.7 OTHER SYSTEM FEATURES

Ionization or photoelectric smoke detectors are used in HVAC ducts to shut down HVAC equipment when smoke is detected where required by NFPA 90A.

Portable hand-held fire extinguishers are provided at all key locations in accordance with the requirements of NFPA 10 or local regulations, whichever is more conservative. The extinguishing agent will be selected based on the fire hazards in the immediate area.

## 43.4 BASIS FOR DESIGN

**Table 1-1**
**Minimum Recommended Fire Suppression and Detection Systems**

| Area or Hazard | System Suppression Type | Actuation | Detection Types | Density (mm/min) | Coverage Area |
|---|---|---|---|---|---|
| Air Quality Control (AQC) AREA | | | | | |
| ESP | Standpipe | Manual | Hose Station | N/A | Entire Penthouse |
| WATER TREATMENT | | | | | |
| Waste Water Treatment Plant | Wet-pipe sprinkler | Automatic | Heat | 10 | Most remote 278 square meters |
| FGD Treatment Plant | Wet-pipe sprinkler (if building is provided) | Automatic | Heat | 10 | Most remote 278 square meters |
| Boiler Make Up Water Treatment Plant | Wet-pipe sprinkler | Automatic | Heat | 10 | Most remote 278 square meters |
| FIRE PUMP ENCLOSURE | | | | | |
| Diesel Engine Driven Fire Water Pump Room | Wet-pipe sprinkler | Automatic | Heat | 10 | Entire Room |
| Motor Driven Fire Water Pump Room | None | N/A | Smoke Detection | N/A | Entire Room |
| COAL HANDLING | | | | | |
| Critical Conveyors | Wet Pipe Spray | Automatic | Heat | 10 top and bottom belt | Most remote |

| Table 1-1<br>Minimum Recommended Fire Suppression and Detection Systems | | | | | |
|---|---|---|---|---|---|
| **Area or Hazard** | **System Suppression Type** | **Actuation** | **Detection Types** | **Density (mm/min)** | **Coverage Area** |
| | | | | | 186 square meters (top and Bottom belt) |
| Critical Coal Yard Transfer Buildings | Wet Pipe Sprinkler | Automatic | Heat | 10 | Most remote 232 Square meters |
| Critical Coal Handling Structures | Wet Pipe Sprinkler | Automatic | Heat | 10 | Most remote 232 Square meters |
| Dust Collectors | Preaction Water Spray | Automatic | Heat | 8 | Protected Area |
| GENERAL REQUIREMENTS | | | | | |
| All Electrical Buildings and Rooms (Example: GEMS Enclosure) | None | N/A | Smoke | N/A | Protected Area |
| GENERAL REQUIREMENTS | | | | | |
| Warehouse | Wet-pipe sprinkler | Automatic | Heat | Per NFPA 13 | Per NFPA 13 |
| Workshop | Wet pip sprinkler | Automatic | Heat | Per NFPA 13 | Per NFPA 13 |
| All Buildings | Portable Fire Extinguishers | Manual | N/A | Per NFPA 10 | All Buildings |
| Oil Filled Transformers | Deluge | Automatic | Dry Pilot | 10 for transformer surface; 6 for Non-absorbing containment surface | Entire Area |
| Hazardous Chemical Areas or Rooms | Wet Pipe Sprinkler (where required by building code. ). | Automatic | Heat | 10 | 278 square meters |

Note:
SPRINKLER/ SPRAY
Wet Pipe--The piping is filled with water under pressure that is immediately discharged when the sprinkler actuates. Water will discharge only from those sprinklers which are fused.

Dry Pipe--Dry pipe systems are used in buildings or building areas that are unheated and where any water in piping might freeze. The piping contains air under pressure that holds back the water at a dry pipe valve in a heated location. When a sprinkler operates and releases air, the drop in air pressure automatically opens the dry pipe valve and admits water to the system. Water will discharge only from those sprinklers which are fused.

Preaction--The automatic preaction spray system is somewhat similar to a dry pipe sprinkler system. The important difference is that a system of heat or smoke detectors is installed throughout the protected area. When a detector is actuated, an automatic water control valve automatically opens to admit water through the spray piping. The spray nozzles are closed as on a dry pipe or wet pipe system and discharge when their fusible elements operate. The system is used where an alarm in advance of suppression operation is desired and where it is particularly important to prevent the accidental discharge of water. Supervisory air pressure in the piping is also maintained; should the pressure drop, a trouble alarm will sound. However, pressure loss does not cause the preaction valve to operate.

Deluge--The automatic deluge system, which has open spray nozzles, is used where it is desirable to deliver water through all spray nozzles simultaneously and to spray the entire protected area. The water supply is held back from the spray piping by a deluge valve automatically actuated by operation of a heat detection system installed throughout the protected area.

Manual deluge systems consist of open nozzles located over the hazard. System actuation is performed by manually opening two valves in series. The two valves are installed in series to mitigate water leak.

Systems will meet the Employer’s insurance requirements, National and local codes, and Authority Having Jurisdiction (AHJ) requirements

**Table 1-2**
**Standpipes and Hose. Connections**

| **Building or Structure** | **Class and Type of Standpipe** |
|---|---|
| All Coal Handling Structures | Class III |
| All AQCS Structures and Areas | Class III |

Class III standpipe systems use 40 and 65 mm hose connections. The 40 mm connection is for trained personnel on-site and the 65 mm connection is for use by the responding fire department.

Wet Standpipe

Standpipe is constantly full of pressurized water up to the hose connection valve.

Dry Standpipe

A dry standpipe system is similar to a dry pipe sprinkler system. The pipe is dry with pressurized air that holds the valve closed. The valve is located in a heated enclosure. When a hose connection valve is opened, air pressure drops allowing the dry pipe valve to open and water to fill the pipe and supply the opened hose connection.

# 44 HIGH-PRESSURE EXTRACTION STEAM

## 44.1 SYSTEM IDENTIFICATION

- System Name: High-Pressure Extraction Steam
- KKS Code LBQ

## 44.2 FUNCTION

The High-Pressure Extraction Steam System provides a flow path for extraction steam from the high-pressure (HP) turbine, Cold Reheat Steam System, and the intermediate-pressure (IP) turbine to the deaerator and the high-pressure feedwater heaters.

## 44.3 PROCESS DESCRIPTION

A process flow diagram of the High-Pressure Extraction Steam System is shown on drawing 10-PM-PAY-03.

The High-Pressure Extraction Steam System includes piping and valves required to provide steam to the following:

- High-Pressure Feedwater Heaters 17 (from the MP turbine).
- High-Pressure Feedwater Heaters 18 (from the Cold Reheat Steam System).
- High-Pressure Feedwater Heaters 19 (from the HP turbine).
- Deaerator (from the MP turbine).
- Associated piping, valves, instruments, controls, and accessories.

The extraction steam lines to High-Pressure Heaters 17, 18 and 19 will each have, in the direction of steam flow, a non-return check valve (in the common piping to each pair of heaters), a motor-operated isolation valve, and an automatic drain to the Extraction Drains System (a drain downstream of the motor operated valve shall be provided if the extraction piping is not self-draining from the isolation valve to the feedwater heater). The non return check valve of the extraction steam line to HP 17&19 are power assisted.

The nonreturn check valves will be provided for turbine overspeed protection. The motor-operated isolation valves will provide support for the turbine water induction prevention system and feedwater heater isolation during maintenance.

Extraction steam from the MP turbine will be provided to HP feedwater heater 17. The extraction line will have a power assisted nonreturn check valve. The steam lines to HP feedwater heaters will have automatic drains to the Extraction Drains System upstream and downstream of the motor operated isolation valves.

Relief valves will be placed on the high pressure feedwater heater shells or in the feedwater heater drain line to provide overpressure protection in the event of thermal expansion caused from isolating the equipment.

The source of steam for the deaerator is from the MP turbine and the source of steam for BFP turbine is from cold reheat line. During startup, or any other time when extraction steam is not available, steam will be supplied from the Auxiliary Steam System or from the Cold Reheat Steam System. The extraction steam line to the deaerator includes an additional nonreturn check valve (total of two valves). A hydraulic-operated gate valve will be located between the two non-return check valves. The hydraulic-operated gate valve will support the turbine water induction prevention system.

## 44.4 BASIS FOR DESIGN

The High-Pressure Extraction Steam System piping shall be designed to meet ASME TOP-1 recommendations and the turbine manufacturer's requirements for turbine water induction protection.

The High-Pressure Extraction Steam System shall be designed and constructed in accordance with ASME Codes and Standards

The maximum allowable pressure loss in the extraction lines to the feedwater heaters will be equal to or less than the loss used in the development of the design heat balance.

Motor-operated extraction isolation valves shall be cast steel gate valves.

The power assisted extraction nonretum valves will be internally or externally balanced check valves. These valves shall be provided with air cylinders which incorporate springs to move the disc into the flow stream under specific conditions. Provisions shall be made for periodic on-line testing of the nonreturn valves to ensure their operability.

Isolation valves furnished for instruments and accessories on this system shall have double isolation valves for personnel protection. Piping and valves shall be either chromium alloy steel or carbon steel.

# 45 LOW-PRESSURE EXTRACTION STEAM

## 45.1 SYSTEM IDENTIFICATION

- System Name: Low-Pressure Extraction Steam
- KKS Code LBS

## 45.2 FUNCTION

The Low-Pressure Extraction Steam System provides a flow path for extraction steam from the low-pressure turbine and the intermediate pressure turbine to the low-pressure feedwater heaters.

## 45.3 PROCESS DESCRIPTION

A process flow diagram of the Low-Pressure Extraction Steam System is shown on drawing 10-PM-PAY-03.

The Low-Pressure Extraction Steam System will include piping and valves required to provide steam to the following feedwater heaters:

- Low-Pressure Feedwater Heater 7A, 7B, 8A, 8B
- Low-Pressure Feedwater Heater 8
- Low-Pressure Feedwater Heater 8A
- Low-Pressure Feedwater Heater 8B
- Associated piping, valves, instruments, controls, and accessories.

The extraction steam lines to Low-Pressure Heaters will each have, in the direction of steam flow, an automatic drain to the condenser, a hydraulic-operated isolation valve, a power assisted non return check valve. The downstream drain can be omitted if the extraction piping is self-draining from the isolation valve to the feedwater heater. The power assisted non return check valves will be provided for turbine overspeed protection. The power operated isolation valves will be provided to support the turbine water induction. The drains provide the capability of draining extraction steam condensate to the condenser.

The Low-Pressure Extraction System shall be designed for steam flow conditions consistent with the turbine generator design rated load heat balance. The maximum allowable pressure loss in the extraction piping shall be no greater than 5% of the steam pressure at the turbine outlet connection.

## 45.4 BASIS FOR DESIGN

The Low-Pressure Extraction Steam System piping will be designed to meet the recommendations of ASME TDP-1 and the turbine manufacturer's requirements for turbine water induction prevention.

The Low-Pressure Extraction Steam System shall be designed and constructed in accordance with ASME Codes and Standards

The maximum allowable pressure loss in the extraction lines to the feedwater heaters shall be equal to or less than the loss used in the development of the design heat balance.

Motor-operated extraction isolation valves shall be cast steel gate valves. The power assisted extraction nonreturn valves will be internally or externally balanced check valves. These valves shall be provided with air cylinders which incorporate springs to move the disc into the flow stream under specific conditions. Provisions shall be made for periodic on-line testing of the nonreturn valves to ensure their operability.

Isolation valves furnished for instruments and accessories on this system shall have single valve isolation.

# 46 EXTRACTION DRAINS

## 46.1 SYSTEM IDENTIFICATION

- System Name: Extraction Drains
- KKS Code LC

## 46.2 FUNCTION

The Extraction Drains System serves the following functions:

- Return of collected condensate drains from the various extraction steam drains (vacuum drains) to the condenser.
- Collection and reclaim of atmospheric condensate drains from systems and equipment throughout the power plant.

## 46.3 PROCESS DESCRIPTION

A process flow diagram of the Extraction Drains System is shown on drawing 10-PM-PSA-03.

- The Two Steam Turbine Area Drain Flash Tanks serve to collect condensate drains that may exist during startup, shutdown, and malfunctions during which turbine water induction prevention systems may operate.
- Low point drains are open during startup to allow gravity drainage of condensate to the Condensate Flash Tank. The vent line will be adequately sized to vent the high level of flash steam flow that may exist under certain transients such as following a turbine trip or hot restart.

## 46.4 BASIS FOR DESIGN

The system shall be designed to handle the maximum expected coincident condensate drain flows. All extraction drain lines shall be routed and sloped continuously downward.

Drain lines and valves shall be sized to provide a flow equal to the maximum warm-up condensate load of placing the line in service at 100 % load times a safety factor of 3 or shall be a 50 mm nominal size, whichever is greater.

Piping and valves shall be either chromium alloy steel or carbon steel based on temperature limitations and shall be designed to ASME Codes and Standards. Piping downstream of drain valves and where flashing drains are present shall be chromium alloy steel.

Because drains tanks will be receiving flows that are typically under significant pressure and temperature following a turbine trip or hot restart, continuous drain is recovered in a flash box associated to condenser. The flash box shell is made of carbon steel with connection consisting of alloyed nozzle with sleeves .for high energy drains and carbon steel nozzles for other drains.

The Condensate Flash Tank will be made of alloy materials to with stand the severity of high energy flows.

# 47 HIGH-PRESSURE (HP) HEATER DRAINS

## 47.1 SYSTEM IDENTIFICATION

- System Name: High-Pressure Heater Drains
- KKS Code LC

## 47.2 FUNCTION

The High-Pressure Heater Drains System provides the normal flow path for condensed extraction steam from each high-pressure feedwater heater to cascade down to the next lower pressure feedwater heater, then to the deaerator, and to provide an alternate high level drain to the Condensate Flash Tank during abnormally high level conditions.

## 47.3 PROCESS DESCRIPTION

A process flow diagram of the High-Pressure Heater Drains System is shown on drawing 10-PM-PAY-03

The High Pressure Heater Drains System will include the following major equipment and components.

- Interconnecting piping and valves to cascade the heater drains system to the next lower pressure heater and then to the deaerator for each of the two heater trains.
- Interconnecting piping and valves to take the heater drains individually to the Condensate Flash Tank during an abnormal high level condition.
- Associated piping, valves, instruments, controls, and accessories.

Under normal operating conditions, the high-pressure drains will cascade from Feedwater Heater 19 to Feedwater Heater 18 to Feedwater Heater 17, and then to the deaerator.

## 47.4 BASIS FOR DESIGN

The High-Pressure Heater Drains System shall be designed for the drain flow conditions consistent with the plant rated load heat balance. Upset conditions such as heaters out of service shall be reviewed to ensure that the system can accept the resultant flow.
Piping design and drain valve sizing shall meet the recommendations of ASME TOP-1 and the turbine manufacturer’s requirements for turbine water induction prevention.

Piping and valves shall be either chromium alloy steel or carbon steel based on temperature limitations and shall be designed to ASME Codes and Standards. Piping downstream of drain valves and where flashing drains are present shall be chromium alloy steel.

# 48 LOW-PRESSURE (LP) HEATER DRAINS

## 48.1 SYSTEM IDENTIFICATION

- System Name: Low-Pressure Heater Drains
- KKS Code LCJ

## 48.2 FUNCTION

The Low-Pressure Heater Drains System provides a flow path for condensed extraction steam to cascade from each low-pressure feedwater heater to the next lower pressure feedwater heater, and from the lowest pressure feedwater heater to the condenser.

## 48.3 PROCESS DESCRIPTION

A process flow diagram of the Low-Pressure Heater Drains System is shown on drawing 10-PM-PAY-03.

The Low-Pressure Heater Drains System will be a cascade type arrangement with the low-pressure feedwater heater drains cascaded to the condenser.

Under normal operating conditions, the low-pressure drains will cascade from LP feedwater heater 10 to LP feedwater heater 9 and will be pumped back to the condenser through LP heaters 8 and 9.

Control valves located downstream of each heater and the drain cooler will control drain flow.

## 48.4 BASIS FOR DESIGN

The Low-Pressure Heater Drains System shall be designed for the drain flow conditions consistent with the plant rated load heat balance. Upset conditions such as heaters out of service, normal level control malfunction, or tube rupture will be reviewed to ensure that the systems can accept the resultant flow.

Piping design and drain valve sizing shall meet the recommendations of ASME TOP-1 and the turbine manufacturer's requirements for turbine water induction prevention.

Piping and valves shall be either chromium alloy steel or carbon steel based on temperature limitations and shall be designed to ASME Codes. Piping downstream of drain valves and where flashing drains are present shall be chromium alloy steel.

# 49 STEAM TURBINE

## 49.1 SYSTEM IDENTIFICATION

- System Name: Steam Turbine
- KKS Code MA

## 49.2 FUNCTION

The Steam Turbine System converts the thermal energy of the steam to mechanical energy required to rotate the generator at 3000 rpm, and provides extraction steam for feedwater heating and miscellaneous heating requirement.

## 49.3 PROCESS DESCRIPTION

The process flow diagram drawing 10-PM-PAY-03 describe the Steam Turbine System and interfaces to interrelated systems:

- Condensing
- Main Steam
- Hot Reheat Steam
- Cold Reheat Steam
- Bypass Steam
- High Pressure Extraction Steam
- Low Pressure Extraction Steam

The Steam Turbine System will include the following major equipment and components.

- Steam turbine casings (HP, MP, and LP).
- Turbine rotor.
- Turbine stop valves.
- Turbine control valves.
- Turning gear with provision, for mechanical or hydraulic device manual turning.
- Electro.-hydraulic control (EHC) system.
- Turbine lube oil system.
- Local and remote instrument and control sensors.
- Interconnecting system piping from the turbine to the HP and .LP extraction steam systems.
- Associated piping, valves, instruments, and accessories.

The primary steam path through the Steam Turbine System is as follows:

- Steam flows from the Main, Steam System through the high-pressure (HP) turbine stop valves and control valves into the HP steam turbine.
- The Steam flows through the HP steam, turbine and discharges to the Cold Reheat Steam System, which:-conveys the steam back to the boiler reheater where heat energy is added to the steam.

- The steam returns via the Hot Reheat Steam System and passes through the medium-pressure (MP) turbine: .stop valves into the IP steam turbine.
- After flowing through the MP steam turbine, the steam passes through the crossover piping to the two low-pressure (LP) steam turbines.
- After passing through the low-pressure steam turbine stages, the steam flow exhausts downward into both turbine exhaust steam ducts to the condenser.

Energy is extracted from the steam as it progress through the steam turbine to rotate the turbine shaft that is direct coupled to the generator which converts the mechanical energy to electrical energy. As the steam passes through the turbine, steam is extracted at various points to provide boiler feedwater heating and steam to the boiler feed pump turbine.

## 49.4 BASIS FOR DESIGN

The Steam Turbine System will be capable of safe, continuous operation, as guaranteed by the manufacturer, under the following conditions:

- Satisfactory operation under approximately 4 cold, 12 warm, and 48 hot starts per year.
- Satisfactory operation under daily load swings from 30% load to the turbine 100% load condition.
- Operation at minimum load for extended periods of time to support only house load.
- Operation at 100% TMCR load condition for extended periods of time.
- Satisfactory operation at maximum extraction steam flow.
- Satisfactory operation at maximum load with all feedwater heaters out of service.
- Safely undergoing 100% TMCR load rejections and designed load runbacks without any damaging overspeed or thermal transients.
- Full arc steam admission to be the normal operation capability.
- Controls capability for boiler following mode.
- Controls capability for turbine following mode.
- Coordinated boiler and turbine control capability.

In addition, operation of the Steam Turbine and Boiler, in combination, shall comply with Bangladesh Grid Code requirements.

The unit will use the following methods to reduce and control thermal stresses in the turbine:

- Sliding pressure operation from minimum load to 100% load condition.
- A rotor stress monitoring system to assist in startup by monitoring and presenting rotor stresses in terms of cycle life expenditure during steam to metal temperature matching, acceleration, and loading.

Startup and initial loading of the turbine will be controlled by the turbine control and instrumentation system by either automatic or fully manual means with operator guidance that will follow the manufacturer's recommended procedure. Loading, of the turbine above initial load will be controlled by the turbine control system or the DCS as determined by the selected control mode.

The Steam Turbine shall be capable of continuous operation with feedwater heaters removed from service. The manufacturer shall provide procedures for the systematic reduction of load when removing feedwater heaters from service.

All protective tripping functions shall be implemented using redundant sensors. Devices and instrumentation shall be redundant so that failure of one device does not make the system inoperable. Self diagnostics shall be provided to identify devices that are out of normal operating range, in which case the system selects the next operable device to continue operation with full controls. The system shall alarm the out of range devices so that they can be noted for repair.

Protective Devices shall include alarms and trips, and test modes for routine verification. The protective devices shall include, but not limited to:

- Loss of speed governor action for turbine tripping.
- Overspeed Trip at 10% and 12% above the rated speed. A manual trip device at the local front standard shall be provided.
- Low Bearing Oil Pressure — the first pre-set pressure value shall trigger an alarm and the second lower preset value shall initiate to shut down the turbine.
- Lube Oil Temperature High alarm
- Low Vacuum Unloading Device
- Low Condenser Vacuum
- Thrust failure protection device for alarm and trip on the thrust bearing with testing facility.
- High Turbine Exhaust Temperature with local thermometer.
- Exhaust Casing pressure Relief Diaphragm/Condenser Relief Valve
- Shaft Vibration for alarm and trip.
- Bearing Metal Temperature High for alarm and trip.
- Differential Expansion monitoring with alarm provided as part of start-up permissive.
- Shaft Eccentricity monitoring and tripping.
- Quick acting vacuum breaker with local or remote selector.

Steam Stop and Control valves with on-load valve freedom testing and temporary fine-mesh elements for initial start -ups shall be provided.

The functional constraints applicable to the Steam Turbine System will be those imposed by the turbine manufacturer and will include such conditions as startup and loading procedure, speed, condenser pressure, throttle and reheat temperature and pressure, and steam quality. The selected turbine manufacturer will determine specific functional constraints and provide startup and operation curves for starting the turbine in the cold, warm, and hot conditions.

The Steam Turbine shall be installed on an indoor pedestal isolated from the Turbine Building and all other installed equipment. The operating floor shall include areas which are designed and designated for heavy loadings resulting from the initial turbine generation assembly and future maintenance.

Relative weights and hook clearances required for proper disassembly of the turbine shall determine the size and placement of main and auxiliary building cranes.

Control of the Steam Turbine System is primarily a function of the Turbine Control and Instrumentation System Logic.

The Turbine Control and Instrumentation System will provide the speed governing control and monitoring of turbine parameters that are used to adjust automatically the startup acceleration rate and the loading rate when in the automatic mode and to provide guidance for operation when in the manual mode. The Turbine Control and Instrumentation System will also control the turbine when on turning gear.

The turbine supervisory instrumentation system and all installed components and devices shall be compatible with DCS equipment including eccentricity, differential expansion, thrust bearing wear, turbine vibration, trip and monitoring system, turbine speed, load control, and valve test.

Formal tests in accordance with ASME will be performed on the steam turbine and auxiliary equipment for final acceptance.

The Steam Turbine System shall be designed for full functional mechanical and control tests.

All data and sample points to be used for performance test requirements shall have instrumentation capable of performing these tests on an annual basis.

Miscellaneous piping and equipment provided with the steam turbine shall be designed and constructed in accordance with ASME requirements.

All exposed surfaces, which during normal operation that have a surface temperature of $55^{o}C$ or above, shall be thermally insulated.

The outer surface temperature of the insulation material proper before the application of finish material or paint should not exceed the station indoor ambient temperature by more than $15^{o}C$. It should be noted that the design station indoor ambient temperature is $40^{o}C$.

All insulation materials shall be to approval and shall be asbestos free, chloride free calcium silicate, vermin proof, non-hygroscopic, odourless and chemically inert when both wet and dry (e.g. non-corrosive to ferrous and non-ferrous materials), fire resistant, and rot and fungus proof.

# 50 GENERATOR

## 50.1 SYSTEM IDENTIFICATION

- System Name: Generator
- KKS Code MKA

## 50.2 CONSTRAINTS AND ASSUMPTIONS

The generator shall have sufficient margin to transform the power and produce the active power at full load without harmful effect on the long-term reliability of the generator or any of its components.

The IEC standard specification for the procurement of generators applies and shall be used as a main reference in the procurement documentation.

The Generator System is capable of withstanding the network fault and abnormal conditions as described in the Bangladesh Grid code without any harmful effects to the generator or parts of it.

The generator shall pass all tests as required by the Employer’s Power Purchase Agreement (PPA), as summarized into Attachment A4 of Section 5.

## 50.3 PERFORMANCE

The generator shall be rated at 50 Hz meant for base load operation. It shall also be suitable for subsequent cyclic load or two shifting operations.

The generators shall be capable of continuous operation between 95 and 105 per cent of rated terminal voltage, producing continuously its rated MVA at any power factor between 0.95 per unit under-excited (leading) and 0.85 overexcited (lagging) over the frequency range 48.5Hz to 51.5Hz without any component exceeding the temperature limits of the design.

The machine shall be designed to withstand without failure a short circuit of any kind at its terminals while operating at any load or voltage within the generator's permissible operating range. Maximum phase current will be limited by external means to a value which does not exceed the maximum phase current obtained from a 3-phase short circuit.

The generator efficiency shall be at least 98.5% at unit rating, including bearing, seal, and excitation losses.

## 50.4 TECHNICAL REQUIREMENTS

### 50.4.1 STATOR CORE

The stator core iron shall be made of high quality laminated, non-aging, silicon-alloyed steel sheets with high permeability, and with each side insulated. The clamping system shall be of the through-bolt design to ensure constant and uniform pressure upon the core iron laminations by means of press plates and press fingers. The generator shall be designed so that the through-bolts can be retightened after the stator coil installation is complete and when the support wedges are loose.

### 50.4.2 STATOR WINDING AND TERMINALS

The stator winding shall be star connected. All six terminals shall be brought out of the machine and shall be available for external connections. Either end of the winding shall be designed for use as a neutral bus or for use as the main generator power leads. The generator neutral connection rating in amperes shall be the same as the generator line terminal rating and shall be based on the maximum MVA rating of the generator operating at minimum allowable generator terminal voltage.

### 50.4.3 ROTOR

The rotor and shaft shall be of a single forging with longitudinal slots of parallel/taper sections to cater for the field windings which are formed from grooved copper strips. The winding shall be supported against centrifugal forces by tensile steel alloy forged rings.

The rotor shall be designed to withstand, without damage, the effects of a sudden interruption of full excitation current. Rotor windings shall be constructed of silver-bearing copper so as to prevent harmful plastic distortion under operating conditions involving cyclic heating and cooling.

### 50.4.4 INSULATION AND MAXIMUM TEMPERATURES

The insulation of the armature windings, field windings, and collectors shall be Class F. The temperature rises and total temperatures shall not exceed those permitted for Class B. The calculated hottest spot temperature shall not exceed 130°C on a machine which is manufactured to IEC standards.

The stator coil insulation shall be a vacuum pressure, resin impregnated, mica type system. Windings shall be insulated for the full rated voltage to ground with no grading of insulation.

### 50.4.5 ROTOR SHAFT EARTHING BRUSH

Rotor shaft earthing brush or brushes shall be provided at locations along the turbine/ generator/exciter shaft system for the on-line monitoring of shaft voltages and bearing insulation as well as the protection of bearing shells against pitting.

### 50.4.6 NEUTRAL EARTHING

The generator neutral point shall not be directly connected to earth. Artificial neutral earthing shall be implemented via the phase isolated busbars by connecting three single phase earthing transformers between the three winding line end terminals and ground, preserving the phase isolation.

### 50.4.7 MONITORING EQUIPMENT

#### 50.4.7.1 STATOR END-WINDING VIBRATION

Not used.

#### 50.4.7.2 ROTOR SHORTED TURNS

Not used.

#### 50.4.7.3 STATOR TEMPERATURES

The system for stator temperature monitoring requires temperature detectors of the thermocouple type shall be fitted in at least the following locations:

- In core plate.
- 12 RTDs for stator core monitoring, 42 RTDs between the upper and lower windings and 84 RTDs at the outer of stator winding which are redundantly designed.
- Between bars - Provision is made for two slots per phase per winding, with one thermocouple at each end of the generator and one in between two ends.
- Provision shall be made for six at each end of the generator
- In cooling circuits - These monitor all inlet and outlet or hot and cold gas and water temperatures necessary to fully evaluate the performance of the rotor and stator cooling systems. Included are gas and water coolers, terminal bushings, hollow conductors and stator bars, and other cooled components.

#### 50.4.7.4 BUS/SLOT COUPLERS FOR PARTIAL DISCHARGE MEASUREMENTS

Bus couplers shall be installed with a partial discharge monitoring system.

### 50.5 MAINTAINABILITY

Similar wearing parts shall be interchangeable between the generators units.

### 50.6 OPERABILITY

The main limits of permissible operation as shown on the PO (real power and reactive power) capability diagram shall be presented on a computer screen on the unit operator's desk and shall be used to ensure that the machine is operated safely within its capability limits.

The unit centralized desk shall be provided with interfacing for automatic generation control (AGC).

## 50.7 APPLICABLE STANDARDS

- IEC 60034
- IEC 60072
- IEC 60136
- IEC 60276
- IEC 60356
- IEC 60560
- IEC 60681-1
- IEC /TR 60078
- IEC 61271-100
- IEC 61271-103
- IEEE 1129-1992
- IEEE C37.013
- ISO 2437

# 51 TURBINE SEALS AND DRAINS

## 51.1 SYSTEM IDENTIFICATION

- System Name: Turbine Seals and Drains
- KKS Code MAJ

## 51.2 FUNCTION

The Turbine Seals and Drains System provides seal steam to the main turbine for shaft sealing; provides steam for prewarming the turbine; provides for recovery and recycling of sealing steam; and provides drainage for the turbine, main steam leads, steam chest, and turbine stop and control valves.

## 51.3 PROCESS DESCRIPTION

The Turbine Seals and Drains System will include the following major equipment and components.

- One gland steam condenser.
- Two 100 % capacity gland steam condenser air exhausters.
- One gland steam drain separator.
- Interconnecting piping within the turbine seal system.
- Interconnecting system piping from the turbine drains to the condenser, miscellaneous drains receiver tank, or condensate flash tank.
- Associate piping, valves, instruments, and accessories.

Seal steam for the turbine packing will be supplied from the Cold Reheat Steam System or the Auxiliary Steam System. Pressure in the turbine packing supply header will be maintained by pressure control valves.

The seal steam supply will be supplemented by steam leakage from the pressure packing on the high-pressure turbine and intermediate-pressure turbine. As the pressure packing leakage increases with load, the steam supplied through the cold reheat steam seal feed valve or the steam seal auxiliary cold reheat feed valve is decreased. Above approximately 50 % load, the leakage from the pressure packing exceeds the steam seal requirements of the low-pressure turbine vacuum packing. As the vacuum packing steam seal requirements are more than satisfied by the pressure packing leakage, the excess steam is discharged through the steam packing unloading valve. The excess steam will be taken from the steam packing unloading valve to feed water heater or the gland steam condenser depending on available pressure and the turbine manufacturer’s recommendation.

When cold reheat steam is not available at startup to seal the turbine and establish vacuum in the condenser, steam will be provided by the Auxiliary Steam System.

An exhaust hood spray system shall be included with each low pressure turbine. During low load and when exhaust temperature is high, a valve shall automatically open and water from the Condensing System is sprayed into the low pressure turbine exhaust hood.

## 51.4 BASIS FOR DESIGN

The Turbine Seal and Drain System shall be designed and constructed in accordance with ASME Codes and Standards and the Malaysian Factories and Machinery Act 1967 (Act 139) and Regulations.

The system shall be capable of automatically supplying the turbine sealing steam requirements under all operating modes. For startup, shutdown, and operation at loads up to approximately 50%, the sealing steam will be supplied from either the Auxiliary Steam System or the Cold Reheat Steam System. At higher loads, seal steam will be provided entirely by pressure packing leakage.

The outer shaft packing shall be kept under a vacuum by the gland condenser and gland condenser exhauster.

Using auxiliary steam, the system shall automatically seal the turbine under all conditions, including operation with worn packing clearances.

The turbine stop valve drains shall be open during turbine startup. The valves should be closed (manually initiated) after synchronization.

The after seat drains shall automatically open and remain open if the unit is tripped or taken off line. The before seat drains shall remain closed during a trip and shut down to conserve thermal energy in the steam system and to prevent thermal cycling of the stop valve metal. The before seat drains must be reopened prior to restarting the unit.

The system must provide the seal steam and drain requirements for the turbine under all operating conditions.

The turbine drain piping shall continuously slope downward to the drain discharge point. The turbine manufacturer’s recommendations for physical constraints will be followed.

The gland condenser shall be controlled to prevent leakage of steam past the turbine outer packing. The Turbine Control System shall control the seal steam regulation.

# 52 TURBINE LUBE OIL

## 52.1 SYSTEM IDENTIFICATION

- System Name: Turbine Lube Oil
- KKS Code MA

## 52.2 FUNCTION

The Turbine Lube Oil System functions to provide storage, cooling, and purification of the lubricating and hydraulic control oil required for the steam turbine generator.

## 52.3 PROCESS DESCRIPTION

The Turbine Lube Oil System includes the following major equipment and components for each unit:

- Oil storage consisting of a clean oil tank and a dedicated dirty oil tank .
- Two 100% capacity turbine lube oil coolers.
- Two 100% capacity oil pumps; consisting of one main oil pump shaft driven and one AC lube oil pump.
- One 100% capacity DC emergency bearing oil pump.
- One duplex lube oil filter. Each filter of duplex set to be able to handle 100% flow.
- Two 100% capacity exhauster fans with mist eliminators (vapor extractor).
- Two lube oil transfer pumps.
- Jacking oil system.
- Hydrogen seal oil system (separate system), if required.
- Lube oil purification unit.
- Associated piping, valves, instruments, and accessories.

Lubricating and hydraulic control oil for the steam turbine generator will be pumped from the main oil tank through oil filters, oil coolers and distributed to each steam turbine generator bearing, the electro-hydraulic control unit, the jacking oil system, and the hydrogen seal oil system on the generator (unless hydrogen seal oil is provided as a separate system). The lubricating oil pumped to the bearings will drain by gravity back to the reservoir through sloped guarded return oil piping.

Guarded piping has the oil under pressure in the inside pipe and the non-pressurized return oil in the outer pipe. Should the pressure pipe develop a leak, the leaked oil is collected in the return oil pipe and returned to the lube oil reservoir.

The main oil tank will be a shop fabricated tank with integrally mounted oil pumps and sized to contain all of the oil that flows back upon shutdown of the steam turbine. The lube oil tank will have two main motor driven lube oil pump (unless shaft driven main oil pump is provided), one auxiliary AC motor driven oil pump, and one 100 % capacity DC motor driven emergency bearing oil pump with an automatic start pressure switch. The oil tank shall also contain two 100% capacity exhauster fans with mist eliminators.

The hydrogen seal oil system will prevent hydrogen leakage from, the generator, by using shaft seals installed in the vicinity of the bearings. These seals will be supplied with pressurized oil, as required by the turbine generator manufacturer, to form a radial liquid seal on the generator shaft.

The jacking oil system will provide pressurized oil to the turbine generator main shaft bearings, when the turbine is being driven by the turning gear. Jacking oil is preferably not necessary at normal barring speed of rotation. The jacking oil system shall include two 100% capacity AC motor driven pumps, control valves and other equipment, as required by the turbine generator manufacturer. The jacking oil system will utilize oil from the main oil tank. Jacking oil pumps will independently take suction from the lube oil reservoir.

The oil storage tank shall be divided in to a clean lube oil tank and dirty lube oil tank. Each side shall be capable of storing the entire lube oil system volume.

In addition, each steam turbine generator will have a lube oil purification unit. A lube oil bypass line shall be provided to allow filling of the main oil tank with the lube oil purification unit removed from service. A percentage of flow will be sent to the lube oil purification unit, purified and returned to the reservoir. The lube oil purification unit will remove any water contamination and maintain particle contamination at or better than the steam turbine manufacturers standard as required for unit operation.

During steam turbine generator normal operation, the lubricating oil in the main oil tank will be filtered and cooled before flowing to the turbine bearings and electro-hydraulic control system.

## 52.4 BASIS FOR DESIGN

The Turbine Lube Oil System shall be capable of automatically controlling the lube oil temperature and pressure to meet the turbine manufacturer’s requirements.

The lube oil piping shall be routed in a manner to avoid crossing or being directly above any steam lines where possible and to allow gravity drainage. The supply and return piping shall be sloped to avoid air pockets and to allow proper drainage. All lube oil supply and return piping shall be stainless steel material.

The lube oil coolers shall be shell and tube type heat exchangers and shall use closed cycle cooling water as the cooling medium.

Lube oil purification equipment shall be designed to meet all of the turbine manufacturer’s purity requirements.

The AC and DC lube oil pumps shall have full test capability for low pressure indication to confirm automatic start of standby AC and emergency DC pumps. The DC lube oil pump shall be powered on separate distributed hardwired circuits and not through the DCS.

The oil tank shall be located on the ground floor near an exterior wall to allow convenient truck access for filling the lube oil tank and removing used oil. The oil tank shall sit In a curbed concrete retaining area (110% of main oil tank capacity) for capture of oil spills or tank leaks.

All supply and return lube oil piping shall be double wall piped for oil containment and fire prevention.

The Turbine Lube Oil System shall be designed and fabricated in accordance with the ASME Codes and Standards

# 53 GENERATOR COOLING AND PURGE

## 53.1 SYSTEM IDENTIFICATION

- System Name: Generator Cooling and Purge
- KKS Code MK

## 53.2 FUNCTION

The Generator Cooling and Purge System supplies hydrogen to the generator for cooling, supplies carbon dioxide to the generator for purging, and supplies seal oil to seal the generator against hydrogen leakage. The system also supplies cooling water to cool the generator stator.

## 53.3 PROCESS DESCRIPTION

The Generator Cooling and Purge System will include the following major equipment and components:

- Generator compressed gas control panel.
- Generator seal oil equipment.
- Generator core monitor equipment.
- Gas dryer.
- Water detector.
- Two 100% hydrogen side seal oil pumps (two AC motor driven).
- Three 100% air side seal oil pumps (two AC motor driven and one driven).
- Stator cooling water coolers.
- Piping, valves, and instrumentation.
- Stator cooling water pumps.
- Stator cooling water storage tank.
- Deionizer.
- Oil drain line loop seal.
- Vapor extractor.
- Hydrogen side drain regulator.
- Hydrogen side seal oil cooler.
- Air side seal oil cooler.

The generator compressed gas equipment supplies hydrogen gas to the generator for use in the closed-loop cooling of the generator field and supplies carbon dioxide to purge the generator before outage or disassembly.

The generator seal oil equipment will prevent the escape of hydrogen from the enclosed generator casing along the rotor shaft and prevent air infiltration. The shaft sealing shall be accomplished by supplying cooled turbine lube oil or separate hydrogen seal oil to the generator seal rings.

The generator compressed gas equipment portion of the Generator Cooling and Purge System will consist of hydrogen coolers; a gas dryer; water detectors; a hydrogen control panel containing gas purity and pressure monitoring equipment; and the necessary valves, pressure gauges, regulators, and other equipment to permit introduction of hydrogen and carbon dioxide gas into the generator.

The hydrogen gas cooler inside the generator frame is used to cool the hydrogen gas. It is composed of a set of water boxes, a bundle of finned tubes set in the tube sheets, and a supporting frame.

Several resistance temperature detectors (RTD) are located between coils in each phase of the stator windings to measure the temperature of the windings. Other resistance temperature detectors are located to measure the temperature of cooling hydrogen gas entering and exiting the hydrogen gas cooler. In addition, several RTD are located to measure the temperature of the stator winding cooling water.

Hydrogen gas is supplied by the low pressure Hydrogen Storage System. Hydrogen gas will enter the generator through the hydrogen manifolds and be maintained at the rated gas pressure by the gas pressure regulator.

Carbon dioxide gas will be supplied from the low pressure Carbon Dioxide Storage System. Carbon dioxide gas will enter the generator through the carbon dioxide manifolds and displaces the air inside the generator casing prior to filling the casing with hydrogen to avoid creating an explosive hydrogen and air mixture. The carbon dioxide is also used to purge the hydrogen from the generator when generator maintenance is required.

The hydrogen gas cooled generator shall have a shaft seal oil system to prevent the hydrogen gas inside the generator from leaking, under all conditions. The seal oil system shall contain an Air oil circuit, Vacuum oil circuit and Hydrogen oil circuit. The Air oil circuit shall act as the main sealing circuit; which contains two (2) 100% AC motors driven seal oil pump and one (1) 100% emergency seal oil pump driven by a DC motor. Hydrogen oil circuit is a closed circuit shall contain two (2) AC motor driven seal oil pumps. The Vacuum oil circuit shall be used for isolating the Air oil and Hydrogen oil. Either circuit shall be capable of preventing hydrogen from leaking. The sealing oil shall be a separated system with the oil coming from the independent sealing oil tank. The Air oil and Hydrogen oil are from the seal oil tank and will be returned to the tank as a circuit. The Vacuum oil side is from the air returned oil and shall be returned to oil tank. The oil pressure of the Vacuum oil and Hydrogen oil will be the same and higher than the Air oil circuit that can separate the Hydrogen oil from the Air oil. As the Air oil pressure is lower than the Vacuum oil, one (1) AC motors driven seal oil pump is used at Vacuum oil side. All circuits shall be controlled by the pressure regulating valves. The shaft seal oil system shall represent a proven technology with safe and reliable operation in case of malfunction, loss of AC power (black plant) or inaction of the Hydrogen side flow.

Continuous hydrogen pressure, temperature, and continuous purity monitoring during hydrogen fill, turning gear operation, and normal turbine generator operation is required.

To monitor the system, instruments such as temperature gauges, flow meters, pressure gauges, etc. are provided on the stator cooling water control panel, and rack installed under the steam turbine generator foundation.

Hydrogen gas shall be dried on a continuous basis using 2 full capacity desiccant type gas dryers.

## 53.4 BASIS FOR DESIGN

Hydrogen coolers shall be sized and individual sections provided so that one section can be removed from service on-line with the generator still capable of operation at the maximum load condition continuously. The maximum load condition of the steam turbine generator occurs at BMCR, which is 3% above the turbine valves wide open (VWO) condition.

Stator cooling water coolant circuit piping, filters, valves, and associated components shall be stainless steel.

The Generator Cooling and Purge System shall be designed in accordance with ASME Codes and Standards

# 54 SERVICE WATER

## 54.1 SYSTEM IDENTIFICATION

- System Name: Service Water
- KKS Code GH

## 54.2 FUNCTION

The Service Water Supply System will distribute service water at the required flows and pressures to various plant users, such as cooling, flushing, wash down, makeup water to the potable and demineralized water treatment systems, mist eliminator wash system, air heater wash and other water users throughout the Plant.

## 54.3 PROCESS DESCRIPTION

A process flow diagram of the service water system is shown on 10-PM-PAYRA-14.

The Service Water System includes the following major equipment and components:

- Two 50 percent capacity service water pumps.
- Two service/fire water storage tanks.
- Associated piping, valves, instruments, controls, and accessories.

Water supplied from the local municipality will be stored in two service/fire water storage tanks. The total storage capacity will be adequate to meet all the service water requirements with a reserve provided for fire water supply.

The service water pumps will draw water from the water storage tanks and supply water through service water header to miscellaneous plant users such as ash conditioning and wash down, and provide makeup water to the demineralized water treatment system.

## 54.4 BASIS FOR DESIGN

The combination service/fire water storage tanks shall have an internal standpipe arrangement that will allow service water to be drawn only from above the fire water storage section of the tanks which is reserved for fire fighting. The tanks shall be coated, carbon steel material.

The tanks shall provide a combined storage capacity of three days normal plant service water supply requirements with the plant operating on a continuous basis at MCR condition plus 2 times boiler fill volume plus the minimum fire protection water volume in accordance with NFPA.

Piping and valves shall be constructed of carbon steel materials. All piping shall be above ground.

The Service Water System shall be designed and fabricated in accordance with ASME Codes and Standards

# 55 POTABLE WATER

## 55.1 SYSTEM IDENTIFICATION

- System Name: Potable Water
- KKS Code GK

## 55.2 FUNCTION

The Potable Water System receives water from the Service/Fire water storage tanks and distributes potable quality water to plumbing, sanitary, safety showers and eyewashes, and any other potable water uses.

## 55.3 PROCESS DESCRIPTION

A process flow diagram of the potable water system is shown on drawing 10-PM-PAY-14.

The Potable Water System will include the following major equipment and components:

- Individual tanks for each building at the roof top level.
- Two 50 percent capacity potable water pumps with minimum flow recirculation control.
- Safety shower/eye wash stations (as required).
- Associated piping, valves, instruments, controls, and accessories.

Potable water will be used to meet the various plant potable water demands such as plumbing for the various buildings and inhabited areas, and the safety shower/eye wash units located within selected plant and chemical areas.

The potable water provided will be of sufficient quality that no further treatment equipment is required. The system is expected to have adequate capacity and pressure required for potable water supply to all users. One potable water pump will operate continuously to ensure system pressure is continuously available for the users and provide minimum flow recirculation protection back to the Service/Fire water storage tanks.

## 55.4 BASIS FOR DESIGN

The Potable Water System will be sterilized in accordance with local requirements prior to use.

All piping shall be above ground and shall be made of 304 stainless steel.

The Potable Water System shall be designed and fabricated in accordance with ASME Codes and Standards

# 56 FIRE PROTECTION WATER SUPPLY

## 56.1 SYSTEM IDENTIFICATION

- System Name: Fire Protection Water Supply
- KKS Code SG

## 56.2 FUNCTION

The function of the Fire Protection Water Supply System is to provide water under pressure to the fire hydrants and fixed water suppression stations in the Site Fire Protection System (STG) and Generation Building Fire Protection System (FPA). It is not the intent of this document to specifically call out all of the necessary fire protection systems, but rather to clarify the minimum requirements. The system design must meet NFPA and local fire code requirements (BOMBA).

## 56.3 PROCESS DESCRIPTION

The Fire Protection Water Supply System will include, as a minimum, the following major components:

- Two 100% motor driven fire water main pump.
- One 100% diesel engine driven fire water main pump.
- Two 100% motor driven pressure maintenance (jockey pump) fire water main pump.
- One pump controller for each fire pump.
- One diesel fire water pump fuel tank for each diesel driven pump.
- Two 100% service/fire water storage tanks.

This system will provide the fire water supply for the Site Fire Protection System (STG) and the Generation Building Fire Protection System. The fire water supply piping will be routed to all areas where fire fighting water (whether it is for hydrants and/or fixed fire fighting systems) is required.

The fire water pumps will take suction from the service/fire water storage tanks provided in the Service Water System.

System pressure will be maintained by the pressure maintenance (Jockey pump) fire water pump.

Due to the higher water supply pressure required for protecting equipment in the upper floors of the boiler buildings, separate fire water booster pumps may be necessary. This will include one 100% motor driven fire water booster pump, one 100% diesel engine driven fire water booster pump, and one pressure maintenance pump, similar to the main fire pump arrangement. The fire water booster pumps will take suction from the main fire pump discharge header.

## 56.4 BASIS FOR DESIGN

The fire water pumps will have separate suction pipes to a minimum of two separate 100% water storage tanks so that if one suction pipe or water storage tank is out of service there is still an available fire water supply source. An isolation valve will be provided at each suction pipe tank connection. The pressure maintenance fire water pump will share a common suction with the motor and diesel driven fire pumps and will be designed to deliver not less than the normal leakage rate from the fire protection piping system.

If a combined service/fire water storage tank is used then the service water pumps must take suction through an internal standpipe arrangement that will allow service water to be drawn only from above the dedicated fire water storage section of the tanks reserved for fire fighting. The tanks will be field erected, composed of coated, carbon steel material, and designed in accordance with NFPA 22 and other relevant Codes.

Demineralized water or condensate storage tanks may not be used as the water supply source for the fire water pumps.

Control logic will include the ability to start the pumps manually, both locally and remotely, and automatically upon pressure drop. The remote start signal will be provided by the Fire Alarm Annunciator Panel (FAAP). The local start and stop switches will be on the front of the controller cabinet. No automatic shutdown of the fire pumps shall be provided. The fire pumps may only be stopped by local manual operation. The control components will include sufficient pressure switches and isolated relay contacts to permit proper operation and remote indication of pump status. A pump running signal will be available in the DCS but the pumps may not be controlled (start/stop) through the DCS.

The motor driven fire water pumps serve as the primary pumps with the diesel driven fire water pumps acting as the backup. A start command will be sequenced for all pumps and controlled by the fire pump controller for each pump as system pressure falls below the start pressure. Start commands will begin individually with the motor driven fire water pumps and will continue to individually start, if necessary, the diesel driven fire water pumps. The fire pump start sequence will be based on system pressure decreases per NFPA.

The pressure maintenance fire water pump will be placed in automatic operation and will start and stop as required to maintain the system pressure. The start and stop commands to the pressure maintenance fire water pump will be initiated from the pressure maintenance fire water pumps controller.

Flow meters will be supplied in the main pump discharge lines with lines leading back to the service/fire water storage tanks. These lines will be used to test the main pumps flow characteristics in situ.

A circulation relief valve line will be supplied from each pump discharge line, as required by NFPA, and will drain to a nearby drain to allow visual identification of relief or leakage.

The motor driven and diesel driven fire water pumps must be installed in separate rooms with a fire wall separating the rooms. A fixed water suppression and detection system will be provided for the diesel driven fire pump enclosure.

Alarms generated by the Fire Protection Water Supply System will be annunciated both locally at a local supervisory panel and remotely at the FAAP.

# 57 DEMINERALIZED WATER TREATMENT

## 57.1 SYSTEM IDENTIFICATION

- System Name: Demineralized Water Treatment
- KKS Code GC

## 57.2 FUNCTION

The function of the Demineralized Water Treatment System is to produce demineralized water of sufficient quantity and quality to supply makeup to the steam cycle and other miscellaneous uses throughout the site. The Demineralized Water Treatment System is also used to support various uses during startup including hydrostatic testing, chemical cleaning, displacement flushes after cleaning, steam blow, and wet storage.

## 57.3 PROCESS DESCRIPTION

Process flow diagrams of the Demineralized Water Treatment System are shown on drawings 10-PM-PAYRA-10. The Demineralized Water Treatment System consists of ultra filtration equipment and Cation, Anion, RO and Mixed Bed ion exchange.

The Demineralized Water Treatment System shall include, but not necessary be limited to the following major components:

- Two full capacity automatic self cleaning strainers.
- Two UF feed pumps.
- Two half capacity UF membrane modules.
- One Filtered water storage tank.
- Two full capacity UF backwash water pumps.
- Two full capacity filtered water transfer pumps.
- One UF filter chemical cleaning skid.
- One NaClO feed skid.
- Primary cation, degasifier, primary anion exchanger vessels.
- One primary demineralized water tank.
- Two full capacity RO feed pumps.
- One RO skid consisting of two full cartridge filters, one RO bypass line, one RO booster pump and one full capacity RO equipment.
- One RO permeate tank.
- Two full capacity RO permeate pumps.
- Working and polishing mixed bed exchanger vessels.
- Cation regeneration system consisting of one hydrochloric acid storage tank with fume scrubber and acid regeneration feed equipment.
- Anion regeneration system consisting of one caustic storage tank, caustic dilution water heater, and caustic regeneration feed equipment.
- One air blower skid.
- Two full capacity regeneration water pumps.

- One Programme Logic Controller(PLC) with local HMI and data link to DCS.
- All necessary piping, valves, and instrumentation required to operating the system.

The water supply to the demineralized water treatment plant shall be raw water from the Service Water System (WSC). The raw water flows through the automatic self cleaning strainers to remove suspended solids from the incoming water. Then the water is pumped to the ultra filter modules via UF feed pumps to further remove suspended solids and colloidal solids. The filtered water is routed to the filtered water tank and then pumped to the demineralizer train. Capability to perform chemically enhanced backwash of the UF modules shall be provided and shall be designed to utilize acid or alkaline cleaning solutions. The dernineralizer train consists of a primary cation exchanger, a degasifier, a primary anion exchanger, a RO equipment and a working mixed bed exchanger and a polishing mixed bed exchanger.

The primary cation exchanger removes the cations, primarily calcium, magnesium, and sodium. Decarbonation of the primary anion exchanger feed water is achieved by degasifier. The primary anion exchanger removes the anions, primarily chlorides, sulfates, nitrate, and silica. The RO equipment removes total organic carbon (TOC) and trace salts. The water is further deionized to the desired quality by the working mixed bed exchanger and the polishing mixed bed exchanger, which contains both strong cation and anion exchange resin.

The effluent of the Demineralized Water Treatment System is directed to the demineralized water storage tanks in the Cycle Makeup and Storage System (FWF). The Demineralized Water Treatment System will stop and start based upon the water level in the demineralized water storage tank. The water level is monitored by a level transmitter.

Regeneration facilities consist of acid and caustic dilute chemical preparation equipment, acid and caustic chemical pumps, a water heater tank for anion resin regeneration, air blowers, and regeneration water pumps.

Chemical waste from the regeneration process is directed to the water treatment area neutralization sump for chemical waste treatment.

The Demineralized Water Treatment System is provided with a local redundant PLC based control system. The PLC system interfaces with the DCS system to provide remote monitoring.

## 57.4 BASIS FOR DESIGN

The Demineralized Water Treatment System is sized to provide cycle makeup equivalent to at least 3.0 percent of the full load steaming rate. The Demineralized Water Treatment System shall be expandable for the future unit.

All piping, except for hydrochloric acid, shall be Type 304L or 316L stainless steel. Hydrochloric acid piping shall be CPVC, Sch.80. All concentrated chemical piping shall be welded construction, no screwed connections.

The Demineralized Water Treatment System is designed to produce a demineralized water quality as follows. The following requirements are the minimum level of treatment required, additional treatment may be required by specific equipment and manufacturer requirements.

In such case, these additional requirements shall be stipulated and met. The quality of the demineralized water shall also meet the boiler manufacturer design requirement under all operating conditions.

- < 0.1 μmho/cm conductivity (25$^{o}$C).
- < 10 ppb silica as $SiO_2$
- < 3 ppb sodium as Na.
- < 3 ppb chloride as C1.
- < 3 ppb $SO_4$ as sulfate.
- < 300 ppb TOC.

# 58 CHEMICAL WASTE COLLECTION AND TREATMENT

## 58.1 SYSTEM IDENTIFICATION

- System Name: Chemical Waste Collection and Treatment
- KKS Code

## 58.2 FUNCTION

The function of the Chemical Waste Collection and Treatment System is to provide for the collection, neutralization, and transportation of chemical wastewater to the industrial wastewater storage pond.

## 58.3 PROCESS DESCRIPTION

The Chemical Waste Collection and Treatment System shall include the following major equipment and components:

- Chemical waste piping and lift station(s), if required.
- One water treatment area chemical waste sump equipped with 100% chemical waste sump pumps.
- One water treatment area neutralization sump with an eductor.
- Two 100% water treatment area neutralized water discharge/ recirculation pumps.
- One condensate polishing regeneration area chemical waste sump equipped with two 100% chemical waste sump pumps.
- One condensate polishing regeneration neutralization sump with an eductor.
- Two 100% condensate polishing regeneration area neutralized waste discharge/recirculation pumps.
- Associated piping, valves, instruments, and controls.

Chemical waste drainage is by gravity flows wherever possible, with lift stations as required due to grade elevations or minimum slope requirements.

The water treatment area chemical waste sump serves as a collection point for chemical wastes from miscellaneous chemical drains and resin regeneration chemical drains in the water treatment area. The water treatment area chemical waste sump is equipped with two 100% sump pumps. The sump pumps are controlled by sump level with an interlock to prevent operation when the water treatment area neutralization sump is full. Chemical wastes from water treatment area are collected to the water treatment area neutralization sump for neutralization. Chemical waste from the demineralization regeneration process is also directed to the water treatment area neutralization sump for neutralization. Chemical wastes shall be treated on a batch basis. Hydrochloric acid and sodium hydroxide from Demineralized Water Treatment System (WTD) are added to the neutralization sump to neutralize the chemical waste. Two 100% water treatment areas neutralized waste discharge/recirculation pumps are used to circulate wastes through the eductor in the neutralization sump for proper mixing during the neutralization process. Neutralized wastes are then transferred to the industrial wastewater storage pond.

The condensate polishing regeneration area chemical waste sump serves as a collection point for chemical wastes from miscellaneous chemical drains in the boilers and turbines area. The condensate polishing regeneration area chemical waste sump is equipped with two 100% sump pumps. The sump pumps are controlled by sump level with an interlock to prevent operation when the condensate polishing regeneration area neutralization sump is full. Chemical wastes from condensate polishing regeneration area are collected to the condensate polishing regeneration area neutralization sump by the chemical waste sump pumps for neutralization. Chemical waste from the condensate polishing regeneration process is also directed to the condensate polishing regeneration area neutralization sump for neutralization. Chemical wastes are treated on a batch basis. Hydrochloric acid and sodium hydroxide are added to the neutralization sump to neutralize the chemical waste. Two 100% condensate polishing regeneration area neutralized waste discharge/recirculation pumps are used to circulate wastes through the eductor in the neutralization sump for proper mixing during the neutralization process. Neutralized wastes are then transferred to the industrial wastewater storage pond.

Each chemical bulk storage tank containment area shall be provided with a valved drain that is normally closed. The containment areas are monitored for chemical spills. If a chemical spill occurs, mobile sump pumps will be used to collect the spill. Uncontaminated water collected in the containment area is drained to the nearest local wastewater collection sump before pumped to the industrial wastewater storage pond.

## 58.4 BASIS FOR DESIGN

The water treatment area neutralization sump shall be sized for at least two volumes of the maximum expected regeneration wastewater from one regeneration process of the demineralizers plus a 20% margin.

The condensate polishing regeneration area neutralization sump shall be sized for at least two volumes of the maximum expected regeneration wastewater from one regeneration process of the condensate polishers plus a 20% margin.

The chemical waste sumps shall be concrete structures with a chemical resistance lining.

Each neutralization sump shall be provided with one mixing eductor to provide complete mixing of the neutralization sump wastewater and neutralization chemicals. Internal support and additional reinforcements shall be provided as required to provide adequate support for the eductor. The internal supports shall be constructed with ample design margins and shall be constructed of material suitable for all conditions. The neutralization sump shall be provided with two entrances, with ladder. Chemical waste piping shall be non.-metallic materials, suitable for chemical wastes at all conditions. Concentrated hydrochloric acid piping shall be of suitable double wall construction.

# 59 SANITARY DRAINAGE AND TREATMENT

## 59.1 SYSTEM IDENTIFICATION

- System Name: Sanitary Drainage and Treatment
- KKS Code GQ

## 59.2 FUNCTION

The function of the Sanitary Drainage and Treatment System is to provide for the collection, treatment, and disposal of plant sanitary wastes.

## 59.3 PROCESS DESCRIPTION

The Sanitary Drainage and Treatment System shall include the following major components:

- Sanitary lift stations.
- Packaged sanitary waste treatment plant.
- Sanitary waste treatment plant effluent lift station.
- Associated piping, valves, instruments, controls, and accessories.

Sanitary wastes are collected in a system of sanitary drains, and routed to the packaged sanitary waste treatment plant. Sanitary waste drainage is by gravity flow wherever possible, with lift stations as required due to grade elevations or minimum slope requirements.

The sanitary lift stations are equipped with two full capacity sanitary grinder pumps. The sanitary lift stations are automatically controlled by sump level and pump the collected plant sanitary wastes to the packaged sanitary waste treatment plant.

The packaged sanitary waste treatment plant shall be of the extended aeration type. The packaged sanitary waste treatment plant consists of 5 sections, anoxic zone, aeration zone, clarifier, sludge storage, and chlorinator. Treated effluent is discharged to the industrial wastewater storage pond. Stored sludge is periodically removed for disposal.

## 59.4 BASIS FOR DESIGN

Each sanitary lift station is sized for the anticipated load based upon the fixtures and operating personnel expected for the area served.

The packaged sanitary waste treatment plant shall have adequate capacity to treat sanitary wastewater for 170 full time operating personnel. Additional capacity shall be provided as required to accommodate periodic temporary maintenance activities on site. The packaged sanitary waste treatment plant shall be expandable for the future unit. Sanitary wastewater will be generated from various areas of the plant including, but not limited to, toilets and sinks, shower areas, canteens, laboratories, etc. Effluent from the sanitary waste treatment plant shall comply with all local and national codes and regulations for discharge.

Collection piping is designed based on accepted civil engineering practices based on the various sanitary facilities and the site layout.

# 60 WASTEWATER COLLECTION AND TREATMENT

## 60.1 SYSTEM IDENTIFICATION

- System Name: Wastewater Collection and Treatment
- KKS Code GM

## 60.2 FUNCTION

The function of the Wastewater Collection and Treatment System is to provide for the collection, treatment, storage, and disposal of plant wastewaters.

## 60.3 PROCESS DESCRIPTION

The Wastewater Collection and Treatment System as a minimum shall include the following major equipment and components:

- Oil/water separators, as required.
- Each provided oil/water separator shall be equipped with two full capacity oil/water discharge pumps. Wastewater collection sumps as required.
- Each sump shall be equipped with two full capacity wastewater transfer pumps.
- Coal yard runoff basin and pump sump with two full capacity pumps to transfer wastewater from the pond to the wastewater treatment plant.
- One wastewater treatment plant consisting of the following major equipment or functional equivalent.
  - pH adjustment Tank and Reaction Tanks as required.
  - One clarifier/solids contact unit.
  - One gravity filter unit.
  - One thickener (if required)
  - Two full capacity filter press feed pumps.
  - One elevated filter press.
  - One solids collection bin located under the filter press.
  - One coagulant feed system including coagulant pump skid and bulk storage tank.
  - One coagulant aid feed system including coagulant aid pump skid and storage tank/aging tank.
  - One sulfide feed system including sulfide pump skid and solution tank.
  - One hypochlorite feed system including hypochlorite pump skid and solution tank.
  - One caustic feed system including caustic pump skid and bulk storage tank.
  - One dewatering polymer feeder skid.
  - Industrial wastewater Ponds with a minimum of two full capacity pumps to collect and pump filter backwash, thickener overflow, and

clarifier/solids contact unit sample sink drain to the wastewater treatment plant.

- Additional pumps as required for treatment and transfer maybe provided.
- Programmable logic control (PLC) system to control the wastewater treatment system pumps.

The wastewater transfer pumps are automatically controlled by sump level, and pump the collected plant wastewater to CW discharge channel or reuse as coal handling and dust suppression water.

## 60.4 BASIS FOR DESIGN

Oil/waster separator(s) is (are) designed to produce effluent concentrations of oil and grease of 10 mg/l or less.

The wastewater treatment system shall be equipped with the necessary reaction systems, mixers, chemical pumps, chemical storage, settling chamber, sludge pumps, sludge holding tank, instrumentation, and PLC controls to provide a fully functional system. The wastewater treatment system shall be designed to treat wastewater to comply with the effluent requirements listed below. The wastewater shall comply with the more stringent of the Bangladesh Standard and IFC/World Bank Standards listed below. The Wastewater Treatment System shall be expandable for the future unit.

Wastewater from the industrial wastewater storage pond shall also comply with these standards. Additional wastewater treatment equipment shall be provided as required to meet this requirement or alternatively, untreated wastewater routed directly to the industrial wastewater storage pond may be routed through the wastewater treatment plant to assure compliance.

| Pollutants | Units | Guideline Value |
|---|---|---|
| pH | pH | 6 – 9 |
| BOD | mg/l | 30 |
| COD | mg/l | 125 |
| Total nitrogen | mg/l | 10 |
| Total phosphorus | mg/l | 2 |
| Oil and grease | mg/l | 10 |
| Total suspended solids | mg/l | 50 |
| Total coliform bacteria | MPN[a] / 100 ml | 400[a] |
| Notes:<br>[a] Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation.<br>[b] MPN = Most Probable Number | | |

## SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT D – GEOTECHNICAL REPORT

| File Number |
| --- |
| 35-F363K-G01 |

# FEASIBILITY STUDY ON PAYRA 2x660MW COAL BASED POWER PLANT

Vol. Four

# Geotechnical Investigation Report

License-issuing Authority: National Development and Reform Commission, the People's Republic of China
Engineering Consultation Qualification: Class A
Certificate No.: Engineering Consulting First Grade 21520070001
June 2015, Fuzhou

# 工程咨询单位资格证书

单位名称：福建省电力勘测设计院　　　　资格等级：甲级

| 专　业 | 服务范围 |
|---|---|
| 火电、其他(新能源) | 规划咨询、编制项目建议书、编制项目可行性研究报告、项目申请报告、资金申请报告、评估咨询、工程设计*、工程项目管理(全过程策划和准备阶段管理) |
| 水文地质、工程测量 | 编制项目建议书、编制项目可行性研究报告、项目申请报告、资金申请报告、工程设计* |
| 岩土工程 | 编制项目建议书、编制项目可行性研究报告、项目申请报告、资金申请报告、工程设计*、工程项目管理(全过程策划和准备阶段管理) |
| 通信信息 | 规划咨询、编制项目建议书、编制项目可行性研究报告、项目申请报告、资金申请报告 |
| 水电 | 编制项目可行性研究报告、项目申请报告、资金申请报告、工程设计* |

以上各专业均涵盖了本专业相应的节能减排和环境治理内容。取得编制项目可行性研究报告、项目申请报告资格的单位，具备编制固定资产投资项目节能评估文件的能力；取得评估咨询资格的单位，具备对固定资产投资项目节能评估文件进行评审的能力。

证书编号：工咨甲21520070001

证书有效期：至2017年08月14日

发证机关

2012年08月15日

带*部分，以国务院有关主管部门颁发的资质证书为准

中华人民共和国国家发展和改革委员会制

**Approved by:**

**Checked by:**

**Reviewed by:**

**Compiled by:**

# 目 录

# 1. Foreword

1.1 Project Profile

In the light of the contact document of project survey by the Civil Engineering Department of Fujian Electric Power Survey & Design Institute, geotechnical investigation for detail design of Payra 1320MW Coal-fired Power Plant Project carry out between November and December 2015。The site is adjacent to the Kazol River or upstream of Rabnabad Channel at Dhankhali Union, Kalapara Upazila, Patuakhali District of Bangladesh. The site is Located in the east of Kalapara and west of Rabnabad Channel. The longitude and latitude of the site is 22°59′ N, 90°18′ E. The distance between the site and Patuakhali is 39km (linear distance, similarly hereinafter), and the distance between the site and Barishal is 78km. The east of the site is the Rabnabad channel and south is the Tiakhali River.Payra。

The owner of the project is North-West Power Generation Company Limited，Bangladesh（NWPGCL），the general contractor is China National Machinery IMP. & EXP. CORP. (CMC)，Fujian Electric Power Survey & Design Institute (FEDI) is in accordance with the demands of owner to carry out the plant’s feasibility study work. The project total investment is about $1.8 billion，and the first phase investment is about $980 million. 2 units of 660 MW supercritical coal-fired units is proposing to set up。

1.2 Survey work Profile

1.2.1 Main technical requirements

Regulations and codes followed by the work shall be mainly China national and industry standards, referring to relevant standards of Bangladesh:

(1) To find out terrains and landforms within the plant, distribution, origin, type and age of layer and the distribution of vertical and horizontal direction of layer.

(2) To find out physical and mechanical properties (Bearing capacity, Modulus of Compression, and so on) of soil and provide calculation parameters necessary for foundation design;

(3) To find out embedment conditions and change law of groundwater. Provide the permeability indicators of soil

(4) To find out the corrosive of soil and groundwater for concrete、steel corrosion. and the change of soil and groundwater corrosive during the period of construction and use of

architectural structures.

(5) Analysis and forecast the environmental geological problems due to the construction and operation, and puts forward prevention measures.

(6) Provide the foundation deformation parameters.

1.2.2 Survey method and the work completed

The investigation level of engineering:

| conditions | | | geotechnical investigation level |
|---|---|---|---|
| Site condition grade | Importance level | Foundation leve | |
| Class I | Class II | Class I | A |

According to the geotechnical investigation level and site conditions, the existing data was collected and evaluated, and field survey on the other hand. First of all, the regional hydrogeology, engineering geology, earthquake geology and structural geology data of factory area was collected and evaluated. Based on that, engineering geological and hydrogeology survey was performed comprehensive accordance with the requirements of specification, contact book. Eventually make a scientific evaluation of the hydrogeology and engineering geological conditions of the site, and put forward feasible Suggestions.

The borehole layout is mainly according to the grid lines, and combined with landscape. 14 boreholes was decorate total，Serial number from BH1 to BH14. Among them, BH7, BH13, BH14 located at the riverbed of Rabnaba, BH11、BH12 located at the river bank，and the rest of the drill hole is located in the rice fields。Details of borehole list in the Attached List 1。Field investigation is undertaken by ENGINEERS ASSOCIATES LIMITED, DACCA, BANGLADESH（EAL）. Giving consideration to local conditions of investigation, with respect to drilling equipment, such drilling equipment as surface casing used for positioning, manual winch drill rod field drilling used for percussion as well as drilling modes of combining downhole blades to cut sand layers, adopting hydraulic mud from water pump for wall protection and SPT core drilling, are applied; full-section drilling cannot be realized and one SPT per 1.0m is conducted to each exploratory hole. Description and lamination are conducted in accordance with SPT drill core, and precision of drilling lamination is relatively low. EAL field engineering technical personnel carry out field records according to local standards (field technical personnel record SPT value of each exploratory hole and wrap up all SPT core samples which are described hierarchically by the engineer). The field technical personnel of our company follow Chinese codes and standards to conduct field edition and record and the respective field records are in line with relevant rules and regulations; and a thick-wall open-top soil sampler is used for taking undisturbed soil sample in the layer of silty and clayey sand. SPT operation is basically correct and actually measured data are bigger than normal due to impact of pulley friction and man coordination as there is no automatic hammer dropping device and labor power is used for hoisting and strike; and such impact on especially SPT of soil layer below 15m is relatively large.

The exploration area approximately 4 $km^2$, distance between two borehole is about 300 m to 900 m, stratum is much differences between each borehole points, and geological profile precision is on the low side. The plane coordinate system of this investigation adopts local coordinate of Bengal while MSL height is height above the mean sea level of Bengal. Field drilling and laying out are conducted by engineering technical personnel of Bengal EAL Company. The referenced results of control points are shown in Table 1-1 and the finished physical goods workload in Table 1-2.

Table 1-1 Results of Control Points

| Point No. | X coordinate | Y coordinate | H height | Class |
|---|---|---|---|---|
| CP1 | 221921.408 | 2433611.433 | 6.182 | Class I |
| CP2 | 221898.350 | 2433602.188 | 6.233 | Class I |
| CP3 | 221927.373 | 2433587.990 | 3.023 | Class I |
| CP4 | 221887.323 | 2434099.999 | 2.647 | Class I |
| CP5 | 222127.286 | 2433940.074 | 5.479 | Class I |
| CP6 | 221638.112 | 2433937.624 | 5.388 | Class I |

Table 1-2 List of Physical Goods Workload

| No. | Project | | Unit | No. |
|---|---|---|---|---|
| 1 | drilling | Number of holes | 1 | 14 |
| | | Drilling depth | | 840 |
| 2 | In-situ test | SPT | 2 | 840 |
| 3 | Fetching soil samples | Original state | 3 | 27 |
| | | Disturbance | | 95 |
| 4 | Measuring fixed points | | | 14 |
| 5 | Simple analysis on water quality | | Set | 14 |
| 6 | Stabilizing underground water level | | Hole | 14 |

1.2.3 Technology Standard

(1) Code for Investigation of Geotechnical Engineering (2009) GB 50021-2001

(2) Code for Design of Building Foundations GB 50007-2011

(3) Code for Seismic Design of Buildings GB 50011-2010

(4) Technical code for investigation of geotechnical Engineering of fossil fuel power plant DL/T 5074-2006

(5) Technical regulations for data compilation of geotechnical Engineering of fossil fuel power plant DL/T5093—1999

(6) Technical code for building foundation treatment JGJ 79-2012

(7) Technical Code for Building Pile Foundation JGJ 94-2008

(8) Technical Code for Design of Building Foundations DBJ13-07-2006

(9) Bangladesh National Building Code (2010)

# 2. Regional Geology

2.1 Regional Structure

The site is located at the south of Bengal Basin, and Shillong Plateau of Precambrian era is in the north of Bengal Basin, Indian Platform in the west, Akarn-Yoma-Naga folding system in the east and Bay of Bengal in the south, shown in Figure 1.The Bay of Bengal is an Exogeosyncline; in other words, the periphery of ancient platform rises to pile up massive rock debris settlings in it. Bengal Foredeep is a part of Bengal Parageosyncline. Bengal Parageosyncline is one of the largest parageosynclines in the world and also a part of Bengal Geosyncline which includes Bengal Basin and Bay of Bengal. The main structural units are as follows:

(1) Shelf Zone. Shelf Zone is a main structural unit of Bengal, located at regions in the west and some regions in the northwest of Bengal. The borderline is northeast-to-southwest and along the base of the borderline, composite steep slope downwards form Hinge Zone. Thickness of settlings on the Shelf Zone is approximately 3,000m and dividing is conducted according to nonconformity situation. Rangpur Platform is in the north and Bogra Shelf in the south. Indian Shield and Shillong Massif, with a width of 100km.

(2) Hinge Zone is a narrow strip with a width of 25km. Monocline angle is 5 to 6 degrees and inclination angle of basic level on the obsequent fault line exceeds 20 degrees. The Hinge Zone in the northeast seems to be connected by east-west zones of fracture and Dauki fracture. It is divided by deep fracture under ground. Parallel to the Hinge Zone,

Bengal Foredeep consists of troughs and culminations.

(3) Bengal Foredeep is a huge extended trough, occupying the area between the Hinge Zone and Akarn-Yoma-Naga folding system. It is fairly deep section of Bengal Basin the foundation of which deeply sinks and the sinkage is directly related to rise of Himalayan-Myanmar mountain range. It is 450km wide in the south of Bengal and narrows down to the northeast. The foundation is about 12 to 15km deep. Indo-Burman folding system constitutes the eastern border of Bengal Foredeep and the total deposition thickness exceeds 12,000m.

(4) Mobile Belt. The eastern part of Bengal Basin is adjacent to the Mobile Belt of Tripura-Chittagong folding belt. It stretches both north and south, which is a part of Indo-Burman Mobile Belt. In Bengal, this Mobile Belt is mainly represented by Chittagong Mountains.

(5) Sub-Himalayan Fore Deep is an India-Ganges geosynclinal belt extending along the foot of Southern Himalayan. It partially encroaches upon the northwestern shoulder of Bengal. Deposit sediments of this unit include coarse to fine debris arising from rise of Himalayan, essentially being river sediments. The borderland in the north of Sub-Himalayan Fore Deep is strongly folded and fractured.

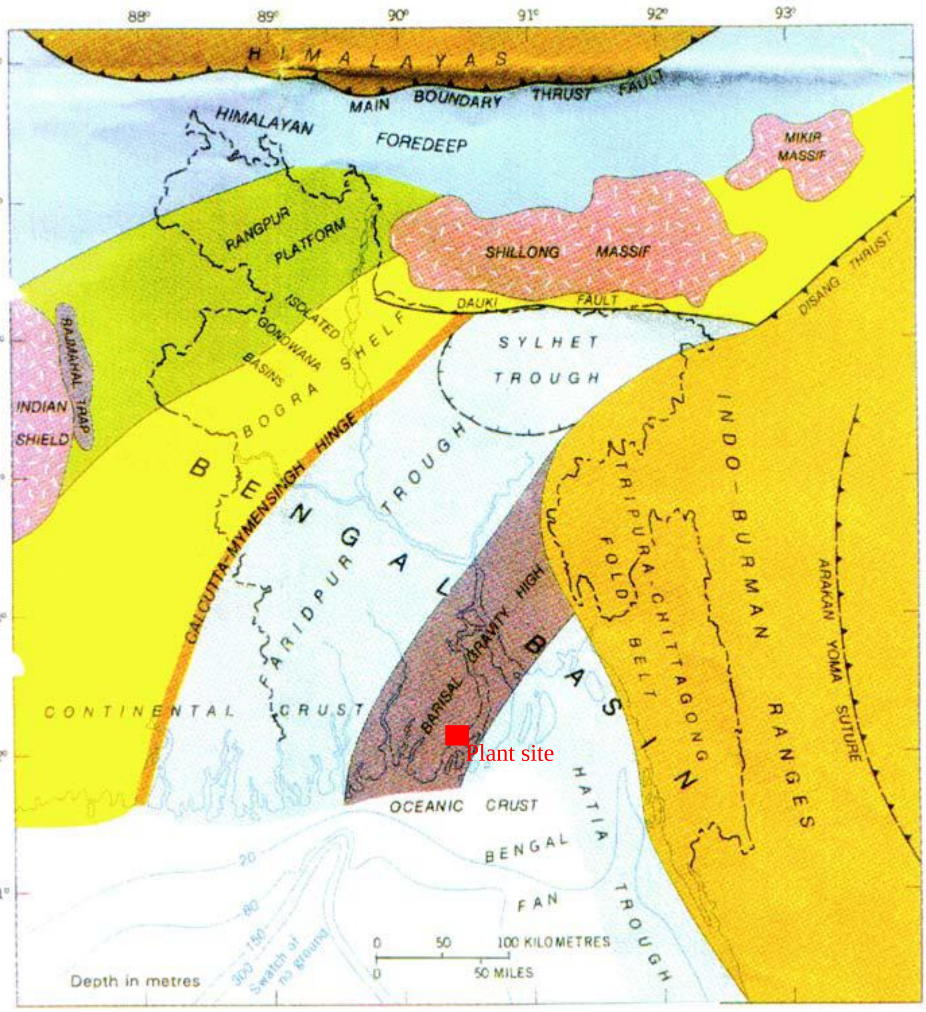

Fig. 1 Geologic Map of Bangladesh

## 2.2 Geomorphology of Region

Bangladesh occupies the most regions of Bengal Basin. The northern part of the Basin borders Himalayas and Shillong Plateau and the eastern border is India-Myanmar Mountain Range, the western border is Craton of India and the south border is Bay of Bengal. The Basin is one of the largest delta complexes (GBM delta) and distribution of regional geomorphic units is shown in Figure 2.

In the regional scope, alluvial plain terrain of GBM delta slopes from north to south, including mountain ridges and tectonic depression such as Sylhet Valley and Atrai depression. Bengal Basin consists of planitia and delta plain, which is surrounded by Tertiary mountains of various origins and formations. In the Madhupur and Barind regions of Bengal Basin, alluvial deposits uplifted in the Pleistocene epoch destroys regional surface gradient in the middle of the Basin.

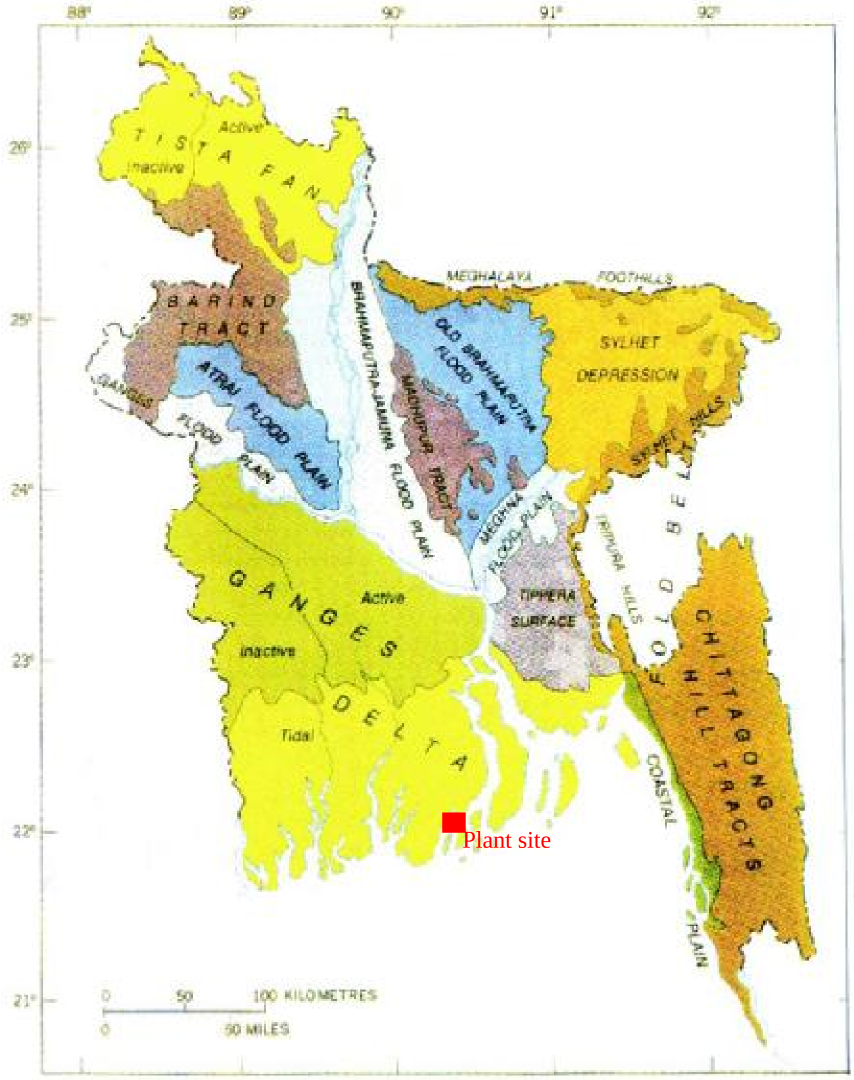


Fig. 2 Physiographic map of Bangladesh

In Bangladesh, surface elevation is less than 1.0m in the south and 1,000m in the Chittagong mountain area in the southeast and the northwest (Tista Alluvial Fan) is higher than other geomorphic units besides CHT. The height gradually reduces from the Tista Alluvial Fan in the northwest to GBM delta in the southeast, and elevation of Madhupur and Barind is fairly high (15m to 40m) and height of GBM delta is slightly different from that of aggraded flood plain newly formed (<1-10m). The elevation of Sylhet Valley located between Madhupur region and eastern folded belt is very low. The surface elevation suddenly increases to 500m in Sylhet and Dauki faults in the northern part and even higher in Shillong Plateau. In the eastern part of GBM delta, the surface elevation is less than 10m and the southern part is the lowest, less than 1m.

Main topographical features of aggraded flood plain and delta are natural levee, flood fan, alluvial sand and river filling deposit. Sylhet Valley is mainly characterized by everglades and peat land and frequently submerged during a monsoon (June to September). Aguada and massive peat basins are in the middle of GBM delta. The southern delta plain is characterized by many tidal furrows and mangrove forest.

## 2.3 Regional Earthquake

Gangetic Plain was originally located in the valley between the Peninsula and the mountain area. Such valley might be formed due to the subsidence of the north part of the Peninsula. Restraining the southward orogenic movement of Himalayas, the valley was rapidly filled with alluvial sediments, which fully covered the original land surface below thousands of feet. During Pliocene, Miocene and Pleistocene of the entire Cainozoic, debris deposition and sedimentation took about thirty million years. Bengal Basin from Rajmahal Hills to Assam Hills was recently formed.

Bangladesh is one part of Bengal Basin. Due to the effect of the tectonic stress generated from the orogenic movement of Himalayas, Bengal Basin has mostly sunken slowly. Though Himalayas is the highest mountain in the world, it does not reach its highest altitude and it is still rising. The slow subsidence is about 1 inch every year in coastal regions. Such change can be obviously seen through the comparison between the positions of a stump at present and about a century ago in Sundarban Region between Khulna and Barisal. In fact, this sets off deposition effects to a great extent. It is estimated that Ganges, Jamuna and Meghna bring about 2 billion tons of mud every year. The entire coastline surveyed and mapped by James Rennel in 1770 does not extend, instead, the land area reduces.

All these indicate that the stratum below Himalayas and the connecting region at its foot are at an extension state and plate movement and tectonic stress have not been balanced. Up to now, earthquake disasters were mostly occur in such regions in India. Bangladesh is located in one of most active tectonic regions. Such three plats as Indian Plate, Tibet Plate and Myanmar Subplate collide and squeeze each other in such region. Some main earthquakes inside and outside Bangladesh arise from the strong earthquake movement in the north and east of Bangladesh. Therefore, the main earthquake risk of the region where this Project is located originates from the north and east of Bangladesh (potential seismically active zones). The area where this plant site is located is of relatively inactive tectonic movement and geological stability is good. The earthquake impact on this Project is mainly distant earthquake impact outside the region.

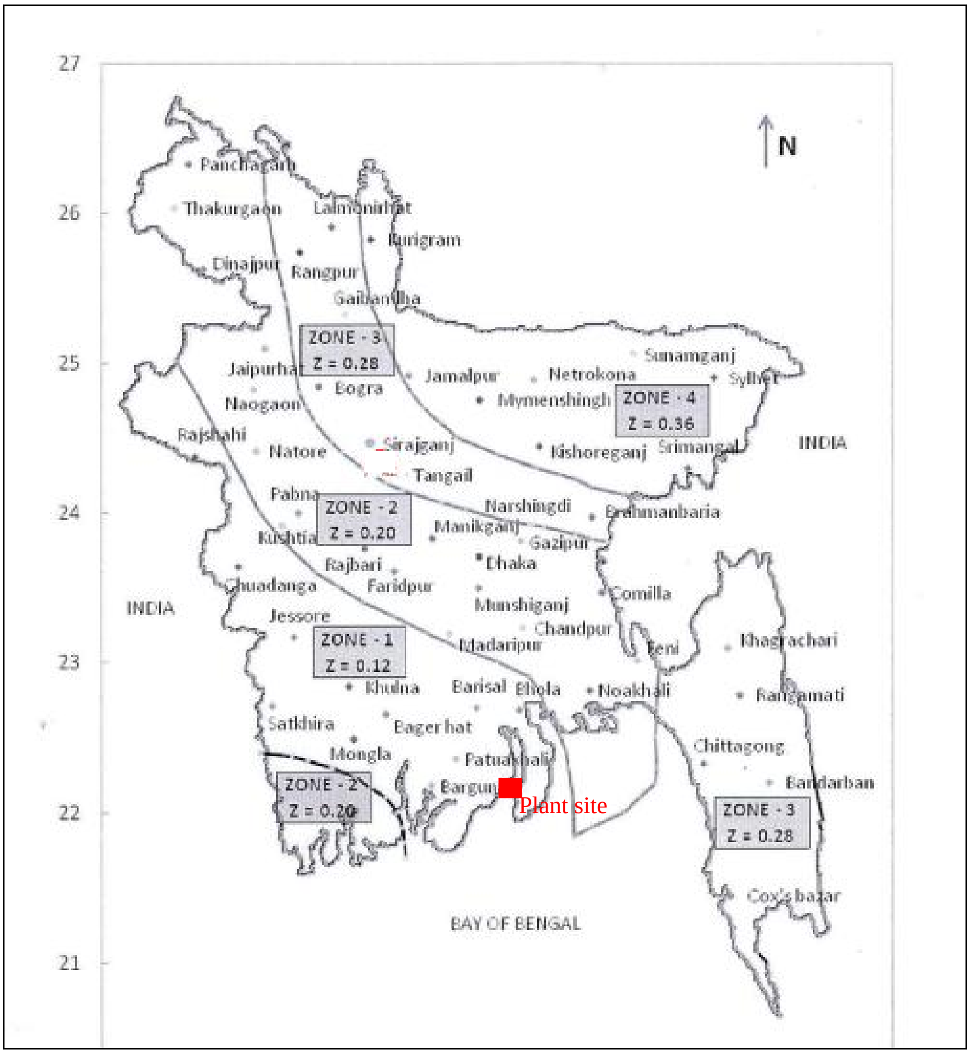


Figure 3 Seismic Zoning Map of Bangladesh, BNBC, 2010

The seismic zoning map addressed in BNBC (Bangladesh National Building Code, 2010) is shown in Figure 3. This project is located in Zone 1, with a seismic zone coefficient Z of 0.12. Corresponding to the Code for Seismic Design of Buildings (2008) (GB50011-2001), the seismic fortification intensity is 7 degrees, the basic seismic acceleration of this site is designed to be 0.15g, and the seismic group should be designed to the third group.

The geological tectonic activities of this site is relatively inactive, Geological structure stability is relatively good. There have no landslide collapse, landslide, collapse and other bad geological effect. To sum up, this site is suitable for the construction of coal-fired power plant project.

## 3. Engineering Geological Conditions

### 3.1 Topography

Landscape of the site is river delta, the topography is flat. the site adjacent to the Ramnabad and Tiakhali river. Three face of the site is water， and earth dam are built in the east, south and west side channel boundary. Earth dam is about 3.5-5.0 m higher than rice paddies internal. Top of earth dam is country dirt road, the road width is about 3.0-4.0 m, There are many tall trees on both sides of the earth dam. outside of the earth dam is scattered dwellings, inside of the earth dam is rice paddies. Water system developed, and some villages scattered. In general, houses are thatched or algam room. Site features is shown in Figure 3-1 to Figure 3-6.

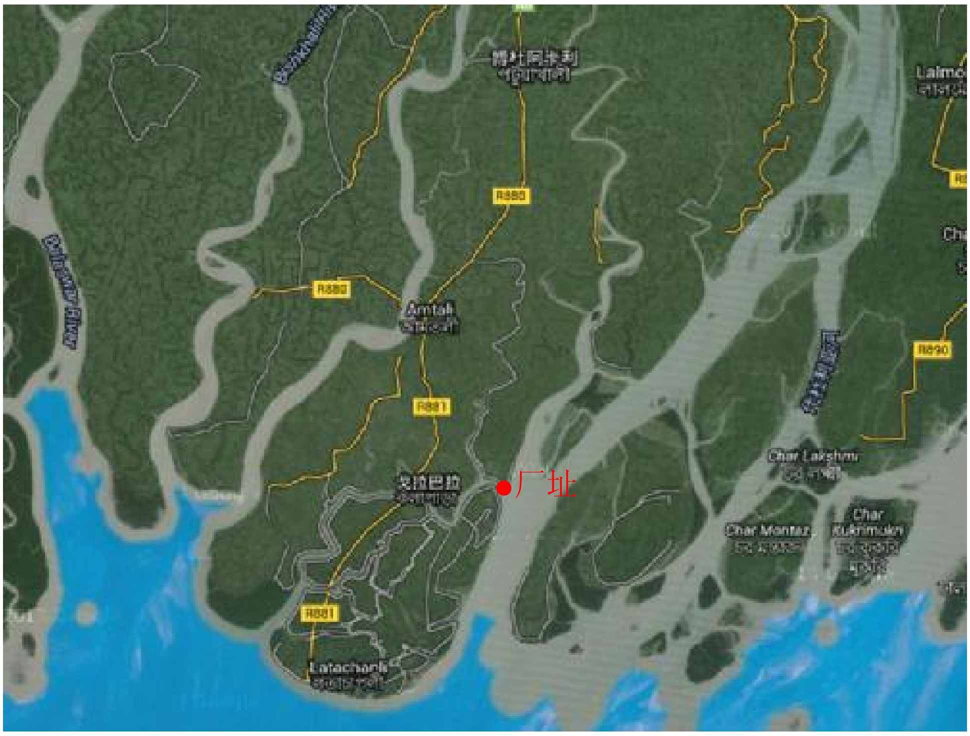


Figure 3-1 Schematic Diagram of Plant Location

Figure 3-2 Site Topography（Satellite imagery）

Figure 3-3 Site Topography（Rice Paddies）

Figure 3-4 Site Topography（Earth Dam）

Figure 3-5 Site Topography（villages）

Figure 3-6 Site Topography（Rive in South）

3.2 Lithology

According to field survey and drilling data, site layer from top to bottom on the site is described below:

① clay: alluvial, tan or gray, plastic, wet to saturated, the main ingredients is clay or silt, contain about 5% of the fine sand, plastic index is about 19.0 on average, toughness and dry strength is medium, The thickness in BH12 is 12 m, the rest of the boreholes with a thick layer of 1.0m ~ 3.0 m.

①-1 clay: alluvial, gray, hard plastic, wet to saturated, the main ingredients is clay or silt, contain about 5% of the fine sand, plastic index is about 17.3 on average, toughness and dry strength is medium. Only exists in the borehole BH8, BH9, BH11, thickness between 1.5m and 3.0 m, 2.25 m on average.

② Silt: alluvial, gray, loose, saturated, the main ingredients dominated by quartz grains followed by mica, clay grain content of 25%, basically no agglutination. In the borehole BH2, BH3, BH12 this layer lack, the thickness of this layer between 2.0 and 18.0 m, 7.71 m on average.

②$_{-1}$ Silt: alluvial, gray, slightly less dense or medium-dense, partially loose, saturated, the main ingredients dominated by quartz grains followed by mica, clay grain content of

25%, basically no agglutination. This layer only exist in BH2, BH3, BH5, BH8, the thickness is between 2.0m and 13.0 m, 6.25 m on average.

③ Silty clay: alluvial, yellow-brown, plastic, saturation, the main ingredients is clay or silt, contain about 10%~ 20% of the fine sand, plastic index is about 14.0 on average, toughness and dry strength is medium. This layer only exist in some parts of the site, the thickness is between 2.0m and 9.0 m, 4.82m on average.

④ Silty and Alayey Sand: alluvial, dark grey, loose, saturated, the main ingredients dominated by quartz grains followed by mica, clay and Silt content of 45%, basically no agglutination. This layer only exists in the borehole BH1, thickness of this layer is 2.0m.

⑤ Silt Sand: alluvial, grey, saturated, loose or slightly less dense, dominated by quartz grains followed by mica, clay grain content of 10-20%, basically no agglutination. This layer only exist in some parts of the site, the thickness is between 6.0m and 17.5m, 12.93m on average.

⑥ Fine Sand: alluvial, grey, saturated, mostly medium-dense, partially slightly less dense, dominated by quartz grains followed by mica, clay grain content of 3-10%, basically no agglutination. This layer exist all over the whole field, the thickness is between 10.0m and 31.5m, 19.25m on average.

$⑥_{-1}$ Fine Sand: alluvial, grey, saturated, mostly dense, partially medium-dense, dominated by quartz grains followed by mica, clay grain content of 3-10%, basically no agglutination. This layer exist all over the whole field, the thickness is between 6.0m and 30.0m, 15.87m on average.

3.3 Groundwater

Groundwater of Bangladesh is mostly distributed in the modern alluvium and Pleistocene epoch alluvium above the structures of aggraded flood plain and delta plain. The aquifer pertains to unconfined aquifer. Three different kinds of aquifer can be distinguished according to the granularity of alluvium: composite or find sand aquifer, aquifer based on coarse sand or coarse sand aquifer and deep aquifer. The maximum burial depth of fine sand aquifer can reach 30-45m under normal circumstances, under which is main aquifer; coarse sand aquifer or deep aquifer is compact and hard, with a burial dept of 100-150m below the earth surface, and such aquifer has a certain amount of clay and slit lenses. There is a certain hydraulic connection between aquifers. During the monsoon of every year (July-September), aquifers can be directly supplied with rain water through infiltration flow.

(1) Occurrence conditions of site groundwater

This site is located on the estuarine delta. Groundwater types as follows: the upper groundwater is perched water in silty clay and clay, the lower groundwater is pore water in the sand, which is unconfined aquifer, mainly supplied by rainwater and neighboring surface river water. The burial depth of the site ground phreatic water is relatively low, with a relatively high water level, the burial depth of the stable groundwater level is measured to be about 1.2~2.8m, and the elevation to be about -0.9~1.5（see engineering geological profiles for details）。Because the drainage development, underground water level amplitude is not obvious in one year. Hydrological report should be reference for the flood level .

(2) Causticity of groundwater

The site of this plant is located in humid region. The soil layer is dominated by strong pervious bed, the environment class of the site is Class II, and the stratum permeability is considered as Class A. According to the results of this simple analysis of water quality, there is no value of $OH^-$, total salinity, aggressive $CO_2$ and $NH_4^+$ (See table 3-1 for more details). Through the comparison between the results of other main test subjects and the criterion in the Code for Investigation of Geotechnical Engineering (2009) (GB50021-20010, it is determined that the site groundwater is faint corrosion to concrete structures, faint corrosion to reinforced bars in reinforced concrete structures under the condition of long-term immersion and weak corrosion under the condition of alternating wet and dry.

According to the stratigraphic conditions and environment, the soil above the underground water level is faint corrosion to concrete structures, reinforced bars in reinforced concrete structures and steel structures.

According to related information, Bangladesh is one of regions where the groundwater pollution is most serious, with the main groundwater pollution elements of arsenic (As), iron (Fe), manganese (Mn), etc. Water for power plant and living should be detected, analyzed and evaluated according to relevant water quality analysis reports and relevant codes and standards.

Table 3-1 Schedule of Evaluation of Causticity of Groundwater to Building Materials

| Type of Corrosion | Corrosion Medium | Groundwater Sample | content | Groundwater Sample | content | corrosion Standard Value | Corrosion Level |
|---|---|---|---|---|---|---|---|
| Evaluation of Corrosion to Concrete according to Environment Type Impact | Sulfate content $SO_4^{2-}$(mg/l) | BH1 | 120.91 | BH8 | 120.33 | Alternation of Drying and Wetting <300<br>Long-term Water Immersion <390 | Faint |
| | | BH2 | 125.33 | BH9 | 98.35 | | |
| | | BH3 | 98.23 | BH10 | 128.35 | | |
| | | BH4 | 110.25 | BH11 | 125.25 | | |
| | | BH5 | 98.15 | BH12 | 155.2 | | |
| | | BH6 | 145.22 | BH13 | 128.65 | | |
| | | BH7 | 175.22 | BH14 | 150.21 | | |
| | Magnesium salt content $Mg^{2+}$(mg/l) | BH1 | 32 | BH8 | 30.15 | Alternation of Drying and Wetting <2000<br>Long-term Water Immersion <2600 | Faint |
| | | BH2 | 32.25 | BH9 | 31.33 | | |
| | | BH3 | 33.2 | BH10 | 32.38 | | |
| | | BH4 | 33.18 | BH11 | 33.33 | | |
| | | BH5 | 32.35 | BH12 | 33.35 | | |
| | | BH6 | 30.55 | BH13 | 33.48 | | |
| | | BH7 | 34.22 | BH14 | 35.35 | | |
| Evaluation of Corrosion to Concrete according to Stratum Permeability | PH | BH1 | 6.85 | BH8 | 6.88 | >6.5 | Faint |
| | | BH2 | 6.9 | BH9 | 6.7 | | |
| | | BH3 | 6.88 | BH10 | 6.75 | | |
| | | BH4 | 6.95 | BH11 | 7.02 | | |
| | | BH5 | 6.9 | BH12 | 7.15 | | |
| | | BH6 | 6.88 | BH13 | 7.15 | | |
| | | BH7 | 7.2 | BH14 | 7.2 | | |
| Corrosion to Reinforced Bar in Reinforced Concrete | $Cl^-$(mg/L) | BH1 | 320.54 | BH8 | 325.65 | Long-term Water Immersion ＜10000 | Faint |
| | | BH2 | 325.6 | BH9 | 315.33 | | |
| | | BH3 | 350.15 | BH10 | 325.36 | | |
| | | BH4 | 345.33 | BH11 | 375.22 | Alternation of Drying and Wetting 100~500 | Weak |
| | | BH5 | 211.25 | BH12 | 365.66 | | |
| | | BH6 | 326.22 | BH13 | 345.65 | | |
| | | BH7 | 375.65 | BH14 | 356.26 | | |
| Corrosion to Steel Structure | $C1^- + SO_4^{2-}$ (mg/L) | BH1 | 441.45 | BH8 | 445.98 | pH=6.74-6.76 ($C1^- + SO_4^{2-}$)< 500 | weak to medium |
| | | BH2 | 450.93 | BH9 | 413.68 | | |
| | | BH3 | 448.38 | BH10 | 453.71 | | |
| | | BH4 | 455.58 | BH11 | 500.47 | | |
| | | BH5 | 309.4 | BH12 | 520.86 | | |
| | | BH6 | 471.44 | BH13 | 474.3 | | |
| | | BH7 | 550.87 | BH14 | 506.47 | | |

# 4. Evaluation of Geotechnical Engineering

4.1 Statistical analysis and evaluation of geotechnical test and in-situ test results

All coarse deviation of geotechnical parameters of the investigation was eliminated by using Robles Grubbs test, Statistics according to non related parameters, adopt the method of unilateral test， and observe the safety benefit principle. The reliability (α) is 0.10 in the statistics of survey data.

The parameter value was corrected according to the following formula:

Revised Value  N=Nm·γs，$\gamma s=1-\left(\frac{1.704}{\sqrt{n}}+\frac{4.678}{n^2}\right)\delta$

Nm: The average value of test results

N: The number of data participate in statistics

δ: Coefficient of variation

γs: Correction coefficient

4.1.1 statistics of Standard penetration test results

The standard penetration test is performed the major geotechnical layer, the statistics of SPT number N in the following table 4-1. The number of SPT (N) attend the statistics was adjusted. The layer ④（Silty and Alayey Sand）only exists in the borehole BH1，the thickness is 2 m，SPT value is 8 and 9, and it can not participate in statistics.

table 4-1 statistics of Standard penetration test results

| Soil Serial number | name of the soil | The number of statistical | maximum | minimum | average | standard deviation | Coefficient of variation | Correction coefficient | Standard values |
|---|---|---|---|---|---|---|---|---|---|
| ① | clay（plastic） | 35 | 5 | 0.9 | 2.3 | 1.093 | 0.482 | 0.866 | 2 |
| ①-1 | clay（hard plastic） | 8 | 19.3 | 6 | 11.6 | 5.092 | 0.44 | 0.744 | 8.6 |
| ② | Silt（loose） | 92 | 11.8 | 0.9 | 5.7 | 2.56 | 0.447 | 0.923 | 5.3 |
| $②_{-1}$ | Silt（slightly less dense or medium-dense） | 48 | 19.3 | 6.3 | 12.8 | 3.253 | 0.254 | 0.94 | 12 |
| ③ | Silty clay（plastic） | 45 | 9.8 | 1.9 | 5.4 | 1.723 | 0.319 | 0.922 | 5 |
| ⑤ | Silt Sand（loose or slightly less dense） | 90 | 19.2 | 4.2 | 10.6 | 3.097 | 0.293 | 0.949 | 10 |
| ⑥ | Fine Sand（medium-dense） | 271 | 35 | 7 | 21.7 | 5.365 | 0.247 | 0.975 | 21.2 |
| $⑥_{-1}$ | Fine Sand（dense） | 236 | 46.9 | 21 | 33 | 4.446 | 0.135 | 0.986 | 32.5 |

we can see from the above table: ①Clay (plastic), coefficient of variation is big, SPT value is low, mechanical properties is very poor. ①-1 Clay (hard plastic), coefficient of variation is big, SPT value is slightly lower, and mechanical properties is general. ②Silt (loose), coefficient of variation is big, SPT value is poor, and mechanical properties is very poor. ②$_{-1}$ Silt (slightly less dense or medium-dense), the variation is a moderate, SPT value is medium, and the mechanical properties is medium; ③ Silty clay（plastic）coefficient of variation is big, SPT value is low, mechanical properties is very poor. ⑤Silt Sand（loose or slightly less dense）, coefficient of variation is big, SPT value is slightly lower, and mechanical properties is general. ⑥ Fine Sand（medium-dense）, SPT value is larger, variation coefficient is low, and mechanical properties is good. ⑥$_{-1}$ Fine Sand（dense）SPT value is big, variation coefficient is low, which Explain that the stratigraphic composition is uniform, uniformity and mechanical properties is good.

4.1.2 statistical of soil test results

Un-disturbance sample and disturbance sample was taken in the process of investigation for indoor basic properties test（detailed results of geotechnical test as shown in the Attached List 2）， The statistical results are shown in table 4-2.

a) ①Clay: variability of physical index is low（excepte liquidity index）， Mechanics index variability is low. Compressibility variability is on the high side， the main reason is time difference is bigger for soil sampling，and moisture content is very different，Liquidity index ($I_L$) is 0.31 on average， According to the table 3.3.11 of Code for Investigation of Geotechnical Engineering (2009) GB 50021-2001, the plastic state of Clay is plastic.

b) ①-1 Clay: The number of soil sample is only 3，so this is impossible to mathematical statistics, and the data is average results. Liquidity index (IL) is 0.07 on average， According to the table 3.3.11 of Code for Investigation of Geotechnical Engineering (2009) GB 50021-2001, the plastic state of Clay is hard plastic。

c) ② Silt: Basically no cohesion, internal friction Angle of 17.3°. ②-1 Silt: Basically no cohesion, internal friction Angle of 18.4°.

d）③Silty clay: variability of physical index is low（excepte liquidity index）, Mechanics index variability is medium. Compressibility variability is on the high side, Liquidity index (IL) is 0.40 on average， According to the table 3.3.11 of Code for Investigation of Geotechnical Engineering (2009) GB 50021-2001, the plastic state of Clay is plastic.

e）⑤Silt Sand: each of the index variability is low, basically no cohesion, internal friction Angle of 20.8°.

f) ⑥Fine Sand: each of the index variability is low, basically no cohesion, internal friction Angle of 24.3°. ⑥-1 Fine Sand: each of the index variability is low, basically no cohesion, internal friction Angle of 29.6°.

Table 4-2 Physical and Mechanical Index Statistics of layer

| layer | Covariance item | wet density $g/cm^3$ | moisture content % | Dry density. $g/cm^3$ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kPa） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm |
| ① clay | number of statistical | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 5 | 8 | 8 | 8 |
| | maximum | 1.75 | 33.11 | 1.32 | 2.62 | 47.00 | 25.00 | 22.00 | 0.50 | 24 | 7.00 | 83.79 | 26.00 | 78.35 | 6.65 |
| | minimum | 1.59 | 24.48 | 1.22 | 2.59 | 40.00 | 23.00 | 17.00 | -0.02 | 18 | 5.00 | 12.14 | 15.00 | 69.50 | 4.50 |
| | average | 1.63 | 29.79 | 1.26 | 2.61 | 43.00 | 24.00 | 19.00 | 0.31 | 22 | 6.00 | 43.12 | 22.00 | 72.09 | 5.91 |
| | standard deviation | 0.05 | 3.14 | 0.03 | 0.01 | 2.20 | 0.93 | 1.51 | 0.19 | 0.02 | 0.53 | 26.18 | 3.66 | 3.25 | 0.73 |
| | Coefficient of variation | 0.03 | 0.11 | 0.03 | 0.00 | 0.05 | 0.04 | 0.08 | 0.59 | 0.09 | 0.09 | 0.61 | 0.17 | 0.05 | 0.12 |
| | Recommended value | 1.63 | 29.79 | 1.26 | 2.61 | 43.00 | 24.00 | 19.00 | 0.31 | 22 | 6.00 | 43.12 | 22.00 | 72.09 | 5.91 |
| ①-1 clay | number of statistical | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| | maximum | 1.86 | 33.21 | 1.40 | 2.63 | 48.00 | 28.00 | 20.00 | 0.26 | 24 | 12.00 | 119.86 | 26.00 | 75.77 | 10.23 |
| | minimum | 1.60 | 23.55 | 1.27 | 2.61 | 37.00 | 25.00 | 12.00 | -0.12 | 15 | 5.00 | 83.79 | 14.00 | 69.50 | 4.50 |
| | average | 1.69 | 27.64 | 1.32 | 2.62 | 43.33 | 26.00 | 17.33 | 0.07 | 20 | 8.00 | 101.83 | 21.33 | 71.80 | 6.87 |
| | standard deviation | | | | | | | | | | | | | | |
| | Coefficient of variation | | | | | | | | | | | | | | |
| | Recommended value | 1.69 | 27.64 | 1.32 | 2.62 | 43.33 | 26.00 | 17.33 | 0.07 | 0.20 | 8.00 | 101.83 | 21.33 | 71.80 | 6.87 |
| ② silt | number of statistical | 18 | 18 | 18 | 18 | 18 | 10 | 10 | 10 | 18 | 18 | | 18 | 18 | 18 |
| | maximum | 1.70 | 32.22 | 1.35 | 2.65 | 34.00 | 24.00 | 10.00 | 1.15 | 0.11 | 20.00 | | 0.00 | 44.00 | 90.44 |
| | minimum | 1.56 | 24.44 | 1.20 | 2.62 | 24.00 | 22.00 | 7.00 | 0.06 | 0.00 | 12.00 | | 0.00 | 9.56 | 56.00 |
| | average | 1.64 | 28.09 | 1.28 | 2.63 | 28.94 | 23.60 | 8.30 | 0.53 | 0.07 | 17.33 | | 0.00 | 26.57 | 73.43 |
| | standard deviation | 0.04 | 2.17 | 0.04 | 0.01 | 3.52 | 0.70 | 0.82 | 0.33 | 0.04 | 2.17 | | 0.00 | 9.84 | 9.84 |
| | Coefficient of variation | 0.02 | 0.08 | 0.03 | 0.00 | 0.12 | 0.03 | 0.10 | 0.63 | 0.53 | 0.13 | | | 0.37 | 0.13 |
| | Recommended value | 1.64 | 28.09 | 1.28 | 2.63 | 28.94 | 23.60 | 8.30 | 0.53 | 0.07 | 17.33 | | 0.00 | 26.57 | 73.43 |

**Table 4-2 (Continued)**

| layer | Covariance item | wet density g/cm³ | moisture content % | Dry density. g/cm³ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kPa） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm |
| ②-1 Silt | number of statistical | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 9 | 9 | | 9 | 9 | 9 |
| | maximum | 1.78 | 30.21 | 1.37 | 2.65 | 34.00 | 25.00 | 9.00 | 0.78 | 0.12 | 24.00 | | 12.00 | 34.67 | 91.31 |
| | minimum | 1.73 | 28.14 | 1.34 | 2.63 | 24.00 | 24.00 | 8.00 | 0.58 | 0.00 | 12.00 | | 0.00 | 8.69 | 55.62 |
| | average | 1.76 | 29.44 | 1.36 | 2.64 | 27.56 | 24.33 | 8.33 | 0.67 | 0.06 | 18.44 | | 1.33 | 24.04 | 74.63 |
| | standard deviation | 0.01 | 0.85 | 0.01 | 0.01 | 3.97 | 0.58 | 0.58 | 0.10 | 0.04 | 3.28 | | 4.00 | 7.99 | 10.24 |
| | Coefficient of variation | 0.01 | 0.03 | 0.01 | 0.00 | 0.14 | 0.02 | 0.07 | 0.15 | 0.71 | 0.18 | | 3.00 | 0.33 | 0.14 |
| | Recommended value | 1.76 | 29.44 | 1.36 | 2.64 | 27.56 | 24.33 | 8.33 | 0.67 | 0.06 | 18.44 | | 1.33 | 24.04 | 74.63 |
| ③ Silty clay | number of statistical | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 7 | 12 | 12 | 12 |
| | maximum | 1.76 | 32.84 | 1.37 | 2.64 | 44.00 | 25.00 | 20.00 | 0.80 | 23 | 15.00 | 107.86 | 26.00 | 74.79 | 45.32 |
| | minimum | 1.63 | 25.65 | 1.23 | 2.59 | 34.00 | 22.00 | 10.00 | 0.11 | 10 | 5.00 | 35.93 | 13.00 | 40.68 | 4.56 |
| | average | 1.68 | 29.20 | 1.30 | 2.62 | 37.75 | 23.75 | 14.00 | 0.40 | 17 | 8.58 | 59.87 | 17.50 | 63.43 | 19.07 |
| | standard deviation | 0.05 | 2.15 | 0.04 | 0.02 | 2.73 | 0.75 | 2.98 | 0.17 | 0.05 | 2.78 | 23.97 | 4.46 | 11.61 | 14.12 |
| | Coefficient of variation | 0.03 | 0.07 | 0.03 | 0.01 | 0.07 | 0.03 | 0.21 | 0.43 | 0.28 | 0.32 | 0.40 | 0.25 | 0.18 | 0.74 |
| | Recommended value | 1.68 | 29.20 | 1.30 | 2.62 | 37.75 | 23.75 | 14.00 | 0.40 | 17 | 8.58 | 59.87 | 17.50 | 63.43 | 19.07 |
| ⑤ Silty sand | number of statistical | 11 | 11 | 11 | 11 | 11 | | | | 11 | 11 | | | 11 | 11 |
| | maximum | 1.73 | 30.25 | 1.37 | 2.65 | 26.00 | | | | 0.08 | 24.00 | | | 21.68 | 93.15 |
| | minimum | 1.65 | 26.44 | 1.27 | 2.64 | 25.00 | | | | 0.00 | 18.00 | | | 6.85 | 78.32 |
| | average | 1.70 | 28.22 | 1.33 | 2.65 | 25.18 | | | | 0.03 | 20.82 | | | 12.75 | 87.25 |
| | standard deviation | 0.03 | 1.64 | 0.03 | 0.01 | 0.40 | | | | 0.03 | 1.94 | | | 4.84 | 4.84 |
| | Coefficient of variation | 0.02 | 0.06 | 0.02 | 0.00 | 0.02 | | | | 1.21 | 0.09 | | | 0.38 | 0.06 |
| | Recommended value | 1.70 | 28.22 | 1.33 | 2.65 | 25.18 | | | | 0.03 | 20.82 | | | 12.75 | 87.25 |

**Table 4-2 (Continued)**

| layer | Covariance item | wet density g/cm³ | moisture content % | Dry density. g/cm³ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kPa） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm |
| ⑥ Fine sand | number of statistical | 26 | 26 | 26 | 26 | 26 | | | | 26 | 26 | | 26 | 26 | 26 |
| | maximum | 1.83 | 32.44 | 1.47 | 2.66 | 26.00 | | | | 0.04 | 29.00 | | | 14.38 | 95.68 |
| | minimum | 1.68 | 22.35 | 1.34 | 2.64 | 24.00 | | | | 0.00 | 20.00 | | | 4.32 | 85.62 |
| | average | 1.76 | 26.71 | 1.39 | 2.65 | 24.81 | | | | 0.01 | 24.27 | | | 8.52 | 91.48 |
| | standard deviation | 0.04 | 2.16 | 0.03 | 0.01 | 0.80 | | | | 0.01 | 2.22 | | | 2.62 | 2.62 |
| | Coefficient of variation | 0.02 | 0.08 | 0.02 | 0.00 | 0.03 | | | | 2.21 | 0.09 | | | 0.31 | 0.03 |
| | Recommended value | 1.76 | 26.71 | 1.39 | 2.65 | 24.81 | | | | 0.01 | 24.27 | | | 8.52 | 91.48 |
| ⑥-1 Fine sand | number of statistical | 31 | 31 | 31 | 31 | 31 | | | | 31 | 31 | | 31 | 31 | 31 |
| | maximum | 1.88 | 30.25 | 1.48 | 2.67 | 26.00 | | | | 0.00 | 34.00 | | 0.00 | 6.80 | 97.25 |
| | minimum | 1.78 | 23.65 | 1.38 | 2.65 | 24.00 | | | | 0.00 | 25.00 | | 0.00 | 2.75 | 93.20 |
| | average | 1.83 | 26.30 | 1.45 | 2.66 | 24.48 | | | | 0.00 | 29.65 | | 0.00 | 4.54 | 95.46 |
| | standard deviation | 0.02 | 1.82 | 0.03 | 0.01 | 0.57 | | | | 0.00 | 2.52 | | 0.00 | 0.97 | 0.97 |
| | Coefficient of variation | 0.01 | 0.07 | 0.02 | 0.00 | 0.02 | | | | | 0.09 | | | 0.21 | 0.01 |
| | Recommended value | 1.83 | 26.30 | 1.45 | 2.66 | 24.48 | | | | 0.00 | 29.65 | | 0.00 | 4.54 | 95.46 |

## 4.2 Evaluation of Foundation Soil

### 4.2.1 Stability and Uniformity Evaluation of Foundation

Within the scope of site area, there is no factors against the engineering such as river, ditch marina, grave and shelter. Besides the influence of earthquake liquefaction of saturated sandy soil, there is no bad geological phenomenon such as surface subsidence and collapse found in the site and surrounding. The mainly geotechnical engineering problems is earthquake liquefaction of saturated sandy soil and its related problems，This problem can be solved by the adoption of pile foundation through liquefaction sandy soil layer. This site is suitable for the construction of the power plant.

①Clay is widespread in the field, mechanical properties and uniformity is poor. ①-1 clay and ④ Silty and Alayey Sand sporadic appear, uneven distribution. ②Silty Sand, ②-1 Silty Sand have general uniformity, and large differences in buried depth and thickness. ③Silty Clay、⑤Silty Sand often take the form of lens, and large differences in buried depth, thickness and distribution. ⑥Fine Sand、 ⑥-1 Fine Sand are widespread in the field, buried depth is larger, and have a good uniformity. Comprehensive analysis, uniformity of the foundation soil is poor.

Major mechanical property indicators of each soil layer are shown in Attached List 3.

### 4.2.2 Evaluation of Foundation Soil

①Clay is widespread in the field，average thickness of about 3.5 m and mainly plastic state. ①-1Clay is hard plastic state, but thickness smaller and uneven distribution. ②Silty Sand is loose. ②-1 Silty Sand is slightly less dense. ③Silty Clay is plastic state. ④Silty and Alayey Sand sporadic appear, and poor of mechanical properties. ⑤Silty Sand is loose or slightly less dense。①Clay、②Silty Sand can be used as general building bearing layer after treatment. Because buried deep or sporadic appear, other layer not suitable for shallow foundation.

⑥Fine Sand, ⑥-1 Fine Sand are widespread in the field and have good uniformity and mechanical properties, but the two layers is too deep for natural foundation. The two layer can be use for pile foundation bearing layer according to the requirements of the design.

## 4.3 Foundation Treatment and Suggestion of Foundation Construction

Because of the poor mechanical properties and liquefaction phenomenon of the upper strata, the site is not eligible for supporting the natural shallow footing of main building. For main building which holds high requirements for foundation bearing capacity and settlement deflection, pile foundation is the right choice. Supporting layer for pile top should be considered based on the building load requirement and soil condition. The main building should use ⑥-1 Fine Sand layer as support for pile top, and appurtenance building should use ⑥ Fine Sand layer or the downer layer as supporting layer for pile top.

Boulders are not identified at the subject site. Since bedrocks are buried deeply and at-depth soil layer ranging from dense to very dense is relatively thick, therefore, pre-made pile or pre-stress tubular piles are usually the quick fix. However, Bangladesh is not domestically engaged in production of pre-stress tubular piles and the readily-available piles are punch cast-in-situ square piles and in-situ pre-made square piles with a size ranging from 30cm×30cm ~40cm× 40cm, which called RCC in short ( Reinforced Cement Concrete). Since the rare application of the later piles, it can be projected that the production and assemble of such piles is so unfamiliar with this country that pile quality cannot be ensured. Besides, such piles' production cycle is also very long; therefore, it is not feasible to use such piles. Taking everything into account, punch cast-in-situ pile is the most practical pile type and layers of medium dense and dense should be used as supporting layer and friction end bearing pile as the deep foundation.

Although vibroflotation, Sand pile and lime pile are effective foundation treatment (composite foundation) for remediating unconsolidated soils and reducing earthquake-induced liquefaction, it is still hard to implement it due to lack of construction equipments in Bangladesh. For cable trench and appurtenant buildings which hold low requirements for foundation strength and settlement insensitive secondary buildings, soil scarification and compaction can be considered adopting. Compact each layer of ①plastic clay and ②Loose silt, the fill depth and compaction coefficient should be decided based on engineer testing conducted at site.

4.4 Estimation of Single Pile Bearing Capacity

The depth of ⑥-1 Fine Sand is 10 ~ 20 m in general , and ⑥-1 Fine Sand is 30 ~ 40 m depth in general. If using pile foundation, pile length is 30 ~ 40 m in general. According to above foundation pile parameters, single pile vertical bearing capacity characteristic value Ra can be calculated with formula:

$$Ra = ( qpkAp+up\sum qsikli) / 2.$$

Liquefaction for unconsolidated soil layer is not taken into account. Please refer to table 4-3

table 4-3 Estimation of Single Pile Bearing Capacity

| Boring Number | Pile Type | Pile Diameter (mm) | Pile Length (m) | Entering Bearing Layer(m) | Bearing Layer | $R_a$ (kN) |
|---|---|---|---|---|---|---|
| BH6 | Punched cast-in-situ pile | φ800 | 30 | 11.0 | ⑥ | 1997 |
| BH9 | Punched cast-in-situ pile | φ800 | 25 | 18.5 | ⑥ | 1755 |
| BH10 | Punched cast-in-situ pile | φ800 | 45 | 4.0 | ⑥-1 | 3124 |

4.5 Land Formation and Foundation Excavation

The designed ground level is 4.90m，and now the ground elevation is 1.8 ~ 2.1 m. So need landfill for large areas，According to the local conditions, the river sand is suggested for landfill. It should pay attention to in the quality of river sand, control the clay content, and hierarchical compaction.

The project site is abundant in groundwater. The groundwater level is 4~5m after Land Formation, and relatively shallow in rainy season. Foundation excavation of this project is not deeper than 3 meters; therefore, groundwater won't be affected. Sloping for shallow foundation excavation should be based on theory of ratio of slope and depth of excavation less than 5m should be sloped by a scale of 1：2.

## 5. Resistance to Seismic of Project

5.1 ground motion parameters

The magnitude of earthquake for the subject site is 7 and the peak ground acceleration is 0.15g and seismic design is catalogue Ⅲ. Based on survey materials available, it can be estimated that equivalent shear wave velocity of soils 20m below subsurface is between 150～250m / s and soils is dominantly the medium soft soils with a thickness of over 50m, which indicates that the architectural-site types zoning is class Ⅲ. Under the impact of catalogue 7 seismic forces, surface loose sands or relatively dense sands will be susceptible to liquefaction, which means project site is seismic unfavorable site. For shear wave velocity of each soil layer, see table 5-1.

Table 5-1 Shear Wave Velocity of Each Soil Layer

| Layer | ① | ①-1 | ② | ②-1 | ③ | ④ | ⑤ | ⑥ | ⑥-1 |
|---|---|---|---|---|---|---|---|---|---|
| Soil Type | clay | clay | silt | silt | silty clay | Silty and Alayey Sand | Silt Sand | fine sand | fine sand |
| Wave Velocity (m/s) | 150 | 230 | 120 | 180 | 150 | 140 | 200 | 220 | 250 |

5.2 Soil Liquefaction

This soil liquefaction discrimination based on the following conditions: Underground water level elevation same with the ground elevation, foundation embedded depth of 2 m, earthquake magnitude of 7, acceleration of 0.15g, earthquake design classification Ⅲ and the analysis depth of 20m.

The results are as follows:②silt: Moderate ~ severe liquefaction， which is regarded as severe liquefaction. ②-1 silt: in few boreholes mild ~ moderate liquefaction， other boreholes not liquefied， which is regarded as mild liquefaction. ④Silty and Alayey Sand not liquefied. ⑤Silt Sand： in few boreholes mild ~ moderate liquefaction, other boreholes not liquefied， which is regarded as mild liquefaction. ⑥fine sand: in few boreholes mild ~ moderate liquefaction, other boreholes not liquefied，which is regarded as mild liquefaction. ⑥-1fine sand: in few boreholes mild liquefaction, other boreholes not liquefied， which is regarded as not liquefied. According to the boreholes, Most of the boreholes is moderate to severe liquefaction. Overall judgment, this site is serious liquefied sites。The liquefaction judgment results are shown in table 5-2. For details, please see the Attached List 3.

table 5-2 Liquefaction Judgment Results

| Borehole Number | BH1 | BH2 | BH3 | BH4 | BH5 | BH6 | BH7 |
|---|---|---|---|---|---|---|---|
| Liquefaction Index | 10.21 | 2.46 | 3.38 | 6.04 | 8.25 | 9.91 | 16.11 |
| Liquefaction Lever | severe | mild | moderate | severe | moderate | moderate | severe |
| Borehole Number | BH8 | BH9 | BH10 | BH11 | BH11 | BH13 | BH14 |
| Liquefaction Index | 16.95 | 7.20 | 8.55 | 15.91 | 0 | 15.46 | 13.91 |
| Liquefaction Lever | severe | severe | moderate | severe | not | severe | severe |

5.2 Earthquake-induced Settlement

①clay (plastic), ①-1clay (hard plastic) won't produce earthquake-induced settlement, earthquake-induced settlement is negligible.

**6、Conclusions and Suggestions**

6.1、Without holocene active fault distribution appear near the site, and it is a regional stability region. Without bad geological role in the site such as Karst, soil cave, landslide, debris flow, dangerous rock, collapse and so on. Without mine and cultural relics. Without buried such as tomb and bomb shelter. But soft soil is relatively deep and need ground treatment. Mainly building need use the pile foundation. After ground treatment and using pile foundation, the site is suitable for power plant construction.

6.2、The layer of the site is mainly sand. Majority of stratigraphic level fluctuation is bigger. The buried depth of groundwater is relatively shallow. So engineering geological conditions is complex.

6.3、Groundwater is faint corrosion to concrete structures, faint corrosion to reinforced bars in reinforced concrete structures under the condition of long-term immersion and weak corrosion under the condition of alternating wet and dry. The soil above the underground water level is faint corrosion to concrete structures, reinforced bars in reinforced concrete structures and steel structures.

6.4、①Clay、②Silty Sand can be used as general building bearing layer after ground treatment. The main building should use ⑥-1 Fine Sand layer as support for pile top, and appurtenance building should use ⑥ Fine Sand layer or the downer layer as supporting layer for pile top. If using pile foundation, pile length is 30 ~ 40 m in general。

6.5 The magnitude of earthquake for the subject site is 7 and the peak ground acceleration is

0.15g and seismic design is catalogue Ⅲ. The layer of the site is soft soil or medium soft soil, the architectural-site types zoning is class Ⅲ, and project site is seismic unfavorable site.

6.6、This report can be used during the phase of feasibility study design.

## Attached List 1: List of Key Data on Exploratory Holes

| No. | Serial Number | Type | Hole Depth (m) | Elevation of Borehole (m) | Coordinate | | sample quantity | | | SPT quantity | Ground water | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | X (A) | Y (B) | Soil | | water | | Fixed level | |
| | | | | | | | Un Disturbed | Disturbed | | | Depth | Elevation |
| 1 | BH1 | Control Borehole | 60 | 1.89 | 220903.90 | 2436157.30 | 2 | 7 | 1 | 60 | 2.13 | -0.24 |
| 2 | BH2 | Control Borehole | 60 | 1.97 | 221474.10 | 2436147.20 | 3 | 7 | 1 | 60 | 2.17 | -0.20 |
| 3 | BH3 | Control Borehole | 60 | 1.87 | 222022.70 | 2436137.50 | 6 | 8 | 1 | 60 | 2.06 | -0.19 |
| 4 | BH4 | Control Borehole | 60 | 2.25 | 220893.60 | 2435573.60 | 3 | 5 | 1 | 60 | 2.12 | 0.13 |
| 5 | BH5 | Control Borehole | 60 | 2.11 | 221463.80 | 2435563.50 | 2 | 6 | 1 | 60 | 2.76 | -0.65 |
| 6 | BH6 | Control Borehole | 60 | 1.25 | 222012.40 | 2435553.80 | 2 | 6 | 1 | 60 | 2.80 | -1.55 |
| 7 | BH7 | Control Borehole | 60 | 0.71 | 222835.70 | 2435539.30 | 1 | 7 | 1 | 60 | -0.16 | 0.87 |
| 8 | BH8 | Control Borehole | 60 | 2.28 | 220881.30 | 2434877.80 | 2 | 8 | 1 | 60 | 1.83 | 0.45 |
| 9 | BH9 | Control Borehole | 60 | 1.88 | 221451.50 | 2434867.80 | 1 | 7 | 1 | 58 | 2.79 | -0.91 |
| 10 | BH10 | Control Borehole | 60 | 2.05 | 222000.20 | 2434858.10 | 1 | 7 | 1 | 60 | 2.06 | -0.01 |
| 11 | BH11 | Control Borehole | 60 | 2.41 | 220051.20 | 2434608.10 | 2 | 9 | 1 | 60 | 2.13 | 0.28 |
| 12 | BH12 | Control Borehole | 70 | 2.67 | 222431.80 | 2434674.70 | 2 | 4 | 1 | 60 | 1.21 | 1.46 |
| 13 | BH13 | Control Borehole | 60 | -4.04 | 222715.70 | 2434541.70 | | 7 | 1 | 60 | -3.17 | -0.87 |
| 14 | BH14 | Control Borehole | 60 | -3.62 | 222835.20 | 2435057.00 | | 7 | 1 | 60 | -2.15 | -1.47 |
| | total | | 840 | | | | 27 | 95 | 14 | 838 | | |

## Attached List 2: Geotechnical Test Results

| Serial Number | Hole Depth (m) | Sample type | wet density $g/cm^3$ | moisture content % | Dry density $g/cm^3$ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | | Classification and name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（$kg/cm^2$） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm | |
| BH1 | 1.5 | UD | 1.62 | 31.54 | 1.23 | 2.6 | 43 | 23 | 20 | 0.43 | 0.22 | 6* | 23.93 | 22 | 72.35 | 5.65 | Clay |
| | 3.5 | D | 1.68 | 26.55 | 1.33 | 2.63 | 25 | - | - | | 0.04 | 19* | | 0 | 22.55 | 77.45 | Silt |
| | 12.5 | UD | 1.69 | 28.32 | 1.32 | 2.63 | 34 | 25 | 9 | 0.37 | 0.1 | 15* | | 14 | 35.78 | 50.22 | Silt |
| | 14.5 | D | 1.73 | 27.35 | 1.36 | 2.65 | 25 | - | - | | 0.03 | 20* | | 0 | 14.46 | 85.54 | Fine Sand |
| | 19.5 | D | 1.7 | 27.98 | 1.33 | 2.64 | 26 | - | - | | 0.08 | 18* | | 0 | 21.68 | 78.32 | Silt |
| | 22.5 | D | 1.73 | 26.48 | 1.37 | 2.65 | 25 | - | - | | 0.02 | 22* | | 0 | 10.68 | 89.32 | Fine Sand |
| | 31.5 | D | 1.78 | 24.58 | 1.43 | 2.66 | 24 | - | - | | 0 | 25* | | 0 | 6.56 | 93.44 | Fine Sand |
| | 46.5 | D | 1.82 | 25.45 | 1.45 | 2.66 | 24 | - | - | | 0 | 27* | | 0 | 4.62 | 95.38 | Fine Sand |
| | 59.5 | D | 1.83 | 24.55 | 1.47 | 2.67 | 25 | - | - | | 0 | 33* | | 0 | 3.83 | 96.17 | Fine Sand |
| BH2 | 1.5 | UD | 1.63 | 27.58 | 1.28 | 2.6 | 43 | 24 | 19 | 0.19 | 0.18 | 6* | 12.00 | 22 | 72.35 | 5.65 | Clay |
| | 4.5 | UD | 1.7 | 30.25 | 1.31 | 2.62 | 36 | 24 | 12 | 0.52 | 0.18 | 9* | | 15 | 61.67 | 23.33 | SlityClay |
| | 7.5 | D | 1.76 | 30.21 | 1.35 | 2.64 | 34 | 25 | 9 | 0.58 | 0.02 | 18* | | 0 | 34.67 | 65.33 | Silt |
| | 18.5 | UD | 1.75 | 31.15 | 1.33 | 2.62 | 40 | 23 | 17 | 0.48 | 0.18 | 6* | 71.72 | 22 | 71.85 | 6.15 | SlityClay |
| | 21.5 | D | 1.75 | 30.15 | 1.34 | 2.64 | 24 | - | - | | 0.08 | 20* | | 0 | 20.77 | 79.23 | Silt |
| | 23.5 | D | 1.76 | 29.32 | 1.36 | 2.63 | 32 | 24 | 8 | 0.67 | 0.12 | 12* | | 12 | 32.38 | 55.62 | Silt |
| | 26.5 | D | 1.75 | 28.14 | 1.37 | 2.65 | 25 | - | - | | 0 | 24* | | 0 | 8.69 | 91.31 | Fine Sand |
| | 41.5 | D | 1.77 | 27.23 | 1.39 | 2.65 | 26 | - | - | | 0.02 | 22* | | 0 | 11.65 | 88.35 | Fine Sand |
| | 52.5 | D | 1.8 | 28.78 | 1.4 | 2.65 | 25 | - | - | | 0 | 28* | | 0 | 6.8 | 93.2 | Fine Sand |
| | 59.5 | D | 1.82 | 27.55 | 1.43 | 2.66 | 24 | - | - | | 0 | 31* | | 0 | 4.46 | 95.54 | Fine Sand |

## Attached List 2:（continue）

| `Serial Number | Hole Depth (m) | Sample type | wet density g/cm³ | moisture content % | Dry density g/cm³ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | | Classification and name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kg/cm²） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm | |
| BH3 | 1.5 | UD | 1.62 | 26.22 | 1.28 | 2.6 | 42 | 24 | 18 | 0.12 | - | - | 12.07 | 18 | 76.35 | 5.65 | Clay |
| | 2.5 | UD | 1.63 | 33.11 | 1.22 | 2.59 | 45 | 25 | 20 | 0.41 | 0.24 | 6* | | 23 | 70.8 | 6.2 | Clay |
| | 4.5 | UD | 1.7 | 32.84 | 1.28 | 2.62 | 35 | 24 | 11 | 0.80 | 0.18 | 8* | 47.93 | 14 | 63.77 | 22.23 | SlityClay |
| | 6.5 | D | 1.76 | 30.21 | 1.35 | 2.64 | 25 | - | - | | 0.02 | 18* | | 0 | 19.77 | 80.23 | Silt |
| | *13.5* | *UD* | 1.86 | 33.21 | 1.4 | 2.63 | 48 | 28 | 20 | 0.26 | 0.2 | 7* | | 26 | 69.5 | 4.5 | Clay |
| | *16.5* | D | 1.78 | 30.21 | 1.37 | 2.64 | 32 | 24 | 8 | 0.78 | 0.1 | 16* | | 0 | 31.44 | 68.56 | Silt |
| | *18.5* | *UD* | 1.75 | 32.55 | 1.32 | 2.62 | 42 | 23 | 19 | 0.50 | 0.18 | 6* | | 24 | 70.77 | 5.23 | Clay |
| | *21.5* | D | 1.75 | 29.25 | 1.35 | 2.65 | 24 | - | - | | 0.08 | 20* | | 0 | 21.17 | 78.83 | Silt |
| | 23.5 | UD | 1.76 | 28.32 | 1.37 | 2.63 | 38 | 22 | 16 | 0.40 | 0.15 | 9* | | 15 | 74.79 | 10.21 | SlityClay |
| | 26.5 | D | 1.73 | 28.14 | 1.35 | 2.65 | 25 | - | - | | 0.09 | 18* | | 0 | 23.68 | 76.32 | Silt |
| | 33.5 | D | 1.78 | 27.25 | 1.4 | 2.66 | 24 | - | - | | 0.04 | 22* | | 0 | 10.75 | 89.25 | Fine Sand |
| | 36.5 | D | 1.77 | 27.23 | 1.39 | 2.65 | 26 | - | - | | 0 | 24* | | 0 | 8.68 | 91.32 | Fine Sand |
| | 46.5 | D | 1.8 | 27.48 | 1.41 | 2.66 | 25 | - | - | | 0 | 26* | | 0 | 6.85 | 93.15 | Fine Sand |
| | 59.5 | D | 1.82 | 29.24 | 1.41 | 2.65 | 24 | - | - | | 0 | 30* | | 0 | 3.75 | 96.25 | Fine Sand |
| BH4 | 1.5 | UD | 1.63 | 32.22 | 1.23 | 2.6 | 44 | 24 | 20 | 0.41 | 0.23 | 5* | 35.93 | 26 | 69.44 | 4.56 | Clay |
| | 2.5 | UD | 1.65 | 30.42 | 1.27 | 2.59 | 36 | 25 | 11 | 0.49 | 0.22 | 8* | 47.86 | 15 | 74.77 | 10.23 | SlityClay |
| | 4.5 | D | 1.68 | 27.45 | 1.32 | 2.63 | 25 | - | - | | 0.04 | 18* | | 0 | 22.55 | 77.45 | Silt |
| | 12.5 | UD | 1.7 | 28.32 | 1.32 | 2.64 | 36 | 24 | 12 | 0.36 | 0.1 | 15* | | 14 | 40.68 | 45.32 | SlityClay |
| | 14.5 | D | 1.72 | 26.44 | 1.36 | 2.65 | 25 | - | - | | 0.03 | 20* | | 0 | 13.56 | 86.44 | Fine Sand |
| | 31.5 | D | 1.8 | 23.65 | 1.46 | 2.66 | 25 | - | - | | 0 | 25* | | 0 | 5.55 | 94.45 | Fine Sand |
| | 46.5 | D | 1.82 | 25.45 | 1.45 | 2.66 | 24 | - | - | | 0 | 26* | | 0 | 4.65 | 95.35 | Fine Sand |
| | 59.5 | D | 1.83 | 24.55 | 1.47 | 2.67 | 25 | - | - | | 0 | 32* | | 0 | 3.55 | 96.45 | Fine Sand |

## Attached List 2:（continue）

| Serial Number | Hole Depth (m) | Sample type | wet density g/cm$^3$ | moisture content % | Dry density g/cm$^3$ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | | Classification and name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kg/cm$^2$） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm | |
| BH5 | 1.5 | UD | 1.63 | 31.55 | 1.24 | 2.6 | 42 | 24 | 18 | 0.42 | 0.22 | 6* | 12.14 | 22 | 72.34 | 5.66 | Clay |
| | 4.5 | D | 1.66 | 28.35 | 1.29 | 2.63 | 25 | - | - | | 0.04 | 19* | | 0 | 21.68 | 78.32 | Silt |
| | 10.5 | UD | 1.7 | 28.32 | 1.32 | 2.64 | 37 | 24 | 13 | 0.33 | 0.1 | 12* | | 13 | 51.78 | 35.22 | SlityClay |
| | 13.5 | D | 1.72 | 27.55 | 1.35 | 2.65 | 25 | - | - | | 0.03 | 20* | | 0 | 13.56 | 86.44 | Fine Sand |
| | 26.5 | D | 1.77 | 26.22 | 1.4 | 2.65 | 25 | - | - | | 0 | 26* | | 0 | 7.65 | 92.35 | Fine Sand |
| | 36.5 | D | 1.82 | 26.21 | 1.44 | 2.66 | 25 | - | - | | 0 | 28* | | 0 | 5.64 | 94.36 | Fine Sand |
| | 48.5 | D | 1.82 | 25.45 | 1.45 | 2.66 | 24 | - | - | | 0 | 30* | | 0 | 4.65 | 95.35 | Fine Sand |
| | 59.5 | D | 1.85 | 25.99 | 1.47 | 2.67 | 24 | - | - | | 0 | 32* | | 0 | 3.23 | 96.77 | Fine Sand |
| BH6 | 1.5 | D | 1.6 | 26.44 | 1.27 | 2.63 | 30 | 22 | 8 | 0.56 | 0.1 | 16* | | 0 | 24.75 | 75.25 | Silt |
| | 4.5 | UD | 1.63 | 27.87 | 1.27 | 2.61 | 38 | 23 | 15 | 0.32 | 0.2 | 7* | 107.86 | 18 | 71.45 | 10.55 | SlityClay |
| | 13.5 | D | 1.65 | 26.44 | 1.3 | 2.64 | 25 | - | - | | 0.04 | 19* | | 0 | 9.89 | 90.11 | Fine Sand |
| | 20.5 | D | 1.68 | 25.78 | 1.34 | 2.65 | 24 | - | - | | 0 | 22* | | 0 | 7.52 | 92.48 | Fine Sand |
| | 33.5 | UD | 1.68 | 27.66 | 1.32 | 2.63 | 34 | 24 | 10 | 0.37 | 0.1 | 10* | | 15 | 44.75 | 40.25 | SlityClay |
| | 40.5 | D | 1.7 | 25.55 | 1.35 | 2.65 | 24 | - | - | | 0 | 24* | 23.93 | 0 | 7.67 | 92.33 | Fine Sand |
| | 50.5 | D | 1.78 | 24.33 | 1.43 | 2.66 | 25 | - | - | | 0 | 28* | | 0 | 5.23 | 94.77 | Fine Sand |
| | 59.5 | D | 1.8 | 24.1 | 1.45 | 2.67 | 24 | - | - | | 0 | 33* | | 0 | 3.9 | 96.1 | Fine Sand |
| BH7 | 1.5 | UD | 1.62 | 29.35 | 1.25 | 2.6 | 40 | 23 | 17 | 0.37 | 0.22 | 6* | 35.93 | 15 | 78.35 | 6.65 | SlityClay |
| | 4.5 | D | 1.65 | 28.48 | 1.28 | 2.63 | 34 | 24 | 10 | 0.45 | 0.1 | 17* | | 0 | 44 | 56 | Silt |
| | 7.5 | D | 1.68 | 29.24 | 1.3 | 2.65 | 24 | - | - | | 0 | 20* | | 0 | 9.56 | 90.44 | Fine Sand |
| | 14.5 | D | 1.65 | 30.25 | 1.27 | 2.64 | 25 | - | - | | 0.08 | 18* | | 0 | 21 | 79 | Silt |
| | 21.5 | D | 1.71 | 29.88 | 1.32 | 2.65 | 25 | - | - | | 0 | 22* | | 0 | 9.32 | 90.68 | Fine Sand |
| | 31.5 | D | 1.76 | 28.45 | 1.37 | 2.65 | 24 | - | - | | 0 | 25* | | 0 | 6.85 | 93.15 | Fine Sand |
| | 46.5 | D | 1.82 | 27.89 | 1.42 | 2.66 | 25 | - | - | | 0 | 28* | | 0 | 5.12 | 94.88 | Fine Sand |
| | 59.5 | D | 1.85 | 25.87 | 1.47 | 2.66 | 24 | - | - | | 0 | 32* | | 0 | 4.23 | 95.77 | Fine Sand |

## Attached List 2:（continue）

| Serial Number | Hole Depth (m) | Sample type | wet density g/cm$^3$ | moisture content % | Dry density g/cm$^3$ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | | Classification and name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kg/cm$^2$） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm | |
| BH8 | 1.5 | UD | 1.6 | 26.15 | 1.27 | 2.61 | 45 | 25 | 20 | 0.06 | 0.24 | 5* | 83.79 | 24 | 70.12 | 5.88 | Clay |
| | 3.5 | D | 1.65 | 28.44 | 1.28 | 2.63 | 32 | 24 | 8 | 0.56 | 0.08 | 16* | 12.07 | 0 | 34.56 | 65.44 | Silt |
| | 6.5 | UD | 1.62 | 32.48 | 1.22 | 2.62 | 42 | 24 | 18 | 0.47 | 0.2 | 6* | | 18 | 75.68 | 6.32 | Clay |
| | 7.5 | D | 1.7 | 30.25 | 1.31 | 2.64 | 26 | - | - | | 0.03 | 19* | | 0 | 29.56 | 70.44 | Silt |
| | 13.5 | D | 1.76 | 29.35 | 1.36 | 2.64 | 27 | - | - | | 0.03 | 20* | | 0 | 23.78 | 76.22 | Silt |
| | 27.5 | D | 1.78 | 28.48 | 1.39 | 2.65 | 25 | - | - | | 0.02 | 22* | | 0 | 12.55 | 87.45 | Fine Sand |
| | 35.5 | D | 1.8 | 27.68 | 1.41 | 2.65 | 25 | - | - | | 0 | 25* | | 0 | 8.52 | 91.48 | Fine Sand |
| | 39.5 | D | 1.82 | 26.85 | 1.43 | 2.66 | 26 | - | - | | 0 | 26* | | 0 | 6.36 | 93.64 | Fine Sand |
| | 46.5 | D | 1.83 | 25.47 | 1.46 | 2.65 | 24 | - | - | | 0 | 28* | | 0 | 5.12 | 94.88 | Fine Sand |
| | 59.5 | D | 1.85 | 25.74 | 1.47 | 2.66 | 25 | - | - | | 0 | 30* | | 0 | 3.88 | 96.12 | Fine Sand |
| BH9 | 1.5 | UD | 1.59 | 24.48 | 1.28 | 2.61 | 47 | 25 | 22 | -0.02 | 0.23 | 6* | 83.79 | 26 | 69.5 | 4.5 | Clay |
| | 2.5 | D | 1.62 | 26.44 | 1.28 | 2.62 | 32 | 24 | 8 | 0.31 | 0.11 | 17* | | 0 | 21.25 | 78.75 | Silt |
| | 7.5 | D | 1.68 | 24.66 | 1.35 | 2.64 | 26 | - | - | | 0.02 | 20* | | 0 | 14.38 | 85.62 | Fine Sand |
| | 18.5 | D | 1.72 | 22.35 | 1.41 | 2.64 | 25 | - | - | | 0 | 22* | | 0 | 9.85 | 90.15 | Fine Sand |
| | 29.5 | D | 1.75 | 23.78 | 1.41 | 2.65 | 24 | - | - | | 0 | 24* | | 0 | 7.66 | 92.34 | Fine Sand |
| | 39.5 | D | 1.78 | 26.85 | 1.4 | 2.66 | 26 | - | - | | 0 | 26* | | 0 | 6.36 | 93.64 | Fine Sand |
| | 46.5 | D | 1.83 | 25.47 | 1.46 | 2.65 | 24 | - | - | | 0 | 28* | | 0 | 5.12 | 94.88 | Fine Sand |
| | 58.5 | D | 1.85 | 24.58 | 1.48 | 2.65 | 25 | - | - | | 0 | 31* | | 0 | 4.65 | 95.35 | Fine Sand |

## Attached List 2:（continue）

| Serial Number | Hole Depth (m) | Sample type | wet density g/cm³ | moisture content % | Dry density g/cm³ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | | Classification and name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kg/cm²） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm | |
| BH10 | 1.5 | UD | 1.62 | 27.33 | 1.27 | 2.62 | 44 | 25 | 19 | 0.12 | 0.23 | 5* | 47.86 | 24 | 69.56 | 6.44 | Clay |
| | 4.5 | D | 1.62 | 28.32 | 1.26 | 2.62 | 32 | 24 | 8 | 0.54 | 0.11 | 16* | | 0 | 23.78 | 76.22 | Silt |
| | 7.5 | D | 1.68 | 24.66 | 1.35 | 2.64 | 26 | - | - | | 0.02 | 20* | | 0 | 14.38 | 85.62 | Fine Sand |
| | 19.5 | D | 1.72 | 24.44 | 1.38 | 2.64 | 25 | - | - | | 0 | 25* | | 0 | 6.78 | 93.22 | Fine Sand |
| | 25.5 | D | 1.75 | 23.78 | 1.41 | 2.65 | 24 | - | - | | 0 | 24* | | 0 | 9.78 | 90.22 | Fine Sand |
| | 31.5 | D | 1.78 | 26.85 | 1.4 | 2.66 | 26 | - | - | | 0 | 26* | | 0 | 6.36 | 93.64 | Fine Sand |
| | 46.5 | D | 1.83 | 25.47 | 1.46 | 2.66 | 24 | - | - | | 0 | 29* | | 0 | 4.78 | 95.22 | Fine Sand |
| | 59.5 | D | 1.85 | 24.58 | 1.48 | 2.65 | 25 | - | - | | 0 | 31* | | 0 | 4.65 | 95.35 | Fine Sand |
| BH11 | 1.5 | UD | 1.6 | 23.55 | 1.3 | 2.62 | 37 | 25 | 12 | -0.12 | 0.15 | 12* | 119.86 | 14 | 75.77 | 10.23 | SlityClay |
| | 3.5 | D | 1.63 | 24.93 | 1.3 | 2.62 | 33 | 24 | 9 | 0.10 | 0.1 | 18* | | 0 | 39.75 | 60.25 | Silt |
| | 9.5 | D | 1.6 | 24.44 | 1.29 | 2.64 | 32 | 24 | 8 | 0.06 | 0.08 | 19* | | 0 | 29.34 | 70.66 | Silt |
| | 12.5 | UD | 1.63 | 27.4 | 1.28 | 2.62 | 40 | 24 | 16 | 0.21 | 0.22 | 6* | 47.86 | 18 | 69.55 | 12.45 | SlityClay |
| | 21.5 | D | 1.75 | 26.56 | 1.38 | 2.65 | 24 | - | - | | 0 | 24* | | 0 | 7.56 | 92.44 | Fine Sand |
| | 23.5 | D | 1.73 | 28.44 | 1.35 | 2.64 | 25 | - | - | | 0 | 23* | | 0 | 9.6 | 90.4 | Fine Sand |
| | 34.5 | D | 1.8 | 30.25 | 1.38 | 2.66 | 24 | - | - | | 0 | 28* | | 0 | 4.45 | 95.55 | Fine Sand |
| | 37.5 | D | 1.78 | 29.48 | 1.37 | 2.65 | 26 | - | - | | 0 | 26* | | 0 | 9.56 | 90.44 | Fine Sand |
| | 42.5 | D | 1.83 | 32.44 | 1.38 | 2.66 | 24 | - | - | | 0 | 28* | | 0 | 4.32 | 95.68 | Fine Sand |
| | 50.5 | D | 1.85 | 29.32 | 1.43 | 2.65 | 25 | - | - | | 0 | 30* | | 0 | 3.78 | 96.22 | Fine Sand |
| | 59.5 | D | 1.88 | 28.32 | 1.47 | 2.66 | 24 | - | - | | 0 | 32* | | 0 | 3.56 | 96.44 | Fine Sand |

## Attached List 2:（continue）

| Serial Number | Hole Depth (m) | Sample type | wet density g/cm$^3$ | moisture content % | Dry density g/cm$^3$ | particles gravity | Limit moisture content % | | | | Direct shear | | Unconfined pressure qu | Particle size distribution（%） | | | Classification and name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | liquid limit | plastic limit | plastic index | Liquidity index | Cohesive force c（kg/cm$^2$） | Angle of internal friction φ（°） | kPa | <0.002mm | 0.002mm~0.075mm | 0.075mm~0.25mm | |
| BH12 | 1.5 | UD | 1.59 | 27.44 | 1.25 | 2.59 | 42 | 23 | 19 | 0.23 | 0.2 | 7* | 35.86 | 24 | 69.75 | 6.25 | Clay |
| | 13.5 | UD | 1.63 | 25.65 | 1.3 | 2.63 | 39 | 24 | 15 | 0.11 | 0.18 | 8* | 59.93 | 25 | 66.68 | 8.32 | SlityClay |
| | 22.5 | D | 1.7 | 26.48 | 1.34 | 2.64 | 26 | - | - | | 0 | 22* | | 0 | 14 | 86 | Fine Sand |
| | 30.5 | D | 1.78 | 24.55 | 1.43 | 2.65 | 25 | - | - | | 0 | 24* | | 0 | 10.68 | 89.32 | Fine Sand |
| | 45.5 | D | 1.83 | 24.55 | 1.47 | 2.66 | 24 | - | - | | 0 | 29* | | 0 | 4.32 | 95.68 | Fine Sand |
| | 59.5 | D | 1.85 | 25.99 | 1.47 | 2.67 | 24 | - | - | | 0 | 33* | | 0 | 3.56 | 96.44 | Fine Sand |
| BH13 | 1.5 | D | 1.56 | 30.25 | 1.2 | 2.62 | 32 | 23 | 9 | 0.81 | 0.1 | 12* | | 0 | 43.45 | 56.55 | Silt |
| | 6.5 | D | 1.65 | 29.48 | 1.27 | 2.63 | 31 | 24 | 7 | 0.78 | 0.04 | 17* | | 0 | 20.68 | 79.32 | Silt |
| | 14.5 | D | 1.65 | 30.25 | 1.27 | 2.64 | 25 | - | - | | 0.08 | 18* | | 0 | 21 | 79 | Silt |
| | 21.5 | D | 1.71 | 29.88 | 1.32 | 2.65 | 25 | - | - | | 0 | 22* | | 0 | 9.32 | 90.68 | Fine Sand |
| | 32.5 | D | 1.76 | 28.45 | 1.37 | 2.65 | 24 | - | - | | 0 | 26* | | 0 | 6.85 | 93.15 | Fine Sand |
| | 48.5 | D | 1.82 | 27.89 | 1.42 | 2.66 | 25 | - | - | | 0 | 28* | | 0 | 4.78 | 95.22 | Fine Sand |
| | 59.5 | D | 1.85 | 25.87 | 1.47 | 2.66 | 24 | - | - | | 0 | 33* | | 0 | 3.68 | 96.32 | Fine Sand |
| BH14 | 1.5 | D | 1.6 | 32.22 | 1.21 | 2.63 | 31 | 23 | 8 | 1.15 | 0.1 | 13* | | 0 | 37.68 | 62.32 | Silt |
| | 4.5 | D | 1.65 | 29.48 | 1.27 | 2.63 | 26 | - | - | | 0.04 | 18* | | 0 | 17.67 | 82.33 | Silt |
| | 13.5 | D | 1.7 | 29.32 | 1.31 | 2.65 | 25 | - | - | | 0 | 22* | | 0 | 9.45 | 90.55 | Fine Sand |
| | 21.5 | D | 1.71 | 29.88 | 1.32 | 2.65 | 25 | - | - | | 0 | 24* | | 0 | 6.85 | 93.15 | Fine Sand |
| | 30.5 | D | 1.76 | 28.45 | 1.37 | 2.65 | 24 | - | - | | 0 | 26* | | 0 | 5.31 | 94.69 | Fine Sand |
| | 47.5 | D | 1.82 | 29.89 | 1.4 | 2.66 | 25 | - | - | | 0 | 30* | | 0 | 3.75 | 96.25 | Fine Sand |
| | 59.5 | D | 1.85 | 25.87 | 1.47 | 2.66 | 24 | - | - | | 0 | 34* | | 0 | 2.75 | 97.25 | Fine Sand |

## Attached List 3: List of Physical and Mechanical index

| Serial Number of Layer | moisture content | Gravity density | particles gravity | void ratio | Direct shear | | SPT value amendatory | cast-in-situ bored pile | | characteristic value of bearing capacity | modulus of compression |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cohesive force | Angle of internal friction | | Characteristic value of ultimate lateral resistance of pile | Characteristic value of ultimate tip resistance of pile | | |
| | W | γ | Gs | e | c | φ | N | $q_{sik}$ | $q_{pk}$ | $f_{ak}$ | $E_{s1-2}$ |
| | % | $kN/m^3$ | | | kPa | ° | | kPa | kPa | kPa | MPa |
| ①clay（plastic） | 24.48~33.11 | 15.9~17.5 | 2.59~2.62 | 0.39~0.46 | 0.18~0.24 | 5~7 | 0.9~5.0 | 68~84 | | 90~110 | 2.0~3.0 |
| ①-1 clay（hard plastic） | 23.55~33.21 | 16.0~18.6 | 2.61~2.63 | 0.38~0.47 | 0.15~0.24 | 5~12 | 6.0~19.3 | 84~96 | | 160~180 | 6.0~8.0 |
| ②Silt（loose） | 24.44~32.22 | 15.6~1.70 | 2.62~2.65 | 0.39~0.46 | 0~0.11 | 12~20 | 0.9~11.8 | 15~22 | | 80~100 | 2.0~3.0 |
| ②-1 Silt（slightly less dense or medium-dense） | 28.14~30.21 | 17.3~17.8 | 2.63~2.65 | 0.43~0.44 | 0~0.12 | 12~24 | 6.3~19.3 | 22~46 | | 100~120 | 3.0~6.0 |
| ③Silty clay（plastic） | 25.65~32.84 | 16.3~17.6 | 2.59~2.64 | 0.40~0.46 | 0.1~0.23 | 5~15 | 1.9~9.8 | 53~68 | | 100~120 | 3.0~4.0 |
| ④Silty and Alayey Sand（loose） | 28.32 | 16.9 | 2.63 | 0.42 | 0.1 | 15 | 7~9 | 15~22 | | 80~100 | 3.0~5.0 |
| ⑤Silt Sand（loose or slightly less dense） | 26.44~30.25 | 16.5~17.3 | 2.64~2.65 | 0.41~0.44 | 0~0.08 | 18~24 | 4.2~19.2 | 22~46 | 650~750 | 100~120 | 9~11 |
| ⑥Fine Sand（medium-dense） | 28.14~30.21 | 17.3~17.8 | 2.63~2.65 | 0.37~0.46 | 0~0.12 | 12~24 | 7.0~35.0 | 46~64 | 1500~1600 | 150~160 | 11~15 |
| ⑥-1 Fine Sand（dense） | 23.65~30.25 | 17.8~18.8 | 1.38~1.48 | 0.41~0.45 | 0 | 25~34 | 21.0~46.9 | 64~84 | 1600~1800 | 180~200 | 15~19 |

Note: 1) The indicator of pile foundation according to the Technical Code for Building Pile Foundation (JGJ 94-2008) and Technical Code for Design of Building Foundations( DBJ13-07-2006)

2）Physical and Mechanical index according to the Code for Investigation of Geotechnical Engineering (2009) (GB 50021-2001).

## Attached List 4: Liquefaction Evaluation Results of Sandy Soil

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index | | | Liquefaction class | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index of soil layer | Liquefaction index of borehole | Liquefaction class of soil layer | Liquefaction class/situation of borehole |
| BH1 | 2 | ② | Slit | 11 | 4 | 3.67 | 1.35 | 3 | 10 | 10.96 | 6 | 0.55 | Liquefaction | 10 | 6.11 | 36.92 | 43.48 | serious | serious |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 11.96 | 8 | 0.67 | Liquefaction | 10 | 3.31 | | | | |
| | | | | | 6 | 5.85 | 1 | 3 | 10 | 12.96 | 9 | 0.69 | Liquefaction | 9.43 | 2.88 | | | | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 13.96 | 2 | 0.14 | Liquefaction | 8.77 | 7.51 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.96 | 3 | 0.2 | Liquefaction | 8.1 | 6.48 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.96 | 6 | 0.38 | Liquefaction | 7.43 | 4.64 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 16.96 | 7 | 0.41 | Liquefaction | 6.77 | 3.97 | | | | |
| | | | | | 11 | 10.68 | 0.65 | 3 | 10 | 17.96 | 9 | 0.5 | Liquefaction | 6.22 | 2.02 | | | | |
| | | ⑤ | Silty Sand | 30 | 14 | 13.68 | 1.35 | 3 | 10 | 20.96 | 13 | 0.62 | Liquefaction | 4.22 | 2.16 | 6.56 | | Medium | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.96 | 10 | 0.46 | Liquefaction | 3.43 | 1.87 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 22.11 | 12 | 0.54 | Liquefaction | 2.77 | 1.27 | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 22.11 | 18 | 0.81 | Liquefaction | 2.1 | 0.39 | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 22.11 | 17 | 0.77 | Liquefaction | 1.43 | 0.33 | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 22.11 | 9 | 0.41 | Liquefaction | 0.77 | 0.45 | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 22.11 | 8 | 0.36 | Liquefaction | 0.22 | 0.09 | | | | |
| BH2 | 2 | ②-1 | Slit | 17 | 7 | 6.68 | 1.35 | 3 | 10 | 13.88 | 12 | 0.86 | Liquefaction | 8.88 | 1.62 | 5.80 | 5.80 | Slight | Slight |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.88 | 12 | 0.81 | Liquefaction | 8.1 | 1.57 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.88 | 14 | 0.88 | Liquefaction | 7.43 | 0.88 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 16.88 | 15 | 0.89 | Liquefaction | 6.77 | 0.75 | | | | |
| | | | | | 11 | 10.85 | 1 | 3 | 10 | 17.88 | 18 | 1.01 | non-Liquefaction | | | | | | |
| | | | | | 12 | 11.85 | 1 | 3 | 10 | 18.88 | 20 | 1.06 | non-Liquefaction | | | | | | |
| | | | | | 13 | 12.85 | 1 | 3 | 10 | 19.88 | 23 | 1.16 | non-Liquefaction | | | | | | |
| | | | | | 14 | 13.85 | 1 | 3 | 10 | 20.88 | 25 | 1.2 | non-Liquefaction | | | | | | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.88 | 19 | 0.87 | Liquefaction | 3.43 | 0.45 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 22.03 | 23 | 1.04 | non-Liquefaction | | | | | | |
| | | | | | 17 | 16.67 | 0.65 | 3 | 10 | 22.03 | 14 | 0.64 | Liquefaction | 2.22 | 0.53 | | | | |

## Attached List 4:（continue）

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index: Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index: Liquefaction index of soil layer | Liquefaction index: Liquefaction index of borehole | Liquefaction class: Liquefaction class of soil layer | Liquefaction class: Liquefaction class/situation of borehole |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH3 | 2 | ②-1 | Slit | 12 | 6 | 5.68 | 1.35 | 3 | 10 | 12.98 | 10 | 0.77 | Liquefaction | 9.55 | 2.96 | 7.52 | 7.52 | Medium | Medium |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 13.98 | 12 | 0.86 | Liquefaction | 8.77 | 1.24 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.98 | 12 | 0.8 | Liquefaction | 8.1 | 1.61 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.98 | 14 | 0.88 | Liquefaction | 7.43 | 0.92 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 16.98 | 15 | 0.88 | Liquefaction | 6.77 | 0.79 | | | | |
| | | | | | 11 | 10.85 | 1 | 3 | 10 | 17.98 | 18 | 1 | non-Liquefaction | | | | | | |
| | | | | | 12 | 11.68 | 0.65 | 3 | 10 | 18.98 | 20 | 1.05 | non-Liquefaction | | | | | | |
| | | ②-1 | Slit | 17 | | | | | | | | | | | | | | | |
| BH4 | 2 | ② | Slit | 11 | 4 | 3.67 | 1.35 | 3 | 10 | 10.6 | 7 | 0.66 | Liquefaction | 10 | 4.58 | 32.83 | 38.19 | serious | serious |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 11.6 | 9 | 0.78 | Liquefaction | 10 | 2.24 | | | | |
| | | | | | 6 | 5.85 | 1 | 3 | 10 | 12.6 | 5 | 0.4 | Liquefaction | 9.43 | 5.69 | | | | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 13.6 | 2 | 0.15 | Liquefaction | 8.77 | 7.48 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.6 | 5 | 0.34 | Liquefaction | 8.1 | 5.33 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.6 | 10 | 0.64 | Liquefaction | 7.43 | 2.67 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 16.6 | 9 | 0.54 | Liquefaction | 6.77 | 3.1 | | | | |
| | | | | | 11 | 10.68 | 0.65 | 3 | 10 | 17.6 | 10 | 0.57 | Liquefaction | 6.22 | 1.74 | | | | |
| | | ⑤ | Silty Sand | 30 | 14 | 13.68 | 1.35 | 3 | 10 | 20.6 | 15 | 0.73 | Liquefaction | 4.22 | 1.55 | 5.36 | | Slight | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.6 | 10 | 0.46 | Liquefaction | 3.43 | 1.84 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 21.75 | 14 | 0.64 | Liquefaction | 2.77 | 0.99 | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 21.75 | 20 | 0.92 | Liquefaction | 2.1 | 0.17 | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 21.75 | 18 | 0.83 | Liquefaction | 1.43 | 0.25 | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 21.75 | 8 | 0.37 | Liquefaction | 0.77 | 0.48 | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 21.75 | 9 | 0.41 | Liquefaction | 0.22 | 0.08 | | | | |

**Attached List 4:（continue）**

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index | | | Liquefaction class | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index of soil layer | Liquefaction index of borehole | Liquefaction class of soil layer | Liquefaction class/situation of borehole |
| BH5 | 2 | ② | Slit | 5 | 4 | 3.67 | 1.35 | 3 | 10 | 10.74 | 5 | 0.47 | Liquefaction | 10 | 7.22 | 8.73 | 11.63 | Medium | Medium |
| | | | | | 5 | 4.68 | 0.65 | 3 | 10 | 11.74 | 9 | 0.77 | Liquefaction | 10 | 1.52 | | | | |
| | | ②-1 | Slit | 9 | 6 | 5.68 | 1.35 | 3 | 10 | 12.74 | 12 | 0.94 | Liquefaction | 9.55 | 0.75 | 0.75 | | Slight | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 13.74 | 14 | 1.02 | non-Liquefaction | | | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.74 | 16 | 1.09 | non-Liquefaction | | | | | | |
| | | | | | 9 | 8.68 | 0.65 | 3 | 10 | 15.74 | 17 | 1.08 | non-Liquefaction | | | | | | |
| | | ⑥ | Fine Sand | 37 | 14 | 13.68 | 1.35 | 3 | 10 | 20.74 | 20 | 0.96 | Liquefaction | 4.22 | 0.2 | 2.15 | | Slight | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.74 | 21 | 0.97 | Liquefaction | 3.43 | 0.12 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 21.89 | 12 | 0.55 | Liquefaction | 2.77 | 1.25 | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 21.89 | 16 | 0.73 | Liquefaction | 2.1 | 0.57 | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 21.89 | 25 | 1.14 | non-Liquefaction | | | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 21.89 | 26 | 1.19 | non-Liquefaction | | | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 21.89 | 20 | 0.91 | Liquefaction | 0.22 | 0.01 | | | | |
| BH6 | 1 | ② | Slit | 3 | 2 | 1.8 | 1.1 | 3 | 10 | 9.6 | 5 | 0.52 | Liquefaction | 10 | 5.27 | 6.25 | 6.25 | Medium | Medium |
| | | | | | 3 | 2.67 | 0.65 | 3 | 10 | 10.6 | 9 | 0.85 | Liquefaction | 10 | 0.98 | | | | |
| | | ⑤ | Silty Sand | 19 | | | | | | | | | | | | | | | |
| | | ⑥ | Fine Sand | 32 | | | | | | | | | | | | | | | |

## Attached List 4:（continue）

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index: Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index: Liquefaction index of soil layer | Liquefaction index: Liquefaction index of borehole | Liquefaction class: Liquefaction class of soil layer | Liquefaction class: Liquefaction class/situation of borehole |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH7 | 1 | ② | Slit | 14.5 | 4 | 3.67 | 1.35 | 3 | 10 | 12.14 | 1 | 0.08 | Liquefaction | 10 | 12.39 | 62.60 | 65.12 | serious | serious |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 13.14 | 2 | 0.15 | Liquefaction | 10 | 8.48 | | | | |
| | | | | | 6 | 5.85 | 1 | 3 | 10 | 14.14 | 3 | 0.21 | Liquefaction | 9.43 | 7.43 | | | | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 15.14 | 5 | 0.33 | Liquefaction | 8.77 | 5.87 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 16.14 | 4 | 0.25 | Liquefaction | 8.1 | 6.09 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 17.14 | 6 | 0.35 | Liquefaction | 7.43 | 4.83 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 18.14 | 4 | 0.22 | Liquefaction | 6.77 | 5.27 | | | | |
| | | | | | 11 | 10.85 | 1 | 3 | 10 | 19.14 | 6 | 0.31 | Liquefaction | 6.1 | 4.19 | | | | |
| | | | | | 12 | 11.85 | 1 | 3 | 10 | 20.14 | 10 | 0.5 | Liquefaction | 5.43 | 2.74 | | | | |
| | | | | | 13 | 12.85 | 1 | 3 | 10 | 21.14 | 8 | 0.38 | Liquefaction | 4.77 | 2.96 | | | | |
| | | | | | 14 | 13.93 | 1.15 | 3 | 10 | 22.14 | 11 | 0.5 | Liquefaction | 4.05 | 2.34 | | | | |
| | | ⑤ | Silty Sand | 30 | 15 | 14.93 | 0.85 | 3 | 10 | 23.14 | 16 | 0.69 | Liquefaction | 3.38 | 0.89 | 2.52 | | Slight | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 23.29 | 18 | 0.77 | Liquefaction | 2.77 | 0.63 | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 23.29 | 21 | 0.9 | Liquefaction | 2.1 | 0.21 | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 23.29 | 16 | 0.69 | Liquefaction | 1.43 | 0.45 | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 23.29 | 15 | 0.64 | Liquefaction | 0.77 | 0.27 | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 23.29 | 11 | 0.47 | Liquefaction | 0.22 | 0.07 | | | | |
| | | ②-1 | Slit | 26 | 14 | 13.68 | 1.35 | 3 | 10 | 20.57 | 14 | 0.68 | Liquefaction | 4.22 | 1.82 | 3.06 | | Slight | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.57 | 16 | 0.74 | Liquefaction | 3.43 | 0.89 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 21.72 | 23 | 1.06 | non-Liquefaction | | | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 21.72 | 20 | 0.92 | Liquefaction | 2.1 | 0.17 | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 21.72 | 21 | 0.97 | Liquefaction | 1.43 | 0.05 | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 21.72 | 19 | 0.87 | Liquefaction | 0.77 | 0.1 | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 21.72 | 15 | 0.69 | Liquefaction | 0.22 | 0.04 | | | | |

## Attached List 4:（continue）

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index: Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index: Liquefaction index of soil layer | Liquefaction index: Liquefaction index of borehole | Liquefaction class: Liquefaction class of soil layer | Liquefaction class: Liquefaction class/situation of borehole |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH8 | 2 | ② | Slit | 5 | 3 | 2.82 | 1.07 | 3 | 10 | 9.57 | 3 | 0.31 | Liquefaction | 10 | 7.35 | 16.69 | 44.27 | Medium | serious |
| | | | | | 4 | 3.85 | 1 | 3 | 10 | 10.57 | 4 | 0.38 | Liquefaction | 10 | 6.22 | | | | |
| | | | | | 5 | 4.68 | 0.65 | 3 | 10 | 11.57 | 6 | 0.52 | Liquefaction | 10 | 3.13 | | | | |
| | | ② | Slit | 13 | 7 | 6.93 | 0.85 | 3 | 10 | 13.57 | 7 | 0.52 | Liquefaction | 8.72 | 3.59 | 24.52 | | serious | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.57 | 5 | 0.34 | Liquefaction | 8.1 | 5.32 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.57 | 5 | 0.32 | Liquefaction | 7.43 | 5.05 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 16.57 | 7 | 0.42 | Liquefaction | 6.77 | 3.91 | | | | |
| | | | | | 11 | 10.85 | 1 | 3 | 10 | 17.57 | 10 | 0.57 | Liquefaction | 6.1 | 2.63 | | | | |
| | | | | | 12 | 11.85 | 1 | 3 | 10 | 18.57 | 9 | 0.48 | Liquefaction | 5.43 | 2.8 | | | | |
| | | | | | 13 | 12.68 | 0.65 | 3 | 10 | 19.57 | 12 | 0.61 | Liquefaction | 4.88 | 1.23 | | | | |
| | | ②-1 | Slit | 26 | 14 | 13.68 | 1.35 | 3 | 10 | 20.57 | 14 | 0.68 | Liquefaction | 4.22 | 1.82 | 3.06 | | Slight | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.57 | 16 | 0.74 | Liquefaction | 3.43 | 0.89 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 21.72 | 23 | 1.06 | non-Liquefaction | | | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 21.72 | 20 | 0.92 | Liquefaction | 2.1 | 0.17 | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 21.72 | 21 | 0.97 | Liquefaction | 1.43 | 0.05 | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 21.72 | 19 | 0.87 | Liquefaction | 0.77 | 0.1 | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 21.72 | 15 | 0.69 | Liquefaction | 0.22 | 0.04 | | | | |

## Attached List 4:（continue）

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index | | | Liquefaction class | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index of soil layer | Liquefaction index of borehole | Liquefaction class of soil layer | Liquefaction class/situation of borehole |
| BH9 | 2 | ② | Slit | 6.5 | 3 | 2.62 | 1.47 | 3 | 10 | 9.97 | 4 | 0.4 | Liquefaction | 10 | 8.8 | 24.72 | 28.43 | serious | serious |
| | | | | | 4 | 3.85 | 1 | 3 | 10 | 10.97 | 9 | 0.82 | Liquefaction | 10 | 1.8 | | | | |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 11.97 | 3 | 0.25 | Liquefaction | 10 | 7.49 | | | | |
| | | | | | 6 | 5.93 | 1.15 | 3 | 10 | 12.97 | 5 | 0.39 | Liquefaction | 9.38 | 6.63 | | | | |
| | | ⑥ | Fine Sand | 38 | 7 | 6.93 | 0.85 | 3 | 10 | 13.97 | 14 | 1 | non-Liquefaction | | | 3.71 | | Slight | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.97 | 20 | 1.34 | non-Liquefaction | | | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.97 | 30 | 1.88 | non-Liquefaction | | | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 16.97 | 14 | 0.82 | Liquefaction | 6.77 | 1.18 | | | | |
| | | | | | 11 | 10.85 | 1 | 3 | 10 | 17.97 | 12 | 0.67 | Liquefaction | 6.1 | 2.03 | | | | |
| | | | | | 12 | 11.85 | 1 | 3 | 10 | 18.97 | 19 | 1 | non-Liquefaction | | | | | | |
| | | | | | 13 | 12.85 | 1 | 3 | 10 | 19.97 | 18 | 0.9 | Liquefaction | 4.77 | 0.47 | | | | |
| | | | | | 14 | 13.85 | 1 | 3 | 10 | 20.97 | 23 | 1.1 | non-Liquefaction | | | | | | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.97 | 27 | 1.23 | non-Liquefaction | | | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 22.12 | 24 | 1.08 | non-Liquefaction | | | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 22.12 | 29 | 1.31 | non-Liquefaction | | | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 22.12 | 39 | 1.76 | non-Liquefaction | | | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 22.12 | 40 | 1.81 | non-Liquefaction | | | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 22.12 | 18 | 0.81 | Liquefaction | 0.22 | 0.03 | | | | |

## Attached List 4:（continue）

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index | | | Liquefaction class | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index of soil layer | Liquefaction index of borehole | Liquefaction class of soil layer | Liquefaction class/situation of borehole |
| BH10 | 2 | ② | Slit | 10 | 4 | 3.67 | 1.35 | 3 | 10 | 10.8 | 6 | 0.56 | Liquefaction | 10 | 6 | 17.16 | 17.71 | Medium | Medium |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 11.8 | 9 | 0.76 | Liquefaction | 10 | 2.37 | | | | |
| | | | | | 6 | 5.85 | 1 | 3 | 10 | 12.8 | 8 | 0.63 | Liquefaction | 9.43 | 3.54 | | | | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 13.8 | 11 | 0.8 | Liquefaction | 8.77 | 1.78 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.8 | 10 | 0.68 | Liquefaction | 8.1 | 2.63 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.8 | 14 | 0.89 | Liquefaction | 7.43 | 0.85 | | | | |
| | | | | | 10 | 9.68 | 0.65 | 3 | 10 | 16.8 | 21 | 1.25 | non-Liquefaction | | | | | | |
| | | ⑥ | Fine Sand | 41 | 11 | 10.68 | 1.35 | 3 | 10 | 17.8 | 23 | 1.29 | non-Liquefaction | | | 0.55 | | Slight | |
| | | | | | 12 | 11.85 | 1 | 3 | 10 | 18.8 | 24 | 1.28 | non-Liquefaction | | | | | | |
| | | | | | 13 | 12.85 | 1 | 3 | 10 | 19.8 | 20 | 1.01 | non-Liquefaction | | | | | | |
| | | | | | 14 | 13.85 | 1 | 3 | 10 | 20.8 | 18 | 0.87 | Liquefaction | 4.1 | 0.55 | | | | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 21.8 | 22 | 1.01 | non-Liquefaction | | | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 21.95 | 24 | 1.09 | non-Liquefaction | | | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 21.95 | 27 | 1.23 | non-Liquefaction | | | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 21.95 | 26 | 1.18 | non-Liquefaction | | | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 21.95 | 30 | 1.37 | non-Liquefaction | | | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 21.95 | 32 | 1.46 | non-Liquefaction | | | | | | |
| BH11 | 2 | ② | Slit | 11 | 3 | 2.92 | 0.85 | 3 | 10 | 9.44 | 1 | 0.11 | Liquefaction | 10 | 7.6 | 43.51 | 43.51 | serious | serious |
| | | | | | 4 | 3.85 | 1 | 3 | 10 | 10.44 | 2 | 0.19 | Liquefaction | 10 | 8.08 | | | | |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 11.44 | 3 | 0.26 | Liquefaction | 10 | 7.38 | | | | |
| | | | | | 6 | 5.85 | 1 | 3 | 10 | 12.44 | 4 | 0.32 | Liquefaction | 9.43 | 6.4 | | | | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 13.44 | 6 | 0.45 | Liquefaction | 8.77 | 4.85 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 14.44 | 5 | 0.35 | Liquefaction | 8.1 | 5.3 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 15.44 | 13 | 0.84 | Liquefaction | 7.43 | 1.17 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 16.44 | 14 | 0.85 | Liquefaction | 6.77 | 1 | | | | |
| | | | | | 11 | 10.68 | 0.65 | 3 | 10 | 17.44 | 10 | 0.57 | Liquefaction | 6.22 | 1.72 | | | | |

## Attached List 4:（continue）

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index: Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index: Liquefaction index of soil layer | Liquefaction index: Liquefaction index of borehole | Liquefaction class: Liquefaction class of soil layer | Liquefaction class: Liquefaction class/situation of borehole |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH12 | 3 | | | | | | | | | | | | | | | | | | non-Liquefaction |
| BH13 | Above the ground | ② | Slit | 18 | 1 | 0.68 | 1.35 | 3 | 10 | 9.85 | 2 | 0.2 | Liquefaction | 10 | 10.76 | 84.72 | 85.11 | serious | serious |
| | | | | | 2 | 1.85 | 1 | 3 | 10 | 10.85 | 3 | 0.28 | Liquefaction | 10 | 7.24 | | | | |
| | | | | | 3 | 2.85 | 1 | 3 | 10 | 11.85 | 2 | 0.17 | Liquefaction | 10 | 8.31 | | | | |
| | | | | | 4 | 3.85 | 1 | 3 | 10 | 12.85 | 3 | 0.23 | Liquefaction | 10 | 7.67 | | | | |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 13.85 | 3 | 0.22 | Liquefaction | 10 | 7.83 | | | | |
| | | | | | 6 | 5.85 | 1 | 3 | 10 | 14.85 | 5 | 0.34 | Liquefaction | 9.43 | 6.26 | | | | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 15.85 | 6 | 0.38 | Liquefaction | 8.77 | 5.45 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 16.85 | 4 | 0.24 | Liquefaction | 8.1 | 6.18 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 17.85 | 7 | 0.39 | Liquefaction | 7.43 | 4.52 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 18.85 | 9 | 0.48 | Liquefaction | 6.77 | 3.54 | | | | |
| | | | | | 11 | 10.85 | 1 | 3 | 10 | 19.85 | 7 | 0.35 | Liquefaction | 6.1 | 3.95 | | | | |
| | | | | | 12 | 11.85 | 1 | 3 | 10 | 20.85 | 9 | 0.43 | Liquefaction | 5.43 | 3.09 | | | | |
| | | | | | 13 | 12.85 | 1 | 3 | 10 | 21.85 | 8 | 0.37 | Liquefaction | 4.77 | 3.02 | | | | |
| | | | | | 14 | 13.85 | 1 | 3 | 10 | 22.85 | 12 | 0.53 | Liquefaction | 4.1 | 1.95 | | | | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 23.85 | 11 | 0.46 | Liquefaction | 3.43 | 1.85 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 24 | 10 | 0.42 | Liquefaction | 2.77 | 1.61 | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 24 | 13 | 0.54 | Liquefaction | 2.1 | 0.96 | | | | |
| | | | | | 18 | 17.67 | 0.65 | 3 | 10 | 24 | 11 | 0.46 | Liquefaction | 1.55 | 0.55 | | | | |
| | | ⑤ | Silty Sand | 28.5 | 19 | 18.67 | 1.35 | 3 | 10 | 24 | 17 | 0.71 | Liquefaction | 0.88 | 0.35 | 0.39 | | Slight | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 24 | 16 | 0.67 | Liquefaction | 0.22 | 0.05 | | | | |

## Attached List 4:（continue）

| Number of Borehole | Ground water depth by liquefaction evaluation dw(m) | NO.of soil layer | Name of soil layer | Bottom depth of layer (m) | Depth of standard penetration point (m) | Mid-point depth of soil layer represented by the standard penetration point ds(m) | Thickness of soil layer represented by the standard penetration point di(m) | clay content ρc (%) | SPT blow count reference No (blow)) | Critical blow count Ncri (blow) | Actual blow count Ni (blow) | Ni/Ncri | Evaluation result | Weights Wi | Liquefaction index | | | Liquefaction class | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | Liquefaction index of standard penetration point (1-Ni/Ncri) *Wi*di | Liquefaction index of soil layer | Liquefaction index of borehole | Liquefaction class of soil layer | Liquefaction class/situation of borehole |
| BH14 | Above the ground | ② | Slit | 12 | 1 | 0.68 | 1.35 | 3 | 10 | 9.85 | 1 | 0.1 | Liquefaction | 10 | 12.13 | 60.79 | 70.51 | serious | serious |
| | | | | | 2 | 1.85 | 1 | 3 | 10 | 10.85 | 3 | 0.28 | Liquefaction | 10 | 7.24 | | | | |
| | | | | | 3 | 2.85 | 1 | 3 | 10 | 11.85 | 5 | 0.42 | Liquefaction | 10 | 5.78 | | | | |
| | | | | | 4 | 3.85 | 1 | 3 | 10 | 12.85 | 9 | 0.7 | Liquefaction | 10 | 3 | | | | |
| | | | | | 5 | 4.85 | 1 | 3 | 10 | 13.85 | 8 | 0.58 | Liquefaction | 10 | 4.22 | | | | |
| | | | | | 6 | 5.85 | 1 | 3 | 10 | 14.85 | 9 | 0.61 | Liquefaction | 9.43 | 3.72 | | | | |
| | | | | | 7 | 6.85 | 1 | 3 | 10 | 15.85 | 5 | 0.32 | Liquefaction | 8.77 | 6 | | | | |
| | | | | | 8 | 7.85 | 1 | 3 | 10 | 16.85 | 6 | 0.36 | Liquefaction | 8.1 | 5.22 | | | | |
| | | | | | 9 | 8.85 | 1 | 3 | 10 | 17.85 | 9 | 0.5 | Liquefaction | 7.43 | 3.69 | | | | |
| | | | | | 10 | 9.85 | 1 | 3 | 10 | 18.85 | 7 | 0.37 | Liquefaction | 6.77 | 4.25 | | | | |
| | | | | | 11 | 10.85 | 1 | 3 | 10 | 19.85 | 9 | 0.45 | Liquefaction | 6.1 | 3.33 | | | | |
| | | | | | 12 | 11.68 | 0.65 | 3 | 10 | 20.85 | 8 | 0.38 | Liquefaction | 5.55 | 2.22 | | | | |
| | | ⑤ | Silty Sand | 29.5 | 13 | 12.68 | 1.35 | 3 | 10 | 21.85 | 13 | 0.59 | Liquefaction | 4.88 | 2.67 | 9.72 | | Medium | |
| | | | | | 14 | 13.85 | 1 | 3 | 10 | 22.85 | 12 | 0.53 | Liquefaction | 4.1 | 1.95 | | | | |
| | | | | | 15 | 14.85 | 1 | 3 | 10 | 23.85 | 10 | 0.42 | Liquefaction | 3.43 | 1.99 | | | | |
| | | | | | 16 | 15.85 | 1 | 3 | 10 | 24 | 12 | 0.5 | Liquefaction | 2.77 | 1.38 | | | | |
| | | | | | 17 | 16.85 | 1 | 3 | 10 | 24 | 18 | 0.75 | Liquefaction | 2.1 | 0.52 | | | | |
| | | | | | 18 | 17.85 | 1 | 3 | 10 | 24 | 11 | 0.46 | Liquefaction | 1.43 | 0.78 | | | | |
| | | | | | 19 | 18.85 | 1 | 3 | 10 | 24 | 13 | 0.54 | Liquefaction | 0.77 | 0.35 | | | | |
| | | | | | 20 | 19.67 | 0.65 | 3 | 10 | 24 | 12 | 0.5 | 液化 | 0.22 | 0.07 | | | | |

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FEDI

孟加拉Payra 1320MW燃煤电厂 工程
Bangaldesh Payra 2x660MW Coal Based Power Plant

图纸目录
DRAWING LIST

地质部分 第 一 卷 第 / 册 第 / 分册
Geotechnic Part Vol. No. I Book No. / Sub-Book No. /

卷册名称 岩土工程勘察报告
Vol. Name Geotechnical Investigation Report

卷册检索号 VOL. INDEX NO.
35-F363K-G

图纸 8 张 说明 1 本 清册 / 本
Drawings 8 shts Reports 1 Copies Lists / Copies

项目负责人: Eng. Manager:
主要设计人: Lead Designer:
组长: Discipline Leader:
卷册负责人: Designer:

签发日期: ISSUED DATE 2015 06

| 序号 NO. | 图号 DRAWING NO. | 图名 DRAWING NAME | 张数 SHT | 套用卷册检索号、图号 APPLICABLE DRAWING No. |
|---|---|---|---|---|
| 1 | 35-F363K-G01-01 | 岩土工程勘察报告 | 1 | |
| | | Geotechnical Investigation Report | | |
| 2 | 35-F363K-G01-02 | 勘探点平面布置图 | 1 | |
| | | Map of borehole layout | | |
| 3 | 35-F363K-G01-03 | 工程地质剖面图 1-1′ | 1 | |
| | | Geological Profile 1-1′ | | |
| 4 | 35-F363K-G01-04 | 工程地质剖面图 2-2′ | 1 | |
| | | Geological Profile 2-2′ | | |
| 5 | 35-F363K-G01-05 | 工程地质剖面图 3-3′ | 1 | |
| | | Geological Profile 3-3′ | | |
| 6 | 35-F363K-G01-06 | 工程地质剖面图 4-4′ | 1 | |
| | | Geological Profile 4-4′ | | |
| 7 | 35-F363K-G01-07 | 工程地质剖面图 5-5′ | 1 | |
| | | Geological Profile 5-5′ | | |
| 8 | 35-F363K-G01-08 | 工程地质剖面图 6-6′ | 1 | |
| | | Geological Profile 6-6′ | | |
| 9 | 35-F363K-G01-09 | 工程地质剖面图 7-7′ | 1 | |
| | | Geological Profile 7-7′ | | |
| | | | | |
| | | | | |
| | | | | |

# Map of Borehole Layout


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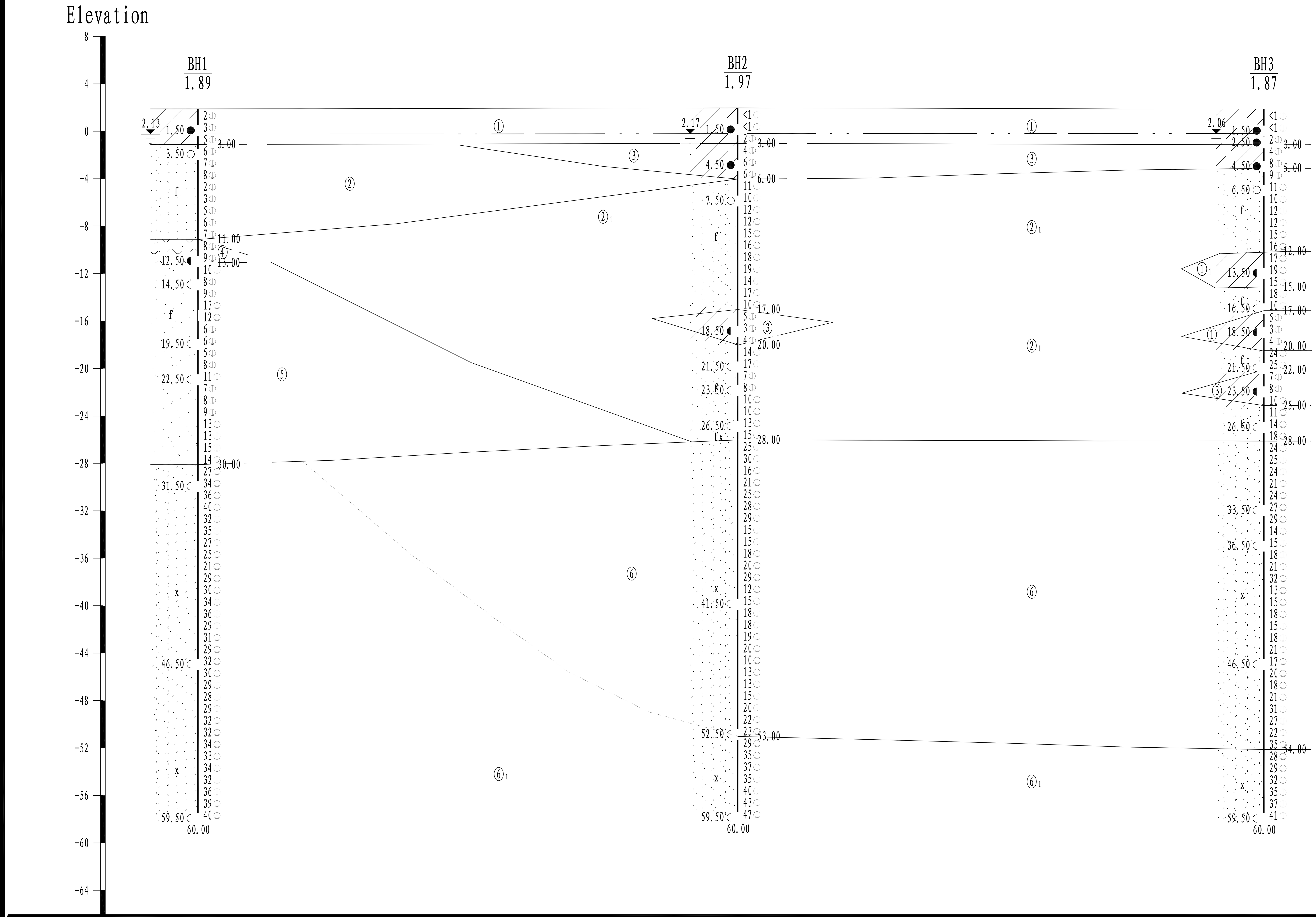
| | | | |
|---|---|---|---|
| Payra 1320MW Coal-fired Power Plant Project, Bangladesh | | feasibility study 设计阶段 | |
| 批准 APPR. | | prospecting line profile map | |
| 审核 REVIEWED | | | |
| 校核 CHECKED | | | |
| 设计 DESIGN | | | |
| 日期 DATE 2015.03 | 比例 Scale 1:5000 | 图号 DRAWING NO. | F0363S-G01-02 |

# Engineering Geological Profile 1-1′

Scale: Horizon: 1 : 5000      verticality: 1 : 400




## Legend

- ① clay (plastic)
- ①₁ clay (hard plastic)
- f ② Silt (loose)
- f ②₁ Silt (slightly less dense or medium-dense)
- ③ Silty clay (plastic)
- ④ Silty and Alayey Sand (loose)
- ⑤ fx Silt Sand (loose or slightly less dense)
- x ⑥ Fine Sand (medium-dense)
- x ⑥₁ Fine Sand (dense)

ground line
6.80-2052.19 Layered boundary and elevation
6.80-2052.19 Layered boundary and elevation
4.50-2055.45 Static water depth and elevation
position of take undisturbed sample
position of take disturbed sample
position of SPT

| | BH1 | | BH2 | | BH3 |
|---|---|---|---|---|---|
| hole depth (m) | 60.00 | | 60.00 | | 60.00 |
| spacing of hole (m) | | 569.00 | | 554.41 | |

| | | | |
|---|---|---|---|
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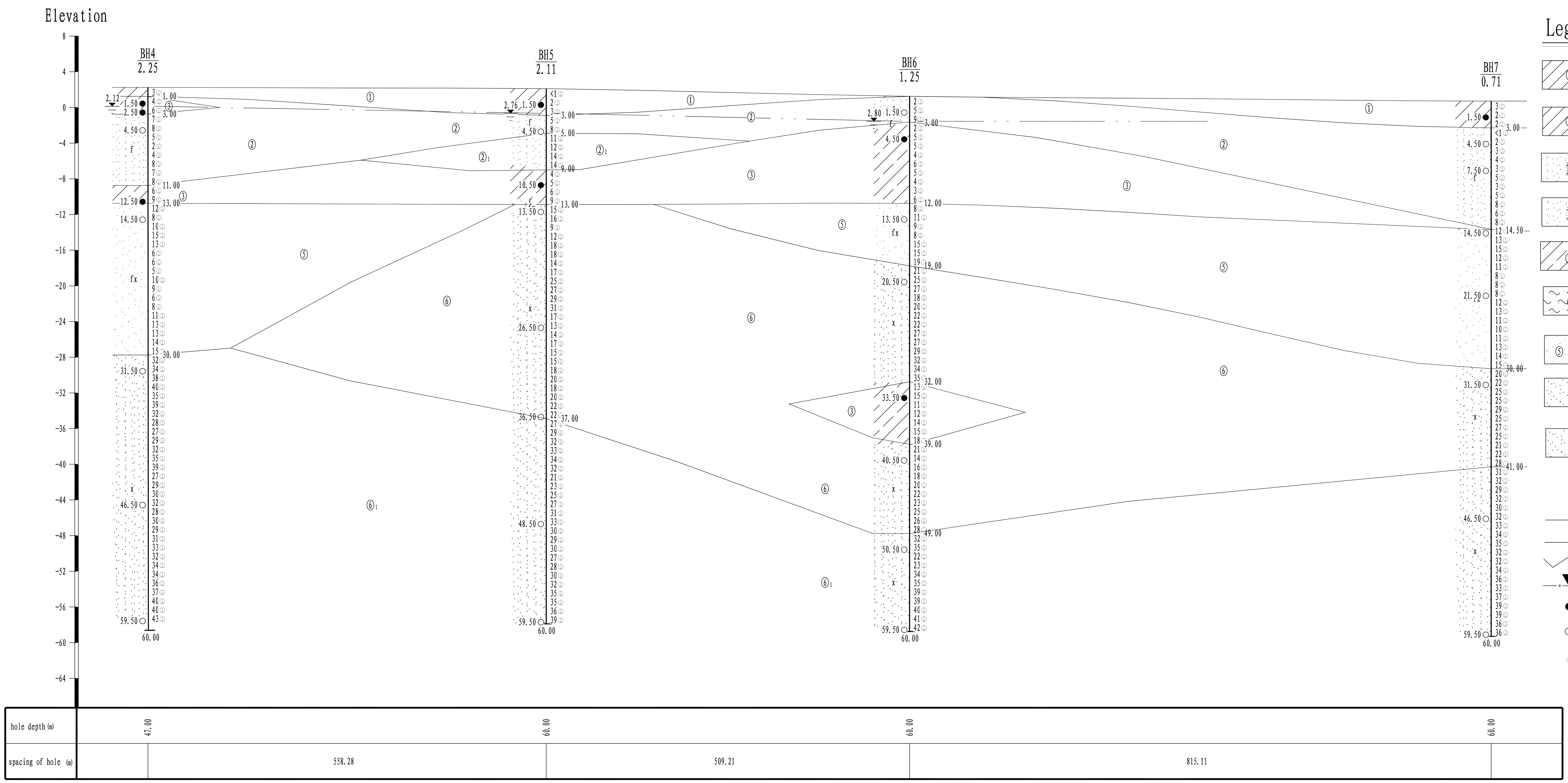
| REVIEWED | CAD DRAWER | | |
| | Scale | | |
| CHECKED | DATE 2015.03 | DRAWING NO. | F0363S-G01-03 |

# Engineering Geological Profile 2-2′

Scale: Horizon: 1：5000　　verticality: 1：400




## Legend

- ① clay (plastic)
- ①₁ clay (hard plastic)
- f ② Silt (loose)
- f ②₁ Silt (slightly less dense or medium-dense)
- ③ Silty clay (plastic)
- ④ Silty and Alayey Sand (loose)
- ⑤ fx Silt Sand (loose or slightly less dense)
- x ⑥ Fine Sand (medium-dense)
- x ⑥₁ Fine Sand (dense)

- ground line
- 6.80-2052.19 Layered boundary and elevation
- 6.80-2052.19 Layered boundary and elevation
- 4.50-2055.45 Static water depth and elevation
- position of take undisturbed sample
- position of take disturbed sample
- position of SPT

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|---|---|---|---|---|---|
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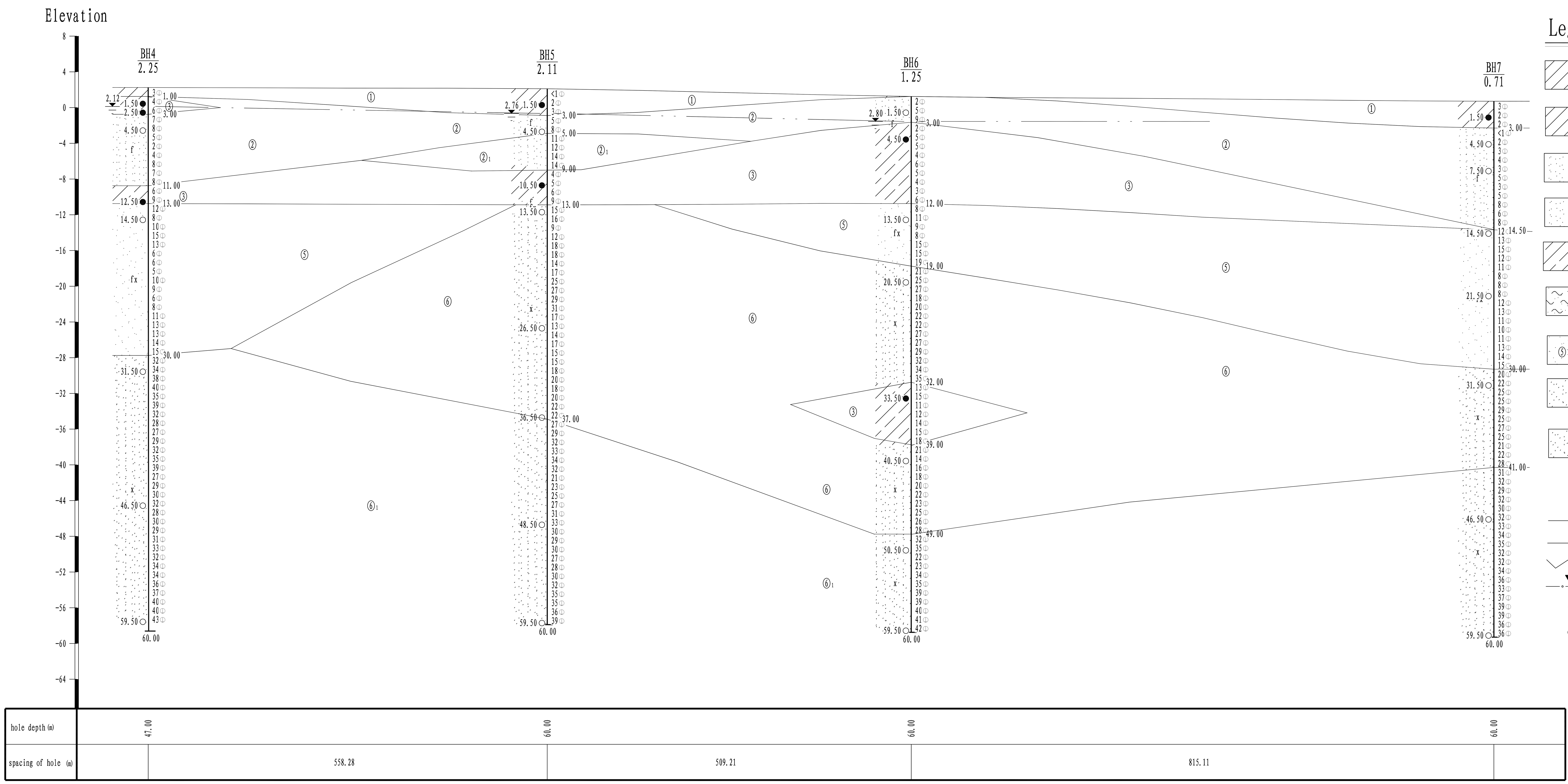
| REVIEWED | | CAD DRAWER | | | |
| | | Scale | | | |
| CHECKED | | DATE | 2015.03 | DRAWING NO. | F0363S-G01-04 |

# Engineering Geological Profile 2-2′

Scale: Horizon: 1 : 5000   verticality: 1 : 400




## Legend

- ① clay (plastic)
- ①₁ clay (hard plastic)
- f ② Silt (loose)
- f ②₁ Silt (slightly less dense or medium-dense)
- ③ Silty clay (plastic)
- ④ Silty and Alayey Sand (loose)
- ⑤ fx Silt Sand (loose or slightly less dense)
- x ⑥ Fine Sand (medium-dense)
- x ⑥₁ Fine Sand (dense)

- ground line
- 6.80-2052.19 Layered boundary and elevation
- 6.80-2052.19 Layered boundary and elevation
- 4.50-2055.45 Static water depth and elevation
- ● position of take undisturbed sample
- ○ position of take disturbed sample
- position of SPT

| | | | | |
|---|---|---|---|---|
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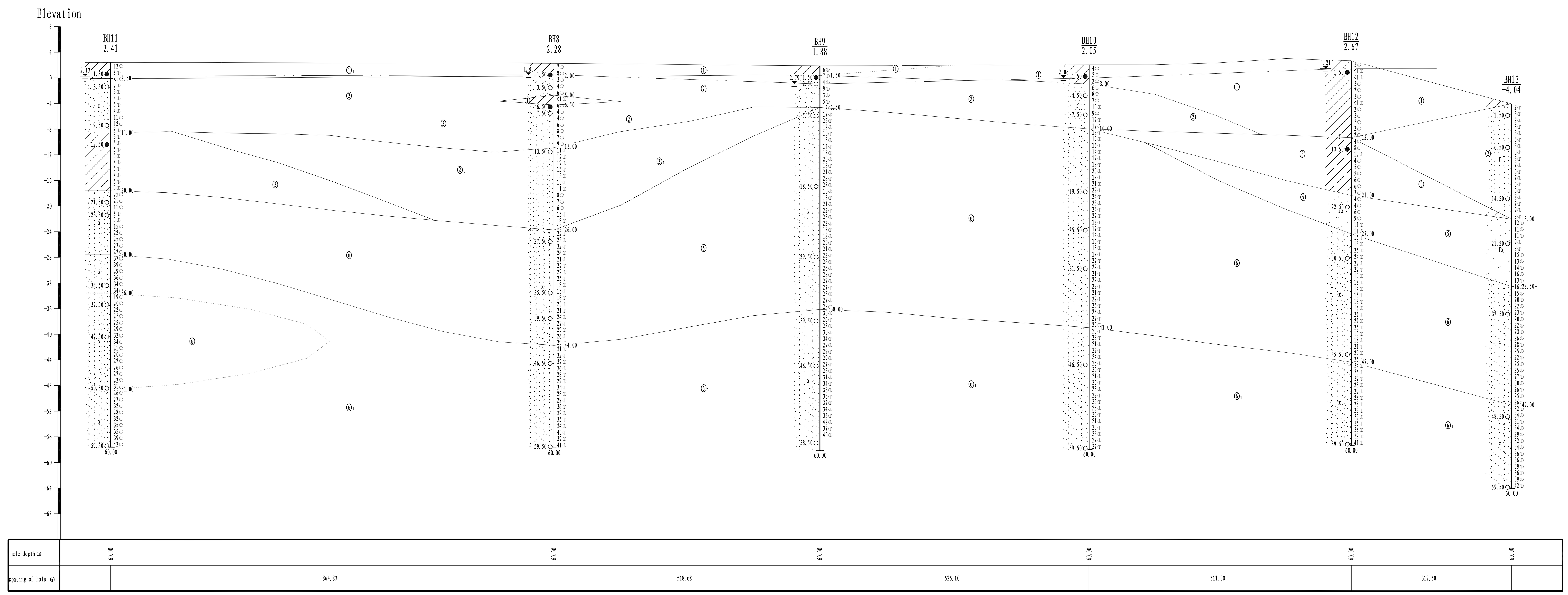
| APPR. | | DESIGN | Engineering Geological Profile 2-2′ | |
| REVIEWED | | CAD DRAWER | | |
| | | Scale | | |
| CHECKED | | DATE 2015.03 | DRAWING NO. | F0363S-G01-04 |

# Engineering Geological Profile 3-3′

Scale: Horizon: 1 : 5000 verticality: 1 : 400




## Legend

- clay (plastic)
- clay (hard plastic)
- Silt (loose)
- Silt (slightly less dense or medium-dense)
- Silty clay (plastic)
- Silty and Alayey Sand (loose)
- Silt Sand (loose or slightly less dense)
- Fine Sand (medium-dense)
- Fine Sand (dense)

- ground line
- Layered boundary and elevation
- Layered boundary and elevation
- Static water depth and elevation
- position of take undisturbed sample
- position of take disturbed sample
- position of SPT

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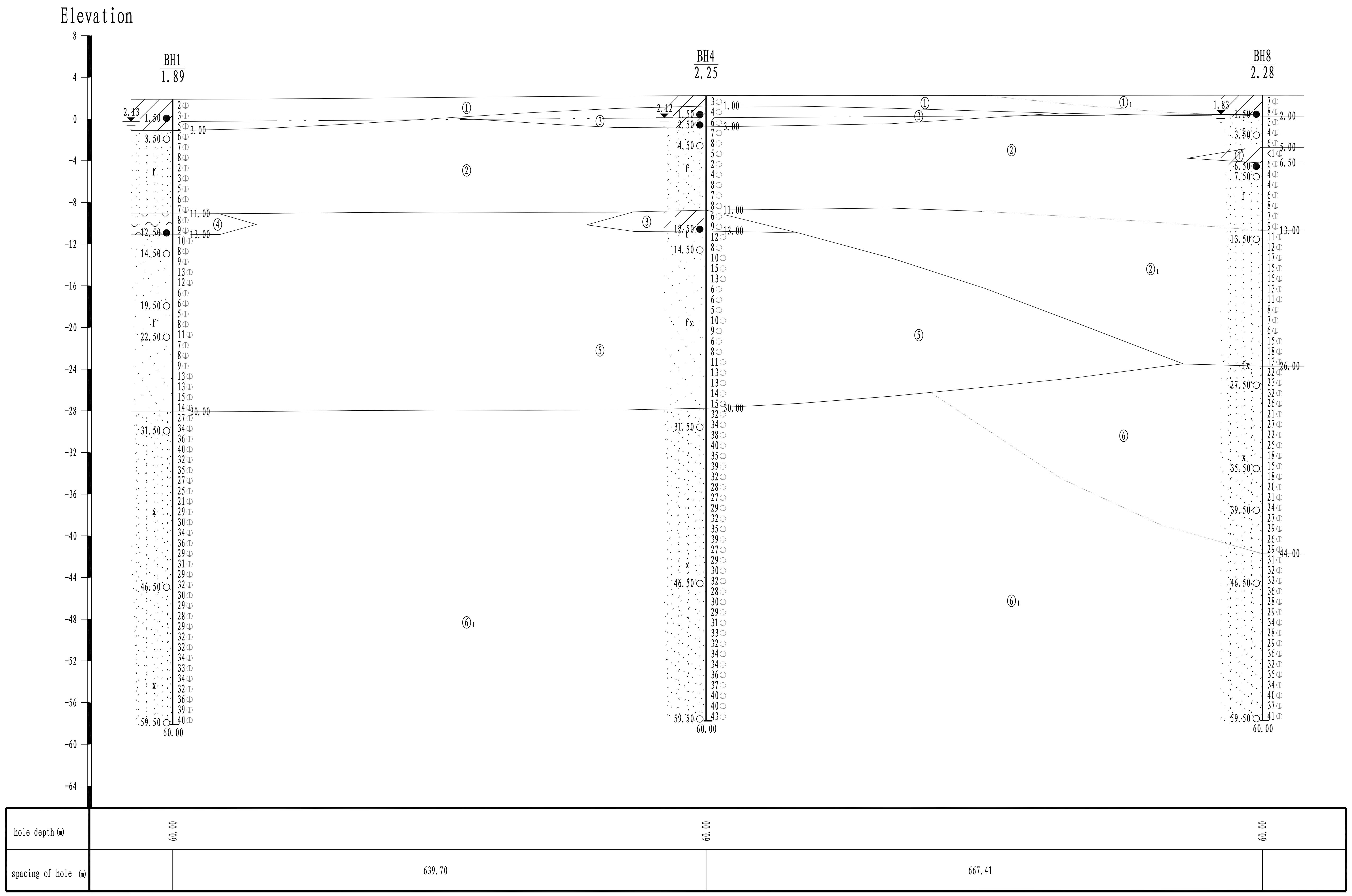
|---|---|---|---|---|
| APPR. | DESIGN | | Engineering Geological Profile 3-3′ | |
| REVIEWED | CAD DRAWER | | | |
| | Scale | | | |
| CHECKED | DATE | 2015.03 | DRAWING NO. | F0363S-G01-05 |

# Engineering Geological Profile 4-4′

Scale: Horizon: 1 : 5000  verticality: 1 : 400




## Legend

- ① clay (plastic)
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- f ② Silt (loose)
- f ②₁ Silt (slightly less dense or medium-dense)
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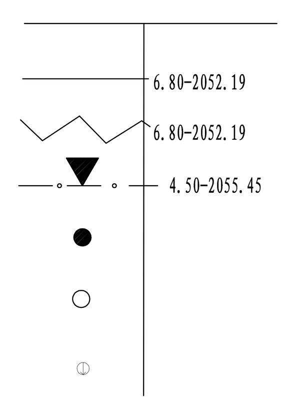
- x ⑥ Fine Sand (medium-dense)
- x ⑥₁ Fine Sand (dense)




- ground line
- Layered boundary and elevation
- Layered boundary and elevation
- Static water depth and elevation
- position of take undisturbed sample
- position of take disturbed sample
- position of SPT

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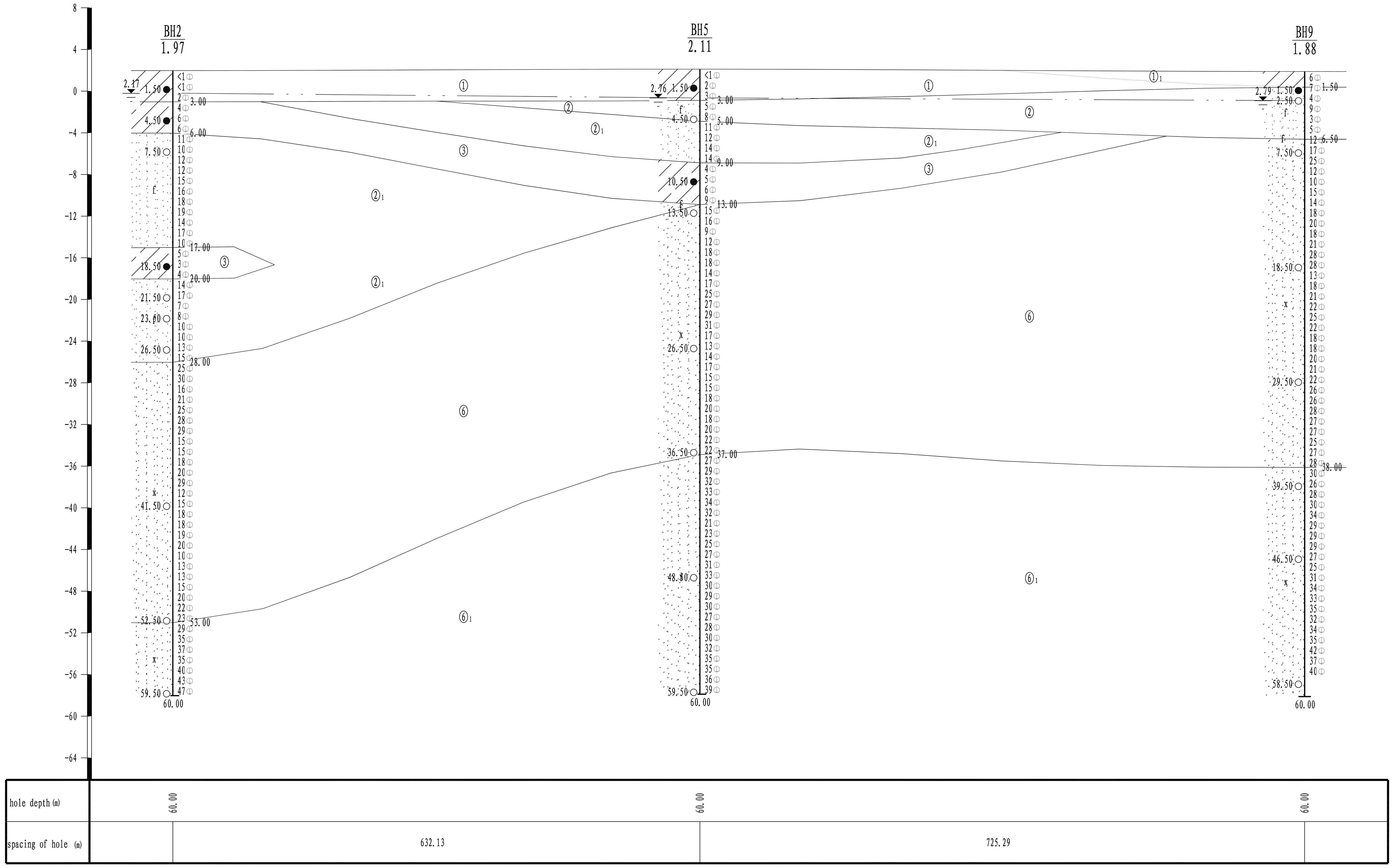
|---|---|---|---|---|---|
| APPR. | | DESIGN | | Engineering Geological Profile 4-4′ | |
| REVIEWED | | CAD DRAWER | | | |
| | | Scale | | | |
| CHECKED | | DATE | 2015.03 | DRAWING NO. | F0363S-G01-06 |

# Engineering Geological Profile 5-5′

Scale: Horizon: 1 : 5000 verticality: 1 : 400




## Legend

- ① clay (plastic)
- ①₁ clay (hard plastic)
- f ② Silt (loose)
- f ②₁ Silt (slightly less dense or medium-dense)
- ③ Silty clay (plastic)
- ④ Silty and Alayey Sand (loose)
- ⑤ fx Silt Sand (loose or slightly less dense)
- x ⑥ Fine Sand (medium-dense)
- x ⑥₁ Fine Sand (dense)

- ground line
- 6.80-2052.19 Layered boundary and elevation
- 6.80-2052.19 Layered boundary and elevation
- 4.50-2055.45 Static water depth and elevation
- ● position of take undisturbed sample
- ○ position of take disturbed sample
- position of SPT

| | | | | |
|---|---|---|---|---|
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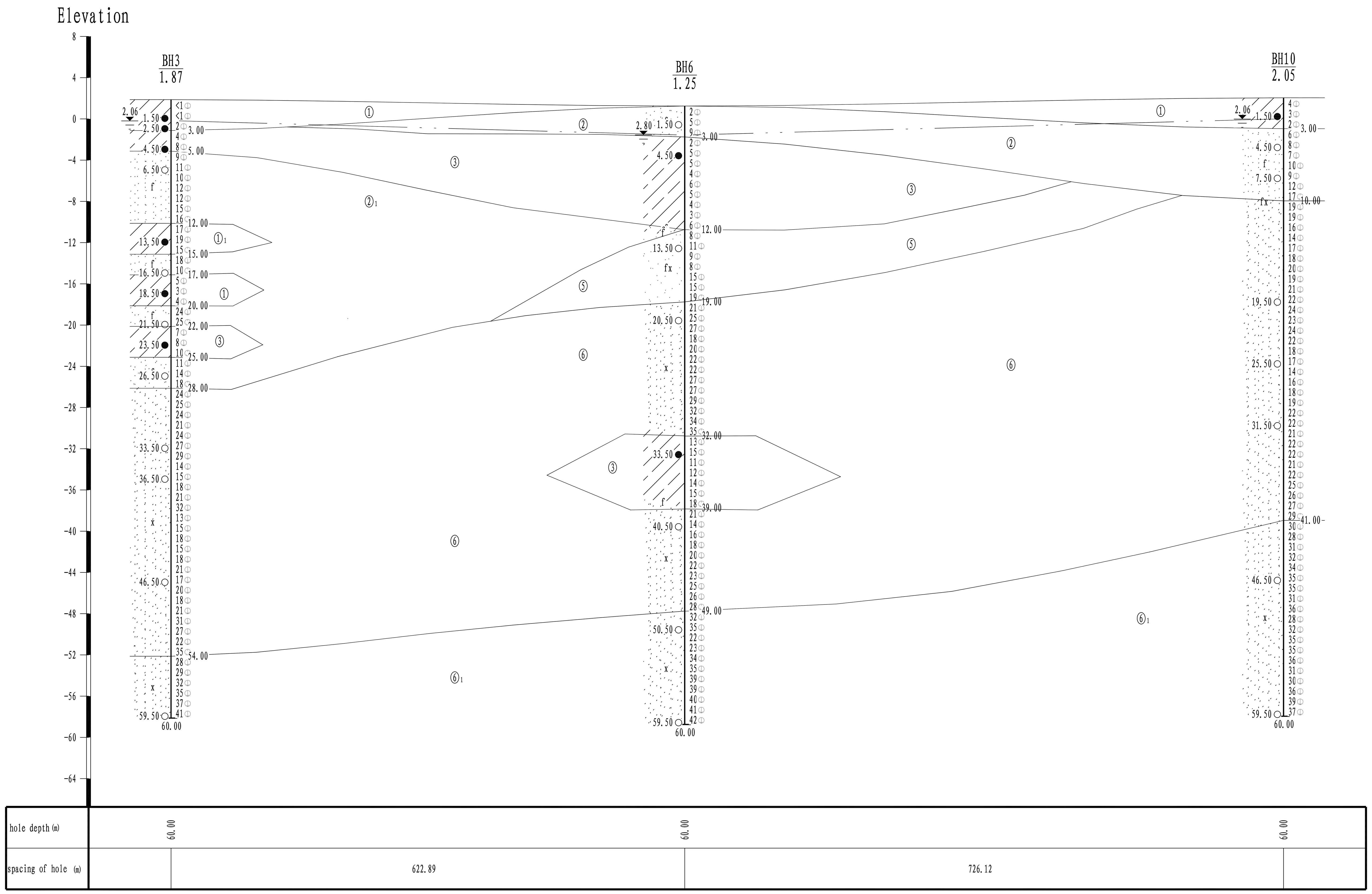
| APPR. | | DESIGN | Engineering Geological Profile 5-5′ | |
| REVIEWED | | CAD DRAWER | | |
| | | Scale | | |
| CHECKED | | DATE 2015.03 | DRAWING NO. | F0363S-G01-07 |

# Engineering Geological Profile 6-6′

Scale: Horizon: 1 : 5000　　verticality: 1 : 400




## Legend

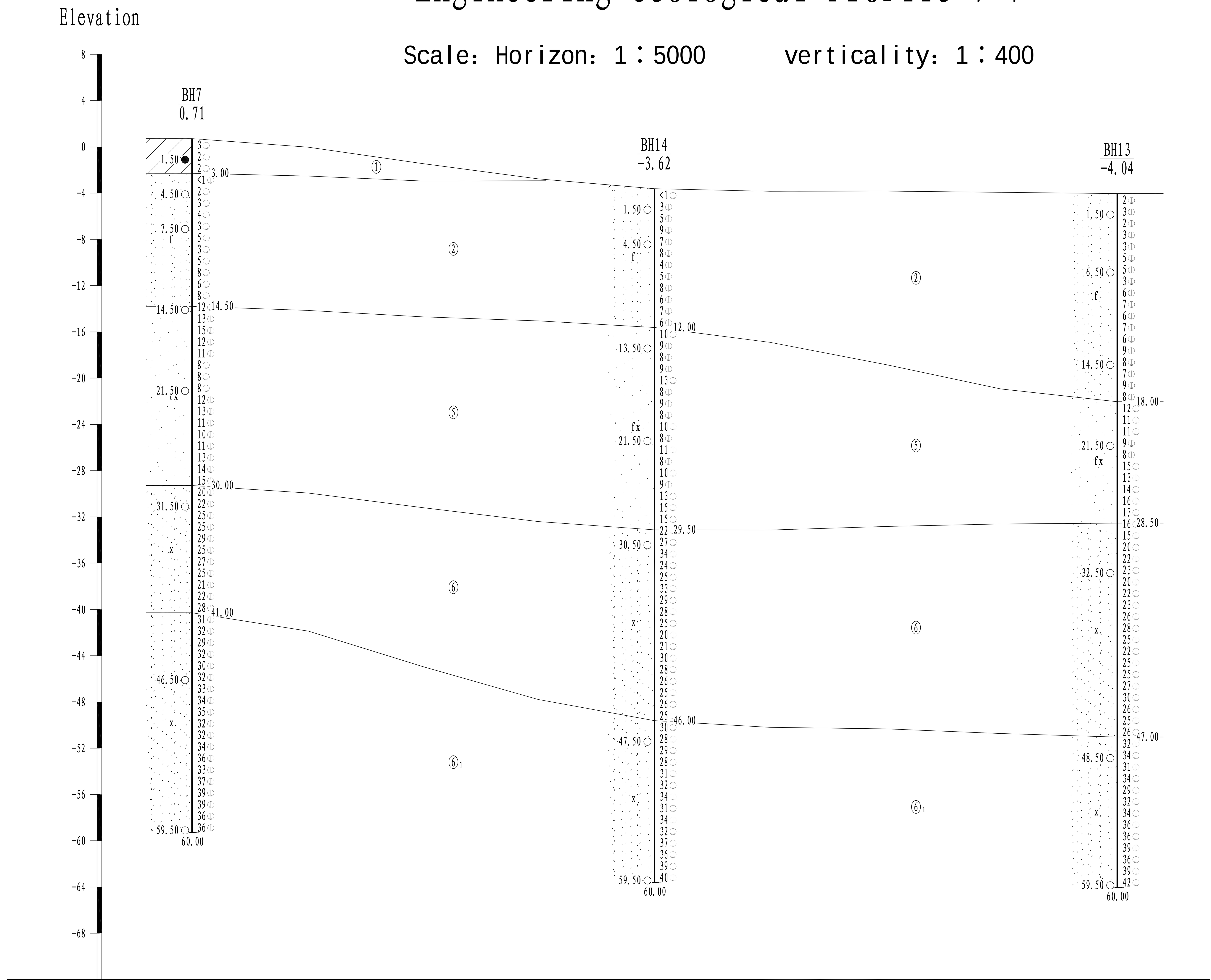
- ① clay (plastic)
- ①₁ clay (hard plastic)
- f ② Silt (loose)
- f ②₁ Silt (slightly less dense or medium-dense)
- ③ Silty clay (plastic)
- ④ Silty and Alayey Sand (loose)
- ⑤ fx Silt Sand (loose or slightly less dense)
- x ⑥ Fine Sand (medium-dense)
- x ⑥₁ Fine Sand (dense)

- ground line
- 6.80-2052.19 Layered boundary and elevation
- 6.80-2052.19 Layered boundary and elevation
- 4.50-2055.45 Static water depth and elevation
- ● position of take undisturbed sample
- ○ position of take disturbed sample
- position of SPT

| FUJIAN ELECTRIC POWER SURVEY & DESIGN INSTITUTE | | | | Payra 1320MW Coal-fired Power Plant Project, Bangladesh | feasibility study |
|---|---|---|---|---|---|
| APPR. | | DESIGN | | Engineering Geological Profile 6-6′ | |
| REVIEWED | | CAD DRAWER | | | |
| | | Scale | | | |
| CHECKED | | DATE | 2015.03 | DRAWING NO. | F0363S-G01-08 |

# Engineering Geological Profile 7-7′

Scale: Horizon: 1 : 5000    verticality: 1 : 400




## Legend

- ① clay (plastic)
- ①₁ clay (hard plastic)
- f ② Silt (loose)
- f ②₁ Silt (slightly less dense or medium-dense)
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- ④ Silty and Alayey Sand (loose)
- ⑤ fx Silt Sand (loose or slightly less dense)
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- x ⑥₁ Fine Sand (dense)

- ground line
- 6.80-2052.19 Layered boundary and elevation
- 6.80-2052.19 Layered boundary and elevation
- 4.50-2055.45 Static water depth and elevation
- position of take undisturbed sample
- position of take disturbed sample
- position of SPT

| | | | |
|---|---|---|---|
| hole depth (m) | 60.00 | 60.00 | 60.00 |
| spacing of hole (m) | 499.48 | 500.00 | |

| | | | | |
|---|---|---|---|---|
| FEDI FUJIAN ELECTRIC POWER SURVEY & DESIGN INSTITUTE | | | Payra 1320MW Coal-fired Power Plant Project, Bangladesh | feasibility study |
| APPR. | | DESIGN | Engineering Geological Profile 7-7' | |
| REVIEWED | | CAD DRAWER | | |
| | | Scale | | |
| CHECKED | | DATE 2015.03 | DRAWING NO. | F0363S-G01-09 |

## SECTION 5 – EMPLOYER'S REQUIREMENTS

# ATTACHMENT E – WATER QUALITY ANALYSIS

# CONTENTS

# 1. WATER QUALITY ANALYSIS

Table 1-1 Raw Water Quality Analysis Report 1

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 1 | | | | Date of Test: | 25/11/2014 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 28°C | | |
| Position of Sample: | | Near North Bank of River | | | | Water Temperature: | 24°C | | |
| Sampling Date: | | 17/11/2014 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Surface Water (0.50m Depth) | | | | | | | |
| Clarity: 3 ft | | Unit | | BECR | | Turbidity: 4.02 NTU | Colour: 12 (Pt-Co) | | |
| Items | | mg/L | mmol/L | mg/L | Items | | Value | Unit | BECR |
| Cation | $k^+$ | 30.0 | 0.767 | 12.0 | Hardness | Total hardness | 48.00 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 25.0 | 1.087 | 200.0 | | Noncarbonate hardness | 45.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 7.0 | 0.350 | 75.0 | | Carbonate hardness | 3.00 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 12.0 | 0.988 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.2 | 0.007 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 49.60 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.1 | 0.005 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.20 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.0 | 0.000 | 0.20 | | Phenolphthalein Acidity | 3.41 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.0 | 0.000 | 0.50 | | pH | 7.30 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.0 | 0.000 | 0.0 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 2.0 | 0.046 | - | | CO2 | 3.00 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.1 | 0.004 | 0.10 | | $COD_{Mn/Cr}$ | 3.20 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.0 | 0.000 | 0.05 | | $BOD_5$ | 1.25 | mg/l | 0.2 |
| | Total | | 3.254 | | | Dissolved Solid | 560.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 70.0 | 1.972 | 150-600 | | Total Solid | 666.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.0 | 0.000 | 400.00 | | Suspended Solid | 106.00 | mg/l | - |
| | $HCO_3^-$ | 67.0 | 1.098 | - | | Bacterical Content | 4.65 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.1 | 0.001 | - | | ($SiO_2$) total Silicon | 15.56 | mg/l | - |
| | $NO_3^-$ | 10.0 | 0.161 | 10.00 | | ($SiO_2$) nonactivated silica | 5.42 | mg/l | - |
| | $NO_2^-$ | 0.0 | 0.000 | <1.0 | | (28°C) Conductivity | 105.00 | µs/cm | - |
| | $OH^-$ | 0.0 | 0.000 | - | | TOC | 0.50 | mg/l | - |
| | Total | | 3.234 | | | Dissolved Oxygen | 6.50 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 95.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 19.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE): ±0.3% | | | | | | | pH error:±0 | | |

*Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard.

Table 1-2 Raw Water Quality Analysis Report 2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 2 | | | | Date of Test: | 25/11/2014 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 28◦C | | |
| Position of Sample: | | Middle of River | | | | Water Temperature: | 24◦C | | |
| Sampling Date: | | 17/11/2014 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Surface Water (0.50m Depth) | | | | | | | |
| Clarity: 4 ft | | Unit | | BECR | Salty | Turbidity: 6.36 NTU | Colour: 13 (Pt-Co) | | |
| Items | | mg/L | mmol/L | mg/L | | Items | mg/L | Unit | BECR |
| Cation | $K^+$ | 28.0 | 0.716 | 12.00 | Hardness | Total hardness | 56.00 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 35.0 | 1.522 | 200.00 | | Noncarbonate hardness | 51.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 10.0 | 0.500 | 75.00 | | Carbonate hardness | 5.00 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 18.0 | 1.481 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.2 | 0.007 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 49.20 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.1 | 0.005 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.15 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.0 | 0.000 | 0.20 | | Phenolphthalein Acidity | 2.27 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.0 | 0.000 | 0.50 | | pH | 7.35 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.0 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.8 | 0.041 | - | | CO2 | 2.00 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.1 | 0.004 | 0.10 | | $COD_{Mn/Cr}$ | 2.70 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.0 | 0.000 | 0.05 | | $BOD_5$ | 1.32 | mg/l | 0.2 |
| | Total | | 4.276 | | | Dissolved Solid | 420.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 100.0 | 2.817 | 150-600 | | Total Solid | 560.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.0 | 0.000 | 400.00 | | Suspended Solid | 140.00 | mg/l | - |
| | $HCO_3^-$ | 65.0 | 1.066 | - | | Bacterical Content | 4.32 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.1 | 0.001 | - | | ($SiO_2$) total Silicon | 15.89 | mg/l | - |
| | $NO_3^-$ | 10.0 | 0.161 | 10.00 | | ($SiO_2$) nonactivated silica | 6.58 | mg/l | - |
| | $NO_2^-$ | 0.0 | 0.000 | <1.0 | | (28◦C) Conductivity | 125.00 | µs/cm | - |
| | $OH^-$ | 0.0 | 0.000 | - | | TOC | 0.48 | mg/l | - |
| | Total | | 4.045 | | | Dissolved Oxygen | 6.75 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 92.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 18.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE): ±2.78% | | | | | | | pH error:±0 | | |
| *Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard. | | | | | | | | | |

Table 1-3 Raw Water Quality Analysis Report 3

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 3 | | | | Date of Test: | 25/11/2014 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 28°C | | |
| Position of Sample: | | Middle of River | | | | Water Temperature: | 23°C | | |
| Sampling Date: | | 17/11/2014 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Middle Water (5.0m Depth) | | | | | | | |
| Clarity: - | | Unit | | BECR | | Turbidity: 5.01 NTU | Colour: 13 (Pt-Co) | | |
| Items | | mg/L | mmol/L | mg/L | | Items | mg/L | Unit | BECR |
| Cation | $K^+$ | 25.3 | 0.647 | 12.00 | Hardness | Total hardness | 85.00 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 32.3 | 1.404 | 200.00 | | Noncarbonate hardness | 70.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 8.0 | 0.400 | 75.00 | | Carbonate hardness | 15.00 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 13.0 | 1.070 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.1 | 0.004 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 45.50 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.1 | 0.005 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.16 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.0 | 0.000 | 0.20 | | Phenolphthalein Acidity | 3.41 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.0 | 0.000 | 0.50 | | pH | 7.08 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.0 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.7 | 0.039 | - | | $CO_2$ | 3.00 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.1 | 0.004 | 0.10 | | $COD_{Mn/Cr}$ | 2.70 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.0 | 0.000 | 0.05 | | $BOD_5$ | 1.28 | mg/l | 0.2 |
| | Total | | 3.573 | | | Dissolved Solid | 610.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 80.0 | 2.254 | 150-600 | | Total Solid | 725.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.0 | 0.000 | 400.00 | | Suspended Solid | 115.00 | mg/l | - |
| | $HCO_3^-$ | 62.0 | 1.016 | - | | Bacterical Content | 3.25 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.1 | 0.001 | - | | ($SiO_2$) total Silicon | 18.25 | mg/l | - |
| | $NO_3^-$ | 11.0 | 0.177 | 10.00 | | ($SiO_2$) nonactivated silica | 7.65 | mg/l | - |
| | $NO_2^-$ | 0.0 | 0.000 | <1.0 | | (28°C) Conductivity | 180.00 | μs/cm | - |
| | $OH^-$ | 0.0 | 0.000 | - | | TOC | 0.49 | mg/l | - |
| | Total | | 3.448 | | | Dissolved Oxygen | 5.88 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 88.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 16.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE): ±1.78% | | | | | | | pH error:±0 | | |
| *Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard. | | | | | | | | | |

Table 1-4 Raw Water Quality Analysis Report 4

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 4 | | | | Date of Test: | 25/11/2014 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 27°C | | |
| Position of Sample: | | Middle of River | | | | Water Temperature: | 22°C | | |
| Sampling Date: | | 17/11/2014 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Ground Water (10.0m Depth) | | | | | | | |
| Clarity: - | | Unit | | BECR | | Turbidity: 5.55 NTU | Colour: 14 (Pt-Co) | | |
| Items | | mg/L | mmol/L | mg/L | | Items | mg/L | Unit | BECR |
| Cation | $K^+$ | 26.6 | 0.680 | 12.00 | Hardness | Total hardness | 160 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 31.0 | 1.348 | 200.00 | | Noncarbonate hardness | 142 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 15.0 | 0.750 | 75.00 | | Carbonate hardness | 18 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 18.0 | 1.481 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.1 | 0.004 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 48.3 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.1 | 0.005 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.19 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.0 | 0.000 | 0.20 | | Phenolphthalein Acidity | 5.68 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.0 | 0.000 | 0.50 | | pH | 7.15 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.0 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.6 | 0.037 | - | | CO2 | 5.00 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.1 | 0.004 | 0.10 | | $COD_{Mn/Cr}$ | 3.25 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.0 | 0.000 | 0.05 | | $BOD_5$ | 1.56 | mg/l | 0.2 |
| | Total | | 4.309 | | | Dissolved Solid | 720.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 110.0 | 3.099 | 150-600 | | Total Solid | 835.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.0 | 0.000 | 400.00 | | Suspended Solid | 115.00 | mg/l | - |
| | $HCO_3^-$ | 60.0 | 0.984 | - | | Bacterical Content | 4.65 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.1 | 0.001 | - | | ($SiO_2$) total Silicon | 17.30 | mg/l | - |
| | $NO_3^-$ | 10.0 | 0.161 | 10.00 | | ($SiO_2$) nonactivated silica | 5.55 | mg/l | - |
| | $NO_2^-$ | 0.0 | 0.000 | <1.0 | | (28°C) Conductivity | 300.00 | µs/cm | - |
| | $OH^-$ | 0.0 | 0.000 | - | | TOC | 0.88 | mg/l | - |
| | Total | | 4.245 | | | Dissolved Oxygen | 4.88 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 75.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 14.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE): ±0.75% | | | | | | | pH error:±0 | | |
| *Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard. | | | | | | | | | |

Table 1-5 Raw Water Quality Analysis Report 5

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 5 | | | | Date of Test: | 25/11/2014 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 28◦C | | |
| Position of Sample: | | Near South Bank of River | | | | Water Temperature: | 24◦C | | |
| Sampling Date: | | 17/11/2014 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Surface Water (0.50m Depth) | | | | | | | |
| Clarity: 4 ft | | Unit | | BECR | | Turbidity: 6.40 NTU | Colour: 14 (Pt-Co) | | |
| Items | | mg/L | mmol/L | mg/L | | Items | mg/L | Unit | BECR |
| Cation | $k^+$ | 26.3 | 0.673 | 12.00 | Hardness | Total hardness | 52 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 30.2 | 1.313 | 200.00 | | Noncarbonate hardness | 47 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 6.0 | 0.300 | 75.00 | | Carbonate hardness | 5 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 11.0 | 0.905 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.2 | 0.007 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 52.9 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.1 | 0.005 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.13 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.0 | 0.000 | 0.20 | | Phenolphthalein Acidity | 3.41 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.0 | 0.000 | 0.50 | | pH | 7.02 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.0 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 2.0 | 0.046 | - | | CO2 | 3.00 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.1 | 0.004 | 0.10 | | $COD_{Mn/Cr}$ | 2.90 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.0 | 0.000 | 0.05 | | $BOD_5$ | 1.26 | mg/l | 0.2 |
| | Total | | 3.253 | | | Dissolved Solid | 540.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 70.0 | 1.972 | 150-600 | | Total Solid | 620.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.0 | 0.000 | 400.00 | | Suspended Solid | 80.00 | mg/l | - |
| | $HCO_3^-$ | 62.3 | 1.021 | - | | Bacterical Content | 5.65 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.1 | 0.001 | - | | ($SiO_2$) total Silicon | 18.56 | mg/l | - |
| | $NO_3^-$ | 10.0 | 0.161 | 10.00 | | ($SiO_2$) nonactivated silica | 3.21 | mg/l | - |
| | $NO_2^-$ | 0.0 | 0.000 | <1.0 | | (28◦C) Conductivity | 115.00 | µs/cm | - |
| | $OH^-$ | 0.0 | 0.000 | - | | TOC | 0.49 | mg/l | - |
| | Total | | 3.155 | | | Dissolved Oxygen | 6.80 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 88.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 17.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE): ±1.53% | | | | | | | pH error:±0 | | |
| *Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard. | | | | | | | | | |

Table 1-6 Raw Water Quality Analysis Report 6

| | | | |
|---|---|---|---|
| Project Name: | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | |
| Sample No: | 1 | Date of Test: | 11/3/2015 |
| Sampling Site: | Andhar Manik River | Air Temperature: | 28◦C |
| Position of Sample: | Near North Bank of River | Water Temperature: | 26◦C |
| Sampling Date: | 2/22/2015 | Taste & Odor: | Salty |
| Kind of Water Sample: | Surface Water (0.50m Depth) | | |

| Clarity: 3 ft | | Unit | | BECR | | Turbidity: 11.50 NTU | Colour: 14 (Pt-Co) | | |
|---|---|---|---|---|---|---|---|---|---|
| Items | | mg/L | mmol/L | mg/L | | Items | Value | Unit | BECR |
| Cation | $k^+$ | 14.30 | 0.366 | 12.0 | Hardness | Total hardness | 40.50 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 30.21 | 1.313 | 200.0 | | Noncarbonate hardness | 35.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 8.32 | 0.416 | 75.0 | | Carbonate hardness | 5.00 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 15.00 | 1.235 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.25 | 0.009 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 53.00 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.15 | 0.008 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.15 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.00 | 0.000 | 0.20 | | Phenolphthalein Acidity | 3.58 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.00 | 0.000 | 0.50 | | pH | 7.25 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.00 | 0.000 | 0.0 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.50 | 0.034 | - | | CO2 | 3.15 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.40 | 0.015 | 0.10 | | $COD_{Mn/Cr}$ | 3.20 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.00 | 0.000 | 0.05 | | $BOD_5$ | 1.25 | mg/l | 0.2 |
| | Total | | 3.396 | | | Dissolved Solid | 376.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 68.4 | 1.927 | 150-600 | | Total Solid | 525.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.0 | 0.000 | 400.00 | | Suspended Solid | 149.00 | mg/l | - |
| | $HCO_3^-$ | 69.0 | 1.131 | - | | Bacterical Content | 2.44 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.1 | 0.003 | - | | ($SiO_2$) total Silicon | 16.65 | mg/l | - |
| | $NO_3^-$ | 9.0 | 0.145 | 10.00 | | ($SiO_2$) nonactivated silica | 3.22 | mg/l | - |
| | $NO_2^-$ | 0.0 | 0.000 | <1.0 | | (28◦C) Conductivity | 95.22 | µs/cm | - |
| | $OH^-$ | 0.0 | 0.000 | - | | TOC | 0.45 | mg/l | - |
| | Total | | 3.206 | | | Dissolved Oxygen | 6.48 | mg/l | 6.0 |
| | - | | | | | Total Coliforms | 86.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 13.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE):= | | | 2.87 | % | | | pH error:±0 | | |

*Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard.

Table 1-7 Raw Water Quality Analysis Report 7

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 2 | | | | Date of Test: | 11/3/2015 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 28°C | | |
| Position of Sample: | | Middle of River | | | | Water Temperature: | 24°C | | |
| Sampling Date: | | 2/22/2015 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Surface Water (0.50m Depth) | | | | | | | |
| Clarity: 4 ft | | Unit | | BECR | Salty | Turbidity: 6.36 NTU | Colour: 13 (Pt-Co) | | |
| | Items | mg/L | mmol/L | mg/L | | Items | mg/L | Unit | BECR |
| Cation | $k^+$ | 15.30 | 0.391 | 12.00 | Hardness | Total hardness | 56.00 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 28.40 | 1.235 | 200.00 | | Noncarbonate hardness | 51.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 8.32 | 0.416 | 75.00 | | Carbonate hardness | 6.10 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 15.00 | 1.235 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.31 | 0.011 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 56.10 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.19 | 0.010 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.18 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.00 | 0.000 | 0.20 | | Phenolphthalein Acidity | 2.27 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.00 | 0.000 | 0.50 | | pH | 7.35 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.00 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.90 | 0.043 | - | | CO2 | 2.00 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.51 | 0.019 | 0.10 | | $COD_{Mn/Cr}$ | 2.70 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.00 | 0.000 | 0.05 | | $BOD_5$ | 1.32 | mg/l | 0.2 |
| | Total | | 3.360 | | | Dissolved Solid | 420.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 68.70 | 1.935 | 150-600 | | Total Solid | 560.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.00 | 0.000 | 400.00 | | Suspended Solid | 140.00 | mg/l | - |
| | $HCO_3^-$ | 71.20 | 1.167 | - | | Bacterical Content | 4.32 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.11 | 0.004 | - | | ($SiO_2$) total Silicon | 15.89 | mg/l | - |
| | $NO_3^-$ | 11.10 | 0.179 | 10.00 | | ($SiO_2$) nonactivated silica | 6.58 | mg/l | - |
| | $NO_2^-$ | 0.00 | 0.000 | <1.0 | | (28°C) Conductivity | 125.00 | µs/cm | - |
| | $OH^-$ | 0.02 | 0.000 | - | | TOC | 0.48 | mg/l | - |
| | Total | | 3.285 | | | Dissolved Oxygen | 6.75 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 92.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 18.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE):= | | 1.13 | % | | | | pH error:±0 | | |
| *Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard. | | | | | | | | | |

Table 1-8 Raw Water Quality Analysis Report 8

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 3 | | | | Date of Test: | 11/3/2015 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 28°C | | |
| Position of Sample: | | Middle of River | | | | Water Temperature: | 23°C | | |
| Sampling Date: | | 2/22/2015 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Middle Water (5.0m Depth) | | | | | | | |
| Clarity: - | | Unit | | BECR | | Turbidity: 5.01 NTU | Colour: 13 (Pt-Co) | | |
| Items | | mg/L | mmol/L | mg/L | | Items | mg/L | Unit | BECR |
| Cation | $K^+$ | 14.80 | 0.379 | 12.00 | Hardness | Total hardness | 85.00 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 27.60 | 1.200 | 200.00 | | Noncarbonate hardness | 70.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 11.20 | 0.560 | 75.00 | | Carbonate hardness | 15.00 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 16.50 | 1.358 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.28 | 0.010 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 57.20 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.29 | 0.016 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.21 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.00 | 0.000 | 0.20 | | Phenolphthalein Acidity | 4.10 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.00 | 0.000 | 0.50 | | pH | 7.08 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.00 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.70 | 0.039 | - | | CO2 | 3.60 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.45 | 0.016 | 0.10 | | $COD_{Mn/Cr}$ | 2.70 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.00 | 0.000 | 0.05 | | $BOD_5$ | 1.28 | mg/l | 0.2 |
| | Total | | 3.577 | | | Dissolved Solid | 510.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 68.90 | 1.941 | 150-600 | | Total Solid | 625.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.00 | 0.000 | 400.00 | | Suspended Solid | 115.00 | mg/l | - |
| | $HCO_3^-$ | 70.10 | 1.149 | - | | Bacterical Content | 4.15 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.13 | 0.004 | - | | ($SiO_2$) total Silicon | 17.25 | mg/l | - |
| | $NO_3^-$ | 11.80 | 0.190 | 10.00 | | ($SiO_2$) nonactivated silica | 6.65 | mg/l | - |
| | $NO_2^-$ | 0.00 | 0.000 | <1.0 | | (28°C) Conductivity | 140.00 | µs/cm | - |
| | $OH^-$ | 0.00 | 0.000 | - | | TOC | 0.49 | mg/l | - |
| | Total | | 3.285 | | | Dissolved Oxygen | 6.88 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 88.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 16.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE):= | | | 4.27 | % | | | pH error:±0 | | |
| *Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard. | | | | | | | | | |

Table 1-9 Raw Water Quality Analysis Report 9

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Project Name: | | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | | | | | | |
| Sample No: | | 4 | | | | Date of Test: | 11/3/2015 | | |
| Sampling Site: | | Andhar Manik River | | | | Air Temperature: | 27◦C | | |
| Position of Sample: | | Middle of River | | | | Water Temperature: | 22◦C | | |
| Sampling Date: | | 2/22/2015 | | | | Taste & Odor: | Salty | | |
| Kind of Water Sample: | | Ground Water (10.0m Depth) | | | | | | | |
| Clarity: - | | Unit | | BECR | | Turbidity: 5.55 NTU | Colour: 14 (Pt-Co) | | |
| Items | | mg/L | mmol/L | mg/L | | Items | mg/L | Unit | BECR |
| Cation | $k^+$ | 13.50 | 0.345 | 12.00 | Hardness | Total hardness | 160.00 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 26.80 | 1.165 | 200.00 | | Noncarbonate hardness | 142.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 12.20 | 0.610 | 75.00 | | Carbonate hardness | 18.00 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 16.40 | 1.350 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.29 | 0.010 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 58.6 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.19 | 0.010 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.25 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.00 | 0.000 | 0.20 | | Phenolphthalein Acidity | 5.68 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.00 | 0.000 | 0.50 | | pH | 7.15 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.00 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.20 | 0.027 | - | | CO2 | 5.00 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.26 | 0.009 | 0.10 | | $COD_{Mn/Cr}$ | 2.60 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.00 | 0.000 | 0.05 | | $BOD_5$ | 1.20 | mg/l | 0.2 |
| | Total | | 3.5277 | | | Dissolved Solid | 410.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 73.20 | 2.062 | 150-600 | | Total Solid | 526.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.00 | 0.000 | 400.00 | | Suspended Solid | 116.00 | mg/l | - |
| | $HCO_3^-$ | 72.10 | 1.182 | - | | Bacterical Content | 4.65 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.16 | 0.005 | - | | ($SiO_2$) total Silicon | 16.30 | mg/l | - |
| | $NO_3^-$ | 12.30 | 0.198 | 10.00 | | ($SiO_2$) nonactivated silica | 5.55 | mg/l | - |
| | $NO_2^-$ | 0.00 | 0.000 | <1.0 | | (28◦C) Conductivity | 110.00 | μs/cm | - |
| | $OH^-$ | 0.00 | 0.000 | - | | TOC | 0.68 | mg/l | - |
| | Total | | 3.4477 | | | Dissolved Oxygen | 4.88 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 65.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 14.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE):= | | | 1.15 | % | | | pH error:±0 | | |
| *Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard. | | | | | | | | | |

Table 1-10 Raw Water Quality Analysis Report 10

| | | | |
|---|---|---|---|
| Project Name: | Payra 1320MW Thermal Power Plant Project, kalapara, Patuakhali. | | |
| Sample No: | 5 | Date of Test: | 11/3/2015 |
| Sampling Site: | Andhar Manik River | Air Temperature: | 28°C |
| Position of Sample: | Near South Bank of River | Water Temperature: | 24°C |
| Sampling Date: | 2/22/2015 | Taste & Odor: | Salty |
| Kind of Water Sample: | Surface Water (0.50m Depth) | | |

| Clarity: 4 ft | | Unit | | BECR | | Turbidity: 6.40 NTU | Colour: 14 (Pt-Co) | | |
|---|---|---|---|---|---|---|---|---|---|
| Items | | mg/L | mmol/L | mg/L | Items | | mg/L | Unit | BECR |
| Cation | $K^+$ | 12.90 | 0.330 | 12.00 | Hardness | Total hardness | 52.00 | mg/l as $CaCO_3$ | 200-500 |
| | $Na^+$ | 25.30 | 1.100 | 200.00 | | Noncarbonate hardness | 47.00 | mg/l as $CaCO_3$ | - |
| | $1/2Ca^{2+}$ | 9.56 | 0.478 | 75.00 | | Carbonate hardness | 5.00 | mg/l as $CaCO_3$ | - |
| | $1/2Mg^{2+}$ | 16.20 | 1.333 | 30-35 | | Negative hardness | 0.00 | mg/l as $CaCO_3$ | - |
| | $1/2Fe^{2+}$ | 0.23 | 0.008 | 0.3-1.0 | Acidity and Alkalinity | Methyl orange Alkalinity | 54.90 | mg/l as $CaCO_3$ | - |
| | $1/3Fe^{3+}$ | 0.31 | 0.017 | 0.3-1.0 | | Phenolphthalein alkalinity | 0.23 | mg/l as $CaCO_3$ | - |
| | $1/3Al^{3+}$ | 0.00 | 0.000 | 0.20 | | Phenolphthalein Acidity | 4.77 | mg/l as $CaCO_3$ | - |
| | $NH_4^+$ | 0.00 | 0.000 | 0.50 | | pH | 7.02 | | 6.5-8.5 |
| | $1/2Ba^{2+}$ | 0.00 | 0.000 | 0.01 | Other | Ammonia Nitrogen | 0.00 | mg/l | - |
| | $1/2Sr^{2+}$ | 1.90 | 0.043 | - | | CO2 | 4.20 | mg/l | - |
| | $1/2Mn^{2+}$ | 0.45 | 0.016 | 0.10 | | $COD_{Mn/Cr}$ | 2.90 | mg/l | 4.0 |
| | $1/3As^{3+}$ | 0.00 | 0.000 | 0.05 | | $BOD_5$ | 1.10 | mg/l | 0.2 |
| | Total | | 3.3259 | | | Dissolved Solid | 340.00 | mg/l | 1000.0 |
| Anion | $Cl^-$ | 66.50 | 1.873 | 150-600 | | Total Solid | 620.00 | mg/l | - |
| | $1/2SO_4^{2-}$ | 0.00 | 0.000 | 400.00 | | Suspended Solid | 280.00 | mg/l | - |
| | $HCO_3^-$ | 68.60 | 1.125 | - | | Bacterical Content | 5.65 | mg/l | - |
| | $1/2\ CO_3^{2-}$ | 0.14 | 0.005 | - | | ($SiO_2$) total Silicon | 18.56 | mg/l | - |
| | $NO_3^-$ | 10.50 | 0.169 | 10.00 | | ($SiO_2$) nonactivated silica | 3.21 | mg/l | - |
| | $NO_2^-$ | 0.00 | 0.000 | <1.0 | | (28°C) Conductivity | 115.00 | µs/cm | - |
| | $OH^-$ | 0.02 | 0.000 | - | | TOC | 0.59 | mg/l | - |
| | Total | | 3.1719 | | | Dissolved Oxygen | 4.80 | mg/l | 6.0 |
| | | | | | | Total Coliforms | 78.00 | n/100ml | 0.0 |
| | | | | | | Salinity | 13.00 | ppt | - |
| | | | | | | Hydrogen Sulfide | 0.00 | mg/l | - |
| Ion Balance Error (IBE):= | | | 2.37 % | | | | pH error:±0 | | |

*Note: BECR= Bangladesh Environment Conservation Rules(1997) drinking water standard.