MEDUPI POWER STATION
6 x 800 MW (GROSS) UNITS
WET FLUE GAS DESULFURIZATION (FGD) RETROFIT

PROJECT DESIGN MANUAL

B&V File 22.0000
SPF File 200-61989

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1.0 Project Description - Site-Specific Design Criteria

1.1 Overview

The Medupi Power Station will consist of six 800 MW coal fired steam electric generating units located in Limpopo Province, approximately 15 kilometers (km) west of the town of Lephalale, South Africa. The units are planned to enter commercial operation sequentially beginning in 2014. The FGD Retrofit Project will result in the addition of wet limestone open spray tower flue gas desulfurization (FGD) systems to each of the units, to be operational within 6 years from the date of commercial operation of the respective generating unit.

This Project Design Manual is specific to the FGD Retrofit Project. A Project Design Manual has also been prepared for the Medupi Power Station Project (Document 200-32065).

- Client/Owner: Eskom.
- Project Name: Medupi.
- Project Site Location: Limpopo Province, approximately 15 km west of the town of Lephalale, South Africa). Refer also to Appendix A, Site Location Drawings.
- Project Type/Size: Wet FGD retrofit for six by 800 megawatt (MW) (gross) units.
- Commercial Operation Date: December 2018 (first unit).
- Indoor/Outdoor Unit: Indoor turbine generator, semi-enclosed boiler.
- Fuel: Coal (minemouth).
- Raw Water Source: Pipeline from Mokolo Dam (initially), eventually supplemented by water from the Crocodile-West System.
- Fire Water and Potable Water Source: Treated raw water.
- Emission Control: Fabric filter with a wet FGD scrubber per unit.

1.2 Scope of Facilities

The general scope of facilities is listed below. Project scope items provided by others, but requiring technical interface, are also listed below:

- Wet FGD system.
- Limestone handling system.
- Gypsum dewatering system.
- Limestone preparation system.
- Water management facilities, including water supply and treatment, waste collection (including local collection conservancy tanks) and treatment, and chemical storage equipment, chemical feed equipment, and sample panel/laboratory equipment, and zero liquid discharge (ZLD) treatment equipment.
- Continuous emissions monitoring systems (CEMSs).
- Equipment cooling system (including closed cycle cooling plant).
- Control and electrical equipment for unit protection and operation.
- Fire protection equipment.
- Interconnecting piping.
- On-site fencing, roads, and railroads.
- Drainage systems, including storm water, chemical, and wastewater.
- Administrative offices, maintenance facilities, laboratories, and warehouses.
- Construction facilities.
- Ash handling systems (technical interface).
- Gypsum handling systems.
- Potable water transfer and safety shower equipment.
- Service and instrument air systems.
- Auxiliary steam pipeline.

Project scope items by others are as follows:

- Limestone supply to plant battery limits.
- Raw and potable water supply (transport and distribution system within project scope).
- Auxiliary steam supply.
- Chemical supply.
- Environmental permits.
- Construction water and power.
- Off-site access roads.
- Off-site railroad.
- Limestone delivery/gypsum off take rail yard.

1.3 Basis of Design

Proven equipment specifications and design practices, supplemented by Eskom requirements, shall serve as the basis for system and equipment design. A summary of the codes and industry standards to be used in the design are listed in Section 2.0, Design Codes and Standards.

Local building codes and South African National Standard (SANS) design standards shall govern, but the latest edition of the International Building Code (IBC) accepted by the governing authority may be used when either the SANS or Eskom standards are not clear or they do not provide sufficient information in a particular area. Where there are discrepancies between the standards, SANS design standards shall apply.

1.4 Design and Performance

This section summarizes plant design and performance criteria, scope of work interfaces, and Owner responsibilities.

1.4.1 Unit Performance

Plant design is based on the criteria listed in Table 1-1, Performance Basis.

Table 1-1
Performance Basis

Parameter	Value
Ambient Temperature	23.7° C
Ambient Pressure	91.33 kPa (900 meters ground altitude above sea level)
Ambient Humidity	50 percent
Fuel Analysis	According to Table 1-2
Test Intolerance/Uncertainty	Not allowed
FGD system pressure loss	2.5 kpa (10 in. wc)
Outlet SO_2 concentration	400 mg/Nm3 @ 6% O_2, dry basis utilizing the worst case coal without attemperating air
Maximum chloride level in the FGD slurry	30,000 ppm

1.4.2 System Descriptions

System descriptions for the various plant systems are included in Appendix B. Associated piping and instrument diagrams and process flow diagrams are included in Appendix C.

1.4.3 Fuel Specifications

Tables 1-2 and 1-3 define the minimum/maximum values or limiting conditions for the plant fuel supply, including ash analysis.

Table 1-2
Fuel Specifications (Coal)

	Unit	Design Basis	Minimum	Maximum
Higher Heating Value (HHV) - Air Dried at 25° C	MJ/kg	20.5	19.0	21.5
Total Moisture as Received	%	10.5	5.0	12.0
Ultimate Analysis – Air Dried Basis				
Inherent Moisture	%	2.0	1.5	2.5
Ash	%	35.0	31.0	38.0
Total Carbon	%	50.7	50.3	53.4
Hydrogen	%	3.0	2.4	3.6
Nitrogen	%	1.0	0.7	1.5
Sulphur	%	1.2	0.8	1.8
Carbonates (CO_3)	%	1.1	0.6	1.5
Chlorine	%	<0.1		
Fluorine	%	<0.05		
Oxygen	%	6.0	5.9	7.6
Total	%	100.0		
Proximate Analysis				
Volatile	%	25.9	24.1	29.1
Fixed Carbon	%	37.1	37.7	40.6
Physical Properties				
Hardgrove Grindability Index		51	45	56
Abrasiveness (refer to Note 1)	mg Fe/kg	500	200	500
Coal size > 100 mm	%	0		
Coal size > 40 mm	%	5		10
Coal size < 1 mm	%	25		35
Coal Burn-Out Time (refer to Note 2)	secs	2.3	2.1	2.6
Ash Analysis				
Silicon (as SiO_2)	%	57.46	52.69	62.24
Aluminum (as Al_2O_3)	%	26.24	24.03	28.46
Iron (as Fe_2O_3)	%	5.79	4.98	6.61
Titanium (as TiO_2)	%	1.24	1.11	1.36
Phosphorus (P_2O_6)	%	0.47	0.34	0.60

Table 1-2
Fuel Specifications (Coal)

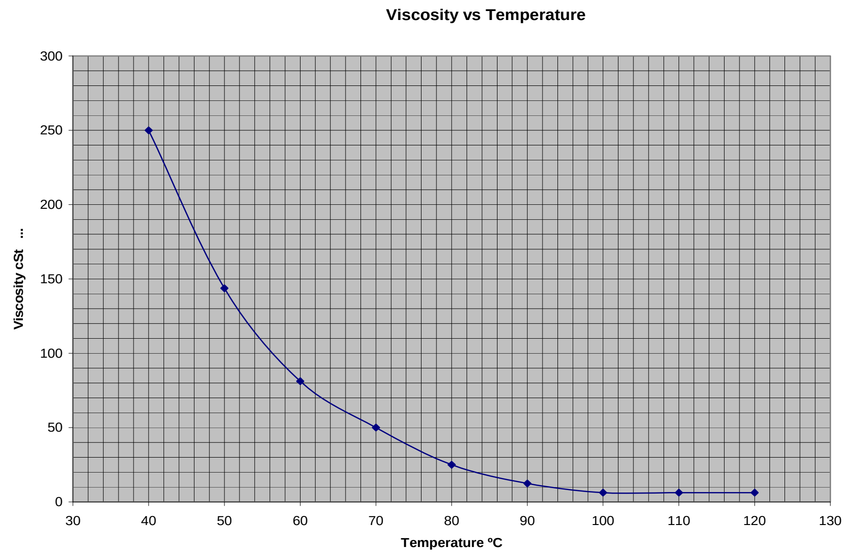
	Unit	Design Basis	Minimum	Maximum
Calcium (as CaO)	%	3.19	1.90	4.48
Magnesium (as MgO)	%	1.11	0.62	1.61
Sodium (as Na_2O)	%	0.07	0.00	0.29
Potassium (as K_2O)	%	0.76	0.54	0.99
Sulphur (as SO_3)	%	2.60	1.41	3.79
Manganese	%	0.06	0.04	0.08
Ash Characteristics				
Initial Deformation Temperature (Reduction)	° C	N/A	1,250	N/A

Notes:

1. Eskom mining house methodology.
2. Burn-out time is defined as the time taken to achieve 98 percent combustion efficiency at 1,400^{o} C in a drop tube furnace, in a 3 percent oxygen environment (300-600 percent over stoichiometric). The size grading of the coal for the burn-out time measurement is based on the drop furnace and the combustion procedure.

Table 1-3
Liquid Fuel Specifications (Eskom Grade 3 (Fuel Oil 150) Fuel Oil)

Parameter	Units	
Flash point (PMCC) min	°C	60
Water (v/v) max	%	0.5
Sediment (v/v) max	%	0.1
Total sediment in residual fuels by standard aging (v/v)	%	0.1
Viscosity at 50° C, min	cSt	90
Viscosity at 50° C, max	cSt	150
Viscosity at 100° C, max	cSt	20
Conradson carbon residue mass, max	%	15
Ash mass, max	%	0.1
Sulphur mass, max	%	3.5
Copper strip corrosion rating, (3 hours at 100° C) max		
Density at 20° C, max	kg/m^3	991
Pouring point (winter), max	°C	9
Aluminum, max	mg/kg	30
Silicon, max	mg/kg	
Aluminum and silicon, max	mg/kg	80
Vanadium, max	mg/kg	400
Iron	mg/kg	50
Acid number		Nil
Stability: Accelerated dry sludge, (m/m), max	%	0.1
Stability: Existent dry sludge, (m/m), max	%	0.1
Energy content, min	MJ/kg	41



1.4.4 Water

1.4.4.1 Quality Requirements. Water quality for raw water, including construction water provided to the site is expected to be in accordance with the values in Tables 1-4 and 1-5. The initial water supply for the Medupi Power Station will be sourced from the Mokolo Dam, with the quality and constituents described in Table 1-4. At some point, probably during the commissioning and initial operation of the first three FGD units, the Mokolo water supply may be supplemented and entirely replaced by water from the Crocodile-West water system. The quality and constituents of the Crocodile-West raw water supply are described in Table 1-5.

Treated potable water is treated to meet the requirements of Eskom 240-55864764 (Chemistry for Potable Water Standard) and the requirements of SANS 241-1, -2:2011 (Potable Water). The required average expected quality for other water sources, once treated on-site, will be in accordance with the values in Table 1-6.

1.4.4.2 Design Basis Water Balance. The water balance(s) included in Appendix D represent the design basis for water supply quantities, based on the water quality indicated in Tables 1-4 and 1-5.

1.4.5 Emissions

Generating plant design is based on limiting particulate emissions to 50 mg/Nm^3, where Nm^3 refers to standard (normal) cubic meters, measured at 0° C at 101.325 kilopascal (kPa) pressure. The sulphur dioxide (SO_2) emissions limits for the FGD system shall be 400 mg/Nm^3 @ 6% O_2, dry basis utilizing the worst case coal without attemperating air.

Table 1-4
Raw Water Analysis - Mokolo Water Supply

Constituent/Water Quality	Raw Water - Maximum	Raw Water - Minimum	Raw Water - Average	Design Basis
Turbidity, NTU	3.6	0.7	1.5	1.8
Suspended Solids, mg/L	10.0	10.0	10.0	12.0
pH	9.5	6.0	8.1	8.8
Conductivity, K_{25}, µS/cm	112.3	66.7	88.6	106.3
Alkalinity to pH 8.3, P-alk as $CaCO_3$, mg/L	15.0	1.0	5.7	6.9
Alkalinity to pH 4.5, M-alk as $CaCO_3$, mg/L	36.9	22.1	31.3	37.6
Total Alkalinity, T-Alk, as $CaCO_3$, mg/L	50.0	22.1	32.6	39.1
Magnesium Hardness, MgH, as $CaCO_3$, mg/L	22.3	5.0	17.5	21.0
Calcium Hardness, CaH, as $CaCO_3$, mg/L	36.0	10.1	15.9	19.1
Total Hardness, TH, as $CaCO_3$, mg/L	56.0	18.0	32.0	38.5
Sodium, Na, mg/L	15.2	5.0	6.2	7.4
Potassium, K, mg/L	1.5	1.1	1.3	1.6
Ammonia NH_3, mg/L	1.5	0.0	0.6	0.7
Chloride, Cl, mg/L	24.8	5.3	10.0	12.0
Sulphate, SO_4, mg/L	3.7	0.5	1.8	2.2
Fluoride, F, mg/L	0.2	0.1	0.1	0.2
Nitrate, NO_3, mg/L	--	--	--	--
Oxygen Absorbed (OA), as $KMnO_4$, mg/L	3.3	1.2	2.3	2.7
Reactive Silica, as SiO_2, mg/L	99.2	4.9	15.8	19.0
Strontium, Sr, ug/L	90.0	90.0	90.0	108.0
Barium, Ba, ug/L	20.0	20.0	20.0	24.0
Iron, Fe, ug/L	5.0	5.0	5.0	6.0
Manganese, Mn, ug/L	5.0	5.0	5.0	6.0
Boron, B, ug/L	70.0	20.0	42.5	51.0

Table 1-5
Raw Water Analysis - Crocodile-West Water Supply

Constituent / Water Quality	Raw Water - Average		Design Basis	
	As Such	As $CaCO_3$	As Such	As $CaCO_3$
pH, at 25° C	9		9.1	
Conductivity, K_{25}, at 25° C, μS/cm	792		950.4	
Turbidity, NTU	14.3		17.16	
Total Suspended Solids, TSS, mg/l	29		34.8	
Dissolved Solids at 180° C, TDS, mg/L	496	--	595.2	--
Estimated TDS, mg/L	534.3	--	641.112	--
Sodium, Na, mg/L	84.0	182.6	100.8	219.1
Sodium, Na, meq/L	3.65		4.38	
Potassium, K, mg/L	13.0	16.7	15.6	20.0
Potassium, K, meq/L	0.33		0.40	
Calcium, Ca, mg/L	42.8	107.0	51.36	128.4
Calcium, Ca, meq/L	2.14		2.57	
Magnesium, mg/L	23.8	99.2	28.56	119.0
Magnesium, Mg, meq/L	1.98		2.34	
Ammonia, NH_3, mg/L	0.36	1.1	0.44	1.34
Ammonia, NH_3, meq/L	0.02		0.02	
Calcium Hardness, CaH, mg/L	--	107.0	--	128.4
Magnesium Hardness, MgH, mg/L	--	99.2	--	119.0
Total Hardness, TH, mg/L	--	206.2	--	247.4
Carbonate, CH, mg/L	--	208.7	--	250.44
Non-Carbonate, NCH, mg/L	--	0.0	--	0.0
Chloride, Cl, mg/L	89.7	126.3	107.6	151.5
Chloride, Cl, meq/L	2.53		3.03	
Sulphate, SO_4, mg/L	74.8	77.9	89.8	93.5
Sulphate, SO_4, meq/L	1.56		1,87	
Fluoride, F, mg/L	0.53	1.4	0.64	1.69
Fluoride, F, meq/L	0.03		0.03	
Nitrate, NO_3, mg/L	3.9	3.1	4.68	3.72
Nitrate, NO_3, meq/L	0.06		0.07	

Table 1-5
Raw Water Analysis - Crocodile-West Water Supply

Constituent / Water Quality	Raw Water - Average		Design Basis	
	As Such	As $CaCO_3$	As Such	As $CaCO_3$
Nitrite, NO_2, mg/L	0.329	0.4	0.39	0.47
Nitrite, NO_2, meq/L	0.01		0.01	
Orthophosphate, PO_4, mg/L	3.1	1.6	3.72	1.92
Orthophosphate, PO_4, meq/L	0.033		0.04	
P-Alkalinity, mg/L	--	30.3	--	36.36
M-Alkalinity, mg/L	--	208.7	--	250.44
Bicarbonate Alkalinity, HCO_3-Alk, mg/L	--	148.1	--	177.72
Bicarbonate Alkalinity, HCO_3-Alk, meq/L	--	2.96	--	2.96
Carbonate Alkalinity, CO_3-Alk, mg/L	--	60.6	--	72.72
Carbonate Alkalinity, CO_3-Alk, meq/L	--	1.21	--	1.45
Hydroxide Alkalinity, OH-Alk, mg/L	--	0.0	--	0.0
Hydroxide Alkalinity, OH-Alk, meq/L	--	0.0	--	0.0
Total Alkalinity, T-Alk, mg/L	--	208.7	--	250.44
Total Cations, TC, mg/L	164.0	406.51	196.8	
Total Cations, TC, meq/L	8.13		--	
Total Anions, TA, mg/L	389.4	419.48	467.3	
Total Anions, TA, meq/L	8.39		--	
Cation:Anion Balance, %	-1.6%	--	--	--
Oxygen Absorbed, OA, mg/L as O_2	0.94	--	1.13	--
Chemical Oxygen Demand. COD, mg/L	23.3	--	28.0	--
Dissolved Organic Carbon, DOC, mg/L as C	7.1	--	8.5	--
Total Organic Carbon, TOC, mg/L as C	7.9	--	9.4	--
Ratio DOC:TOC, %	97	--	97	--
Ratio TOC:COD, %	24	--	24	--
Total Silica, SIO_2, mg/L	14.3	--	17.16	
Silica, Reactive (Soluble/Ionic), mg/L as SiO_2	10.9		13.8	
Silica, Non-Reactive (colloidal/particulate), mg/L as SiO_2	3.4		4.08	
Barium, Ba, mg/L	0.08		0.10	

Table 1-5
Raw Water Analysis - Crocodile-West Water Supply

Constituent / Water Quality	Raw Water - Average		Design Basis	
	As Such	As $CaCO_3$	As Such	As $CaCO_3$
Iron, Fe, (Total) mg/L	0.2		0.24	
Manganese, Mn, mg/L	0.02		0.02	
Boron, B, mg/L	0.27		0.32	
Aluminum, Al, mg/L	0.03		0.04	
Arsenic, As, µg/L	NR			
Beryllium, Be, mg/L	0.005		0.01	
Cadmium, Cd, mg/L	0.005		0.01	
Chromium, Cr, mg/L	0.024		0.03	
Cobalt, Co, mg/L	0.01		0.01	
Copper, Cu, mg/L	0.01		0.01	
Cyanide, Cn, mg/L	0.025		0.03	
Lead, Pb, mg/L	0.03		0.04	
Mercury, Hg, µg/L	NR			
Molybdenum, Mo, mg/L	NR			
Nickel, Ni, mg/L	0.01		0.01	
Phosphorus, P, mg/L	1.0		1.20	
Selenium, Se, mg/L	NR			
Strontium, Sr, mg/L	0.20		0.24	
Vanadium, V, mg/L	0.023		0.03	
Zinc, Zn, mg/L	0.039		0.05	

Table 1-6
Design Basis Quality for Other Water Sources

Constituent	FGD Blowdown (85% Limestone Case)	FGD Blowdown (96% Limestone Case)	Cooling Tower Blowdown	TOC Scavenger Waste
Calcium, Ca, mg/L	4400	16400	103	0
Magnesium, Mg, mg/L	8800	340	57	0
Sodium, Na, mg/L	1310	1200	202	16812
Potassium, K, mg/L	200	200	31	0
Chloride, Cl , mg/L	30000	30000	215	18561
Fluoride, F, mg/L	30	30	1.28	0
Sulphate, as $SO_{3\backslash 4}$, mg/L	5520	850	525	3435
Nitrates, as NO_3, mg/L	600	600	9	148
Phosphates, P, mg/L				22
Silica, SiO_2, mg/L			34	0
Ammonium, NH_4, mg/L	200	200	0.88	0
Carbon Dioxide, CO_2, mg/L	10	10		
Bicarbonate, HCO_3, mg/L	800	800	178.6	0
Carbonate, CO_3, mg/L	0	0	0	
Hydroxides, OH, mg/L				1284
pH	6	6	< 8.3	13.14
Total Suspended Solids, mg/L	35900	14767	69.6	0
Aluminum, Al, mg/L	50	50	0.08	
Antimony, Sb, mg/L	1	1		
Arsenic, As, mg/L	1	1		
Barium, Ba, mg/L	30	30	0.2	0
Boron, B, mg/L	40	40		
Cadmium, Cd, mg/L	0.6	0.6	0.02	
Cobalt, Co, mg/L	1	1		
Chromium, Cr, mg/L	3	3	0.06	
Copper, Cu, mg/L	2	2	0.02	
Iron, Fe, mg/L	40	40	0.48	
Lead, Pb, mg/L	2	2		
Manganese, Mn, mg/L	30	30	0.04	

Table 1-6
Design Basis Quality for Other Water Sources

Constituent	FGD Blowdown (85% Limestone Case)	FGD Blowdown (96% Limestone Case)	Cooling Tower Blowdown	TOC Scavenger Waste
Mercury, Hg, mg/L	0.2	0.2		
Molybdenum, Mo, mg/L	2	2		
Nickel, Ni, mg/L	3	3	0.02	
Selenium, Se, mg/L	1	1		
Silver, Ag, mg/L	2	2		
Strontium, Sr, mg/L	120	120	0.48	
Titanium, Ti, mg/L	0.6	0.6		
Vanadium, V, mg/L	0.8	0.8		
Zinc, Zn, mg/L	5	5	0.1	
Biological Oxygen Demand, BOD, mg/L	60	60		
Chemical Oxygen Demand, COD, mg/L	250	250		
Total Organic Carbon, TOC, C, mg/L			18.8	183

1.4.6 Landfill Waste Disposal

Ash and combustion waste products will be transferred by a system of conveyors to a separate ash dump for permanent storage. An emergency ash dump with a reclaiming system will be provided to stockpile a 24 hour accumulation of waste products (boiler bottom ash) on-site to allow for interruptions in conveying operations.

The ash dump will be located west of the main power station and will be designated as Ash Dump North. The ash dump will be sized for 31 years of plant operation with all six units in service at a 90 percent capacity factor. Area has been allocated for a future Ash Dump South adjacent to Ash Dump North for use when the initial ash dump is full.

Disposal of the dewatered ZLD pretreatment sludge and dewatered brine from the Zero Liquid Discharge Treatment System will be to a landfill that is designed for these wastes.

1.4.7 Classification of Hazardous Areas

Electrical equipment, materials, and raceway wiring will be selected, designed, and installed in accordance with SANS 10142-1 (The wiring of premises Part 1: Low-voltage installations), SANS 10108 (The classification of hazardous locations and the selection of aparatus for use in such locations), SANS 60079-10 (Electrical apparatus for explosive gas atmospheres Part 10: Classification of hazardous areas), and other applicable requirements.

Eskom will do the Hazardous Area Classification and the design must meet the approved area classification requirements.

1.4.8 Noise

The environmental noise emissions during normal plant operation shall comply with SANS 10083-2012 (The measurement and assessment of occupational noise for hearing conservation purposes) and applicable local noise regulations. The National Noise Control Regulations (NCR) of the Environmental Conservation Act (No. 73 of 1989), Government Notice No. R55 of January 1994, apply for this project.

Noise levels (sound pressure levels) of every item of the plant, measured according to SANS 10083-2012 at a distance of 3 meters from the item in its permanent location at site, shall not exceed 85 decibels A (dBA). In cases where the noise levels are exceeded, acoustic treatment (cladding, silencers, screens) necessary to reduce the noise level to 85 dBA shall be employed. This applies to normal operating conditions at site, for items of plant operating periodically; this shall apply for the time they are operating.

Major rotating equipment and control valves shall be specified with a sound level of 85 dBA to control in-plant noise emissions. When noise levels in operating areas exceed 85 dBA, an occurrence generally caused by the cumulative effects of several equipment components, and/or sound amplification because of reflection, these areas shall be marked accordingly and administrative control measures, including hearing protection warning signs, shall be implemented. Reasonable mitigation measures will be taken to restrict noise within enclosures to 115 dBA, or as required by the Advisory Council for Occuptaional Health and Safety if the operating staff is able to enter the enclosure during normal plant operation. If facility personnel occupy such enclosures during facility operation, access doors shall be clearly marked with hearing protection warning signs.

During intermittent operations such as startup and shutdown, or during upset conditions such as emergency steam release, sound levels within the plant may exceed the sound levels experienced during normal operation. However, the sound level in areas not requiring hearing protection shall not exceed 115 dBA or OSHA limits.

1.4.9 Reliability, Availability, Safety and Maintainability (RAM)

Reliability, Availability, and Maintainability studies of the complete FGD system and subsystems shall be performed. All equipment, including electrical and C&I, must be included.

The VisualSPAR latest version reliability simulation software package shall be used in performing the RAM analysis. All plant components shall have a proven track record in terms of reliability, safety availability and maintainability and the plant shall be designed with due consideration for ease of Operations and Maintenance.

1.4.9.1 Failure Mode Effects and Criticality Analysis (FMECA). Formal Failure Mode Effects and Criticality Analysis Studies shall be carried out on all systems. These studies shall be done in accordance with the requirements as laid down in Eskom's FMECA Guideline: 240-49230046. These studies are to be submitted to Eskom for approval/acceptance.

1.4.9.2 Hazard and Operability Studies (HAZOP). Formal Hazard and Operability (HAZOP) Studies shall be carried out on all systems. These studies shall be done in accordance with the requirements as laid down in the Eskom's HAZOP Guideline: 240-49230111. These studies are to be submitted to Eskom for approval/acceptance.

1.5 Permits and Licenses

1.5.1 Permits and Licenses

Legal and environmental requirements for the project have been developed by Eskom to address the requirements of national, provincial, and local regulations and rulings. A listing of the applicable legislation and authorizations serving as a basis for the required permits and licenses is included in Appendix I.

1.6 Site Investigations

1.6.1 Air Quality Monitoring

Eskom has established an air monitoring network in the plant site area. Ambient air quality, along with supportive meteorology, has been measured. The purpose of the air quality monitoring program is to establish background concentrations of pollutants, including SO_2, NO_x, and particulates in the site vicinity. The information developed by the air quality monitoring program will be compared with computer model predictions for pollutant concentrations resulting from operation of the plant.

1.6.2 Surveys and Topography

Site boundaries are tied to the South African WGS084 grid system. An aerial survey of the plant site and surrounding area has been developed to provide topographical information.

1.6.3 Geology and Seismology

Additional soil borings have been located specifically for the Medupi FGD Retrofit Project area, and additional soil borings will begin in 2016.

Regional and site-specific geotechnical surveys for the Medupi FGD power island area have been carried out previously, and the results are contained in the reports below:

- Stage 1--Preliminary Survey (Dated November 2005 – Ref. 8006/7579/1/G).
- Stage 2--Power Island (Dated 1-8/05_January 2007).
- Stage 3--Hydro Geological Survey (Dated February 2007).
- Stage 4--Additional geotechnical reports as warranted by specific contractors.

Topographically, the area is portion of a gently undulating pediment adjacent to the mountain massif of the Waterberg, the face of which rises by approximately 200 meters some 15 km to the south. Up to and including the station site, this pediment is cut across rocks of the Waterberg Group; across the Eenzaamheid Fault, close to the northern boundary of the site, this pediment continues, but is cut across rocks of the Karoo Supergroup. Gradients are low, ranging from 5 percent to less than 1 percent (average about 1.25 percent). Absolute elevations range from 890 meters to 907.5 meters. No active watercourses are present, although a gentle drainage depression near the southern boundary of Naauw Ontkomen contains alluvial soils. The entire area forms part of the Post-African I erosion surface, which is of early Miocene age (about 20 million years).

The site is underlain by sedimentary rocks of the Waterberg Group. These rocks are terminated along the Eenzaamheid Fault near the northern boundary of Naauw Ontkomen; to the north of this fault, rocks of the Karoo Supergroup are present. The Waterberg rocks, which are of Mokolian age (1,600 to 1,700 million years) have been intruded by a number of diabase dykes. The Karoo rocks in the area are of Permian age (250 to 300 million years). Outcrops are rare in the area, although the surface of the Waterberg rocks has been exposed over considerable areas on Naauw Ontkomen by shallow excavations for road building material. The major part of the site is covered by soils of varying thickness.

The Eenzaamheid Fault, which strikes east-west near the northern boundary of the site, forms the northern limit of Waterberg rocks in the area. It is a normal fault along which a downthrow to the north of about 250 meters has occurred. The age of movement along this feature is unknown, but probably predates the deposition of the Karoo rocks in the area. There is no evidence of recent reactivation.

In addition, the presence of a prominent lineation along the east bank of the Tamboti River, to the east of the study area has been noted and interpreted as a fault, with a downthrow to the north-east. This fault may have been reactivated within the Quaternary (i.e., within the last 2 million years). The trace of this feature is 15 km from the site at its closest point. It is discussed further in Section 1.7.2, Site Seismicity.

1.6.4 Noise

A noise characteristic investigation of the site will be conducted by Eskom. The investigation will include an on-site noise monitoring program establishing baseline levels of the daytime and nighttime ambient noise at the plant site boundaries. In addition, estimates for the ambient noise levels from major plant noise sources will be developed by the various major contractors.

1.6.5 Groundwater

Groundwater quality will be monitored during the life of the plant. Groundwater testing will be conducted by Eskom prior to the start of construction to establish baseline groundwater quality. Eskom will establish a groundwater quality monitoring program for the duration of construction and plant operation.

1.6.6 Water Quality Management

- All provisions of the National Water Act, Act 36 of 1998, shall be adhered to. Specific requirements and recommendations with regard to water quality management are included in the Environmental Management Plan developed for the project.

1.7 Environmental Design Criteria

1.7.1 Meteorology

Table 1-7 contains meteorological data required for the plant design. The design basis is established from data available from the Matimba Power Station. Design wind parameters are in accordance with SANS 10160 (Basis of Structural Design and Actions for Buildings and Industrial Structures).

Wind data obtained from the South African (SA) weather services for the periods 2002 to 2003 and 2004 to 2005 have been used to generate the wind roses shown as Figure 1-1.

1.7.2 Site Seismicity

Site seismicity shall be according to SANS 10160-4:2011.

The robustness requirements of SANS 10160, Clause 5.6.7.1 to 5.6.7.3 shall be applied for all structures.

Table 1-7
Meteorological Data

Design Parameter	Minimum Design	Maximum Design	Units
Rainfall - 24 Hour, 50 Year Event -24 Hour, 100 Year Event -1 Hour, 50 Year Event (Design rainfall parameters may vary depending on local codes or agencies.)	--	126 145 250	mm mm mm
Wind Design Parameters			
Wind Velocity • Basic Wind Speed (10 min average) per SANS 10160-3:2011 Figure 1 • Peak Wind Speed per SANS 10160-3:2011	-- --	28.0 39.2	m/sec m/sec
Kinetic Power (kp) (site altitude is nominally 900 m)		0.53	kg/m^3
Intrinsic Drag Coefficient (kr)		1.0	--
Terrain Category per SANS 10160-3:2011		--	--
Importance Factor per SANS 10160:2011		--	--
Annual Barometric Pressure Data, adjusted to site elevation	896	899	hPa
Ambient Temperature (extremes)	-7.6 Dry Bulb (DB)	42.3 DB	°C
Freeze Protection Design Conditions	-2 DB with 10 kph coincident wind	--	°C
Space Conditioning Ambient Design Temperature (Matimba Station Weather Data, 2.0 percent summer/99.0 percent winter)	4 DB (2 DB – Turbine Building only)	36 DB/20 WB	°C

1.8 Soil Resistivity

The electrical soil resistivity profile used for grounding design is defined in Table 1-8. Data were assembled from the Soil Resistivity Survey Report in Appendix H.

Table 1-8
Electrical Soil Resistivity Profile

Layer	Resistivity (ohmmeters)	Depth Below Grade (m)
1	234	0.516
2	3302	2.63
3	3302	Infinite

1.9 Electrical Design Data

The electrical power system design shall be based on the unit one-line diagram and station power one-line diagram included in Appendix F.

Table 1-9 contains preliminary electrical design data required for the plant design. The design data were established by Eskom. The electrical data contained in Table 1-9 must be verified during the Definition Phase of the project.

Table 1-9
Electrical Design Data
TO BE VERIFIED DURING THE DEFINITION PHASE OF THE PROJECT

Design Parameter	Value			Units
Maximum Available System Fault at Electrical System Interface Point	By Eskom, reference Document 200-14348, Medupi Load Flow Fault Study			kA kA
Minimum Available System Fault at Electrical System Interface Point	By Eskom, reference Document 200-14348, Medupi Load Flow Fault Study			kA kA
Required var Output at Electrical System Interface Point	By Eskom			kvars or power factor
Substation voltage	Min 360	Max 440	Nominal 411	kV
Substation basic impulse level (BIL)	1,300			kV

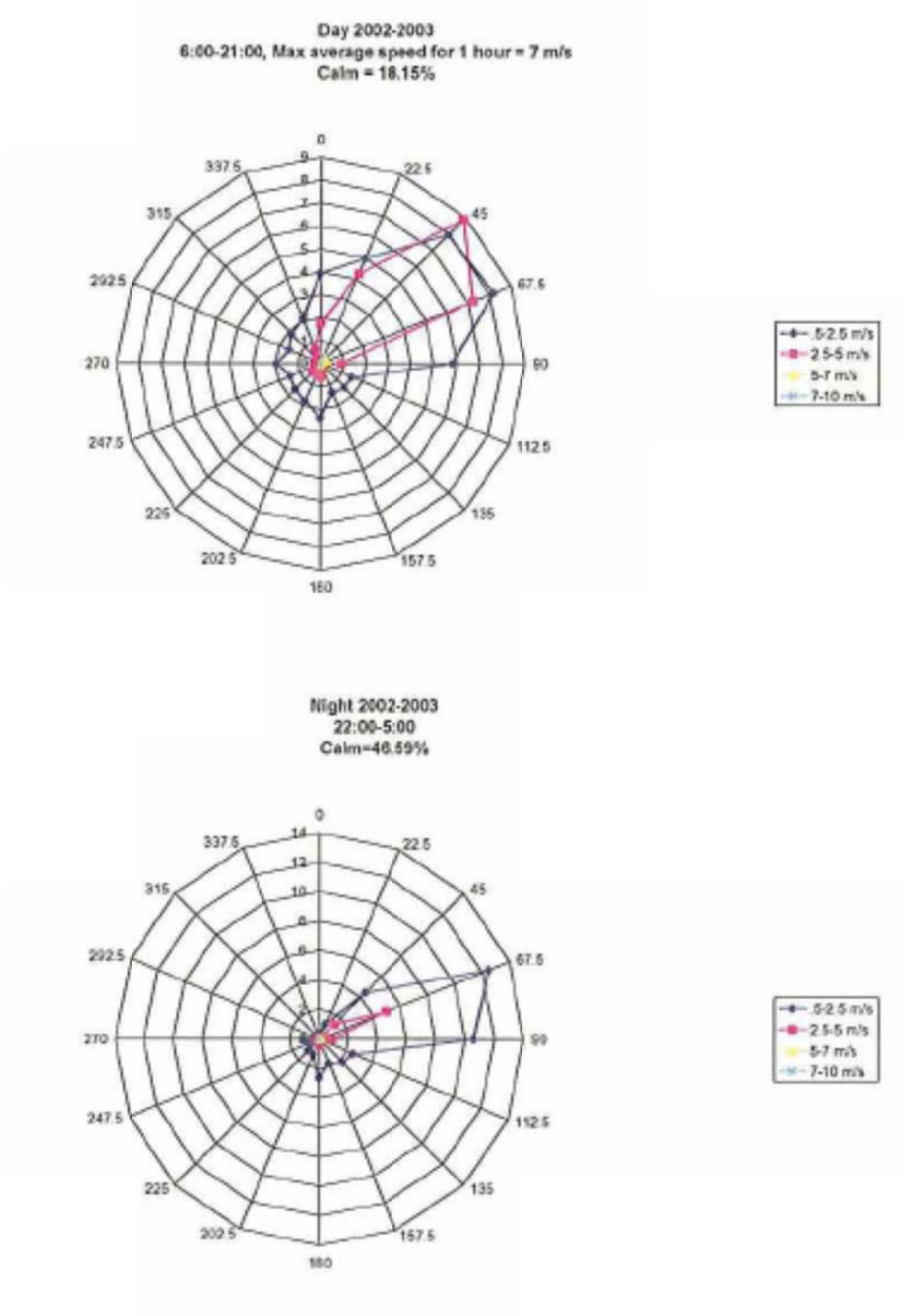
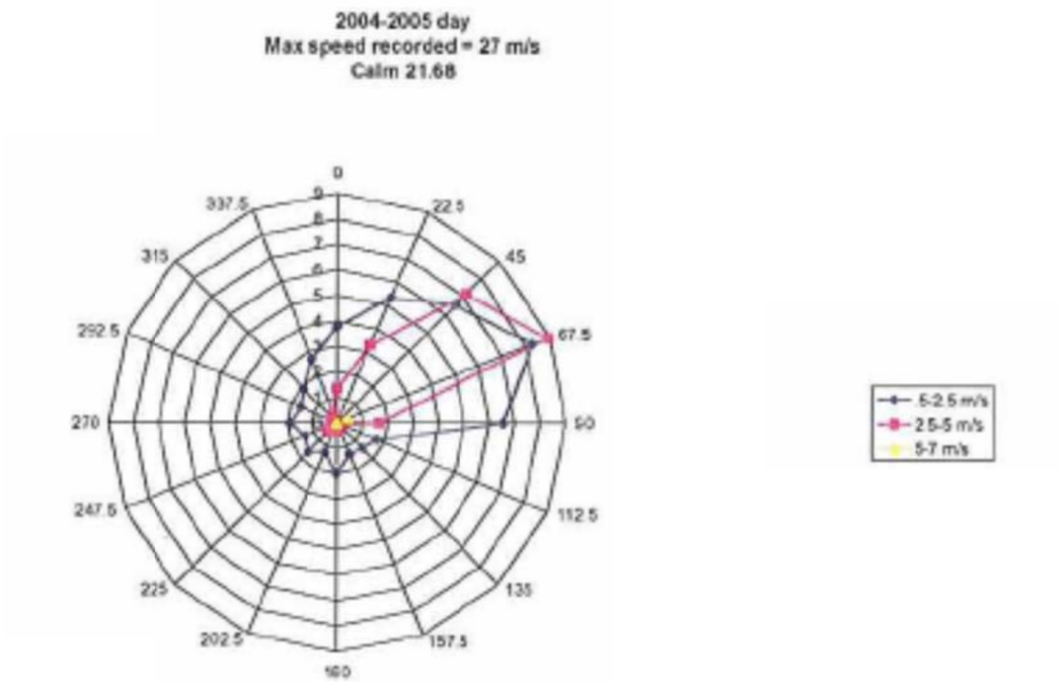


Figure 1-1
Wind Roses



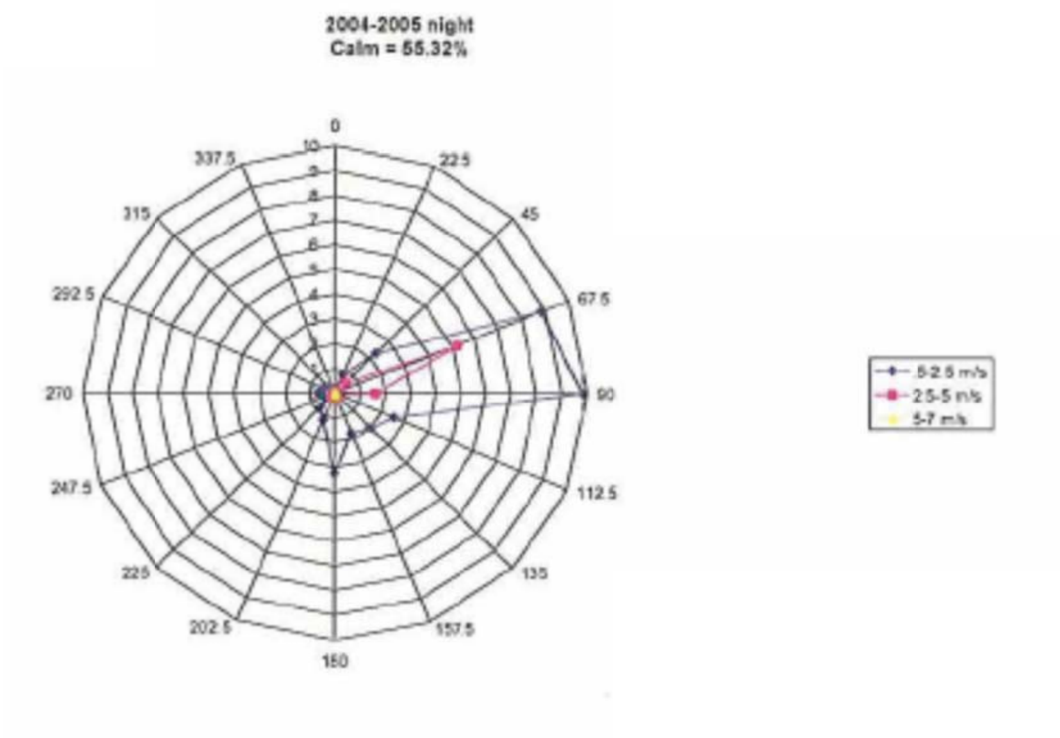


Figure 1-1 Continued)
Wind Roses

Table 1-10 lists expected voltages and frequencies at the project site.

Table 1-10
Electrical Equipment and System Voltages

System	Continuous Voltage (Volts) Max Nom Min	Voltage Dip, Mom. (% of Nominal)	Frequency (Hz) Nom Max Min	Configuration	System Neutral Grounding	Transfer to Alternate Source	Isc (symm) Max @ V_{MAX} (Amps) 3-Phase Ph-earth
Medium Voltage (MV-1)	11,550 11,000 10,450	75	50 51.5 48.5	(3/PE) 3-phase, 3-wire Wye	Low Resistance	Incoming Fast Transfer and Manual	31.5 kA or as approved by Eskom 120 A
Medium Voltage (MV-2)	6930 6600 6,270	75	50 51.5 48.5	(3/PE) 3-phase 3-wire	Low Resistance	N/A	25 kA or as approved by Eskom 300 A
Low Voltage (LV-1)	420Y/242 400Y/230 380Y/219	80	50 51.5 48.5	(3/N/PE) 3-phase, 4-wire Wye	Solidly Grounded	N/A	50 kA or as approved by Eskom
Inverter AC Power (UPS-1)	406 400 394	95	50 50.5 49.5	3/N/PE	Solidly Grounded	Static 1/2 Cycle	50 kA or as approved by Eskom
Inverter AC Power (UPS-2)	242 230 219	95	50 50.5 49.5	1/N/PE	Solidly Grounded	Static 1/2 Cycle	N/A 10,000
DC Power (DC-1)	242 220 187	70	0 0 0	2-Pole	Ungrounded	N/A	N/A N/A

Table 1-10
Electrical Equipment and System Voltages

System	Continuous Voltage (Volts) Max Nom Min	Voltage Dip, Mom. (% of Nominal)	Frequency (Hz) Nom Max Min	Configuration	System Neutral Grounding	Transfer to Alternate Source	Isc (symm) Max @ V_{MAX} (Amps) 3-Phase Ph-earth
DC Power (DC-2)	30 24 20.4	90	0	2-Pole	Ungrounded	N/A	N/A
AC Control Power (CP-1)	242 230 219	85	50 51.5 48.5	1/N/PE	Solidly Grounded	N/A	N/A 10,000

1.10 Temporary Facilities

Construction support services will be required by all on-site contractors and their personnel. The following list summarizes the construction facilities that are expected to be required:

- Communications link.
- Client field office(s).
- Client field office equipment.
- Construction management office and equipment.
- Material storage needs:
  - Material lay-down area(s).
  - Construction crane pads.
  - Access roads.
  - Fencing.
  - Warehousing.
- Lighting.
- Project parking requirements.
- Site security needs.
- Utilities:
  - Electricity.
  - Water (potable and raw water).
  - Sanitary.
  - Trash disposal.
  - Scrap disposal/recovery.

  - Telephone.
  - Data.
- Concrete mix and batch plant.
- Construction permits and licenses.

1.11 Fire Protection

Eskom will serve as the Authority Having Jurisdiction (AHJ) on the Medupi FGD Project. Eskom will consult with the local officials and the local fire department for additional input.

Fire protection systems, materials and components, methods, and design will be in accordance with applicable SANS. The construction methods used in building design and construction will meet the definition of non-combustible accordingly to SANS 428 (Fire performance classification of thermal insulated building envelope systems). Applicable requirements of SANS 310 (Storage tank facilities for hazardous chemicals - Above-ground storage tank facilities for flammable, combustible and non-flammable chemicals) with regard to risk assessment and facility layout will also be met. Hose reels and fire extinguishers will be located in accordance with SANS 10400 (The application of the National Building Regulations) and will meet the applicable requirements of SANS 543 (Covers dimensions, construction, materials and performance requirements for fire hose reels fitted with hose).

The hierarchy of design documents and standards will be as follows:

- SANS standards.
- Site specific fire protection design documents and permit requirements.
  - 240-56737448 - Fire Detection and Life Safety Design Standard
  - 240-56737654 - Inspection, Testing and Maintenance of Fire Detection Systems Standard
  - 240-54937450 - Fire Protection and Life Safety Design Standard
  - 240-54937454 - Inspection, Testing and Maintenance of Fire Protection Systems Standard
  - 240-54937439 - Fire Protection/Detection Assessment Standard
  - NFPA standards where the previously cited standards are silent.

2.0 Design Codes and Standards

2.1 Project Specifications

To the extent possible, technical procurement documents for this project will be based on the information included in Appendix L. The format of the procurement documents will be in accordance with the International Federation of Consulting Engineers (FIDIC), supplemented by Eskom technical requirements.

2.2 Codes and Standards

The design and specification of work shall be in accordance with applicable South African codes, local codes and ordinances, Eskom specific codes, or International codes. Where no South African or Eskom specific codes are available, British standard codes will be used. If British standard codes are not available, American or International codes will be used.

Some of the South African codes and industry standards used for design, fabrication, and construction are listed below. Other recognized standards may also be used as design, fabrication, and construction guidelines. Codes and standards to be used for specific equipment procurements and construction will be defined as technical specifications are developed, and tenders evaluated and awarded. The codes and standards used will be the editions in effect, including all addenda, as stated in equipment and construction purchase or contract documents:

- American Association of State Highway and Traffic Officials (AASHTO).
- American Concrete Institute (ACI).
- American National Standards Institute (ANSI).
- American Petroleum Institute (API).
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
- American Society of Mechanical Engineers (ASME).
- American Society for Testing and Materials (ASTM).
- American Water Works Association (AWWA).
- American Welding Society (AWS).

- British Standards (BS).
- Compressed Gas Association (CGA).
- Cooling Tower Institute (CTI).
- European Standards (EN).
- Factory Mutual (FM).
- Illuminating Engineering Society (IES).
- Institute of Electrical and Electronics Engineers (IEEE).
- Instrument Society of America (ISA).
- Insulated Cable Engineers Association (ICEA).
- International Building Code (IBC) (when no local codes prevail).
- International Electrical Code (IEC) (when no local codes prevail).

Number	Revision	Title
IEC 60870-5-104		Telecontrol equipment and systems Part 5-101: Transmission protocols – Companion standard for basic telecontrol task
IEC 61238-1		Compression and Mechanical Connectors for Power Cables for rated voltages up to 30 kV : Part 1 - Test methods and requirements
IEC 61508-0		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 0: Functional safety and IEC 61508
IEC 61508-1		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 1: General Requirements
IEC 61508-2		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 2: Requirements for Electrical/Electronic/Programmable Electronic Safety Related Systems
IEC 61508-3		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 3: Software Requirements
IEC 61508-4		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 4: Definitions and Abbreviations

Number	Revision	Title
IEC 61508-5		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 5: Examples of Methods for determining Safety Integrity Levels
IEC 61508-6		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 6: Guidelines on the application of IEC 61508-2 and IEC 61508-3
IEC 61508-7		Functional safety of Electrical/Electronic/Programmable Electronic Safety Related Systems, Part 7: Overview of techniques and measures
IEC 61511-1		Functional safety - Safety instrumented systems for the process industry sector, Part 1: Framework, definitions, system, hardware and software requirements
IEC 61511-2		Functional safety - Safety instrumented systems for the process industry sector, Part 2: Guidelines for the application of IEC 61511-1
IEC 61511-3		Functional safety - Safety instrumented systems for the process industry sector, Part 3: Guidance for the determination of the required safety integrity levels
IEC 61850		Standard for the design of substation automation
IEC 62337		Commissioning of electrical, instrumentation & control systems
IEC 62381		Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT)
IEC 62382		Electrical and instrumentation loop check

- International Plumbing Code (IPC) (when no local codes prevail).
- National Fire Protection Association (NFPA).
- Occupational Safety and Health Administration (Act) (OSHA).
- South African Grid Code.
- South African National Standards (SANS).

Number	Revision	Title
SANS 10100		The structural use of concrete
SANS 10108		The Classification of Hazardous Locations and the Selection of Apparatus for Use in such Locations
SANS 60079-10		Electrical apparatus for explosive gas atmospheres Part 10: Classification of hazardous areas

Number	Revision	Title
SANS 101003-2004		Noise Level
SANS 10142-1		The Wiring of Premises, Part 1: Low-voltage installations
SANS 10160		Basis of structural design and actions for buildings and industrial structures
SANS 10162		The structural use of steel
SANS 10164		The structural use of masonry
SANS 10164-2		The structural us of masonry, Part 2: structural design and requirements for reinforced and prestressed masonry
SANS 1200 HC		Corrosion protection of structural steelwork
SANS 1411-1		Materials of Insulated Electric Cables and Flexible Cords, Part 1:Conductors
SANS 1411-7		Materials of Insulated Electric Cables and Flexible Cords, Part 7: Polyethylene (PE)
SANS 1574		Electric cables – Flexible Cords and Cables
SANS 1632-1		Batteries, Part 1 – General information – Definitions, abbreviations and symbols
SANS 1632-2		Batteries, Part 2 – Vented-type stationary lead-acid cells and batteries
SANS 1632-3		Batteries, Part 3 – Vented-type prismatic nickel-cadmium cells and batteries
SANS 1632-4		Batteries, Part 4 - Valve regulated type stationary lead-acid cells and batteries
SANS 1652		Battery Chargers - Industrial Type
SANS 10109		Concrete floors
SANS 10400		The application of the National Building Regulations
SANS 1200 set		Standardized specification for civil engineering construction
SANS 60034-1		Rotating Electrical machines Part 1 – Rating and performance
SANS 60079-14		Explosive atmospheres Part 14: Electrical installations design, selection and erection
SANS 60794-1-1		Optical fiber cables Part 1-1: Generic specification – General
SANS 60794-1-2		Optical fiber cables Part 1-2: Generic specification – Basic optical cable test procedures
SANS 61312		Protection against lightning electromagnetic impulse
SANS 61312-1		Protection against lightning electromagnetic impulse Part 1: General Principles
SANS 61312-2		Protection against lightning electromagnetic impulse Part 2: Shielding of structures, bonding inside structures and earthing
SANS 61312-3		Protection against lightning electromagnetic impulse Part 3: Requirements of surge protective devices (SPDs)

Number	Revision	Title
SANS 61312-4		Protection against lightning electromagnetic impulse Part 4: Protection of equipment in existing structure
SANS 1085:2004		Wall outlet boxes for the enclosure of electrical accessories
SANS 1433-1-2:2008		Electrical terminals and connectors
SANS 10198-1-5:2004		The selection, handling and installation of electric power cables of rating not exceeding 33 Kv
SANS 60034-1-34:2010		Rotating electrical machines
SANS 60044-1-8:2003		Instrument transformers
SANS 60050-441:1984		International electrotechnical vocabulary Chapter 441: Switchgear, controlgear and fuses
SANS 60072-1-3:1991		Dimensions and output series for rotating electrical machines
SANS 60076-1-21:2011		Power transformers
SANS 60086-1-5:2011		Primary batteries
SANS 60099-1-8		Surge arresters
SANS 60204-1-32:2009		Safety of machinery
SANS 60227-1-5:2006		Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
SANS 60269-1-6:2010		Low-voltage fuses
SANS 60282-1-2:2010		High-voltage fuses
SANS 60287-1-3:2010		Electric cables – Calculation of the current rating
SANS 60309-1-4:2012		Plugs, socket-outlets and couplers for industrial purposes
SANS 60439-1-5:2004		Low-voltage switchgear and controlgear assemblies
SANS 60502-4:2006		Power cables with extruded insulation and their accessories for rated voltages from 1 Kv (Um = 1,2 Kv) up to 30 Kv (Um = 36 Kv) Part 4
SANS 60614-2-3-14:1990		Specification for conduits for electrical installations
SANS 60909-0-4: 2010		Short-circuit currents in three-phase a.c. systems
SANS 60947-1-8:2012		Low-voltage switchgear and controlgear

Number	Revision	Title
SANS 61800-1-8		Adjustable speed electrical power drive systems
SANS 61869-1-5:2013		Instrument transformers
SANS 61936-1		Power installations exceeding 1 Kv a.c
SANS 62262:2004		Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
SANS 62271-All Parts		High-voltage switchgear and controlgear
SANS 60529:2001 / IEC 60529:2001		Degrees of protection provided by enclosures (IP Code)
SANS 10329:2004		The design and construction of sectional steel tanks for storage of liquids at or above ground level
SANS 10252-1		Water supply and drainage for buildings Part 1: Water supply installations for buildings
SANS 966-1		Components of pressure pipe systems Part 1 : Unplasticized poly(vinyl chloride) (PVC-U) pressure pipe systems
TMH 7		Code of Practice for the design of highway bridges and culverts in South Africa
TRH		Technical recommendations for highways

- South African National Standards (SANS).

Number	Revision	Title
SANS 1411-2		Materials of Insulated Electric Cables and Flexible Cords. Part 2: PVC
SANS 1411-3		Materials of Insulated Electric Cables and Flexible Cords. Part 3: Elastomers
SANS 1411-4		Materials of Insulated Electric Cables and Flexible Cords. Part 4: Cross-linked polyethylene (XPLE)
SANS 1411-5		Materials of Insulated Electric Cables and Flexible Cords. Part 5: Halogen-free, flame-retardant materials
SANS 1411-6		Materials of Insulated Electric Cables and Flexible Cords. Part 6: Armour

- Eskom Standards:

Number	Revision	Title
0.00/1310		Standard Power & Control Cable Code
36-721		Generation MV And LV Protection Philosophy For Eskom Power Stations
240-56176852		Essential Power Supplies For Power Stations Standard
240-56247004	1	Thermal Insulation Standard
0.54/393		Earthing Standard
ANSI/ISA–77 20–1993		Fossil Fuel Power Plant Simulators
EED_GTD_C&I _007		EED/GTD Technical Guideline: Modes of Operation - Local & Remote
240-56355808		Guideline for Ergonomic Design of Power Station Control Suites
GGS 0462		Quality Requirements For Engineering And Construction *Works* In Generation
240-56227443	5	Requirements for Power and Control Cables for Power Stations
240-56357518		Power Station electric Motors Procurement Standard
240-56356530		Environmental Conditions For Process Control Electronic Equipment Used at Power Stations
240-56227516	4	Specification for LV Switchgear and Control Gear Assemblies and Associated Equipment for Voltages up to and including 1000 V AC and 1500 V DC
240-53114214	1	Station cabling and racking standard
240-56356396	1	Earthing and lighting standard
GGSS 0690	0	Medium Pressure Pipelines
GGSS 0839		Eskom specification for self contained battery and charger
240-53114256		Eskom specification for battery stands
GGS 1427		Instrument Piping
N.PSZ 45-698		Engineering Drawing Office and Engineering Documentation Standard
NRS 042		Guide For the Protection of Electronic Equipment against Damaging Transients
NWP 3058, VOL 6		Battery Test Procedure For Acceptance and Type Testing of Lead Acid Vented Stationery Cells and Valve Regulated Sealed Lead Acid Cells
NWS 1582	1	Labels on Control Relay Panels and other Indoor and Outdoor Equipment
240-49230111		Hazard and Operability (HAZOP) Study Guideline

Number	Revision	Title
240-49230046	0	Failure Mode Effects (And Criticality) Analysis (FMECA) Guideline
240-56242363		Emission Monitoring and Reporting Standard
240-56242850		Continuous Emission Monitoring System Selection Standard
IEEE 1050 - 2004		IEEE Guide for Instrumentation and Control Equipment Grounding in Generating Stations
IEEE Green Book 142 -2007		IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
ISO 898-1		Mechanical Properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs
ISO 898-5		Mechanical Properties of fasteners made of carbon steel and alloy steel - Part 5: Set screws & similar threaded fasteners not under tensile stresses
ISO 9000: 2005		Quality Management System – Fundamentals and Vocabulary
ISO 9001: 2008		Quality Management Systems – Requirements
ISO 10006:2003		Quality Management System – Guideline for Quality Management in Projects
ISO 10005: 2005		Quality Management Systems - Guidelines for Quality Plans Standard
NERSA GRID CODE		NERSA - South African Grid Code
NRS 013:2007		Medium-voltage cables
32-9		Definition of Eskom Documents
32-85		Eskom Information Security Policy
32-188		Procurement and Supply Chain Management Procedure
32-391		Integrated Risk Management Framework and Standard
32-894		Server Rooms and Data Centres Standard
36-193		The Management of Plant Simulations
240-56355910		The Management of Plant Software
36-776		Environmental conditions of Process Control Equipment used in Power Stations
240-56355541		Control System Computer Equipment Habitat Requirements
39-59		Project/Process Quality plan
39-60		Contract Quality Requirements Standard
240-53114190		Internal Audit Standard
240-53114186		Document and Record Management Procedure
249-53114194		Control of Non-conforming Product

Number	Revision	Title
39-65		Quality Management System Policy
39-66		Quality Management System Manual
240-53114192		Corrective and Preventive Action Standard
39-71		Quality Control Plan Standard
240-558964825		Design of Vertical Flat Base and Horizontal Steel Storage Tanks Guidelines
QM-1		Supplier Audit Standard
240-53113685		Design Review Procedure
240-53114002		Engineering Change Procedure
240-53114026		Project Engineering Change Management Procedure
32-1155		Eskom Standard Project Life Cycle Model Policy
240-55864784		Guideline for the preparation of a specification for an Expert Chemistry System (ECS)
240-5584789		Analytical Chemistry Laboratory Method Validation Guideline
240-55864833		Chemistry Manual for Auxiliary and Ancillary Cooling Water Systems
240-55864830		Design Guideline for Bulk Liquid Chemical Off-loading/Unloading Systems
240-55864855		Design Guideline for Semi Bulk Liquid Chemical Handling
240-55864827		Specification for Flexible Hose Suitable for Use with Aggressive Fluids (Ammonia, Sodium Hydroxide and Sulphuric Acid)
ISO 8573.1		Guide to Compressed air systems
ASME VIII		Pressure Vessels
GGS 0529		Compressed Air Testing
TBD GGR 0992		Plant Safety Regulations
240-52843902		Engineering Terms and Abbreviation Standard
240-56356376		Procedure for On-site Commissioning of Low Pressure Systems
GGSS 0317		Specification for storage Tanks
ESKSCAAC6		Pipeline Identification Specification
240-56227902		Dry Type Transformers Used In Power Stations Specification
240-56176953		Acdc Board Installation And Commissioning Manual
240-56177006		Acdc Board Maintenance Manual
240-56177100		Acdc Systems User Guideline
240-56177186		Design Guide For Power Station Battery Rooms Guideline

Number	Revision	Title
240-56177396		Battery Capacity Test Manual
240-56178099		Battery Charger Installation And Commissioning Manual
240-56176078		Battery Commissioning Manual
240-56176082		Battery Installation Manual
240-56176097		Cable Schedule Template
240-55714363		Coal Fired Power Stations Lighting And Small Power Installation Standard
TBD 369		Dc And Ups Settings Document
240-56356396		Earthing And Lightning Protection Standard
240-56355574		Earthing Standards
240-56227648		Maintenance Of L M H Range Nickel Cadmiu Batteries Work Instruction
240-56227711		Maintenance Of Vantage Nickel Cadmium Cells Standard
TBD 406		Mv Load Motor Parameters
240-56227773		Switchgear Schedule Template
240-56227778		Fault Current Calculations Rating Switch Gear Standard
240-56356445		Earthing And Lightning Protection Of Equipment Moving On Rails Coal Stackers Reclaimers And Ash Stackers Guideline
240-56227780		Installation Of Cables And Cable Racks At Power Stations Specification
240-56227929		Power Station Standby Diesel Generators Specification Standard
240-56239133		High Pressure Pipework Supports Standard
240-56356455		Rectifier Specification
240-56227788		Safe Disposal Of Redundant Batteries Work Instruction
240-53114248		Battery Chargers Specification
240-53114294		Flat Plate Lead Acid Cells Specification
240-56227809		Specification For Lv Power And Control Cable Rated Voltage 600 1000V Specification
240-53113666		Specification For Medium Power Transformers Used In Power Stations Schedule A B
240-56227823		Medium Voltage Impregnated Paper And Xlpe Insulated Cables Specification
240-56356460		Perimeter Security Lighting At Eskom Installations Standard
240-56356465		Switchboard List Template
240-56227830		The Safe Handling Of Batteries And Electrolyte Work Instruction
240-56228095		Transportation Of Electrolyte And Battery Cells Standard
TBD 439		Ups And Dc Schedule

Number	Revision	Title
240-56227573D		Ac Metal Enclosed Metal Clad Swithgear And Control Gear For Voltages Above 1Kv Up To And Including 52Kv Specification
240-56227881		Arc Flash Protective Clothing And Personal Protective Equipment Against The Thermal Hazard Of Electrical Arc Specification
240-56227883		Battery Test And Type Testing Of Lead Acid Vented Stationary Cells And Valve Regulated Sealed Lead Acid Cells Work Instruction
240-56356472		Clean Conditions For Power Transformer Outage Standard
240-56356486		Conveyor Belt Interface To Ac Metal Enclosed Switchgear And Control gear For 1Kv to 52 Kv Specification
240-56356491		Dc Earth Fault Detection Manual
240-56356510		Definitions Of Terms Applicable To Dc Emergency Supplies Standard
240-56356523		Section 1 Mv And Lv Distribution System Earthing Standard
240-56535950		Electrical Plant Information Files Standard
240-56356530		Environmental Conditions For Process Control Electronic Equipment And Components Used At Power Stations Manual
240-56227426		Management Of Power Station Mv And Lv Protection And Settings Standard
240-56227430		Eskom’s Undervoltage Philosophy For Large Fossil Fuel Power Stations Guideline
240-56356411		Fire Barrier Seals For Electrical Cable Installations At Power Plants Standard
240-56227515		Eskom Under Voltage Philosophy For Large Fossil Fuel Power Stations Guideline
240-56227520		Large Power Generator Transformers In Power Stations Specification
240-56227923		Quality Requirements For Stationary Vented Nickel Cadmium And Lead Acid Batteries For Power Stations Standard
240-57859177		Control Of Clean Conditions When Working On Generators And Large Motors Standard
240-56536488		Control Of Works Performed On Large Power Transformers Standard
TBD 486		Insulation Testing Of Mv Metal Clad Switchgear
240-56357314		Interlocking On Ac Metal Enclosed Switchgear And Control gear For Voltages 1Kv To 52 Kv Specification
240-56357332		Licensing Generating Facilities Work Instruction
240-56357346		List Of Approved Relays For Use On Power Stations Standard
240-56357366		Long Term Plant Health Indicators Manual
240-56535959		Management Of Emergency Ac And Dc Supplies At Power Stations Standard

Number	Revision	Title
240-56535964		Management Of Power Station Mv And Lv Protection Standard
240-56356630		Management Of Generation Protection Standard
240-56536505		Management Of Hazardous Locations Standard
240-56535978		Management Of Large Generators During Outages And Works Standard
240-56357421		Measurements And Metering Standard
240-56357424		Mv And Lv Switchgear Protection Standard
TBD 504		Medium Voltage Switchboard Maintenance
TBD 505		Management Of Safety Risks Of Mv Switchboard
240-56357438		Mv Motor Heater Interface To Ac Metal Enclosed Switchgear And Control gear For Voltages 1Kv To 52Kv Specification
240-60238757		On Site Dry Out Of Power Transformers Within Generation
240-56357462		Guideline On Shaft Voltage And Current Monitoring Manual
240-56357489		Plant Related Abbreviations For Inter System Use Standard
240-56535985		Power Station Medium Voltage Switchgear Management Standard
240-56357579		Precommissioning Of Large Power Transformers Standard
240-56357641		Electricity Impurity Tests For Lead Acid Batteries At Power Stations Work Instruction
240-56357725		Water Impurity Tests For Lead Acid Batteries And Nickel Cadmium Batteries Standard
240-56356630D		Management Of Generator Protection Standard
240-56356668		Maintenance Of Power Station Earthing And Earth Mats Guideline
240-56356675		Partial Discharge Testing Guideline
240-56356687		Transformer Long Term Plant Health Indicator Guideline
240-56356696		Monitoring Generator By Gas Analysis Guideline
240-56357019		Replacement Of Above Ground Copper Earthing Networks With Aluminum Guideline
240-56357281		Lay Up Mothballing Of Generation Electrical And Process Control Equipment In Power Stations Manual
240-56227292		Specification For Corrosion Protection Of Plant And Equipment With Coatings Specification
240-56227389		Specification For Loose Starters For Power Stations For Voltages Up To 1000V Ac And 1200V Dc Specification
240-56227394		Portable Earthing Equipment Specification

Number	Revision	Title
240-56227409		Refurbishment Of Battery Chargers At Power Stations Specification
240-56227419		Actions And Precautions To Be Followed When Receiving A Buccholtz Alarm Standard
240-56227424		Commissioning And Recommissioning Of Power Transformers Standard
240-56358929		Electronic Protection And Fault Monitoring Equipment For Power Systems Standard
240-56358993		Maintenance Of Power Transformers Standard
240-56359013		Maintenance Of Substation Isolators Standard
240-56359053		Transformer Hand Condition Monitoring Standard
240-56359083		Requirements For Measurement And Metering Systems For All Eskom Power Stations In Generation Standard
240-56359118		Low Voltage Variable Speed Drive Control Equipment Standard
240-56359660		Specification For Medium Voltage Motor Switching Devices Standard
240-56360031		Static Uninterruptible Power Supplies Specification
240-56360034		Stationary Vented Lead Acid Batteries Standard
240-56360086		Stationary Vented Nickel Cadmium Batteries Standard
240-56360387		Storage Of Power Station Electric Motors Standard
240-56361164		Sweep Frequency Response Analysis Testing Guideline
240-56361242		Non Phase Segregated Gas Insulated Ac Metal Enclosed Switchgear And Control gear for 1Kv To 52Kv Specification
240-56361296		Circuit Breakers To Independent Supplies In Ac Metal Enclosed Switchgear And Control gear For 1Kv And Up Specification
240-56361382		Transformer Hand Condition Monitoring Guideline
240-56361422		Transformer Insulation Moisture Measurement Guideline
240-56361435		Transport Of Power Station Electric Motors Standard
240-56361454		Undervoltage Protection Standard
240-56357751		Protection Of Electronic Equipment Against Damage By The Discharge Of Static Electricity Work Instruction
240-56357765		Radio Station Earthing And Bonding Standard
240-56357787		Diesel Alternator Sets For Fixed Installations Specification
240-56358788		Refurbishment Of Generator Stators For Steam Or Gas Turbines Standard

Number	Revision	Title
240-56178825		Requirements For Transportation And Movement Of Large Electrical Equipment Standard
TBD 591		Responsibilities For The Management Of Transformer
TBD 592		Rotary Current Asynchroous Motors Technical Requirements
240-56179027		Safety Measures Personal Protective Equipment for Thermal Hazard Of Electrical Arc For Metal Clad Switchgear Up To 11Kv Standard
240-56358900		Sampling And Testing Of Mineral Insulating Oil For Power Transformers Within Generation Division Standard
240-57859036		Lv Motor Deviation Schedule Template
240-57859043		Lv Motor Document Submittal Schedule Vdss Template
240-57859046		Lv Motor Technical Schedule Template
240-57617998		Typical General Arrangement Template
240-57617975		Procurement Of Power Station Low Voltage Electric Motors Specification Standard
240-64430501		Low Voltage Speed Drive Control Equipment Standard
BS 8007		Code of practice for design of concrete structures for retaining aqueous liquids
ESK PB AAQ 3	2	Interior specifications for Eskom
32-402		Energized perimeter fence
200-6166		Backfill specification
200-26680		Architectural technical specification
200-37830		Medupi User Requirement Specification
200-42385		Master Document List
84CIVL007		Conceptual architectural design specifications for Structures and other Buildings
84CIVL036		Stormwater design criteria
84CIVL037		Sewer network
84CIVL053		Concrete specification
240-56364537		Design of steel structures standard
240-56364542		Standard for reinforced concrete foundations and structures
240-56364545		Structural design and engineering standard
240-53458817		Design bulk material handling plant
1S0 5048:1989		Continuous mechanical handling equipment. Belt conveyors with carrying idlers -Calculation of operating power and tensile forces.

Number	Revision	Title
240-55864434		Storage and Handling of Conveyor Belting in Eskom Guideline
240-55864498		Operation and Selection of Fluid and Mechanical Couplings Specification
240-55864499		Specification for Belt Conveying Systems (Rev 1) Standard
240-55864504		Belt Conveyor Structural Steelwork and Welding Specification
240-55864505		Erection of belt Conveyor Mechanicals Specification
240-55864509		Ceramic Lagging for Pulleys Specification
240-55864544		Quality Requirements for the Purchasing of Conveyor Belting Guideline
240-55864546		Ceramic Lagging for Pulleys Guideline
240-55864551		Ash Stacker and Tripper Equipment Standard
240-55864562		Steelcord Reinforced Conveyor Belting Specification
240-55864564		Conveyor Belt Rolls Standard
240-55864521		Transfer Houses Cladding Guideline Manual
240-55864479		Belt Conveyor Chute Design Manual
240-55864503		Belt Conveyor Mechanical Components Standard
240-55864574		On-site Hot Repairs on Steel Cord Reinforced Conveyer Belt Standard
240-55864585		Textile Ply Belt Splicing Quality Control Standard
240-55864586		Steel Cord Belt Splicing Quality Control Standard
240-55864587		Conveyor Belt Manufacturing Repairs Standard
240-55864550		Mass Meters for Coal Measurement in Power Stations Design Specification
240-55864553		Magnetic Separators and Metal Detectors Specification
240-55864558		General Purpose Textile Reinforced Conveyor Belting Standard.
240-56737448		Fire Detection and Life Safety Design Standard
240-56737654		Inspection Testing and Maintenance of Fire Detection Systems Standard
240-54937450		Fire Protection and Life Safety Design Standard
240-54937454		Inspection Testing and Maintenance of Fire Protection Systems Standard
240-54937439		Fire Protection - Detection Assessment Standard
ESKAMAAA1		Corporate Identity Document
N.PSZ 45-45		Kraftwerk Kennzeichen System (KKS) Key Part – Fossil Power Station

Number	Revision	Title
N.SSZ 45-629		KKS Plant Labeling Specification
200-4190		The Application of KKS Plant Coding
200-5343		Medupi Power Station Project – Standard Abbreviations
200-41103		Medupi Diesel Generator Operating, Control and Protection Philosophy
200-35586		Medupi MV switchgear Interlocking philosophy
200-50085		Medupi PS Project - Chop-over Philosophy
200-19408		Medupi Power Station, Auxiliary power system description
200-72508		Low voltage switchgear protection and control philosophy for Medupi Power Station,
240-53573084		Design Structures and Buildings
240-53573086		Design Roads and Railways
240-53573079		Perform Geotechnical Engineering
240-53573085		Design Dams,Waterways and Hydro

- The following Codes have been proposed by the Process Design Consultant and are subject to Eskom's review and approval prior to being used during detailed design.

Number	Revision	Title
DIN 16965		Wound Glass Fibre Reinforced Polyester Resin Pipes
VGB 502		Flue Gas Desulfurization Plant
TDR		Technical Requirement for Pressure Part
EN-14878		Organic Corrosion Protection
EN 12952-13: 2003		Requirements for flue gas cleaning systems (German version)
VGB-R 502 H		Manufacture and construction plus construction and controlling of FGD plants.
VGB --		Library of VGB-instructions and VGB-Recommendations for the control system; Part 12: Follow-up and acceptance tests for Flue Gas Desulfurization Plants
VGB 202		Construction and Operation of Recycling Plants for FGD By-products
VGB-M 415		FGD waste water treatment
VGB-M 419		Code of practice for construction design, operation and maintenance of FGD plants.

Number	Revision	Title
VGB-M 701e		Analysis of FGD Gypsum (remark: also in A 8.13: Determination of reactivity of limestone)
VGB-M 702		Analytics of FGD waste water
VGB-Standard		Type, operation and maintenance of Flue Gas Desulphurization Plants (FGD)
DIN EN 13480		Metallic industrial piping
DGRL		“Druck Geräte Richt Linie” Pressure equipment directive 97/23 as of 1 JAN 2011
DIN 14692		Glass-reinforced plastics (GRP) piping
DIN 18800: T1-T4		Constructional steel work
DIN		Welding engineering
DIN EN 14879 1-4		Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media, 2005
DIN 13923		Filament-wound FRP pressure vessels – materials, design, manufacturing and testing

2.3 Engineering Drawings and Data Content

To the extent practical, engineering drawings will use Eskom standards for tagging schemes KKS, drawing content, borders, drawing software and formats, symbols, data report content and formats, virtual modeling format and protocols, and interfaces to subcontractor drawings and data. Interfaces to other contractor’s engineering drawings will be sufficient to represent the complete design. Major equipment interfaces will be represented as needed to support construction.

3.0 FGD Design and Performance

This section defines the FGD system design criteria and interfaces.

3.1 FGD System Performance

The FGD system design is based on the criteria listed in Table 3-1. The FGD system shall be designed to support manufacturers recommended FGD system startup, operating, trip, and shutdown modes.

Table 3-1
Performance Design Basis (100% BMCR)

Parameter	Design Basis Design Fuel	Design Basis Worst Fuel (L/G Dimensioning)	Design Basis Worst Fuel with Tempering Air (Absorber Dimensioning)
Maximum Inlet Flue Gas Temperature, °C	200	200	200
Inlet Flue Gas Flow Rate, Nm^3/hr, wet	2.427.840	2.495.520	2.814.610
Inlet Flue Gas Flow Rate, Nm^3/hr, dry	2.225.480	2.274.840	2.588.754
Inlet Flue Gas Temperature, °C	137	137	137
Inlet Flue Gas Pressure Range, kPa	91,62	91.64	91.71
Maximum Inlet SO_2			
kg/h	8.262	13.320	13.320
mg/Nm^3 dry @ 6% O_2	3.406	5.339	5.378
Maximum Inlet Particulate Matter			
kg/h	121.3	124.7	123.85
mg/Nm^3 dry @ 6% O_2	50	50	50
Maximum Inlet HCl			
kg/h	388.3	399.2	396.3

3.2 Limestone Reagent

The Owner-supplied limestone reagent shall meet the physical and chemical characteristics listed in Table 3-2. Performance design parameters shall use a limestone reagent meeting these criteria. Percents are on a mass basis.

Table 3-2
Limestone Reagent

Parameter	Design Basis Value (Range)	Design Basis Value (Range)
$CaCO_3$, % minimum	85	96 (94-97)
$MgCO_3$, % maximum	*	2.2 (2-3)
SiO_2, % maximum	*	2.5 (2-3)
Other Inerts, % maximum	*	2 (1-4)
Bond Work Index, kWh/kg maximum	12 (11-13)	12 (11-13)
Size Range, mm.	19x0	19x0
* Combined value of 15% to be specified/split during the Basic Design Phase.		

3.3 FGD Makeup and Cooling Water

The makeup water quality for the FGD Project is listed in Table 1-4 and Table 1-5. Makeup water used for equipment cooling and other services shall be treated by Eskom as required. Water supply for the closed cycle cooling water loop shall be demineralised quality as listed in Table 1-6, with appropriate inhibitors added. Open cycle cooling water makeup water quality shall be FGD Makeup Pretreatment effluent. Systems shall be designed for 100 percent supply from Crocodile-West. The FGD plant wastewater streams will be utilized in the Medupi FGD and treated to minimize the FGD makeup water and wastewater disposal requirements of the FGD plant water system. All process waste waters not able to be utilized otherwise will be processed by the zero liquid discharge treatment plant included in the FGD balance of plant design.

3.4 Performance Design Values

3.4.1 Emissions

The design FGD system emissions shall be as listed in Table 3-3. All values of volumetric emission limits are referenced to 6 percent O_2.

Table 3-3
FGD System Emissions Design Basis

Parameter	**Design Value**
SO_2	
mg/NSm^3,dry, maximum	400
ppmdv, maximum	136.52
Particulate Matter (total)	
Removal efficiency, % minimum	95
Fine Particulate Matter, PM_{10}	
Removal efficiency, % minimum	50
HCl	
Removal efficiency, % minimum	98

3.4.2 Reagent Utilization

The utilization of limestone reagent shall not be less than 93%[1] percent as measured in the byproduct solids using the following formula:

$$\text{Reagent Utilization} = \left((CaSO_3 + CaSO_4) / (CaSO_3 + CaSO_4 + CaCO_3) \right) \times 100\%$$

where:

$CaSO_3$ = calcium sulfite in the byproduct solids, mg/kg

$CaSO_4$ = calcium sulfate in the byproduct solids, mg/kg

$CaCO_3$ = calcium carbonate in the byproduct solids, mg/kg

[1] Lower than normal utilization specified due to unknown limestone reagent characteristics during this project.

3.4.3 Byproduct Quality

The characteristics of the FGD system byproduct shall meet the criteria listed in Table 3-4.

Table 3-4
FGD System Byproduct Design Basis

Parameter	Design Value	Design Value
$CaSO_4 \cdot 2H_2O$, % minimum*	83	88
$CaSO_3 \cdot 1/2H_2O$, % maximum*	0.12	0.12
Free Moisture, % maximum	15	15
Water Soluble Chlorides, mg/kg maximum	111	111
Mean Particle Size distribution, µm minimum	35 (D-50)	35 (D-50)

*Expressed as a percentage of total calcium contained in the scrubber byproduct.

4.0 Civil, Structural, and Architectural Design Criteria

4.1 Design Loads

Design loads and load combinations for all buildings, structures, structural elements and components, handrails, guardrails, and connections shall be determined according to the criteria specified in this section (Table 4-1), unless the applicable building code requires more severe design conditions. Loads imposed on structural systems from the weight of all temporary and permanent construction, occupants and their possessions, environmental effects, differential settlement, and restrained dimensional changes shall be considered.

The live loads used in the design of buildings and structures shall be the maximum loads likely to be imposed by the intended use or occupancy, but will not be less than the minimum uniform live loads presented in Table 4-2. The loads in Table 4-2 were specified within the various package specifications for specific areas within the scope of the packages. Where not specified, minimum design loads shall be as defined by the governing building code. Components of the structural system may be designed for a reduced live load in accordance with the local building code. Roofs shall be designed to preclude instability resulting from ponding effects by ensuring adequate primary and secondary drainage systems, slope, and member stiffness.

Densities for coal, ash, and other bulk materials are presented in Table 9-1.

Structural elements supporting major equipment shall be designed for the greater of the uniform live load or the loading imposed by the actual equipment.

4.1.1 Structures and Other Buildings

Structural design shall be completed in accordance with Eskom Conceptual Architectural Design Specifications for Structures and Other Buildings, Document 84CIVL007, Revision P04, and the codes and standards referenced therein, unless otherwise specified. Alternate or additional structural design requirements for specific structures completed within the scope of the Construction Packages are located as follows. Several of the Construction Package contracts also reference Document 84CIVL007, in addition to the following:

- Design requirements for the Chimneys are documented in the Chimney and Silos Contract Package P07, Section 3.2, Subsection 1.3. Design requirements for the Coal and Ash Silos are documented in the same package, Section 3.2, Subsection 2.3.
- Design requirements for the Dust Handling Facilities are documented in the Dust Handling Contract Package P32, Section 3.3.3, Document 84CIVL002a, Revision A.

Table 4-1
Design Loads

Load Types	Criteria/Source
Dead Loads	SANS 10160, Section B-2 through B-6
Pipe Support, major piping	Specifically determined, including thermal and dynamic loads, and verified against final pipe routing and analysis.
Pipe Support, other piping and electrical conduit and cable tray	Preliminary design for uniform area loads, plus a concentrated phantom load located to create maximum moment and shear.
Live Loads	Calculated weight of the contents of tanks, silos, bins, and hoppers, in accordance with Table 4-3; movable loads, such as people, equipment, tools, and components during construction, operations, and maintenance; maximum loads likely to be imposed by intended use or occupancy, but not less than the loads in Table 4-2, nor actual equipment weight.
Impact Loads	Table 4-2 loads allow for ordinary impact conditions. Reciprocating or rotating machinery, elevators, cranes, pumps, and compressors shall have specific calculations addressing dynamic forces. Impact loads shall be a minimum of 25 percent of the crane capacity for crawler beams and supporting structures. Other impact loads shall be as specified in SANS 10160 and DIN 4024 Parts 1 and2, unless analysis indicates higher values are required.
Soil and Hydrostatic Loads	Below grade structures shall include lateral soil pressure, hydrostatic pressure or buoyancy, and potential surcharge loads from normal service or construction.
Wind Loads, buildings and structures	Basic design wind speed shall be in accordance with Table 1-7. No shielding shall be permitted for ground conditions or for adjacent structural members. Importance factor, when required, shall be for structures supporting emergency services.
Wind Loads, concrete chimneys	Loads and design in accordance with CICIND Model Code for Chimneys.
Seismic Loads, buildings (by building, if appropriate)	Refer to Subsection 1.7.2.
Seismic Loads, components and attachments	Amplification and response modification factors in accordance with SANS 10160.
Pipe Sleeves at Crossings for Underground Pipe	80 kN.

Table 4-2
Minimum Uniform Live Loads

Area	Live Load, kN/m²
FGD Area Ground Floor Slabs	
Ball mill laydown area	12
Shops, warehouses	6
Other areas	7.2
FGD Suspended Floors	
Grating floors	3
Control Room	4.8
Storage Areas	Weight of stored material, but not less than 6
Other Concrete Floors	4.8
Open Grid Flooring	4.9
Roofs	0.3 imposed load 0.5 load of services Self-weight of purlins, rafters, and sheeting (SANS 10160-2:2011)
Conveyor/Feeder Floors	3.5
Bulk Materials Transfer Houses	
Floor areas outside equipment perimeter	5
Floor areas beneath conveyors	2.5
Roofs	0.5 plus 2.5 over 8 meter wide strip centered beneath conveyor galleries
Stairs	4.9

- Design requirements for the Terrace Coal and Ash Handling structures are documented in the Terrace Coal and Ash Handling Contract Package P33, Section 3.2.7, Document 84CIVL054, Revision A.

- Design requirements for Construction Facilities and Temporary Structures are documented in the Enabling Works Contract Package P10, Appendix 7, Document 84CIVL0017.

4.1.2 Construction Loads

Construction or crane access considerations may dictate the use of temporary structural systems. Special considerations will be made to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

4.1.3 Ductwork Pressure Loads and Temperatures

Pressure loads and temperatures used in the design of ductwork shall not be less than the minimum pressure loads and temperatures indicated in Table 4-3.

Table 4-3
Ductwork Pressure Loads and Temperatures
TO BE VERIFIED DURING THE DETAILED DESIGN PHASE OF THE PROJECT

Ductwork Section	Operating Temperature (°C)	Operating Pressure (mbar)	Excursion Pressure (mbar)
	130	**5**	**407,9**

Ash loads for the design of ductwork shall be calculated based on a maximum depth of 23 cm (9 inches). Ash loads shall not be used on duct surfaces inclined at 45° or greater. Hoppers shall be designed for full depth of ash plus a maximum of 23 cm (9 inches) of depth associated with the duct.

Gypsum loads for the design of the FGD Outlet ductwork shall be calculated based on a maximum depth of 15 cm (6 inches). Gypsum loads shall not be used on duct surfaces inclined at 45° or greater.

4.2 Architecture

- Architectural design shall be completed in accordance with Eskom Conceptual Architectural Design Specifications for Structures and Other Buildings, Document 84CIVL007, Revision P04, and the codes and standards referenced therein, unless otherwise specified. Alternate or additional architectural design requirements for specific structures completed within the scope of the Construction Packages are located as follows. Several of the Construction Package contracts also reference Document 84CIVL007, in addition to the following:

- Architectural and finishes requirements for the Boiler Structure and auxiliaries are documented in the Boiler Contract; Construction Package P02; Section 6; Structural Steel, Platforms, and Civil Work.

- Architectural and finishes requirements for construction facilities and temporary structures are documented in the Enabling Works Contract Package P10, Appendix 7, Document 84CIVL0017.

4.2.1 Exterior Architecture Criteria

The exterior architectural systems provide a durable, weathertight enclosure to protect systems and personnel and allow for a controlled interior environment. Exterior architectural systems shall conform to the general design criteria for main plant buildings and principal yard buildings indicated in Table 4-5 and Eskom Document 84CIVL007.

4.2.2 Interior Architecture Criteria

The interior architectural systems provide a functional, low maintenance, aesthetically pleasing environment. Interior architectural systems shall conform to the general design criteria indicated in Table 4-6 and Eskom Documents 84CIVL007, ESK PB AAQ 3, and ESKAMAAA1.

4.3 Concrete

Reinforced concrete structures will be designed in accordance with the Specification for Structural Concrete, Document 84CIVL053, with the requirements of SANS 10100, South African Standard, Code of Practice, Structural Use of Concrete, referenced therein, and the design parameters indicated in Tables 4-4, 4-5, and 4-6.

4.3.1 Mix Design

Maximum coarse aggregate size will be specified in accordance with Specification 84CIVL053 VA-G 3.4.1 for all mix designs. A larger coarse aggregate size may be considered for mass concrete, but plums will not be used. Grout is “sand-only” mix.

In addition, a 20 MPa strength, 19 mm aggregate size mix shall be used for kerbs at fence lines.

Table 4-4
Exterior Architecture Criteria

Item	Criteria
Walls	Reference Document 84CIVL007, Article 3.2.5.1.
Roofs	Reference Document 84CIVL007, Article 3.2.2.
Masonry	May consist of fair-face bricks, minimum Class Face Brick Standard (FBS), or concrete block, which may be utilized for enclosure and separation purposes.
Thermal Insulation	Shall have insulation incorporated into the walls and roofs for thermal design.
Acoustical Insulation	Shall have insulation incorporated into the walls and roofs for acoustical design.
Louvers	Shall include vertical storm louvers as required by the ventilation design.
Windows	Reference Document 84CIVL007, Articles 3.2.7 and 3.2.7.3.
Personnel and Equipment Access Doors	Reference Document 84CIVL007, Article 3.2.6.
Finish Painting and Colors	Exterior steel materials not galvanized or factory finished shall be finish painted. Colors shall be in accordance with the guidelines of Reference Document 84CIVL007, Articles 2.1, 3.2.2.2, and 3.2.5.1.

Table 4-5
Interior Architecture Criteria

Item	Criteria
Partitions	Reference Document 84CIVL007, Article 3.2.5.2. Finishes shall be in accordance with 84CIVL007, Table 1.
Windows	Reference Document 84CIVL007, Articles 3.2.7 and 3.2.7.4.
Personnel Doors	Reference Document 84CIVL007, Article 3.2.6.
Ceilings	Reference Document 84CIVL007, Article 3.2.4.1. Finishes shall be in accordance with 84CIVL007, Table 1.
Floors and Floor Coverings	Reference Document 84CIVL007, Article 3.2.3. Finishes shall be in accordance with 84CIVL007, Table 1.
Wall Coverings	Wall covering and finishes shall be in accordance with 84CIVL007, Table 1.
Finish Painting	Reference Document 84CIVL007, Article 2.1.
Sanitary Facilities	Reference Document 84CIVL007, Article 3.2.10.

Table 4-6
Mix Design

Class	Use	f_{cu} 28 Day Strength, MPa	Water/Cement Ratio, wc by weight
A	Mud slabs, fill, duct bank	15	0.55
B	General	35	0.50
C	Cooling towers, basins, structures in contact with water	35	0.40
Grout	Structure to concrete bearing surfaces	35	--

4.3.2 Materials Usage

Materials usage requirements are indicated in Table 4-7.

Table 4-7
Materials Usage Requirements

Material	Usage	Requirements
Cement	In accordance with mix design, local supply	SANS 50197-1/2 or SANS 5841.
Water	In accordance with mix design, local supply	From the potable water supply and conforming to SABS 10100-2 and SANS 51008, DIN EN 13480.
Aggregate	In accordance with mix design, local supply	SANS 5841.
Reinforcing Steel, main	In accordance with detail design requirements	SANS 920, 450 MPa.
Reinforcing Steel, ties and stirrups	No. 12	SANS 920, 450 MPa.
Forms	All exposed concrete surfaces (not flatwork)	SANS 10100 and SANS 1200G as amended by Specification 84CIVL053.

4.3.3 Materials Application

Minimum cement content will be 420 kg/m^3. Concrete cover to reinforcement will be in accordance with Specification 84CIVL053 VA-G 5.1.3 and will be documented on the design drawings. The design of large mass pours of concrete will take into account the control of heat of hydration and cracking in accordance with Specification 84CIVL053 VA-G 5.5.16.

4.3.4 Materials Application Criteria

Materials application criteria are listed in Table 4-8.

Table 4-8
Materials Application Criteria

Member	Criteria
Suspended Slabs	Two-way reinforced; 40 mm minimum cover; 150 mm minimum thickness; steel trowel finish; spray with curing compound.
Structural Beams	Singularly reinforced; 40 mm minimum cover interior, 38 mm cover exterior; beam width in 50 mm increments, minimum 205 mm; beam depth in 50 mm increments, minimum 305 mm; cured 3 days in forms.
Grade Beams	Singularly reinforced; 60 mm cover; beam width in accordance with excavator requirements, minimum 205 mm; void forms between pier supports, 100 mm minimum thickness.
Spread Footings/Below Grade Structure (Limestone Unloading Basement/Tunnel)	150 mm dimension increments for footing dimensions less than 2.75 m; 60 mm bottom cover on soil; 40 mm bottom cover on mudmat/60 mm interior; 70mm exterior.
Special Massive Machine Foundations	60 mm cover; dimensions to nearest 50 mm, unless specifically for machine interface as required; reinforced for surface crack control.

4.4 Steel Structures

4.4.1 Structural Steel

Steel framed structures shall be designed in accordance with SANS 10162-1, for Structural Steel Buildings, or other previously approved applicable and recognized national design codes. In addition, steel framed structures shall be designed in accordance with the criteria discussed in the following subsections.

4.4.1.1 Materials. Construction of steel structures shall use materials complying with SANS 2001-CS1:2005, Clause 4.1. Grade 350W steel shall be used as far as possible. All steel sections, including plate, shall comply with the requirements of the standards listed in Table 1 of SANS 2001-CS1:2005, Clause 4.1.1, headed “Structural Steel and as defined in Table 4-9.

Table 4-9
Structural Steel Materials

Material	Criteria
General Use Steel Shapes, Plates, Appurtenances	Multicertification SANS 2001-CS1:2005,SANS 50025, DIN 188000 T1-T4
Steel Tube, rectangular or square	SANS 657-1, SANS 50025 , DIN EN 13480
Bolts	19 mm (3/4 inch), 22 mm (7/8 inch), or 25 mm (1 inch) diameter, 6 mm (1/4 inch) increments of length, 6 mm (1/4 inch) increments on bolt diameter when different bolt sizes are used, bearing type with 22 mm (7/8 inch) threads included in the shear plane for all connections except where slip-critical connections are required. Bracing connections are slip critical. SANS 1282, SANS 1700
Weld Filler Metal	4,920 k/cm^2 (70 ksi) tensile strength. 480 MPa Tensile strength (SANS 2001-CS1:2005)
Atmospheric Corrosion-Resistant Steel	SANS 50025-5
Extreme Corrosion-Resistant Stainless Steel	SANS 10120-2 HC, SANS 50025-5
Guardrail and Handrail Pipe	40 mm (1-1/2 inch) diameter, SANS 10160, SANS 10162 , SANS 10400
Steel Grating	5 mm (3/16 inch) by 32 mm (1-1/4 inch) bearing bars, painted for interior exposure, galvanized for corrosive environments. (SANS 10160, SANS 10162 , SANS 10400)
Anchor Bolts, sized for design loads	6 mm (1/4 inch). (SANS 10160, SANS 10162 , SANS 10400, SANS 1282, SANS 1700) increments of diameter.
Anchor Bolts, sized for design loads and pretensioned	SANS 1700, 6 mm (1/4 inch) increments of diameter.
Miscellaneous Channels, Angles, Plates, and Embedded Shapes	(SANS 10160, SANS 10162 , SANS 10400, SANS 50025)
Stair Stringers	ASTM A36, minimum.
Stair Treads	Steel grating, cast abrasive or bent checker plate nosings. (SANS 10160, SANS 10162 , SANS 10400)
Conveyor Walkway	Galvanized, expanded metal grating, 30.5 ksm (6.25 psf) minimum weight.
Metal Deck, roof	40 mm (1-1/2 inch) profile depth, 22 gauge minimum, galvanized.
Metal Deck, form	25 mm (1 inch) profile depth, 24 gauge minimum, painted or galvanized (composite deck form only).
Ladders	Fabricated from ASTM A36 bar rails 65 mm (2-1/2 inches) x 13 mm (1/2 inch) with 25 mm (1 inch) diameter rungs. (SANS 10160, SANS 10162 , SANS 10400)

4.4.1.2 Design. Construction of steel structures shall use design practices defined by SANS 10160, 10162-1, 10162-2, and 10162-4 and local building codes. Galleries and stairways shall not be less than 915 mm wide on the tread. Main walkways shall not be less than 1,250 mm wide. Design and arrangement of stairs shall comply with SANS 10400. The criteria for structural steel design are indicated in Table 4-10.

Table 4-10
Structural Steel Design

System	Criteria
Rigid Frames (preengineered metal buildings, piperack, cantilevered supports)	for specified design loads. (SANS 10160, SANS 10162 , SANS 10400), DIN 18800
Braced Frames (all structures other than the above)	for specified design loads, recognizing zero connection moment capacity. (SANS 10160, SANS 10162 , SANS 10400)
Lateral Building Drift, rigid frame structures	(Story or building height)/100 under wind, for seismic. (SANS 10160, SANS 10162 , SANS 10400)
Lateral Building Drift, braced frame structures	(Story or building height)/200 under wind for seismic. (SANS 10160, SANS 10162 , SANS 10400)
Vertical Bracing Members	Detailed for concentric loading, unless analyzed for work point eccentricity. Compression and tension capable, “pinned” at all connection points.
Horizontal Bracing Members	Detailed for eccentric loading. Compression and tension capable, “pinned” at all connection points.
Beams - Lateral-Torsional Buckling Brace Points	The following shall be considered as points of lateral-torsional stability bracing for beams: • Roof deck connections, L_b = 3 times deck fastener spacing • Floor deck connections, L_b = Lesser of 3 times deck fastener spacing or the actual shear connector spacing • Floor grating, welded connections--Use 25 mm (1 inch) fillet welds at 300 mm (12 inch) spacing (min.), add drawing notes to caution against removing grating, L_b = weld spacing • Horizontal truss panel point incident beams--Incident beam top of steel offset 75 mm (3 inches) or (1/6)(braced beam depth), maximum • Incident beams axially aligned with horizontal truss panel points--Incident beam top of steel offset 75 mm (3 inches) or (1/6)(braced beam depth), maximum • Incident beams connected to H-brace stability connections--Incident beam top of steel offset 75 mm (3 inches) or (1/6)(braced beam depth), maximum

Table 4-10
Structural Steel Design

System	Criteria
	• Incident beams connected to floor slabs or roof truss diaphragms--Incident beam top of steel offset 75 mm (3 inches) or (1/6)(braced beam depth), maximum • Incident beams connecting three or more parallel beams, parallel beams have 20 percent or less difference in weight--Incident beam top of steel offset 75 mm (3 inches) or (1/6)(braced beam depth), maximum • Incident beams connecting two parallel beams--Verified by calculation only
Columns - Lateral-Torsional Buckling Brace Points	The following shall be considered as points of lateral-torsional stability bracing for columns: • Incident beams connected to the space truss--Note for standard column sizes (355 mm (14 inches) and smaller), incident beams connecting to the center of the column web restrain the column flanges against lateral buckling. For deep columns (405 mm (16 inches) and larger), the incident beams may require special connections to restrain the column compression flange(s) against lateral movement. • Incident beams connecting three or more adjacent columns--Note for standard column sizes (355 mm (14 inches) and smaller), incident beams connecting to the center of the column web restrain the column flanges against lateral buckling. For deep columns (405 mm (16 inches) and larger), the incident beams may require special connections to restrain the column compression flange(s) against lateral movement. • Girts with flange braces
Beams - Major Axis Compression Buckling Brace Points	The major axis compression buckling points for beams shall occur only at the beam supports. Major axis unbraced length for beams, L_x, shall equal the beam span.

Table 4-10
Structural Steel Design

System	Criteria
Beams - Minor Axis Compression Buckling Brace Points	The following shall be considered as points of weak-axis compression-buckling stability bracing for beams: • Horizontal truss panel points with or without incident beams • Incident beams axially aligned with horizontal truss panel points • Incident beams connected to floor slabs or roof truss diaphragms
Columns - Major and Minor Axis Compression Buckling Brace Points	The following shall be considered as points of compression-buckling stability bracing for columns: • Incident beams connected to the space truss • Incident beams connecting two adjacent columns--Verified by calculation only
Vertical Braces - Compression Buckling Brace Points	The following shall be considered as brace points for vertical bracing: • Buckling in the plane of the truss--“X-bracing” or single side strut • Buckling out of the plane of the truss--“X-bracing”
Unbraced Length, pipe bracing in ducts	KL/r $\leq$ 120, checked for vortex shedding in flow and thermal restraint forces.
Deflection, floors and roofs, live load only	Span/360, vertical, unless attached to more rigid, brittle members (SANS 10162-1:2011).
Deflection, floors and roofs, dead and live load combined	Span/240, vertical (SANS 10162-1:2011).
Deflection, girts	Span/180, horizontal. Span/360 when over and under glass, horizontal.
Deflection, crane and hoist support beams (without “impact”)	Span/600, vertical; span/400, lateral.
Deflection, duct plates (between stiffeners)	Span/100, normal operations only.
Deflection, duct plate stiffeners	Span/240, normal operations only.
Deflection, grating (488 kg/sm uniform load)	6 mm (1/4 inch) maximum.

4.5 Site

4.5.1 Grading and Drainage

Site grading and drainage shall be designed to comply with all applicable national and local regulations and shall be integrated with existing site drainage systems so far as possible.

Stormwater management design shall be in accordance with the Medupi Power Station Stormwater Design Criteria, Revision 2, dated September 2007. This document is included as Appendix J to this document.

4.5.2 Roads

Road design component criteria are defined and detailed in the standard road cross sections and details contained in Drawings 0.84/94, 0.84/95, and 0.84/96 and in Table 4-11. The majority of the roads will be constructed using naturally occurring gravels located at or near the site.

Terrace roads shall be kerbed or shall be be provided with a concrete edge restraint. Pavement design for the terrace roads shall meet Pavement Class ES3, Category C, with 25 mm of asphalt surfacing. Secondary or temporary roads shall be in accordance with the requirements specified in the Enabling Works Specification, Appendix 3, Article 3.

Table 4-11
Road Design Component Criteria

Design Component	Criteria
Grading Slope, minimum	1 percent in main plant complex, or as appropriate for surface type, conveying storm runoff away from permanent facilities.
Grading Slope, maximum	8 percent unless Owner agrees to steeper slope.
Drainage Storm Event, unless local code or regulations control	25 year, 24 hour runoff event.
Finish Floor Relative Elevation	150 to 300 mm (6 to 12 inches) above 1 percent probability (100 year) storm event.
Channels, ditches	Trapezoidal cross section, designed to reduce erosion.
Culverts	Reinforced concrete, corrugated metal, or corrugated high density polyethylene (HDPE) pipes; reinforced concrete box where necessary.
Detention, Retention, and Evaporation Pond Storm Event, unless local code or regulations control	10 year, 24 hour runoff event.
Roads, main plant access	Two 3.0 m (10 foot) asphalt paved lanes, optional 90 cm (3 foot) aggregate surfaced shoulders.
Roads, other than main plant access	Two 3.0 m (10 foot) aggregate surfaced lanes, no shoulders.

4.5.3 Railway Siding

The Limestone unloading and gypsum loadout facilities will be tied to the on-site rail yard by others. These facilities will incorporate trackage which ties into the on-site rail yard system, and shall also include a compressed air layout acceptable to Transnet Freight Rail (TFR) to charge the brakes on a rake of wagons ready to depart. A description of that rail yard facility follows.

A rail yard shall be provided for the delivery of limestone and bulk fuel oil, dispatch (loadout) of gypsum, and the transportation of materials and equipment for construction, operation, and maintenance. The rail yard shall be constructed to a standard acceptable to TFR for it to bring in and remove trains.

A shunting locomotive of adequate power shall be provided to place wagons where required for loading and unloading purposes, and for making up trains ready to be subsequently taken away by TFR.

A compressed air layout/system acceptable to TFR shall be provided to charge the brakes on a rake of wagons ready to depart.

In the yard it shall be possible to inspect wagons for defects and pre-departure checks, and a rail spur shall be provided for defective wagons undergoing repair.

Provision shall be made to operate turnouts in the yard by electric motors and to set them remotely, if the decision is made not to use shunters.

The safety of operation in the yard shall be in agreement with the requirements of TFR and to the approval of the Rail Safety regulator.

4.5.4 Flue Gas Desulfurization Limestone Handling and Storage

The site arrangement is based on future railroad delivery of FGD sorbent material and a separate handling and storage system common to all six units.

Refer to Subsection 9.1.2 for the site FGD limestone storage facilities design requirements.

4.5.5 Landfill Waste Handling and Disposal

Combustion wastes (and future FGD byproducts) will be stored using semidry stockout techniques in the ash dump. The ash dump is located to the west of the main power station. The ash handling system will consist of a series of on-site collectors and conveyors transferring ash to overland conveyors for transfer of ash to the ash dump. An emergency stockout and reclaim system will be provided in case of conveyor interruption. The overland conveyors will transfer ash to a series of extendable conveyors and crawler-mounted stackers for deposit of ash directly in the ash dump. An emergency ash off-loading facility will be provided in the area of the ash dump in case of equipment interruption at the ash dump. Refer to Subsection 1.4.6 for the ash dump design requirements.

The North Ash Dump will be developed as a part of the power station construction, with the South Ash Dump being developed in the future. The ash dump will be lined with a compacted liner. The sealing requirements of the landfill area will be determined based on a review of the site soil conditions and environmental requirements.

A concrete-lined contaminated storm water trench system will transport dirty water and runoff collected within the ash dump area to three lined dams, where contaminated storm water originating from the dump will be stored. An uncontaminated storm water trench system will be used to divert clean water away from the dump facility and into the environment to minimize the runoff entering the active dump area from the nonactive area.

4.5.6 Water and Wastewater Storage Dams

Water and wastewater storage dams shall be earth diked structures. The inside dam slopes shall be stable under all possible water conditions, and riprap or other suitable slope protection shall be designed to suit the prevailing site wind conditions and resulting wave heights. Ponds designated for containment of waste materials shall be sized to contain the runoff resulting from a 1:50 year, 24 hour storm, unless more stringent requirements are mandated by national or local regulations. Clean and dirty water dams shall be sized in accordance with Eskom Document 84CIVL011.

Pond sealing requirements shall be consistent with the site soil conditions and the environmental requirements regarding the waste material stored in the pond. The wastewater holding ponds shall be lined with an impermeable manufactured liner material.

4.5.7 Fencing and Security

The perimeter fence around the site boundary will consist of a double row of welded mesh 3.0 meter (10 foot) high (including overhang), electrified security fencing. The perimeter fencing system will include normally locked swing gates for access. Fencing details will be in accordance with Barrier Fencing and SANS 10222-3.

4.5.8 Existing Electrical Trench Usage

If reserve space is available, existing cable trenches shall be used to the extent practical for the Medupi FGD Retrofit project area's new electrical power and control circuits. If existing facilities do not have reserve space, all new FGD circuits will be routed on utility racks.

4.6 Foundations

4.6.1 General Criteria

Foundations shall be designed using reinforced concrete to resist the loading imposed by the building, structure, tanks, or equipment being supported. The foundation design shall consider the following:

- Soil bearing capacities.
- Deep foundation capacities.
- Lateral earth pressures.
- Allowable settlements, including differential settlements.
- Structure, equipment, and environmental loadings.

- Equipment performance criteria.
- Access and maintenance.
- Temporary construction loading.
- Existing foundations and underground structures, including their current settlement conditions.

Foundations shall be designed to comply with codes for buildings and structures applicable to the structure being designed. Design codes shall be in accordance with, but not limited to, the following:

- SANS 10100-1 --The Structural Use of Concrete, Part 1.
- SANS 10100-2 --The Structural Use of Concrete, Part 2.
- SANS 10109-1 --Concrete Floors, Part 1.
- N.PSZ 45-698 -- Engineering Drawing Office and Engineering Documentation Standard
- SANS 10144--Detailing of Steel Reinforcement for Concrete.
- SANS 10160--General Procedures and Loadings to Be Adopted in the Design of Buildings.
- SANS 10161--Design of Foundations for Buildings.
- Geotechnical exploration, testing, and analysis information shall be used to determine the most suitable foundation system. Elastic (short-term) and consolidation (long-term) foundation settlements shall be calculated and limited to appropriate design values.

4.6.2 Foundation Design Criteria

Foundation design criteria will be developed by Eskom’s project design team to be in compliance with the equipment/plant manufacturer’s specifications for loads; arrangements; anchorages; sizes etc., based on the Geotechnical Investigation Report in Appendix E and supplementary reports as may be deemed necessary.

4.6.3 Special Foundation Requirements for Rotating Equipment

The foundation systems for major rotating equipment shall be sized and proportioned so as not to exceed the bearing and settlement criteria and to ensure satisfactory performance of the equipment. In addition to a static analysis, a dynamic analysis may be performed to determine the fundamental frequencies of the foundation system for selected major rotating equipment as determined necessary by Eskom's project design team. To preclude resonance, fundamental frequencies of the foundation associated with rigid body motion shall be 25 percent removed from the operational frequency of the equipment. Should the foundation system not meet this criteria a balance quality grade, appropriate for the equipment, will be determined from ISO 1940, Balance Quality Requirements of Rigid Motors - Part 1. The dynamic behavior of the foundation will be evaluated for this level of unbalance and compared to ISO 10816, Mechanical Vibration-Evaluation of Machine Vibration by Measurements on Nonrotating Parts, Parts 1 through 6. The resultant vibration level shall not exceed the limit for evaluation of this standard. Where required, the foundation shall also be designed to meet manufacturer's requirements.

4.6.4 Equipment Plinths

All equipment shall be supplied with an equipment plinth suitable for its operation. Where the equipment could induce vibration problems, the plinth shall have adequate mass to dampen vibration motions. Special consideration shall be given to vibration and stiffness criteria where specified by an equipment manufacturer.

Equipment plinths may be concrete or an integral metal skid. Concrete plinths shall have minimum temperature and shrinkage reinforcing, unless it is determined that additional reinforcement is required for the equipment loads.

4.6.5 Thermal Insulation

When required by the local code, foundations and below grade portions of space-conditioned buildings above those foundations shall be insulated.

5.0 Mechanical and Chemical Design Criteria

5.1 Piping, Components, and Accessories

5.1.1 Design Pressure and Design Temperature

The design pressure and temperature for piping will be consistent with conditions established for the design of the associated system.

For systems that specific criteria regarding temperature and pressure design conditions cannot be established, the design pressure of a piping system generally will be based on the maximum sustained pressure that may act on the system plus 170 kPa, and rounded up to the next 50 kPa increment. The design temperature of a piping system generally will be based on the maximum sustained temperature which may act on the system plus 6° C, and rounded up to the next 5° C increment.

5.1.2 General Design and Selection Criteria for Pipe/Tubing

High-pressure piping shall be designed in accordance with EN 13480 Metallic Industrial Piping. Medium- and low-pressure piping shall be designed in accordance with Eskom Specification for Medium Pressure Pipelines, GGSS 0690. Equivalent international codes, such as ASME B31.1, Power Piping; B31.3, Process Piping; American Water Works Association (AWWA) codes; AISB; and/or NFPA criteria as appropriate for the system. Equivalent International and/or South African codes (SABS/SANS codes) will also be used.

General criteria for selection of pipe and tubing, including medium- and low-pressure piping, fittings, and connections, shall be designed in accordance with Table 5-1. Medium- and low-pressure pipe is defined as piping operating under working pressures up to 4,000 kPa and within a temperature range of -10° C to +100° C.

The minimum nominal bores of piping, valves, and associated items shall be designed in accordance with the limiting velocities of flow shown in Table 5-2.

Other materials may be used depending on the service, media, and conditions. High density polyethylene (HDPE) pipe shall meet National Sanitation Foundation (NSF) and local code requirements and be certified when used for potable water service.

Fire water systems shall use Factory Mutual (FM) certified materials and installation methods where required by code.

Schedule/nominal wall thickness pipe shall be used unless the service conditions exceed heaviest schedule pipe limitations. Corrosion/additional allowance on pipe wall thickness will be 0 to 1 mm except where service conditions require a greater allowance.

Steam lines shall use 0.5 mm minimum corrosion allowance. FRP pipe linings for slurry service will be 1.52 mm (0.060 inch) to 6.35 mm (0.250 inch) thick to meet service conditions.

5.1.3 Pipe and Tubing Size Selection

The pipe sizes shown in Table 5-3 shall be used for ASTM carbon steel and low/intermediate alloy steel.

The pipe sizes shown in Table 5-4 shall be used for SANS mild steel pipe.

The pipe sizes shown in Table 5-5 shall be used for stainless steel pipe.

The tubing specifications shown in Table 5-6 shall be used for chemical feed, instrument primary piping, compressed air, and sample line systems. Other tubing sizes may be used as part of a vendor equipment package. Refer to Section 7.0 for Instrument Piping specifications.

Tubing material shall be stainless steel tubing using butt-weld, grip type, or socket-welded fittings as described in Table 5-6.

Table 5-1
General Pipe and Tubing Selection Criteria

Material	Typical Standard	Typical Temp. Range	Minimum Pipe Wall Thickness: Diameter, ≤ 50 mm	Minimum Pipe Wall Thickness: Diameter, > 50 mm	Notes
Carbon Steel	A53, A106, A134, A672	-29°C to 413°C	Sch XS	Std wt	Lined pipe may use other criteria
Stainless Steel	A312	-29°C to 649°C	Sch 10S*	Sch 10S	--
Stainless Steel Tubing	A213 TP304 or TP316	-29°C to 649°C	Refer to Table 5-6	--	EAW and U not allowed; Rockwell hardness less than B90 (B80 or less preferred)
Concrete Cylinder Pipe	AWWA	0°C to 65°C	--	Varies	Specific type of pipe varies
HDPE	SANS 4427	18°C to 49°C	SDR 11	SDR 17	Air, slurry, ash, or water service (PE1000 resin or heavier wall required for compressed air service)
PVC/CPVC	D1785 F441	4°C to 82°C	Sch 40	Sch 40	--
FRP (or GRP)	SANS 1748-2:2005	4°C to 99°C	Varies	Varies	Interior lining selected to be compatible with media, DIN 14692
Ductile/Cast Iron	C151 A123	4°C to 102°C	--	Class 50	--
Alloy 20	B464 N08020	-29°C to 427°C	Sch 40	Sch 10	--
Mild Steel	SANS 62 SANS 719		Varies	Varies	--

*For Victaulic Pressfit® systems, pipe shall be certified Vic-Press 304 with 1.25 mm wall thickness.

Table 5-2
Limiting Velocities and Pressure Drop Range of Flow

Service		Limiting Velocity for Design Conditions: 50 mm and smaller (Nominal)	65 mm to 200 mm (Nominal)	250 mm to 350 mm (Nominal)	Pressure Drop - Range
Auxiliary steam (1,2 MPa)		30 m/s	30 m/s	30 m/s	10 to 40 kPa/100 m
Auxiliary steam (4 MPa)		35 m/s	35 m/s	35 m/s	10 to 40 kPa/100 m
Blow off line to silencer		80 m/s	80 m/s	80 m/s	10 to 40 kPa/100 m
Oil cooler water		2.5 m/s	2.5 m/s	2.5 m/s	5 to 25 kPa/100 m
Oil		2.5 m/s	2.5 m/s	2.5 m/s	5 to 25 kPa/100 m
Compressed air		9 m/s	9 m/s	9 m/s	2.5 to 50 kPa/100 m
Slurries		1.5 m/s to 3 m/s	1.5 m/s to 3 m/s	1.5 m/s to 3 m/s	NA
Process water		2.5 m/s	2.5 m/s	2.5 m/s	5 to 50 kPa/100 m
Raw Water	Pump Suction	0.6 m/s	1.5 m/s	1.82 m/s	-
	Pump Discharge	1.5 m/s	3.0 m/s	3.7 m/s	-
Makeup Water	Pump Suction	0.6 m/s	1.5 m/s	1.82 m/s	-
	Pump Discharge	1.5 m/s	3.0 m/s	3.7 m/s	-
Auxiliary Cooling Water	Pump Suction	0.6 m/s	1.5 m/s	1.82 m/s	-
	Pump Discharge	1.5 m/s	3.0 m/s	3.7 m/s	-
Closed Cycle Cooling Water	Pump Suction	0.6 m/s	1.5 m/s	1.82 m/s	-
	Pump Discharge	1.5 m/s	3.0 m/s	3.7 m/s	-
Reclaim (Process)	Pump Suction	0.6 m/s	1.5 m/s	1.82 m/s	-
	Pump Discharge	1.5 m/s	3.0 m/s	3.0 m/s	-

Table 5-3
Carbon/Low Alloy Pipe (ASTM)

Nominal Pipe Size (NPS)	Service	Schedules	Connection
25 mm	All	XS, XXS	SW or flanged
50 mm	All	XS, 160, XXS	SW or flanged
65 mm and up	All	Std wt min	BW or flanged

Table 5-4
Mild Steel Pipe (SANS)

Nominal Pipe Size (NPS)	Service	Schedules	Connection
Up to 50 mm	All	Varies	Threaded
65 mm and up	All	Varies	BW or flanged

Table 5-5
Stainless Steel Pipe

Nominal Pipe Size (NPS)	Service	Schedules	Connection
25 mm	All	10S*, 40S	SW, flanged, or grip type
50 mm	All	10S*, 40S	SW, flanged, or grip type
65 mm and up	All	10S and up	BW or flanged

*1.25 mm wall for Victaulic Pressfit® systems only.

Table 5-6
Tubing Requirements
Note: EN and SANS codes may be used

Tubing Design Parameter	Project Design Basis
Tubing Fittings (wall thickness 2.11 mm and less)	316 SS grip type, or butt-weld. For 2.11 mm (0.083 inch) wall tubing, all joints shall be checked using manufacturer's gap inspection gauge.
Tubing Fittings (wall thickness greater than 2.11 mm)	316 SS butt-weld.
Tubing Direction Changes	Tubing fitting or bending (bending will affect pressure and temperature rating).
Tubing Supports	In accordance with ASME B31.1 to allow thermal expansion or as required to protect tube from damage.
Tubing Design Pressure and Temperature	In accordance with mechanical design criteria for process pipe connected to and ASME B31.1.
Tubing Sizing	
Sample Lines, Chemical Lines, Compressed Air	12 mm OD with minimum wall thickness (average wall thickness not acceptable) of 1.0, 1.6, or 2.6 mm depending on process design pressures and temperatures, and Eskom Standard GGS 1427.
Sample Lines, Compressed Air	12 mm OD with minimal wall thickness (average wall thickness not acceptable) of 1.0, 1.6, or 2.6 mm depending on process design pressures and temperatures, and ASME B31.1.
Flow and Level Measurement by Differential Pressure	Use pressure tubing criteria.
Using Separate Instrument Manifolds (not direct mounted)	6 mm OD with minimal wall thickness of 1.0 mm as flex lines (less than 0.9 m length).
Note: Direct manifold mounting to the instrument is preferred.	

5.1.4 Fittings and Flanges, Miscellaneous Branch and Instrument Connections

Fittings, flanges, and other pipework components shall be selected in accordance with Section 4.9 of GGSS-0690, and Tables 5-7 and 5-7A, as a minimum, except as otherwise required by more stringent requirements due to service conditions of the system under design. Nonmetallic (HDPE and FRP) fittings shall be selected to match the service and manufacturer's requirements and may be flanged, threaded, or solvent or thermal welded type.

Forged steel socket-weld and threaded fittings shall have the minimum class rating described in Table 5-8. All welded fittings shall be of the same material as the pipe.

Integrally reinforced branch fittings (such as o-lets and pipettes) shall have the minimum class rating described in Table 5-9. Reduced size branch fittings in FRP and HDPE piping systems shall be designed and fabricated by the pipe manufacturer to have equivalent strength to the main line. All welded fittings shall be of the same material as the header pipe. Fittings between dissimilar branch/header materials shall be considered on a case-by-case basis. The fabricator shall provide calculations to verify suitability. Tap types and sizes are identified in Table 5-10.

Table 5-7
Fittings and Flanges

System/Application	Limitations
Fittings 65 mm and larger	Butt-weld type, in accordance with ASME B 16.9.
Fittings 50 mm and smaller	Forged steel socket-weld and threaded type, in accordance with ASME B16.11.
Flanges, cast iron or steel, to mate with nonmetallic flange	Flat faced slip-on type or threaded, in accordance with B16.5.
Flanges 150 class	Raised face weld neck, socket weld (50 mm and smaller) or slip-on type, in accordance with B16.5.
Flanges 300 class and higher	Raised face weld neck type only in accordance with B16.5.
Grooved pipe joints	Rolled or cut grooved joints in accordance with AWWA C606 (rolled grooves preferred).
Crimp type joints	Victaulic Pressfit® system only.

Table 5-7A
(SANS)

System/Application	Limitations
Fittings 65 mm and larger	Butt-weld type, in accordance with JIS B2311.
Fittings 50 mm and smaller	Threaded type, in accordance with SANS 14.
Flanges	SANS 1123

Table 5-8
Forged Steel Fittings Minimum Class Ratings

	Fitting Type	
Pipe Wall Thickness	**Threaded**	**Socket Welded**
Schedule 80 or less	3,000	3,000
Over Schedule 80 to Schedule 160	3,000	6,000

Table 5-9
Integrally Reinforced Branch Fittings Minimum Class Ratings

	Fitting Type	
Pipe Wall Thickness Range	**Threaded**	**Socket Welded**
Schedule 80 or Less	3,000	3,000
Over Schedule 80 to Schedule 160	6,000	6,000

*Engineer must verify with the fitting supplier that the class is suitable for the application.

Table 5-10
Branch and Instrument Connections

System	Service	Tap Size/Type
All Systems (except as below)	Vents, drains, test connections	25 mm BSI, threadolet
	Pressure connections (Pressure 0.1 MPa or less)	25 mm British Standard Pipe (BSP), threadolet
	Pressure connections (Pressure exceeding 0.1 MPa)	19 mm BSP minimum, except same size as the line when the process line is less than 19 mm
	Temperature connections	12 mm BSP, threadolet
	Float type level switch connections	25 mm BSP, threadolet
	Float type level transmitter connections	50 mm BSP, threadolet, varies
	Sample connections	25 mm BSP, threadolet
	Orifice flange connections	12 mm BSP, threaded
	Flow nozzle connections	25 mm BSP, threadolet
	Chemical injection	25 mm BSP, threadolet
Slurry Systems (>3.5 percent solids by weight)	Vents, drains, test connections	38 mm NPS or larger, flanged
	Pressure connections	50 mm NPS, flanged
	Temperature connections	38 mm NPS, flanged
	Level switch and level transmitter connections	50 mm NPS, flanged
	Sample connections	25 mm NPS, flanged
	Orifice flange connections	38 mm NPS, flanged
	Chemical injection	38 mm NPS, flanged
	Cleanout connections	50 mm NPS, flanged, with blind flange
	Flushing connections	50 mm NPS minimum, flanged
All Steam Systems	Temperature connections	38 mm NPS, weldolet
	All others	Refer to above
Air and Flue Ducting	All connections	50 mm NPS, threaded half couplings*

*For coal fired plants, arrangement shall include plugged cleanout port for all pressure connections.

5.1.5 Gaskets

Gaskets and seals shall not contain asbestos. Gasket and seal material shall be in accordance with Table 5-11. Some chemical and glycol systems may require the use of special gasket materials.

Table 5-11
Gaskets

Joint	Gasket	Gasket Limitations
Class 150 SW Flanges and RFSO Flanges	1.6 mm compressed fiber type. Nonasbestos.	Class 150 systems or lower. (Within temperature limits of gasket material.)
FF Flanges, Nonmetallic Flanges, and Cast Iron Flanges	3.2 mm red rubber type (EPDM for hot service)	With backing rings as needed. (Up to 65° C only; above 65° C to 102° C use ethylene-propylene-diene-monomer [EPDM].)
Nonmetallic Flanges on Slurry Systems (FRP)	1.6 mm compressed type. Nonasbestos.	Use with metallic flange backing rings only.
RF Flanges (except as above)	Spiral wound type. Nonasbestos.	Not for use with nonmetallic flanges.
"Press-Fit" Joints (e.g., Victaulic Pressfit®)	EPDM (water) or nitrile (air) O-ring	Cold air and water systems (less than or equal to 102° C and less than or equal to 20.7 barg).
Grooved Pipe Joints	EPDM (water) or nitrile (air) rubber	Cold air and water systems (less than or equal to 102° C and less than or equal to 20.7 barg).
Bell and Spigot CI and DI	EPDM rubber	Gravity drains less than or equal to 102° C and roof conduits.
Mechanical Joints and Bell and Spigot CI and DI with restrained joints.	EPDM rubber	Cold water systems (less than or equal to 102° C and less than or equal to 20.7 barg).
SANS 1123 Flange	3 mm full face made from aramid fibres bound with nitrile butadine rubber	--
HDPE Joints	No gasket	--

5.1.6 Studs, Nuts, and Bolts

Flange bolts, studs, and nuts shall be as described in Table 5-12. Stainless steel bolting shall not be used. Lengths of bolts and studs shall be sized so that a minimum of half to two full threads extend beyond the nut upon tightening of the fastener.

Table 5-12
Studs, Nuts, and Bolts

Application	Studs/Nuts/Bolts
Alloy bolting for pipe design temperature less than 413° C including stainless steel	A193/A193M Grade B7 studs, electroplated cadmium. A194/A194M Grade 2H nuts, electroplated cadmium.
Nonmetallic flanges without backing ring	Follow nonmetallic flange manufacturer's recommendation.
Carbon steel bolting for slip-on flanges, cast iron flanges, non-metallic flanges, and flanges less than Class 150	A307 Grade B bolts or studs, mechanically deposited zinc coated A563 Grade A heavy hex nuts, mechanically deposited zinc coated.
SANS mild steel bolting	SANS 1700

5.1.7 Cathodic Protection

Underground metallic piping (except ductile iron) shall be cathodically protected and electrically isolated. Typical methods include coatings, galvanic anodes, impressed current systems, isolation flanges, and combinations thereof. A cathodic protection plan will be established for underground pipe. Ductile iron pipe will not be protected, because of its inherent corrosion-resistant characteristics, unless water migration is probable. In this case, polyethylene bags shall be installed over the ductile iron pipe.

Earthing for equipment and structures shall meet the requirements of Eskom Standard for Earthing and Lightning Protection 84ELEC001.

5.1.8 Inspection and Testing

Inspection and testing of piping shall be performed in accordance with the requirements of the applicable code. Inspection and testing practices shall follow the requirements of Section 4.14 of GGSS-0690 and Table 5-13. Pressure testing of piping systems, including hydrostatic, pneumatic, or initial service testing, shall be performed on systems following completion of erection. Shop leak testing of piping to be field erected will not be required. All underground piping shall be tested before the line is covered.

Nondestructive testing of piping shall be performed in accordance with applicable codes.

Table 5-13
Inspection and Testing

Systems	**Test Method**
Compressed air, compressed gas, and concentrated chemical systems where piping should remain free of water	Pneumatic (air/nitrogen) test at 1.2 times design pressure (special safety procedures apply).
All instrument tubing, vents, drains; piping between isolation valves and equipment connections; temporary piping systems; compressed air; and all piping for which valving or blanking is not practical (piping terminal flanges shall not be separated for testing)	Initial service test only. No hydrostatic or pneumatic test required.
Systems designed with conditions equal to or more than 4 MPa, 250° C and those for hazardous fluids	Water or process fluid hydrostatic test at 1.25 times the maximum permissible operating pressure of the process fluid at 16° C and held for 30 minutes.
Systems designed with conditions less than 4 MPa, or 250° C	Pneumatic test at 1.1 times the maximum permissible operating pressure of the process fluid and held for 30 minutes.
SANS mild steel piping	a) 100% visual check of welds b) 25% dye penetrant check of welds c) Pressure test to ASME B31.1 and ASME B31.3 at 1.5 times design pressure
All other systems and situations	Water hydrostatic test at 1.5 times design pressure with clean water at not more than 38° C (water chemically treated as required); in no case to exceed limitations of B31.1, Section 137.

5.1.9 Pipe Stress Analysis Support Design

Pipe supports shall be designed in accordance with ASME B31.1 and/or EN and Eskom codes and standards, such as 240-56239133. Methods shall be shown as in Table 5-14.

Table 5-14
Pipe Support Analysis Methods

Design Criteria	Analysis Method
Design temperature of piping 260° C or higher and 65 mm NPS and larger	Computer analysis
Design temperature of piping 150° C or higher and piping is connected to rotating equipment or heat exchangers and 65 mm NPS and larger	Computer analysis
Nonmetallic piping (FRP or HDPE) with design temperature of 49° C or higher, all sizes	Computer analysis or manufacturer's recommendations
All others 65 mm NPS and larger	Manual methods
50 mm NPS and smaller	Manual methods

5.1.10 Cold Bending

Cold bending of pipe 100 mm NPS and smaller may be performed in accordance with ASME B31.1, Sections 129 and 104.2.1. Specific procedures shall be developed to control cold bending, including prohibiting the use of silica-bearing fill media, controlling minimum bend diameters, verifying outside bend minimum wall thickness on each bend, and using other critical control measures.

5.1.11 Pipe Cleanliness Control

Pipe internal cleanliness shall be controlled as described in Section 4.20 of GGSS-0690. The purpose is to establish fabrication cleaning, preservative treatment, and post installation cleaning criteria for each system.

Pipe routings and plant equipment arrangements shall avoid dead legs, nonvalved bypasses, and inaccessible or nonflushable piping sections where contaminants can collect and reside.

Equipment internal pipe bracing and other support members should be designed or provided with drain holes to preclude stagnant nonflow areas and water accumulation, corrosion products, grit blasting materials, and other contaminants that could impair cycle cleanliness.

Piping stored prior to erection shall be maintained in the same type of packaging as it was received if not the original packaging materials. This packaging includes pipe and valve caps and covers, nitrogen blanketing, desiccants, and similar requirements. Piping shall not be stored in direct contact with the ground.

Temporary caps, covers, or similar methods of protection shall be in place during suspended work periods such as shift changes, weekends, etc. Cleanliness practices shall be part of the site quality control (QC) procedures, and routine inspections and corrective actions shall be established in advance of erection activities. Nitrogen blanketing and other corrosion control measures will need to be temporarily suspended during the erection phase, but these measures shall be reinstated as soon as practical following erection.

5.2 Valves

Valves shall be provided that are compatible with the materials of the piping systems to which they are applied. Valve pressure and temperature ratings shall meet or exceed the system design conditions, including hydrostatic test conditions. Low-pressure valves shall be specified in accordance with ASME B15.5 and B16.34.

Valve types to be used may include various gate, globe, ball, plug, butterfly, swing check, lift check, in-line check, stop check, slide, diaphragm, knife, relief, safety, and pilot type valves as required for system function.

Valve selection criteria are shown in Table 5-15.

Table 5-15
Valve Selection Criteria[1]

	Isolation						Throttling												
	≤ 50 mm			≥ 65 mm			≤ 50 mm			≥ 65 mm			Vent			Drain			
KKS System	Type	Mat'l	Ends	Type	Mat'l	Ends	Type	Mat'l	Ends	Type	Mat'l	Ends	Type	Mat'l	Ends	Type	Mat'l	Ends	Notes
QFB	B	SS BRZ	Scrd P-fit BR	B (3) G	CS SS	FLG BW	B T	SS CS	Scrd P-fit FLG	B T F	CS SS	FLG BW	B	SS BRZ	Scrd P-fit BR	B	SS BRZ	Scrd P-fit BR	
GKC -	B G T	SS CS BRZ	Scrd P-fit SW	F G	CI DI CS	FLG WFR GRV BW	B T	SS CS BRZ	Scrd P-fit SW	F T	CI CS DI	WFR FLG BW	B G T	SS CS BRZ	Scrd P-fit SW	B G	SS CS BRZ	Scrd P-fit SW	
SGA	B G	SS CS	Scrd	F G	CI DI	FLG GRV	B T	SS CS	Scrd	F T	CI CS DI	FLG BW GRV	B G	SS CS	Scrd	B G	SS CS	Scrd	
PGB -	B G	SS CS BRZ	Scrd SW FLG	F G	CI CS DI SS	FLG WFR GRV BW	B T	SS CS BRZ	Scrd SW FLG P-fit	F T	CI CS DI SS	FLG WFR BW	B G T	SS CS BRZ	Scrd SW FLG P-fit	B G T	SS CS BRZ	Scrd SW FLG P-fit	
LBG	G T Y	CS Chrm	SW	G	CS Chrm	FLG BW	T B	CS Chrm	SW FLG	T	CS Chrm	FLG BW	T Y	CS Chrm	FLG SW	G Y	CS Chrm	SW	
HTT GNG	B G	SS CS PVC CPVC Alloy 20 FRP	FLG SW	F B G	SS Lined PVC CPVC Alloy 20 FRP CS	BW FLG	B T	SS PVC CPVC Alloy 20 FRP CS	FLG SW	F B T	SS Lined PVC CPVC Alloy 20 FRP CS	FLG BW	B G	SS PVC CPVC Alloy 20 FRP CS	FLG SW	B G	SS PVC CPVC Alloy 20 FRP CS	FLG SW	2

Table 5-15
Valve Selection Criteria[1]

KKS System	Isolation ≤ 50 mm Type	Mat'l	Ends	Isolation ≥ 65 mm Type	Mat'l	Ends	Throttling ≤ 50 mm Type	Mat'l	Ends	Throttling ≥ 65 mm Type	Mat'l	Ends	Vent Type	Mat'l	Ends	Drain Type	Mat'l	Ends	Notes
HTQ	B	SS		F	CI	FLG	B	SS	Scrd	F	CI	FLG	B	SS	Scrd	B	SS		2
	G	CS	SW	G	CS	BW	T	CS	BW	T	CS	BW	G	CS	SW	G	CS	SW	
	D	PVC	FLG	D	SS		D	SS	FLG	D	SS		D	PVC	FLG	D	PVC	FLG	
		CPVC			Lined			PVC			Lined			CPVC		F	CPVC		
		Alloy 20			PVC			CPVC			PVC			Alloy 20			Alloy 20		
					CPVC			Alloy 20			CPVC			FRP			FRP		
		FRP			Alloy 20			FRP			Alloy 20								
					FRP						FRP								

Notes:
1. Where more than one entry is listed in the table, the preferred selection is at the top of the list, with preferences in descending order.
2. Material selection to suit specific services.
3. Isolation valves 150 mm and larger shall be gate.

Key:

Systems:
- QFB = FGD Compressed Air
- GKC = FGD Potable Water
- HTQ = FGD Makeup Water Supply
- SGA = FGD Fire Protection
- PGB = FGD Closed Cycle Cooling Water
- LBG = FGD Auxiliary Steam
- HTT = FGD Sumps
- GNG = FGD Zero Liquid Discharge Treatment

Valve Types:
- B = Ball
- G = Gate
- H = Slide Gate
- J = Pinch
- K = Knife Gate
- T = Globe
- F = Butterfly
- P = Plug
- D = Diaphragm
- Y = Y-pattern globe

Materials:
- CS = Carbon Steel
- SS = Stainless Steel
- BRZ = Bronze
- PVC = Polyvinyl Chloride
- CPVC = Chlorinated PVC
- Alloy 20 = Alloy 20 (UNS N08020)
- Chrm = P11; P22; P5; P91; etc.
- CI = Cast Iron
- DI = Ductile Iron
- Lined = Lined Carbon Steel/Cast Iron/Ductile Iron
- FRP = Fiberglass Reinforced Plastic

Ends:
- P-fit = Victaulic Press Fit
- Scrd = Threaded
- SW = Socket Welded
- BW = Butt Welded
- FLG = Flanged
- WFR = Wafer or Lug Wafer
- GRV = Grooved
- BR = Brazed

5.3 Insulation, Jacketing, and Lagging

Insulation and jacketing shall be in accordance with the Eskom Thermal Insulation Standard 240-56247004, and the latest EN standards.

Items not addressed by Eskom Standard shall meet the following requirements:

Insulation and lagging shall be applied to equipment, piping, valves, specialties, and ductwork as shown in Table 5-16. Insulation and lagging shall be designed for 3 km/h airflow velocity. Insulation for heat traced lines shall be optimized to require 33 w/m or less of applied heat at the minimum design conditions indicated in Section 5.5.

The following specific situations may deviate from the above guidelines:

- Pipe, tubing, and valves over 50° C, but that are not accessible to personnel during normal operations and that do not require heat loss prevention, need not be insulated. Examples are hot drain piping, vent stacks, vents, compressed air and gas lines, and similar items.

- Anti-sweat insulation may be applied to indoor piping, equipment, and ductwork that operates below 13° C in summer or 4° C in winter.

- Piping, tubing, instruments, and equipment requiring freeze protection.

- Steam traps shall not be insulated.

Table 5-16
Insulation

Service Conditions	Insulation and Lagging
Equipment and irregular surfaces with normal operating surface temperatures over 50° C	Type E glass or mineral wool fabric blanket assemblies with weatherproof jacketing.
Pipe and tubing with normal operating surface temperatures over 50° C, including fittings and heat traced lines	Expanded perlite, calcium silicate, or high density mineral fiber preformed insulation without FRP-pipes, with stucco embossed aluminum jacketing.
Valves and pipe specialties with normal operating surface temperatures over 50° C, not including valve operators	Type E glass fabric blanket assemblies with weatherproof jacketing or preformed expanded perlite, calcium silicate, or high density mineral fiber with stucco embossed aluminum jacketing.
Valve operators outside normal insulation thickness for piping	None.
Ductwork, hot casings, and flat surfaces that are accessible to personnel or that require control of heat losses and have normal operating surface temperatures over 50° C	Mineral fiber block or board, or perlite board, with stucco embossed ribbed aluminum lagging.
Instrument and sample tubing exposed to freezing conditions as indicated in Section 5.5	Pre-insulated (mineral wool or fiber glass) and pre-heat traced (self regulating heat tracing) with polyurethane jacketing.

5.4 Site Chemical Storage

Typical chemical storage provisions and containments shall be:

- At minimum, sulfuric acid (H_2SO_4), sodium hydroxide (NaOH), and sodium hypochlorite (NaHOCl) shall be delivered and stored in bulk storage tanks. Each tank shall be located in a separate concrete containment bund sized for 100 percent of single tank capacity, plus allowance for rainfall, 150 mm of freeboard, and the volume of firewater suppression/deluge system in areas affected by these flows.

- Semi-bulk liquid chemicals shall be delivered and stored in portable totes less than or equal to 2,000 liters in size or in drums. Totes and drums shall be located in 150 mm curbed concrete containments.

- Semi-bulk and bulk liquid chemical containment areas shall be sloped to a recessed area for pump out with a portable sump pump. Bulk containment areas located outdoors will have a manual drain valve for drainage of rainwater.

- Containment coatings, if required based on the chemical being contained, shall meet the service conditions.

5.5 Freeze Protection

Piping freeze protection and temperature maintenance systems may be required for outdoor piping, instruments, and equipment devices subject to cold weather. When required, the following design parameters shall be used and coordinated with insulation systems defined in Section 5.3, Insulation, Jacketing, and Lagging. Freeze protection shall be designed on the basis of the minimum design temperature defined in Subsection 1.7.1, Meteorology. When required, electric heat tracing shall be provided that is powered from 230V AC, single phase.

5.6 Seam Welded Pipe

Seam welded pipe may be used in the applications listed in Table 5-17, or where seamless pipe is not available.

Table 5-17
Seam Welded Pipe

System/Application	Limitations
Stainless Steel, Steam, and Water Applications	No limitations where design complies with B31.1.
Carbon Steel, Steam, and Water Applications with Low Corrosion Potential	Class 300 systems and lower; not in slurry or wastewater applications.

5.7 Space Conditioning

Space conditioning consisting of heating, ventilating, and air conditioning (HVAC) shall be provided as required to ensure design basis environmental conditions are met for equipment and personnel.

HVAC systems shall be designed to maintain the indoor conditions listed in Table 5-18 and as indicated herein. Heating of mechanical and electrical equipment areas is not required unless minimum temperaure unless required by the equipment in the building being served. The maximum termperature for ventilated areas is ambient temperature plus 4 degrees Celsius unless equipment in the building requires a lower temperature. Maxium temperatures in electrical eqiupment and C&I equipment room shall be 22+/- 2° C.

Design shall be based on the space conditioning ambient temperatures listed in .

Minimum ventilation rates shall be provided in normally continuously occupied areas in accordance with local codes. In the absence of applicable local codes, ASHRAE Standard 62 requirements shall be met.

The filtration efficiencies in Table 5-18 are as defined in the ASHRAE Standard 52.1 and 52.2 and shall meet the following requirements:

- Where two stages of filtration are specified in Table 5-18, a primary filter of 92 percent average gravimetric efficiency is required with a secondary filtration of 85 percent dust spot efficiency.

- Where one stage of filtration is specified in Table 5-18, an average gravimetric efficiency of 92 percent is required.

Noise criteria (NC) are indicated in Table 5-18 as NC levels, decibels, or as background. NC values are as indicated in the ASHRAE Handbook series for acoustical design criteria. Decibels are sound pressure levels, A-weighted to a reference of 0.0002 microbar at 2 meters from the equipment, as measured in a free field with a single reflecting plane. Background indicates that the HVAC equipment shall be designed so that the contribution shall be 2 dB or less than the overall room noise at 2 meters above the floor with normal plant equipment in operation.

Mechanical equipment rooms containing refrigerants shall be designed in accordance with the requirements of ASHRAE Standard 15, Safety Code for Mechanical Refrigeration.

A minimum of five air changes per hour of ventilation or recirculation air shall be provided for effective mixing during heat removal ventilation or air conditioning.

Laboratory design ventilation rates shall be based on local codes.

N+1 redundancy (2 x 100%, 3 x 50%, etc.) for major active equipment (air handling units, fans, and chillers) shall be provided for HVAC systems serving electrical equipment rooms and C&I equipment rooms. For ventilated mechanical equipment areas, multiplicity of equipment shall be provided. Multiplicity means that more than one parital capcity ventilation device shall be used, resulting in some capacity being provided with a single component failure.

Table 5-18
HVAC Design Criteria

	Buildings/Areas with HVAC Systems	Filtration	Fresh Air as % of Supply	Refrigerated Cooling	Heating	Noise/ Attenuation NC	Humidification	Smoke Ventilation	Operation h/day	Gas Extraction Note 2
1.1	C&I Equipment Rooms	2-stage	15-100%	X	None	35	None	X	24	None
1.2	Chemical Laboratories	2-stage	15-100%	X	X	35	None	None	10	X
2.	Buildings									
2.1	Limestone Preparation Building	None	100%	None	None	50	None	None	24	None
2.2	Limestone Railcar Unloading Building	None	100%	None	None	50	None	None	24	None
2.3	Gypsum Dewatering Building	None	100%	None	None	50	None	None	24	None
2.4	Gypsum Storage Building	None	100%	None	None	50	None	None	24	None
2.5	FGD Makeup Water Pretreatment Building	None	100%	None	None	50	None	None	24	None
2.6	FGD Zero Liquid Discharge Treatment Building	None	100%	None	None	50	None	None	24	None
2.7	FGD Emergency Generation Building	None	100%	None	None	50	None	None	24	None
2.8	FGD Common Pump Building	None	100%	None	None	50	None	None	24	None
2.9	Substations	2-stage	15-100%	X	None	50	None	X	24	None
2.10	Absorber Pump Buildings	None	100%	None	None	50	None	None	24	None
2.11	Cable Spreading Rooms	None	100%	None	None	50	None	X	24	None

Notes:
1. Filtration efficiencies (ASHRAE standard)
   a. Where 2-stage filtration is specified, it requires a primary filter of 92 percent average gravimetric efficiency and secondary filtration of 85 percent dust spot efficiency.
   b. Where 1-stage filtration is specified, it requires an average gravimetric efficiency of 92.
2. Laboratories shall have gas extraction as required for fume hood operation.

6.0 Electrical Design Criteria

In general, SANS, SABS, and Eskom Standards will be used for design and construction of electrical and control systems. Where SANS and SABS standards do not exist, International Electrotechnical Commission (IEC) standards, in consultation with Eskom, will be followed for the equipment and installation. Additionally, the design will follow the South African Grid Code for design aspects, as applicable to the scope of this project.

In some instances, equipment specified but not covered by SANS, SABS, or IEC standards, will revert to the appropriate US standards and current industry accepted design practices, in consultation with Eskom.

Refer to the electrical system one-line diagrams provided in Appendix F. It should be noted that these drawings are for one generator unit and common plant, and additional units will have a duplicate configuration. Unit systems will not be shared, systems common to all units will be fed from a medium voltage loop board.

6.1 Electrical System and Voltage Levels

The plant electrical system design is dictated by the project overall one-line diagram included in Appendix F. The system voltage levels and design shall be according to the project one-line diagrams and Table 1-10, Electrical Equipment and System Voltages.

6.2 Electric Motors

Motors shall be purchased with the driven equipment, in accordance with 240-50237155, 240-56357518, and IEC 60034-1, as summarized in Tables 6-1, 6-2, 6-3, and 6-4.

Table 6-1
Medium Voltage Induction Motors

Design Parameter	Design Basis
Nominal Voltage, frequency (Power Supply Code)	11,000 V, 50 Hz (MV-1) 6,600 V, 50 Hz (MV-2)
Motor Rated Voltage (Power Supply Code)	11,000 V (MV-1) 6,600 V, (MV-2)
Kilowatt Ratings	160 kW and above
Temperature Rise	IEC 60034-1
Enclosure	This refers to Ingress Protection (IP) of enclosures. Standard SANS 60034-5 is applicable to IP ratings of motor enclosures (for indoor, clean areas). This refers to Ingress Protection (IP) of enclosures. Standard SANS 60034-5 is applicable to IP ratings of motor enclosures (outdoors or dirty areas). Special enclosures for hazardous areas.
Insulation and Windings	Class F, VPI system.
Space Heaters	All MV motors. Space heaters rated 400 V, single-phase, operated at 230 V, single-phase. When heater load exceeds 10 A, shall be powered at 400 V, single-phase.
Stator Winding Temperature Detectors	Two resistance temperature detectors (RTDs) (100 ohm platinum) per winding. One set wired to multifunction protective relay.
Bearing Temperature Detectors	One Duplex Type K thermocouple or 100 ohm platinum RTD per motor bearing and wired to DCS.
Torque Characteristics	Breakaway, run-up/pull-up, and pull-out breakdown torque shall at all times be at least 10 percent higher than the load-torque of the driven machine at minimum specified starting voltages.

Table 6-2
Low Voltage Induction Motors

Design Parameter	Design Basis
Nominal Voltage, frequency (Power Supply Code)	400 V, 50 Hz (LV-1)
Motor Rated Voltage	400 V (LV-1)
Kilowatt Ratings	1 kW to 159 kW
Temperature Rise	IEC 60034-1
Enclosure	This refers to Ingress Protection (IP) of enclosures. Standard SANS 60034-5 is applicable to IP ratings of motor enclosures or dust ignitionproof
Insulation Classification	Class F, sealed system
Space Heaters	Motors rated 22 kW and larger located outdoors Space heaters shall be rated 400 V, single-phase, operated at 230 V

Table 6-3
Single-Phase Induction Motors

Design Parameter	Design Basis
Nominal Voltage, frequency (Power Supply Code)	230 V, 50 Hz (LV-2)
Motor Rated Voltage	230 V
Kilowatt Ratings	Below 1.0 kW
Enclosure	This refers to Ingress Protection (IP) of enclosures. Standard SANS 60034-5 is applicable to IP ratings of motor enclosures
Insulation Classification	Class F or Class B if the requirements of GGS 0802, Article 4.1.6 are met
Space Heaters	Not applicable

Table 6-4
Electric Actuators (Motor Operators for Valves)

Design Parameter	Design Basis
Nominal Voltage, frequency (Power Supply Code)	400 V, 3-phase, 50 Hz (LV-2)
Motor Rated Voltage	400 V, 3-phase
Kilowatt Ratings	As required for service
Enclosure	This refers to Ingress Protection (IP) of enclosures. Standard SANS 60034-5 is applicable to IP ratings of motor enclosures
Insulation Classification	Class F
Motor Space Heaters	Rated 230 V, single-phase, powered from control circuit
Torque Characteristic	Motor starting torque shall not be less than 500 percent of rated full load torque

6.3 DC/Battery System

Critical unit ac and dc loads will be powered from a single unitized battery system. In addition to each unit's individual battery system, critical station ac and dc loads will be served by a separate, single, station battery system as indicated in Table 6-5:

Table 6-5
DC/Battery System

System/Parameter	Description
Ac and dc loads:	Distributed Control System (DCS), steam turbine control, and programmable logic controller (PLC)
	Critical equipment and instruments
	Switchgear relays and operational power
	Unit protection
	Emergency lube oil pumps
	Fans and pumps required for emergency shutdown
	Emergency lighting if battery packs are not used for emergency lighting
	Emergency FGD functionalities For the floating and pumping out of the limestone and slurry and the operation of the mixers. Valves that must operate on the loss of normal power

Each battery system shall be sized to accommodate the essential dc and ac loads for the minimum time required by the manufacturer, plus 2 hours. For durations where power has not been restored by the end of the battery duty cycle, the diesel generator(s) will provide required power capable of serving the essential services while simultaneously recharging the batteries.

6.4 Classification of Hazardous Areas

Mechanical, chemical, and process equipment will determine hazardous area classification in accordance with SANS 10108 and applicable local codes and standards, along with other space control and life safety issues. Electrical equipment, materials, and raceway wiring will be selected, designed, and installed in accordance with Subsection 1.4.9.

6.5 Earthing

The plant earthing system will follow the recommendations of applicable SANS standards and will meet the requirements of Eskom Standard 084ELEC001, Earthing and Lightning Protection.

6.6 Lightning Protection

The plant lightning protection system will follow the recommendations of applicable SANS standards and will meet the requirements of Eskom Standard 084ELEC001, Earthing and Lightning Protection.

6.7 Lighting

The plant lighting system will follow the recommendations of SANS 10114-1 and other applicable SANS standards, and meet the requirements of Eskom Standard 084ELEC002, Lighting and Small Power Installation. Lighting levels along fences shall be a nominal 10 lux, 5 lux minimum.

6.8 Cabling and Racking

The plant cabling and racking will follow the recommendations of applicable SANS standards and will meet the requirements of Eskom Standard 084ELEC008, Station Cabling and Racking.

6.9 Plant Communication

Station communications shall be as indicated in Table 6-6. Components installed within hazardous areas shall be suitably rated for the location, with installation in accordance with SANS and Eskom design and safety practices.

Table 6-6
Plant Communication System

Communication System	Type of System	Extent of Installation
Telephone	Service from local telephone company.	Jack stations, cable, and raceway.
Paging/Radio	Page/party system (distributed amplifiers).	Handsets and speakers.
Closed-Circuit TV (CCTV)	Camera and monitor. Pan and tilt drives. Zoom lenses. Switches or multiplexers.	Gate camera and control room monitor.
Data	Local area network (LAN).	Jack stations, cable, and raceway only.

6.10 Power Sources for Fire Pumps

Backup to the electric fire pumps (100 percent) is being provided by diesel driven fire pumps.

The electric driven fire pumps will be fed directly from the 6.6 kV station board in Substation West.

7.0 Instrument and Controls Design Criteria

7.1 Control Design Criteria

7.1.1 Control and Design Philosophy

The control system provides the principal functions in programmable, microprocessor based hardware, as described in the following subsections. The primary control is achieved in a DCS that employs functional distribution and redundancy to achieve a high level of system reliability. The overall philosophy is to integrate all process and equipment control into the DCS. In some cases where integration is not possible, stand-alone systems may be provided using a PLC or proprietary microprocessor based system.

Stand-alone systems must be fully interfaced to the DCS. System control strategies shall be implemented using software based control techniques unless the vendor's standard offering is accepted (i.e., not software based).

A single integrated human-machine interface (HMI) system shall be used for all FGD limestone handling, and ZLD plant operations. A centralized control concept will be followed with a main control room for unit controls and a remote control room shall be used for BOP, FGD control and ZLD control. (Refer to the control architecture drawing in Appendix G). Local control interfaces will be provided where operator visibility of the equipment is required for its operation.

Fans and pumps shall have a local control station for maintenance and use during checkout.

Standardization of all control equipment is required. This includes control equipment (DCS and PLC), transmitters, signal conditioners, control valve/damper actuators, and miscellaneous instrumentation. All equipment should have an established local support base.

All control and instrumentation, protection system, and control components shall be supported and maintainable for a minimum of 20 years. Only the latest power plant proven technology shall be incorporated into the control system; no unproven technology shall be allowed.

A high level of automation of the complete plant is required so that minimal operator intervention is required during transients (such as startups) and that one operator can operate three units during steady-state conditions without cognitive overload. One push button for startup and shutdown of the unit sets shall be possible.

A high level of availability is required of the plant and, particularly, the control equipment. The control and instrumentation system structure shall be designed to minimise the effects of equipment failure on the overall plant. The instrumentation, control, and automation system shall be designed and configured through functional distribution of equipment for the following:

- Safety--No single failure of any part of the system shall lead to a condition that will endanger the safety of the plant or people or jeopardise the integrity of the major plant.

- Power Island Trip/Load Loss--No single failure of any part of the system shall cause a Power Island trip, forced outage, or more than a 40 percent load loss.

- Multi-Power Island Trip--No single failure of any part of the system shall cause a multi-Power Island trip.

- Operator Interface--No individual fault shall cause the loss of an operator workstation. No individual loss shall cause the loss of control or operator information.

- Transmitters--All transmitters shall have a minimum long-term stability of 0.15 percent drift in 6 years, guaranteed for at least 6 years from the date of Owner acceptance.

The required analogue control and binary control (sequence control, protection, and interlocking) shall be developed in conjunction with the Instrument Schedule, Drive, and Actuator Schedule and the piping and instrumentation diagrams (P&IDs) for the various systems. The plant operating philosophies for the Power Island and Balance-of-Plant (BOP), together with the plant descriptions of each system, are detailed in Appendix 10 and Appendix 11 of Contract P17, and this information forms the basis for design of the control and instrumentation system.

The following control philosophy provides the specific control strategies that shall be applied to various systems.

7.1.2 Operational Philosophy

The Medupi Power Station will be divided into the following distinct control and instrumentation systems:

- Six (6) Power Island control and instrumentation systems.

- BOP control and instrumentation system.

The Power Island control and instrumentation system is depicted on Figure 7-1 and consists of the field instrumentation, control equipment, power supplies and interfaces to third party controls systems; expert systems; and HMI equipment for the control, operation, monitoring, and engineering of the Power Island concerned. Unitized FGD equipment, such as monitoring of the FGD recycle pumps, shall be monitored and controlled from the Power Island control and instrumentation system.

Each of the six Power Island control and instrumentation systems will be autonomous in all aspects and will not have any control and instrumentation equipment common to another Power Island Plant control and instrumentation system. The only exception to this concept is the Subsystem Function Group EFG02 electrical reticulation systems. The EFG02 I/O for the Power Island concerned will be contained in that Power Island's control and instrumentation system. However, the EFG02 from all the Power Island areas will be monitored and operated from the electrical operating desk (EOD) work station.

Any control and instrumentation equipment that is common between Power Island plant control and instrumentation systems shall be incorporated in the BOP control and instrumentation system.

The BOP control and instrumentation system is depicted on Figure 7-2 and consists of a fully self-contained and independent system that includes the field instrumentation; control equipment; power supplies and interfaces to third party controls systems and expert systems; and HMI for the control, operation, monitoring, and engineering of the BOP.

The six Power Island control and instrumentation systems and the BOP control and instrumentation system are combined to form the Medupi control and instrumentation system as depicted on Figure 7-3. The Medupi control and instrumentation system will further include subsystems that are common to the Power Island and BOP such as the plant information system (PIS), asset management system, and centralised expert systems.

The Medupi control and instrumentation system will be integrated on an information level. Information from all plant areas in the Power Islands and the BOP areas will be available to all Power Islands and the BOP operators at all operator stations. Information for the purpose of control and interlocking will be available between a Power Island control system and the BOP control system.

The six Power Island areas each consist of a boiler/turbine/generator/air-cooled condenser (ACC)/pulse jet fabric filter plant (PJFFP)/condensate polishing plant (CPP) set, and associated auxiliaries. This includes the Power Island electrical reticulation systems. The plant areas and processes that make up the Power Island control and instrumentation system will be further divided into function groups as required.

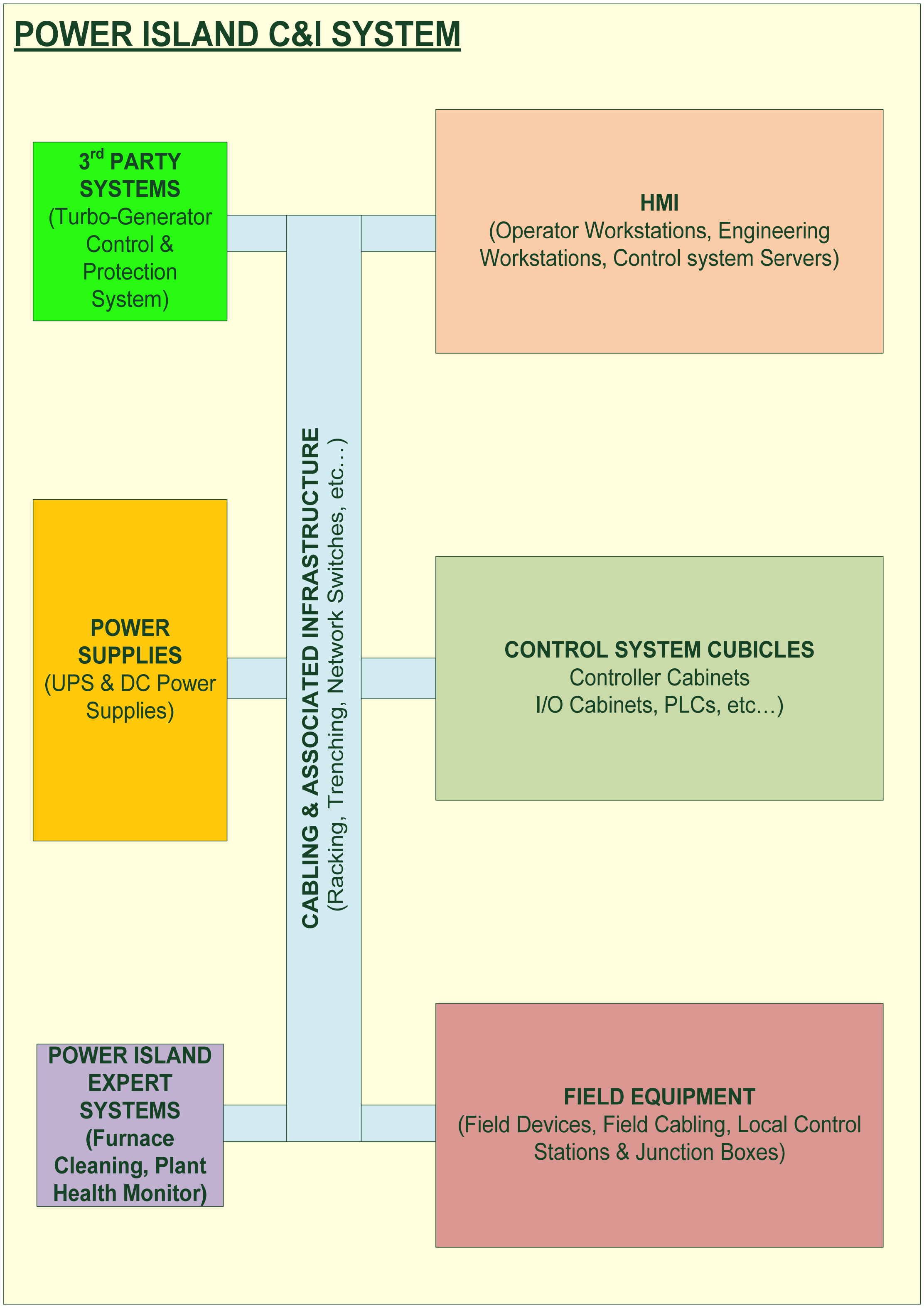


Figure 7-1
Power Island Control and Instrumentation System

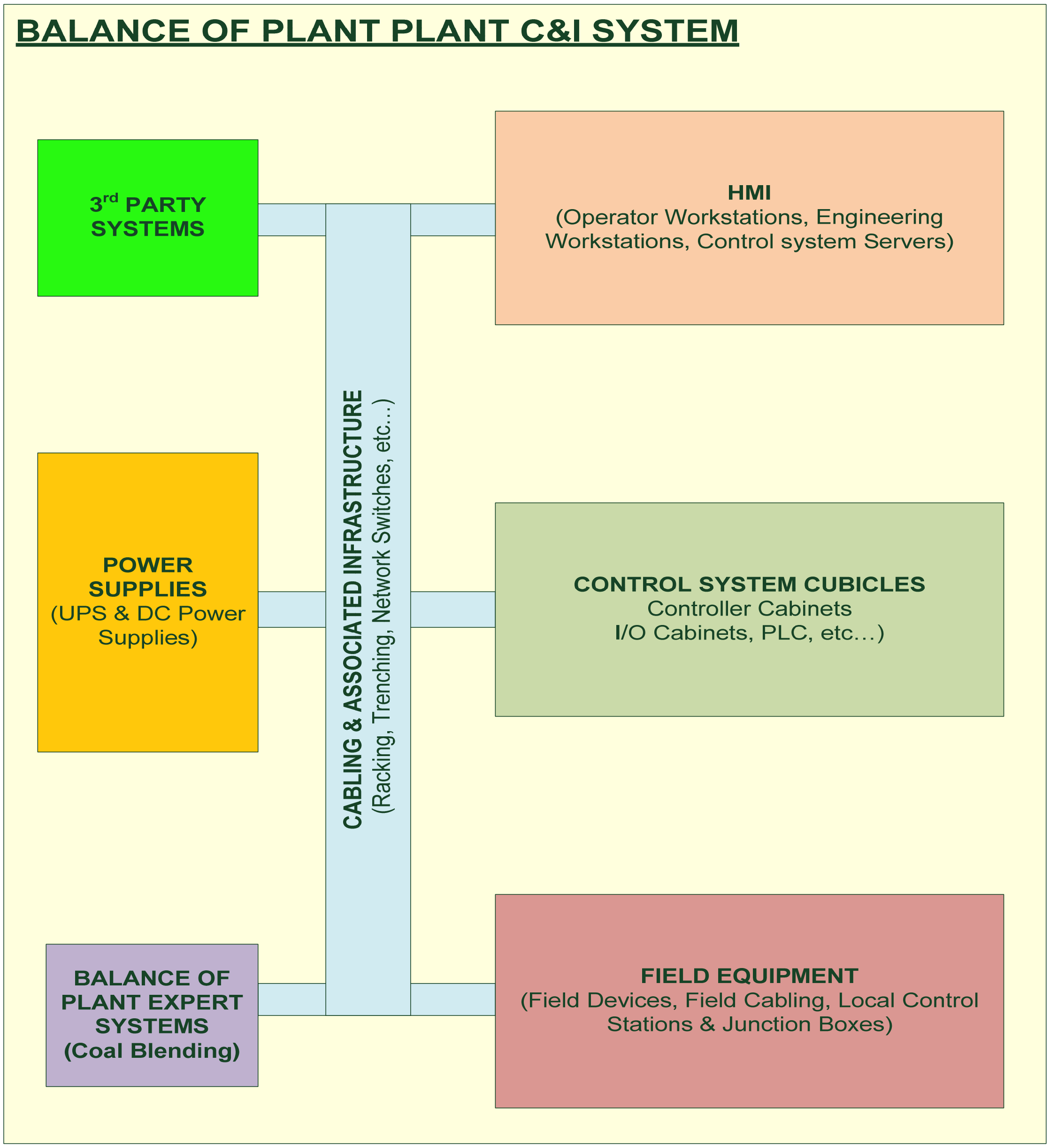


Figure 7-2
Balance-of-Plant Control and Instrumentation System

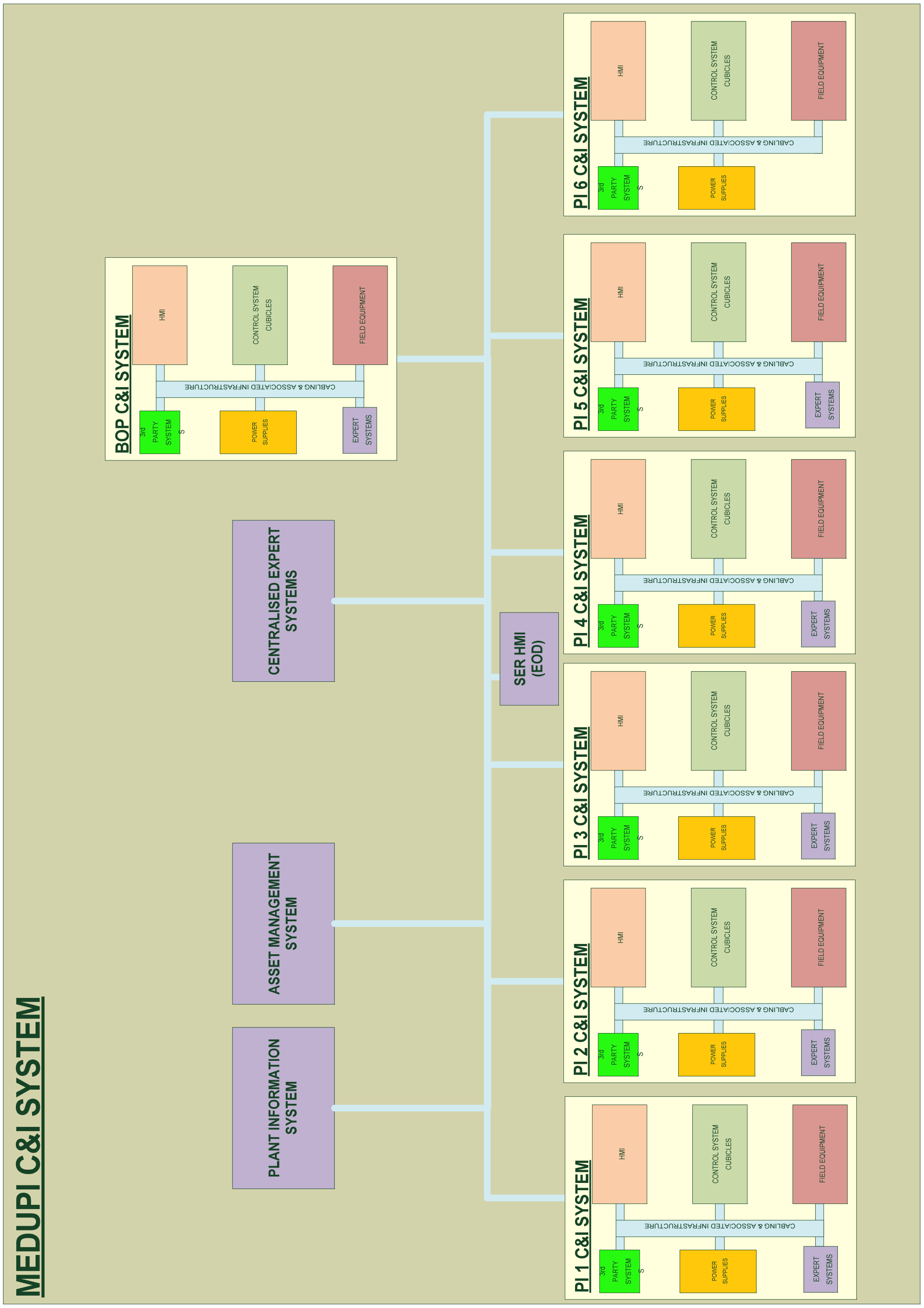


Figure 7-3
Medupi Control and Instrumentation System

The BOP control and instrumentation system consists of all non-Power Island plant and equipment. This includes the station electrical reticulation systems. The BOP area is further divided in the following subsections:

- Water Treatment Plant (WTP).
- Low Pressure Services (LPS).
- Coal.
- Ash.
- Limestone
- Zero Liquid Discharge (ZLD)
- Flue Gas Desulfurization System (FGD)
- Other Systems.
- Station Electrical Reticulation.

At a minimum, the following functions shall be catered for by the control and instrumentation system.

7.1.2.1 Load Cycle. The system shall provide, as a minimum, the following capability for all load segments:

- Fully automatic operation (all control loops on automatic and in coordinated mode) from 40 percent steam flow to 100 percent maximum continuous rating (MCR).
- Load following capability. (Boiler and turbine following.)
- Compliance to the NER Grid Code.
- AGC functionality in accordance with the NER Grid Code.
- Baseload operation.
- 2 shifting.

7.1.2.2 Runbacks. When a Power Island is on load and a trip, malfunctioning process plant, or abnormal condition has been detected, the control and instrumentation system shall take specific automatic runback actions (capability operation), in parallel with any possible trip functions, to place the plant and major components in a safe, stable, and controllable operating state.

No fuel oil support should be required to maintain combustion stability at loads between 40 percent and 100 percent MCR during normal operating conditions. The control objective is to reach this lower energy state (minimum load) in a controlled manner and to remain in a controlled stable state. This requirement is necessary to enable adequate time for the Operator to decide on further actions (e.g., restart or total shutdown of plant or plant components).

7.1.2.3 Power Island Islanding. The control and instrumentation system of a Power Island shall be capable of tripping to house load and continued stable operation under unit-islanded conditions. The Power Island shall be islanded in all cases of network disturbances which would otherwise lead to plant shutdown.

All the requirements of the Network Code of the NERSA Grid Code (GCR 2) and Generation Standard 240-56030600 shall be fulfilled.

7.1.2.4 Alarm Indication. Operators shall be alerted to the occurrence of abnormal events and the return of abnormal events to normal operating conditions. Conditions to be alarmed are those potentially dangerous to personnel or damaging to equipment, those affecting the plant's load carrying capability, and those indicative of processes or equipment operating in an abnormal condition. Alarms shall be assigned to appropriate priority groups to focus the operator on situations requiring the most immediate attention. Alarm display to the operator will include time of occurrence. Alarm priority groups will be differentiated on the operator display by text color or font and audible tone. Sequence-of-events (one millisecond resolution) monitoring is provided for conditions that can directly trip the unit or major equipment where a record of the sequential events is important to post-event review.

The Contractor shall apply a common alarm generating and display philosophy throughout the entire power station in accordance with 240-57859210:Alarm System Performance of Load Rejection and Speed Control Verification Standard; the Eskom Alarm Development Policy; and EED-GTD-C&I-006, Eskom Technical Guideline for Alarm Management Systems. Document 240-57859210 shall be followed to prevent nuisance alarms caused by normal operating conditions, such as low pressure when a pump is not operating.

7.1.3 Operator Interface

The control system operator interface, consisting of visual display unit (VDU) work stations, allows the operator to efficiently monitor and safely control plant operations. The work stations provide on-line, real-time information regarding the status and operating condition of plant equipment. The control room design and operator station layouts shall be according to Eskom Document 240-56355808, Guideline for Ergonomic Design of Power Station Control Suites.

The operating manpower that will be used to determine the level of automation and that should be used as a guideline in the designing of the Operator interfaces are as follows:

- One (1) Operating Manager.
- One (1) Shift Manager per shift.
- Six (6) Power Island Controllers per shift.
- Six (6) Senior Plant Operators per shift.
- One (1) Electrical Controller per shift.
- One (1) Senior Electrical Plant Operator per shift.
- One (1) BOP Controller per shift.
- One (1) WTP Controller per shift.
- Two or three (2 or 3) Senior BOP Operators per shift.
- To support the FGD and ZLD operations, the additional operating manpower are anticipated as noted below.
- One (1) FGD Controller per shift
- One (1) ZLD Controller per shift

The philosophy is based on a five shift cycle, and the respective Senior Plant Operators will also be responsible for the issuing of plant permits.

Simultaneous startup of multiple Power Islands shall be incorporated into the design. The six individual Power Islands shall be controlled from the Power Island Control Suite (PICS) and shall include all operations including startup, shutdown, load control, transient, and emergency situations.

The desk configuration is such that three Power Islands are adjacent and one operator can operate each Power Island, but it will be designed so that one operator can operate all three Power Island during stable normal operation.

The operator interface will be via a set of operating displays units arranged such that each Power Island operator will be able to operate a single integrated boiler/turbine/generator unit.

The operator interface for the BOP equipment will be via a set of operating displays units arranged such that two operators will be able to operate the BOP equipment.

Each Power Island operator workstation will have a minimum of eight operating display units and three operator display processors. Each operator display processor will have the capability of driving four display units. One operator display processor will be connected to four operator display units and two operator processor units to two operator display units.

The BOP (coal, ash, limestone, H_2 plant, N_2 plant, fuel oil, and low-pressure services (LPS)), Zero Liquid Discharge (ZLD), and Water Treatment Plant will be controlled from a single BOP control suite located in the Station Services Building (SSB).

Three independent and concurrent operations with associated input devices shall be possible. Failure of one operator processor shall limit the loss to one operator input and two operator display units. The functionality of switching the display units connected to the operator processor with four display units to any of the operator processors with the two spare display unit outputs shall therefore be possible.

7.1.4 Design Conditions

7.1.4.1 Environmental Conditions. Design environmental conditions shall be in accordance with Environmental Conditions for Process Control Electronic Equipment and Components Used at Power Stations.

7.2 Control Hardware

7.2.1 Distributed Control System

7.2.1.1 System Configuration. DCS processor, data highway, power supply, and remote I/O communication equipment shall be designed so that a single point failure does not disable any control functions or prevent operator control actions, indications, or alarms. Redundancy shall be maintained for all control components supporting equipment for safe shutdown or turbine water induction prevention.

The six Power Islands and Station Electrical Reticulation will be controlled from a single centralised Power Island Control Suite (PICS) located in the Auxiliary Bay. The PICS should house three control areas, adequately spaced to accommodate all operating activities for the following:

- Control of Power Island 1 to 3 and CCTV monitoring per Power Island.
- The EOD (control of the Station Power Reticulation), iBMS, and CCTV monitoring and control and electrical engineering workstation with two (2) 21” monitors.
- Control of Power Island 4 to 6 and CCTV monitoring per Power Island.
- The design of the three operating areas will be such that it will control traffic to the PICS without losing the operating efficiency benefits gained from the control centralisation concept.

The following will be provided in the PICS:

- Six (6) Power Island Operator workstations – One (1) per Power Island with space accommodation for two operators.
- One (1) EOD operator workstation.
- Shift supervisor workstation (same configuration as engineering workstation).
- Two (2) engineering workstations.
- Ergonomics and work flow studies.
- The design and furniture for all other control suite facilities as specified in 240-56355808(simulator suite, smokers’ room, ablution, offices, conference rooms, permit rooms).
- Design space for one (1) office computer per operator station.
- Design space for a one (1) CCTV viewing facility per operator station.
- Design space for the electrical engineering workstation (including two 21” monitors).

The BOP (coal, ash, limestone, FGD equipment, Hydrogen (H_2) plant, Nitrogen (N_2) plant, fuel oil, and low-pressure services) and Water Treatment Plant will be controlled from a single BOP control suite located in the Station Services Building (SSB). The following will be provided in the BOP control suite:

- One (1) WTP operation workstation (same configuration as Power Island operator workstation).
- One (1) materials handling and LPS operator workstation (same configuration as Power Island operator workstation).
- Two (2) engineering workstations: one for the WTP and one for the materials handling and LPS area.
- Sufficient space for an iBMS workstation capable of controlling and monitoring the iBMS for the complete power plant, including CCTV monitoring and controlling capabilities.
- Ergonomics and work flow studies.
- The design and furniture for all other Control Suite facilities as specified in 240-56355808 (smokers' room, ablution, offices, conference rooms, and permit rooms).
- Design space for one (1) office computer per operator station.
- Design space for a one (1) CCTV viewing facility per operator station.
- HMIs shall be provided in the FGD Electrical Buildings 1-6, FGD Dewatering Building Control Room, and ZLD Electrical Rooms for use during startup and commissioning of the associated equipment.

Simultaneous startup of multiple Power Islands shall be incorporated into the design. The six individual Power Islands will be controlled from the PICS and include all operations including startup, shutdown, load control, transient, and emergency situations.

7.2.1.2 Function Groups. The plant shall be designed into separate function groups. The design of such shall be to meet the plant availability and reliability requirements. Each function group control and input/output shall be implemented in separate redundant processors.

7.3 Instruments and Final Control Devices

Each instrument shall be provided with an instrument nametag/plate. Vendor package instrumentation shall be supplied and tagged in accordance with the Eskom's Kraftwerk Kennzeichen System (KKS) label standard

Instruments shall be designed, specified, and installed in accordance with the applicable requirements specified in the following Eskom documents:

- 240-56355789- Flow Measurements Systems.
- 240-56355843- Pressure Measurements Systems.
- 240-5635588- Temperature Measurements Systems.
- Field Instrument Installation Standard (FIIS) 28 – Electric Actuator Specification.

8.0 Equipment Numbering and System Codes

8.1 Introduction

This section describes the methodology to be used in establishing component identification numbers assigned to equipment and devices for unique identification on drawings, equipment lists, labels, and other documents. Basic criteria are presented for identifying equipment components, including valves, piping, mechanical and electrical accessory devices, instrumentation and control devices, and other types of components associated with the plant. The component identification numbers will be included in the project listings of items and used as appropriate on drawings, equipment lists, and other documents pertaining to the component. The component identification numbers will also be used as computer address codes and on component identification tags.

The component identification numbers are not to be confused with equipment names or their abbreviations, e.g., boiler feed pump (BFP). Official equipment names and nomenclature for use on drawings will be based on the computerized listing of equipment names developed during the initial stage of detailed design.

8.2 Component Identification System

Each component or item separately identified for any project purpose will be given a unique identification number that will be uniformly used in all applicable documents.

The component identification number will be used in computer lists that define other information, such as engineering data.

The Kraftwerk Kennzeichen System (KKS) system will be used for classifying and designating both plant equipment and their associated documents. KKS system usage will be in accordance with Project Alpha KKS Coding and Labeling, Alpha KKS 01. Assignment of KKS identification numbers will be in accordance with Project Alpha Power Station Standard Abbreviations, Alpha KKS 02.

Blocks of KKS designations will be assigned to each contractor as appropriate.

Each contractor shall be responsible for coding all plant equipment within his scope of supply according to the KKS Classification system to Breakdown Level 3. The relevant KKS codes shall appear on all plant related documentation, drawings, lists, and correspondence provided by each contractor. Each contractor shall be responsible for ensuring the accuracy, completeness, and consistency of the designations on all documents. This applies both to designations within documents (plant designations) and of documents (document designations). The methods of KKS designations, list formulation, and submission format shall be submitted for approval.

9.0 Bulk Material Handling System Design Criteria

9.1 General

Bulk material includes limestone, combustion wastes, FGD byproducts, and similar materials typically handled in bulk form.

Electrical and control devices located in areas made hazardous by the presence of combustible dust or explosive gas shall be suitably rated for the hazardous area in accordance with the requirements of the SANS 10142-1, SANS 10108, and any other applicable requirements. A hazard and operability (HAZOP) study shall be completed in accordance with 240-49230111 for each bulk materials handling system prior to the start of design.

Safety standards for conveyors and related equipment shall be incorporated into all conveying equipment and shall be in accordance with Eskom's artefacts will be utilised for the project and in cases where there are not artefacts, SANS will be used. Where there are discrepancies between the standards the more stringent shall apply.

9.1.1 Limestone Handling and Storage

Limestone will be received via rail (either via bottom discharge containers handled by an overhead crane, or via bottom discharge wagons) or truck (side tippers). Limestone will be conveyed to a stockpile via belt conveyors and stocked out via a traveling tripper and boom stacker into a 30-day capacity longitudinal storage pile. Limestone will be reclaimed from the storage pile by a portal scraper reclaimer and conveyed via a belt conveyor and a shuttle belt conveyor to any of three storage bins near the limestone preparation system. Each storage bin will have a capacity of one-half day giving a total of 1.5 days of limestone storage in the bins.

9.1.2 Gypsum Handling and Storage

Dewatered gypsum will be discharged from up to five vacuum filter belts (four normal, one spare) through diverter gates onto a redundant (two parallel conveyor paths to landfill) belt conveyor system. Gypsum will be transferred between conveyor belts via moving conveyor heads at each transfer point. Ultimately, 80 – 100 percent of the gypsum produced will be conveyed to waste storage via the overland ash conveyors, and 0 – 20 percent of the gypsum produced will be conveyed to a covered storage building for sale. At the covered storage building, an elevated traveling tripper will normally form a longitudinal pile of saleable gypsum. This will allow each section of the pile to be tested to ensure saleability before it is reclaimed. Mobile equipment will be employed to reclaim and load saleable gypsum into trucks, or onto a mobile feeder that discharges onto a belt conveyor that supplies a railcar loadout facility. Gypsum found to be unsuitable for selling, or any excess gypsum stored in the pile, will be reclaimed by mobile equipment and loaded onto a mobile feeder that discharges onto a belt conveyor that supplies gypsum to the overland ash conveyors.

The gypsum storage building will be sized to accommodate a linear pile of three days of full gypsum production in case the overland ash conveyors are out of service. Furthermore, mobile equipment can be used to load excess gypsum into trucks for transportation to the disposal site.

9.1.3 Belt Conveyors

Belt conveyors and components shall generally conform to the basic engineering data provided in Belt Conveyors for Bulk Materials by the Conveyor Equipment Manufacturers Association (CEMA). Max inclination of conveyors shall be limited to 14 degrees for limestone and 10 degrees for ash and gypsum.

9.1.4 Hoppers

Hoppers, silos, or day bins shall be provided where required for bulk material unloading or reclaim, for short-term bulk material storage or surge capacity, or for bulk material flow and distribution purposes.

Mass flow hoppers and silos will be preferred to funnel flow designs for most applications. It should be noted that gypsum discharge from any hopper or silo will require an active feed device, not relying on gravity.

9.1.5 Mass Meters

Belt scales shall be of the digital electronic type. Each belt scale will be used for one or more of the following purposes:

- Belt scales will be used for in-plant inventory determination by weighing bulk material receipts and usage.
- Belt scales will be used for process control or monitoring (such as monitoring conveying rates to preclude overloading, controlling blending ratios, and similar applications).

9.1.6 Dust Control

Control of indoor and outdoor fugitive dust emissions will be provided at the ash landfills, for all bulk material handling systems; except wet gypsum handling systems.

Dust control shall be provided to maintain inhalable and respirable dust at or below levels allowed by the Occupational Health and Safety Act, 1993, Hazardous Chemical Substances Regulations, 1995, Annexure 1, Applying Occupational Exposure Limits.

Dust control shall be by dust collection by air entrainment (generally using inlet hoods and ductwork, a fabric filter unit, and an exhaust fan to induce airflow); or by dust suppression systems using water/surfactant solution sprays, foam sprays, fog sprays, or similar systems. Wet dust suppression systems shall be utilized for limestone unloading, storage, and handling systems.

Industrial Ventilation: A Manual of Recommended Practice, published by the American Conference of Industrial Hygienists (ACGIH), shall be used as a guide for dust collection system duct design and for inlet hood design and placement.

Generally, dust collection system ductwork gauges, reinforcements, flanges, bolting, and supports shall be in accordance with the Round Industrial Duct Construction Standards from the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

9.1.7 Gates

Gates shall be provided as required for one or more of the following reasons:

- For diverting or splitting material flow as it passes through a material handling system.
- For cutting off material flow for maintenance or other reasons.
- For cutting off material flow and permitting water drainage from material in exposed hoppers.

9.1.8 Chutework

Enclosed chutes shall be designed to transfer materials between conveyors, feeders, hoppers, and silos.

9.1.9 Magnetic Separators

In-line, self-cleaning magnetic separators may be provided after unloading or reclaim operations to protect crushers or pulverizers, if necessary. Chutework to direct tramp metal to grade shall be provided, along with a collection bin designed with wheels for moving to a nearby truck or dump area, or with slots for forklift transportation, or with lifting lugs for transportation by waste truck.

9.1.10 Instrumentation

Instrumentation for bulk material handling systems shall be provided as described in Section 7.0, Instrument and Controls Design Criteria.

9.1.11 Feeders

Variable rate feeders shall be used as required to control the flow of bulk materials from receiving, reclaim, and surge hoppers. The flow rate will be adjustable, if required, for one or more of the following reasons:

- To compensate for varying operating methods or requirements.
- To compensate for varying material densities or moisture contents.
- To compensate for varying unit load and fuel characteristics.
- Maximum belt feeder speed shall be limited to 0.8 m/s.

Table 9-1
Bulk Material Densities

Material	Volume Design, kg/m³	Structural Design, kg/m³
Fly Ash		
Dry bulk density	800	1 440
Conditioned (20% moisture) bulk density	1 200	1 440
Limestone		
Yard storage	1 360	1 520
Hoppers	1 360	1 840
Belts and supports	1 360	1,840
Wet FGD Byproducts		
Gypsum or scrubber sludge		
Dry compacted landfill (dry density)	1 200	NA
Hoppers, belts, and supports	1 000	1 840
ZLD Solids		
Fresh waste		
Compacted landfill		

Appendix A

Site Location Drawing

Appendix B

System Descriptions

Appendix C

Process Flow Diagrams & Piping and Instrument Diagrams

Appendix D

Not Used

Appendix E

Geotechnical Investigation Report

Refer to the following reference documents:

SPF 200-116980 – Existing Geotechnical Data to Aid Part 1

SPF 200-116988 – Existing Geotechnical Data to Aid Part 2

SPF 200-115317 – Medupi FGD Geotechnical Scope of Works

Appendix F

Conceptual One-Line Diagrams

Appendix G

DCS Architecture Diagram

Appendix H

Soil Resistivity Data

(Refer to the SFP document number 200-29262)

Appendix I

Applicable Legislation and Authorizations

(Refer to the following pages of Appendix G from the Medupi Project Design Manual Rev. 2 SPF200-32065)

Appendix J

Medupi Power Station Stormwater Design Criteria

(Refer to SPF document number 200-3816)

Appendix K

Not Used

Appendix L

Specification Development Outline