NEW YORK STATE ELECTRIC & GAS

Design Criteria

COMPRESSED AIR ENERGY STORAGE PROJECT

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NEW YORK STATE ELECTRIC & GAS
DESIGN CRITERIA
COMPRESSED AIR ENERGY STORAGE PROJECT

SYNOPSIS

This document presents the Design Criteria for the Compressed Air Energy Storage project.

Disclaimer

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE
A	Issued For Review	Christopher Hartline	Harry G. Eisenbise	Harry G. Eisenbise	5/26/2011
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1. PROJECT DESCRIPTION

The Seneca Compressed Air Energy Storage (CAES) Project is a 130 to 210 MW Compressed Air Energy Storage plant that will consist of a separate, electrically driven compression cycle and a natural gas-fired expansion cycle energy storage plant. New York State Electric & Gas (NYSEG) will evaluate two expansion cycle designs for the plant during Phase 1 of the project and will select the most cost effective technology to proceed with Phase 2 project development should the CAES project be approved for development. The first expansion cycle to be evaluated (Cycle #1) will employ expansion turbine generators with natural gas combustors to pre-heat the storage air prior to admitting it into the expanders. The second expansion cycle (Cycle #2) to be evaluated will consist of a simple cycle combustion turbine with a waste heat recuperator downstream of the combustion turbine exhaust that will be used to pre-heat the storage air prior to admitting it into the expanders.

The Seneca CAES plant will provide sufficient storage to allow full operation during the peak time periods, operating in support of the transmission system and market needs, i.e., approximately 10 to 12 hours per day. This capacity is sufficient to provide a wide range of operational and smart grid benefits on the NYSEG utility power system and provide Department of Energy (DOE) and the United States with a credible demonstration of an advanced CAES plant integrated into a smart grid infrastructure in the state of New York. During operation, the CAES plant will cycle from a maximum pressure of approximately 1,500 psig down to a minimum pressure of approximately 1,150 psig. During charging periods, the compression system will increase cavern pressures back to the maximum noted above during an eight to ten hour charging cycle. The charge/discharge cycles can be expected to routinely occur on a daily basis over the 30 year design life of the facility. The cavern and well system design must affirmatively address this cycling duty and the Contractor will be expected to provide detailed assumptions and analyses supporting the design based on this cycling duty.

CAES plants use off-peak electricity to compress air into an underground reservoir or an above ground air storage system. When electricity is needed, the compressed air is withdrawn from the air store, heated via combustion with natural gas or preheated from the exhaust of a natural gas turbine, and passed through an expansion turbine to drive an electric generator. CAES plants burn about one-third the amount of fuel compared to conventional combustion turbines and produce about one-third the pollutants per kilowatt hour (kWh) generated compared to a conventional combustion turbine.

The advanced CAES facility will generally charge during off-peak periods when excess, low-cost electricity is available and discharge during on-peak hours. Unique to this project, the CAES facility will be capable of quickly switching from charging to discharging to further take advantage of system needs during on-peak periods when the wind generation is beyond the system needs or there is a sudden loss of wind generation. In doing so, more renewable energy can be captured and/or controlled while reducing the extreme volatility in market pricing and operation. In this way, there is a better asset utilization of wind/renewable energy and reduction in the need to purchase ramping and regulation from conventional fossil fuel based power plants.

The overall objective of the advanced CAES demonstration project is to improve reliability of the grid and do so by creating storage and more desirable dispatch for wind energy, which is expected to accelerate instability and congestion in the future when the predicted large amounts of wind generators (forecasted to be about 3,000 MW in New York Independent System Operator (NYISO) queue) are brought on line. The proposed advanced CAES project will enable New York State wind farms to store their output during periods of low demand and then dispatch this stored energy in response to market signals during peak and intermediate load time periods.

There are three phases of the proposed project:

- Phase 1: Develop final engineering design including project capital costs; develop project financials based on the engineering design and updated forecasts of energy market revenues; characterization of the salt cavern to be used for air storage; draft environmental permit exhibits; draft NYISO interconnection filing information and exhibits.

- Phase 2: Plant construction with a target in-service date of late 2016.

- Phase 3: Commercial demonstration, testing, performance reporting.

2. DESIGN CRITERIA

The criteria presented herein are subject to change during the development of the plant design. Final data are defined by the following approved engineering documentation (including but not limited to):

- Piping and Instrumentation Diagrams (P&IDs)
- Piping Line Specifications
- Equipment Procurement and Technical Specifications
- Vendor Data
- Water and Heat Balance Diagrams
- One Line Diagrams

2.1 Design Assumptions

The assumptions presented herein are subject to change during the development of the plant design. Final data are defined by approved engineering documentation.

- Compressed air operating pressures at the wellhead flange are 1,150 psig minimum and 1,500 psig maximum.
- For piping and fuel gas system sizing design, maximum compressed air operating pressure downstream of control valve is 850 psig for Cycle #1. For piping design, maximum compressed air operating pressure downstream of wellhead flange is 1,150 psig for Cycle #2.
- During compression, the average air flow rate at -2 °F. ambient and 170 MW at the wellhead flange is 690 lb. / second for Cycle #1 and 680 lb. / second for Cycle #2 at 1,150 psig and 95 °F.
- During generation, the average air flow rate at maximum generation at the wellhead flange is 400 lb. / second for Cycle #1 and 600 lb. / second for Cycle #2 at 1,150 psig and 95 °F.

- During generation, the minimum air temperature at the wellhead flange will be below dewpoint and will require insulation and water traps.
- Usable cavern volume will be approximately 15 million ft^3.
- Transmission line maximum limit is 210 MW generation capability.
- Transmission line maximum limit is 170 MW compression load capability.
- Circulating cooling water would range from 60 °F. in January to 80 °F. in July.
- Maximum of 8 to 10 hour compression cycle to go from minimum to maximum wellhead pressure.
- Fuel gas is available at 700 psig to 800 psig.
- Emission limits are approximately 2 ppm NOx, 2 ppm CO, 5 ppm NH_3 slip, and below the 40 tons / year Volatile Organic Compound (VOC) threshold.
- Redundancy and sparing philosophy 2 x 100 % (same as RG&E Russell Station project).
- Elevation is approximately 1,000 feet above MSL.
- Three design points for ambient weather conditions are -2°F, 50% RH; 45°F, 60% RH; and 87 °F, 46% RH.
- Fuel gas analysis same as RG&E Russell Station project.
- Two means of egress are required for the site.
- There is a propane and butane loading, unloading, and above ground storage facility on the property immediately adjacent to the site and at a higher elevation that the CAES plant.
- Cooling tower plume abatement is an option.
- Administration and maintenance facilities similar to RG&E Russell Station project.
- Perimeter noise levels to be 45 dBA.

- Construction limitations similar to RG&E Russell Station project due to nearby homes.
- Design for a manned facility.
- Administration building to include visitor center and parking for up to 20 visitor vehicles.
- New York State Department of Environmental Conservation State Pollutant Discharge Elimination System non-significant minor permit wastewater discharge limits are assumed and standard United States sanitary requirements for septic and drain fields are assumed.

SITE SPECIFIC DATA

General:

Location:	Reading Center, New York
Elevation (feet above mean sea level)	1,000
Outdoor Ambient Temperature Range:	(-)2 to 87 °F
Outdoor Ambient Design Temperature for HVAC (ASHRAE 2009)	
Summer (1.0% cooling):	87˚F DB, 71°F WB
Winter (99.6% heating):	(-) 2˚F DB
Design Indoor Temperature Range (Control Room, DCS Room, Office Areas, Electrical Rooms):	70 to 75°F
Design Indoor RH Range (Control Room, DCS Room, Office Areas, Electrical Rooms):	40 to 60% RH
Design Indoor Temperature Range for Ventilated Areas	45 to 90° F

Structural Data:

Building Design Codes:	IBC 2006 ASCE 7-05
Wind Load	
Exposure Category (IBC 2006, Section 1609.4)	C
Basic Wind Speed, V (IBC 2006), mph	90
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 6-1)	1.15
Snow Load	
Ground Snow Load, p_g (IBC 2006, Figure 1608.2)	35 psf
Exposure Category (IBC 2006, Section 1609.4)	C
Exposure Factor C_e (ASCE 7-05, Table 7-2)	1.0
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 7-4)	1.1
Rainfall	
Annual Average, inches	36
10 yr, 24 hr, inches	3.9
25 yr, 24 hr inches	4.5
Earthquake Loads	
Site Class (IBC 2006 Table 1613.5.2)	C
Mapped Spectral Response Acceleration, short period, Ss (IBC 2006 Figure 1613.5(1))	0.162 g
Mapped Spectral Response Acceleration, 1 second period, S_1 (IBC 2006 Figure 1613.5(2))	0.054g
Seismic Design Category (IBC 2006 Table 1613.5.6(1) & Table 1613.5.6(2))	A
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 11.5-1)	1.25

Electrical Data:

AC Power			
Medium Voltage	13.8 kV	3P, 3W	60 Hz
Low Voltage Power	480 V	3P, 3W	60 Hz
	208/120V	3P, 4W	60 Hz
Motors			
<= 1/3 hp motor (Except MOVs)	115 V	1P, 2W	60 Hz
> 1/3 hp but < 250 hp motor and MOVs	460 V	3P, 3W	60 Hz
>= 250 hp motor	13.2 kV	3P, 3W	60 Hz
Welding Receptacles	480 V	3P, 3W	60 Hz
Lighting	480 V	3P, 4W	60 Hz
DC Power			
Control Circuits	125 VDC	NA	NA
Instrument Power	120 VAC	1P, 2W	60 Hz

Mechanical Data:

Maximum Cooling Water Temperature, deg F	80
Site Air	
Instrument Air Maximum Pressure, psig	125
Instrument Air Dewpoint, ºF	-40
Service Air Maximum Pressure, psig	125
Instrument / Service Air Maximum Temperature, ºF	100
Noise Requirements	
Near Field (3 feet horizontally, 5 feet vertically from machine baseline	90 dBA
Far Field (Plant equiment measured 400' from plant site)	45 dBA

Notes:

None

SENECA CAES PROJECT VALUE DRIVERS

Purpose:

This document presents an overview on the different operating modes in which the Seneca CAES is anticipated to operate and the key parameters that will make such operation, and thus the project, successful.

Bidders should optimize these key parameters - moderated against the goals of producing a facility that is characterized by its safety, simplicity of operation, and reliability; and moderated by the incremental cost of further optimizing any particular key parameter.

Key Parameters:

Compression (Cavern Charging):

Minimum time required to charge 5 million cubic foot cavern from its minimum charge of 480 psig to 1,340 psig as measured at well head, limited by maximum available line capacity of 200 MVA with 0.85 power factor. Grade is approximately 1,000 feet above MSL and the top of the cavern is approximately 1,200 feet below MSL.

Turn down to allow compression at reduced available power down to 40 MVA.

Confirm whether compressor-motors can be de-coupled to operate in synchronous condenser mode. If feasible, provide “D” curves (leading and lagging), how much energy is required to spin them, and what is the maximum capacity.

Generation:

Minimum output value (meeting emissions limits).

Maximum output value (limited to same available line capacity as above.)

Heat rate and energy ratio – provide values for each 10% increase in output levels, starting at zero output.

Minimum start-up time – provide time to achieve each 10% increase in total output up to full load.

Confirm a minimum ramp rate of 8 MW/min, up and down, when operating above minimum load.

Minimum time to go from compression to generation. Minimum time to go from generation to compression. Target for both is 5 minutes or less.

SENECA CAES PROJECT VALUE DRIVERS

Minimum time to achieve synchronization.

Confirm whether expanders-generators can be de-coupled to operate in synchronous condenser mode. If feasible, provide "D" curves (leading and lagging), how much energy is required to spin them, and what is the maximum capacity.

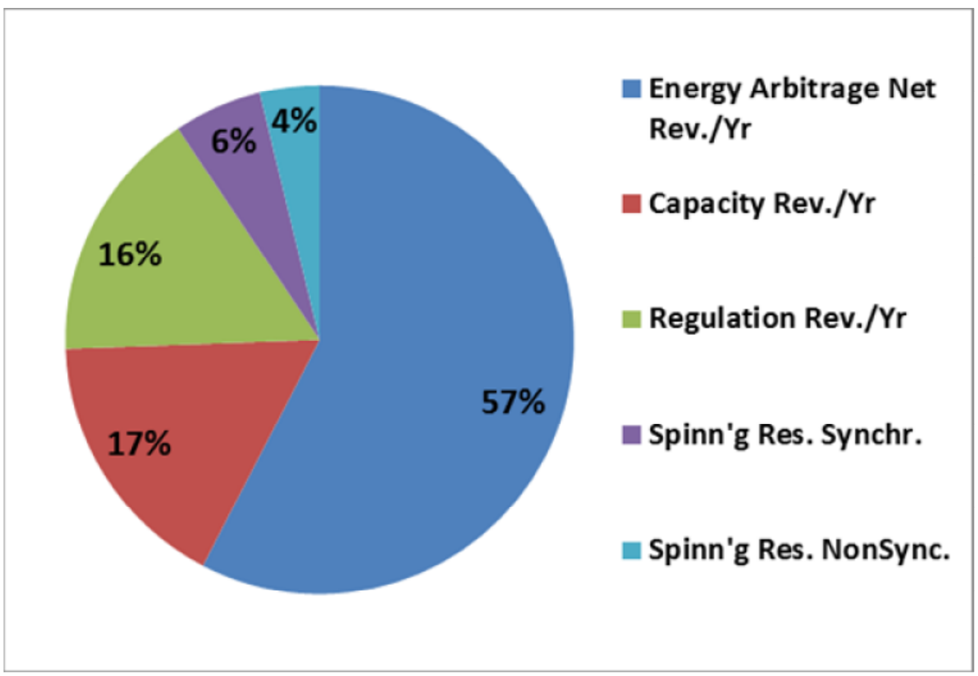
Combined:

What is the breakpoint for energy ratio or heat input with respect to going from 480 psig to 1,340 psig?

Other:

Confirm that black start capability can be provided and provide option price for this feature.

Expected Revenue Opportunity Breakdown:



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NEW YORK STATE ELECTRIC & GAS

Mechanical Design Criteria

COMPRESSED AIR ENERGY STORAGE PROJECT

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CONTENTS

1.0 INTRODUCTION

This document establishes the criteria for materials, design, fabrication, examination, testing, inspection, and certification required in the manufacture and installation of items for mechanical work.

While this document provides general guidance, it is not a substitute for good engineering judgement which should be applied as appropriate with the approval of the Lead Mechanical Engineer.

2.0 BASIS OF DESIGN

2.1 Plant Operating Modes

The plant will be designed for operating modes involving daily starting and stopping. The plant will be designed to operate over the range of conditions given in the project heat balances.

Equipment sizing will be performed based on conditions shown on the heat balances and water balances.

Units

The project will use the standard unit system.

Guaranteed Values

The guaranteed performance data will be achieved under the conditions detailed below.

Ambient Air Conditions

All guaranteed values will be achieved at the specific ambient conditions for the project including dry bulb temperature, relative humidity, and barometric pressure.

Combustion Turbine and Burners Fuel

All guaranteed values will be achieved when the equipment is burning natural gas.

Plant Load

The guaranteed net output for the plant, and the guaranteed auxiliary power consumption will be achieved when operating at the 100% MCR base load, at the below ambient conditions.

2.2 Basis for Performance Guarantees

Plant Performance Guarantees, under the stated ambient conditions:

- Fuel: Natural Gas
- Guarantee values:

  Net plant output: 135,800 kW Cycle #1

  209,900 kW Cycle #2

  Net plant heat rate, (HHV): *4,335* Btu/kWh Cycle #1

  4,267 Btu/kWhr Cycle #2

- Basis for plant performance:

  Circulating water temperature: 60 to 80 °F

  Generator terminal power factor: 0.85 Cycle #1

  0.90 Cycle #2

  Generator terminal frequency: 60 Hz.

2.3 Noise Emissions

Location	Parameter	Units	Value
Near Field	Indoor and outdoor plant equipment measured 3 ft horizontally and 5 ft above the machine baseline.	dB(A)	85
Far Field	Plant equipment measured at the 400 foot distance from the plant site.	dB(A)	45 (based on 30 to 40 ambient + 6)

2.4 Site Conditions

Design ambient dry bulb / relative humidity: 45 °F / 60%

Maximum ambient dry bulb / relative humidity: 87 °F / 46%

Minimum ambient dry bulb / relative humidity: -2 °F / 50%

Barometric pressure:	14.2 psia
Elevation above mean sea level	1,000 feet

3.0 CODES, STANDARDS, AND REFERENCES

The design and specification of all work will be in accordance with all applicable industry codes and standards. A summary of the codes and industry standards to be used in design and construction is listed below:

- Air Conditioning and Refrigeration Institute (ARI).
- Air Diffusion Council (ADC).
- Air Movement and Control Association International (AMCA).
- American Bearing Manufacturers Association (ABMA).
- American Boiler Manufacturers Association (ABMA).
- American Gear Manufacturers Association (AGMA).
- American Institute of Steel Construction (AISC).
- 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 Nondestructive Testing (ASNT).
- American Society of Sanitary Engineers (ASSE).
- American Society for Testing and Materials (ASTM).
- American Welding Society (AWS).
- American Water Works Association (AWWA).
- Cast Iron Soil Pipe Institute (CISPI).

- Conference of Governmental Industrial, Hygienists - Industrial Ventilation, A Manual of Recommended Practice.
- Cooling Technology Institute (CTI).
- Ductile Iron Pipe Research Association (DIPRA).
- Expansion Joint Manufacturers Association (EJMA).
- Factory Mutual (FM).
- Fluid Sealing Association (FSA).
- Heat Exchange Institute (HEI).
- Hoist Manufacturers Institute (HMI).
- Hydraulic Institute (HI).
- International Organization for Standardization (ISO).
- Manufacturers Standardization Society of the Valve and Fitting Industry, Inc. (MSS).
- Mechanical Power Transmission Association (MPTA).
- National Fire Protection Association (NFPA).
- NSF International.
- Occupational Safety and Health Administration (OSHA).
- Pipe Fabrication Institute (PFI).
- Rubber Manufacturers Association (RMA).
- Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA).
- SSPC: The Society for Protective Coatings (SSPC).
- Tubular Exchanger Manufacturers Association (TEMA).
- Underwriter’s Laboratories (UL).

Other recognized international standards will be used as required to serve as design, fabrication, and construction guidelines when not in conflict with the above-listed standards.

The codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including all addenda, in effect on the date as stated in equipment and construction purchase or contract documents.

4.0 EQUIPMENT SELECTION

4.1 General Requirements

This plant will be designed to be highly reliable. It is essential that the plant design and equipment selection be conservative and based upon proven and reliable designs. The plant will be designed to permit ease of access for operation, repair, and maintenance. All frequently operated, inspected or maintained items will be accessible by means of stairs, platforms, or ladders. All heavy motors, reducers, and wear elements not accessible by a fork lift or a mobile crane, will generally be accessible by an overhead crane or monorails.

Sizing of equipment will be based on the design flow rates, capacities, temperature, and pressure, as shown on the heat flow diagrams. Equipment will also be capable of sustained operating at normal flow rates, and occasionally, at minimum flow rates.

Manufacturer's information used during the design phase of the project will take into consideration possible clearance or interference problems resulting from final equipment selection.

Equipment selection will also take into consideration the environmental conditions of the project.

Equipment will be designed to operate on a continuous, 24-hour basis for the conditions specified, unless otherwise approved by the Owner.

This section is devoted to mechanical hardware and equipment including pumps, piping, valves, tanks, and insulation and lagging. In specifying this equipment, the system engineer will consider material selection carefully with corrosion mitigation/prevention in mind. This is critical when developing equipment specifications, piping line specifications, and technical specifications (i.e. bedding & backfilling, coatings, paint, etc). The system engineer will interface with corporate as well as external resources as needed to define these items.

Early project studies of soil conditions and raw water quality will determine buried pipe materials, coatings, fasteners and aboveground piping materials. Project-specific corrosion control recommendations for materials coatings, cathodic protection, and chemical treatment will be determined by the responsible system engineer in conjunction with corporate and external resources. Corrosion mitigation/prevention details will be enumerated in the following project-specific documents:

- Piping Materials Service Index listing piping recommended materials, design requirements, and associated Piping Line Specifications.
- Cathodic Protection Technical Specification in coordination with Electrical Engineering.
- Coatings/paint selections for piping, equipment, and tanks, in coordination with Structural Engineering.
- Materials, corrosion, coatings, and related recommendations will also be inserted into Equipment and Technical Specification documents within the project work scope.

4.2 Equipment Numbering

Equipment will be numbered in accordance with the project numbering system.

4.3 Pumps

4.3.1 General

Pumps will be selected with a shutoff head at least 115 to 125% above the design total head, where possible.

4.3.2 Pump Design Margin for Miscellaneous Pumps

The capacity margin should be 5 % rounded off to the next higher step as follows:

Capacity, gpm	Step, gpm
10,000 – 100,000	500
1.000 – 10,000	50
100 – 1,000	5

A total head margin of 5 % is normally adequate. After adding the 5 %, the total head should be rounded off to the next whole foot for less than 100 foot application and to the next 5 feet for more than 100 foot total head pumps.

The diameter of the impeller for the design flow point will not exceed 90 % of the diameter of the largest impeller than can be installed in the casing.

The pump motors will be sized to permit the pump to operate anywhere on the certified pump curve without overloading

4.4 Tanks

4.4.1 Field Erected Tanks

Field erected tanks will be designed to AWWA (typically water storage) and NFPA 22 (for fire fighting). Tanks will be specified using the WorleyParsons standard specification and any project-specific requirements.

Tank connections requiring expansion joints will be provided with block valves between the tank connection and the expansion joint to allow for repair or replacement of the expansion joint without draining the tank. Where the tanks are a suction source for a pump or pump manifold and the pumps are on a foundation independent from the tank foundation (non-monolithic), an expansion joint will be used at the tank nozzle (after valve) to allow for differential settlement.

The following features will be provided:

- Process, vent (may require a conservation vent depending on process fluid), overflow, and drain connections for startup, operation, and maintenance. Depending on the fluid stored, the tank vent may require a filter and the tank a vacuum breaker.
- Materials will be compatible with the fluid being handled. Carbon steel tanks will have a minimum interior corrosion allowance of 1/16-inch unless coated or lined.
- Personnel access opening(s) for maintenance or cleaning access. Add davit and hinge to manway opening to support manway during entry.
- Shop-installed insulation clips and insulation support rings for tanks requiring insulation (clips will not be spaced greater than 18-inches on center).
- Ladders, stairs and platforms as required for access and maintenance. Handrails and non-skid paint on roof.
- Depending on process fluid, a double wall tank or dike may be required. Multiple tanks inside a common dike may require a small separation dike in accordance with NFPA 30.
- Consideration will be given to welded or bolted construction depending on cost and client preference.
- The tanks provided with sloped bottom will have drains as close to the low point of the bottom as possible.
- Tanks will be provided with overflow sized to handle 1.5 times the total maximum design inflow to the tank.

4.4.2 Shop Fabricated Tanks

Consideration should be given to designing atmospheric tanks in accordance with the requirements of ASME B&PVC, Section VIII, Division 1 without the code stamp. Tanks will be specified using the WorleyParsons standard specification and any project-specific requirements. The following features will be provided:

- Process, vent, and drain connections for startup, operation, and maintenance.
- Materials will be compatible with the fluid being handled. Carbon steel tanks will have a minimum interior corrosion allowance of 1/16-inch unless coated or lined.
- A minimum of one personnel access opening and one air ventilation opening (e.g., handhole), where required for maintenance or cleaning access.
- Shop-installed insulation clips and insulation support rings for tanks requiring insulation (clips will not be spaced greater than 18 inches on center)
- Coating and cathodic protection design consideration for tank intemals and externals will be coordinated on a project-specific basis.

4.4.3 Pressure Vessels

Shop fabricated tanks will be designed in accordance with the requirements of ASME B&PVC, Section VIII, Division 1, and provided with a code stamp. Tanks will be specified using the WorleyParsons standard specification and any project-specific requirements. The following features will be provided:

- Pressure vessels will be designed in accordance with the requirements of ASME B&PVC, Section VIII, Division 1.
- Relief valves will be in accordance with the applicable codes.
- Process, vent, and drain connections for startup, operation, and maintenance.
- Materials compatible with the fluid being handled. Carbon steel tanks will have a minimum interior corrosion allowance of 1/16-inch unless coated or lined.
- A minimum of one personnel access opening and one air ventilation opening (e.g., handhole), where required for maintenance or cleaning access.
- Shop-installed insulation clips and insulation support rings for tanks requiring insulation (clips will not be spaced greater than 18-inches on center)

4.5 Combustion Turbine Generator and Accessories

The Cycle #2 combustion turbine generator will be provided with inlet air filtration system; inlet silencer; hydraulic control oil systems with cooling provisions; excitation starting systems; acoustical enclosures including heating and ventilation; control systems including supervisory; fire protection; and fuel systems. The combustion turbines will fire natural gas, and will use a dry, low NOx combustion system.

The generator will be provided with the combustion turbine package. The generator will be the manufacturer's standard, constructed to meet ANSI and NEMA standards for turbine-driven synchronous generators.

Significant features of the combustion turbine generator are as follows:

- Lubricating and hydraulic oil system.
- Oil-to-water lube oil coolers.
- Fuel gas system, including liquid separators, flow orifice meters, startup strainers, and pressure regulating valves.
- Inlet air filtration system.
- Exhaust system.
- Fire protection/detection system (utilizing FM200 or equal).
- Starting system.
- Turbine compartment vent fans.
- Generator compartment vent fans.
- Generator water/air heat exchangers.
- Turbine controls.
- Generator controls, protection, excitation, power system stabilizer, and automatic governor control.
- Neutral grounding and surge protection equipment.
- 125 V DC battery system for each unit.
- Online/offline water wash system.

- Piping, valves, piping specialties, and instrumentation.

4.6 Air Expander Generator and Accessories

The air expander generator will be provided with all auxiliary systems for a complete operating air expander generator.

The generator will be provided with the air expander turbine package. The generator will be the manufacturer's standard, constructed to meet ANSI and NEMA standards for turbine-driven synchronous generators.

Significant features of the air expander turbine generator are as follows:

- Cycle #1 will have LP and HP burners.
- High pressure inlet stop and control valves.
- Low pressure inlet stop and control valves (Cycle #1 only).
- Seal system.
- Exhaust casing blowout diaphragms.
- Lagging.
- Local gauge panel.
- Actuated drain valves.
- Lubrication system.
- Hydraulic power unit.
- AC motor-driven turning gear.
- Control system.
- Generator.
- Generator excitation system.

4.7 Recuperator

The recuperator is designed to recover heat from the air expander exhaust and transfer it to the compressed air feed for Cycle #1 or to recover heat from the combustion turbine exhaust and transfer it to the compressed air feed for Cycle #2. The recuperator is designed to be fully integrated into the heat cycle and includes required inlet/outlet ducts, structural supports, piping, and accessories.

The recuperator proper is designed, fabricated, and inspected in accordance with the requirement of Section I (Power Boilers) of the ASME Boiler and Pressure Vessel Code (B&PVC) for both technical and administrative jurisdiction.

The recuperator external piping is furnished in accordance with the requirements of ASME B31.1 Power Piping (for technical jurisdiction only) and ASME, Section I, B&PVC (for administrative jurisdiction only).

All valves, trim, and accessories necessary for the operation of the recuperator are provided.

A system of platforms, stairways, and ladders is provided for inspection and maintenance access to valves and instrumentation. Access lanes are provided within the recuperator for inspection. Each lane is equipped with an access door.

An Inlet duct system is provided to deliver the air expander exhaust for Cycle #1 or the combustion turbine exhaust for Cycle #2 to the recuperator inlet. The duct system includes an expansion joint and horizontal ducting. The duct is designed to meet pressure drip limitations and distribute the exhaust gas to the inlet.

An outlet duct system is provided to deliver recuperator exhast to the stack. The outlet transition duct is provided with personnel protection (expanded metal) to a height of 8 feet. Stand-offs are provided for attachment of the expanded metal.

The recuperator heat transfer sections, steam drum, inlet/outlet, duct systems, and interconnecting piping are supported by a support structure designed in accordance with the equipment data, the site conditions and the applicable structural codes and standards.

Stairways, ladders, and platforms are provided for operation and maintenance access to valves. Instrumentation, steam drums, emission test ports, and stack closure. All stairways and platforms are provided with handrails and kick plates. Platform grating and stair treads are open, hot dipped galvanized steel

Recuperator interconnecting piping is provided to transfer heat from the recuperator to the compressed air feed. The piping is supported from the recuperator support structure.

4.8 Process Air Compressors

The process air compressors will be supplying atmospheric air to three interconnected 5 million cubic feet caverns for storage at pressures ranging from 1,150 to 1,500 psig. The desired compression time is 8-10 hours. The desired efficiency will be greater than 80%.

The compressors will be provided with inlet air filtration system; inlet silencer; starting systems; inter stage and after coolers; acoustical enclosures including ventilation; control systems.

Significant features of the process air compressors are as follows:

- Inlet air filtration system.
- Inter stage and after air to water coolers.
- VFD starting system.
- Isolation and control valves.
- Water wash system.
- Lagging.
- Local controls and instruments.
- Actuated vent and drain valves.
- Lubrication system.
- Oil to water coolers.
- AC synchronous motor.
- Control system.

4.9 Piping

Review project piping specification CAES-0-TS-15062.

Piping will be designed, selected, and fabricated in accordance with the following criteria:

<u>Design Temperature and Design Pressure</u>

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

- The design temperature of a piping system generally will be based on the maximum sustained temperature that may act on the system plus 10 °F except where specific design guides or criteria stated herein dictate otherwise. The piping design temperature will be rounded up to the next 5 °F increment, unless otherwise noted.

- The design pressure of a piping system generally will be based on the maximum sustained pressure that may act on the system plus 25 psi, unless otherwise noted in the specific design parameters for the system. All design pressure values will be rounded up to the next 10 psi increment, unless otherwise noted.

Piping Design and Selection Criteria

- Piping will be designed in accordance with the requirements of ASME B31.1 Power Piping and other codes and standards referenced in Section 3.0, as applicable. WorleyParsons standard piping line specifications will be used; special wall piping applications will require project-specific line specifications.

- Piping that is 1-1/4-, 3-1/2-, 5-, or 7-inches in nominal diameter will not be used for general system design. However, it is recognized that short segments may be required at connections to equipment.

- Minimum wall thickness of straight pipe under internal pressure will be designed in accordance with Paragraph 104.1.2 and 104.1.4 of ASME B31.1, as applicable.

- Allowable Fluid Velocities

The recommended range of fluid velocities will be as follows:

SERVICE	**VELOCITY**	**RESULTANT ΔP** psi/100 ft (steel pipe)
STEAM		
LP saturated ≤ 30 psig	1,000 fpm/inch ID: 1,000 to 12,000 fpm	Calculate
MP saturated ≤ 200 psig	1,000 fpm/inch ID: 1,500 to 12,000 fpm	Calculate
WATER		
General service discharge 2” to 6”	5 to 8 fps	Calculate
8” and over	5 to 12 fps	
Suction 2 to 6 inches	2 to 4 fps	
Suction 8 inches & over	3 to 5 fps	
Circulating Water 8” & over	6 to 12 fps	Calculate

SERVICE	VELOCITY	RESULTANT ΔP psi/100 ft (steel pipe)
AIR		
Compressed air (≤100 psig)	700 fpm/inch ID: 900 to 4,500 fpm	Calculate
Compressed air (>100 psig)	500 fpm/inch ID: 600 to 3,000 fpm	Calculate
GAS		
Fuel	3,000 fpm maximum(for noise consideration)	

- Allowance for variations from normal operation, consideration for local conditions, and transients will be in accordance with Paragraphs 102.2.4 and 102.2.5 of ASME B31.1.

- The calculated value of SE will not exceed that given in Appendix A of ASME B31.1 for the respective material at the design temperature. These values include the weld joint efficiency. For longitudinal welded or spiral welded pipe operating in the creep range, paragraph 104.1.4 will be complied with.

- The value of A must be selected to compensate for material removed in threading, corrosion, erosion, and to provide mechanical strength. The following minimum allowances should be applied:

  – Special wall piping 2-1/2-inches (65 mm) and larger – The value of A will be at least 0.01-inch (0.25 mm) on alloy steel pipe and 0.06-inch (1.52 mm) on carbon steel pipe.

  – Schedule wall piping 2-1/2-inches (65 mm) and larger (typically considered large bore pipe) – The value of A will generally be 0.01-inch (0.25 mm) on alloy steel pipe and 0.06 inch-(1.52 mm) on carbon steel pipe except when additional thickness is considered necessary for a specific service.

  – Schedule wall piping 2-inches (50 mm) and smaller (typically considered small bore pipe) – The value of A should be selected to provide adequate mechanical strength. The minimum A value of 0.01-inch (0.25 mm) on alloy steel pipe and 0.06-inch (1.52 mm) on carbon steel pipe is suggested, but is not mandatory.

  – Threaded piping – The value of A will not be less than the depth of thread. Threading of pipe will consider minimum wall thickness. For small bore pipe, this implies using at least schedule 80 material.

- The pressure-temperature ratings for seamless and ERW (welded with no filler) schedule wall pipe will be based on minimum wall values, which are 87-1/2 percent of the nominal pipe wall thickness per ASME B31.1. This allows for the minus 12-1/2 percent manufacturing tolerance on wall thickness. For the design of ASME flow nozzles, the vendors must consider this allowance when detailing the OD of nozzles and the weld lip for insertion into steam lines.

- Material selection will generally be based on the design temperature and service conditions in accordance with the following:
  - All power cycle piping will be of metallic material.
  - The use of fibreglass-reinforced plastic (FRP), high-density polyethylene (HDPE), chlorinated polyvinyl chloride (CPVC), and polyvinyl chloride (PVC) piping will be limited as shown in Table 1.
  - Carbon steel piping materials will be used for design temperatures less than or equal to 800 °F (427 °C).
  - Chromium-molybdenum alloy steel or stainless steel piping materials will be used for design temperatures great then 800 °F (427 °C).
- Stainless steel piping materials will be used as follows:
  - Piping applications requiring a high degree of cleanliness generally including air compressor inlet piping, miscellaneous lubricating oil system piping, instrument air piping, and sampling piping after process isolation valves.
  - Piping generally subjected to corrosive service applications.
  - Material selection will be performed by the system engineer using corporate and external resources on a per system basis generally following the above and will be documented in a project-specific Piping Materials Service Index as follows:
    - The Piping Materials Service Index will be updated by the system engineer and the corrosion engineer throughout the project as design, operating, and shut-in conditions are determined / revised.
    - The Piping Materials Service Index serves as an input to all Piping Line Specifications and Piping and Instrumentation Diagrams.
    - Materials selection for water-wetted components will reference the project-specific Water Quality Analysis Report including raw and treated water, cycles of concentration, and chemical treatment considerations, as well as the chemical treatment plan.

- o Materials selection may also consider the worst case of normal operation, peak load, partial load, and shut-down conditions.

Table 1
Application of PVC, CPVC, HDPE and FRP Piping

Application Chart

Application	HDPE	PVC/CPVC	FRP
Power Plant Thermal Cycle	None	None	None
Circulating Water System	X	None	X
Water Treatment System drains (above grade)	None	None	X
Water Treatment System drains (below grade)	X	X	None
Fire protection water, underground	X	None	None
Fire protection water, aboveground	None	None	None
Cast into concrete	X	None	X
Plant Equipment and Drains Piping	X	X	X
Overflow Drains on Chemical Solution Tanks	X	X	X
Wastewater	X	X	X
Roof Drains	X	X	X
Potable Water (aboveground)	None	None	None
Potable Water (belowground)	X	None	None
Sodium Hypochlorite	None	X	None

Additional application rules for plastic (CPVC, PVC, FRP, and HPDE) piping:

- Limited to low-pressure applications. Generally limited to 75 psig.
- Temperature for nonmetallic piping will be limited to the temperature listed in ASME B31.1, except where designed in accordance with governing plumbing codes (in these cases, use industry/manufacturer ratings as applicable)
- Detailed installation and fabrication specifications will be used.
- Certification of joiners will be specified.
- Flanged and threaded pipe will be avoided, when possible, in chemically aggressive applications.
- Underground fire protection loops using HDPE must employ FM 200 rated pipe. Also consider the use of cement-lined ductile iron.

Copper and/or stainless steel piping materials will be used for instrument air piping downstream of the air dryers. Carbon steel will be used for instrument air systems upstream of the air dryers and throughout service air systems.

Copper piping materials will be used for aboveground potable water piping, including safety showers and eyewashes. HDPE piping will be used for underground potable water systems. Copper may be used as an alternative to HDPE provided that the soil conditions are favourable (i.e. not elevated levels of sulphate or chlorides and not retaining significant moisture).

The Piping Materials Service Index will document above and below ground piping materials on a project-specific basis.

The above-listed materials will be used where required for special service to meet specific requirements.

Miscellaneous Piping Design and Selection Criteria

The minimum pipe size and wall thickness for miscellaneous piping, other than control and instrument piping, will generally be in accordance with the following criteria:

- The pipe size will be ¾-inch minimum, except for sample piping and cycle chemical feed piping. However, it is recognized that short segments of ½-inch pipe may be required at connections to equipment.
- Sample piping will be 1/4-inch, 3/8-inch, or 1/2-inch stainless steel tubing or piping to maintain proper velocities and response times.
- In general, all carbon steel, low alloy steel, and stainless steel will be specified for but welding or socket welding as appropriate. The use of flanges will be limited to connection to equipment or required for maintenance. A gas tungsten arc weld (GTAW) root pass will be specified where required for cleanliness. These systems will include all main power cycle systems such as steam, feedwater and condensate, oil systems, natural gas systems and stainless steel systems (both socket and butt welded joints).
- Cycle chemical feed piping will be ¼-inch and 3/8-inch stainless steel tubing.

Vent and Drain Piping Design Criteria

High point vent and low point drain piping will generally be in accordance with the following criteria:

- The recommendations of ASME TDP-1 will be followed for all power cycle steam piping drains.
- Vent and drain piping through the isolation valve or drain line termination will be as described for miscellaneous piping and will be consistent with the piping for the main piping system.
- Vent connections will be provided at all high points in water and oil piping, and all high points in other piping, including steam lines, which will be pressure tested.
- Drain connections will be provided at all non-drainable low points in steam, water, and oil piping, and all other piping, which will be pressure tested.
- Drain connections will be provided at all control valve stations. The drain will be located to drain the control valve as completely as possible.

- All vent and drain connections will be provided with manually operated isolation valves in accordance with the following table:

SYSTEM	**VENT**	**DRAIN**
Steam	Globe	Globe
Natural Gas	Ball	Ball
Compressed Air	Not Vented	Ball
Lube Oil	Globe or Ball	Globe or Ball
All Others	Gate or Ball	Gate or Ball

- Piping systems such as steam systems may have the high point vent valve omitted following pressure testing, with the vent connection plugged by welding a fitting in place of the vent valve. ASME B31.1, paragraph 137.8, will be consulted for re-hydro requirements when welds have been completed on the pressure boundary after the first hydro.

- Vent and drain connections that require frequent operation will be piped to a suitable drain. Vent or drain connections that normally require operation when hot fluids will be discharged will be piped to a safe termination point (drain funnel or floor area discharge). All other connections will terminate with the isolation valve.

- Valved vents: Piping highpoint vents will be 1-inch minimum size, capped, for piping sizes being vented that are equal to, or greater than, 1 inch. Use two valves in series for Class 900 systems and higher; one valve is used for Class 600 and lower.

- Valved drains: Piping low point drains will be 1-inch minimum size, valved, nippled, and capped for piping sizes being drained that are equal to, or greater than, 1 inch. Use two valves in series for Class 900 systems and higher; one valve is used for Class 600 and lower.

- Drain pot drains will be minimum 2-inch to accommodate cleaning of the piping by high pressure water blast.

Piping Materials

Piping materials will be in accordance with applicable ASME, AWWA, and ASTM standards. Materials to be incorporated in permanent systems will be new, unused, and undamaged. Piping materials will generally be in accordance with the following criteria and will be documented by system on a project-specific basis in the Piping Materials Service Index:

Ductile Iron Pipe

Ductile iron piping (sizes 3 to 16-inches) will be AWWA.

Carbon Steel Pipe

Carbon steel piping 2-inches nominal size and smaller will typically be ASTM A 106 or A53, Grade B minimum.

Carbon steel piping 2-1/2-inch through 24-inch nominal size will be ASTM A 53, Grade B seamless or A 106, Grade B Carbon steel piping larger than 24-inch nominal size will be ASTM A 672, Grade C70 seam welded Class 22 for steam service with an operating temperature less than 800°F, and ASTM A 672, Grade B60, Class 22, Grade B or A 106 Grade B for cold water service. API-5L, Grade B may be used as an alternate for cold water service and AWWA C200 may be used for circulating water.

The use of ASTM A 53 piping material will be limited to 2-1/2-inch nominal size and larger piping, with a design temperature of 200 °F or less and a maximum design pressure of 200 psig.

Electric Fusion welded steel pipe will be of the welded straight seam type.

Schedule numbers, sizes and dimensions of all carbon steel pipe will conform to ASME B36.10.

Stainless Steel Pipe

Stainless steel pipe will be ASTM A 312, Grades TP 304, TP 316, or TP 316L, seamless/welded piping. All stainless steel piping materials will be fully solution annealed before fabrication. Type 316 will be used for high resistance to corrosion. Type 316L will be used for handling solutions that are high in chlorides.

Steel plate piping will be of the welded straight-seam type.

Sizes and dimensions of stainless steel pipe designated as Schedule 5S, 10S, 40S, or 80S will conform to ASME B36.19. Schedule numbers, sizes, and dimensions of stainless steel pipe not designed as 5S, 10S, 40S, or 80S will conform to ASME B36.10.

Small bore fuel oil and lube oil piping will use socket-welded joints.

Copper Tubing

Copper tubing will conform to ASTM B 88 Seamless Copper Water Tube. For both aboveground and underground service, only type K is to be used; types L & M will not be used.

Polypropylene-Lined Pipe

Polypropylene-lined pipe will be ASTM A 53 Grade B steel pipe seamless/welded with an applied liner of polypropylene. The pipe will be the type as manufactured by Resistoflex Corporation or WorleyParsons approved equal.

Fiberglass-Reinforced Plastic Pipe

Fiberglass-reinforced plastic pipe will be chosen in accordance with the specific service requirements. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III. WorleyParsons standard fittings/piping database uses RPS/ABCO. The use of another supplier dictates adjustments to the database for routing of pipe.

Polyvinyl Chloride Pipe

Polyvinyl chloride (PVC) pipe will conform to ASTM D 1785 or ASTM D 2241. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III.

Chlorinated Polyvinyl Chloride Pipe

Chlorinated polyvinyl chloride (CPVC) pipe will conform to ASTM D 1784. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III.

High Density Polyethylene Pipe

High density polyethylene pipe (HDPE) will conform to ASTM D 3350. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III.

Alloy 20 Pipe (UNS N08020)

CR-Ni-Fe-Mo-Cu-Cb stabilized alloy piping (Carpenter Steel Alloy 20) will conform to ASTM B 464 or B 729.

Pipe Fittings

Cast Steel-Flanged Fittings

Cast Carbon steel-flanged fittings will conform to ASME B16.5 and be manufactured from materials conforming to ASTM A 216 Grade WCB and WCC.

Welded Steel Fittings

Reducing outlet tees or specially designed adapters will be used for branch piping 2-1/2 inches and larger. The type of branch connection will be determined as indicated in the WorleyParsons piping specifications. If not addressed in the piping specifications, Mechanical Engineering Standards DS-169-13 and DS-169-14 will be followed. Specially designed adapters will be postweld heat treated, when required by the material specification and the ASME Code requirements. Specially designed adapters will be Weldolets, Sweepolets or forged nozzles as manufactured by Bonney Forge Corporations, WFI International, Inc. or WorleyParsons approval equal. Welded steel fittings will conform to ASME B16.9 and B16.11 and materials conforming to ASTM A 105, A 182, and A 234 as applicable. Circulating water pipe fittings greater than 24-inch will conform to AWWA C208.

Branch connections 2-inches and smaller will be made with special reinforced welding adapters such as Bonney Forge Thredolets or Sockolets or WorleyParsons approved equal, or will be special welded and drilled pads.

Brass and Bronze Fittings

Screwed brass and bronze pipe fittings will be designed to match the pressure temperature ratings of the pipe. Molded fittings will be used where practical. Fabricated fittings will be produced with smaller SDR (i.e. thicker) piping as required to meet the ratings of the matching pipe.

High Density Polyethylene (HDPE) Fittings

High density polyethylene fittings will be designed to match the pressure temperature ratings of the pipe. Molded fittings will be used where practical. Fabricated fittings will be produced with smaller SDR (i.e. thicker) piping as required to meet the ratings of the matching pipe.

Polypropylene-Lined Ductile Iron Fittings

Flanged ductile iron fittings used with polypropylene-lined steel pipe will be ductile iron fittings conforming to ASME B16.42 and will be lined with the same material as the pipe with which they are used.

Fiberglass-Reinforced Plastic Fittings

Fittings and joints for use with fiberglass-reinforced plastic pipe will be compatible with and furnished by the same company as the fiberglass pipe.

Polyvinyl Chloride Fittings

Polyvinyl chloride pipe and fittings will be manufactured from PVC material of the same type as the pipe with which they are used. The fittings will have socket ends with internal shoulders designed for solvent cementing.

Chlorinated Polyvinyl Chloride Fittings

Chlorinated polyvinyl chloride fittings will be manufactured from CPVC material of the same type as the pipe with which they are used. The fittings will have socket ends with internal shoulders designed for solvent cementing.

Flanges, Gaskets, Bolting, and Unions

Flanged joints will be in accordance with the following requirements:

Flange Selection

Flanges mating with flanges on piping, valves, and equipment will be of sizes, drillings, and facings that match the connecting flanges of the piping, valves, and equipment.

Flange class ratings will be adequate to meet the design pressures and temperatures specified for the piping with which they are used.

Flanges will be constructed of materials equivalent to the pipe with which they are used.

Steel Flanges

Steel flanges will conform to ASME B16.5 for sizes through 24-inch (600 mm) and ASME B16.47 from 26-inch (650 mm) through 60-inch (1500 mm).

Low pressure circulating water system pipe flanges 26-inches (650 mm) or larger will conform to AWWA C207.

Steel flanges will have raised-face flange preparation. Flat-face flanges will be used to mate with cast iron, ductile iron (except class 250), high density polyethylene, fiberglass-reinforced plastic, polyvinyl chloride, or bronze flanges.

Carbon steel flanges will be of ASTM A 105 material. Carbon steel flanges will not be used for temperatures exceeding 800 °F (400 °C).

Chromium alloy steel and stainless steel flanges will conform to ASTM A 182.

Brass and Bronze Flanges

Brass and bronze screwed companion flanges will be plain forced and will conform to class 150 or class 300 classifications of ASME B16.24. Drilling will be in accordance with ASME class 125 or class 250 standards.

High Density Polyethylene Flanges

HDPE flanged connections will be made with HDPE flange adapters (stub end type) and metallic lap joint flanges (i.e. back-up rings). Flanges will be designed to be leak tight for hydrotest at 1.5 times the pipe ratings.

Gaskets

Non-metallic gaskets will be used with flat-face and raised-face flanges within the limitations of the gasket materials. Spiral-wound gaskets will be used with raised-face for steam, high temperature and flammable (fire-safe) service. No asbestos containing gaskets will be specified.

Gaskets will be suitable for the fluid design pressures and temperatures. Unconfined, non-metallic gaskets will not be used above 720 psig (4964 kPa) or 750 °F (399 °C) per ASME B31.1.

Non-metallic Gaskets

Non-metallic gaskets will be in accordance with ASME B16.21, and materials will be suitable for the system design conditions and be compatible with the system fluids. Gaskets will be dimensioned to suit the contact facing. Gaskets will be full faced for flat-face flanges and will extend to the inside edge of the bolt holes on raised-face flanges. Gaskets for plain-finished surfaces will be not less than 1/16-inch (1.6 mm) thick. Gaskets for serrated surfaces will be not less than 3/32-inch (2.4 mm) thick. The gasket will be selected for the service requirements in accordance with the recommendations of the manufacturer.

Spiral-Wound Gaskets

Spiral-wound gaskets will be in accordance with ASME B16.20 and be constructed of a continuous stainless steel ribbon wound into a spiral with non-asbestos filler between adjacent coils. The gasket will be inserted into a steel gauge ring whose outside diameter will fit inside the flange bolts properly positioning the gasket. The gauge ring will serve to limit the compression of the gasket to the proper value. Compressed gasket thickness will be 0.130-inch (3.3 mm) plus or minus 0.005-inch (0.13 mm). For temperatures to 800 °F the filler material will be Flexible Graphite, as manufactured by Flexitallic Gasket Company or WorleyParsons approved equal. For temperatures between 800 °F and 975 °F the filler material will be thermiculite as manufactured by Flexitallic or WorleyParsons approved equal. Flexicarb filler will be specified for fuel gas service. Inner ring gaskets, Flexitallic Style CGI will be specified for vacuum service, erosive service, temperatures exceeding 950 °F (510 °C) and where winding failure can damage downstream rotating equipment. Style CGI is required for all ASME class 900 and higher flanges and for all flanges with a surface finish smoother than 125 rms. Style CG will be used for ASME class 600 and lower flanges.

Ring Joint Gaskets

Ring joint gaskets will be octagonal in cross section and will have dimensions conforming to ASME B16.20. Material will be suitable for the service conditions encountered and will be softer than the flange material.

Rubber Gasket

Rubber gasket materials will conform to ASME B16.21. They will be full face and 1/16-inch (1.6 mm) or 1/8-inch (3.2mm) thick as recommended by the vendor and industry standards.

Bolting and Unions

Alloy steel bolting will be used for joining all steel flanges, except for large diameter low pressure water pipe flanges and will conform to the following:

- Bolting will conform to the requirements of ASME B16.5.
- Bolting will consist of threaded studs and two nuts for each stud.
- Bolted joints are not permitted above 975 °F (524 °C).
- Material for studs will be ASTM A 193, Grade B16, for piping design temperatures between 800 °F (427 °C) and 975 °F (524 °C), and Grade B7 for piping design temperatures less than 800 °F (427 °C)
- Material for nuts will be ASTM A 194, Grade 3, for piping design temperatures between 800 °F (427 °C) and 975 °F 524 °C), and Grade 2H for piping design temperatures less than 800 °F (427 °C).
- Carbon steel bolting will be used for joining flanges on large diameter, low pressure water piping and will conform to the following:
- Bolting will conform to the requirements of ASME B16.1 and ASME B16.24.
- Bolting for bolt sizes 1-1/2-inches (40 mm) and larger will consist of threaded studs and two nuts. Bolting for bolt sizes less than 1-1/2-inches (40 mm) may be threaded studs and nuts or bolts and nuts.

- Bolts and nuts will be heavy hexagonal head conforming to ASME B18.2.1 and B18.2.2.

Buried bolting and bolting outdoors will be zinc plated in accordance with ASTM A 153. Fasteners may also be stainless steel. Buried bolting will be specified consistent with other Buried Piping corrosion recommendations.

Piping unions will be of the ground joint type constructed of materials equivalent in alloy composition and strength to other fittings in the piping systems in which they are installed. Union class ratings and end connections will be the same as the fittings in the piping systems in which they are installed.

Insulating Flanges

Where required, underground piping will be electronically isolated from aboveground piping and other steel components to allow the underground piping to be cathodically protected. Isolation will be by installation of isolation flanges with insulating gaskets, bolt tubes, and washers (Pikotek or approved equal)

Insulating kits will be fire tested when used in or in close proximity to flammable liquid or gas systems (Pikotek or approved equal).

Piping Fabrication

Piping fabrication will generally be in accordance with the requirements stated herein.

Dimensions

The dimensions indicated on the drawings will not make allowance for welding gaps or welding shrinkage. Allowances will be made for gaskets in the dimension indicated. Fabrication tolerances will be in accordance with PFI Standard ES-3, “Fabricating Tolerances.”

The wall thickness and outside pipe diameter of all special wall piping will be measured and recorded before fabrication. The spool weights of all special wall piping will be calculated based on the actual dimensions of the piping.

Fittings

Fitting such as tees, crosses, elbows, caps, and reducers will be used for all changes in direction, intersections, size changes, and end closures of piping, unless the use of fittings is impractical.

Couplings will be used for joining straight lengths of 2-inch (50 mm) and smaller piping.

Branch welds and mitered fittings will not be used except where specifically required. The radius of mitered fittings will be greater than or equal to the diameter of the pipe. Mitered segment angles will not exceed 15 degrees for aboveground piping and 11-1/2 degrees for below ground piping.

Welding adapters, drilled and welded pads, and branch weld connections will be reinforced to meet the requirements of paragraph 104.3 of ASME B31.1. Safety valve nozzles will be additionally reinforced, as required, to resist thrust due to valve operation and will be designed in accordance with ASME B31.1 Non-Mandatory Appendix II Rules the Design of Safety Valve Installations.

Backing Rings

Backing rings are not permitted.

Bends

Pipe bending will be used only when specifically designated on the piping drawings or where the use of elbows is impractical.

All bends will be smooth, without buckles, and truly circular. The allowable flattening, as determined by the difference between the minor and major axes, will not be greater than 5 percent of the nominal diameter.

Allowance will be made for thinning of the pipe wall in accordance with the requirements of paragraph 102.4.5 of ASME B31.1 to ensure that minimum wall thickness after bending is not less than the minimum wall thickness required.

Brazed Joints

Brazing will be accomplished in accordance with the requirements specified in ASME B31.1.

Brazing filler metals will be either silver or copper-phosphorus alloys. Filler metals containing phosphorus will not be used for brazing steel or nickel base materials.

High Density Polyethylene (HDPE) Pipe Joints

Joints in high-density polyethylene (HDPE) piping will be fusion welded in accordance with the pipe manufacturer's recommendations. Where physically impractical to use the fusion bonding machine, electro-fusion couplings and fittings may be used with prior approval.

Fiberglass-Reinforced Plastic Pipe Joints

Fiberglass-reinforced plastic piping will be in accordance with the pipe manufacturer's standards. The type of joint (bell/taper or butt-wrap) will be agreed upon by all parties prior to detailed design commencing.

Certified joiners will make all joints. Individual joiners will be trained and tested under a Bonding Procedure and program developed in accordance with ASME B31.1, Appendix III for the specific pipe brand, type of joint, and pipe sizes to be used.

The Bonding procedure will be submitted for review before beginning the work. The certification program will provide training and examination of persons who will assemble the pipe joints. The certification program will include as a minimum, equipment training, joint preparation, fitting, bonding, curing, repair, and testing by written examination and by testing of a joined pipe.

A copy of the current certification for each joiner will be submitted before starting the work by any particular joiner.

PVC and CPVC Pipe Joints

Joints in polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) piping will be the solvent-cemented type using methods recommended by the pipe manufacturer.

Solder Joints

Soldering will be in accordance with requirements specified in ASME B31.1.

Solder filler metals will be 94 Tim – 6 Silver accordance with ASTM B 32 Grade Sn94.

<u>Buried Piping:</u>

Corrosion control of buried piping will be determined by the responsible System Engineer using corporate as well as external resources. Designed considerations and deliverables will include:

- Coatings will be specified based upon review of the project-specific Geotechnical Engineering Soil Test Report, the P&ID's, and the system design and operating requirements.

- Cathodic protection for buried piping must be coordinated through the Electrical Engineer on a project, system, material, and segment/location-specific basis.

- Flange insulation kits are required on al buried piping systems that are cathodically-protected or in close proximity to other cathodically-protected piping.

- Buried piping above 180 °F may require special coatings and backfill requirements. Piping above 240 °F will not be buried.
- Buried piping will also consider design requirements for pigging and/or other non-destructive testing methods.

4.10 Valves

Valve pressure classes, sizes, types, body materials, and end preparations will generally be as described herein. Special features and special application valves will be used where required.

Valves specified to have flange, socket welded, or screwed connections will have ends prepared in accordance with the applicable ASME standards. Steel flanges will be raised-face type, unless otherwise required. Cast iron and bronze flanges will be flat-faced type. Butt-welding ends will be prepared for GTAW root-pass in accordance with ASME B16.25 Figures 4, 5B, or 6B as appropriate.

Steel body gate, globe, angle, ball, and check valves will be specified and constructed in accordance with ASME B16.34, as applicable. Valve bodies and bonnets will be specified to suppose the valve operators (handwheel, gear, piston, diaphragm, or motor) with the valve in any position without external support.

<u>Steel Body Gate, Globe, and Check Valves 2-inches and Smaller</u>

Steel body valves 2-inches (50 mm) and smaller will have forged steel bodies. Forged steel valves complying with the standards and specifications listed in Table 126.1 of ASME B31.1 will be used within the manufacturer’s specified pressure temperature ratings with the following limitations. The use of ASME class 600, 1500, 2500, and 4500 forged steel valves will be limited in accordance with the pressure temperature ratings specified in ASME B16.34. API class 800 valves may be substituted for class 600 valves.

Class 600, 800, 1500, 2500, and 4500 forged steel valves will be constructed as follows:

Class 600 and 800 valves will be specified with bolted bonnet joints. Class 1500, 2500, and 4500 valves will have pressure seal, welded bonnet or bolted bonnet joints (limit is Class 1500); valves may be used with integral bonnets. Gate, globe, and angle valves will have outside screw and yoke construction.

All valves, except gate valves, will have seats specified as hardened cobalt alloy (stellite or equal), integral type. Gate valves may have renewable or integral seats.

Class 1500, 2500, and 4500 globe valves will be of the Y-pattern type with removable – loose or threaded-in – back seat design.

Valve ends will be socket weld type, unless otherwise required.

Except as otherwise required, check valves will be of the guided piston or swing disk type. All check valves except guided piston will be designed for installation in either horizontal piping or vertical piping with upward flow. Guided piston check valves must be installed in horizontal piping.

<u>Steel Body Gate, Globe, and Check Valves 2-1/2-Inches and Larger</u>

Steel body gate, globe, and check valves 2-1/2-inches (65 mm) and larger will have either cast steel or forged bodies. The face-to-face and end-to-end dimensions will conform to ASME B16.10. The use of these valves will be in accordance with the pressure temperature ratings specified in ASME B16.34, as applicable.

Gate, globe, and angle valves will be provided with back seating construction. Gate, globe, and angle valves will be of outside screw and yoke construction. Gate valves 4 inches (100 mm) and larger will have flexible wedge disks. Valves will have full-size ports, except where venturi ports are specifically permitted. The use of valves with venturi ports will be limited to selected large diameter, high-pressure valve applications.

Class 150, 300, and 600 valves 2-1/2-inches (65 mm) and larger will be specified as follows:

Bonnet joints will be of the bolted flanged type having flat-face flange facing for class 150 valves and male and female facings for class 300 and 600 valves.

Body ends will be butt weld type, unless otherwise required.

Class 600, 900, 1500, 2500, and 4500 valves 2-1/2-inches (65 mm) and larger will be constructed as follows:

Bonnet joints will be of the pressure seal type.

All Class 600, 900, 1500, 2500, and 4500 valves will have grease-lubricated, anti-friction-bearing yoke sleeves.

Body ends will be butt weld type, unless otherwise required.

Check valves used on multiple pump discharge installations, and on other applications in which the valves may be subjected to significant reverse flow water hammer or fluid surges, will generally be the non-slam, tilting-disk or double disk water type. All other check valves will be of the guided piston, swing disk, or double-disk spring check type. All check valves except guided piston will be designed for installation in either horizontal piping or vertical piping with upward flow. Guided piston check valves must be installed in horizontal piping. The use of double-disk wafer spring check valves will be limited to 4-inch and larger cold water services. Stop check valves, where specified, will be Y-pattern globe type or angle pattern.

Iron Body Valves

Iron body gate, globe, and check valves will have iron bodies and will be bronze mounted. The face-to-face dimensions will be in accordance with ASME B16.10 or appropriate AWWA standards. These valves will have flanged bonnet joints. Gate and globe valves installed aboveground will be of the outside screw and yoke construction. Body seats will be of the renewable type. Gate valves will be of the wedge disk type.

Butterfly Valves

Resilient-seated butterfly valves will be in accordance with MSS SP-67 or AWWA C504. Valves of the wafer or lug-wafer type will be designed for installation between two ASME flanges. Valves with flanged ends will be faced and drilled in accordance with ASME B16.5, B16.47 or AWWA C207 as required to match the piping system into which it is installed. The selected use of butterfly valves will be in accordance with the pressure and temperature ratings specified in industry standards, the pressure and temperature ratings specified by the manufacturer, and as specified in the following criteria:

Resilient/rubber-seated single and double offset butterfly valves will generally be used for 4-inch (100 mm) and larger cold water services only.

Consideration should be given to removing a section of pipe and having the ability to dead-end the upstream or downstream section of piping remaining. This is achieved with a lug style body butterfly valve.

Butterfly valves for buried service will be of cast or ductile iron body materials and will be equipped with flanged ends.

Cast iron butterfly valves will have pressure classes selected, based on the piping design pressure as follows:

Piping Design Pressure	Valve Class
25 psig (172.4 kPa) and below	Class 25
Above 25 psig (172.4 kPa) to 75 psig (517.1 kPa)	Class 75
Above 75 psig (517.1 kPa) to 150 psig (1034.2 kPa)	Class 150

Cast iron butterfly valves will be limited to use with piping systems having a design temperature of 125 °F (52 °C) or less.

Butterfly valves for other than buried service will be carbon steel or cast iron body material, depending on the service application. Valves 26-inches (650 mm) and larger will have flanged ends. Valves 24-inches (600 mm) and small will be the wafer type, or lug-wafer type, if used with steel or alloy steel piping, and will be flanged if used with other piping materials (cast iron, ductile iron, FRP, PVC, CPVC, etc.).

Resilient/rubber seated carbon steel butterfly valves will be limited to use with piping systems having designed temperature of 400 °F (204 °C) or less and will be specified in accordance with manufacturers limitations for the resilient seating material specified.

High performance single and double offset butterfly valves for special service applications will be the wafer or lug-water type and will be designed for installation between ASME flanges – Class 150 and 300. These valves will be fabricated from either carbon or stainless steel with either PTFE or RTFE seats recessed in the body and the disc will be 316 SS. These valves are position-seated, bi-directional and rated for dead-end service. These valves will be in accordance with MSS-SP-68 and API-609. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

High performance triple offset metal torque seated butterfly valves designed in accordance with MSS SP-68, API-609 and inherently fire-safe per API-607 will be used where applicable in main power cycle systems. These valves will be ASME Class 150, 300, or 600. These will be specified for use between ASME flanges (specified as narrow, double flanged) or as butt weld end connection.

Bronze Body Valves

Bronze gate and globe valves 2-inches (50 mm) and smaller will have union bonnet joints and screwed ends. Gate valves will be inside screw, rising stem type with solid wedge disks. Globe valves will have renewable seats and disks.

Bronze check valves 2-inches (50 mm) and small will be Y-pattern, swing disk type, or guided piston type will be designed for satisfactory operation on both horizontal piping and vertical piping with upward flow. Guided piston check valves must be installed in horizontal piping.

The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer and in accordance with the criteria established in MSS SP-80. Bronze valves will generally be class 200 and will be limited to service with piping systems having design pressures of 200 psig (1379 kPa) or less, and design temperatures of 150 °F (66 °C) or less.

Bronze valves will generally be limited to a size of 3 inches (800 mm) or less.

Plug Valves

Plug valves will be of the eccentric, or PTFE sleeve plug type, as required by the service. Lubricated plug valves are not permitted. Plug valve bodies will conform to the requirements of ASME for dimensions, material thickness, and material specifications. Bonnets will be of the bolted flange type. Body ends will be flanged, faced, and drilled for installation between ASME flanges. The use of these valves will be in accordance with pressure temperature ratings specified by the manufacturer.

Ball Valves

Ball valves bodies 2-inches (50 mm) and smaller will have threaded or socket weld end connections. Ball valves 2-1/2-inches (65 mm) and larger will have flanged or butt weld ends.

The valves will not require lubrication. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

Valves specified for use in cold water, instrument air, service air, gas, oil and chemical service will be use PTFE seats. In addition, ball valves specified for natural gas, hydrogen, and compressed air service will be specified for fire safe service and conform to the latest version of API-607. Ball valves specified for use in steam service will be metal seated. Ball valves will normally be specified with a regular port unless a full ported valve is required.

Ball Valves specified in steam service will be metal seated and in accordance with ASME TDP-1 2006. The Hard Coatings on the Metal Seated Ball and Seat will either be HVOF Chrome Carbide with a bond strength of 10,000 psi minimum or Chromium Carbide Spray & Fused with a bond strength of 70,000 psi minimum. For Actuated/High Cycle Chrome Body F11/F22/F91 Metal Seated Ball Valves above 580 °F a Chromium Carbide Spray & Fused or approved equal is recommended. Metal Seated Ball Valves will have bore sizes in accordance with ASME TDP-1 2006 paragraph 3.7.13.

Diaphragm Valves

Diaphragm valves will be straight-away or weir bodies with flanged ends faced and drilled for installation between ASME flanges. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

Polyvinyl Chloride (PVC) and Chlorinated Polyvinyl Chloride (CPVC) Valves

PVC and CPVC valves will be constructed entirely from polyvinyl chloride, chlorinated polyvinyl chloride, and PTFE. Bodies will be double-entry flanged or true union screwed type. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

Valve Materials

Valve bodies will generally be constructed of materials equivalent to the pipe with which they are used. Valve body and trim materials of construction will be in accordance with applicable ASTM and ASME standards.

The main cycle system valves will be free of copper materials to allow the cycle to be treated at the optimum pH for corrosion protection of carbon steel components.

Valve Operators

Valves will be provided with manual or automatic operators, as required, for the service application and system control philosophy. Automatic operators will be motor, piston, or diaphragm type.

Manual operators will be lever, handwheel, or gear type, with the use of lever operators to be limited to valves requiring a maximum of 90 °F stem rotation from full open to full closed position on valve sizes 6-inches (150 mm) and smaller. All operators will be sized to operate the valve with the valve exposed to maximum differential pressure (maximum system pressure minus atmospheric). Rim pull will be limited to 80 lbs.

The use of gearing for manually operated valves will generally be as follows. Some service applications, seats and valve types may require that gear operators be used on valves smaller than as indicated in the following.

Class	**Gate, Globe**	**Butterfly**	**Ball**
150	≥ 8”	≥ 8”	≥ 8”
300	≥ 8”	≥ 8”	≥ 6”
400 and 600	≥ 6”		≥ 4”
900	≥ 4”		≥ 4”

Valve Special Features

Valves will be provided with locking devices, handwheel extensions, vacuum service packing, limit switches, and other special features, as required. Locking devices, when furnished, will allow the valve to be locked either open or closed with a standard padlock. Limit switches, when furnished, will be provided for the open and closed position of the valve.

All valve bonnets for valves potentially exposed to high temperatures over 150 °F (66 °C) will be provided with internal drains. The drains will prevent the bonnets from being exposed to excessive pressure when the bonnet is full of water and the valve is exposed to elevated temperatures.

Valves will not be equipped with bypass, unless specifically required.

4.11 Insulation and Lagging

The insulation and lagging to be applied to piping, equipment, and ductwork for reducing heat loss, reducing sweating, and providing personnel protection will be in accordance with the following criteria:

Insulation Materials

Insulation materials will be specified to contain no asbestos, chlorides, or halogens.

All piping operating from 140 °F to 850 °F will be insulated for heat conservation or personnel protection with mineral fiber insulation in accordance with ASTM C 547 and as stated in the project-specific insulation thickness table.

All piping operating above 850 °F will be insulated for heat conservation or personnel protection with calcium silicate molded insulation in accordance with ASTM C 533 and as stated in the project-specific insulation thickness table. Piping operating above 140 °F and subject to foot traffic or other compressive loads will use calcium silicate.

All outdoor piping and equipment will be designed to have a surface temperature that does not exceed 140 °F with an outdoor ambient temperature and a wind speed based on project-specific site design conditions.

All indoor piping and equipment will be designed to have a surface temperature that does not exceed 140 °F with an indoor ambient temperature based on project-specific site design conditions.

All piping and equipment not insulated for economic reasons in excess of 140 °F surface temperature that is personnel accessible will be insulated, covered, or guarded for personnel protection. Personnel accessible is defined as 7 feet from floor and 15 inches from handrail.

Equipment and ducts operating at elevated temperature will be insulated with fibreglass or mineral fiber blanket insulation.

Mineral fiber blanket insulation will be in accordance with ASTM C 592, Class II.

Insulating cements will be mineral fiber thermal insulating cements and will conform to ASTM C 195.

Anti-sweat insulation will be flexible elastomeric cellular thermal insulation, ASTM C552. Outdoor anti-sweat insulation will be protected with paint or lagging in accordance with the manufacturer's recommendations.

Piping and small-diameter cylindrical equipment installation will be hollow cylindrical shapes, split in half lengthwise, or curved segments. Large-diameter cylindrical equipment and other items of equipment will be insulated with block or scored block insulation, as required, to obtain a close fit to the contour. Pipe fittings and accessories will be insulated, using either molded insulation or by insulation fabrication from straight pipe insulation segments.

Ducts will be insulated where required for thermal conservation or personnel protection. Ducts with external stiffeners will have the insulation installed over the stiffeners so that the stiffeners are insulated and a level surface achieved.

Lagging Materials

All insulated surfaces of equipment, ductwork, piping, and valves will be lagged using aluminum lagging 0.016-inches thick up to 72-inches in diameter. Use 0.024-inch lagging over 72-inches in diameter.

All aluminium lagging will be in accordance with ASTM B209. Aluminum lagging will be stucco embossed and painted or anodized to obtain a minimum outer surface emissivity of 0.80.

Insulation Classes for Piping and Equipment

Piping and equipment insulation thickness are calculated for project-specific design conditions using the WorleyParsons standard calculation spreadsheet for insulation thickness (PPSD Insulation.xls). The insulation classes for piping systems will be designated by letters, which will be indicated in the pipeline listing.

Minimum insulation thickness is based on 140 °F surface temperatures, which is derived from ASTM C 1055, "Heated System Surface Conditions That Produce Contact Burn Injuries." Jacketing will be stucco embossed aluminum painted or anodized to obtain a minimum outer surface emissivity of 0.8.

The insulation for piping accessories will be of the same type as indicated for the piping. Insulation materials for miscellaneous piping and equipment will be suitable for the actual operating temperatures and will, whenever possible, be of the same insulation type as insulated main piping and equipment operating under similar temperatures.

Anti-sweat Insulation

All indoor aboveground cold water piping will be provided with anti-sweat insulation with the exception of piping in which fluid flow is not normally expected.

Heat Tracing

Heat trace and insulate stagnant water lines per site-specific datasheet. Also, heat trace and insulate stand-by water lines per system operating philosophy.

4.12 Cycle Makeup System

4.12.1 General

The cycle makeup system produces demineralized water for plant makeup. It also stores and transports demineralized water. Uses of demineralized water include air expander low NOx burners and combustion turbine cleaning.

The water treatment portion of the system is done using a reverse osmosis and electrodeionization system for water pretreatment and demineralization.

Makeup water is taken from the demineralized water storage tank and sent to the plant when necessary.

4.12.2 Demineralized Water Storage Tank

Quantity:	One.
Location:	Outdoors on foundation at grade.
Construction:	Design in accordance with AWWA D100.
Material:	Stainless steel.
Design Pressure:	Atmospheric.
Design Temperature:	Use range of minimum to maximum ambient temperatures.

4.12.3 Cycle Makeup Pumps

Design Temperature:	Equal to maximum ambient temperature.
Design Pressure:	Cold water shutoff head of the cycle makeup pumps plus a design margin of 25 psi rounded to the next highest 10 psi.
Material:	ASTM A 312 Grade 316 stainless steel.

Capacity:	Based on the total feedwater flow to the air expander low NOx burners.
Total Head:	Calculated based on system requirements with 5% margin on total head rounded to the next highest 5 feet.
Type:	Horizontal, centrifugal, motor driven.

4.13 Ammonia Storage and Forwarding System

4.13.1 General

The ammonia storage and forwarding system provides for the safe unloading, storage, and forwarding of ammonia solution to the selective catalytic reduction modules in the recuperator.

4.13.2 Ammonia Storage Tank

Design Pressure:	50 psig and full vacuum.
Design Temperature:	120 °F.

4.13.3 Ammonia Pumps

Design Temperature:	Equal to maximum ambient temperature.
Design Pressure:	Shutoff head of the cycle makeup pumps plus a design margin of 25 psi rounded to the next highest 10 psi.
Material:	ASTM A 312 Grade 316 stainless steel.
Capacity:	Based on the total flow to the recuperator selective catalytic reduction system need.
Total Head:	Calculated based on system requirements with 5% margin on total head rounded to the next highest 5 feet.
Type:	Horizontal, centrifugal, motor driven.

4.14 Circulating Water System

4.14.1 General

The circulating water system will consist of a cooling tower, circulating water pumps, and interconnecting piping. The heated circulating water from the compressors will be cooled by a counterflow, mechanical draft cooling tower with single speed fans. Circulating water will be treated to control corrosion, biological growth, and pH.

4.14.2 Design Parameters

Main Circulating Water System:

Design Pressure:	Based on the shutoff head of the circulating water pumps.
Velocity:	In accordance with Section 4.8

4.14.3 Special Requirements

Pumps will have motor operated butterfly valves on discharge, interlocked with pump start-up operation. Expansion joints at the pump discharge will be specified with control rods.

4.14.4 Pump Trash Screens

Each circulating water pump suction bay is protected by a trash screen to remove large debris at the inlet to the circulating water pump basin.

Design Flow:	Equal to circulating water pump flow.
Maximum ΔP with 50% clean screens:	1 foot of water.

4.15 Circulating Water Chemical Feed System

4.15.1 General

The circulating water chemical feed system consists of the sodium hypochlorite feed system, the acid feed system, and the corrosion/scale inhibitor feed system.

Biological fouling of the circulating water system is controlled by periodic injection of sodium hypochlorite.

The corrosion/scale inhibitor feed system transfers corrosion/scale inhibitor to the cooling tower basin based on cooling tower make-up flow.

For pH control of the circulating water 66 degree Baume' sulfuric acid is pumped into the cooling tower basin using a metering pump.

4.15.2 Sodium Hypochlorite

Design Parameters

Chemical:	Sodium hypochlorite.
Pressure at the diffuser:	50 psig.

Storage Tank

Size:	Tote bin.
Pressure:	Atmospheric.
Material:	Polyethylene.

Chemical Feed Pumps

Quantity:	Two 100% capacity.
Location:	On skid with accessories.
Type:	Positive displacement, diaphragm type metering pump.
Materials:	PTFE diaphragms and PVC wetted parts.
Piping Material:	CPVC.

4.15.3 Acid Design

Parameters

Chemical:	Sulfuric acid.

Storage Tank

Size:	Tote bin.
Pressure:	Atmospheric.

Chemical Feed Pumps

Quantity:	Two 100% capacity.
Location:	On skid with accessories.
Type:	Positive displacement, diaphragm type metering pump.
Materials:	PTFE diaphragms and Alloy 20 wetted parts.

4.15.4 Corrosion Inhibitor

Design Parameters

Chemical:	Corrosion/scale inhibitor.

Storage Tank

Size:	Tote bin.
Pressure:	Atmospheric.

Chemical Feed Pumps

Quantity:	Two 100% capacity each.
Location:	On skid with accessories.
Type:	Positive displacement, diaphragm type metering pump.
Materials:	PTFE diaphragms and 316 stainless steel wetted parts.

4.16 Wastewater Collection and Treatment System

4.16.1 General

The wastewater collection and treatment system receives, segregates, and transfers all plant liquid waste streams.

The wastewater collection and treatment system consists of an oil / water separator, sumps, and sump pumps to collect the plant wastes and transport them.

Chemical spills for the chemical feed areas are contained locally to the spill area by curbs and are removed from the site by a special waste truck.

4.16.2 Oil / Water Separator

The oil water separator ensures conformance to the following oil and grease values for the effluent water:

Item	Units	mg/l	Limit Value
Oil and Grease			15 or less based on removal of all free droplets equal to or greater than 60 microns in diameter.
pH:	6 to 9		
Temperature:	180 °F maximum.		

4.16.3 Oil / Water Separator Water Effluent Pumps

Quantity:	Two 100% capacity pumps.
Capacity:	Total required system flow plus 10% margin.
Total Head:	System pressure drop at total required system flow plus margin.
Type:	Submersible, centrifugal, motor driven.
Materials:	Ductile iron or cast iron casing, stainless impeller, stainless steel shaft and sleeve.

4.16.4 Miscellaneous Area Sumps

Drains from throughout the plant, as needed, are pumped to the oil / water separator. All drains will be controlled by an administrative isolation valve for the release of storm water to the oil / water separator which handles trace oil only. If an oil or chemical spill occurs, then a waste disposal vendor should be used to remove the oil or chemical.

4.16.5 Miscellaneous Area Sump Pumps

Quantity:	Two 100% capacity pumps.
Capacity:	Total required system flow plus 10% margin.

Total Head:	System pressure drop at total required system flow plus margin.
Type:	Submersible, centrifugal, motor driven.
Materials:	Ductile iron or cast iron casing, stainless impeller, stainless steel shaft and sleeve.

4.17 Compressed Air System

4.17.1 General

The plant will process compressed air to supply the instrument air and service air needs. The compressed air system will be provided with two heatless, desiccant-type air dryer, which will be equipped with dual prefilters and after-filters.

4.17.2 Air Receiver

Type:	Vertical, with safety valve, support legs, automatic drain valves.
Quantity:	One.
Capacity:	90 ft^3
Construction:	Per ASME B&PVC Section VIII. Code stamp required.
Materials:	Carbon steel.
Design Pressure:	150 psig.
Design Temperature:	150 °F.

4.17.3 Air Dryer

Quantity:	Two 100 % capacity dryers (two drying towers each)
Type:	Heatless, automatic regenerative with two 100% capacity coalescing pre-filters and two 100% capacity after-filters, complete with integral control valves, regeneration controls, and automatic moisture sensing control. ASME B&PV Code Section VIII, code stamp

	required. Purge air values will be limited to between 10 and 15% of total air flow.
Inlet Air Temperature:	125 °F.
Exit Air Dew Point:	Minus 40 °F at 125 psig.
Pressure Drop:	5 psi, maximum.
Design Pressure:	150 psig.
Design Temperature:	150 °F.

4.17.4 Piping

Materials:	Copper or stainless steel.
Design Pressure:	150 psig.
Design Temperature:	150 °F.
Piping:	Including low-point condensate traps to remove accumulated water.

4.18 Compressed Gas System

4.18.1 Nitrogen

A nitrogen blanketing system provides for shutdown corrosion protection of the internal surfaces of the recuperator. The nitrogen system consists of a manifold with valves and instrumentation for regulating the supply of nitrogen to the recuperator. The system maintains a nitrogen pressure of 5 psig in each recuperator. The nitrogen bulk storage is either bottles or a tube trailer.

4.19 Fire Protection System

See separate project Fire Protection Plan

4.20 Raw Water and Filtered Water System

4.20.1 General

The raw water will be routed to the filtered water/fire water storage tank after passing through a pretreatment filter system if necessary. The fire water section of the tank will be sized based upon two hours of continuous fire pump operation at maximum pump output, plus eight hours of storage of filtered water plus general plant service water and evaporative cooler make-up water (if required).

4.21 Fuel Gas System

4.21.1 General

Natural gas is used as the primary fuel for the Cycle #2 combustion turbine and the Cycle #1 air expander burners.

4.21.2 Fuel gas Compressor

A natural gas compressor is supplied for the Cycle #1 air expander HP burners.

4.21.3 Piping

All piping upstream of the fuel gas separator is ASTM A106B, seamless carbon steel. Piping downstream of the fuel gas separator is stainless steel. Although not a code requirement, consideration will be given to x-ray examination of all welds.

4.21.4 Fuel Gas Cleanliness / Filtration

Final filtration of the fuel gas system is required to meet the contaminant limitation requirements of the combustion turbine and the air expander burners. The fuel gas final filters are included as part of the scope of supply of the combustion turbines. These final filters are to be located in consideration of the hazardous classification of this equipment.

Solids removal capability	Particle Size	Removal Efficiency
By CT Vendor	By CT Vendor	By CT Vendor
Liquids removal capability	Particle Size	Removal Efficiency
By CT Vendor	By CT Vendor	By CT Vendor

4.21.5 Fuel Gas Dew Point Heater

Heating Water Source: Fuel gas.

Type:	Shell and tube, TEMA Class R, in accordance with TEMA, and ASME B&PVC Section VIII.

4.22 Bridge Crane

4.22.1 General

Cranes are provided for use in equipment maintenance and lifting heavy pieces. All hoists will be designed for true vertical fit.

4.22.2 Air Expander Turbine And Compressor Crane

Type:	Double girder-top running bridge crane.
Span (column to column):	66 2/3 feet Cycle #1
	99 1/6 feet Cycle #2
Bridge Travel Distance:	389 feet Cycle #1
	420 feet Cycle #2
CMAA Class:	A1.
Main Hoist	
Capacity:	35 tons Cycle #1
	80 tons Cycle #2
Type:	Wire Rope (anti-twist designed for true vertical lift).
Speed:	10 ft./min.
Lift:	35 ½ feet Cycle #1
	59 feet Cycle #2
Auxiliary Hoist	
Capacity:	15 tons.

Type:	Wire Rope (anti-twist designed for true vertical lift).
Speed:	10 ft./min.
Lift:	35 ½ feet Cycle #1
	59 feet Cycle #2

Miscellaneous Hoists and Trolleys

4.22.3 General

Hoists and trolleys are provided for use in equipment maintenance and lifting heavy pieces. Hoists may also be needed for SCR catalyst exchange and in a mechanical equipment building housing the main mechanical auxiliaries.

4.22.4 Hoist and Trolleys

Quantity:	
Capacity:	*Later*
Type:	Manual chain hoist and manual trolley
Lift Height:	*Later*

4.23 Heating, Ventilating, and Air Conditioning Systems

4.23.1 General

Special consideration will be given to projects located where extreme ambient conditions exist (cold or hot) and where environmental issues (i.e. sand, dirt, salt) may impact equipment design.

The HVAC systems provide an environment within the buildings suitable for personnel and/or equipment operation, with consideration given to maintaining acceptable conditions of temperature, humidity, filtration, fresh air supply, air movement, and exhaust removal of poor quality air or contaminated air.

The HVAC system is interlocked with the plant fire protection and detection systems. Smoke evacuation and purge provisions are incorporated into the HVAC design as required by the applicable codes and regulations. Duct penetrations through firewalls are protected with fire dampers protecting the fire resistance integrity of the wall.

4.23.2 Air Conditioning and Ventilation System Design Conditions

Ambient Design Conditions:

- Summer: 87 °F dry bulb and 71 °F wet bulb.
- Winter: -2 °F dry bulb.

Indoor Design Conditions:

Administration offices

- PDC Building
- Control Room
- Cooling Tower Electrical Building
- PDC Enclosures
- Battery Room
- Mechanical Equipment Building
- Cooling Tower Chemical Feed Building
- Fire Water Pumps Building

Humidity control will be provided only in those areas having electrical, electronic, computer or other type equipment having specific humidity conditions imposed by the equipment manufacturer. In which case, a written statement of the vendor's requirements will be obtained for timely review and approval of the related criteria.

4.23.3 Ventilation Requirements

The intake and exhaust capacity for ventilation systems is designed to maintain the inside design temperature.

For general ventilation, powered exhaust fans and/or powered supply fans and/or intake louvers or gravity ventilation are used as required. Areas subject to general ventilation are the turbine building, mechanical equipment building, pump houses, cooling tower electrical equipment building, cooling tower chemical feed building, miscellaneous storage facilities, and fire water pumps building. When dictated by building noise conditions, acoustical louvers will be necessary. These louvers have less free area and may impact building design.

Off/on/auto switches are located in the immediate area of the exhaust and supply fans. In the auto mode a thermostat controls the fans. Make-up air enters the buildings through wall louvers.

4.23.4 System Requirements

All design and construction will comply with the International Building Code (IBC) and all other codes having local jurisdiction. The most stringent code will apply.

All HVAC systems will meet the latest safety considerations of the Occupational Safety and Health Act. Noise contribution from HVAC equipment to the air-conditioned spaces will be limited to the RC method recommended by ASHRAE Fundamentals (current edition). All other HVAC noise contribution will comply with OSHA Standard 1910.95 for 8 hours per day occupancy.

All design and installation of HVAC equipment will comply with the NFPA codes and standards.

Design of the air distribution and duct system will be based on ASHRAE Fundamentals, current edition. Duct sizes and velocities are based on the “Recommended Velocities – Industrial Buildings.” Air diffusers, registers, and grilles will be certified as conforming to ADC Standards.

Duct construction will be based on the applicable SMACNA Standards.

Drainable blade intake louvers will provide the make-up air. Ventilation and exhaust systems will be designed so the building negative pressure does not exceed 0.15 inches w.g.

For general air-conditioned spaces such as a control room, self-contained packaged air conditioning units or split systems will be used.

Heating in conditioned spaces will be by electric resistance heaters in the air distribution system supplemented as required by electric baseboard, panel, or unit heaters or heat pump application if economically feasible. General area heating will be provided by electric unit heaters. Heaters in water treating area and other non hazardous areas subject to wash down will have water-tight construction and be suitable for use in these areas.

All make up and recirculation air in air-conditioned areas will be filtered by dry-disposable type filters. Supply air to general ventilation areas will in general not be filtered except where required for equipment protection.

Air flows will be based upon the calculated cooling loads, heating loads, or ventilation requirements whichever is greater. Design of the air distribution and duct systems will be based upon the latest copy of the ASHRAE "Handbook of Fundamentals." Duct size and related velocities will be based upon the "Recommended Velocities - Industrial Buildings", for air conditioning systems and "Maximum Velocities - Industrial Buildings" for all others, except for outside air intakes and as approved otherwise. All outside air intakes will be sized to limit the face velocity not to exceed the manufacturer's recommendations. Pressure drop will not exceed 0.10 in. w.g. and velocities will be below the point of water penetration (intake louvers to have a minimum of 50 percent free area).

All ductwork handling outside air, and air-conditioned supply and return air will be insulated. All chilled water, steam, and condensate piping will be insulated to minimize heat transfer.

Acoustical lining will be used instead of or in addition to duct insulation where required for sound attenuation. All rotating equipment will be isolated from duct and/or piping distribution systems.

Equipment will be arranged to allow easy removal of components as well as full access for inspection and maintenance.

HVAC equipment and ductwork will be equipped with controls and fire dampers in accordance with NFPA No. 90-A.

4.23.5 Materials

Duct material may by carbon steel per ASTM A 1011, galvanized carbon steel per ASTM A 653, aluminum per ASTM B 209 Commercial Designation 3003 Temper H14, or stainless steel per ASTM A 480 Type 304 for the duct sheeting material. Reinforcing angles and flanges will be of compatible metals.

All materials provided, such as flexible connections, insulation, hardware, ductwork, etc., will be fire resistant and will be classified to have a flame spread rating of less than 25, as listed and defined by the UL Fire Resistance Index.

Electric motor and equipment constructions, rating enclosures, electrical characteristics, accessories, etc., will be in accordance with the Project Electrical Design Criteria.

Refrigeration equipment, refrigeration piping, and water pumps and piping will be in conformance with applicable portions of ASME, ARI, and HI pressure codes and ANSI piping standards.

4.23.6 HVAC Calculations

All heat gain and heat loss calculations will comply with the latest ASHRAE Standards. All air distribution system pressure drop calculations will also conform to ASHRAE Standards and recommendations.

4.24 Plumbing

4.24.1 General

For drainage systems, the system engineer will consider the following. There are two types of systems discussed below – one is sanitary and the other is plant equipment/floor/roof drains. The former is designed for half-full pipe flow with traps and vents and the latter is designed for full pipe flow with no traps and vents. Piping materials and connections are different for each as noted below.

The plumbing systems provide an adequate system of in-plant drainage and potable water supply to satisfy the plant needs and fixture requirements within the buildings. Water conserving fixtures will be used in accordance with governing codes.

4.24.2 Design Conditions

Equipment, Floor and Roof Drains

Equipment/floor/roof drainage systems will be designed in conformance with the governing codes and as required by local authorities. Equipment and floor drains will be sized on the basis of the greater of the expected normal drainage rate of equipment to be drained or to take the run-off of the greatest water deluge from the fire protection system in that area. In lieu of specific equipment drainage rates, the lines will be sized on the basis of two equipment floor drains flowing simultaneously at 50 gpm each.

Where combustible fluids are present, area drains will be sized to drain the expected "spill" of combustible liquids plus the fire protection water flow in a manner to prevent flushing the combustible liquids beyond the area protected by sprinklers. All combustible fluids will be collected in a closed drainage tank (vented to outdoors) and/or conveyed outside the building into a safe area. Floor drains in sprinkled areas will be sized on the basis of sprinkler water applied at the rate of 0.50 gpm per square foot of sprinklered floor area. The gravity drainage piping from the drain hub to the first valve (administrative) will be steel, not plastic.

Chemical process wastes will be neutralized before combining with ordinary floor and equipment drains. Drainage from areas containing oil will be processed through oil separators before discharge.

Internal roof drain systems will be designed in conformance with the governing plumbing codes. External roof drain systems consist of gutters and downspouts. These may spill on concrete splash pads at the bottom of the vertical leaders or connect to an underground storm drainage system. Roof drain systems will be designed based on a 60 minute storm duration and a 100 year return or on other rainfall rates determined from approved local weather data. Secondary (emergency) roof drainage systems will be provided as required by code. Secondary systems will have piping and point of discharge separate from primary system. Storm drains will be designed for full flow conditions.

Sanitary Drains

Sanitary drains will be kept separate from all other drains to permit their being routed to separate disposal facilities or connected to the municipal sewer system.

4.24.3 System Requirements

Potable water supply and sanitary drainage facilities will be provided as required by the architectural plans for lavatories, water closets, urinals, service sinks, showers, drinking water coolers, and emergency showers. The emergency shower system design should include delivered water temperature and ANSI/ISEA Z358.1 requirements.

Sanitary floor drains will be provided in toilet rooms, washrooms, and showers, and be connected to the sanitary drainage system.

Cleanouts will be provided on all drainage systems (sanitary and storm) for maintenance and located in accordance with governing plumbing codes.

All connections to the sanitary drainage system will be trapped after each fixture.

A backflow preventer (BFP) will be provided on all connections from the potable water supply system to any and all process or non-potable services in the plant. The BFP will be a factory built assembly specifically intended for use as a device to prevent contamination of potable water systems by backflow from a potentially contaminated system under all conditions of pressure deviations from normal. Type is dependent on the degree of hazard. Ordinary check valves are not acceptable. BFPs will be certified as conforming to ASSE Standard 1013 and AWWA Standard C-506.

Hose bibs will be provided indoors, as required, for equipment and building maintenance. All hose bibs will be provided with vacuum breakers.

All piping will be installed with adequate provisions for pipe expansion and support. All roof drains will be provided with integral expansion joints.

All water supply lines at fixtures will be provided with water hammer arresters.

Where gravity drainage is not feasible to the final connection point, a duplex type electric motor driven pumping station will be provided with alternator type controls. The pumps will be sized to permit either pump of a duplex set to carry the normal design drainage flow. Pump basins may be fiberglass or field poured concrete.

Equipment drains will be provided for all equipment with continuous drips or that are subject to frequent flushing. "Over-the-floor" piping will be avoided. Equipment drains are typically connected to the plant drainage system and not part of the sanitary drainage system due to traces of oil.

The potable water system will be cleaned, disinfected/chlorinated and leak tested in conformance with governing plumbing codes. Drainage systems will be cleaned and pressure tested in accordance with governing plumbing codes.

The design will provide for functional testing of all operating equipment with appropriate documentation.

4.24.4 Materials

Potable Water Supply

Potable water supply piping, valves and fittings 2-inches and smaller for above ground use will be copper or copper alloy tubing with 94 Tin – 6 Silver solder conforming with ASTM B 32 Grade Sn94 for all joints, including those at all valves except those furnished with the fixtures. Brazed joints will be used in concealed areas. Tubing will be hard drawn Type K copper conforming to ASTM B 88. Victaulic PermaLynx may be used as an alternate for lines 1 – 1/2 inch or smaller. Fittings will be wrought copper conforming to ASME B16.22. Fittings may also be cast bronze per ASME B16.18 when permitted by local plumbing codes. Electrolytic couplings or unions will be provided at all copper to ferrous connections.

Potable water piping 3-inches and larger for above ground use will be hard drawn Type K copper conforming to ASTM B 88 with grooved copper couplings and fittings as manufactured by Victaulic.

Potable water piping for below grade use will be HDPE SDR 11 or cement-lined ductile iron. Copper may be considered as an alternate provided that soil conditions are favorable as noted earlier.

Sanitary Drains

Sanitary drain piping will be cast iron hub and spigot, with compression joints using neoprene gaskets for all buried or concealed work. Materials will conform to ASTM A 74. Sanitary drain piping above the floor will be hubless cast iron with neoprene gaskets and stainless steel clamps and sleeves per CISPI Standard 301.

Equipment/Floor/Roof Drains

Internal roof drain piping will be galvanized ASTM A53 Grade B steel pipe with grooved end mechanical couplings. Equipment and floor drain piping will be ductile iron with push-on (preferred) or mechanical joints for all buried or concealed work. Piping above floor level will be schedule 40, ASTM A 120 Grade A or B steel pipe. Joints will be either welded or by means of grooved end mechanical couplings.

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NEW YORK STATE ELECTRIC & GAS

Civil Engineering Design Criteria for Seneca CAES Project

Document: CAES-1-DB-024-0002-RA

May 25, 2011

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NEW YORK STATE ELECTRIC & GAS
CIVIL ENGINEERING DESIGN CRITERIA FOR SENECA CAES PROJECT

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PROJECT - CAES-DB-024-0002CIVIL ENGINEERING DESIGN CRITERIA FOR SENECA CAES PROJECT

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A	Issued for Review	N. Wang	J.Stanislawczyk	N. Wang	25-May-11	N/A	

CONTENTS

1.0 INTRODUCTION

This document presents the Civil Design Criteria for the facility's civil sitework (grading, drainage, roadways). All geotechnical and civil site development shall be designed and constructed in accordance with the most current edition in effect at time of the start of engineering, unless otherwise noted herein, of the applicable codes, industry standards, and local, state, and federal regulations and as otherwise noted in this section and the contract documents. All required local building permits and government agency inspections will be obtained and/or arranged for by the Owner or Contractor. The Engineer will prepare site development and erosion and sedimentation control calculations and plans that are required as part of the permit applications.

If any conflict arises between this guideline and the applicable standards or codes, this shall be resolved either by application of the most stringent design conditions or resolution by the Civil/Geotechnical Engineer.

2.0 CODES, STANDARDS, AND REFERENCES

The design and specification of all work will be in accordance with all applicable industry codes and standards. A summary of the codes and industry standards to be used in design and construction is listed below:

- U.S. Department of Labor, Occupational Safety and Health Administration (OSHA).
- American Concrete Institute (ACI).
- American Society for Testing and Materials (ASTM).
- American Association of State Highway and Transportation Officials (AASHTO).
- Asphalt Institute (AI).
- Code of Federal Regulations, Americans with Disabilities Act (ADA).
- U.S. General Services Administration, Federal Specifications (FS).
- American National Standards Institute (ANSI).
- National Pollutant Discharge Elimination System (NPDES) Permit for Discharges of Stormwater Associated with Construction Activity Water
- New York State Codes, Rules and Regulations (NYCRR).
- New York State Department of Environmental Conservation, SPDES General Permit for Stormwater Discharge from Construction Activity.
- New York State Stormwater Management Design Manual.
- New York Standards and Specifications for Erosion and Sediment Controls.
- New York State Department of Transportation Standard Specifications

3.0 DESIGN LOADS

3.1 Earth Loads

Soil Bearing Capacity shall be based on the results of the geotechnical investigation.

3.2 Highway Loads

Road Traffic - AASHTO HS20-44 or special heavy transport vehicle as information is provided.

3.3 Geotechnical Properties for Foundation Design

Soil properties used in the design of foundations and slab-On-grade floor design shall be based on the results of the geotechnical investigation. The allowable bearing pressure, lateral earth pressures and other soil parameters shall be taken from the Geotechnical Investigation report or approved by the project engineer. The maximum soil bearing pressure shall not exceed the allowable bearing pressure. Bearing pressures may need to be considerably less than the allowable bearing pressure for settlement sensitive structures.

4.0 CIVIL DESIGN DETAIL

Site preparation, excavation, backfill and grading shall be performed as required to construct the facility and achieve finished site grades as described in this section.

The site shall be left properly graded with no construction debris or soil stock piles. Consideration shall be given to drainage to ensure no low lying areas remain that may accumulate water other than those defined on the drawings. All drainage shall be away from the buildings to a collection system.

Engineer will design the plant to maintain major plant systems above 100 year flood elevation.

4.1 Surveying

A plant boundary and topographic survey referenced to the plant horizontal (coordinate grid) and vertical (elevation) datum will be provided by Owner. The Contractor shall maintain the primary control points and provide all detail measurement and layout for the project with qualified survey personnel and certified equipment.

4.2 Site Preparation

Contractor shall be responsible for clearing all plant life, trees, and shrubs to the extent necessary to construct the facility, for rough grading of the site, and for disposal of all waste materials resulting from the site preparation work.

The Owner shall re-locate known in-service utilities in support of Contractor's schedule. Any underground debris or utility encountered during the course of the work should be brought to the attention of the Owner for disposition. If considered an in-service utility, the relocation and removal will be by the Owner. If considered miscellaneous debris, the removal will be performed by the Contractor.

4.3 Excavation

Excavation work shall consist of the removal of fill, soil, vegetation, organic matter, rock, boulders, and debris, etc. to the lines and grades necessary for construction of foundations and underground facilities included in the project. Materials suitable for backfill shall be stockpiled at designated locations using proper erosion protection, moisture control, and safety methods. Disposition of any excess uncontaminated backfill material shall be the Contractor's responsibility. If contaminated materials are encountered, the Owner shall be notified immediately.

Contractor shall provide dewatering of excavations necessitated by flows from surface runoff as required to support the construction activities.

4.4 Backfilling

Backfilling shall be done in uniform layers of specified thickness following the criteria specified by the Engineer as based on the Geotechnical Report. Soil in each layer shall be properly moistened or dried to obtain its specified density. To verify compaction, representative field density and moisture-content tests shall be taken during placement and compaction of each layer.

Structural fill and general site fill shall be compacted following the criteria specified by the Engineer as based on the Geotechnical Report. Contractor shall provide all structural fill specified on the drawings and technical specifications.

Earthwork compaction requirements shall be as specified in the Geotechnical Report. In general, fills and sub-grades under roads and structures shall be compacted to a minimum of 98 percent of the maximum standard proctor density and yard area fills and sub-grades shall be compacted to a minimum 92 percent of the maximum standard proctor density.

4.5 Site Grading

The design of the site grading will take into account the finished geometry of the facilities, roads, parking, and other facilities to be constructed. The design will consider long term slope stability and erosion control. Based on the existing topography, grading the site to balance the cut and fill quantities shall be performed, if it is possible.

The site shall be graded to convey storm water runoff away from permanent facilities. Graded areas shall be smooth, compacted, free from irregular surface changes, and sloped to drain. Final grade adjacent to equipment and buildings shall be below finished floor slab and shall be sloped away from foundations as necessary to maintain positive drainage. Minimum slopes shall be based on surface type. In the main plant complex area, grade shall be sloped away from the building walls and equipment at a minimum of one half percent (0.5%) to provide surface drainage to collection points, however, where possible a slope of one percent (1.0%) shall be used.

4.6 Stormwater Drainage and Management

4.6.1 Stormwater Quantity and Quality Requirements

A stormwater management system will be implemented at the site to regulate the water quality and quantity from storm runoff generated from the site development. The Engineer shall design the stormwater management system and erosion and sediment control plan in accordance with regulatory requirement to support the submittal by the Owner.

The proposed site shall preserve the existing site drainage patterns to the maximum extent feasible, and to promote the protection of groundwater, surface water, adjacent properties, and any wetlands encountered. As a minimum the system shall consist of on-site sediment filtering facilities, perimeter silt fences, ditches/swales, catch basins, manholes, and piping, and must conform to all permit requirements.

- Stormwater management control design criteria: control peak discharge flows from post-development to pre-development flow rates at the following events: 1-year, 2 – year, 10-year, and 100-year storm.
- Implement the Best Management Practices wherever possible to minimize the impact due to land development.

4.6.2 Stormwater Drainage System

Site stormwater drainage system will only collect clean, uncontaminated site surface drainage. Drains or sumps that collect contaminated fluids will be handled by other systems described in the mechanical engineering design criteria document.

The runoff from offsite areas will be collected and conveyed offsite to natural drainage courses. The offsite runoff maybe controlled by diversion systems independent of the plant drains, or, alternately, maybe combined with site runoff and conveyed offsite to natural drainage courses.

Sizing criteria for the plant site drainage system are as following:

- Closed Conveyance System: 25-year Storm
- Open Channels, Outfalls: 10-year Storm

Main plant loop road (Primary Roads) will be crowned to provide surface drainage with a minimum transverse slope of 2 percent. Secondary Roads will be either crowned or sloped to provide surface drainage with a minimum transverse slope of 2 percent. Catch basins will be constructed along the side of the roads to collect the stormwater runoff.

Where site space allows, open drainage ditches will be designed to collect and convey stormwater runoff. The ditch will be vegetated with perennial grasses or gravel lined to provide infiltration if possible, or rip rap lined to prevent erosion where ever is needed.

Stormwater pipes to be used are reinforced concrete pipe (RCP), smooth lined corrugated polyethylene (SLPE), or corrugated steel pipe (CSP).

Drainage inlets and manholes shall be precast reinforced concrete structures. With approval by the Owner, cast-in-place reinforced concrete structures may be utilized.

4.7 Roads and Parking

Site roads and parking areas shall be provided for access, operation and maintenance as shown on the general arrangement drawing. Permanent roads shown on the general arrangement drawings shall be paved with asphalt (bituminous concrete) paving. Shoulders will be dense graded aggregate. Engineer shall design the roadway pavement section following the recommendations provided in the Final Geotechnical Report. The design of the flexible pavement will consider the predicted wheel load applications over the plant life.

Plant yards inside the main perimeter road will be surfaced with dense graded aggregate with geotechnical fabric beneath to provide erosion protection and provide access for maintenance vehicles. Areas outside the perimeter road will be planted with perennial grasses.

4.8 Fencing and Gate

Fencing and security gate will be provided around the facility perimeter.

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NEW YORK STATE ELECTRIC & GAS
COMPRESSED AIR ENERGY STORAGE PROJECT

Electrical Engineering

Design Criteria

Document: CAES-1-DB-023-0001

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EcoNomics™

COMPRESSED AIR ENERGY STORAGE PROJECT
ELECTRICAL ENGINEERING
DESIGN CRITERIA

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A	Issued for Review	G. Panno G. Panno	D. Sterner D. Sterner	G. Panno G. Panno	May 2011
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CONTENTS

1. ELECTRICAL DESIGN CRITERIA

1.1 INTRODUCTION

This design criteria establishes the guidelines for the engineering and design work required for the electrical discipline for the compressed air energy storage facility. The criteria include design basis and equipment and material selection. Design criteria are presented for each major piece of electrical equipment or system.

1.2 CODES AND STANDARDS

The latest edition and published addenda of the following publications are applicable to the extent indicated by the specific reference. All equipment furnished and work performed under this Section will comply with the approved standards, specifications, and regulations, codes, and tests of the following:

A. American Electrical Association (AEA)

B. Association of Edison Illuminating Companies (AEIC)

C. American National Standards Institute (ANSI)

D. Institute of Electrical and Electronics Engineers (IEEE)

E. American Society for Testing and Materials (ASTM)

F. Electronic Industries Association (EIA)

G. Illuminating Engineering Society (IES)

H. National Electric Manufacturers Association (NEMA)

I. National Electric Safety Code (NESC)

J. National Fire Protection Association (NFPA)

K. Underwriters Laboratories (UL)

1.3 115kV HIGH VOLTAGE INTERFACE

A. The primary distribution system within the facility will be 3-phase, 3-wire consisting of the following equipment:

1. One (1)13.8kV-115kV generator step-up transformer (GSU) fed from the plant switchyard.

2. Two (2) 115kV-13.8 compressor transformers fed from the plant switchyard.

3. One (1) 115kV-13.8kV auxiliary supply transformer (UAT) fed from the plant switchyard.

4. 115kV generator breakers, disconnects and associated plant switchyard equipment (Refer to CAES-1-DB-023-0003).

5. Current transformers and potential transformers for the 115kV system to meet all performance testing, protective relaying, metering, synchronizing, substation and/or utility requirements. (Refer to CAES-1-DB-023-0003)

1.4 ISOLATED PHASE BUS DUCT (IPB) or NON-SEGREGATED PHASE BUS DUCT (NPD)

A. One (1) lot of 13.8kV isolated phase bus duct or non-segregated bus duct of appropriate ampacity including all necessary fittings, connections, and supports. Bus duct will, as a minimum, be provided between the generator line terminals and the step-up transformer (as applicable) and between other medium voltage transformers and their secondary load switchgear. Metal enclosed bus duct will be designed, manufactured, and tested in accordance with all the applicable ANSI, IEEE, and NEMA standards.

B. The IPB and NPD will have the following parameters:

1. Nominal Voltage: 13.8kV, 3-phase, 60 Hertz

2. Cooling: Self-cooled

3. Continuous Current: Refer to oneline diagrams for preliminary information

4. Momentary Fault Current: TBD

5. Bus Insulation Level: 150kV BIL

C. The continuous current rating will be determined based on the guaranteed maximum generator current at five-percent under voltage. The momentary withstand fault current rating of the main bus will be determined by assuming a three-phase bolted fault at the generator terminals or on the step-up transformer low voltage terminals, whichever is higher. The momentary withstand fault current rating of the bus taps sections will be determined by assuming a three phase bolted fault at the main bus tap. Outdoor sections of the bus will be supported independently of transformer foundations to permit differential settling.

D. The generator neutral grounding transformer and resistor will be located in a metal cubicle and connected to the generator neutral bus by an insulated conductor internal to the cubicle. Grounding equipment will be sized to limit over voltages during arcing ground faults and to limit ground fault currents to a value, which will significantly limit damage to the bus at the point of the fault. The generator will be tripped expeditiously upon sensing a ground fault.

E. All bus supports, mounting hardware, erection details, notes, and drawings will be provided by the supplier. Coordination of the bus duct with the generator terminals, step-up transformer and main plant layout will be provided by the Engineer. The bus duct is an engineered system that is not suitable for field modifications. Layout details must be finalized prior to release for manufacture.

F. The turbine generator VT'S, surge protection equipment, and neutral grounding equipment are provided by the generator supplier in individual cubicles or in the generator terminal enclosure.

G. IPB and NPD construction features will include:

1. Weather tight, dust-tight;

2. Connections to equipment will be such as to maintain weather tight and dust-tight integrity;

3. Bolt-on, removable covers with re-useable gaskets at all terminations, at all bolted bus joints and at all supporting insulators;

4. Weatherproof seals at structure penetrations;

5. Thermostatically controlled and individually monitored space heaters or a pressurized air system for protection against condensation;

6. Screened drain holes;

7. Expansion joints as required;

8. Steel structures to support the Isolated Phase Bus Duct and Non-segregated Bus Duct;

9. Flexible connections to terminal equipment connecting means will be provided at generator line terminals to permit dielectric testing of this equipment;

1.5 MEDIUM VOLTAGE NON-SEGREGATED PHASE BUS DUCT OR CABLE BUS

A. Non-segregated phase bus ducts or cable bus will be used for all incoming connections to the medium voltage switchgear. The short circuit withstand capability of all bus ducts or cable bus will be determined based on comprehensive fault duty calculations. The bus ducts' or cable bus continuous current ratings will be based on carrying the transformer secondary windings' full rated current and the continuous current ratings of the medium voltage switchgear busses that they feed. The medium voltage bus ducts or cable bus will be rated 4.16 kV, three phase, 60 kV BIL.

1.6 STEP-UP TRANSFORMERS

A. The step-up transformers will transform power generated at 13.8kV from the turbine generator to 115kV high-voltage for transmission to the transmission system. The transformers will be located outdoor in the transformer yard. The layout will accommodate offsite access, as well as a simplified bus arrangement. Final transformer parameters will be defined by the generating equipment purchased and may change from those defined below.

B. The step-up transformers will have the following parameters:

1. MVA Rating: TBD (Refer to oneline diagrams for preliminary information)

2. High Voltage Winding: 115kV

3. High Voltage Connection: Wye Grounded

4. High Voltage Winding Taps: +/-2 @ 2.5%, and 0% CRT Tap

5. Lightning Arresters: Provided

6. Low Voltage Winding: 13.8kV

7. Low Voltage Connection: Delta

8. Cooling: ONAN/ONAF

9. Temperature Rise: 55/65 Degrees C

10. Impedance: TBD (Refer to oneline diagrams for preliminary information)

11. Noise Level: 1 dBA below NEMA Standard

12. Windings Material: Copper

13. Current Transformers Bushing type, quantities and ratios as required

1.7 UNIT AUXILIARY TRANSFORMERS (Including Compressor Transformers)

A. The unit auxiliary transformers and the compressor transformers will be two-winding transformers that transform power at 115kV to 13.8kV.

B. The unit auxiliary transformers will have the following parameters:

1. Rating: TBD (Refer to oneline diagrams for preliminary information)

2. High Voltage Winding: 115kV

3. High Voltage Connection: Delta

4. High Voltage Winding Taps: +/-2 @ 2.5%, and 0% CRT Tap

5. Lightning Arresters: Provided

6. Low Voltage Winding: 13.8kV

7. Low Voltage Connection: Wye Grounded (low Resistance)

8. Cooling: ONAN/ONAF

9. Temperature Rise: 55/65 Degrees C

10. Impedance: TBD (Refer to oneline diagrams for preliminary information)

11. Noise Level: 1dBA below NEMA Standard

12. Windings Material: Copper

13. Current Transformers Bushing type, quantities and ratios as required

1.8 BOP STATION SERVICE TRANSFORMERS

A. The station service transformers will be two-winding transformers that transform power at 13.8kV to 480V or 34.5kV to 480V for the pumphouse area.

B. The station service transformers will have the following parameters:

1. Rating: TBD (Refer to oneline diagrams for preliminary information)

2. High Voltage Winding: 13.8kV or 34.5kV

3. High Voltage Connection: Delta

4. High Voltage Winding Taps: +/-2 @ 2.5%, and 0% CRT Tap

5. Low Voltage Winding: 480V

6. Low Voltage Connection: Wye Grounded (high Resistance)

7. Cooling: AA/FA

8. Temperature Rise: 150 Degrees C

9. Impedance: TBD (Refer to oneline diagrams for preliminary information)

10. Noise Level: 1dB below NEMA Standard

11. Winding Material: Copper

12. Current Transformers Quantities and ratios as required

C. Transformer capacity will be sufficient to allow across the line starting of the largest 460 volt motor, simultaneously with all other motors required for full unit capability running in full load condition, without objectionable voltage drop at any bus in the plant. Consideration will be made to accommodate future load growth. Transformer impedance will be high enough to limit interrupting fault duty on the switchgear, yet low enough to ensure that the voltage dip on starting the largest motor will remain above 80 percent of the motor voltage rating. The voltage profile of the plant under full load conditions will be examined to determine that with the utility system voltage at 115kV, the running voltage at all motors is at least 90 percent of the motor rated voltage. 13,800V-480V or 34,500V-480V transformers may be either oil filled or dry type.

1.9 MEDIUM VOLTAGE SWITCHGEAR

A. The secondary power distribution system will consist of 13.8kV and 4.16kV, 3-phase, 3-wire, resistance grounded neutral equipment described herein.

B. Medium voltage switchgear will be provided to distribute power to the medium voltage loads. Circuit breakers will be vacuum type, draw-out power circuit breakers. Layout of the medium-voltage bus will require compilation of the plant electrical load list. Bus bars will be insulated copper. Auxiliary system calculations will be performed to verify the adequacy of the medium-voltage system, as well as required fault interrupting capacities. A minimum of one spare breaker compartment and one breaker space will be provided on each bus for Owner’s future use. Breaker control voltage will be 125 volts dc.

C. The secondary power distribution system will consist of the following main electrical equipment:

1. Cable runs, cable bus, or NPD connecting the new auxiliary power transformers to the medium voltage switchgear breakers.

2. Metering and protective relays for the medium voltage switchgear.

3. Medium voltage switchgear equipped with all the required draw-out switchgear breakers.

4. The required relays for motor protection will be Multilin 369+; switchgear mains/ties will be Basler BE1-51 phase and ground overcurrent; non-motor feeders will be Basler BE1-51 phase and ground overcurrent. Exact model numbers will be approved by the Owner.

5. Circuit breakers will be remote racking capable, remote racking devices will be provided in such a manner that adequate space is available to allow the worker to maneuver around the equipment at a safe distance. That safe distance will be consistent with findings of the arc flash calculations.

6. A viewing window that is infrared transparent will be provided; the exact size and location to be engineered to ensure the maximum viewing area unless it invalidates the safety margin provided by the structure. The viewing window will allow thermography inspection without opening the front/rear doors.

7. The medium voltage switchgear will include the following protection:

   a. Ground fault protection

   b. Parallel transformer operation

   c. Inter-phase fault protection

   d. Motor and feeder protection

8. The main balance of plant switchgear will have the following parameters:

   a. Voltage: 13.8kV or 4.16kV

   b. BIL: 150kV for (13.8kV) and 60kV for (4.16kV)

   c. Bus Current Rating: TBD (Refer to oneline diagrams for preliminary information)

d. Short Circuit Rating: 50kA symmetrical short circuit interrupting rating (Refer to oneline diagrams for preliminary information)

e. Incoming Main Breaker: TBD (Refer to oneline diagrams for preliminary information)

f. Feeder Breakers: TBD (Refer to oneline diagrams for preliminary information)

g. Tie Breakers: TBD (Refer to oneline diagrams for preliminary information)

1.10 VARIABLE FREQUENCY DRIVES

A. Medium voltage variable frequency drive (VFD) systems or soft start equipment will be used for starting the compressors.

B. Each VFD system will consist of all system components required to meet the performance, protection, safety, testing, and certification criteria of applicable specifications. These components may include incoming harmonic filter / power factor correction unit, input isolation transformer, VFD converter/DC-link/inverter, output filter and bypass contactor.

C. The VFD system will represent a fully integrated package and include all material necessary to interconnect any provided VFD system elements.

1.11 LOW VOLTAGE SWITCHGEAR

A. Secondary Unit Substation Transformers will be provided to distribute 480-volt power to the low voltage Station Service Switchgear. 480-volt switchgear will be provided to distribute power to the 480-volt loads. The exact configuration, single ended versus double ended, will be determined by the Engineer. It may be fed via non-segregated bus duct from the oil-filled or dry-type (for outdoor use) station service transformers, or close coupled via indoor dry type station service transformers. Each station service transformer will be sized to carry the entire busload with the other transformer out of service if a double ended tiebreaker configuration is used. The incoming main switchgear circuit breaker and tiebreaker will be electrically operated. Feeder breakers will be electrically operated. Breakers will be draw-out air magnetic units. 460 volt motors and other loads will be powered from 480-volt motor control centers (MCC's) that are fed from a secondary unit transformer or the 480-volt switchgear. Auxiliary system calculations will be performed to verify the adequacy of the 480-volt system, as well as required fault interrupting capacities. A minimum of one spare breaker compartment and one compartment space will be provided on each bus for the Owner's future use. Breaker control voltage will be 125 volts dc. Final kVA size of transformers will be determined by the Engineer.

B. The 480V, 3-phase, 3-wire, high-resistance grounded distribution system will consist of the following main electrical equipment:

1. Station service transformers; 480V secondary with a 4.16kV primary.

2. 480V switchgear line-up, equipped with the required main breakers, tie breaker, and feeder circuit breakers.

3. Metering and protection.

4. A spare breaker of each current rating will be provided. Spare breakers for main or tie breaker service will be an uninstalled warehouse spare breaker.

5. The required static trip units are MicroVersaTrip Plus PM.

6. Circuit breakers will be remote racking capable, remote racking devices will be provided in such a manner that adequate space is available to allow the worker to maneuver around the equipment at a safe distance. That safe distance will be consistent with findings of the arc flash calculations.

7. A viewing window that is infrared transparent will be provided, the exact size and location to be engineered to ensure the maximum viewing area unless it invalidates the safety margin provide by the structure. The viewing window will allow thermography inspection without opening the front/rear doors.

8. 480V motor control centers.

C. The low voltage switchgear will include the following protection:

1. Bus or Cable under voltage protection.

2. Motor feeder protection.

3. Motor control center feeder protection.

D. The 480V switchgear parameters are as follows:

1. Voltage: 480V, 3-phase, 3-wire, 60 Hertz

2. Bus Current Rating: TBD, copper bus bar (Refer to oneline diagrams for preliminary information)

3. Incoming Breaker Continuous Amps: TBD (Refer to oneline diagrams for preliminary information)

4. Incoming Breaker Interrupting Amps: 65kA (Refer to oneline diagrams for preliminary information)

5. Tie Breaker Continuous Amps: TBD

6. Tie Breaker Interrupting Amps: TBD

7. All Feeders Continuous Amps: TBD

8. All Feeders Interrupting Amps: TBD

1.12 BLACK START GENERATOR

A. A black start natural gas powered generator will be provided to connect at the 480-volt system level. The black start generator will energize the 480V switchgear in order to support starting of the facility. All required switchgear, controls and synchronizing capability will be included in the system.

1.13 480V MOTOR CONTROL CENTERS (MCC'S)

A. 480 volt motor control centers will be provided with combination starters and molded case circuit breakers. These MCC’s will serve low voltage motors and feeders required for plant operations. 480-volt power panels may be used to feed some loads and motor-operated valves. 480-volt MCC's will be provided to control 460-volt, 3-phase, 60 Hz, single speed induction motors and other miscellaneous 480-volt loads. Layout of the MCC's will require compilation of the plant electrical load list. MCC layouts will utilize front access construction. MCC placement will be against a wall, or stand-alone. Auxiliary system calculations will be performed to verify the adequacy of the 480-volt system, as well as required fault interrupting capacities. The equivalent of one vertical stack of compartment spaces will also be provided in each MCC lineup for Owner's future use. Layout will facilitate future expansion of each lineup.

B. 480-volt MCC's will have the following parameters:

1. Voltage: 480V, 3-phase, 3-wire, 60 Hertz

2. Horizontal Bus Current Rating: TBD, copper bar

3. Feeders: Molded Case Thermal Magnetic Circuit Breakers

4. Motor Starters: NEMA Size 1 and larger motor controllers with solid state overloads.

5. Enclosure: NEMA 1 gasketed, or NEMA 3R walk-in

1.14 LOW VOLTAGE SYSTEM

A. Power distribution at ac voltages below 480-volt will utilize 120/208 volt 3-phase, 4- wire, solidly grounded transformers and panels fed from the 480-volt MCC's. These transformers and panels may be located within the MCC's as long as the MCC is designed for outdoor installation or within an appropriate structure internal to the plant, depending upon the design circumstances. Allocation of these panels will be made after the load list provides load concentration details. Motor space heaters, equipment space heaters, equipment lights and power receptacles and equipment miscellaneous power feeds will be fed from power panels.

1.15 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS system will be provided to power all the instrumentation, control and monitoring circuits required for startup, operation, normal and emergency shutdown and offline housekeeping of the new equipment. In addition to static switch transfers, the UPS will provide filtered and regulated power.

B. The UPS will interface with the plant DCS and provide information to the operator in the control room on status, line up, bus voltages, operation, trouble, etc.

C. The UPS system capacity will be sized for 125% of the Control Systems for the turbine generators and the distributed control system and 100% of the remaining loads.

D. UPS expected loads:

1. Control System for the Turbine

2. Distributed Control System

3. Fire Detection System if required (the fire detection system may include individual batteries located in the main fire panel and/or the steam turbine generator valve house)

4. CEM System

5. Communication System

6. Generator Protection/Control System

7. Electrical Field Transmitters

8. Other loads as required by Vendor's supplied equipment (such as PLC's that cannot tolerate loss of power)

E. Normal power supply to the UPS will be from the 125 Vdc bus (normally fed from the ac rectifier and alternately fed from the dc battery) and through the inverter and load transfer switch to the uninterruptible bus. If the output of the inverter fails, the uninterruptible bus will be transferred to the alternate ac supply by means of the load transfer switch and fed through the regulated bypass ac power supply. The load transfer switch will also transfer the uninterruptible bus to the bypass ac supply whenever the current demand by the uninterruptible bus exceeds the capability of the inverter, such as during inrush periods following load energization and for external short circuits. UPS architecture will consist of an inverter section, a static transfer switch, an alternate source regulating transformer, a 120-volt or 120/240-volt ac distribution panel board and a maintenance bypass switch. The emergency source of power to the inverter will be the 125 Vdc systems.

F. The UPS system will have the following parameters:

1. Input Voltage: 480-volt, + 10, -15%; 3-phase; 60 Hertz power for regulated bypass transformer (alternate source);, 125 volts dc, 105 -140 volt dc range power for UPS inverter

2. Output Voltage: 120 volts: plus or minus 1% for all load conditions, 1-phase, 60 Hertz +/- 0.5Hertz

3. Inverter Overcurrent Output: Sufficient to allow use of molded case, circuit breaker distribution panels for feeder short circuit protection

4. Static Switch Transfer Time: 4 milliseconds

5. Enclosure: NEMA 1

6. Noise Level: <85dBA

1.16 DC SYSTEM

A. The dc systems will be designed to provide adequate 125-volt dc power to safely shut down the plant or protect equipment with minimal risk to people or equipment. Typical dc plant loads include turbine expander, generator emergency lube oil pump, UPS, fire protection, control room emergency lighting and switchgear and protective relays control. Assessment of the plant dc loads will be made to determine the appropriate quantities and locations for plant dc systems. Each dc system will include a battery, redundant battery chargers, battery ground detection, and dc distribution panels. Electrical calculations will be performed to verify dc system ratings and interrupting capacities.

1.17 STATION BATTERIES

A. The station battery will be lead-acid flooded cell type. Valve regulated types are not acceptable. Batteries will be manufactured for filtered full voltage float service with a high discharge rate, low deterioration rate, and low maintenance. Batteries will be supplied complete with all accessories (e.g. battery racks, inter-cell connectors). Racks will be in a single-tier of two step configuration such that no part of any cell resides directly above any part of another cell. All batteries will have a full discharge test. Battery sizing will be based on IEEE 485.

B. Electrical calculations will be performed to verify station battery sizing meets the dc load profile. The calculation shall be approved by the Owner.

C. One (1) station 125V dc battery system sized for three (3) hour back-up will be provided. The battery will supply the generator protection panel, switchgear and protective relay control power, emergency pumps, and uninterruptible power supply (UPS) loads.

D. The station batteries will have the following parameters:

1. Voltage: 125Vdc (nominal) 105 Volt (minimum) 140 Volt (maximum)

2. Number of Cells: 60

3. Floating Charging Voltage: 2.25Vdc per cell/ 135 Vdc

4. Equalizing Charging Voltage: 2.33Vdc per cell/ 139.8 Vdc

5. Final Discharge Voltage: 1.75V per cell/ 105 Vdc

6. Design Temperature: 77F plus or minus 2 degrees

7. Design Margin: 10%

8. Aging Factor: 1.25

9. Discharge Duration: 2 hours (3 hours for UPS loads)

1.18 BATTERY AREA

A. The battery area will be independently ventilated, heated and cooled and designed in accordance with IEEE 484, "Recommended Practice for Installation, Design, and Installation of Large Lead Storage Batteries for Generating Stations and Substations", with the following exceptions:

1. An emergency shower and eyewash, in accordance with OSHA 29CFR1910.124(g), will be provided within the battery room. Storage for testing and monitoring equipment for the batteries will be provided.

2. Hydrogen detector with an alarm contact wired to the DCS.

1.19 BATTERY CHARGERS

A. Two battery chargers (100% redundant and with load sharing capability) will be connected to the dc bus and will supply the dc load power requirements during normal operation. Momentary loads in excess of the capacities of the battery chargers will be supplied by the battery connected to the dc bus. Upon loss of the battery chargers, the battery will supply dc power in accordance with its discharge cycle. Upon re-energization, the battery chargers will pick up the normal dc load and recharge the battery in 12 hours. Battery charging equipment will not be installed in same room with the batteries. Normally the steady state dc loads and the battery float and equalizing charge will be supplied by one charger. The second charger will be on standby.

B. Battery chargers will also have a battery equalizing charge mode. Battery chargers will be self-regulating after charging levels are manually selected.

C. Battery chargers will be manufactured in NEMA 1 enclosures suitable for placement in an indoor, environmentally controlled atmosphere. The battery chargers will require only front access, and will allow either top or bottom conduit/cable entry.

D. Battery chargers will use 480V, 3-phase, 60 Hz power to convert to DC power.

1.20 AUXILIARY MOTORS

A. In general, electrical motors will be supplied with the driven equipment and will be premium efficiency grade motor. Motors will be supplied in accordance with motor attachment specifications appended to the driven equipment specification. Motors used for variable frequency drive service will be designed for acceptable operation due to harmonic related or other concerns.

B. Acceptable nameplate voltages for ac induction motors are:

1. 13,200-volt, 3-phase
2. 4000-volt, 3-phase
3. 460-volt, 3-phase
4. 208-volt, 3-phase (HVAC motors rated at 1hp or less)
5. 115-volt, 1-phase

C. In general, motors under 1/3 hp will be single phase; 1/3 hp and larger will be three phase. In general, all motors greater than 250 hp will be 13,200V, 3-phase or 4000V, 3-phase.

D. Acceptable nameplate voltage for dc motors is 115-Vdc.

E. Dc motors will be capable of starting, accelerating and running without damage within the range of 102 to 140 volts for 115V motors.

F. 460-volt, 4000-volt and 13,200-volt 3-phase ac motors will operate satisfactorily over a ±10% range from their rated voltage. Motors will start satisfactorily over a + 10%, -20% voltage range where required by the electrical system related calculations.

G. Motor Frames will be grounded and grounding surfaces cleaned in accordance with the National Electric Code, Article 250. Electrical system calculations will be done to verify the auxiliary power system performance and motor starting capabilities. Compilation of the electrical load list and the electrical calculations will confirm the system requirements.

H. Motors will be sized to at least a 10% capacity margin above that of the maximum horsepower requirement of the driven equipment. The motor's horsepower rating will be determined without taking advantage of the service factor, over 1.0, even for short duration overloads. All motors will have a service factor of 1.15. Motor heaters will be fed from a separate power source than the motor. Mechanical anti-rotation devices will be included on 4000V or 13,200V critical service motors such as circulating water and condensate pumps.

I. Motors, NEMA frame size 180 and larger, will include motor space heaters rated 115 volts, single phase, sized to maintain motor internal temperature above the dew point when motor is at rest. Engineer may take exception if application or environment of motor requires heaters for smaller motors.

J. All motors 4000V and higher will have sleeve-type bearings. Anti-friction bearings may only be used on motors 4000V and higher when technically required or advised and must be approved by Owner. All 4000V and higher motors will have externally lubricated anti-friction bearings, except for motors that drive equipment with forced lube oil bearings. Those motor bearings will share the forced lube oil system of the driven equipment.

K. All 460V and smaller motors will have externally lubricated anti-friction bearings, except for motors that drive equipment with forced lube oil bearings. Those motor bearings will share the forced lube oil system of the driven equipment.

L. 460V motor enclosures will be as follows:

1. Hazardous Areas: As specified in the driven equipment specifications

2. Indoor: Drip proof guarded enclosures, unless totally enclosed fan- cooled (TEFC) specified in the driven equipment specification, or unless TEFC enclosures are supplied as standard

3. Outdoor: TEFC

4. Lubricating Oil, Seal Oil: Totally enclosed

M. 4000V and 13,200V motor enclosures will be as follows:

1. Hazardous Areas: As specified in the driven equipment specifications

2. Indoor: Drip proof guarded enclosures

3. Outdoor: WP II

N. Each 4000-volt and 13,200-volt, 3-phase motor will be provided with a minimum of six (3 spares) 3-wire 100 ohm platinum RTD's, embedded in the stator winding at locations where highest temperatures are expected. Motor bearings will be equipped with dual-element, Type E chromel-constantan thermocouples.

O. For motors 3,000 hp and larger, both ends of each winding will be brought out for application of differential relay protection.

P. All motors will be supplied with connection boxes of sufficient size to accommodate the power lead terminations. Separate connection boxes will be supplied for RTD's and heaters.

Q. All motors will have a nameplate containing information in accordance with NEMA MG1 as well as the motor service factor.

1.21 RELAY PROTECTION SYSTEMS

A. Protective relay Systems for the Work will be designed or specified by the Engineer in accordance with all applicable ANSI/IEEE standards, Owner standards, and the Engineer's engineering standards relay systems. The Engineer will calculate and provide all relay settings and current transformer ratios for all relays not provided by suppliers or the Owner. Owner will review settings and associated calculations prior to implementation.

B. All relays will be solid state or microprocessor based. All voltage relays will have sufficient thermal capacity for continuous energization. Test device switches (ABB type FT -1) will be provided in all Transmission relay current, metering current, potential, and relay trip output contact circuits.

1.22 GENERATOR PROTECTION

A. Primary and backup generator protection will be provided by the generator vendor.

1.23 GENERATOR STEP-UP TRANSFORMER PROTECTION

A. The following is a list of the devices: *Note: Suffixes (X) on relay protection devices will match with transformer designation.*

1. Low and High Voltage Winding, Phase to Phase and Three-Phase Faults, Protected by Differential Relay and Sudden Pressure Relay if Used for Tripping (87/X, 63FP/X).

2. Phase to Phase or Three-Phase Faults in High Voltage Winding by Over-Current Relays, High Voltage Winding Neutral Ground (50/51X).

3. Relay for Line Ground Fault (51N/X).

4. Oil Level Alarm (71Q/X).

5. Pressure Relief alarm if used for Tripping (63PR/X).

6. Thermal Overload Protection (49/X).

1.24 AUXILIARY TRANSFORMER PROTECTION

A. The following is a list of the devices: *Note: Suffixes (X) on relay protection devices will match with transformer designation.*

1. Relay for Differential Protection (87/X).

2. Sudden Pressure Relay if used for Tripping (63FP/X).

3. Phase to Phase or Three-Phase Faults in Either Winding by Over-current Relays (50/51/X).

4. Thermal Overload Protection (49/X).

5. Oil Level Alarm (71Q/X).

6. Relay or Line Ground Fault (51N/X).

1.25 MEDIUM VOLTAGE SYSTEM PROTECTION

A. The medium-voltage, 3-phase systems will be low resistance grounded systems and will be protected by relays, which will trip the medium-voltage circuit breakers. The switchgear bus will be protected against three-phase and phase-to-phase faults by time over-current relays (50/51), which will trip the switchgear main circuit breaker. Motors will be protected against three phase faults, phase-to-phase faults, thermal overload and ground faults by a multifunction motor protective relay.

1.26 480 VOLT SYSTEM PROTECTION

A. The 480-volt system will be a high-resistance grounded neutral system with ground fault detection.

B. The 480-volt switchgear main and feeder circuit breakers will be equipped with solid-state trip devices.

C. The 480-volt motor control centers will be equipped with a molded case breaker and contactor starter for each motor. The breaker will provide short circuit protection for the motor and its feeder. The magnetic contactor will be equipped with a solid-state overload element in each phase which will protect the motor and circuit conductors against excessive heating due to prolonged motor over-current.

1.27 LIGHTNING PROTECTION

A. Lightning protection will be provided where necessary in accordance with NFPA No. 780, UL 96, UL 96A, and Lightning Protection Institute Standards 175, 176 and 177 and per manufacturer’s recommendations. Air terminal, conductors and other related accessories will be UL listed and labeled.

B. Transient Voltage Surge Suppression (TVSS) will be provided on 480 volt distribution centers including 480 volt panel boards, and motor control centers.

C. Air terminals will be installed on top of the exhaust stack with the necessary electrical connections to the plant grounding grid.

D. In addition, outdoor instrumentation should have surge protection. These should be sized in accordance with the above and prevent surge propagation into the DCS cabinets.

1.28 METERING

A. Current Transformers

1. Rating: The primary windings of current transformers will have a continuous rating of at least 120 percent, and approximately no higher than 150 percent of the motor or transformer full-load current. IEEE Standard C57.13 lists the available current transformer ratings. The short-time thermal and mechanical rating of each ratio of current transformer and connecting relays will be specified to successfully withstand the available short-circuit current. These short-time ratings will be obtained from manufacturers' information. Reference IEEE C57.13 for definition of these ratings. The ratings will be given for one, one-second duration of short circuit time and will be equal to I^2t, where t = 1 second.

2. Accuracy Classification: The burden on the current transformer affects the accuracy classification. Therefore, the various burdens will be added to obtain the total burden. In most cases, it is sufficiently accurate to add arithmetically the impedance burden. Current transformers used in differential protective schemes will have a minimum accuracy class of C800. IEEE Standard C57.13 will be used for the accuracy classes, standard burdens for all other current transformers for metering, and relaying and accuracy calculations. The turbine generator suppliers will be responsible for providing an integrated system of CT's, meters, and relays for their equipment.

3. Grounding Methods: Secondary circuits of current transformers will be grounded in accordance with NEC Article 250.

B. Potential Transformers

1. Rating: IEEE C57.13 lists the primary voltage ratings, insulation classes, etc. for potential transformers. Potential transformer standard burdens are based on 120 volts and 69.3 volts. The generator potential transformers will be Y-Y connected with the secondary neutral grounded.

2. Accuracy Classification: Similar to current transformer circuits, the burdens will be added for the potential transformer circuits. IEEE C57.13 will be used for the standard burdens, accuracy classes, and accuracy calculations for potential transformers. The turbine generator suppliers will be responsible for providing an integrated system of PT's, meters, and relays for their equipment.

3. Grounding Methods: The grounding of potential transformer circuits will be done in accordance with NEC Article 250.

C. Instrumentation

1. Voltmeters: Voltmeters reading secondary voltage of potential transformers will have a 150-volt full-scale value with scale markings in primary volts.

2. Watt/Watt-hour Meters: The current transformer and potential transformer ratios multiplied together and then multiplied by a constant K = 1 for three-phase, three-wire circuits will result in an approximate scale. The exact scale will be determined from the manufacturer's scale selector. For example, 400/5 and 7,200/120 multiplied by 1 equals 4,800 kW. Therefore, a 5,000 kW full-scale meter will be specified. Watt-hour meter pulse contacts will be selected for even kWh/pulse values, i.e.100 kWh/P.

3. Ammeters: Ammeters will have a full-scale value equal to the current transformer primary rating and be rated for 5 amps input current. For auxiliary loads, current transformer ratios will be selected to give an approximately two-thirds full scale reading at rated loads.

4. Varmeters: The varmeter will have the same scale as the wattmeter, except it will be a zero center meter. The sum of the left-hand scale and the right-hand scale will equal the wattmeter full scale.

5. Plant Control System: All analog meter inputs to the Plant Control System will be 4-20 mA or datalink. Totalizing meters will provide digital inputs to the Plant Control System. Overall accuracy will be 0.2% or better.

1.29 CABLE RACEWAY

A. Cable raceways will primarily consist of cable tray and conduit. Cable raceway center-to-center separation will be determined during design based on equipment requirements.

1.30 CABLE TRAYS

A. The cable tray system will utilize multiple classes of tray, and cable tray separation will be determined during design based on equipment requirements. This separation isolates power and control cables from instrument cables for safety and electrical noise purposes. The cable trays will be continuous with straight lengths interconnected with horizontal and vertical fittings. Where required, cable trays will totally enclose the cables they transport.

B. The cable tray classification also indicates the sequence of cable tray placement in a vertical array, with medium-voltage tray at the top and instrumentation at the bottom. The separation between the low voltage (600V) and control can be 0" if both cables are insulated at 600V.

C. Medium-voltage cable trays will be ladder style with ventilated covers to prevent accidental contact with the medium-voltage cables while avoiding additional cable derating for heat affects. All other trays will be ladder type, except instrumentation, which will be solid bottom. Covers will be installed on the top tray of all outdoor trays, horizontal runs under grating, and on vertical runs, which penetrate platforms and floors (to a height of eight feet).

D. Cable trays and covers installed indoors will be aluminum. Cable trays and covers for normal outdoor atmosphere will be aluminum. Instrument trays, both indoor and outdoor will be ladder style. Solid covers will be provided on all outdoor and on indoor horizontal trays exposed to falling objects or subject to the accumulation of debris. Cable trays, which run under floor gratings or access platforms, or parallel to walkways and in close proximity thereto, will be provided with covers. Trays under gratings and walkways will have these covers extended 5 feet beyond the extremity of the walkway or grating. On multiple cable tray installations, the foregoing requirement applies only to the top tray. Tray covers will be provided for trays where contained cables are exposed to direct sunlight and in areas where cables may be damaged from falling objects.

E. All metallic cable tray runs will be electrically continuous. Where breaks occur, stranded copper ground straps will be installed as bonding jumpers to maintain continuity.

F. Where possible, cable trays will avoid all fire hazard locations, such as turbine oil tanks, main turbine lube oil reservoir, etc. Cable trays will also be routed to avoid maintenance access areas for equipment.

G. Nominal cable fill for random lay trays will be according to NEC.

1.31 CABLE TRAY SUPPORTS

A. Cable tray supports will be field installed. The basic material and structures will be "Unistrut" type or galvanized threaded rod type trapeze hangers. Typical tray support designs and installation criteria will be provided on the drawings. Cable tray support spacing criteria will be in accordance with tray manufacturer requirements. Cable trays will not be supported from piping.

1.32 CONDUIT

A. All exposed conduits, except for flexible connections, will be rigid galvanized steel. Conduit embedded in a concrete floor will be PVC with galvanized steel risers.

B. Liquid-tight flexible conduits will connect the conduit to all loads subject to vibration, thermal movement or requiring flexibility to be moved aside during maintenance.

C. All above ground conduits will be schedule Rigid Galvanized Steel. No direct bury conduit will be used.

D. Cables will be routed in the conduit system using computer database software. Nominal cable fill for conduits will be according to NEC (NFPA 70, chapter 9, Table 4). Conduit voltage class separation will be the same as for cable tray.

E. There will be a maximum of four 90 degree bends or the equivalent thereof in one conduit run. Pull boxes or pull sleeves will be used when necessary to comply with this requirement.

F. Straight runs of conduit over 100 feet in length will have expansion fittings if there are no pull boxes.

G. Conduit connection points located outdoors or exposed to conditions that result in frequent wetting will not enter from the top. Bottom entry is preferred; under certain conditions, side entry is permissible. Weep holes or bug screws will be provided at low points for removal of water that does get into the conduit. Weep holes will be large enough that small debris will not plug the weep hole, but small enough to protect the cable from damage. When possible, conduits can be arranged to drain to pull boxes and panels with provisions for drains in the bottom.

H. Conduits containing Data Highway Cables (Fiber, CAT 5e, etc.) will be clearly identified as such and identify between Primary and Secondary runs.

1.33 CONDUIT SUPPORTS

A. Conduits will be supported by hangers spaced in accordance with the National Electric Code (NEC), Section 344 for rigid metal conduit. Piping will not be utilized for conduit support.

B. Conduit supports will be field installed. The basic materials will be "Unistrut" type.

1.34 UNDERGROUND DUCTBANKS AND MANHOLES

A. Underground duct banks will consist of concrete encased PVC conduit (Heavy wall PVC in accordance with NEMA TC2). The underground duct bank system will be designed- with enough manholes that cable installation can be performed without damaging cables due to excessive pulling tension. The encased conduit will be sloped so that water will drain out of the conduit. Where undrained conduits are completely unavoidable, the conduits will be sealed with sealing compound after the cables have been installed.

B. Underground concrete duct banks will be marked with red dye in the concrete on the top of the bank.

C. Manholes will have sump areas.

D. Where ducts pass under roadways or in areas subject to movement of heavy equipment, they must be encased in a concrete envelope structurally adequate for the loads imposed.

E. As much as practical, when equipment is served by below-grade conduit, embedded conduits will be employed to reduce the above grade conduit runs and keep them out of walking spaces.

F. Main underground ductbank trunk runs will have approximately 20% spare ducts upon initial design.

1.35 PRECAST CONCRETE TRENCH

A. A pre-cast concrete cable trench system may be used for the distribution of medium voltage power, and low voltage power and control cables, where practical.

1.36 CABLE

A. Cables will be specified in accordance with the Engineer's, NEMA and ICEA standards. Cable outside diameters used for design purposes will be a composite of standard industry values.

B. Voltage Rating

1. The following table gives the voltage rating and service voltage of cables:

POWER				
Service	Nominal Cable Voltage Rating	Insulation	Jacket	Shield
13,800-Volt ac	15,000	133% EPR	CPE or CSP (Hypalon)	Shielded
4,160-Volt ac	5,000	133% EPR	CPE or CSP (Hypalon)	Shielded
480-Volt ac 120/208-Volt ac (Power Feeders)	600	FR-XLPE, FR-EPR, XHHW-2	CPE or CSP (Hypalon)	Unshielded
120/208-Volt ac (Lighting and Receptacles)	600	FR-XLPE, XHHW-2	N/A	Unshielded

125-Volt dc	600	FR-XLPE, FR-EPR	CPE or CSP (Hypalon)	Unshielded
24 or 48-Volt dc	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Twisted/ Shielded

CONTROL				
Service	Nominal Cable Voltage Rating	Insulation	Jacket	Shield
125-Volt dc & 120-Volt ac	600	FR-XLPE, FR-EPR	CPE or CSP (Hypalon)	Unshielded or Shielded

INSTRUMENTATION				
Service	Nominal Cable Voltage Rating	Insulation	Jacket	Shield
Analog	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Shielded, twisted pairs or triads
24- Volt dc Digital	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Twisted/ Shielded
48- Volt dc Digital	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Twisted/ Shielded

C. Cable Sizing

1. Cable sizing will be in accordance with the NEC, ICEA Publications and IEEE Standards.

D. Cable Terminations

1. Medium-voltage power cables will be terminated with prefabricated 3M Cold Shrink QT-H terminal kits. Lugs will be long barrel copper compression type. Unless otherwise noted, cable shields will be grounded at both ends.

2. Compression type, double indent, two-hole copper lugs will be used for all power cables larger than #6 AWG and where designed for use.

3. Medium voltage auxiliary motors will be terminated with 3M 5380 Series Re-moveable/Re-useable Motor Lead Splicing kits.

4. Solid insulated ring type connections will be used on all control, instrumentation, CT and PT connections.

5. Grounding cables will be color-coded for identification. Where phase leads are color- coded, tagging is required at feeder end only.

1.37 LIGHTING AND RECEPTACLES

A. Light Intensities

1. Illuminating Society of America (IES) recommendations, Owner standards, and the Engineer' s Engineering standards will be followed for light intensities and light sources. Minimum plant lighting levels are defined as follows:

a.	Roadways	1 foot-candle
b.	Platforms & Stairways	2 foot-candles
c.	Power Block	5 foot-candles
d.	Generator Enclosure	10 foot-candles
e.	Transformer Yard	3 foot-candles

B. Lighting Calculations

1. Lighting calculations will be performed to determine the required number of lighting fixtures and fixture geometry to produce the recommended lighting levels.

C. Lighting Systems

1. Normal ac, emergency ac, and dc lighting systems will be provided to ensure the availability of necessary illumination during normal and emergency operations. Each system will have its own separate supply source and lighting fixtures. Outdoor fixtures will be weatherproof.

2. In general, exterior lighting systems will be directed downward to diminish visual disturbances to surrounding properties.

3. In general, the normal ac systems will be supplied power from 480-volt or 120/208-volt Lighting or Power Panels (for 60 Hertz systems only). The lighting system power will be distributed to the fixture circuits by circuit breaker panel boards.

4. Electric power to light fixtures will be switched with locally mounted light switches in areas where the light can be "off" when the area is not occupied. Electric power to light fixtures located outdoors that are required to be on for safety purposes will be switched with photoelectric controllers.

5. The dc Emergency lighting will be supplied from the plant dc distribution system, or from individual battery powered lights. Emergency lighting will be employed wherever personnel egress lighting must be available per safety and code regulations. Typically, remote areas needing emergency lighting will utilize the individual battery powered lights. Special consideration will be given to matching fixture types to the environmental conditions.

6. Emergency ac Lighting will be designated as required.

7. Lighting fixtures and material will be in accordance with IES standards. The Engineer will perform basic and detailed lighting design.

8. Normal AC Lighting System: The normal ac lighting system will provide illumination for the plant when the unit auxiliary power system is available. The

lighting transformers and panels will be located in the general vicinity of the lighting fixtures, which are being supplied and controlled from these panels. The operating voltages for these fixtures will be 120/208-volts. Street Lights may use 480 Vac fixtures. Each single-phase feeder circuit in the lighting panels will be loaded so that all three phases in the panel have as balanced loading as practical. In general, a group of lighting fixtures will be controlled from a single circuit breaker located at the lighting panel. Where offices or infrequently accessed areas are involved, local switching of the lights will be provided. Outdoor areas requiring nightly access will have the lighting controlled from a photocell/contactor arrangement.

9. Dc Lighting System: Dc lights fed from the station batteries will remain operational for at least 3 hours after loss of ac power. The batteries for the individually powered emergency lanterns will be nickel cadmium and have sufficient power to keep the lanterns energized for at least 90 minutes after the 120-volt single phase supply has been de-energized. Self-contained battery operated exit lights will be provided as required by governing codes.

10. Security Lighting System: Security lighting will be limited to outdoor areas to be monitored by plant security which otherwise would not require lighting.

D. Convenience Receptacles

1. 120-volt duplex, specification grade convenience receptacles will be provided in general plant areas where periodic maintenance is performed. Frequency of receptacles will be based on the use of 100-foot extension cords. In areas where heavier maintenance work than normal is expected, the quantity of receptacles will be increased. Ground fault receptacles or ground fault branch circuit breakers will be used for outdoor receptacles and in areas required by the NEC.

2. Receptacles will be powered from the 120/208-volt lighting transformers and panel boards. All transformers will include a minimum of 20% capacity reserved for future use.

3. 480-volt, 3-phase, 3 wire, plus ground, 60 ampere with safety switch, welding receptacles will be installed in those areas where periodic maintenance welding is anticipated. These receptacles will be Siemens ITE Enclosed Switch Vacu-Break Clampmatic with Crouse Hinds 4 prong receptacle, catalog

HNF362SCH, Series A, 60 AMP 600 Volt, 3 Phase 277V/480V, Type 4/4X enclosure.

1.38 ELECTRICAL HEAT TRACING

A. Self-regulating parallel type heat tracing will be used to provide both freeze protection and process heat tracing. Self limiting heat tape is also required on the supply line from the water heater to the emergency showers to maintain a 60 degree temperature. Systems requiring heat tracing will be annotated as such on the P&IDs. Heat tracing calculations will utilize plant specific values for temperatures and insulation values. Individual freeze protection and process heat tracing circuits will use individual thermostats for control. Where large quantities of freeze protection circuits exist in the same area, a thermostat/contactor arrangement to switch an entire distribution panel will be used. Power for heat tracing will come from 120/208- volt distribution panels designated for heat tracing use. Open circuit indication will be provided from each panel to the DCS. Electrical heat tracing systems will be covered by a performance specification prepared by the Engineer. Heat tracing will be designed, installed and tested in accordance with IEEE 515.

B. Heat tracing will be designed per the minimum ambient temperature provided in this design criteria and will be provided as generally identified on the P&IDs. Heat tracing electrical circuits will be shown in isometric format.

1.39 CATHODIC PROTECTION

A. Cathodic protection systems will be provided in accordance with the Piping Line Specs. Systems will primarily be sacrificial anode systems based on a 20-year anode life. Should larger systems be required, a rectifier powered anode system will be used.

B. Care will be taken to coordinate the cathodic protection system with the ground grid system to preclude destructive interaction of these two systems.

C. Soil resistivity studies will be performed as needed to support design of the cathodic protection system.

D. Appropriate test stations for the cathodic protection systems will be provided with segregated test terminal points for each separate cathodic circuit. Test Stations will be located away from traffic areas, not in roadways or maintenance areas where they could be damaged.

1.40 GROUNDING SYSTEM

A. System Design

1. The grounding system will be designed to provide personnel safety and to provide protection to electrical equipment. The design of the grounding system will be in accordance with-the requirements of the current revision of IEEE 80, 81, 81.2, 142, 665-and 1050, NESC and the NEC. Soil resistivity will be measured as described in IEEE 80.

2. After the ground grid potential profile analysis has been determined, the tolerable step and touch potential will be checked in accordance with IEEE 80 procedures.

3. The ground grid will be designed such that, after it has been installed, its resistance to remote earth is measured as described in IEEE 80. The entire station resistance to remote earth will be less than 3.0 OHMS. The resistance to ground of different ground grid sections will be verified prior to permanent connection together. Remote areas within the main plant and outside the main plant fence will have a minimum of two connections to the main plant ground grid. New units or power blocks will be connected to the existing ground grid in multiple locations at no less than four locations. Ground grid perimeter will extend 3' outside all fencing and buried at a minimum of 18" deep.

4. All connections, except for those made to equipment, will be exothermic welded. Equipment connections will be bolted to facilitate equipment removal. All electrical equipment, including main generators, transformers, breakers, motors and other components will share a common grounding grid.

5. Fence grounding will also meet IEEE 80 and will be continuously connected to the common grounding grid, even the section of fence under transmission circuits at the switchyard and GSUs.

6. The isolated (i.e. floating) instrument ground from the Control System will be connected to the intersection of the ground grid cables, unless this point is in close proximity to a lightning post ground connection. If a lightning post ground connection is nearby, the instrument ground cable will not exceed twenty-five feet in length and will be located as far as possible from the lightning pole ground connection. The instrument ground cable will be an insulated 4/0 AWG cable.

7. Instrument cable shields will be grounded at the DCS cabinet end only to prevent circulating currents. Care will be taken to extend the continuity of the cable pair shields in all field terminal boxes. At points of termination, pair shields, and drain wires will remain on the pair as close to the termination point as is practical. Shields will be permanently taped to prevent unraveling and the drain wires will have insulating sleeves installed up to the point of termination.

8. All ground stringers through concrete will be insulated or run through PVC.

B. Main Plant Design

1. The main plant ground grid will consist of bare copper cable buried in earth or embedded in concrete as shown on the drawings. In the vicinity of the main power block, the parallel grid lines will be continuous under the foundation. Where resistance to ground measurements indicates greater than 3-ohm, additional copper-weld ground rods will be driven into earth and exothermically welded to the grid. The addition of ground rods will continue until the 3-ohm measurement is obtained.

2. Electrical equipment at grade or on the first floor of the power block will be directly connected to the ground grid via riser cables. Steel columns will be directly connected to the ground grid via riser cables. Column structural splices will be made electrically continuous. Equipment located above the first floor will have their grounds connected to building steel provided the structural steel splices have been made electrically continuous.

3. The generators will be grounded in accordance with the Supplier's requirements, and the Engineer's and NEMA Engineering standards. The generator frame will be grounded at four points by cable directly to the main ground grid.

4. Underground duct banks will include bare 4/0 AWG cables that will be run on top of the ductbank for connection of the ground grids at each end of the duct bank. In manholes, these ground cables will be extended around opposite sides of the manhole.

C. Transformer Yard Fence

1. The transformer yard fence will be grounded by tying it to the plant ground grid if located over the plant grid or by using a separate grid tied to the plant grid. If

a separate grid is used, one 4/0 AWG bare copper cable will be buried 3 feet outside the fence at a depth of 18 inches and will be connected to every other fence post with #2 AWG bare copper cable. The 4/0 AWG cable will be tied to the main plant or switchyard ground grid at four distinct points (i.e. each side of the transformer fence). Ground rods will be provided in accordance with the requirements of the ground grid design. Ground fittings for fence connection will be cast copper alloy with silicone bronze hardware. Copper-strap ground connectors and ferrous hardware will not be used. All gate hinges, and/or moveable connections, will be jumpered using flexible #2 AWG cable, such that all sections of the fence are hardwired to the ground grid. All connections between the transformer yard fence, the transformer ground grid, and the plant ground grid will be by exothermic connections, compression type connectors are only allowed for the connection to the fence itself.

D. Remote Areas Outside Plant Boundaries

1. A 4/0 AWG ground grid will be installed in the vicinity of all the remote plant structures, which contain electrical equipment. Each ground grid will be interconnected to the main plant ground grid in at least one place with minimum 4/0 AWG cable. The three (3) ohm resistance to ground requirement is valid at each of these locations.

1.41 HAZARDOUS AREAS

A. Hazardous areas will be determined in accordance with the NFPA. Areas of the plant will receive classifications as follows:

1. Non-hazardous; Class I, Division 2; Class I, Division 1

2. Known hazardous material is natural gas and fuel oil.

B. A plot plan will be developed for the plant and remote areas showing the hazardous area classifications.

C. Electrical equipment and construction specifications will require all electrical equipment, materials, and installation practices to adhere to the NEC hazardous area requirements for the area in which the equipment is located. The Engineer's design will minimize the impacts of hazardous areas by reducing the amount of equipment located within classified areas as much as possible.

1.42 COMMUNICATIONS SYSTEM

A. The communication system will include a plant wide paging system, and communication ports/data links in the remote buildings. Handsets, paging amplifiers and loudspeakers will be located as required to provide adequate plant coverage. Power supply for the communication system will be from the UPS system.

B. The system will be designed to produce a sound intensity of at least 6 dB above a possible 100 dB background from the turbine generator or other noise producing equipment. The loud speakers will have a frequency range of 85 to 7500 hertz.

C. System will include alarm capability that will be activated from the main control room.

D. The system will contain spare capacity for future addition of a minimum of 25% additional communication instruments and alarm conditions without procuring new or supplementary system hardware or software.

E. Communication equipment will have weatherproof ratings so that installation prior to building enclosure will not degrade the equipment.

F. Handsets will be of the desk or wall-mounted type as required for a particular location. Where required, sound-attenuating enclosures may be required plus enclosures will be highly visible and well marked.

G. Required vendor is GAI-Tronics.

1.43 PLANT SECURITY SYSTEM

A. A plant security system will be required.

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COMPRESSED AIR ENERGY STORAGE PROJECT

I&C Engineering

Design Criteria

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COMPRESSED AIR ENERGY STORAGE PROJECT
I&C ENGINEERING
DESIGN CRITERIA

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CONTENTS

1. INSTRUMENTATION AND CONTROLS DESIGN CRITERIA

1.1 Introduction

The instrumentation and controls design criteria provides the basis for the plant control philosophy, the control systems, the instrumentation design, and the instrument installation design. The intent of this criteria document is to provide the design criteria for engineered systems, as well as to provide the design basis to which vendor-supplied systems are specified and reviewed.

1.2 Codes and Standards

The latest edition and published addenda of the following publications are applicable to the extent indicated by the specific reference. All equipment furnished and work performed under this Section shall comply with the approved standards, specifications, and regulations, codes, and tests of the following:

A. ASME:

1. B16.5, "Pipe Flanges and Flanged Fittings."
2. B16.34, "Valves - Flanged, Threaded, and Welding End"
3. B16.10, "Face-to-Face and End-to-End Dimensions of Valves"
4. B31.1, "Power Piping."
5. MFC-3M, "Measurement of Fluid Flow in Pipes using Orifices, Nozzles, and Venturi"
6. PTC 19.3, "Temperature Measurement Instruments and Apparatus"
7. PTC 19.5, "Flow Measurement"

B. Institute of Electrical and Electronics Engineers (IEEE):

1. 1050, "Guide for Instrumentation and Control Equipment Grounding in Generating Stations"

2. 1100, “Recommend Practice for Powering and Grounding Electronic Equipment”

3. C 37.90.1, "Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus."

C. National Fire Protection Association (NFPA):

1. 70, “National Electrical Code.”

2. 85, "Boiler and Combustion Systems Hazards Code.”

D. National Electrical Manufacturers Association (NEMA).

1. ICS 1, “Industrial Controls and Systems General Requirements”

2. 250, “Enclosures for Electrical Equipment (1000 Volts Maximum)”

E. The International Society of Automation (ISA):

1. 5.1, “Instrumentation Symbols and Identification.”

2. 5.2, "Binary Logic Diagrams for Process Operations."

3. 51.1, “Process Instrumentation Terminology.”

4. 75.01.01, “Flow Equations for Sizing Control Valves.”

5. 75.02.01, “Control Valve Capacity Test Procedure.”

6. MC 96.1, “Temperature Measurement Thermocouples.”

F. The Measurement, Control, and Automation Association (MCAA)

1. Functional Diagramming of Instrument and Control Systems

1.3 General

A. Unit and Scale

1. The following units of measure shall be the standard for this project:

a. Positive gauge pressure: psi, inH2O
b. Vacuum: mmHg, inH2O
c. Temperature: °F
d. Flow:

i. Liquid: GPM
ii. Steam: lb/hr
iii. Air and Gas: lb/hr, SCFM
iv. Solids and slurry: lb/hr

e. Level: inches, feet – as appropriate for the application

2. Scales shall be designed to read directly in engineering units, unless otherwise specified.

B. Symbols and Legends

1. In general, instrument and control symbols and identifications shall be as indicated in ISA and The Measurement, Control, and Automation Association standards or approved equivalent.

2. All documents, instructions, legends, charts, scales, and nameplates shall be in the English language.

3. All tag numbers for equipment and instrumentations shall be as indicated in the project specific tagging structure.

C. Control Signal

1. Electrical control signal: 4 – 20mA DC

2. Pneumatic signal: 3 - 15 psig

D. Control shall utilize Distributed Control System (DCS) technology by using fully redundant microprocessor technology with redundant, high speed, fault tolerant communications and multiple screen operator interfaces.

E. Controls shall include safety logic that shall automatically alarm and execute preprogrammed actions in cases where unsafe situations are likely or imminent.

F. The general design of control room operator interface criteria shall be for a soft display-based control and monitoring system with minimal "hard" devices.

G. The control system shall be designed so that the entire plant process and ancillary plant systems can be safely operated through the unit control room DCS display console. These displays will provide a single, integrated, cohesive, interface to all plant equipment and processes.

H. All alarms that jeopardize plant operation shall be collected by the DCS, evaluated and sorted according to process system groups and alarm severity.

I. Control facilities shall be designed so that major operation of Combustion Turbine (CT) Generator, Recuperator and plant auxiliaries can be accomplished from the control room.

J. "Hard" manual-automatic control stations will not be provided.

K. The use of local pneumatic controls shall be minimized.

L. PLC's or vendor standard controls shall be provided for the following:

1. Air Compressor Control Systems Local Control Panels
2. Domestic Water Treatment System PLC Control Stations
3. Industrial Sewage Water Treatment
4. Auxiliary Boiler (aux boiler enclosure)
5. Ammonia storage, forwarding and feed systems
6. CEMS Operator Stations (CEMS enclosure at chimney, and in the unit control room)

Datalinks shall be provided between all PLCs and DCS.

M. Instrument Air Systems

1. The instrument air supply shall be distributed at 80 to 125 psig with design dew point of minus 40 ºF. It shall be oil and solid free (no particulate greater than 10 microns) and shall consist of atmospheric air compressed by a non-lubricated

pump. Surge capacity shall be provided by over-sizing sections of the distribution header throughout the plant.

2. If automatic emergency provisions are included for devices for backup from Service Air, design shall not permit loss of pressure of the Instrument Air header on a catastrophic failure of the Service Air header.

3. A dual tower air dryer system shall be supplied. Transfer to the back-up air dryer shall occur on low instrument air pressure or high moisture.

N. Motor Control

1. Most motors are controlled from the DCS. Local control, in lieu of DCS control, is provided in instances where DCS control is not warranted due to limited need for control room operator interface, or due to the infrequent use of the equipment.

2. Standby Starts - Components in a system (such as 2 x 100% pumps) that are redundant will have a standby mode included in the control logic. If the redundant pump is in the standby mode when the operating pump is tripped, or a process parameter indicates that the operating pump has failed, the standby pump will standby-start. An alarm will alert the operator that the pump has standby-started.

3. Medium voltage motor switchgear feeder breakers will have the following I/O for control and monitoring from the DCS:

a. One digital output for start, momentary closed contact to start

b. One digital output for stop, momentary closed contact to stop

c. One digital input for motor status

d. One digital input for trouble alarm from the multifunction motor protection relay. Any alarm condition detected by the relay will initiate this alarm, including loss of control power. Three RTDs for motor winding temperature where provided will be wired to the multifunction relay. A high temperature on any of these RTDs will initiate this trouble alarm.

e. One digital input to indicate that DCS control is enabled. This contact indicates that the breaker is racked in and the local control switch is in the “Remote” position indicating that it is ready for remote control.

4. Low voltage motor starters in motor control centers will have the following I/O for control and monitoring from the DCS:

   a. One digital output for start/stop, maintained closed to run (normally open contact)

   b. One digital input for motor status

   c. One digital input for control power available

5. All motor operated valves will have local starters and local control stations on the valves. Motor operated valves in open/close service will have the following I/O for control and monitoring from the DCS:

   a. One digital output for valve open (forward) command (normally open contact)

   b. One digital output for valve closed (reverse) command (normally open contact)

   c. Two digital inputs for valve position (full opened and full closed)

   d. One digital input for Local/Remote switch feedback (Remote = 1)

   e. One digital input for trouble alarm (includes control power available)

6. Motor operated valves in jogging service will have the following I/O for control and monitoring from the DCS:

   a. One maintained digital output for valve open (forward) command (normally open contact)

   b. One maintained digital output for valve closed (reverse) command (normally open contact)

   c. Two digital inputs for valve position (full opened and full closed)

d. One digital input for Local/Remote switch feedback (Remote = 1)

e. One digital input for trouble alarm (includes control power available)

f. One analog input for valve position

O. Breaker Control

1. Medium voltage switchgear main breakers will have the following I/O for control and monitoring from the DCS:

   a. Digital output for breaker close command

   b. Digital output for breaker open command

   c. Digital input for breaker closed status

   d. Digital input for breaker common trouble alarm

   e. Digital input for breaker racked in

2. Medium voltage switchgear tie breakers will have the following I/O for control and monitoring from the DCS:

   a. Digital output for breaker close command

   b. Digital output for breaker open command

   c. Digital input for breaker closed status

   d. Digital input for breaker common trouble alarm

   e. Digital input for breaker racked in

3. Medium voltage switchgear feeder breaker will have the following I/O for control and monitoring from the DCS:

   a. Digital output for breaker close command

   b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

4. Low voltage switchgear main breakers will have the following I/O for control and monitoring from the DCS:

    a. Digital output for breaker close command

    b. Digital output for breaker open command

    c. Digital input for breaker closed status

    d. Digital input for breaker common trouble alarm

    e. Digital input for breaker racked in

    f. Digital input for bus ground fault

5. Low voltage switchgear tie breakers will have the following I/O for control and monitoring from the DCS:

    a. Digital output for breaker close command

    b. Digital output for breaker open command

    c. Digital input for breaker closed status

    d. Digital input for breaker common trouble alarm

    e. Digital input for breaker racked in

6. Low voltage switchgear feeder breakers will have the following I/O for control and monitoring from the DCS:

    a. Digital output for breaker close command

    b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

f. Digital input for bus ground fault

P. Control Valves and Drives

1. The fail-safe position of the valve or damper will be when the signal or electric power or pneumatic power is not present.

2. Pneumatic modulating control valves will receive a 24 VDC-powered, 4-20 mA DC control signal. Limit switches and air failure lockup devices will not be used unless needed for special control or monitoring.

3. Pneumatic on-off control valves or drives will have the following I/O for control and monitoring from the DCS:

   a. One or two digital outputs, depending of failure position, of a 120 VAC signal from the control system to power a three way solenoid.

      i. Fail Open or Closed: one digital output

      ii. Fail in Place: two digital outputs

   b. Two digital inputs for valve or drive position (full opened and full closed)

4. Electric modulating control drives will have the following I/O for control and monitoring from the DCS:

   a. One 24 VDC-powered 4-20 mA DC analog for drive position demand

   b. Drive position feedback via HART protocol

5. Pneumatic modulating control drives will have the following I/O for control and monitoring from the DCS:

   a. One 24 VDC-powered 4-20 mA DC analog for drive position demand

b. Drive position feedback via HART protocol except for critical valve position feedback which will be hardwired

6. Electric on-off control drives will have the following I/O for control and monitoring from the DCS:

a. One digital output for drive open (forward) command (normally open contact)

b. One digital output for drive closed (reverse) command (normally open contact)

c. Two digital inputs for drive position (full opened and full closed)

d. One digital input for Local/Remote switch feedback (Remote = 1)

Q. Trips and Interlocks

1. Trips and interlocks will be implemented in the DCS to the maximum extent possible except in the following instances:

a. Code required direct hardwired means of tripping

b. Required response time for the interlock is faster than can be implemented through the DCS.

2. All required equipment interlocks shall be shown on equipment vendor logic diagrams. Interlocks implemented in the DCS shall be shown on DCS control system logic diagrams. Hardwired interlocks will be shown on wiring diagrams.

1.4 Control Room and Electronics Room

A. Control Room

1. Normal temperature of central control room shall be 72 - 78 °F and allowable temperature shall be 68 - 82 °F.

2. Relative humidity of the central control room shall be 40 - 60% (minimum 20%).

3. Lighting in the control room shall be designed with the ability of the operator to adjust the level for optimum reading of displays.

4. All control room panels and consoles shall be designed to prevent the operator from being subjected to objectionable noise from fans, printers, and any other background noise source, including equipment external to the Control Room. Background noise levels should be less than 65 dBA.

B. Operator’s Control Console Layout

1. Control console design will be for a soft DCS display-based operator interface.

2. The control console shall be arranged to accommodate one or two operators.

3. Console items shall be placed for ease of operation and in logical relationships with respect to each other.

4. The control console shall accommodate page system and phone system handsets.

C. The following equipment shall be located in the control room:

1. Operator's Control Console

a. Three dual screen DCS operator workstations

b. One CTG control system workstation

c. Operator work surface to accommodate phone and page sets, and drawing/document laydown area

d. CEMS operator interface display.

e. Water Treatment operator interface display.

f. Auxiliary Boiler display

g. Air compressor display

2. One (1) ceiling-mounted large flat panel overview displays

3. Auxiliary Benchboard Control Panel

   a. Hardwired trip pushbuttons for the CT and the Auxiliary Boiler.

4. Vibration monitoring system and analysis workstation

5. One (1) DCS historical data storage system workstation

6. One (1) DCS alarm printer

7. Fire alarm panel

D. The following equipment shall be located in the electronics room:

1. Power Distribution panels

2. DCS control processor cabinets

3. DCS I/O cabinets (if required)

4. DCS Network Cabinets

5. One (1) DCS engineering workstation

6. One (1) DCS engineering workstation printers

7. Tables, files, and other miscellaneous furniture

8. Telephone and paging communication cabinet

9. Fiber Optic Termination Cabinet(s) (if required)

E. All instruments located in the control room or electronics room, susceptible to EMI, shall be designed in accordance with applicable standards.

1.5 Distributed Control System (DCS)

A. The DCS will be used to control and protect the main plant equipment and systems and will serve as the central interface for the operators. This system will be connected to the various instrumentation and control devices throughout the plant.

B. The DCS will be a hierarchical, microprocessor-based control system. All DCS control and monitoring functions will be implemented in control processors. All processors will be a minimum of 32-bit, multi-speed standard software design, with self-checking features to allow detection of processor malfunctions.

C. Each control processor shall be equipped with capacity required to perform its functions plus a spare capacity of 40 percent of all control processors memory, control processor utilization, addressable points, and any other factor that affects control processor utilization. Each distributed controller shall have at least 25 percent spare duty cycle under worst case conditions.

D. The DCS equipment will be designed such that a system component failure or a DCS power source failure will not disrupt control system functions. Each control processor cabinet will provide redundant control processors, power supplies, and data highway interfaces. Each I/O cabinet will provide redundant power supplies, and data highway interfaces. If the system detects a control processor failure, a power supply failure, or a communications failure, the failed equipment will automatically transfer to its back-up. In the case of a processor failure, if the back-up is unavailable, the processor outputs will fail to their fail-safe position and allow a manual shut-down of the equipment affected. Upon a back-up power supply failure, the affected equipment will fail in its de-energized position.

E. The DCS shall be the primary means of controlling most of the plant for all operating conditions. It shall implement analog and digital (logic) functions to bring the plant from start, up to the desired operating conditions, and back to complete shutdown. It shall also include all interlock and control functions to sustain any postulated transient condition. The DCS shall provide for automatic control, however the operator shall always have the capability to intercept the auto mode and to control the unit manually (subject to safety and protection restraints). Primary operator interface shall be provided though DCS operator displays in control room consoles.

F. Elements of both functional and geographic distribution shall be used in locating the hardware and assigning tasks to the control processors of the DCS. Where concentrations of field devices can be identified in the plant, geographic distribution shall be applied. Where extreme speed of response is essential, or where data communications are not sufficiently secure, functional distribution shall be applied. When functional distribution is applied, care should be exercised to ensure that failure of a single station has minimal effect on plant operation. To the greatest extent possible, a single data station shall serve process segments that are interdependent.

G. Control Functions

1. The primary purpose of the DCS is to maintain control over the plant processes. The objective is to obtain maximum efficiency, longest equipment life, and minimum environmental effects.

2. The system shall be readily configurable and capable of on-line configuration and maintenance. It shall be self-documenting, fault tolerant, highly dependable, and reliable.

3. The response time of the control actions shall be sufficient to maintain control over the process under all operating scenarios. This response time shall include consideration of delay and dead times, both internal and external to the DCS and shall be selected based on the process requirements.

4. The control system shall transfer to manual control and alarm upon loss of valid process data.

H. Safety and Protection Functions

1. Protective functions shall be designed to be very dependable and be designed to prevent failure to trip and false trips. Protective actions may be initiated based on an event, a threshold value, operator intervention, or an analysis of the plant status. The applicable safety codes governing each application shall be followed.

2. Failure or loss of a single component shall not cause a protective function to be disabled.

3. Protection functions require periodic testing and calibration. The DCS shall recognize and accommodate this requirement.

4. The interlocking and protecting functions that are applied in the DCS shall be implemented in a very careful, conservative, and fault tolerant structure, with assurances that the response time is adequate for each situation.

I. Data Highway Communications Network Design

1. The data highway shall be redundant. The data highway inside the control room and electronics rooms will utilize an Ethernet, twisted shielded pair, or fiber optic cable. The data highway outside these rooms will use fiber optic cables.

2. Redundant data highway cables shall be routed in separate conduits above ground. Under ground, redundant data highway cables may be routed in a single conduit.

3. The fiber optic cables used for DCS communication links will be a 12-fiber cable. All communication fiber will terminate in fiber optic patch panels at both ends, with all fiber strands terminated in the panel. Connection to the final termination point will be via 2-fiber patch cables.

4. Datalinks shall be provided between the DCS and the following:

   a. PLCs

   b. Medium Voltage Switchgear

   c. Motor Control Centers

J. Input and Output (I/O)

1. The following I/O signal types and I/O cards shall be used:

   a. 4-20 mA DC system powered analog output

   b. 4-20 mA DC system or field powered analog input

   c. Thermocouple analog input (Type K typical)

   d. RTD analog input (3 or 4-Wire 100 ohm platinum typical)

   e. 24 or 48 VDC system powered digital input

   f. 24 or 48 VDC system powered SOE input

   g. 125 VDC or 120VAC externally powered digital input

   h. Dry contact rated 120 VAC or 125 VDC digital output

i. Internally-powered 120 VAC digital output

2. The as-shipped control systems shall have twenty percent (20%) spare wired I/O provided for each I/O type in each cabinet and twenty percent (20%) spare slots and unwired terminations in each I/O cabinet.

3. I/O modules shall be available to accept all required signals and all analog I/O modules shall reject the common mode voltages that might appear between sensor ground and A-D converter ground.

4. A single component failure including a blown fuse shall not result in the loss of more than one I/O signal. The DCS shall monitor the status and alarm on the loss of any fuse.

5. As with all printed circuit cards in the system, the I/O modules shall be capable of installation or removal with the backplane energized, and without disturbing adjacent cards or field wiring. The modules shall be designed in such a manner that will prevent damage or misoperation if they are installed in the wrong slot.

6. The I/O system shall evaluate the quality of the incoming signals from the transmitters and sensing devices. They shall:

   a. Verify that the signal is within the valid sensor range for the variable.

   b. Detect open or shorted field wiring, without adversely affecting the function of the field device.

   c. Take immediate corrective action to avoid any upset to the controlled process on detection of a failed control input, and notify the operator of the failure.

7. I/O cards shall support Hart communication with all Hart enabled field equipment through the 4-20 mA analog input and analog output cards.

8. Communications links between I/O cards and control processors shall be redundant.

K. Power Supply Considerations

1. The DCS shall include all power supply conditioning necessary to accommodate normal variations in electrical supply to the system. The system shall accept a primary 120 VAC UPS power feed and a secondary 125 VDC power feed for all stations. Redundancy shall be provided in the DCS's power conditioning circuits.

2. DCS I/O cabinets which contain internally-powered 120 VAC digital output cards, shall have separate redundant 120 VAC UPS power feeds to provide the motive force. In addition, a relay shall be provided to automatically switch to the backup power feed in the event the primary feed is lost. Alarm shall be provided for loss of either power feed.

3. Field wiring for contact interrogation and device control shall be protected such that a fault in these cables does not cause a loss of more than one signal.

L. Control cabinets

1. Control processor cabinets shall be free standing and rated NEMA 12. These cabinets shall contain communication cards, processor cards, and power supplies. Control processor cabinets will be located in an environmentally controlled area; e.g. an electronic equipment room or a prefabricated room. Cabinets shall have front and rear access. Cable entry is through the top and bottom of the cabinet.

2. I/O cabinets located in an indoor controlled environment shall be NEMA 12 free standing. These cabinets shall contain communication cards, I/O cards, power supplies, and I/O terminations.

3. I/O cabinets located outdoor or in an uncontrolled environment shall be NEMA 4 free standing. These cabinets shall contain communication cards, I/O cards, power supplies, and I/O terminations. Outdoor cabinets shall be provided with the proper environmental controls (i.e. air conditioning)

M. Operator Interface

1. The control room operator console shall include three dual screen operator stations with twenty-two inch (22”) flat panel LCD displays, QWERTY keyboard and mouse. The control console will be arranged in a horseshoe, with wedge sections used to provide operator workspace and accommodate telephone and page system interface.

2. One (1) forty-two inch (42") flat panel LCD displays will be mounted from the control room ceiling above the operator console for display of overviews.

3. One (1) color laser printer is provided in the main control room for printing alarms, reports, and graphics.

4. The operator interfaces shall provide for the functions of control, monitoring, fault detection, reporting, system diagnosis, self-diagnosis, and testing.

N. Operator Display Techniques

1. The user shall have the capability to configure graphics on-line, while the process in running.

2. The operator interface shall be the same for all control and monitoring functions. The location, layout, and orientation of data and objects on the operator displays must be consistent and logical such that the operator will instinctively know where on the display to find the needed information.

3. Picture content shall be structured to contain only vital and essential information. The most important information shall be the data, not the precise physical layout of the plant equipment.

4. Data required for the evaluation of the operating status of the plant systems shall be complete and provided quickly to the operator.

5. Dynamic permissive and interlock lists shall be provided for each device to allow the operator to quickly determine why the device does not have an operational permissive. First-out trip indication shall be provided for all devices with multiple interlocks where the cause of trip may not be apparent to the operator.

6. Standardized rules regarding color usage, operating status, picture area arrangement, data display, graphic programming, and symbols shall be defined and observed for all graphics.

7. Display hierarchy techniques shall be incorporated to enable an operator to proceed from overviews to group/subsystem displays and back to obtain process detail.

8. The design should be such that minimum actions are necessary to move through displays.

O. Engineering Interface

1. One (1) dual screen engineering workstation (EWS) shall be provided for the distributed control system.

2. The EWS will be capable of control function manipulation to execute all binary and analog logic.

3. The engineering workstation and printer are powered from an uninterruptable power source (UPS).

4. Engineering tasks need not be performed in real time, but shall be performed with the control system in service - i.e. on-line. They include tasks for:

   a. Control system optimization

   b. Control system diagnostics and maintenance

   c. Historical performance analysis

   d. Data logging, trending, and storage

P. Alarm Requirements

1. Visual and audible alarms shall be provided to alert the operator to off-normal operating conditions and to provide a record of operations events.

2. Analog inputs shall be compared with high or low alarm limits to determine alarm conditions and initiation of an alarm. The return to normal of analog inputs shall be governed by separate alarm limits to provide a deadband limit for all high and low alarm limits. Digital inputs status shall be compared with previous status and changes shall initiate an alarm or return to normal signal.

3. Self-diagnostic alarming shall be provided to guide service personnel to quickly identify faulty modules of the DCS. Details concerning the self and system diagnostics shall be specific enough to enable the service personnel to find and exchange a faulty module within an hour at most.

4. Alarms shall be displayed or presented in the order of occurrence. The resolution between alarmed events shall be less than one second. Resolution to the millisecond shall be provided for sequence-of-events logging.

5. Alarm suppression techniques shall be utilized to avoid overloading and confusing the operators during an emergency operation.

6. The alarm list or history shall be provided on an operator display. It shall consist of all alarm operations, incremental limits, and return to normal, with time occurrence, in chronological order.

7. All alarms shall be recorded in the unit data historian for later evaluation.

8. Alarm messages shall be complete with the following minimum information:

   a. Time: The time of day using a 24 hour clock, using typical one (1) second resolution. SOE resolution shall be in milliseconds.

   b. Date: The day of the month, month, and year.

   c. Description: The equipment involved shall be described along with the problem.

   d. Point identification: The specific point name shall be identified

   e. Alarm status: Identify the condition that caused the alarm. Use terms such as HIGH, HIGH-HIGH, LOW, LOW-LOW, ALARM, NORM, OPEN, DEV, etc.

   f. Value: The measured dynamic value shall be used. e.g. IN, OUT, CLOSED, etc.

   g. Engineering units: These shall be specified. e.g. psi, ºF, etc.

   h. Limit: Identify the set point or limit value.

   i. Alarm summary access: A separate historical alarm summary shall be available and accessible to the operator. This summary shall show the alarm messages in the time order that they were received.

Q. Historical Data Storage

1. The DCS will have data historical storage and retrieval capabilities in order to facilitate long-term monitoring of plant equipment and performance. This system shall provide the ability to generate reports and trends of the stored historical data including the following:

   a. Periodic Logging. At hourly intervals analog inputs and integrated pulse inputs shall be printed on the periodic log reports. Alternatively, the hourly logs may be saved until midnight and then printed at one time per day.

   b. Group Review Logging. Selected groups of points may be called up and a printout made on the utility printer.

   c. Sequence of Events Logging.

   d. Historical Trending. Operator selectable analog points in data storage shall be trended over an operator selected time period.

R. Time Synchronization

1. A GPS time synchronization system will be supplied with the DCS. IRIG B signals from this system shall be used to synchronize time in all DCS equipment as well as align other control systems such as the CT control system

2. This will enable historical data and events to be precisely correlated.

S. Diagnostic Functions

1. Diagnostic functions shall be provided to identify faulty or failed equipment. The resulting output of diagnostic functions shall be the identification and documentation of faulty or failed control and monitoring equipment or process equipment to the highest level of detail possible.

2. Maintenance functions shall be provided to identify maintenance requirements, schedule, and provide guidance for all identified plant maintenance activities. The resulting output of maintenance functions shall be the identification and documentation of plant maintenance status, needs, and procedures consistent with the objective of maximum plant availability.

3. The DCS shall include a full set of on-line self-diagnostics using real time measurements. These shall include but not be limited to: hardware card voltages over/under range, A/D converter offset over range, microprocessor stall (failure), memory check sums/parity validation, communication failures, processor loading excessive, and a set of power-up diagnostics.

1.6 PLC and Other Control Systems

A. All BOP systems are controlled and monitored through the DCS unless specifically noted otherwise. Programmable logic controllers (PLC) and other control systems will only be used for the systems and equipment listed below:

1. Air Compressor Control Systems

2. Domestic Water Treatment Control System

3. Industrial Sewage Treatment Control System

4. Auxiliary Boiler Control System

5. Ammonia storage, forwarding and feed systems

6. Continuous Emissions Monitoring System (CEMS)

B. In general, all PLC control systems shall be Allen-Bradley ControlLogix with 1756 series I/O or SLC series control processors with 1746 series I/O. Standalone Equipment such as the Air compressor may utilize Equipment Suppliers standard controller as approved by the Owner/Engineer.

C. Local PC-based operator interface shall be implemented using a Panelmate LCD flat panel display for small systems or Wonderware Intouch HMI software and a Microsoft XP-based operating system.

D. Datalink shall be provided between PLCs and DCS.

1.7 System Controls

A. Load Control

1. The CT controls shall provide adjustments and control functions for:

a. The establishment of desired generation (either manually or by an automatic load control system).

b. The introduction of frequency bias to accommodate the inherent regulation of the turbine governor.

c. The establishment of appropriate maximum and minimum generation limits and maximum rate of change of unit output.

B. Fuel Systems

1. Control of the fuel gas system will be implemented through the DCS and coordinated with the CT control system.

C. Circulating Water System

1. Manual control for the circulating water pumps shall be provided in the control room through DCS. Pump discharge valves shall be interlocked with the pump motors and staged as per pump manufacturer's requirements.

2. Cooling tower fans operation and cooling tower basin level shall also be controlled and monitored through the DCS.

D. Domestic Water Treatment System

1. Control of the water treatment system will be through a PLC-based control system provided by the equipment supplier in a local control panel. A local PC-based operator interface shall be provided with the PLC at the same location.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

3. Control of any periodic backflush or regeneration cycles will require local operator control and monitoring.

E. Industrial Sewage Treatment System

1. Control of the industrial water treatment system will be through a PLC-based control system provided by the equipment supplier in a local control panel. A

local PC-based operator interface shall be provided with the PLC at the same location.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

F. Auxiliary Boiler

1. Control of the auxiliary boiler control system will be through a PLC-based burner management system provided by the manufacturer with the equipment. A local operator interface shall be provided with the PLC at the same local control panel.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

G. Ammonia storage, forwarding and feed systems

1. Control of the ammonia system will be through a PLC-based control system provided by the manufacturer with the equipment. A local operator interface shall be provided with the PLC at the same local control panel.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

H. Sump Pump Control

1. Sumps and sump pumps are located throughout the plant. Under Normal operation conditions the controls will be in automatic mode and require no operator action and will be controlled from a local control panel.

1.8 Instrumentation

A. General Instrumentation Design Requirements

1. Analog output signals from field instrumentation to the control systems shall be 4-20 mA DC signals. Instrumentation can be self-powered or loop powered from the control systems. Self-powered analog signals will be true “isolated from ground” signals.

2. All instruments and analyzers will employ RF protection in the system design.

3. Instrument tags will be permanently attached to the devices. If this is not possible, the instrument tag will be fastened to the instrument with stainless steel wire. The wired instrument tag will be supplied as 1 inch by 3 inch, stainless steel instrument tags. Tag thickness is 1/16 inch and stamped with instrument tag number. Tag number characters are 3/8 inch in height.

4. All instrumentation mounted inside, away from direct exposure to the elements, will be as a minimum NEMA 12 construction unless it is in an environmentally controlled environment (e.g., the control room). If the instrument is mounted in an environmentally controlled environment, the instrument will be as a minimum NEMA 1 construction.

5. All instrumentation mounted outside, exposed to the elements, in non-corrosive environments, will be as a minimum NEMA 4 construction.

6. All instrumentation mounted outside, exposed to the elements, in corrosive environments, will be as a minimum NEMA 4X construction.

7. Switches will generally be snap-acting type, DPDT action, with individual “on” and “off” points to be on a calibrated scale or dial. Where switches are not available in DPDT, switches shall be of the snap action type and shall have a minimum of two SPDT contacts unless the application requires types furnished only as SPDT because of deadband requirement. If additional contacts are required, contracts shall be multiplied by relays.

B. Transmitters

1. Transmitters shall be electronic, 2-wire, with isolated 4-20 ma dc output signals and with an appropriate valve manifold to allow on-line calibration.

2. Transmitters will be capable of driving a load up to 600 ohm at 24 VDC, and will be generally powered from the control system I/O cards.

3. Pressure, flow, differential pressure, level, and other miscellaneous transmitters’ accuracy will be within 0.1% of calibrated span.

4. Local LCD indicators shall be provided.

5. Transmitters shall generally be "smart" and shall also communicate via "Hart" communications protocol.

6. The transmitters are needed to interface with the DCS, providing process signals throughout the plant, and shall include the following types:

   a. Pressure transmitters.

   b. Temperature transmitters will typically not be utilized since thermocouples and RTDs shall be read by DCS directly.

   c. Ultrasonic or Radar transmitters will be used to measure level in atmospheric tanks. Differential pressure transmitters will be used in tanks at saturated pressure using a liquid-filled reference leg.

   d. Generally, flow signals shall be transmitted by means of d/p cell transmitters, with square root extraction in the DCS.

7. Gage and absolute pressure transmitters will be supplied with integral mounted two-valve manifolds directly mounted to the transmitter.

8. Differential pressure transmitters (flow, level, dP, etc.,) will be supplied with integral mounted three valve manifolds directly mounted to the transmitter.

C. Switches

1. All level switches shall be of the packless type (i.e., Magnetrol or equal). Contact requirements shall be the same as for pressure and temperature applications.

D. Flow Instrumentation

1. Flow nozzles shall be used, in general, for flow measurements. Consideration shall be given to the use of low-loss flow tubes where unrecovered head loss must be kept at a minimum. Calibrated flow nozzles shall be used for main feedwater or condensate flow.

2. Orifice plates will be used if accuracy requirements are minimized by application. Local indicating rotometers will be as per the instrument list.

3. Flow elements will conform to requirements of ASME 19.5, "Application, Part II of Fluid Meters: Interim Supplement on Instruments and Apparatus."

4. Flow nozzles will be of the weld-in holding ring type ASME long radius, with dual wall taps. Depending on the piping line specification, the nozzle material will either match the piping material or will be made of stainless steel. Metered pipe run and nozzle will match the pipe material and size in which the metered section is to be installed.

5. Orifice plates will be 316 SS, sharp square edge thin plate, paddle type suitable for installation between raised face orifice flanges. Orifice flanges, gaskets, and jacking screws will be furnished by the piping Contractor. Paddle will be stamped with the orifice ID bore diameter on the upstream side. Orifice flanges will be of the raised-face, weld-neck type with dual sets of taps.

6. Complete design data, sizing calculations, installation drawings, and installation procedures will be provided by the supplier with each nozzle and orifice. Beta ratios will generally be between 0.4 and 0.75.

7. Square root extraction shall be performed in the DCS. Transmitters will be configured to provide a local flow indication.

E. Pressure Instrumentation

1. All pressure transmitters will be capable of withstanding their body rating conditions without permanent damage or loss of calibration.

2. Differential pressure transmitters of the force balance low displacement type, regardless of the applied service, will be capable of withstanding a differential pressure equal to full process pressure on either side of the measurement element without damage or loss of calibration. Minimum accuracy will be 0.1% of calibrated span.

3. Local pressure gauges shall have 4-1/2 inch round dials, solid front safety case type with blowout back, 1/2 inch NPT bottom connection, phenol or drawn stainless steel case, with black figures on white face. Bourdon tube types shall be used for pressures of 10 psi and above and bellows for pressures below 10 psi and vacuum service. Movements are to be of nylon and stainless steel except for corrosive service where Monel shall be used. Pigtail syphons are to be used for steam service, snubbers for pulsating flows, chemical seals for acid and caustic service.

4. Pressure test points shall be supplied on all piping to permit pressure determination in the future without removing sensing lines for remote gauges. In general, test points shall be supplied before and after each major piece of equipment which can affect pressure such as pumps, control valves, flow measurement devices, filters, and heat exchangers. All tanks shall have pressure test points.

5. Pressure test points will not be supplied adjacent to pressure gauge or transmitter taps. Test instrumentation can be connected through the two valve manifold of a pressure transmitter or the pressure gauge connection, if necessary.

6. In general, pressure points shall be valved so that local gauges can be isolated without affecting remote equipment.

F. Temperature Instrumentation

1. Temperature measurements for control and monitoring shall be made with RTDs or thermocouples.

2. RTDs furnished by equipment suppliers will be of the dual-element, four-wire type made with 100 ohm platinum resistance elements. The RTDs will be contained in an insulated material and a sheath or sleeve of stainless steel, and will be so mounted that they can withstand the greatest shocks and vibrations that can be imposed upon them in the system piping without deterioration.

3. Thermocouples will be dual element with ungrounded measuring junction, manufactured in accordance with the ISA Standard MC96.1, "Temperature Measurement Thermocouples." All thermocouples will be Type K. Local cold junctions shall not be used. Cold junctions shall be located at the receiving end with automatic reference junction compensation provided (i.e., at the monitor input cabinets). All thermocouple and low level d-c wiring shall be shielded.

4. Thermocouples will have dual elements and will be of swaged construction. The sheath or sleeve will be spring-loaded to maintain thermal and electrical contact with the bottom of the protecting well. Ungrounded multiple-element thermocouples will have electrically isolated measuring junctions.

5. Bimetallic dial type thermometers with minimum 4-1/2 inch dial, every angle form, hermetically sealed with external recalibration adjustment, 3/8 inch OD SS stem,

1/2 inch NPT connection, and SS case shall be used wherever possible. Where the point of measurement is not easily available for viewing, the filled-bulb type with long capillary tube may be used.

6. All RTDs, thermocouples, thermometers, and remote temperature sensing elements installed in pipelines or ducts shall have thermowells or protection tubes. Temperature elements for surface temperature measurement shall be directly welded directly to the surface.

7. Test thermowells shall be provided to permit testing of systems. Test thermowells and/or thermometers shall be provided before and after each piece of equipment that affects temperature, i.e., large pumps, heat exchangers, and coolers. If local thermometers are provided, test wells may be omitted except for those wells required for performance tests.

8. Thermowells shall generally be tapered type with welded or screwed pipe connection depending on the system. Thermowell lagging extensions shall extend beyond the pipe insulation so insulation will not drop into the thermowell when the temperature element is removed. Test thermowells will be furnished with a plug and chain to seal the thermowell when not in use.

9. An extension nipple or union nipple will be furnished for each thermocouple or RTD assembly. Terminal blocks will be marked with polarity, and connectors will be resistant to heat, vibration, and galling. The cap will provide a weathertight enclosure and a chain will be provided to prevent loss of cap. The cap will be made of cast aluminum.

10. Temperature switches shall normally be avoided and instead a thermocouple will be installed and the setpoint configured in the DCS.

G. Level Instrumentation

1. Ultrasonic or Radar transmitters will be used to measure level in atmospheric tanks, special applications and large tanks. Differential pressure transmitters will be used in tanks at saturated pressure using a liquid-filled reference leg. Guided wave radar level transmitters shall be used in low pressure and vacuum applications where there is a potential for evaporation of the filled leg of a differential pressure level measurement system.

2. All level transmitters shall provide 4-20 mA DC output signals and Hart communications interface. Ultrasonic level transmitters will be 120 VAC powered, with isolated 4-20 mA DC output signals powered from the transmitters.

3. Level instruments for local indication shall be supplied on all tanks. These shall, in general, consist of local magnetic level indicators or gauge glasses with guards to protect glass from breakage. On large tanks, an indicator powered from the level transmitter loop will be provided at grade.

4. Tubular gauge glasses will be used for low-pressure applications. Transparent or reflex gauges will be used for high-pressure applications.

5. All gauge glasses shall be fitted with ballchecks and have means for isolation and flushing (cleaning) glasses. Gauge glass shall not be used where glass breakage cannot be tolerated (such as acid and caustic tanks).

6. Level switches will generally be cage float type, rated for ASME B31.1 requirements. Sump level switches will be float type.

H. Local Control Panels

1. Local control panels will be furnished as complete control systems, including instrumentation and controls piped and wired to headers and terminal blocks. Push buttons and indicating lights will be installed and wired on the control panel for start-up of all motors associated with driven equipment.

2. Large freestanding upright panels will be provided with internal light switch and 120 VAC duplex grounding-type receptacle wired to a junction box to be fed from a separate external circuit. Doors will be the double-swing half type.

3. Voltages in excess of 125 VDC or 120 VAC will be restricted from instrumentation and control systems panels.

4. The color scheme for control/instrument panel indicating lights will be as follows:

   a. Green: Equipment not running/valve closed
   b. Red: Equipment running/valve open
   c. Yellow: Alarm or Tripped

5. Unless otherwise specified, all control switches shall be furnished with contacts rated 10 amperes, 120 volts a-c or 5 amperes, 125 volts d-c, continuously.

6. Alarm contacts will be closed during normal operation and open on fault condition or loss of power.

1.9 Instrument Racks and Enclosures

A. Where instrument access and service conditions permit, close-coupled instrument mounting to process piping with the instrument supported from the pipe tap will be used. This system may be used for pressure transmitters and flow transmitters on orifice flanges. Transmitter valve manifold assemblies shall be welded or screwed into a sockolet or threadolet provided on the pipe or flange. Pressure transmitters shall be furnished complete with an isolation valve and a bleed valve between the isolation valve and the instrument. Differential pressure transmitters shall be furnished complete with two isolation valves and an equalizing valve between the high and low pressure legs after the isolation valves.

B. Close-coupled transmitter mounting shall not be used where dual isolation valves are required or direct access to the instrument cannot be provided.

C. Local instruments that require remote mounting shall be functionally grouped in local panels or transmitter racks rather than individually mounted.

D. Spacing between multiple instruments mounted on the same support will be sufficient to allow ample clearance area in order to perform service, maintenance, calibration, and testing.

E. Indoor racks shall be open structures fabricated from Modular Instrument Support Systems.

F. Terminal blocks shall be 600 volt, front connected, full depth insulating barrier type, with marker strips identifying all internal and external wiring. Terminal blocks shall have at least 20% spare terminals.

G. Wiring for low-level signal transmission (i.e., 4-20 mA, T/Cs and RTDs) shall be twisted pairs or triplets, with shield.

H. Flame resistant insulation shall be used as panel control wiring. Hinge wire shall be extra flexible.

1.10 Instrument Installation

A. General Requirements

1. Instrument process tubing will be designed in accordance with Control System Standard instrument tubing line specifications 150Q-1, Low Pressure Stainless Steel Tubing Line Specification, 250Q-2 High Pressure High Temperature Stainless Steel Line Specification and 250Q-4, High Pressure High Temperature H-grade Stainless Steel Tubing Line Specification. Tubing line specifications utilize Swagelok compression fittings. Design pressure and temperature requirements will determine the appropriate line specification.

2. Instrument air tubing will be designed in accordance with Control System Standard instrument tubing line specification 150Q-1, Low Pressure Stainless Steel Tubing Line Specification.

3. All instruments, process connections, including isolation valves and associated devices, will be located in easily accessible locations for maintenance, calibration, and replacement. All maintenance, calibration, and replacement operations on a given device must be possible without interruption of service to adjacent equipment.

4. Instrument tubing installations will be designed in accordance with ASME B31.1, "Power Piping."

B. Instrument Sensing Lines

1. Minimum bending radius of instrument sensing line tubing will be three times the tube diameter.

2. Instrument sensing lines will be sloped in their horizontal runs, a minimum of 1/4 inch per foot. In general, liquid and steam lines will slope from their process tap connection down to the instrument. For steam, the line will slope down from the condensate tee to the process connection. In general, gas and non-condensing vapor lines will slope from their process tap connection up to the instrument.

3. Instrument sensing lines will be routed as directly as practical from the process root valve to the instrument. The length of instrument tubing from the root valve to the instrument will be limited to maximum of 40 feet for compressible fluids

and 50 feet for non-compressible fluids. Expansion loops shall be provided to allow for thermal expansion of tubing.

4. Instrument sensing lines will be grouped together as much as practical to benefit from the use of common support members and to present a finished installation that is routed in a neat and orderly manner. Care will be exercised to ensure that spacing between adjacent tubes in the same group is maintained uniform and that tubes do not cross under or over one another at any point. Wherever practical, changes in direction of tubing will be done by the use of tube bends and not tube fittings.

5. A single blowdown valve or double blowdown valves (if the process root valves are doubled) will be installed on the sensing lines of all pressure transmitters that are tapped off liquid or steam process systems. These valves will be located at the instrument and the drains may be headered together. These tapping points shall be equipped with one root valve for design pressures less than 600 psig. For systems with design pressure greater than 600 psig, two root valves shall be utilized.

C. Instrument Air Lines

1. All branch lines from the instrument air line header will be made from the top of the air header and will not be smaller than 1/2 inch. Branch lines will have root valves at the process connections.

D. Instrument Connections

1. Connections for pressure transmitters mounted external to the pipe will be a 3/4 inch sockolet on pipe, mounted on the side of the pipe for liquid and steam lines and on the top for gas applications. On the instrument side of the 3/4 inch root valve, a 3/4 inch SW to 1/2 inch compression fitting will be welded into the root valve by the Piping Contractor.

2. Connections for pressure gauges and switches mounted directly on the pipe will be 3/4 inch sockolet or threadolet according to the piping line specification. Connections will be on the side of the pipe for liquid and steam lines and on the top for gas applications. For sockolet connections, a 3/4 inch plain both ends pipe nipple will be welded into the sockolet, then a 3/4 inch SW root valve, then a 3/4 inch to 1/2 inch reducing insert with a 1/2 inch plain pipe nipple threaded at the top then a 1/2 inch threaded coupling. For threadolet connections, a 3/4 inch

threaded both ends pipe nipple will be threaded into the threadolet, then a 3/4 inch threaded root valve, then a 3/4 inch to 1/2 inch reducing insert with a 1/2 inch threaded pipe nipple threaded at the top then a 1/2 inch threaded coupling. The root valve, reducing insert, and pipe nipple will be installed by the Piping Contractor. (A plain 3/4 inch by threaded 1/2 inch threaded swage may be used in place of the 3/4 inch to 1/2 inch reducing insert with a 1/2 inch plain pipe nipple threaded at the top.)

3. Connections on flow nozzles will be two sets of 3/4 inch socket weld connections mounted on the side of the nozzles. Transmitters for flow nozzles will be mounted external to the nozzles. A 3/4 inch plain both ends pipe nipple and 3/4 inch SW root valve will be installed by the Piping Contractor. On the instrument side of the 3/4 inch root valve, a 3/4 inch SW to 1/2 inch compression fitting will be welded into the root valve by the Piping Contractor. Both sets of taps, including the spare set, will have root valves and the compression fitting installed in the field.

4. Connections on orifice plate flow elements will be through orifice-tapped flanges. Two sets of orifice flange connections will be provided.

5. For installations using 1/2 inch SW taps, 1/2 inch plain both ends pipe nipples from each tap, then 1/2 inch SW root valves, then a 1/2 inch SW to 1/2 inch compression fitting will be shown on the piping isometric drawing and installed by the Piping Contractor. For installations using 1/2 inch threaded taps, 1/2 inch threaded pipe nipples from each tap, then 1/2 inch NPT root valves, then a 1/2 inch NPT to 1/2 inch compression fitting will be shown on the piping isometric drawing and installed by the Piping Contractor. For installations using 3/4 inch taps, 3/4 inch plain both ends pipe nipples from each tap, then 3/4 inch SW root valves, then a 3/4 inch SW to 1/2 inch compression fitting will be shown on the piping isometric drawing and installed by the Piping Contractor. The connections are orientated on the side of the pipe for all applications. If the second set of orifice flange connections is not used, they shall be plugged with plain end plugs.

6. Thermowell immersion length will be between 1/3 and 2/3 the distance to the center of the pipe. Where thermowells are installed in lines smaller than 3 inches, the piping will be expanded to 3 inch size to accommodate the thermowell.

7. Thermowells in high velocity water pipes will have an ASME PTC 19.3 calculation for determination of their resonant frequency. Thermowells that do not meet the acceptance criteria will be resized or relocated as necessary.

8. Thermowells installed in pipes on the high pressure water or gas systems will use a 1-1/2 inch SW sockolet. Thermowells installed in all other systems will use 1 inch SW sockolet or threaded threadolets. Thermowell material for installations in Chrome-Moly alloy pipe shall match the pipe material. All other thermowells shall be 316 SS. Welded thermowells will be installed in the field by the Piping Contractor.

9. Tank level transmitters using DP pressure transmitters mounted external to tanks will be the same as pressure transmitters mounted external to pipe. Tank level transmitters may also be flange mounted to nozzles at the tanks.

10. The tanks that see an operating pressure less than atmospheric will use direct mounted guided wave radar level transmitters. Connections on the tanks will be 1-1/2 inch or 2 inch SW half couplings. These level transmitters will be installed in the field by the Piping Contractor.

11. Magnetic level indicators and water column level gauges will be direct mounted to tanks using 2 inch SW half couplings mounted on the tanks. They will be installed in the field by the Piping Contractor.

12. Radar and Ultrasonic level transmitters will be direct mounted to minimum 6 inch ASME Class 150 flanges on the tops of tanks or wells. Installation of radar or ultrasonic level transmitters will be by the Instrument Installation Contractor.

13. Direct mounted level switches on steam line drip pots will use 1 inch sockolets and 1 inch root valves. Direct mounted level switches will be installed by the Piping Contractor.

1.11 Final Control Elements

A. Control Valves

1. Control valves will be pneumatic or hydraulically operated modulating valves, or pneumatic, hydraulic, or motor-operated on/off service valves.

2. Valve flow coefficient (CV) at rated (normal) operating conditions will not exceed 85% of maximum CV unless stated otherwise on the valve data sheet, and valve will remain above 10% stroke for minimum controllable flow and below 90% stroke for maximum controllable flow.

3. Instrument air shutoff valve and air set, consisting of a combination regulator, filter, pressure gauge, and relief valve, will be provided on each pneumatic control valve assembly.

4. End connections will be socket-weld for 2 inches and under control valve bodies and butt-weld for 2-1/2 inch and over control valve bodies.

5. Valve bodies will be single-port unless otherwise required and will be no less than one-half the line size in which they are installed.

6. Cage guided valves will be used predominantly for steam and water severe service applications where potential for cavitation, flashing, and/or trim noise is present.

7. Valve body material will be as specified in the piping line specifications.

8. All integrally-mounted instrumentation (controllers, positioners, regulators, etc.) will be designed for the stated maximum instrument air supply pressure.

9. Pneumatic actuators shall generally be diaphragm type except where size and operating force require the use of a piston operator. Pneumatic actuators shall be sized to supply the required thrust down to 60 psig instrument air supply pressure.

10. Each control valve shall have a manual operating device or suitable set of manual bypass valves.

11. Electro-pneumatic positioners will be integrally mounted to the control valves. All positioners will be of the digital type and support Hart communication for setup, calibration, and diagnostic functions.

12. The failure position of each valve will be selected based on the service to fail either open (FO), closed (FC), or locked in current position (FL) in event of loss of signal or loss of motive power.

13. In general, limit switches, override solenoids and position transmitters will not be required for modulating control valves.

14. Pilot solenoid valves for on-off service control valves will be designed for 120 VAC with a minimum orifice size of 1/4 inch.

15. Control valve body size shall generally not be less than one standard size smaller than line size for 10 inch and smaller piping systems. In piping systems 12 inches and larger, control valve body size shall generally not be more than two standard sizes smaller than line size. Minimum body size shall be one inch nominal with reduced trim as applicable, except that body size will not exceed line size.

16. All valve position indicators will read 0 percent with valve fully closed and 100 percent with valves fully open with intermediate marking.

B. Control Drives

1. Control drives shall be either of the electric, pneumatic, or hydraulic type suitable for the service conditions.

2. Electric control drives are preferred for modulating service where torque rating exceeds 1000 lb/ft.

3. Instrument air shutoff valve and air set, consisting of a combination regulator, filter, pressure gauge, and relief valve, will be provided on each pneumatic control drive assembly.

4. Generally, all modulating control drives shall fail in position, however, each drive application shall be investigated individually for failure position requirements.

5. All control drives shall be equipped with handwheels or other devices for local operation by one man without disconnecting linkage.

6. All modulating control drives shall include a position transmitter to provide feedback to the DCS. Open and closed limit switches with a minimum of two (2) form C (SPDT) dry contacts shall be provided for all on-off service control drives.

7. Drive housings shall be weatherproof and have heaters where required.

8. Piston type operators are preferred for all pneumatic control drive operators. Operators shall be suitable for outdoor installations. All drives shall operate properly and provide the required shutoff at a supply pressure of 60 psig.

9. Modulating pneumatic control drives shall include integral positioners. Positioners shall be smart electronic type with HART communications capability.

10. An air shut-off valve, filter-regulator, and position transmitter shall be provided for pneumatic control drives with positioners

11. Current to pneumatic converters shall be provided for positioning all control drives provided without positioners.

12. Pneumatic control drives for on-off operation shall include a 120 VAC three-way solenoid valve and open and closed limit switches.

13. Electric control drives for on-off operation shall include integral reversing starter, local control station and terminals for remote control and drive position indication connections. The local control station shall include LOCAL/REMOTE control switch and OPEN, CLOSE, and STOP push buttons. Remote OPEN and CLOSE control commands shall not be sealed in at the drive. An auxiliary dry contact indicating drive available for remote control shall be provided.

1.12 Continuous Emissions Monitoring System (CEMS)

A. A continuous emissions monitoring system (CEMS) will be provided to monitor the gaseous emission levels of regulated constituents. CEMS sample probes will be located in the stack and the CEMS will be located in a building at the base of the stack. This system will be a highly reliable extractive-type design and will record, trend, alarm, and report through the DCS in order to keep the plant operator properly informed.

B. The CEMS will monitor NOx, O2 and CO2. The system will be in compliance with all applicable regulations and the approved Air Permit for the project

C. The CEMS will consist of a sample, hose and sample extraction/conditioning systems, rack mounted analyzers, CEMS equipment enclosure, and a data acquisition and reporting system. The probe will continuously extract a sample for analysis.

D. The system will be designed to permit calibration of analyzers without disconnection of equipment from the process while the unit is in service. The CEMS will provide for manual/automatic zero and span calibration checks using EPA approved techniques and provide manual/automatic calibration, measure, and record of zero and span drift correction. The system will be designed to allow calibration checks with the system on line.

E. The sample system will be the extractive type. A single microprocessor-based sampling controller will control purge air, calibration gases, sample gases, and direct gases to proper devices for all modes of operation. The controller will receive the raw signals from the analyzer and convert the raw values into the required permit values.

F. The analyzers and sample controller will be located in an enclosure at the base of the stack to minimize the length of sample runs. The enclosure will be heated and air conditioned and have space for maintenance. The calibration gas bottles will be mounted in a rack outside of the enclosure.

G. The data acquisition and reporting system will be a PC based system with both local and control room operator interface. The PC will retrieve data from the sampling controller, format the data for report generation, print reports, store the data for archival purposes, generate alarms, record the reason codes for noncompliant periods, perform other data manipulation tasks such as daily averages, rolling averages, high/low daily value.

H. Each analyzer shall provide measured values and analyzed data for DCS input.

I. The equipment shall have the highest availability and operation-proved reliability. No first generation equipment shall be utilized.

1.13 Vibration Monitoring System

A. A vibration monitoring and analysis system will be provided for the CT.

B. All vibration monitors will be provided by the rotating equipment Contractor mounted in racks within cabinets located near the associated rotating equipment.

C. A vibration analysis computer will be provided with the CT. Communication links will be installed from all monitoring racks to the vibration analysis computer.

D. Vibration monitoring will be provided for the following devices but will not include a complete vibration monitoring rack:

1. Circulating Water Pumps (2)

2. Air Compressors (2)

WorleyParsons
resources & energy

EcoNomics™

NEW YORK STATE ELECTRIC & GAS

STRUCTURAL ENGINEERING
Design Criteria

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Revision B

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COMPRESSED AIR ENERGY STORAGE PROJECT
STRUCTURAL ENGINEERING
DESIGN CRITERIA

Disclaimer

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PROJECT - EPF-0003 STRUCTURAL ENGINEERING

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CUSTOMER APPROVAL	DATE
A	Issued for Review	P. Khan	R. McDonel	P. Khan	26-May-11	N/A	
B	Issued for Review	P. Khan	R. McDonel	P. Khan	19-Oct-11	N/A	

CONTENTS

Appendices

NONE

1.0 STRUCTURAL ENGINEERING DESIGN CRITERIA

1.1 Purpose

This Section establishes criteria for the design, fabrication and installation of materials used in the structural and pipe stress/support work for the NYSEG CAES Project.

1.2 Codes and Standards

The following Codes and Standards will apply to the structural engineering, pipe stress/support engineering, and design work performed on the project. Unless noted otherwise, the edition and published addenda in effect on the date of Contract Award will apply to the work.

In the event of any conflicts between codes, or between specifications and codes, the more stringent regulation will apply.

1. American Concrete Institute (ACI):

    a. ACI 117 - Specification for Tolerances for Concrete Construction and Materials.

    b. ACI 207.2R – Effect of Restraint, Volume Change, and Reinforcement on Cracking of Mass Concrete.

    c. ACI 301 – Specifications for Structural Concrete.

    d. ACI 318 – Building Code Requirements for Structural Concrete.

    e. ACI 347 – Guide to Formwork for Concrete.

    f. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures.

    g. ACI 351.3R – Foundations for Dynamic Equipment.

    h. ACI 360R – Guide to Design of Slabs-on-Ground.

    i. ACI 530 – Building Code Requirements for Masonry Structures.

    j. ACI 530.1 – Specification for Masonry Structures.

2. American Institute of Steel Construction (AISC):

    a. Steel Construction Manual – 13th Edition.

    b. AISC 303 – Code of Standard Practice for Steel Buildings and Bridges.

    c. AISC 341 – Seismic Provisions for Structural Steel Buildings.

    d. AISC 360 – Specification for Structural Steel Buildings.

3. American Iron and Steel Institute (AISI):

    a. SG02-1, "North American Specification for the Design of Cold-Formed Steel Structural Members."

4. American Petroleum Institute (API):

    a. API STD 650-07 (11th Edition, with Addendum 1 & 2) - Welded Steel Tanks for Oil Storage.

5. American Society of Civil Engineers (ASCE):

    a. 7-05 - Minimum Design Loads for Buildings and Other Structures.

    b. Design of Large Steam Turbine-Generator Foundations, 1987

    c. 37-02 - Design Loads on Structures During Construction (SEI/ASCE Standard).

6. American Society of Mechanical Engineers (ASME):

    a. A17.1 – Safety Code for Elevators and Escalators.

    b. B31.1 – Power Piping Code.

7. American Society of Safety Engineers (ASSE):

    a. ASSE/ANSI A10.4 - Safety Requirements for Personnel Hoists and Employee Elevators.

8. ASTM International (ASTM):

a. See appropriate technical specification for specific references of ASTM Standards for materials used.

9. American Water Works Association (AWWA):

    a. D100 – Welded Carbon Steel Tanks for Water Storage.

10. American Welding Society (AWS):

    a. D1.1 – Structural Welding Code – Steel.

    b. D1.3 – Structural Welding Code – Sheet Steel.

11. Concrete Reinforcing Steel Institute (CRSI):

    a. MSP-2 – Manual of Standard Practice.

12. International Code Council, Inc. (ICC):

    a. IBC 2006 – International Building Code 2006 as adopted by the 2010 Building Code of New York State with associated amendments.

13. Manufacturers Standard Society of the Valve and Fitting Industry (MSS):

    a. SP 58 – Pipe Hangers and Supports – Materials, Design, and Manufacture.

    b. SP 69 – Pipe Hangers and Supports – Selection and Application.

    c. SP 77 – Guidelines for Pipe Support Contractual Relationships.

    d. SP 89 – Fabrication and Installation Practices.

    e. SP 90 – Guidelines on Terminology.

14. National Association of Architectural Metals Manufacturers (NAAMM):

    a. MBG 531– Metal Bar Grating Manual.

    b. MBG 532 – Heavy Duty Metal Bar Grating Manual.

15. National Fire Protection Association (NFPA):

a. NFPA 850 – Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations, 2005 Edition

16. Precast/Prestressed Concrete Institute (PCI):

    a. MNL-116 – Manual for quality Control for Plants and Production of Precast and Prestressed Concrete Products.

17. Research Council on Structural Connections (RCSC):

    a. Specification for Structural Joints Using ASTM A 325 or A490 Bolts.

18. The Society for Protective Coatings (SSPC):

    a. PA-1 – Shop, Field, and Maintenance Painting.

    b. SP-1 – Solvent Cleaning.

    c. SP-2 – Hand Tool Cleaning.

    d. SP-3 – Power Tool Cleaning.

    e. SP-5 – Metal Blast Cleaning.

    f. SP-6 – Commercial Blast Cleaning.

    g. SP-7 – Brush-off Blast Cleaning.

    h. SP-10 – Near White Blast Cleaning.

    i. SP-11 – Power-Tool Cleaning to Bare Metal.

19. Steel Deck Institute (SDI):

    a. SDI 30, Design Manual for Composite Decks, Form Decks and Roof Decks.

    b. SDI MOC1, Manual of Construction with Steel Deck.

20. U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), 29 CFR

a. Part 1910 - Occupational Safety and Health Standards.

b. Part 1926 – Safety and Health Regulations for Construction.

1.2.1 References

1. Geotechnical Report for the NYSEG CAES Project (CAES-1-LI-024-001).

1.3 Materials

1.3.1 Structural Steel, Steel Plate, and Accessories

1. Materials:

See CAES project technical specifications (TS) for specific references of Standards for materials used.

a. Structural steel wide flange shapes and sections cut from wide flange shapes: ASTM A 992.

b. Structural steel channels, angles and plates for general use: ASTM A 36.

c. Structural steel channels, angles of high strength material: ASTM A 529, Grade 50 or ASTM A 572, Grade 50.

d. Structural plate, high strength material: ASTM A 572, Grade 50.

e. Rectangular tubing: ASTM A 500, Grade B.

f. Steel pipe for columns: ASTM A 53, Grade B, Type S.

g. High-strength bolts (3/4” diameter and larger): ASTM A 325, Type 1 mechanically galvanized per ASTM A 563 and lubricated.

h. High-strength bolts (up to 5/8” diameter): ASTM A 449 mechanically galvanized and lubricated.

i. Nuts for use with high-strength and plain bolts: ASTM A 563, heavy hex, Grade DH Mechanically galvanized and lubricated.

j. Washers: ASTM F 436, mechanically galvanized.

k. Direct tension indicator washers: ASTM F959.

l. Filler plates and shim plates:

1) 3/16-inch or less in thickness: ASTM A 1011, Grade 36.

2) Greater than 3/16-inch in thickness: ASTM A 36.

m. Steel studs: Section 7 of AWS D1.1.

n. Generation Building Crane rails and accessories:

1) Crane rails: ASTM A 759.

2) Joint bars: ASTM A 49.

3) Joint bar bolts: ASTM A 325, Type 1.

4) Pressed or forged steel used for rail clamps and filler plates.

5) High strength bolts for attachment of rails to top flanges of support girders: ASTM A 325, Type 1.

o. Welding electrodes and filler metal:

1) Carbon and alloy steels: AWS D1.1, Table 3.1 for type of steel. Low hydrogen type, 70 ksi, minimum tensile strength.

p. Expansion Bearing Assemblies: CON-SLIDE, Type CHP high load expansion bearings as manufactured by CON-SERV Inc. or equal.

1.3.2 Miscellaneous Metals and Accessories

1. Grating, stair treads and accessories, checkered steel floor plate, and grating assemblies:

a. Materials:

1) Grating, banding, stair treads: ASTM A 1011 Commercial Steel (Type 2).

2) Checkered steel floor plate: ASTM A 36 (or equivalent) with regular raised pattern, galvanized.

3) Toe plate: ASTM A 36 (or equivalent).

4) Saddle clips: ASTM A 653, galvanized.

5) Welded studs: ¼-inch diameter, stainless steel conforming to ASTM A 276, Type 304. Nuts for use with studs, cadmium plated conforming to ASTM A 563.

6) Bolts and nuts for connecting stair treads to stair stringers: 3/8-inch bolts conforming to ASTM A 307 and nuts conforming to ASTM A 563. Bolts and nuts galvanized.

b. Construction:

1) Grating: Welded type, 3/16-inch thick bearing bars X depth to suit loading spaced at 1-3/16 inches center-to center. Crossbars spaced at 4 inches center-to-center. Serrated top for outdoor applications. Use “EPI GRATE CLAMP” saddle clip fasteners or approved equal.

2) Stair treads: Welded type, 1 inch x 3/16-inch bearing bars, 3/16-inch cross bars with cast aluminum checkered plate nosing, (Wooster Type 120 Alumogrit or approved equal). Plain top surface with galvanized finish for level platforms and walkways. Serrated top surface with galvanized finish for sloped conveyor gallery walkways.

3) Banding: Grating panels banded at openings for equipment and piping penetrations. Banding bars 1/4-inch thick.

4) Checkered steel floor plate and grating assemblies to consist of 1-inch deep grating welded to ¼-inch thick checkered floor plate. Checkered plate connected to grating panels with 3/16-inch fillet welds, 1-1/2 inches long, spaced at 1’-0” centers along all panel edges and at 1’-6” centers interior to the panel edges.

5) Toeplate: 1/4-inch plate extending 4 inches above top of floor line.

2. Guardrail system per OSHA design criteria:

a. Materials:

1) Top rails and mid-rails: ASTM A 53, Grade B, Type E or S; or ASTM A 501, 1-1/2-inch standard (schedule 40) pipe.

2) Posts: ASTM A 53, Grade B, Type E or S; or ASTM A 501, 1-1/2-inch schedule 80 pipe.

b. Construction: Welded continuous construction. Two-rail system with top rail 3'-6" above finished floor and mid-rail 1'-9" above finished floor. Posts spaced not more than 8'-0" center-to-center, bolted or welded to supporting steel.

3. Stairs: Channel sections conforming to ASTM A 36. Minimum size channel section used for stringers, C10 x 15.3.

4. Girt systems: Channel sections conforming to ASTM A 36 or wide flange sections conforming to ASTM A 36, ASTM A 572, Grade 50, or ASTM A 992. Sag rods ¾-inch diameter conforming to ASTM A 36.

5. Metal form deck for concrete floors and roofs: ASTM A 653, SS, Grade 80, minimum yield strength of 80 ksi, with G 60 galvanized coating.

a. Non-composite form deck used as permanent forms for elevated concrete floors and roofs having a thickness of 4 to 6 inches:

1) Metal thickness: Minimum 20 gage (0.0358 inches).

2) Flute height: 1-5/16 inches.

3) Flute sides: Plain vertical face or ribbed.

b. Non-composite form deck used as permanent forms for elevated concrete floors having a thickness of 8 inches:

1) Metal thickness: Minimum 18 gage (0.045 inches).

2) Flute height: 2 inches.

3) Flute sides: Plain vertical face or ribbed.

6. Metal deck for roofs (engineering building):

20 gauge minimum, metal coated steel, ASTM A 446, Grade A; hot-dip galvanized in accordance with ASTM A 525, designation G90, before forming; prefabricated side lap units; 1-1/2 inch depth minimum.

7. Metal deck for roofs (pre-engineered building):

   22 gauge minimum, metal coated steel, ASTM A 792 SQ, Grade 50B; with AZ55 coating, before forming; prefabricated T shaped vertical seam side joint; 2 depth minimum.

1.3.3 Pipe Supports

1. Materials for pipe support assemblies and components will be in accordance with ASTM Specifications, the requirements of ASME B31.1, and Manufacturers Standardization Society recommendations for materials, design, and manufacture of pipe hangers and supports (publication SP 58).

2. The following anchoring systems or Engineer-approved equal will be provided for attachments of pipe support assemblies and supplemental steel framing to concrete and masonry structures:

   a. Hilti HDA Undercut Anchoring System.

   b. Hilti HIT-RE-500-SD Adhesive Anchoring System.

   c. Hilti Kwik Bolt TZ Carbon and Stainless Steel Anchors

1.3.4 Concrete Mixes

1. Concrete strength, psi (at 28 days):

Foundations, Piers, Pedestals, Walls, Grade Slabs, Elevated Slabs, Topping Slabs	4,000 psi
Massive Concrete (Minimum dimension of more than 48 inches)	4,000 psi
Water Containing Structures	5,000 psi
Electrical Underground Ductbanks	2,000 psi
Subgrade Mud Mats where required (4 inches thick	2,000 psi

below all mat foundations, footings, and grade beams where specified on drawings), Lean Fill

1.3.5 Concrete, Reinforcing and Concrete Appliances

1. Cement: Portland Cement, ASTM C 150, Type I, II, or V.

2. Fine Aggregates: ASTM C 33. Minimum specific gravity of 2.55 (saturated dry surface basis), ASTM C 128.

3. Coarse Aggregates: ASTM C 33. Specific gravity of 2.6 (saturated dry surface basis) and maximum absorption of 1.5 percent, ASTM C 127.

4. Admixtures:

   a. Air entraining admixture: ASTM C 260. Concrete mix designs developed for foundation, pier, wall, and slab construction, and underground duct banks and manholes to include entrained air in amounts varying from 4.0 percent to 6.0 percent. Concrete mixes for fill concrete will not have entrained air.

   b. Water reducing admixtures: ASTM C 494. Slump limited to 4 inches for concrete with Type A admixture. Slump for mixes using a high range water reducing admixture (superplasticizer) conforming to ASTM C 494, Type F limited to 8 inches.

5. Water: ASTM C 94, Table 1.

6. Maximum temperature of concrete at delivery:

   a. Mass concrete: 80 degrees F per ACI 301 for concrete between 4 to 8 feet in thickness. 70 degrees F per ACI 301 for concrete greater than 8 feet in thickness.

   b. All other concrete: 90 degrees F per ACI 301.

7. Fly Ash: ASTM C 618, Class C or F.

   a. Required weight of fly ash as a percentage of total weight of cementitious material in concrete mix designs:

Placement Type	Minimum	Maximum
Mix designs for mass concrete	15 %	25 %
Mix designs for all other concrete work	15%	20%

8. Liquid membrane curing compounds: ASTM C 309 R, Type 1.

9. Waterstops:

   a. PVC Waterstop Material: dumb bell or serrated center bulb type, polyvinyl chloride, in accordance with CRD-C572.

   b. TPE-R Chemical Resistant Waterstop Material: dumb bell or serrated center bulb type, thermoplastic elastomeric rubber, in accordance with ASTM D 471.

   c. Impervious Laminate Waterstop Material: Parastop II as manufactured by Tremco.

10. Expansion joints:

    a. Filler: ASTM D 1751 or ASTM D 1752 Type II as indicated on the drawings.

    b. Sealer: ASTM C 920, compatible with filler. Sealer will be a multi-component elastomeric joint sealant.

11. Control joints: Saw-cut control joints will be filled with a two-component flexible control joint resin.

12. Reinforcing steel and accessories:

    a. Deformed bars: ASTM A 615, Grade 60.

    b. Bar supports: Class 3, CRSI Manual of Standard Practice, Chapter 3.

    c. Tie wire: Minimum #16 gage black, soft annealed wire.

    d. Bar-to-bar filler metal splice sleeves (cadwelds): ASTM A 513 or A519.

    e. Swaged bar-to-bar splices: ASTM A 108, ASTM A 519, or ASTM A 576.

f. Taper threaded bar-to-bar splices: ASTM A 576.

13. Anchor assemblies and embedded items:

a. All anchors and other embedded items, not requiring chemical resistance, shall be hot-dipped galvanized.

b. Anchors and embedments in the cooling tower area, water treatment area, chemical feed area, chemical unloading area, chemical spill containment areas, and other areas subject to chemical attack or continuous submergence shall be Type 316 stainless steel or engineer approved equal.

c. Anchor assemblies: ASTM F1554, Grade 36, Grade 55 (weldable), or Grade 105.

d. Nuts: ASTM A 563, heavy hex, Grade DH.

e. Washers: Hardened Steel ASTM F 436, or ASTM A 36 fabricated plate washers.

1.3.6 Masonry

1. Concrete block building structures and walls shall be concrete block meeting the following requirements: ASTM C 90, Grade N,,except compression strength shall be 2,000 psi minimum, 8 inch x 16 inch, steam-cured; sand, gravel, or crushed stone aggregates conforming to ASTM C 33; moisture controlled for linear shrinkage of 0.03% or less.

1.3.7 Non-shrink Grout

1. Non-shrink cementitious grout will be used under column base plates and equipment soleplates. The grout will be a Portland cement based pre-packaged mix requiring only the addition of water, and conforming to the requirements of ASTM C 1107, Grades B or C and CRD-C 621.

1.4 Site Design Conditions

1.	Frost Depth	48 inches
2.	Site Elevation (approx. finish grade in Power block area)	340 ft AMSL

1.5 Design Loads

1. The design loads and load combinations described or referenced herein will be the minimum used for the design of structures and foundations for the Kleen Energy Systems Project.

1.5.1 Dead Load

1. Includes all permanent gravity loads due to self-weight of the structure and weight of permanent equipment, tanks, vessels, piping and cable tray.

2. The contents of equipment, tanks, vessels and piping including fluids will be considered as dead load in the design of structures and foundations. The effects of both full and empty conditions will be considered in gravity load combinations.

3. The dead load of electrical raceways, lighting and mechanical systems, and miscellaneous piping suspended from floors and roofs in plant buildings and structures will be accounted for and labeled as uniformly distributed hung loads on the design drawings.

1.5.2 Building/Structure Live Loads

1. General:

   a. Live loads are those produced by the use and occupancy of the structure. Included in this category are floor, platform, walkway, stairway, roof live loads and temporary and/or operating loads from equipment within buildings and structures.

2. Ground floor loads:

   a. Ground floor slabs will be designed for a minimum of 350 psf or HS-20-44 truck load in the power block area and all other areas where a 5-ton forklift can operate. Consideration will be given to designing appropriate areas of the ground floor for support of heavy construction equipment.

   b. Ground floor slabs for shops and auxiliary buildings will be designed for 150 psf. Storage areas will be designed for the actual weight of the stored material, but no less than 150 psf.

3. Elevated platform, walkway, and stairway loads:

a. Unless otherwise required by function or by special purpose, platforms, walkways and stairways covered with metal grating or metal panels consisting of grating and checkered floor plate will be designed for a uniform live load of 125 psf and grating will be designed for a live load of 150 psf.

4. Elevated concrete floor live loads:

a. Turbine building:

Floor Level	Live Load (psf)
Mezzanine Floor	150
Operating Floor	500[1]

1 – Laydown loads – The floor area will be designed for a laydown load of (later) area placed directly over any floor beam with no additional laydown loads within 3 ft. of the periphery.

b. Elevated slabs will be designed for a live load of 125 psf unless specific higher loads are specified for equipments maintenance and laydown from equipment manufacturers.

5. Roofs:

a. Roofs will be designed for snow and ice loads or for a minimum live load of 30 psf, whichever is greater. In addition, roofs will be designed with the capability to support a concentrated load of 300 pounds placed anywhere on the roof.

b. The turbine building roof will be evaluated for the accumulation of rain water in accordance with the provisions of Section 1611 in IBC 2006.

c. All roofs will be designed considering the effects of uplift from wind.

6. Reduction in live loads:

a. The provisions of Section 1607.9.1 in IBC 2006 will be used when considering live load reduction in the design of structures supporting floors, platforms, and walkways.

1.5.3 Crane, Hoist, and Elevator Loads

1. Crane loads will be applied in accordance with Sections 1607.12 IBC 2006 plus the following:

Vertical	Maximum wheel loads plus 25 percent for impact
Horizontal (longitudinal)	10 percent of maximum wheel loads in either direction at top of each runway rail
Horizontal (lateral)	20 percent of sum of the lifted load capacity and trolley weight applied in either direction to the top of the rails. Distribution to each rail will be made with due regard for lateral stiffness of the structure supporting the rails.

2. Hoist loads:

Vertical	Design capacity plus weight of hoist and trolley, if any, plus 15 percent of total for impact.
Horizontal (longitudinal)	10 percent of maximum wheel loads in either direction at top of each runway rail
Horizontal (lateral)	20 percent of sum of the lifted load capacity and trolley weight applied in either direction to the top of the rails.

3. Elevator loads:

Vertical	Design capacity plus weight of cab and appurtenances plus 100 percent of total for impact.

1.5.4 Impact Loads

1. Impact loads will be added to applied loads to account for the dynamic effects associated with operation of equipment or application of live loads to structures. The following impact loads will be used, unless analysis indicates using higher or lower values.

   a. Cranes, hoists, and elevators – Refer to Section 1.5.3.

   b. Rotating and reciprocating equipment – 50 percent of the machine weight (except for Air Expander foundation design) when operating loads are not provided by the vendor.

   c. Elevator machinery – Refer to Section 1.5.3.

   d. Hangers supporting floors and platforms – 33 percent of the sum of the dead and live load.

   e. Rigid pavement design for roadways – 20 percent of the wheel or crawler loads.

1.5.5 Equipment Loads

1. Equipment loads will be specifically determined and located. For major equipment, structural members and bases will be specifically located and designed to carry the equipment load into the structural system. Equipment loads will be noted in the design calculations to permit separation in calculation of uplift and stability.

2. Live loading in areas reserved for equipment laydown during maintenance operations will be increased, if necessary, to meet the capacity requirements for the parts and pieces of equipment to be supported.

3. Equipment dynamic loads shall be considered and applied in accordance with the manufacturer's specifications, criteria, or recommendations, and industry standards, including ACI 351. Rotating parts shall be considered as a vibrating mass.

1.5.6 Pipe Hanger Loads

1. Pipe hanger loads for the major piping systems will be specifically determined and located. Loads imposed on perimeter beams around pipe chase areas will also be considered on an individual basis.

1.5.7 Thermal Loads

1. Thermal load includes self-straining forces and effects arising from contraction or expansion from temperature changes, shrinkage, and moisture changes.

2. Steel structures will be designed with the capability to withstand forces due to thermal loads. Horizontal slots for connections in shear, slide bearing plates for seated connections, and expansion joints in building siding and roofing systems will be used to minimize forces resulting from thermal loads.

3. Concrete sections (walls and slabs) will be reinforced to accommodate stresses resulting from long-term temperature differential at opposite faces.

1.5.8 Snow Loads

1. Snow loads for buildings and structures will be computed using IBC 2006 and ASCE 7-05.

2. Parameters and coefficients from Site Specific Data Sheets, IBC 2006 and Chapter 7 of ASCE 7-05:

Ground Snow Load, p_g (IBC 2006, Figure 1608.2)	35 psf
Exposure Category (IBC 2006, Section 1609.4)	C
Exposure Factor C_e (ASCE 7-05, Table 7-2)	1.0
Occupancy Category of Building and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 7-4)	1.1

3. Snow loads for flat roof will be developed in accordance with Section 7.3 of ASCE 7-05.

4. Snow loads for sloped roof will be developed in accordance with Section 7.4 of ASCE 7-05.

5. Snow Partial Loading, Unbalanced Snow Loads, Snow Drift & Sliding & Snow Ponding Instability have to be considered (if applicable) in accordance with Section 7.5 ~ 7.11 of ASCE 7-05.

1.5.9 Ice Loads

1. Ice loads for ice-sensitive open structures (such as truss tower, catwalks, platforms, flagpoles & signs) will be computed using ASCE 7-05. Parameters and coefficients are used in accordance with Chapter 10 of ASCE 7-05.

1.5.10 Wind Loads

1. Wind loads for buildings and structures will be computed using IBC 2006 and ASCE 7-05.

2. Parameters and coefficients from Site Specific Data Sheets, IBC 2006 and Chapter 6 of ASCE 7-05:

Basic Wind Speed, V (IBC 2006, Figure 1609)	90 mph
Exposure Category (IBC 2006, Section 1609.4)	C
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 6-1)	1.15

3. General Procedures:

   a. In general, the Analytical Procedure will be used for wind load calculation in accordance with Section 6.5 of ASCE 7-05.

   b. Wind gust effect factor will be determined in accordance with Section 6.5.8 of ASCE 7-05.

   c. An enclosure classification will be determined in accordance with Section 6.5.9 of ASCE 7-05.

   Topographic effects will be determined in accordance with Section 6.5.7 of ASCE 7-05.

   Per ASCE 7-05 section 6.5.7.1, the CAES site does not meet the criteria for Wind Speed-up over Hills, Ridges and Escarpments. Therefore, the topographic effects does not apply to the wind load calculation (K_{zt} = 1.0).

Topographic Picture of job site for CAES

d. Wind load calculation procedure will be developed in accordance with Section 6.5.3 of ASCE 7-05.

e. Wind loads for enclosed and partially enclosed buildings will be developed in accordance with Section 6.5.12 of ASCE 7-05.

f. Wind loads for open buildings with monoslope, pitched, or troughed roofs will be developed in accordance with Section 6.5.13 of ASCE 7-05.

g. Wind loads for solid freestanding walls and solid signs will be developed in accordance with Section 6.5.14 of ASCE 7-05.

h. Wind loads for other structures will be developed in accordance with Section 6.5.15 of ASCE 7-05.

1.5.11 Seismic Loads

1. Seismic loads for buildings and structures will be computed using IBC 2006.

Site Class (IBC 2006 Table 1613.5.2)	C
Mapped Spectral Response Acceleration, short period (IBC 2006 Figure 1613.5(1))	S_S = 0.162g
Mapped Spectral Response Acceleration, 1 second period (IBC 2006 Figure 1613.5(2))	S_1 = 0.054g
Seismic Design Category (IBC 2006 Table 1613.5.6(1) & Table 1613.5.6(2))	A
Occupancy Category of Building and Structures (IBC 2006 Table 1604.5)	III
Importance Factor, I (ASCE 7-05 Table 11.5-1)	1.25

2. General Procedures (For Buildings)

   a. Seismic loads for building structures will be developed in accordance with the requirements in section 1.4 Site Design Conditions and the provisions of Section 1613 of IBC 2006.

3. General Procedures (For Non-Building Structures)

   a. Seismic loads for non-building structures similar to buildings, non-building structures not similar to buildings, and non-building structures supported by other structures with weight of the non-building structure 25 percent or more of the combined weight of the non-building structure and supported structure will be developed using the procedures in Chapter 15 of ASCE 7-05. Seismic loads for the combustion air and flue gas ductwork and their support structures will be determined in accordance with these criteria.

   b. Seismic loads for mechanical and electrical equipment supported by buildings and structures will be developed in accordance with Chapter 13 of ASCE 7-05.

   c. Seismic loads for architectural components or systems will be developed in accordance with Chapter 13 of ASCE 7-05.

d. Seismic loads for the absorber vessel and other process tanks will be developed in accordance with Appendix E of API 650.

1.5.12 Soil Loads

1. Earth Pressure Parameters will be as specified in Section LATER of the Project Geotechnical Report.

2. The earth pressure on walls during an earthquake will be characterized for design as a transient load increasing uniformly from the base to the top of the wall (inverted triangle). The magnitude of the load will be provided as part the foundation design recommendations in the project geotechnical report.

3. The water table is generally follows the rock contours at this site and localized dewatering can be expected at excavations below elevations of 30 feet.

4. Surcharge loading from adjacent structures will be determined by the project geotechnical engineer. For walls not adjacent to other structures, a uniform surcharge load of 300 psf will be used.

1.5.13 Differential Settlement

1. The effects of differential settlement will be considered in the design of all structures and foundations. Flexible or sliding connections will be used judiciously between adjoining structures to mitigate the effects of differential settlement if required.

1.5.14 Hydraulic Loads

1. Pressurized circulating water, service water, and makeup systems will be designed to a static pressure equal to the shutoff head of the pumps plus static head where applicable. No compensating external loading will be considered.

2. A transient analysis will be made of any piping run of significant length and resulting surge loading will be considered in the pipe design.

3. Pipe and/or tunnel walls will be analyzed for competence against external forces due to soil and surcharge loading with zero internal pressure or vacuum if applicable.

1.5.15 Vehicle Loads

1. HS20-44 loading will be used for roadway design and for surcharge loading over buried piping, culverts, and embankments. Where appropriate, loads from crawler cranes and heavy equipment transport vehicles will be evaluated.

2. Floors in all buildings where warehousing or storage provisions are present will be designed for loads transmitted by a fork lift truck having a material loaded weight of 2,000 pounds on elevated floors or 10,000 pounds on ground floor plus dead load of the fork lift truck.

1.5.16 Construction Loads

1. Structures and foundations will be designed for temporary erection and rigging loads during construction. Structures will include redundancy in the design as required to accommodate leave-out of permanent steel framing during the installation of equipment.

1.5.17 Loading Combinations

1. Combining Nominal Loads Using Allowable Stress Design

   a. Allowable strength design may be used in the design of steel structures. The provisions of Section 2.4 of ASCE 7-05 will be the basis for developing load combinations. The provisions of Design Requirements of Section B3.4 of AISC 360-05 will be the basis for steel structural design.

   b. Allowable stress design will be used in determination of load bearing and stability requirements for foundations and structural serviceability design. The provisions of Section 2.4 of ASCE 7-05 will be the basis for developing load combinations.

   c. Allowable strength for individual members in steel structures will be increased one-third (use $\Omega/1.33$) when subjected to temporary construction or equipment startup loading conditions.

   d. Allowable strength for individual members in steel structures will be increased one-half (use $\Omega/1.5$ but not greater than 0.9 Rn) when subjected to transient load conditions due to failure in mechanical or electrical systems; or when subjected to transient steam and water hammer loads from high energy piping systems. Allowable stresses will be increased when loads from these sources act alone or when combined with other vertical and horizontal loads. Earthquake load will not be combined with transient loads.

e. ASD load combinations for Dead (D), Live (L or L_r), Snow or Ice (S), Rain (R), Fluid (F), Earth Pressure (H) and Wind (W):

D + F	IBC 2006, Eq. 16-8
D + H + F + L + T	IBC 2006, Eq. 16-9
D + H + F + (L_r or S or R)	IBC 2006, Eq. 16-10
D + H + F + 0.75 (L + T) + 0.75 (L_r or S or R)	IBC 2006, Eq. 16-11
D + H + F + W	IBC 2006, Eq. 16-12
D + H + F + 0.75 (W + L + (L_r or S or R))	IBC 2006, Eq. 16-13
0.6 D + 1.0 H + 1.0 W	IBC 2006, Eq. 16-14

ASD load combinations for Ice (D_i) and Wind-on-ice (W_i) per ASCE 7, Section 2.4.3:

D + H + F + L + T + D_i
D + H + F + 0.7 D_i + 0.7 W_i + S
0.6 D + 0.7 D_i + 0.7 W_i + H

ASD load combinations for Seismic (E):

D + H + F + 0.7 E	IBC 2006, Eq. 16-12
D + H + F + 0.75(0.7 E + L + (L_r or S or R))	IBC 2006, Eq. 16-13
0.6 D + H + 0.7 E	IBC 2006, Eq. 16-15

Special seismic load combinations (IBC 2006 Section 1605.4):

1.2 D + f_1 L + E_m	IBC 2006, Eq. 16-22
0.9 D + E_m	IBC 2006, Eq. 16-23

Note: $E = E_h = \rho Q_E$
$E_m = E_{mh} = \Omega o Q_E$, where Q_E = Effect of horizontal seismic force

2. Combining Factored Loads Using Strength Design

a. Ultimate strength design will be used in the design of concrete structures including foundations, elevated equipment pedestals, and concrete walls. Ultimate strength design may also be used for design of steel structures. The provisions of Section 2.3 of ASCE 7-05 will be the basis for developing factored load combinations along with any specific criteria for combining loads from equipment manufacturers.

b. Loading combinations used for design of the turbine-generator pedestal and mat foundation will be developed using the provisions of ACI 351.3R-04, the provisions of Section 2.3 of ASCE 7-05 and the ASCE publication, "Design of Large Steam Turbine-Generator Foundations" along with any specific criteria for combining loads from equipment manufacturers.

c. Strength Design load combinations for Dead (D), Live (L or L_r), Snow or Ice (S), Rain (R), Fluid (F), Earth Pressure (H) and Wind (W):

1.4 (D + F)	IBC 2006, Eq. 16-1
1.2 (D +F + T) + 1.6 (L + H) + 0.5 (L_r or S or R)	IBC 2006, Eq. 16-2
1.2 D + f_1 L + 1.6 (L_r or S or R)	IBC 2006, Eq. 16-3
1.2 D + 0.8 W + 1.6 (L_r or S or R)	IBC 2006, Eq. 16-3
1.2 D + 1.6 W + f_1 L + 0.5 (Lr or S or R)	IBC 2006, Eq. 16-4
0.9 D + 1.6 W + 1.6 H	IBC 2006, Eq. 16-6

Strength Design load combinations for Seismic (E):

1.2 D + 1.0 E + f_1 L + f_2 S	IBC 2006, Eq. 16-5
0.9 D + 1.0 E + 1.6 H	IBC 2006, Eq. 16-7

Strength Design load combinations for Ice (D_i) and Wind-on-ice (W_i) per ASCE 7, Section 2.3.4:

1.2 (D + F + T) + 1.6 (L + H) + 0.2 D_i + 0.5 S
1.2 D + L + D_i + W_i + 0.5 S
0.9 D + D_i + W_i + 1.6 H

Special seismic load combinations (IBC 2003 Section 1605.4)

1.2 D + f_1 L + E_m	IBC 2006, Eq. 16-22
0.9 D + E_m	IBC 2006, Eq. 16-23

Note: $E = E_h = \rho Q_E$
$E_m = E_{mh} = \Omega o Q_{E,}$ where Q_E = Effect of horizontal seismic force

1.6 Design of Concrete Structures and Foundations

1.6.1 Reinforced Concrete Design

a. Reinforced concrete structures and foundations will be designed in accordance with the following documents:

a. ACI 318-05 – Building Code Requirements for Structural Concrete.

b. ACI 350-06 – Code Requirements for Environmental Engineering Concrete Structures.

c. IBC 2006, Chapters 18 and 19.

d. Specific requirements of ACI or ASCE publications for specialty concrete structures or foundations:

    i. Turbine-generator pedestal – ACI 351.3R-04 & ASCE "Design of Large Steam Turbine-Generator Foundations".

e. Any specific requirements of equipment vendors, including static and dynamic performance criteria for foundations supporting rotating or vibrating equipment.

1.6.2 Foundation Design

1. Support for heavily loaded and/or settlement sensitive structures will be provided by mat type foundation systems. Mat foundations will be used for the Air Expander and Recuperator. Tanks will be supported on ring wall foundations or mats, based on their diameter, height, and location.

2. Soil-supported mat foundations and spread footings will be used for the generation building and pipe bridges, switchyard structures, pre-engineered buildings and enclosures for electrical and mechanical equipment, sumps, and other structures with foundations having relatively low contact pressures. Allowable bearing pressure for sizing foundations and subsurface preparation requirements, such as over-excavation and replacement with structural fill or other soil improvement techniques, will be established based on foundation design recommendations in the project geotechnical report.

3. The effects of fluctuating ground water elevation will be taken into account in the design of all plant foundations including buried pipes, tunnels, sumps, and manholes. Buoyancy on foundations and buried structures will be investigated based on high ground water elevation at grade.

4. Uplift Conditions:

    a. Foundation design conditions resulting in temporary uplift from environmental loads (wind, seismic) or permanent uplift from cantilevered construction will generally not be permitted. Exceptions will be considered on a case by case basis with the approval of the Project Lead Structural Engineer.

5. Frost protection for soil supported footings, pipes, and other frost-susceptible structures will be designed on a frost depth of 48 inches.

6. Minimum embedment in the soil for all foundations will be two foot with proper soil improvement. Minimum embedment for sidewalks, concrete pads at building doorways, and step off pads for ladders and stairways will be twelve inches.

7. Top surfaces of concrete topping slabs at grade, both interior and exterior, will be sloped at ¼-inch per foot (1/8” minimum) for positive drainage to collection trenches and sumps. This requirement will also apply to the top surface of the cooling tower basin mat.

8. Soil parameters for the design of foundations are as follows:

Geotechnical Data

Passive lateral pressure:	250 pcf*
Allowable skin friction	200 psf
Coefficient of Friction:	0.40
Dynamic Shear Modulus (G’):	16.7 ksi
Poisson’s Ratio (μ):	TBD
At-rest earth pressure:	65 pcf
Active earth pressure:	35 pcf
Angle of friction (ϕ):	33°
Total Unit Weight of Soil:	125 pcf
Liquefaction Potential:	Very Low
Water Table:	Below 7.5ft

Average Site Grade: El. TBD

Finished Floor Elevation: El. TBD

9. Factors of safety for foundation design will be as follows:

	Normal	Transient or Construction
Overturning:	1.5	1.25
Sliding:	1.5	1.25
Uplift:	1.15	1.1

a. For calculations that involve overturning, use the combination of loading that produces the greatest ratio of overturning moment to the corresponding vertical load.

$SR_{ot} = M_r / M_o$

M_o = the max overturning moment.

M_r = the resisting moment

1.6.3 Design of Slabs on Grade

1. Design slabs in accordance with ACI 360R, ACI 302.1, and ACI 302.2.

2. Provide a 6 mil polyethylene vapor barrier between the granular base and the concrete for all building slabs and paving placed on subgrade. Use a vapor barrier type recommended for below slab applications. Slabs which are on mudmats or lean fill do not require a vapor barrier.

1.6.4 Design of Formwork

1. Formwork for cast-in-place concrete will be designed in accordance with ACI 301 and ACI 347.

2. The design of formwork will be assigned to the concrete installation contractors.

3. Contractors will be required to account for the following in the design of formwork:

   a. Vertical dead loads including the weight of the wet concrete at 150 pcf, the weight of the reinforcing steel, and the weight of the formwork.

   b. Vertical live loads including any impact load from the weight of moving construction personnel and equipment used for concrete placement.

   c. Lateral load from liquid head of wet concrete calculated in accordance with Chapter 2 of ACI 347 and verified for use at the CAES site; lateral loads from equipment used in the placement of concrete; and lateral load from wind on the formwork calculated in accordance with Section 1.5.10.

4. Contractors will be required to submit engineering design calculations including detailed formwork drawings of the following for review by the Engineer:

   a. All placements requiring massive concrete such as deep foundation mats and footings.

   b. Elevated concrete pedestal structures supporting the compressors, air expander, and transformers.

   c. Concrete walls and roof slab for the circulating pump structure.

   d. Concrete walls and roof slabs of deep sumps and pits in the power block and yard areas.

1.7 Masonry Design

1. Masonry structures will be designed in accordance with the following documents:

   a. ACI 530 – Building Code Requirements for Masonry Structures.

   b. IBC 2006, Chapter 21.

2. Masonry block units will be used to provide an emergency means of egress by providing a fire separation for the stair towers. The masonry units will be hollow cored block with lightweight aggregate, 8” high by 8 or 12” deep by 16” long. Reinforcement will be supplied, both horizontally and vertically, based on actual required design strength, but not less than code required minimums.

3. Masonry block units will be used to provide a fire separation and to limit noise in several other areas. The masonry units will be hollow cored block with lightweight aggregate, 8" high by 8" or 12" deep by 16" long. Reinforcement will be supplied, both horizontally and vertically, based on actual required design strength, but not less than code required minimums.

1.8 Structural Steel Design

1.8.1 Steel Framing Design

1. All steel framed structures shall be designed as "rigid frame" or "simple" braced frames, utilizing single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels. The use of rigid frames shall be limited to one-story, open garage, warehouse or shed type structures, or to small prefabricated metal buildings except where required in the generation building to increase stiffness at locations that occur a significant distance from vertically braced bays. Pipe racks may be designed as rigid frames utilizing fully-restrained moment connections or braced frames utilizing vertical diagonal bracing at the column lines and horizontal bracing at rack levels. All other framed structures, except at the generation building which will utilize a dual system of "rigid frame" and "simple" braced frames, shall utilize "simple" braced frame design and construction.

2. Steel framing for platform and floor systems, including struts, horizontal and vertical bracing members, and columns, will be designed in accordance with the AISC 360-05 – Specification for Structural Steel Buildings and the procedures given in the Steel Construction Manual, 13th edition.

3. Each platform beam will be designed for a contingency load at midspan of 5 kips. This load is intended to account for unknown piping, cable tray, and equipment loads. This load will not be transferred to girders or columns, but girders will be designed for the 5 kip concentrated load at midspan. The minimum beam vertical reaction capacity shall be 9 kips.

4. Each brace shall include a 5 kip load in its design as a contingency placed at a location to maximize shear and bending stresses.

5. All primary building columns shall be designed for a collateral load of 25 kips in addition to normal dead and live loads.

6. The depth of beams and girders in floors and platforms will not be less than 1/24 times the span (for non-secondary load bearing members). If members of less depth are used, the allowable unit stress in bending will be decreased by the same ratio as the depth is decreased from that recommended. Refer to applicable Sections for deflection limits on special members such as crane support girders and monorails.

7. A minimum flange width of 5-1/4 inches will be selected for floor and platform members that are part of lateral bracing systems in order to allow for a bolted flange connection.

8. Maximum Deflections:

   The following guidelines for maximum deflection will be followed:

   a. Floor beams – 1/240 x span (live load deflection).

   b. Roof beams – 1/240 x span (live load deflection).

   c. Floor or roof members supporting plaster ceilings or masonry walls – 1/360 x span (for live load)

   d. Structural members supporting masonry walls 1/600 x span or 0.3 in. max. with dead and live load, whichever is more stringent.

   e. Metal panel wall girts:

      1) Vertical – 1/240 x span (for dead load of siding).

      2) Horizontal – 1/180 x span.

   f. Crane and hoist support beams, rails, and monorail support beams. The deflections are based on maximum wheel loads.

      1) 1/600 x span (without impact).

9. Minimum Sizes:

   a. "W" shapes used as framing members – W8 x 15.

   b. "W" shapes used as posts or columns – W10 x 33.

   c. "W" shapes used as misc. supports – W8 x 18.

10. Single angles will not be used except as lateral support for platform members or as posts for small equipment access platforms. Minimum angle size used will be L3x3x1/4.

11. Structural Tees used for horizontal diagonal bracing members and connected by their flanges only will be designed considering the effects of connection eccentricity. The same procedure will apply for double angles connected eccentrically with a single plate on the outstanding legs.

12. Beams spanning between columns and located above the apex of a chevron-type brace will be designed for the full span length between columns. However, the chevron brace will be designed for axial load considering the brace as an intermediate support point for the beam.

13. For hangers consisting of back-to-back members, each back-to-back member will be designed for 75 percent of the total load.

14. Columns will be designed considering all applied moments, including applied point loads between bracing points and the effects of knee-braced platforms.

15. Connections:

    a. Welded and bolted connections will develop greater of following for beams:

        1) Vertical reaction and axial load on the Drawings. Minimum vertical reaction shall be 9 kips.

        2) Strength of framed connections as shown in AISC Steel Construction Manual, Parts 9 thru 15, having connection length (L) greater than one-half “dimension T” as given for beam in the AISC Steel Construction Manual.

    b. In the absence of vertical reactions on Drawings, develop the connection for one-half of total uniform load shear capacity shown in “Maximum Total Uniform Load Tables” of the AISC Steel Construction Manual, plus axial loads given on the Drawings. For short beams where required connection length exceeds beam depth, an exception to design loads criteria will be made based on required capacity versus the available beam depth.

c. All beams framed into columns will have as a minimum, the largest standard connection length (L) allowed based on the dimension "T" given for the beam in Part 1 of the AISC Steel Construction Manual.

d. For trusses, bottom chord braces, sway frames, vertical bracing, hangers, and similar type members, develop either the greater of forces indicated on Drawings or one-half of the effective strength of the member. In addition, connections for trusses and members in bracing systems will meet the minimum bolting requirements below:

WF flange connection	8 bolts
WF web connection	4 bolts
WT flange connection	4 bolts
Single angle	2 bolts
Double angle	2 bolts double shear or 4 bolts single shear

e. Bolting requirements:

1) Pre-tensioned bearing type connections with threads included in the shear plane with high strength bolts (ASTM A 325, Type 1) will be used for standard beam and girder end connections.

2) Slip critical type connections with high strength bolts will be used for horizontal and vertical bracing members, column splices, and all other members subjected to vibratory loads. Allowable bolt shear for slip critical connections will be based on the use of oversized holes to mitigate fit-up problems. These connections will be identified using the designation (SC) on the design drawings.

3) Shear bearing type (snug tight) connections with high strength bolts will be used judiciously for members not subjected to axial load (i.e., in-fill beams in floor and platform systems). Floor and platform beams with shear bearing connections will be identified using the designation ST (snug tight) on the design drawings.

4) Shear bearing type connections using A325 high strength bolts or connections using A449 high-strength bolts will be acceptable for the following:

   a) Removable beams.

   b) Stairways, landings, and ladders.

   c) Girts.

5) With the exception of column base plates, a minimum of two bolts will be used in all connections. For column base plates, a minimum of four bolts will be used, except for small angle posts.

6) Unless otherwise required, end connections for beams, girders, and struts will be Simple Connections as defined by Section J1.2 of the AISC 360-05.

f. Welding requirements:

1) Welded connections will be sized such that stresses within the base or weld metal will not exceed the available stress values presented in Chapter J, Table J2.5 of the AISC 360-05.

2) Prequalified welds conforming to AWS D1.1 will be used in all welded connections.

16. Stability

a. The following criteria will be used to determine the unbraced length used for design of isolated beams and beams supporting grating:

1) Grating will not be considered as lateral support for beams or beam columns. Stair treads will be considered as lateral support for stair stringers at midspan only.

2) Beams or beam columns connected to panel points of horizontal trusses will be considered as laterally supported at the panel point.

3) Members used for lateral bracing will be positioned no more than 3" or 1/6 of the supported member depth below the top or compression flange of the supported member.

4) Parallel beams having less than 20 percent difference in weight and connected by perpendicular beams not connecting to panel points of a horizontal truss will be considered laterally supported in accordance with the following:

   a) Maximum unbraced length used in design will not be less than the beam span divided by the number of beams connected in parallel.

   b) Two parallel beams will be considered braced by one perpendicular beam provided the beam span/spacing ratio is less than 12 (spacing is the distance between parallel beams). If the span/spacing ratio is greater than 12, a horizontal truss will be provided.

   c) When axial load in a parallel beam is greater than 10 kips, a horizontal truss will be provided for lateral support of the beam/column.

5) Parallel beams having more than 20 percent difference in weight and connected by perpendicular beams not connecting to the panel points of a horizontal truss will be considered laterally supported in accordance with the following:

   a) The lighter beam will be considered laterally supported at the connection points of the perpendicular beams. The heavier beam will be considered laterally unsupported for its full span unless braced with a horizontal truss.

6) At the points of support for beams, girders and trusses, restraint against rotation about their longitudinal axis shall be provided.

7) Beam bracing shall prevent the relative displacement of the top and bottom flanges. Lateral stability of beams shall be provided by lateral bracing, torsional bracing or a combination of the two.

8) Horizontal trusses provided only for beam lateral support will be designed for a lateral force equal to 0.008 times the sum of the flange compressive forces for the beams being supported. These beam stability forces will be ignored for the design of other horizontal trusses.

b. Column stability will be evaluated in accordance with the following guidelines:

1) The design of column stability bracing shall be in accordance with the following:

Relative Brace: See AISC 360-05, Appendix 6.2.1

Single Point Brace: See AISC 360-05, Appendix 6.2.2

2) Platform beams and column struts which are required to brace a column, or line of columns, will be designed for the accumulated axial load required to transfer the column stability load to the bracing system. A maximum of 8 columns will be considered to apply load to the bracing system.

3) It will be assumed, since columns tend to buckle in the form of a sine curve, that stability forces cancel between brace points. Accordingly, stability forces will only be considered as shears between braced points and not summed down to grade. Stability forces do not contribute to overturning, therefore columns, column splices, base plates, and anchor bolts will not be designed for stability forces.

1.9 Pipe Support Design and Pipe Stress Analysis

1.9.1 Pipe Support Design

1. In general, piping will be supported from structural steel members or anchored steel plates utilizing the most practical and cost effective configuration and method of attachment.

2. Supplemental steel supporting piping will be designed in accordance with the AISC 360-05 Specification for Structural Steel Buildings in the AISC Manual, 13th edition.

3. Piping 2-1/2 inches in diameter and larger will have supports arranged so that any valve can be removed without need for temporary support of the pipe. Supporting straps

around pipe flanges of valves will not be used. Supports will be positioned near valves and joints that will require removal during maintenance.

4. Pipe support design for high-energy piping will include devices to restrict pipe dynamic loads.

5. Piping will be supported within a maximum span in accordance with either ASME B31.1 or Manufacturers Standardization Society publication SP 69.

6. Pipe restraints for safety valve transients will be evaluated per the requirements of Appendix II in ASME B31.1.

1.9.2 Pipe Stress Analysis

1. Piping exposed to temperatures above 300 degrees F and above will be analyzed using appropriate computer programs for flexibility and stresses. In addition, piping subject to dynamic loads such as steam hammer will be analyzed. Piping systems will be designed to limit forces transmitted to the equipment to that permitted by the equipment manufacturers.

2. Piping not exposed to temperatures above 300 degrees F or not subject to dynamic loads such as steam hammer will not be analyzed. Cold pipe support spacing criteria will be developed per MSS guidelines.

3. Tubing subject to temperatures above 300 degrees F will be reviewed for flexibility including development of support criteria per MSS guidelines.

1.10 Generation Building

1.10.1 Foundations

1. Generation Building Foundation

    a. Building columns will be supported on individual and combined shallow spread footings and equipment located inside the structure will be supported on individual soil supported foundation mats.

    b. The finished topping slab will be sloped for drainage.

    c. See Section 1.6.2 for foundation design requirements.

2. Air Expander Pedestal and Foundation Mat

a. Physical Arrangement

1) The air expander foundation will consist of a large soil supported concrete mat with a raised reinforced concrete pedestal.

b. Acceptance Criteria

Foundation and pedestal structure will be evaluated for conformance with vendor specified static and dynamic criteria.

c. Analytical Approach

1) STAAD Pro will be used to perform the analysis of the combined soil, concrete mat, superstructure & machine. Serviceability (SF of against overturning moment & sliding, soil bearing & settlement, foundation displacement & drift) design will also be determined by STAAD Pro analyses to assess static load criterion given by machine vendor and design codes.

2) DYNA5 will be used to generate the soil frequency-dependant impedance (stiffness & damping ratio) used in the STAAD Pro foundation models.

a) Damping Safety Factor = 2.0 (To reduce the possibility of damping overestimation and thus response underestimation).

b) Soil Material Damping Ratio = 0.05

c) Footing Flexibility = Rigid

d) Foundation Type = Elastic Half-Space and Homogenous

e) Consider Side Embedment Effects

f) Harmonic Loads (fmax = 75Hz, fmin = 0Hz, step = 5hz)

g) The max soil damping ratio (material damping + geometric damping) = 0.5 (for vertical, conservatively use 0.25), 0.2 (for horizontal), 0.1(for rocking) and 0.15 (for torsional) (ACI 351.3R-04, section 4.2.2)

3) STAAD Pro will be used to perform the modal dynamic (free vibration with composite damping accounted) analysis of the soil-foundation-machine system to solve the natural frequencies (eigenvalues) and mode shapes (eiganvectors). Identify the fundamental frequency (usually the lowest value of the natural frequencies) and mode. They can be compared with the frequency of the acting dynamic force so that a possible resonance condition can be prevented.

4) STAAD Pro will be used to perform the steady state harmonic dynamic analysis of the structure to extract member vibration displacement, velocity, and acceleration amplitudes if required.

5) STAAD Pro will be used to generate member and element forces for use in reinforced concrete load combinations defined in IBC 2006, ACI 318-05, ASCE 7-05, and ASCE Publication "Design of Large Steam Turbine-Generator Foundations."

6) PCACOL and MathCAD will be used in the design of reinforced concrete members in accordance with IBC 2006 and ACI 318-05.

d. Loads

Design loads will be in accordance with Section 1.5 and the following supplementary loading provisions:

1) Seismic loads will be developed in accordance with Section 1.5.10

Seismic-Force Resisting System – Block type concrete foundation with properties same as Nonbuilding structure not similar to building per the requirements of Section 15.6 and Table 15.4-2 of ASCE 7-05.

Redundancy Factor ρ (based on classification as a non-building type structure) = 1.0

Overstrength Factor Ω_0 = 2.0

Deflection Amplification Factor C_d = 2.5

2) Condenser loads – Condenser loads will be in accordance with loading arrangement diagram provided by the condenser vendor.

3) Primary loads

Primary load category types will be as follows:

D = Dead load
L = Live load
H = Soil load (buoyancy)
E = Seismic load
A = Accident load
O = Operating load (normal torque, normal unbalance, etc.)

e. Load Combinations (confirm with vendor info later)

See Section 1.5.17 for load combinations. (confirm with vendor info later)

1.10.2 Generation Building Superstructure

1. The enclosed structure will be of steel Ordinary Concentrically Braced Frames (OCBF) (simple connection) construction with rigid moment frames as required and with the following features:

a. The structure will be equipped with a bridge crane to assist with initial installation of the turbine and generator and then after startup, assist with machine maintenance during outages. The crane will be limited in main hook capacity of 35 ton for Cycle 1 and 80 ton for Cycle 2 based on the weight of the heaviest piece of equipment required for maintenance lift following installation of the expander, compressor, turbine and generator. Stepped columns will be used to create a support seat for the crane support girders. The turbine/generator bays will include a number of local platforms for access to and support of equipment and piping systems.

The platforms will consist of grating over steel framing for providing direct access to the underside of the turbine, generator and other miscellaneous valves and instruments at elevated levels.

b. The steel roof structure will consist of purlins spanning over top of steel plate girders. Roofing materials will consist of steel deck covered with rigid board insulation and an EPDM roof membrane system.

c. Lateral stability for the building structure will be accomplished by placement of diagonal bracing members in selected bays and the use of moment frames away from the end bays of the building at the east and west ends.

2. Loads

Design loads and load combinations for the generation building structure will be in accordance with Section 1.5 and the following supplementary provisions:

a. Hung loads for electrical and mechanical systems will be considered as dead load and will be accounted for as follows:

Location	Load (psf)
Miscellaneous Platforms	50
Roof between Column Lines	10

b. Seismic loads for the generation building steel superstructure will be developed in accordance with Section 1.5.10 and Section 12.8 of ASCE 7-05 for structures in Seismic Design Category A.

c. Seismic loads for reinforced masonry will be developed in accordance with Section 1.5.10 and Section 12.8 of ASCE 7-05 for structures in Seismic Design Category A.

d. Piping loads – For major piping systems (main steam, hot reheat, cold reheat, feedwater, condensate, extraction) individual pipe support loads will be included in the structural analysis for the turbine building. Loads from small bore piping will be included in dead load allowance.

3. Load Combinations

Load combinations for the turbine building superstructure will be in accordance with Section 1.5.17.

1.11 Combustion Turbine/Generator (If Required)

1.11.1 Foundations

1. Combustion Turbine/Generator Support Structure Foundation

a. The combustion turbine/generator support structures and foundations shall be designed in accordance with the manufacturer's recommendations and the geotechnical report. Both static and dynamic loading criteria set forth by the manufacturer shall be considered. In general, the structure will be a soil supported foundation mat.

1.12 Recuperator Foundation and Structure

1.12.1 Foundations

1. Recuperator Foundations

   a. Recuperator structure will be supported on an individual foundation mat. The foundation mat will be supported by soil.

2. Recuperator Auxiliary Equipment Foundations

   a. Auxiliary equipment at the Recuperator structures will be supported either the Recuperator mat foundation or on individual soil supported foundation mats.

1.12.2 Superstructure

1. Design of structural steel for the Recuperator will be the responsibility of the Recuperator vendor.

2. Steel grating walkways, platforms, and stairways will be provided to facilitate maintenance of all of the equipment items. Service platforms at all levels will be arranged such that they are accessible by walkways from either of two main stair towers provided at one side of each structure. Access to these stairs will be provided from the utility bridge.

1.13 Utility Bridge

1.13.1 Foundations

1. Utility Bridge Foundations

   a. Utility bridge foundations shall be shallow soil supported individual or combined footings.

1.13.2 Superstructure

1. The utility racks and pipe/bridge(s) shall be multilevel steel structures on reinforced concrete foundations. The structure shall consist of galvanized structural steel members in a combination of simple braced, and/or moment resisting frames; field connected with galvanized high-strength bolts. All critical steel piping shall be considered to be top hung from the bottom of steel. Lateral and longitudinal directional wind and seismic forces will be transferred to the lateral load resisting system via horizontal and vertical bracings and moment connections.

2. The dead load of all walkways/platforms, cable trays, analysed piping, and cold piping shall be considered in the utility bridge structural design.

3. A live load of 100 psf shall be used on all the walkways and platforms attached to the utility bridge structure.

4. Seismic loads for the utility bridge steel superstructure shall be developed in accordance with Section 1.5.10 and Section 15.5 of ASCE 7-05 for structures in Seismic Design Category A.

1.14 Cooling Tower Area

1.14.1 Cooling Tower Basin

1. The cooling tower will be of the rectilinear, fiberglass framed, film filled, multiple cell, mechanical induced draft counterflow type and will be supported on a rectangular foundation mat supported by soil. A concrete wall with a height of 4’-0” will be constructed around the perimeter of the mat to form a basin for retaining water fill during tower operation.

2. Loads

   Design loads for the basin mat will be in accordance with Section 1.5 and the following supplementary loading and performance provisions:

   a. Cooling tower loads and performance criteria:

      1) Live load at roof level – per Vendor based on 35 psf ground snow load

      2) Seismic loads developed by Vendor in accordance with the Site Specific Criteria.

3) Crane load – 300 psf surcharge on basin mat

b. Other loads on basin mat:

1) Water fill in basin:

a) Vertical surcharge from 4’-0” (depth to be confirmed) full depth of water.

3. Load Combinations

Load combinations will be in accordance with Section 1.5.17 and the following supplemental provisions:

a. Load combinations for basin concrete design will be as follows from Section 9.2 of ACI 350-06.

b. Required strength shall be multiplied by the environmental durability factors S_d per Section 9.2.6 of ACI 350-06.

1.14.2 Cooling Tower Pump Structure

1. A concrete pump structure 75’-0” long by 27’-8” wide will be provided adjacent to the cooling tower. The bottom mat of the pump structure will be recessed 15’-6” below grade (T/mat El. later) to provide a well for the vertical pumps. The bottom mat of the pump structure and the spillway mat will be supported by soil.

2. The pump structure will be fitted with slots in the roof slab and key ways installed in the walls and base mat to accommodate trash screens, flow modification devices, and stop logs upstream of the circulating water pumps as follows:

a. Trash screens:

Two banks of (later) wide by (later) high frames ((later) required) fabricated from galvanized steel rolled shapes and covered with 0.12-inch diameter, 3/4-inch center-to-center, type 304 stainless wire cloth. Screen assemblies fitted with single 9” x 9” basket along upstream side at bottom for trash drop-out and collection. The trash screens may be fabricated of HDPE materials.

b. Flow distributor screens: (If Required)

One full-width by full-height ((later) wide by (later) high) screen fabricated from galvanized steel rolled shapes. Spacing and configuration of shapes will be as recommended by flow model results.

c. Bulkhead gates: (If Required)

Two full-width by half-height ((later) wide by (later) high) assemblies fabricated from galvanized steel rolled shapes and plates and fitted with rubber bulb seals and strips to minimize leakage while in use.

3. Loads

Design loads for the pump structure will be in accordance with Section 1.5 and the following supplementary loading provisions:

a. Live loads on pump structure roof as follows:

Location	Load
Concrete roof and supporting beams	150 psf
Grating covered openings for screens, etc.	150 psf

b. Circulating water pumps supported on roof – (later) lbs. each

c. Seismic load from sloshing water against walls of pump structure will be calculated in accordance with the section 15.7 of ASCE 7-05.

4. Load Combinations

Load combinations will be in accordance with the provisions of Section 1.5.17.

1.15 Transformer Area

1.15.1 Foundations and Superstructure

1. Transformers

a. All transformers will be supported on individual or common mat foundations. Mat foundations will be supported by soil.

b. Mat foundations will be recessed and fitted with perimeter walls to form pits for water and oil retention. Concrete piers and pedestals will be extended up from the top of recessed foundation mats for support of the transformers at grade elevation Pits will be covered with 1 ½" to 2" deep grating supported by steel beams connected to the pedestals and pit walls (to be confirmed). A 12" thick layer of rocks may be placed on top of steel grating for additional fire protection.

c. Reinforced concrete pit walls will be extended above grade where required for protection of adjacent transformers and plant facilities (i.e., turbine building) in the event of a transformer fire.

d. Sizing Criteria for Pits/Walls

1) Transformer pits

Plan dimensions:

a) Inside face of pit walls should be a minimum of 5'-0" away from the greatest projection on each side of the transformer. Lesser clearance must be approved by project Electrical and Structural engineers.

b) Ground clearance will be provided between the transformer bushings and grounded objects, including concrete fire walls. Clearance will be measured as a sphere with diameter of 5'-0" (to be confirmed) radiating outward from the outside of the transformer bushing.

2) Depth:

a) Minimum depth of retention area will be 1'-0".

b) Pit walls will extend a minimum of 6 inches above grade.

c) Retention area will be sized to contain the full volume of the oil in the transformer plus 10%. No extra allowance for rain, deluge, or fire hose water will be provided for as each pit will be fitted with a sump and piped to a common collection sump in the yard (to be confirmed).

e. Fire walls

1) NFPA 850, Sections 5.2.4.1– Outdoor oil-insulated transformers should be separated from adjacent structures and from each other by firewalls, spatial separation, or other approved means for the purpose of limiting the damage and potential spread of fire from a transformer failure. Basis for determining minimum (line-of-sight) separation with fire walls will be a transformer oil capacity of over 500 gallons. Separation between structures and a transformer will extend vertically and horizontally as indicated in Figure 5.2.4.3.

2) NFPA 850, Section 5.2.4.4 – Fire walls provided between transformers will extend a minimum of 1'-0" above the top of the transformer casing and oil conservator tank and at least 2"-0" beyond the width of the transformer and cooling radiators.

Fuel Gas Composition

Component	Typical Analysis (mole %)	Range (mole %)
Methane	94.9	87.0 - 96.0
Ethane	2.5	1.8 - 5.1
Propane	0.2	0.1 - 1.5
iso - Butane	0.03	0.01 - 0.3
n - Butane	0.03	0.01 - 0.3
iso - Pentane	0.01	Trace - 0.14
n - Pentane	0.01	Trace - 0.04
Hexanes+	0.01	Trace - 0.06
Nitrogen	1.6	1.3 - 5.6
Carbon Dioxide	0.7	0.1 - 1.0
Oxygen	0.02	0.01 - 0.1
Hydrogen	trace	Trace - 0.02
Specific Gravity	0.585	0.57 – 0.62
Lower Heating Value (Btu/scf), dry basis	960	914 - 1021

Data based on Russell Station Project.

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NEW YORK STATE ELECTRIC & GAS

COMPRESSED AIR ENERGY STORAGE PROJECT

Electrical Engineering

Plant Switchyard (Collector Station) Design Criteria

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COMPRESSED AIR ENERGY STORAGE PROJECT
ELECTRICAL ENGINEERING
PLANT SWITCHYARD (COLLECTOR STATION) DESIGN CRITERIA

Disclaimer

REV	DESCRIPTION	ORIGINATOR	REVIEWER	APPROVER	DATE
A	Issued for Review	B.Williams B. Williams	B. Chernisky B. Chernisky	B. Chernisky B. Chernisky	9/27/11

CONTENTS

1. SCOPE

1.1 Background

The Compressed Air Energy Storage (CAES) plant will consist of a separate, electrically driven compression cycle and a natural-gas fired expansion cycle to generate electricity. The CAES plant will use off-peak electricity to compress air into an underground reservoir. When electricity is needed, the compressed air is withdrawn, heated, and passed through an expansion turbine to generate power.

The CAES generated power will flow through the Plant Switchyard, through a 0.7 mile , 115kV single circuit, transmission line commencing at the Plant Switchyard and ending at the Interconnect (POI-Point of Interface) Switchyard where it will interface with existing 115kV NYSEG transmission lines 967 and 970. Existing transmission lines 967 and 970 run from the AES Greenidge Station to the Montour Falls Station. The Plant Switchyard (Collector Station) shall be an outdoor, open-air, ring bus type arrangement.

The Scope of this document is for the Plant switchyard (Collector Station). The Interconnect (POI) Switchyard Design Criteria is described in document CAES-1-DB-023-0002.

1.2 Equipment To Be Provided

A. The switchyard shall consist of the following major equipment:

Equipment	Quantity
• 123kV Class Deadtank SF6 High Voltage Circuit Breakers.	6
• Center Break Disconnect Switches:	28
• Surge Arresters, 115 kV System Voltage	3
• 1-phase CCVT, 115kV System Voltage	18
• Overhead Lightning Protection System	1 Lot
• Switchyard Relay and Control System	1 Lot

Equipment	Quantity
• Extended Range Metering Equipment , 1-Phase	15
• Switchyard AC Distribution System	1 Lot
• Primary and Backup Battery, (2) Battery Chargers, UPS and DC Distribution Panels	1 Lot
• Aluminum Tubular Bus and Accessories. Main bus conductor size is 3" AL Sch 40, 6061-T6.	1 Lot
• 550 kV BIL Suspension Insulators with deadend ACSR Cable Terminators	1 Lot
• 550kV BIL Station Post Type Bus Support Insulators	1 Lot
• Underground and above grade raceway system for use by both the Vendor for installing his cable within the switchyard.	1 Lot
• Switchyard lighting system	1 Lot
• Control and Instrumentation Signal Interface	1 Lot
• Switchyard Miscellaneous equipment (conductor, connectors, etc.)	1 Lot

• Steel Structures for outgoing lines terminations, equipment and bus supporting system	1 Lot
• Foundations for all structures and equipment	1 Lot
• Grounding System	1 Lot
• Fencing, Gates, Grading , Retaining Walls, Soil Erosion and Sedimentation Control, and Yard Surfacing	1 Lot
• Foundation Excavation, Backfill, and Compaction	1 Lot
• Switchyard Control House complete with lighting.	One

2. CODES AND STANDARDS

A. The latest edition and published addenda of the following publications in effect on the date of Contract Award are a part of this Section. All equipment furnished and work performed shall comply with the approved standards, specifications, regulations, codes and tests of the following:

1. ANSI — American National Standards Institute
2. ASME — American Society of Mechanical Engineers
3. FERC — Federal Energy Regulatory Commission
4. IEEE — Institute of Electrical & Electronics Engineers
   - IEEE C37.04, "IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers".
   - IEEE C37.06, "IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000V".
   - IEEE C37.09, "IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis".
   - IEEE C37.012, "IEEE Application Guide for Capacitive Current Switching for AC High-Voltage Circuit Breakers."
   - IEEE C37.016, "IEEE Standard for AC High-Voltage Circuit Switchers rated 15.5kV through 245kV".
   - IEEE C57.13, "IEEE Standard Requirements for Instrument Transformers".
   - IEEE C57.19.00, "IEEE Standard General Requirements and Test Procedure for Power Apparatus Bushings".

- IEEE 605-2008, "IEEE Guide for Bus Design in Air Insulated Substations".
- IEEE 80-2000, "IEEE Guide for Safety in AC Substation Grounding"
- IEEE 998-1996, "IEEE Guide for Direct Lightning Stroke Shielding of Substations"
- IEEE 1410-2010, "IEEE Guide for Improving the Lightning Performance of Electric Power Overhead Distribution Lines"
- IEEE 1243-1997, "Guide for Improving the Lightning Performance of Transmission Lines"
- IEEE 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications"
- IEEE 450-2002, "IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented lead-Acid Batteries for Stationary Applications"
- IEEE C2-2007, National Electrical Safety Code

5. IES Illuminating Engineering Society
6. NBC National Building Code
7. NERC North American Electric Reliability Corporation
    - NERC CIP Standards
8. NPCC Northeast Power Coordination Council, Inc.
    - Directory #1 "Design and Operation of the Bulk Power System"
    - Directory #4 "Bulk Power System Protection Criteria"

9. NYSEG New York State Electric & Gas

- Bulletin 86-01 "Requirements For The Interconnection of Generation, Transmission and End-User Facilities".

- NYSEG Specifications and Standards

10. NEMA National Electrical Manufacturer's Association

- MG-1, "Motors and Generators"

11. REA Rural Electrification Act

- 1724E-300, "Design Guide for Rural Substations"

B. In the event of any conflict between codes, or between Specifications and codes, the more stringent regulation shall apply.

3. DESIGN AND CONSTRUCTION FEATURES

3.1 Terminal Points

Terminal points listed below and further indicated in the enclosed drawings are indicative only. The Vendor shall determine the exact terminal point arrangements in coordination with the interfacing Vendor/agencies/utility company.

- 115kV dead end structure to interface to Interconnect (POI) Switchyard--(1) location
- 115kV dead end structures for Plant 115kV supply –(4) locations
- For control and signaling between the Plant Switchyard and the Interconnect (POI) Switchyard the terminal point shall be the fiber optic communication cables in the OPGW located on the 115kV dead end structure to the Interconnect (POI) Switchyard. (1) location.

3.2 Design Requirements

A. General:

All equipment and material furnished shall meet the following general requirements:

- Utility Interconnection Requirements as stated in NYSEG specification SPR-980.
- Ring bus arrangement with 6 total breakers.
- The Plant Switchyard shall be designed such that it can easily be made to meet NPCC Bulk Power System Protection Criteria. This means that each element of the 115kV station is to be protected by two independent protection groups, the groups must be physically separated and no common failure can disable both systems.
- Conform to the requirements REA Bulletin 1724E-300 for outdoor switchyard equipment and materials. These are minimum requirements and are superseded by any more stringent requirements mentioned in this specification.
- Overall space limitations as indicated in the Drawings.

- Sufficient aisle space for operation, maintenance and removal/replacement of equipment.
- A clear space of at least 10 feet must be maintained on the exterior of all fences. Switchyard buildings may be no closer than 15 feet from the fence.
- Conform interphase spacing and clearance to the recommended NYSEG standards, unless larger dimensions are indicated.
- Be suitable for the application and not overstressed mechanically or electrically.
- Instrument transformers used for revenue metering applications in New York must be PSC (Public Service Commission) approved. The following PSC website contains a list of approved devices: http://www.dps.state.ny.us/approved_meter_list.pdf.
- All equipment furnished shall perform satisfactorily under the stipulated site conditions stated in an attachment included with the Engineering Requisition.
- All Local, State and National codes and standards.

B. Switchyard Equipment:

1. The 123kV Class circuit breakers shall be provided with dual tripping coils rated for the DC control voltage stated in the Engineering Requisition.
2. Synch-check facilities shall be provided for the switchyard circuit breakers.
3. The 123 kV equipment and connections shall be designed to withstand without damage or distortion the stresses caused by an electrical fault having the maximum fault level specified in the Engineering Requisition (ac rms symmetrical) for 3 seconds.
4. The 123 kV circuit breakers shall be capable of interrupting maximum fault current and line charging currents.
5. Full electrical interlocking facilities shall be provided for the circuit breakers and disconnect switches to ensure safe operation of the equipment under all service conditions.

6. Surge Arrestors shall be sized as follows: If the system is effectively grounded for all single contingencies, i.e. the system Ro/X1 < 1 and X0/X1 < 3; then use a 96kV rated arrester with a 76kV MCOV. If the system is not effectively grounded, use a full voltage 120kV arrestor with a 98kV MCOV.

7. Any equipment required to meet NERC Cybersecurity (CIPS 2-9) must be installed.

8. Extended range revenue metering CT's are required.

C. Bus System:

1. The tubular bus system shall be as per NYSEG 115kV Standard Module drawing SME-AFT-SD which uses 3" AL, Sch 40 , 6061-T6 bus as the main conductor. The bus conductor system shall be verified to not exceed the bus conductor limits as specified on NYSEG drawing SUO-CCA-05. The sag under any loading conditions shall not exceed 1/2 the diameter of the bus tubing.

2. Incoming shield wire shall contain fiber optic conductors for data communication.

3. The loading and strength to be used in designing the aerial line shall comply with Grade B loading criteria of Section 26 of the National Electric Safety Code (NESC) . For calculating conductor tension the total load on the wire or conductor shall be the resultant of a vertical and a horizontal load component calculated at the applicable temperature plus the corresponding constant given in Table 250-1 of the NESC. The Vendor shall provide the Engineer/Owner with copies of the conductor sizing and sag engineering calculations for approval to support this bus design. The vertical load component on a wire or conductor shall be the weight of the conductor plus the weight of any spacers, or equipment that it supports and ice where required by Rule 250 of the NESC. The horizontal load component on a wire or conductor shall be the horizontal wind pressure as determined under Rule 250, or 25.6 psf (whichever is greater) applied at a right angle to the direction of the line using the projected area of the conductor, spacers or equipment that it supports and ice where required by Rule 250 of the NESC. Insulators used on the aerial line shall meet the requirements of Section 27 of the NESC. Arial insulators shall be non-ceramic.

D. Clearances:

The clearances shall be per NESC and NYSEG requirements.

E. Switchyard Control and Metering Concept:

1. General Notes and Comments:

The interface for the control and monitoring of 115kV switchyard components shall be from the following locations:

- Local at the equipment
- Switchyard Control Panel (SCP)
- SCADA System
- Plant DCS (Distributed Control System)

2. Disconnect Switches:

All command operations shall be initiated either locally at the equipment or remotely. When both the upstream and downstream disconnect switches associated with a breaker are open, that breaker shall be allowed to operate in a “LOCAL” mode. For normal operation of a breaker to be allowed, both the upstream and downstream disconnect switches associated with a breaker must be closed. Mechanical indication of the disconnect switch position shall be visible locally at the equipment. Status contacts for both open and closed position feedback of the disconnect switches shall be provided for use by the switchyard control panel (SCP), Plant DCS system and the switchyard SCADA system.

3. Open Commands:

   The motor operated disconnect switches shall have the capability to be opened at any time, local at the Disconnect Switch Local Control Panel (DSLCP) if its associated circuit breaker is open (no load operation only). It shall be able to be opened remote from the Switchyard Control Panel (SCP) or remote via Plant DCS or SCADA systems if its associated circuit breaker are open (no load operation only).

4. Close Commands:

   The capability of issuing a motor operated disconnect switch closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Disconnect Switch Local Control Panel (DSLCP) and the Switchyard Control Panel (SCP) to ensure that any switch closing operation can be initiated from only one location at a time. For each L/R switch a separate DCS status contact shall be required.

   a. Local at the Motor Operated Disconnect Switch (DSLCP):

      A close command can only be initiated at the switch, if the L/R switch on the disconnect switch local operator panel is in LOCAL mode and the associated circuit breakers are open. If the associated circuit breaker is closed, the local close command is inactive. All other interlocks shall be by-passed in this mode.

   b. Switchyard Control Panel (SCP):

      All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position, and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode.

c. Plant DCS/SCADA:

All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode.

5. Circuit Breakers:

The circuit breakers shall be controlled as indicated below. Hard-wired permissives and interlocks are the responsibility of the Vendor. Status contacts for both open and closed position feedback of each of the circuit breakers shall be provided at the switchyard control panel, the Plant DCS system and the SCADA system. Interposing relays shall be provided by the Vendor for DCS commands, if required.

6. Open Commands:

The circuit breakers shall have the capability to be opened at any time, local at the Circuit Breaker Local Control Panel (CBLCP), remote from the Switchyard Control Panel (SCP) or remote via the Plant DCS or SCADA systems.

7. Close Commands:

The capability of issuing a circuit breaker closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Circuit Breaker Local Control Panel (CBLCP) and the Switchyard Control Panel (SCP) to ensure that any breaker closing operation can be initiated from only one location at a time. For each L/R switch a separate DCS status contact shall be required.

a. Local at the Circuit Breaker (CBLCP):

A close command can only be initiated at the breaker, if the L/R switch on the circuit breaker local operator panel is in LOCAL mode and the associated disconnect switches are closed. If the disconnect switches on either side of the circuit breaker are open, the local close command is inactive. All other interlocks shall be by-passed in this mode.

b. Switchyard Control Panel (SCP):

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position, and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

c. Plant DCS/SCADA:

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

F. Annunciation:

The Switchyard Control Panel (SCP) shall have audiovisual annunciators. Any abnormality in the switchyard equipment and its auxiliary systems shall be annunciated at the Switchyard Control Panel. Group alarm (pretrip and trip) for each circuit and strategic auxiliary system shall be wired to the interface terminal panel for remote alarm via SCADA or Plant DCS. The trip circuits of each circuit breaker and the lockout relay coils shall be supervised and alarmed at Switchyard Control Panel.

G. DCS/SCADA Interface Requirements

1. The interface for discrete contacts shall be defined as alarms, status, or control. The shelf state contact positions shall be configured to provide the appropriate feedback signal. Alarm contacts shall be designed such that the contact shall be in the open position when in the alarm state. Status contacts shall be designed such that the contact shall be in the closed position when in the stated position. Digital input alarm and status contacts shall be rated for pilot duty. All contacts provided for digital input signals to the DCS shall be dry contacts. Interrogation voltage for DCS digital inputs shall be supplied from the DCS and shall be

24VDC or 48VDC. The contacts for other than digital inputs shall be configured as dry contacts, and shall be capable of either AC or DC wetting voltages stated in the Engineering Requisition.

2. Control outputs are dry contacts with the wetting voltage supplied by the Vendor. These contacts shall be programmed as momentary contacts with a contact closure time of 1.0 seconds. DCS digital outputs shall be rated as 10A 120VAC or 0.5A 125VDC inductive. Where necessary, interposing relays shall be used to prevent damage to the DCS/SCADA output contacts.

3. The Plant DCS operator interface shall be located in the power plant control room and shall be provided by Others. The wiring interface from the interface terminal panel to the DCS I/O termination cabinet shall be by Others. The DCS and SCADA system I/O wiring termination shall be configured to observe signal type and distance separation criteria as provided in LATER. As a minimum, the wiring interface for analog and digital terminations shall occupy opposite sides of the cabinet and separated from all other control and protection wiring. All wiring shall utilize twisted shielded pairs with an overall shield for multiple pair cables. All shields shall be terminated next to their respective signal wire terminations.

4. A RTU (Remote Terminal Unit) is required for SCADA. The RTU will be specified and commissioned by NYSEG/RGE.

5. Plant Switchyard breaker amperes will be derived from an SEL-351-6 relay dedicated to each breaker.

6. The RTU must be powered from the substation battery. A 4-wire leased telephone facility will need to be ordered and procured by the Plant Switchyard Owner. The telephone equipment must be powered by the station battery. Status points use a dry "a" contact (wetting voltage supplied by the RTU) to indicate the state of a circuit breaker.

7. The Interconnect Switchyard Vendor will determine if NYISO plant dispatch information is to be supplied through the Interconnect (POI) Station RTU in DNP 3.0 Protocol or via a separate Plant Switchyard RTU.

8. All I/O point contacts shall be identified on vendor drawings and shall include the appropriate I/O point tags. These point tags shall be provided during the review cycle.

9. Responsibility for designing the control and automation strategy for the switchyard shall remain with the switchyard Vendor. All documentation for modulating and discrete control and all equipment operating sequence requirements to be implemented in the DCS or SCADA system shall be provided by the switchyard Vendor. After review and approval by the Engineer/Owner, this control and sequencing strategy shall be implemented. A design review meeting between NYSEG, the switchyard Vendor and NYISO shall be held.

10. The switchyard Vendor shall provide the following documentation to support the implementation of the switchyard control strategy:

    a. I/O List

       Prepare a list of all inputs and outputs required between the switchyard and the DCS and SCADA system. The I/O list shall indicate all points to be included in the Sequence of Events (SOE) recording system.

    b. Control Logic Diagrams

       The switchyard Vendor shall prepare drawings defining the control logic for the supplied equipment. The control logic drawings shall include complete definition of all modulating and discrete control logic for all supplied equipment. Modulating and discrete control logic diagrams shall be provided as separate drawings.

       All control and monitoring signals associated with the switchyard equipment shall be included with all permissives and interlocks for safe and efficient operation of the equipment in all operating conditions, both normal and emergency. All sensors, indicators, alarms, setpoints, control commands, final elements, control switches, and other operator interface elements shall be included.

       The drawings shall include both hardwired control elements provided by the switchyard Vendor for local operator interface and control, and control elements to be implemented in the software of the DCS or SCADA system. The drawings shall clearly indicate portions of the control logic implemented in the field control elements provided by the switchyard supplier and portions of the control logic to be implemented by DCS/SCADA.

11. Control & Protective Relaying

    a. The transmission line connecting the Plant Switchyard and the Interconnect switchyard shall require two sets of high speed protection. Since this will be new line construction, fiber will be used for both high-speed protection systems. Current differential relaying will be provided for the "A" and "B" relay packages.

    b. There will be two independent groups covering each zone of protection. These groups may be of the same manufacturer but should not utilize the same technology. The schemes shall be physically separated.

    c. ANSI C800 relay accuracy CT's are used for protective relays unless otherwise specified.

    d. Control and Protective relaying shall be located within the Pre-Engineered Metal Control House to be supplied by the Vendor.

    e. The Vendor shall be responsible for all internal panel wiring as well as between the panels and between panels field devices.

    f. The Vendor shall design, supply, factory test, deliver to site, unload and store at site install, test and commission one set of control and relay panels for the switchyard containing the devices shown on the one-line diagrams and other drawings and documents included with the Engineering Requisition and as required by the Owner.

3.3 Low Voltage AC Power Distribution System

A. The Vendor shall design, supply, install, test and place in service a low voltage AC power distribution system for the switchyard. The AC Power distribution system for the Plant Switchyard shall be two independent house service supplies with an Automatic Transfer Switch (ATS).

B. The low voltage power distribution system shall distribute electrical power for all required functions in the switchyard, including:

    1. Circuit breaker charging motors

2. Space heaters

3. Lighting

4. Convenience Outlets at switchyard equipment

C. The Vendor as part of his system design shall ensure that all system protective devices are properly sized and suitably coordinated with other system protective devices to ensure the safety and reliability of the system.

D. All system cable and wiring shall be designed, supplied, installed, tested and placed in service by the Vendor.

E. At a minimum the completed system shall comply with the applicable requirements of the latest edition of the NESC.

3.4 Lighting and Receptacle System

A. The Vendor shall design, supply, install, test and place in service a complete lighting and receptacle system for the switchyard.

B. Unless indicated otherwise, the illumination levels of different areas to be maintained shall be as per the IES standards.

C. Power distribution panels shall comply with the requirements of Specification **LATER**.

D. The lighting and receptacle system shall comply with the requirements of Specification **LATER**.

E. The Vendor shall furnish back-up calculations to justify the number and size of fixtures included in his design, the sizes of all cable and wire included in his design and the sizes of all cable raceways used to circuit illumination system wiring. These calculations shall be subject to Owner/Engineer's approval.

3.5 DC Control Power System

A. The dc system shall be designed to provide reliable power for switchyard equipment control and protection.

B. Two lead-acid station battery systems are required including two separate battery chargers. Each battery system must be capable of supplying the complete emergency load of the station. DC for the independent protection groups shall be fed from physically separate DC panels.

C. The dc system shall be designed and sized in accordance with IEEE 485 as applicable. The battery shall be sized to supply the control power for at least 8 hours after loss of ac power to the battery charger or as required by NERC or NPCC criteria. The Vendor shall develop the load profile to be used in the sizing of the battery and shall submit the battery calculation for review and approval.

D. The dc system shall be operated ungrounded to prevent a single ground fault from disabling the dc system. Provisions shall be provided for checking and alarming for grounds on the positive or negative leads.

E. All circuits shall be properly protected to limit the damage to the faulted circuit.

3.6 Grounding System

A. The Vendor shall design, supply, install, test and place in service a switchyard ground grid as required to cover the entire switchyard area. It shall provide personnel protection from electrical shock and lightning. The Vendor shall measure the soil resistivity and calculate the length of the conductor and cross-section of conductor required for the grounding grid so as to maintain the touch and step voltages within allowable limits. The procedure given in the publication IEEE-80 shall be followed for grounding. The calculation shall be submitted to Engineer for approval.

B. The fault current to be considered in calculation shall be as specified in the Engineering Requisition. The fault clearing time shall be considered as 0.5 second.

C. The grounding resistance of the switchyard shall not be more then 1.0 ohm.

D. The Vendor shall extend the below grade ground grid above grade and connect all steel structures, electrical equipment, overhead static lines and lightning protection downconductor circuits to the grounding system. The Vendor shall provide conductor sizing calculations and installation details to the Engineer for approval.

E. Stranded bare copper conductor shall be used for grounding and unless specifically indicated shall be laid at a minimum 18” below grade unless more depth is required to suit the design requirement and standards and codes.

F. The switchyard area shall be covered with crushed rock as required by the grounding calculations.

3.7 Lightning Protection

A. The switchyard equipment shall be shielded from direct lightning strikes by shield wires and/or lightning masts. The design shall follow the recommendations of IEEE 998-1996, IEEE1410-2010 and IEEE 1243-1997. Vendor's lightning protection design is subject to approval by Owner/Engineer.

B. Lightning arrestors shall be provided on all incoming transmission lines to protect equipment from lightning induced surges.

C. Preliminary estimate of lightning protection equipment also includes the following which is subject to change during Vendor's final design:

1. (4) Lightning Masts for capacitor bank area, 60'height. Reference NYSEG Drawing SMN-LMH-94.

2. (4) Lightning Masts for the ring bus area, 60' height. Reference NYSEG Drawing SMN-LMH-94.

3. Ten (10) Air Termination Rods, 21 feet height. NYSEG SS #800-795-03. To be located on top of overhead conductor towers.

3.8 Capacitor Bank

A. A capacitor bank, if required, is proposed to be located on the eastern side of the Plant Switchyard and will consist of four 50MVAR fuseless capacitor groups for a total of 200MVAR. Each 50MVAR capacitor group will be controlled by a circuit switcher. Series reactors shall be provided for each capacitor group to limit back-to-back switching current. The connection of the capacitor bank to the Plant Switchyard will be via bus conductor. It should be noted that the Capacitor bank location is also being considered at the Interconnect Switchyard.

4. CIVIL/STRUCTURAL FEATURES

This section describes the civil, structural, and architectural design basis for the facility's structures, and general civil work. All civil/structural work will be designed in accordance with applicable codes, industry standards, and local, state, and federal regulations. All required local building permits and inspections will be obtained by the Contractor. See Appendix A for Site Specific Data.

4.1 Facility Description

The switchyard will consist of a control house building, bus support structures, transformers, circuit breakers, disconnect switches, surge arresters, ccvt's, and other miscellaneous switchyard equipment.

Surface finishing (roads, ground cover, etc.) for the site will be as indicated on the General Arrangement drawing. The project will be located within a new perimeter fence. Main access to and from the site will be off of the paved main entrance road.

4.2 Sitework

Civil works design shall comply with the requirements of New York State Electric and Gas Corporation's "Site Development Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1442)

A. Stormwater Management

Assumed stream can collect stormwater and therefore no retention pond needed in preliminary design.

A Stormwater Pollution Prevention Plan (SWPPP) will be developed by the Company for the final stabilized site. The stormwater management plan for use during construction phase and during operation shall be developed by the Engineer with support from specialty engineering services. The intent of the stormwater management plan and the SWPPP will be to preserve the existing pre-development drainage patterns to the extent possible. The plan will include a clean stormwater collection system and an industrial stormwater collection system, consisting of catch basins, piping, a subsurface detention basin, and a suitable water treatment facility as required by the New York Department of Environmental Conservation (DEC). The stormwater collection systems will collect runoff from developed areas of the site and discharge them appropriately.

B. Roads and Parking

Asphalt site roads and parking will be provided for access, operation and maintenance as shown on the General Arrangement drawing. Alternative access, if required by local regulations, will be provided as shown on the general arrangement drawing.

C. Site Area Paving

Areas within the power block will be surfaced with concrete or gravel as shown on the General Arrangement drawing. All roads will be paved with asphalt unless specifically shown otherwise on the General Arrangement. The roads will be designed in general accordance with the recommendations presented in the Geotechnical Report and designed to withstand the loading conditions.

Site roads will be provided that will conform to the following:

Operating speed of 10 miles per hour.

Minimum road width of 12 feet, with 2-foot shoulders.

AASHTO HS-20-44 loading conditions (minimum requirement).

Maximum transverse gradient of 2 percent.

D. Wetlands Protection

The Contractor will comply with requirements specified by any laws, codes, and permits.

E. Landscaping and Fencing

Any detailed landscape design, fine grading, furnishing and placement of trees, shrubbery, and/or grass, will be provided by the Company. Any embankment area around the perimeter of the switchyard and any unpaved areas on site will be gravel. The Contractor will restore to its original condition any offsite area that is disturbed during construction.

Contractor will furnish and install temporary chain link fencing around the contractor parking area as shown on the Construction Laydown, Staging, and Parking Plan. Contractor will also furnish and install a gate at the new site entrance point. The gate will serve as both the construction entrance gate and the permanent site entrance gate following completion of construction. The gate shall be a new 25-foot-wide automatic slide main gate, with a keypad for vehicle use. A temporary guard house shall be placed at the permanent site gate during construction. Following completion of construction, the temporary guard house shall be removed.

4.3 Structural Design

A. Codes and Standards:

The 2010 New York State Building Code and local/state-building codes will be incorporated into the design of building and structures. Steel structures will be designed in accordance with the design specifications for structural steel buildings published by the American Institute of Steel Construction (AISC). Reinforced concrete structures will be designed in accordance with the design requirements for concrete buildings and structures published by the American Concrete Institute (ACI).

Allowable variances and applicable local code interpretations will be established before project commencement.

Additionally all plant areas and structures will be designed and configured to meet OSHA requirements contained in Part 1910 of the U.S. Code of Federal Regulations.

B. Steel Structure Design and Fabrication:

The design and fabrication of the supporting steel structures shall comply with the New York State Electric and Gas Corporation's "Structures, Material Requirements for Substation Structures" specification requirements. (Ref. Specification SP-1 252).

The structures shall include but not be limited to the following:

Qty.	Description
5	115kV deadend structures per NYSEG structure type SMDE-3-25.
26	115kV disconnect switch supports
5	115kV CCVT supports (for 3 CCVT's)
3	115kV CCVT supports (for single CCVT)

1 Lot	115 kV bus support insulators

The Vendor shall perform a structural analysis of all steel structures designed and shall submit the same to the Engineer for approval.

The Vendor shall submit material and fabrication specifications to the Engineer for approval.

Structure used to support manufacturer supplied equipment shall comply with the manufacturer's suggested (recommended) support design.

C. Loads and Load Combinations

1. Dead Loads

Dead loads will consist of the weight of all permanent construction including, but not limited to, fixed equipment, framing, bus work, and any other structures, contents of transformers, etc.

2. Seismic Loads

All equipment will be designed to withstand the seismic loading requirement specified in the governing building code for the specified seismic zone

In addition, equipment anchorages and supports will be designed to prevent overturning, displacement and dislocation in accordance with governing building code requirements.

3. Wind Loads

Wind pressures and shape factors will be applied to all system components and exposed equipment in accordance with governing building code.

Allowances will not be made for the effect of shielding by other structures.

4. Snow Loads

The overturning moment calculated from wind pressure will not exceed two thirds of the dead load resisting moment. The uplifting forces calculated from the wind pressure will not exceed two thirds of the resisting dead loads and adequate structure-foundation ties will be designed to resist wind forces.

Snow loads, including potential drifting, will be applied to all buildings, structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

5. Ice Loads

Ice loads will be applied to all structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

6. Other Loads

Other expected loads (short circuit loads, etc) required to predict the response of structures will be considered where appropriate.

Proper load combinations will be used for structural steel and reinforced concrete to comply with the applicable codes and standards and with vendor requirements.

7. Structural Steel

Nonheaded anchor bolts will conform to ASTM A 1554 Grade 36, unless higher strength bolting materials are required by design. Exterior exposed anchor bolts that are not high-grade fine thread will not be hot dipped galvanized.

The galvanized coating used on switchyard steel structures shall have an average thickness of 5 mils with no point being less than 4 mils.

D. Foundation Design:

1. Structural Concrete

Foundation design shall comply with the requirements of New York State Electric and Gas Corporation's "Foundations Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1445)

Concrete design shall comply with the requirements of the New York State Electric and Gas Corporation's "Materials Specification for Concrete" specification unless otherwise indicated. (Ref. Specification TD-1070)

The Vendor shall design and install foundations all switchyard equipment and structures including but not limited to the following:

- 115kV circuit breakers
- 115 kV disconnect switches
- 115 kV bus supports
- 115 kV CCVT instrument transformers
- 115kV Metering Equipment
- 115 kV transmission line dead end structures and turning towers
- Switchyard outdoor lighting standards
- Relay and control house
- Lightning Masts

All foundations shall be reinforced concrete spread footings or augur type drill caissons. The Vendor shall be responsible for providing the reaction forces at the top of the foundation for the transformer dead-end structures to the Owner.

Anchor bolt diameters, material and projection above the concrete shall be specified by the Vendor. The Vendor shall provide the anchor bolt location drawings and templates for field installation of the anchor bolts.

The Vendor shall submit foundation design calculations and drawings to the Engineer for approval.

4.4 Wire and Cable

Wire and cable design requirements and material requirements shall be in accordance with the following specifications:

LATER	Control Cable
LATER	Instrument Cable
LATER	LV Power Cable
LATER	Wire and Cable Installation

4.5 Cable Raceways

Cable raceway design and material requirements shall be in accordance with the following specifications:

LATER	Conduit
LATER	Embedded Conduits, Underground Ductbanks & Trenches
LATER	Cable Tray

5. TESTING

5.1 General

A. The requirements of this clause shall be met in conjunction with the other sections of the Engineering Requisition.

B. All inspection/tests to be performed during manufacture, fabrication and trial operation shall be as stated in the Engineering Requisition.

C. Where no specific test is mentioned, the various materials and equipment shall be tested in accordance with the appropriate standards, or other recommendations. Where no appropriate standard is available, tests shall be carried out in accordance with manufacturer's standard, subject to the prior approval of the Owner/Engineer.

D. Before commencement of any test, copies of relevant drawings and documents shall be submitted to the Owner/Engineer and approval obtained.

E. Switchyard testing shall include Doble, Ductor and Thermal Imaging tests.

5.2 Test Certificates

All principal test records, test certificates and performance details for all tests carried out in accordance with the provisions of this Contract shall be supplied to the Owner/Engineer. These test records, certificates and performance details shall be supplied for all tests, whether or not the Engineer has witnessed them. The information given on such test certificates and performance details shall be sufficient to identify the material or equipment to which the certificate refers. Certificates shall also bear the contract reference and heading.

5.3 Tests at Site

These tests shall be carried out for different equipment, material and systems prior to and during commissioning of the switchyard. The Vendor shall submit a detail test schedule including the procedure for the site tests for Owner/Engineer's approval.

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6. ADDITIONAL INFORMATION

TYPICAL VALUES FOR MAJOR SWITCHYARD EQUIPMENT

Power Circuit Breakers:

4.2.1	a.	Type	Dead Tank SF6 Gas
	b.	Rated Voltage	123 kV rms Rated Maximum Voltage
	c.	Basic Insulation Level	550 kV
	e.	Rated Continuous Current	2000 A rms
	f.	Rated Interrupting Current	40 kA sym. rms
	g.	Rated Interrupting Time	3 cycles
	j.	Frequency	60 Hz
	k.	3-Second Short Time Current Carrying Capability	40 kA sym. rms

Disconnect Switch:

4.2.2	a.	Nominal Voltage	115 kV
	b.	Rated Maximum Voltage	121 kV
	c.	Type	3-Phase Group Operated
	d.	Current Rating	2000A Continuous, 100kA Momentary
	h.	BIL	550 kV
	i.	Frequency	60 Hertz

APPENDIX A – SITE SPECIFIC DATA

Location	Reading, NY
Project Name	caes pROJECT
Site Conditions	
Max Dry Bulb Temperature (°F)	86
Coincident Wet Bulb Temperature (°F)	71
Winter Dry Bulb Temperature (°F)	-2
TOP OF CONCRETE (TOC) Elevation, (feet above mean sea level)	TBD
FROST LINE, in	54
Soil Type	CLAY, SILT, MAINLY SAND AND GRAVEL
ALLOWABLE SOIL LOAD BEARING CAPACITY	3000 PSF
Precipitation	
24 hr. Maximum, 25 Year Storm (in)	4.5

Wind Loading

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE
WIND ZONE	C
Basic Wind Speed	90 mph
Occupancy Category	iii
Exposure Category	C
Importance Factor	1.15

Seismic

Design Code	2010 NEW YORK STATE BUILDING CODE
SITE CLASS	C
Seismic DESIGN CATEGORY	B
SITE COEFFICIENT	Fa=1.6, fv=2.4
Seismic Coefficient	Ss=0.2, Sl=0.006
IMPORTANCE FACTOR	1.25

SNOW LOAD

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE

BASIC SNOW LOAD	Pf=25 psf
IMPORTANCE FACTOR	1.10

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EcoNomics™

NEW YORK STATE ELECTRIC & GAS

COMPRESSED AIR ENERGY STORAGE PROJECT

Electrical Engineering

Interconnect (POI) Switchyard Design Criteria

Document: CAES-1-DB-023-0002

Revision: A

Date: September 2011

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EcoNomics™

COMPRESSED AIR ENERGY STORAGE PROJECT

ELECTRICAL ENGINEERING

INTERCONNECT (POI) SWITCHYARD DESIGN CRITERIA

Disclaimer

REV	DESCRIPTION	ORIGINATOR	REVIEWER	APPROVER	DATE
A	Issued for Review	B.Williams B. Williams	B. Chernisky B. Chernisky	B. Chernisky B. Chernisky	9/26/11

CONTENTS

1. SCOPE

1.1 Background

The Compressed Air Energy Storage (CAES) plant will consist of a separate, electrically driven compression cycle and a natural-gas fired expansion cycle to generate electricity. The CAES plant will use off-peak electricity to compress air into an underground reservoir. When electricity is needed, the compressed air is withdrawn, heated, and passed through an expansion turbine to generate power.

The CAES generated power will flow through the Plant Switchyard, through a 0.7 mile , 115kV single circuit, transmission line commencing at the Plant Switchyard and ending at the Interconnect (POI-Point of Interface) Switchyard where it will interface with existing 115kV NYSEG transmission lines 967 and 970. Existing transmission lines 967 and 970 run from the AES Greenidge Station to the Montour Falls Station. The Interconnect (POI) switchyard shall be outdoor, open-air, breaker-and-a-half type arrangement.

The Scope of this document is for the Interconnect (POI) switchyard. The Plant Switchyard Design Criteria is described in document CAES-1-DB-023-0003.

1.2 Equipment To Be Provided

A. The switchyard shall consist of the following major equipment:

Equipment	Quantity
• 123kV Class Deadtank SF6 High Voltage Circuit Breakers.	10
• Center Break Disconnect Switches:	27
• Surge Arresters, 115 kV System Voltage	18
• 1-phase CCVT, 115kV System Voltage	20
• Overhead Lightning Protection System	1 Lot
• Switchyard Relay and Control System	1 Lot

Equipment	Quantity
• Extended Range Metering Equipment for CAES Plant Power, 1-Phase	3
• Switchyard AC Distribution System	1 Lot
• Primary and Backup Battery, (2) Battery Chargers, UPS and DC Distribution Panels	1 Lot
• Aluminum Tubular Bus and Accessories. Main bus conductor size is 3" AL Sch 40, 6061-T6.	1 Lot
• 550 kV BIL Suspension Insulators with deadend ACSR Cable Terminators	1 Lot
• 550kV BIL Station Post Type Bus Support Insulators	1 Lot
• Underground and above grade raceway system for use by both the Vendor for installing his cable within the switchyard.	1 Lot
• Switchyard lighting system	1 Lot
• Control and Instrumentation Signal Interface	1 Lot
• Switchyard Miscellaneous equipment (conductor, connectors, etc.)	1 Lot

• Steel Structures for outgoing lines terminations, equipment and bus supporting system	1 Lot
• Foundations for all structures and equipment	1 Lot
• Grounding System	1 Lot
• Fencing, Gates, Grading , Retaining Walls, Soil Erosion and Sedimentation Control, and Yard Surfacing	1 Lot
• Foundation Excavation, Backfill, and Compaction	1 Lot
• Switchyard Control House complete with lighting.	One

2. CODES AND STANDARDS

A. The latest edition and published addenda of the following publications in effect on the date of Contract Award are a part of this Section. All equipment furnished and work performed shall comply with the approved standards, specifications, regulations, codes and tests of the following:

1. ANSI American National Standards Institute

2. ASME American Society of Mechanical Engineers

3. FERC Federal Energy Regulatory Commission

4. IEEE Institute of Electrical & Electronics Engineers

   - IEEE C37.04, “IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers”.
   - IEEE C37.06, “IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000V”.
   - IEEE C37.09, “IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis”.
   - IEEE C37.012, "IEEE Application Guide for Capacitive Current Switching for AC High-Voltage Circuit Breakers".
   - IEEE C37.016, "IEEE Standard for AC High-Voltage Circuit Switchers rated 15.5kV through 245kV".
   - IEEE C57.13, “IEEE Standard Requirements for Instrument Transformers”.
   - IEEE C57.19.00, “IEEE Standard General Requirements and Test Procedure for Power Apparatus Bushings”.

- IEEE 605-2008, "IEEE Guide for Bus Design in Air Insulated Substations".
- IEEE 80-2000, "IEEE Guide for Safety in AC Substation Grounding"
- IEEE 998-1996, "IEEE Guide for Direct Lightning Stroke Shielding of Substations"
- IEEE 1410-2010, "IEEE Guide for Improving the Lightning Performance of Electric Power Overhead Distribution Lines"
- IEEE 1243-1997, "Guide for Improving the Lightning Performance of Transmission Lines"
- IEEE 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications"
- IEEE 450-2002, "IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented lead-Acid Batteries for Stationary Applications"
- IEEE C2-2007, National Electrical Safety Code

5. IES Illuminating Engineering Society

6. NBC National Building Code

7. NERC North American Electric Reliability Corporation

   - NERC CIP Standards

8. NPCC Northeast Power Coordination Council, Inc.

   - Directory #1 "Design and Operation of the Bulk Power System"
   - Directory #4 "Bulk Power System Protection Criteria"

9. NYSEG New York State Electric & Gas

- SPR-980 "115kV Point of Interconnection Station Guide"
- Bulletin 86-01 "Requirements For The Interconnection of Generation, Transmission and End-User Facilities".
- NYSEG Substation Layout Drawing SLE-BHAANA for 115kV breaker-and-a-half configuration.
- NYSEG Specifications and Standards

10. NEMA National Electrical Manufacturer's Association

- MG-1, “Motors and Generators”

11. REA Rural Electrification Act

- 1724E-300, "Design Guide for Rural Substations"

B. In the event of any conflict between codes, or between Specifications and codes, the more stringent regulation shall apply.

3. DESIGN AND CONSTRUCTION FEATURES

3.1 Terminal Points

Terminal points listed below and further indicated in the enclosed drawings are indicative only. The Vendor shall determine the exact terminal point arrangements in coordination with the interfacing Vendor/agencies/utility company.

- 115kV dead end structures to interface with existing NYSEG transmission lines 967 and 970– (4) locations
- 115kV dead end structure for Isolation Breaker –(1) location
- For control and signaling between the Interface Switchyard and the Plant Switchyard the terminal point shall be the fiber optic communication cables in the OPGW located on the 115kV dead end structure for the Isolation Breaker. (1) location.

3.2 Design Requirements

A. General:

All equipment and material furnished shall meet the following general requirements:

- Utility Interconnection Requirements as stated in NYSEG specification SPR-980.
- Breaker-and-a-half arrangement with 9 total breakers per NYSEG standard SLE-BHAANA.
- NYSEG/RGE requires an isolation breaker. Ownership of the isolation breaker will be transferred to the CAES Plant Owner. NYSEG/RGE must have the ability for emergency trip and lockout of the isolation breaker. NYSEG/RGE will not have the capability to close the isolation breaker. The isolation breaker shall be located immediately adjacent to the Interconnect Switchyard (POI Station).
- Interconnect Switchyard shall be designed such that it can easily be made to meet NPCC Bulk Power System Protection Criteria. This means that each element of the 115kV station is to be protected by two independent protection groups, the groups must be physically separated and no common failure can disable both systems.

- Conform to the requirements REA Bulletin 1724E-300 for outdoor switchyard equipment and materials. These are minimum requirements and are superseded by any more stringent requirements mentioned in this specification.
- Overall space limitations as indicated in the Drawings.
- Sufficient aisle space for operation, maintenance and removal/replacement of equipment.
- A clear space of at least 10 feet must be maintained on the exterior of all fences. Switchyard buildings may be no closer than 15 feet from the fence.
- The Interconnect Switchyard may not be located on a NYSEG/RGE Right of Way.
- Conform interphase spacing and clearance to the recommended NYSEG standards, unless larger dimensions are indicated.
- Be suitable for the application and not overstressed mechanically or electrically.
- Instrument transformers used for revenue metering applications in New York must be PSC (Public Service Commission) approved. The following PSC website contains a list of approved devices: http://www.dps.state.ny.us/approved_meter_list.pdf.
- All equipment furnished shall perform satisfactorily under the stipulated site conditions stated in an attachment included with the Engineering Requisition.
- All Local, State and National codes and standards.

B. Switchyard Equipment:

1. The 123kV Class circuit breakers shall be provided with dual tripping coils rated for the DC control voltage stated in the Engineering Requisition.
2. Synch-check facilities shall be provided for the switchyard circuit breakers.
3. The 123 kV equipment and connections shall be designed to withstand without damage or distortion the stresses caused by an electrical fault having the maximum fault level specified in the Engineering Requisition (ac rms symmetrical) for 3 seconds.

4. The 123 kV circuit breakers shall be capable of interrupting maximum fault current and line charging currents.

5. Full electrical interlocking facilities shall be provided for the circuit breakers and disconnect switches to ensure safe operation of the equipment under all service conditions.

6. Surge Arrestors shall be sized as follows: If the system is effectively grounded for all single contingencies, i.e. the system Ro/X1 < 1 and X0/X1 < 3; then use a 96kV rated arrester with a 76kV MCOV. If the system is not effectively grounded, use a full voltage 120kV arrestor with a 98kV MCOV.

7. Any equipment required to meet NERC Cybersecurity (CIPS 2-9) must be installed.

8. Extended range revenue metering CT's are required.

C. Bus System:

1. The tubular bus system shall be as per NYSEG 115kV Standard Module drawing SME-AFT-SD which uses 3" AL, Sch 40 , 6061-T6 bus as the main conductor. The bus conductor system shall be verified to not exceed the bus conductor limits as specified on NYSEG drawing SUO-CCA-05. The sag under any loading conditions shall not exceed 1/2 the diameter of the bus tubing.

2. Incoming shield wires shall contain fiber optic conductors for data communication.

3. The loading and strength to be used in designing the aerial line shall comply with Grade B loading criteria of Section 26 of the National Electric Safety Code (NESC) . For calculating conductor tension the total load on the wire or conductor shall be the resultant of a vertical and a horizontal load component calculated at the applicable temperature plus the corresponding constant given in Table 250-1 of the NESC. The Vendor shall provide the Engineer/Owner with copies of the conductor sizing and sag engineering calculations for approval to support this bus design. The vertical load component on a wire or conductor shall be the weight of the conductor plus the weight of any spacers, or equipment that it supports and ice where required by Rule 250 of the NESC. The horizontal load component on a wire or conductor shall be the horizontal wind pressure as determined under Rule 250, or 25.6 psf (whichever is greater) applied at a right

angle to the direction of the line using the projected area of the conductor, spacers or equipment that it supports and ice where required by Rule 250 of the NESC. Insulators used on the aerial line shall meet the requirements of Section 27 of the NESC. Arial insulators shall be non-ceramic.

D. Clearances:

The clearances shall be per NESC and NYSEG requirements.

E. Switchyard Control and Metering Concept:

1. General Notes and Comments:

The interface for the control and monitoring of 115kV switchyard components shall be from the following locations:

- Local at the equipment
- Switchyard Control Panel (SCP)
- SCADA System

2. Disconnect Switches:

All command operations shall be initiated either locally at the equipment or remotely. When both the upstream and downstream disconnect switches associated with a breaker are open, that breaker shall be allowed to operate in a "LOCAL" mode. For normal operation of a breaker to be allowed, both the upstream and downstream disconnect switches associated with a breaker must be closed. Mechanical indication of the disconnect switch position shall be visible locally at the equipment. Status contacts for both open and closed position feedback of the disconnect switches shall be provided for use by the switchyard control panel (SCP) and the switchyard SCADA system.

3. Open Commands:

The motor operated disconnect switches shall have the capability to be opened at any time, local at the Disconnect Switch Local Control Panel (DSLCP) if its associated circuit breaker is open (no load operation only). It shall be able to be opened remote from the Switchyard Control Panel (SCP) or remote via the SCADA systems if its associated circuit breaker is open (no load operation only).

4. Close Commands:

The capability of issuing a motor operated disconnect switch closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Disconnect Switch Local Control Panel (DSLCP) and the Switchyard Control Panel (SCP) to ensure that any switch closing operation can be initiated from only one location at a time. For each L/R switch a separate status contact shall be required.

a. Local at the Motor Operated Disconnect Switch (DSLCP):

A close command can only be initiated at the switch, if the L/R switch on the disconnect switch local operator panel is in LOCAL mode and the associated circuit breakers are open. If the associated circuit breaker is closed, the local close command is inactive. All other interlocks shall be by-passed in this mode.

b. Switchyard Control Panel (SCP):

All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position, and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode.

c. SCADA:

All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode.

5. Circuit Breakers:

The circuit breakers shall be controlled as indicated below. Hard-wired permissives and interlocks are the responsibility of the Vendor. Status contacts for both open and closed position feedback of each of the circuit breakers shall be provided at the switchyard control panel and the SCADA system.

6. Open Commands:

The circuit breakers shall have the capability to be opened at any time, local at the Circuit Breaker Local Control Panel (CBLCP), remote from the Switchyard Control Panel (SCP) or remote via the SCADA systems.

7. Close Commands:

The capability of issuing a circuit breaker closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Circuit Breaker Local Control Panel (CBLCP) and the Switchyard Control Panel (SCP) to ensure that any breaker closing operation can be initiated from only one location at a time. For each L/R switch a separate status contact shall be required.

a. Local at the Circuit Breaker (CBLCP):

A close command can only be initiated at the breaker, if the L/R switch on the circuit breaker local operator panel is in LOCAL mode and the associated disconnect switches are closed. If the disconnect switches on either side of the circuit breaker are open, the local close command is inactive. All other interlocks shall be by-passed in this mode.

b. Switchyard Control Panel (SCP):

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position, and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

c. SCADA:

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

F. Annunciation:

The Switchyard Control Panel (SCP) shall have audiovisual annunciators. Any abnormality in the switchyard equipment and its auxiliary systems shall be annunciated at the Switchyard Control Panel. Group alarm (pretrip and trip) for each circuit and strategic auxiliary system shall be wired to the interface terminal panel for remote alarm via SCADA. The trip circuits of each circuit breaker and the lockout relay coils shall be supervised and alarmed at Switchyard Control Panel.

G. SCADA Interface Requirements

1. The interface for discrete contacts shall be defined as alarms, status, or control.

2. A RTU (Remote Terminal Unit) is required for SCADA. The RTU will be specified and commissioned by NYSEG/RGE.

3. Interconnect Switchyard breaker amperes will be derived from an SEL-351-6 relay dedicated to each breaker.

4. The RTU must be powered from the substation battery. A 4-wire leased telephone facility will need to be ordered and procured by the Interconnect Switchyard Owner. The telephone equipment must be powered by the station battery. The RTU control output contacts are normally open contacts. When a control sequence is initiated, the normally open contact will close momentarily for 250 ms (1000ms for RGE) and then reopen. This applies to both trip and close controls for the circuit breakers. Status points use a dry "a" contact (wetting voltage supplied by the RTU) to indicate the state of a circuit breaker.

5. It is the Interconnect Switchyard Vendor's responsibility to determine if NYISO plant dispatch information is to be supplied through the Interconnect (POI) Station RTU in DNP 3.0 Protocol or via a separate Plant Switchyard RTU.

6. All I/O point contacts shall be identified on vendor drawings and shall include the appropriate I/O point tags. These point tags shall be provided during the review cycle.

7. As a minimum, the wiring interface for analog and digital terminations shall occupy opposite sides of the cabinet and separated from all other control and protection wiring. All wiring shall utilize twisted shielded pairs with an overall shield for multiple pair cables. All shields shall be terminated next to their respective signal wire terminations.

8. Responsibility for designing the control and automation strategy for the switchyard shall remain with the switchyard Vendor. All documentation for modulating and discrete control and all equipment operating sequence requirements to be implemented in the SCADA system shall be provided by the switchyard Vendor. After review and approval by the Engineer/Owner, this control and sequencing strategy shall be implemented. A design review meeting between NYSEG, the switchyard Vendor and NYISO shall be held.

9. The switchyard Vendor shall provide the following documentation to support the implementation of the switchyard control strategy:

    a. I/O List

    Prepare a list of all inputs and outputs required between the switchyard and the SCADA system. The I/O list shall indicate all points to be included in the Sequence of Events (SOE) recording system.

b. Control Logic Diagrams

The switchyard Vendor shall prepare drawings defining the control logic for the supplied equipment. The control logic drawings shall include complete definition of all modulating and discrete control logic for all supplied equipment. Modulating and discrete control logic diagrams shall be provided as separate drawings.

All control and monitoring signals associated with the switchyard equipment shall be included with all permissives and interlocks for safe and efficient operation of the equipment in all operating conditions, both normal and emergency. All sensors, indicators, alarms, setpoints, control commands, final elements, control switches, and other operator interface elements shall be included.

The drawings shall include both hardwired control elements provided by the switchyard Vendor for local operator interface and control, and control elements to be implemented in the software of the SCADA system. The drawings shall clearly indicate portions of the control logic implemented in the field control elements provided by the switchyard supplier and portions of the control logic to be implemented by SCADA.

10. Control & Protective Relaying

a. The transmission line connecting the Plant Switchyard and the Interconnect switchyard shall require two sets of high speed protection. Since this will be new line construction, fiber will be used for both high-speed protection systems. Current differential relaying will be provided for the "A" and "B" relay packages.

b. There will be two independent groups covering each zone of protection. These groups may be of the same manufacturer but should not utilize the same technology. The schemes shall be physically separated.

c. ANSI C800 relay accuracy CT's are used for protective relays unless otherwise specified.

d. Control and Protective relaying shall be located within the Pre-Engineered Metal Control House to be supplied by the Vendor.

e. The Vendor shall be responsible for all internal panel wiring as well as between the panels and between panels field devices.

f. The Vendor shall design, supply, factory test, deliver to site, unload and store at site install, test and commission one set of control and relay panels for the switchyard containing the devices shown on the one-line diagrams and other drawings and documents included with the Engineering Requisition and as required by the Owner.

3.3 Low Voltage AC Power Distribution System

A. The Vendor shall design, supply, install, test and place in service a low voltage AC power distribution system for the switchyard. The AC Power distribution system for the Interconnect Switchyard shall be two independent house service supplies with an Automatic Transfer Switch (ATS).

B. The low voltage power distribution system shall distribute electrical power for all required functions in the switchyard, including:

1. Circuit breaker charging motors

2. Space heaters

3. Lighting

4. Convenience Outlets at switchyard equipment

C. The Vendor as part of his system design shall ensure that all system protective devices are properly sized and suitably coordinated with other system protective devices to ensure the safety and reliability of the system.

D. All system cable and wiring shall be designed, supplied, installed, tested and placed in service by the Vendor.

E. At a minimum the completed system shall comply with the applicable requirements of the latest edition of the NESC.

3.4 Lighting and Receptacle System

A. The Vendor shall design, supply, install, test and place in service a complete lighting and receptacle system for the switchyard.

B. Unless indicated otherwise, the illumination levels of different areas to be maintained shall be as per the IES standards.

C. Power distribution panels shall comply with the requirements of Specification **LATER**.

D. The lighting and receptacle system shall comply with the requirements of Specification **LATER**.

E. The Vendor shall furnish back-up calculations to justify the number and size of fixtures included in his design, the sizes of all cable and wire included in his design and the sizes of all cable raceways used to circuit illumination system wiring. These calculations shall be subject to Owner/Engineer's approval.

3.5 DC Control Power System

A. The dc system shall be designed to provide reliable power for switchyard equipment control and protection.

B. Two lead-acid station battery systems are required including two separate battery chargers. Each battery system must be capable of supplying the complete emergency load of the station. DC for the independent protection groups shall be fed from physically separate DC panels.

C. The dc system shall be designed and sized in accordance with IEEE 485 as applicable. The battery shall be sized to supply the control power for at least 8 hours after loss of ac power to the battery charger or as required by NERC or NPCC criteria. The Vendor shall develop the load profile to be used in the sizing of the battery and shall submit the battery calculation for review and approval.

D. The dc system shall be operated ungrounded to prevent a single ground fault from disabling the dc system. Provisions shall be provided for checking and alarming for grounds on the positive or negative leads.

E. All circuits shall be properly protected to limit the damage to the faulted circuit.

3.6 Grounding System

A. The Vendor shall design, supply, install, test and place in service a switchyard ground grid as required to cover the entire switchyard area. It shall provide personnel protection from electrical shock and lightning. The Vendor shall measure the soil resistivity and calculate the length of the conductor and cross-section of conductor required for the grounding grid so as to maintain the touch and step voltages within allowable limits. The procedure given in the publication IEEE-80 shall be followed for grounding. The calculation shall be submitted to Engineer for approval.

B. The fault current to be considered in calculation shall be as specified in the Engineering Requisition. The fault clearing time shall be considered as 0.5 second.

C. The grounding resistance of the switchyard shall not be more then 1.0 ohm.

D. The Vendor shall extend the below grade ground grid above grade and connect all steel structures, electrical equipment, overhead static lines and lightning protection downconductor circuits to the grounding system. The Vendor shall provide conductor sizing calculations and installation details to the Engineer for approval.

E. Stranded bare copper conductor shall be used for grounding and unless specifically indicated shall be laid at a minimum 18" below grade unless more depth is required to suit the design requirement and standards and codes.

F. The switchyard area shall be covered with crushed rock as required by the grounding calculations.

3.7 Lightning Protection

A. The switchyard equipment shall be shielded from direct lightning strikes by shield wires and/or lightning masts. The design shall follow the recommendations of IEEE 998-1996, IEEE1410-2010 and IEEE 1243-1997. Vendor's lightning protection design is subject to approval by Owner/Engineer.

B. Lightning arrestors shall be provided on all incoming transmission lines to protect equipment from lightning induced surges.

C. Preliminary estimate of lightning protection equipment also includes the following which is subject to change during Vendor's final design:

1. (4) Lightning Masts for capacitor bank area (if required), 60'height. Reference NYSEG Drawing SMN-LMH-94.

2. Twelve (14) Air Termination Rods, 21 feet height. NYSEG SS #800-795-03. To be located on top of overhead conductor towers.

3.8 Capacitor Bank

A. A capacitor bank, if required, is proposed to be located to the west of the Transmission Right-Of-Way and will consist of four 50MVAR fuseless capacitor groups for a total of 200MVAR. Each 50MVAR capacitor group will be controlled by a circuit switcher. Series reactors shall be provided for each capacitor group to limit back-to-back switching current. It should be noted that the Capacitor bank location is also being considered at the Plant Switchyard.

B. The capacitor bank, if located at the Interconnect Switchyard, will be connected to the switchyard by 285 circuit feet of Crosslinked Polyethylene (XLPE) Solid Dielectric Cable. The 115kV underground bus will be encased in a single steel casing. There will be six 115kV terminators and six lightning arrestors required. The terminators will rest on a stand-alone termination structure. Special engineering considerations will have to be applied when selecting the surge arrestors due to the capacitor bank.

4. CIVIL/STRUCTURAL FEATURES

This section describes the civil, structural, and architectural design basis for the facility's structures, and general civil work. All civil/structural work will be designed in accordance with applicable codes, industry standards, and local, state, and federal regulations. All required local building permits and inspections will be obtained by the Contractor. See Appendix A for Site Specific Data.

4.1 Facility Description

The switchyard will consist of a control house building, bus support structures, transformers, circuit breakers, disconnect switches, surge arresters, ccvt's, and other miscellaneous switchyard equipment.

Surface finishing (roads, ground cover, etc.) for the site will be as indicated on the General Arrangement drawing. The project will be located within a new perimeter fence. Main access to and from the site will be off of the paved main entrance road (Jennings Road).

4.2 Sitework

Civil works design shall comply with the requirements of New York State Electric and Gas Corporation's "Site Development Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1442)

A. Stormwater Management

Assumed stream can collect stormwater and therefore no catch basin needed in preliminary design.

A Stormwater Pollution Prevention Plan (SWPPP) will be developed by the Company for the final stabilized site. The stormwater management plan for use during construction phase and during operation shall be developed by the Engineer with support from specialty engineering services. The intent of the stormwater management plan and the SWPPP will be to preserve the existing pre-development drainage patterns to the extent possible. The plan will include a clean stormwater collection system and an industrial stormwater collection system, consisting of catch basins, piping, a subsurface detention basin, and a suitable water treatment facility as required by the New York Department of Environmental Conservation (DEC). The stormwater collection systems will collect runoff from developed areas of the site and discharge them appropriately.

B. Roads and Parking

Asphalt site roads and parking will be provided for access, operation and maintenance as shown on the General Arrangement drawing. Alternative access, if required by local regulations, will be provided as shown on the general arrangement drawing.

C. Site Area Paving

Areas within the power block will be surfaced with concrete or gravel as shown on the General Arrangement drawing. All roads will be paved with asphalt unless specifically shown otherwise on the General Arrangement. The roads will be designed in general accordance with the recommendations presented in the Geotechnical Report and designed to withstand the loading conditions.

Site roads will be provided that will conform to the following:

Operating speed of 10 miles per hour.

Minimum road width of 12 feet, with 2-foot shoulders.

AASHTO HS-20-44 loading conditions (minimum requirement).

Maximum transverse gradient of 2 percent.

D. Wetlands Protection

The Contractor will comply with requirements specified by any laws, codes, and permits.

E. Landscaping and Fencing

Any detailed landscape design, fine grading, furnishing and placement of trees, shrubbery, and/or grass, will be provided by the Company. Any embankment area around the perimeter of the switchyard and any unpaved areas on site will be gravel. The Contractor will restore to its original condition any offsite area that is disturbed during construction.

Contractor will furnish and install temporary chain link fencing around the contractor parking area as shown on the Construction Laydown, Staging, and Parking Plan. Contractor will also furnish and install a gate at the new site entrance point off of Jennings Road. The gate will serve as both the construction entrance gate and the permanent site entrance gate following completion of construction. The gate shall be a new 25-foot-wide automatic slide main gate, with a keypad for vehicle use. A temporary guard house shall be placed at the permanent site gate during construction. Following completion of construction, the temporary guard house shall be removed.

4.3 Structural Design

A. Codes and Standards:

The 2010 New York State Building Code and local/state-building codes will be incorporated into the design of building and structures. Steel structures will be designed in accordance with the design specifications for structural steel buildings published by the American Institute of Steel Construction (AISC). Reinforced concrete structures will be designed in accordance with the design requirements for concrete buildings and structures published by the American Concrete Institute (ACI).

Allowable variances and applicable local code interpretations will be established before project commencement.

Additionally all plant areas and structures will be designed and configured to meet OSHA requirements contained in Part 1910 of the U.S. Code of Federal Regulations.

B. Steel Structure Design and Fabrication:

The design and fabrication of the supporting steel structures shall comply with the New York State Electric and Gas Corporation's "Structures, Material Requirements for Substation Structures" specification requirements. (Ref. Specification SP-1 252).

The structures shall include but not be limited to the following:

Qty.	Description
10	115kV deadend structures per NYSEG Drawing SLE-BHAANA structure type SMDE-3-25.
17	115kV disconnect switch supports
15	115kV CCVT supports
1 Lot	115 kV bus support insulators

The Vendor shall perform a structural analysis of all steel structures designed and shall submit the same to the Engineer for approval.

The Vendor shall submit material and fabrication specifications to the Engineer for approval.

Structure used to support manufacturer supplied equipment shall comply with the manufacturer's suggested (recommended) support design.

C. Loads and Load Combinations

1. Dead Loads

Dead loads will consist of the weight of all permanent construction including, but not limited to, fixed equipment, framing, bus work, and any other structures, contents of transformers, etc.

2. Seismic Loads

All equipment will be designed to withstand the seismic loading requirement specified in the governing building code for the specified seismic zone

In addition, equipment anchorages and supports will be designed to prevent overturning, displacement and dislocation in accordance with governing building code requirements.

3. Wind Loads

Wind pressures and shape factors will be applied to all system components and exposed equipment in accordance with governing building code.

Allowances will not be made for the effect of shielding by other structures.

4. Snow Loads

The overturning moment calculated from wind pressure will not exceed two thirds of the dead load resisting moment. The uplifting forces calculated from the wind pressure will not exceed two thirds of the resisting dead loads and adequate structure-foundation ties will be designed to resist wind forces.

Snow loads, including potential drifting, will be applied to all buildings, structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

5. Ice Loads

Ice loads will be applied to all structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

6. Other Loads

Other expected loads (short circuit loads, etc) required to predict the response of structures will be considered where appropriate.

Proper load combinations will be used for structural steel and reinforced concrete to comply with the applicable codes and standards and with vendor requirements.

7. Structural Steel

Nonheaded anchor bolts will conform to ASTM A 1554 Grade 36, unless higher strength bolting materials are required by design. Exterior exposed anchor bolts that are not high-grade fine thread will not be hot dipped galvanized.

The galvanized coating used on switchyard steel structures shall have an average thickness of 5 mils with no point being less than 4 mils.

D. Foundation Design:

1. Structural Concrete

Foundation design shall comply with the requirements of New York State Electric and Gas Corporation's "Foundations Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1445)

Concrete design shall comply with the requirements of the New York State Electric and Gas Corporation's "Materials Specification for Concrete" specification unless otherwise indicated. (Ref. Specification TD-1070)

The Vendor shall design and install foundations all switchyard equipment and structures including but not limited to the following:

- 115kV circuit breakers
- 115 kV disconnect switches
- 115 kV bus supports
- 115 kV CCVT instrument transformers
- 115kV Metering Equipment
- 115 kV transmission line dead end structures and turning towers
- Switchyard outdoor lighting standards
- Relay and control house
- Lightning Masts

All foundations shall be reinforced concrete spread footings or augur type drill caissons. The Vendor shall be responsible for providing the reaction forces at the top of the foundation for the transformer dead-end structures to the Owner.

Anchor bolt diameters, material and projection above the concrete shall be specified by the Vendor. The Vendor shall provide the anchor bolt location drawings and templates for field installation of the anchor bolts.

The Vendor shall submit foundation design calculations and drawings to the Engineer for approval.

4.4 Wire and Cable

Wire and cable design requirements and material requirements shall be in accordance with the following specifications:

LATER	Control Cable
LATER	Instrument Cable
LATER	LV Power Cable
LATER	Wire and Cable Installation

4.5 Cable Raceways

Cable raceway design and material requirements shall be in accordance with the following specifications:

LATER	Conduit
LATER	Embedded Conduits, Underground Ductbanks & Trenches
LATER	Cable Tray

5. TESTING

5.1 General

A. The requirements of this clause shall be met in conjunction with the other sections of the Engineering Requisition.

B. All inspection/tests to be performed during manufacture, fabrication and trial operation shall be as stated in the Engineering Requisition.

C. Where no specific test is mentioned, the various materials and equipment shall be tested in accordance with the appropriate standards, or other recommendations. Where no appropriate standard is available, tests shall be carried out in accordance with manufacturer's standard, subject to the prior approval of the Owner/Engineer.

D. Before commencement of any test, copies of relevant drawings and documents shall be submitted to the Owner/Engineer and approval obtained.

E. Switchyard testing shall include Doble, Ductor and Thermal Imaging tests.

5.2 Test Certificates

All principal test records, test certificates and performance details for all tests carried out in accordance with the provisions of this Contract shall be supplied to the Owner/Engineer. These test records, certificates and performance details shall be supplied for all tests, whether or not the Engineer has witnessed them. The information given on such test certificates and performance details shall be sufficient to identify the material or equipment to which the certificate refers. Certificates shall also bear the contract reference and heading.

5.3 Tests at Site

These tests shall be carried out for different equipment, material and systems prior to and during commissioning of the switchyard. The Vendor shall submit a detail test schedule including the procedure for the site tests for Owner/Engineer's approval.

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6. ADDITIONAL INFORMATION

TYPICAL VALUES FOR MAJOR SWITCHYARD EQUIPMENT

Power Circuit Breakers:

4.2.1	a.	Type	Dead Tank SF6 Gas
	b.	Rated Voltage	123 kV rms Rated Maximum Voltage
	c.	Basic Insulation Level	550 kV
	e.	Rated Continuous Current	2000 A rms
	f.	Rated Interrupting Current	40 kA sym. rms
	g.	Rated Interrupting Time	3 cycles
	j.	Frequency	60 Hz
	k.	3-Second Short Time Current Carrying Capability	40 kA sym. rms

Disconnect Switch:

4.2.2	a.	Nominal Voltage	115 kV
	b.	Rated Maximum Voltage	121 kV
	c.	Type	3-Phase Group Operated
	d.	Current Rating	2000A Continuous, 100kA Momentary
	h.	BIL	550 kV
	i.	Frequency	60 Hertz

APPENDIX A – SITE SPECIFIC DATA

Location	Reading, NY
Project Name	caes pROJECT
Site Conditions	
Max Dry Bulb Temperature (°F)	86
Coincident Wet Bulb Temperature (°F)	71
Winter Dry Bulb Temperature (°F)	-2
TOP OF CONCRETE (TOC) Elevation, (feet above mean sea level)	TBD
FROST LINE, in	54
Soil Type	CLAY, SILT, MAINLY SAND AND GRAVEL
ALLOWABLE SOIL LOAD BEARING CAPACITY	3000 PSF
Precipitation	
24 hr. Maximum, 25 Year Storm (in)	4.5

Wind Loading

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE
WIND ZONE	C
Basic Wind Speed	90 mph
Occupancy Category	iii
Exposure Category	C
Importance Factor	1.15

Seismic

Design Code	2010 NEW YORK STATE BUILDING CODE
SITE CLASS	C
Seismic DESIGN CATEGORY	B
SITE COEFFICIENT	Fa=1.6, fv=2.4
Seismic Coefficient	Ss=0.2, Sl=0.006
IMPORTANCE FACTOR	1.25

SNOW LOAD

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE

BASIC SNOW LOAD	Pf=25 psf
IMPORTANCE FACTOR	1.10