SECTION M1

GENERAL MECHANICAL REQUIREMENTS

1. GENERAL: The Seller shall comply with all requirements of this Section.

2. SKID-MOUNTED AND SELLER-ENGINEERED SYSTEMS: The following requirements apply to Seller-furnished skid-mounted systems, packaged modular designs and/or Seller-engineered systems. Skid interface point end preparations shall be in accordance with Table 1 at the end of this Section.

2.1. MECHANICAL DESIGN CRITERIA:

2.1.1. Where the Buyer is determining pump size, the Seller shall use the design values provided in the Technical Specification (TS) or Data Sheet(s) (DS) without the margins described elsewhere in this paragraph. Where the seller is providing Seller-engineered pumping systems, the following pump design margins shall be applied as a minimum unless specifically detailed in the TS or EDR:

At the maximum sustained system operating conditions:

	Centrifugal Pumps	Positive Displacement Pumps
Flow Margin	0%	10%
Head Margin	10% of Calculated Head	0%
Minimum Rise to Shutoff	120%	N/A
Maximum Rise to Shutoff	125% for multiple stage pumps 140% for single stage pumps	N/A
NSPH margin	NPSHa*(0.8) >= NPSHr	NPSHa*(0.8) >= NPSHr

2.1.2. Pumps shall be suitable for operation at the design point which shall be as close the pump best efficiency point (BEP) as possible. Pumps shall be capable of delivering their rated capacity at efficiency of no less than 50%, or where applicable, NEMA MG1 efficiencies shall

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apply. The operating envelope of the pump shall fall substantially within the preferred operating range (POR) as defined in Hydraulics Institute Guideline 9.6.3. Pumps curves shall be supplied without dips or peaks with continuous rise from run out to shutoff and shall be designed to be non-overloading.

2.1.3. Equipment design shall include appropriate margins for system fouling and equipment degradation per the design life requirements. System underperformance resulting from Seller's allowance of a negative tolerance on Seller supplied equipment will not relieve the Seller from meeting or exceeding the specified requirements.

2.1.4. Freeze Protection Design Parameters:

Description		**Notes**
Design Temperature	-10°F	Based on a 20 mph wind occurs for a duration of 48 hours.
Fluid Temperature in Pipe	40°F	

2.2. Equipment requiring insulation shall be designed to meet the intent of the following:

2.2.1. When indicated in the Technical Specification, Seller shall include the supply and installation of insulation materials as detailed in those therein. Insulation provided by Seller for personnel protection shall be provided on surfaces above 140 °F which are within 7 ft vertically above grade or platforms, and 3 ft horizontally from the periphery of walkways, ladders, platforms, floors, and other areas where operating personnel may be present. Where gaps in personnel protection less than 10 ft would exist, the insulation shall be run continuously. Pre-insulated, skidded equipment shall be fabricated such that sufficient access is provided for routine maintenance activities.

2.2.2. Materials: All insulation for hot surfaces shall be of high thermal efficiency and shall be capable of withstanding the maximum specified work temperatures to which they will be subjected without deterioration and without loss of thermal efficiency. All insulation for cold surfaces shall be highly effective in preventing sweating and shall be capable of resisting the effects of moisture. Contractor shall not install any cracked or damaged insulation. Any insulation that is cracked or damaged during installation shall be removed and replaced. All material shall be asbestos and refractory ceramic fiber (RCF) free and shall have a fire rating of 25 or less when tested by ASTM E84 method. Insulation coverings containing polyvinyl chloride or polyurethane compounds shall not be employed anywhere in the Facility. Where required by the process, heat conservation insulation on piping and equipment shall be provided. In general, for equipment and process piping above 140°F Mineral Wool, materials or approved equal shall be used.

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2.2.3. Multiple Layers Insulation: All block, segmental, and sectional insulation for all piping, etc., 3 inches and above in total thickness or 1/2 inch less than the thickness of the outer layer where this is not practical shall require multiple layers of insulation. Staggered joint construction shall be used for joints in both directions on all multiple layer insulation. Single-layer insulation and the outer layer of insulation for all double-layer applications shall be fastened with 16-gauge or heavier galvanized steel wire. The inner layer of insulation for all double layer application shall be fastened with 16-gauge or heavier stainless steel wire. In addition to the above requirements, any fastening wire coming in contact with surfaces over 499°F shall be 16-gauge or heavier stainless steel.

2.2.4. Joints: All insulation shall be laid with butted joints, and all voids, chipped corners, or other openings in the insulation sections or blocks shall be filled with an approved insulating cement, finished smooth and neat.

2.2.5. Insulation for Hot Piping: When the segmental form is necessarily used, segments shall fit the curved surfaces to which they are applied. Not less than three insulation tie wires shall be applied on each 3-ft-long section of sectional pipe insulation. All fastening wire shall be at right angles to the axis of the pipe, not diagonally wound on. End tie wires shall be applied 3 inches in from the end of each insulation section. The tie wires applied to outer layers shall be tightly twisted together, bent over and pressed into the insulation so as to leave no projection visible on the finished surface. Each layer of insulation shall be fastened independently of other layers. On pipelines that originate or terminate at a piece of Equipment, insulation shall be finished complete to the Equipment. All projecting hanger lugs and hanger clamps on piping with operating temperatures of 300°F and above and on all outdoor heat insulated piping shall be completely insulated with the same type and thickness of insulation as that specified for the pipeline in which the hanger is located.

2.2.6. Insulation for Hot Valves and Fittings: All valves and fittings shall be covered with insulating materials of the same kind and thickness as that specified for the pipelines in which they are installed. Valves and flanges shall be encased with removable, reusable covers of the type described below. In the case of reducing fittings, the largest pipe size shall determine the thickness of the insulation to be used. All valves, including safety and relief valves (except electromagnetic relief valves) installed in pipes to be insulated, shall be completely insulated to and include the valve bonnet joint in each case. Each insulated safety valve shall be provided with a metal sleeve through the insulation to provide access to those portions, which require adjusting, such as the ring pin. Electromagnetic relief valve bodies shall be insulated completely up to and including the top flange of the valve. Pilot valves and interconnecting piping between the electromagnetic relief valve and the pilot valve shall also be insulated on all outdoor installations. Insulation sections or segments used for covering valves, fittings, etc., shall be properly mitered as required and shall fit together snugly. Insulation shall be properly secured by tie wire as previously specified. Insulation for valves and fittings where the OD of the insulation is 6 inches or greater shall be reinforced with 1-inch mesh, 18-gauge galvanized wire netting and finished with a 1/2-inch thick (when dry) coating of hard finish cement. Netting shall not be visible through the cement finish. Insulation for valves and fittings made in accordance with ASTM specification C450 will not require mesh-reinforced cement over the insulation. Mineral wool insulating cement may be used to insulate valves and fittings in 2-inch and smaller piping to be insulated with 2 inches or less of insulation.

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2.2.7. All removable, reusable covers for valves, flanges, etc., shall be of the following types:

a. Insulated Cans
b. Metal Mesh Encased Blankers
c. Fabricated Encased Blankets

2.2.8. Personnel Protection: In addition to the specified insulation, personnel protection insulation shall be provided for the following:

a. Insulation for personnel protection shall be provided on surfaces above 140°F and within 3' horizontally or 7' vertically of walkways, ladders and platforms. Required thickness shall be based on an ambient temperature of 91°F and a wind speed of 3mph.
b. Steam trap bodies and condensate pots shall not be insulated, but shall be provided with personnel protection shields. The shield shall be fabricated from minimum 18-gauge expanded galvanized or stainless steel. Shields shall be of the removable type, employing screws and nuts for servicing of the steam traps.

2.2.9. Insulation for Cold Water Piping: Black rubber (½ inch minimum thickness) "Armaflex" or equivalent anti-sweat insulation for cold water piping shall be used where the dropping of condensation could cause damage. All building interior cold piping shall be insulated. Anti-sweat insulation on piping and equipment with operating temperatures below 50°F. Insulation shall be mineral fiber, fiberglass or elastomeric type (closed cell or foam glass). A fire-retardant vapor barrier (permeance >0.02 perms) shall be provided for piping such as cold water or chilled water piping which operates below ambient temperatures, to prevent condensate formation from corroding the piping.

2.2.10. All vertical pipe runs on pipe 6" and larger shall have support rings at a minimum 10' spacing.

2.2.11. All carbon steel piping shall have at least an epoxy primer coating under insulation.

2.2.12. Piping insulation thickness shall be selected considering availability as defined in ASTM C585-10. Contractor shall submit their insulation thickness calculation for review.

2.2.13. Lagging Material and Thickness:

2.2.13.1. Ductwork, Breaching, Exposed Drums, Field erected tanks, and deaerator: 0.036" embossed, box ribbed aluminum, weather-proofed appropriately with 0.2 emittance.

2.2.13.2. Piping: 0.02" embossed aluminum with 0.2 emittance.

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2.2.13.3. Valves & Fittings: 0.02" embossed aluminum with 0.2 emittance.

2.2.13.4. Insulation shall be provided with a vapor barrier and lagging.

2.2.13.5. End of pipe insulation at intervals of not more than 9 feet on continuous runs of pipe, and at flanges, valves and fittings shall be sealed off with a vapor-proof mastic.

2.2.13.6. Hanger rods shall be caulked and sealed with vapor-proof mastic prior to installation of the jacketing. Hangers and pipe clamps with thickness of 1/2 inch or small that are attached directly to the pipe may be buried in the specified thickness of insulation. All other hangers and pipe clamps shall be covered with a sleeve or oversized pipe insulation section. Hangers attached directly to the pipe shall be covered with insulation the same thickness as that specified for pipeline in which the hanger is located.

2.2.14. For equipment which does not require personnel protection, Seller shall provide installation drawings and details specifying piping and tubing requiring freeze protection based on site conditions listed. An appropriate amount of space for installation of the insulation and heat tracing for required piping and tubing shall be allotted as part of Seller design. Buyer will procure and install insulation and heat tracing (as required) unless otherwise specified within these Specifications.

2.3. Seller's equipment, valves, piping, and specialties shall have dimensions controlled to the corresponding equipment/material standard requirements or tolerances of +/- 1/8 inch , whichever is more stringent.

2.3.1. Seller's engineered skids shall be designed and fabricated to ensure the equipment is accessible for maintenance to the extent that interconnecting components (pipe, tubing, wiring, conduit, etc.) will not be damaged during routine maintenance. For skids which provide fully redundant (i.e. 2x100%) components, the design shall allow removal of the spare component while the other component remains operating. Plant Equipment shall be designed to be maintained in place with minimum disassembly of surrounding Equipment and minimize use of temporary scaffolding and handling Equipment.

2.3.2. Lifting eyes shall be provided on Equipment to facilitate installation and removal for maintenance.

2.4. Minimum allowable resultant force at each equipment nozzle shall be 250 lb times the nominal pipe size (NPS), and the minimum allowable resultant moment at each equipment nozzle shall be 500 ft-lb times the NPS. For instance, a 4 inch nozzle shall be designed for minimum 1,000 lb resultant force and 2,000 ft-lb resultant moment.

2.5. All equipment and components that have been hydrotested shall be fully drained of test fluid, and completely dried prior to shipment. All openings in pipe and equipment shall be covered.

2.6. All equipment shall meet the minimum metal design temperatures listed below:

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All outdoor equipment and materials	-20°F
Indoor Equipment	Minimum Indoor Design Temperature for enclosure

3. EQUIPMENT ARRANGEMENT: Equipment shall be arranged to optimize maintenance work by providing adequate space around equipment and control panels. Install and orient all glass gauges, local instrumentation and controllers for operation and maintenance as practical and standard to the industry. Provide adequate work platforms, ladders, and stairs and locate manual operators, etc. within reach of plant operators.

3.1. Operability and Safety: Equipment, valves, instrumentation, motor controls and testing devices shall be designed for ease of operation and easy access, i.e. without the need for portable ladders. The use of piping, headers, or other equipment as stepping points for means of access shall not be allowed unless appropriately fitted with stair treads and handrail if required. The design shall comply with the Occupational Safety and Health Administration (OSHA) requirements.

3.2. Sample and Test Connections: Piping shall be provided with adequate permanent connections to perform acceptance testing while the equipment is in operation. Wastewater streams leaving the system shall be provided with sampling facilities for manual extraction of representative samples.

3.3. Root Connections: Root connections on horizontal or sloping lines shall not be located below the center of the line. The following guidelines shall apply:

a. Root connections for service on steam and condensate vapors or wet gas shall be located at any point above the center of the pipe.
b. Root connections for service on liquids shall be taken only from the side of the pipe with the root nipple horizontal.
c. Root connections for service on dry gas shall be taken from the top of the pipe.

3.3.1. Pressure connections on process lines and vessels and the root valves for most applications shall be 3/4-inch minimum and be suitable for the service.

3.4. Vents and Drains: High points shall be vented and low points shall be drained to ensure quick and efficient testing, commissioning, startup and operation of all mechanical systems. Silencers shall be provided if necessary to meet noise requirements, for all venting normally used during startup and operation.

3.4.1. Vents and drains shall be located on general arrangement and/or piping drawings.

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3.4.2. Except for natural gas piping, all low and high-pressure vent valves shall be of a globe valve style. For natural gas service, only plug or ball valves shall be used. Drains shall normally be isolated with gate valves in low pressure liquid service.

3.4.3. Vent and drains valves shall be provided by the Seller and shall be installed such that valve operators are accessible.

3.4.4. The outlet of vents and drains shall be open to atmosphere. If a terminal nipple with threaded outlet is provided, the threads shall be protected.

3.4.5. Normally operated maintenance drains, not including low point drains, from skid-mounted equipment shall be headered together, with a flanged connection terminated at the edge of the skid with sufficient elevation to allow access for the Buyer to continue the drains to an appropriate equipment drain.

3.5. Nameplates and Labels: Permanent instruction plates, nameplates and labels shall be provided for all items of the plant giving particulars of duty, size, serial number and full information for identification and operation. Labels shall be of sufficient size to carry a full description of the plant item and unique project tag number. For any metallic non-boiler external piping-covered piping system (NBEP-CPS), each part, subassembly, or assembly listed shall be marked in accordance with ASME B31.1 Appendix R, directly traceable to form(s) CC-2.

3.6. Piping flanges shall not be located over electrical Equipment.

3.7. Locally mounted pressure gauges shall be provided upstream and downstream of each piece of equipment that can affect process pressure, i.e., pumps, filters, heat exchangers, etc.

4. ALIGNMENT AND BALANCE: All rotating parts shall be true and dynamically balanced. Excessive noise or vibration shall be sufficient cause for rejection of the Equipment. All rotating components and assemblies shall be dynamically balanced in accordance with ISO 21940-11. Equipment found to be in non-compliance after installation can be rejected and shall be the Seller's responsibility to correct.

5. CORROSION PROTECTION: All equipment, except surfaces specified to be field-coated, shall be protected from corrosion due to the specified environment and service. Corrosion-resistant materials and coatings shall be utilized, and dissimilar metals shall be electrically isolated where necessary. All external screw fasteners shall be hot dipped galvanized, cadmium plated, Polytetrafluoroethylene (PTFE), or stainless steel. Other surfaces not receiving paint coatings such as bearing surfaces, internal piping and connection surfaces, shall be adequately protected by removable tape or other means.

5.1. In all cases when a piping connection is made between steel and aluminum or copper, the mating surfaces shall be electrically isolated. For 2-1/2 inch and larger piping, flanges shall be used and the flanged joint shall be made using an electrically nonconducting gasket and flange bolts fitted with plastic ferrules and plastic washers under the bolt heads. The electrical isolation shall be verified after installation. Two-inch and smaller connections may be made using flanges, as stated above, or with dielectric type couplings, bushings or unions.

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6. LUBRICATION: Equipment shall be lubricated by systems designed for continuous operations. All moving parts shall be efficiently lubricated by either oil or grease. A separate nipple or zerk style fitting shall be used for grease lubricating points for valves, shafts, etc. in accordance with American Nation Standards Institute (ANSI). Where material thickness is such as to preclude the use of these nipples without recourse to special adaptors, lubrication nipples in accordance with ANSI Standards or other approved equivalent may be fitted subject in each case to the Buyer's approval. If a lubrication point is not safely or ergonomically accessible during normal operation, extensions to the grease nipples shall be provided to permit reasonable and safe access by maintenance personnel. Grease fittings shall be extended through the safety guards and positioned for ease of access without interference from other Equipment, insulation, etc. For oil lubricated systems, the equipment shall be designed to operate with a single oil type/grade that will operate over the entire ambient range. Equipment that may require oil type/grade changes due to changes in ambient conditions will not be accepted.

6.1. Oil lubricant level indicators shall be furnished on all bearing boxes and marked to indicate proper levels under both non-operating and operating conditions.

6.2. Pump bearings shall be oil lubricated with external constant level oil bulb unless a circulating oil system is required by the Technical Specification.

7. ENCLOSED GEAR DRIVE UNITS: Enclosed gear drive units shall be designed for continuous service and shall be in accordance with the latest American Gear Manufacturers Association (AGMA) standards for the type of gear drive being furnished. Each gear drive unit shall be capable of withstanding 5% more than the motor torque developed during start acceleration, and deceleration if stalled.

8. SAFETY GUARDS: Guards meeting OSHA requirements or other governing regional code shall be provided for protection of personnel for all exposed moving and/or rotating machine elements. Guards shall be easily removable for servicing of Equipment.

9. EQUIPMENT BASES: A fabricated steel base plate (mounting plate) shall be provided for all rotating equipment for proper alignment and stability and provided with jack screws for leveling. The base plate shall not be deformed and shall be separate from the skid base or support steel. All equipment shall be designed such that the in-fill of grout is not required. If this is not possible, Seller to provide vent and fill holes. Anchorage for equipment with grout, should it be required, shall be limited to placement under the anchor plates and not the entire skid frame. The equipment base plate shall also be designed in such a way as to allow for installation of post-installed anchors by allowing ample work space to maneuver a hammer drill and to facilitate installation of anchor bolts such that the work can be performed with the equipment "in position."

9.1. Mounting surfaces for the feet of general-purpose equipment and ASME pumps driven by low-voltage motors, shall be leveled longitudinally and transversely to within 0.005 inches per foot.

9.2. Mounting surfaces for the feet of general-purpose equipment and ASME pumps driven by medium-voltage motors, and for all API pumps, shall be leveled longitudinally and

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transversely to within 0.003 inches per foot, and shall be spot-faced at least 1 inch beyond the equipment feet in all directions.

9.3. Base plates for horizontal pumps shall be of cast iron or fabricated steel extended to receive the motor. If required, a sub-base under the motor or pump shall be furnished as part of the base plate. The base plate shall extend under all parts of the pump and motor from which fluid may drip. A drip lip shall extend along the two sides to a tapped drain connection located in the middle of the pump end of the base.

10. SHAFT COUPLINGS: Shaft couplings shall be used between all drives and driven equipment. Couplings shall be attached to driver and driven shafts by press fits and keys.

10.1. Shaft couplings shall be capable of transmitting the maximum torque requirements of the driven equipment with a service factor of not less than 1.5 unless otherwise indicated in the Technical Specifications.

10.2. Couplings shall be of the flexible spacer type.

11. PIPING: All piping shall be in accordance with ASME B31.1 - Power Piping, other codes and any other applicable standards referenced in this specification. Pipe stress and flexibility analysis shall be performed on all piping operating at temperatures greater than 300 °F and in accordance with ASME B31.1 in accordance with best industry practices or where required by the Seller's design. At a minimum this piping shall include HP steam, HR steam, CR steam, LP Steam, Feedwater, Gland Steam, auxiliary steam, steam drains and any FRP piping. The package shall include stress isometrics, input echo prints, and output data for all analyzed load cases. Output should include nodal displacements, hanger loads and deflections, internal system forces and moments, and calculated Code stresses. All pipe supports shall be suitable to restrain the piping where subjected to external loads. Pipe end preparations shall be in accordance with Table 1 at the end of this Section.

11.1. Maximum fluid velocities for the purpose of pipe sizing shall be in accordance with the following table. Drains, vents, or lines sized on available pressure drop may exceed these values.

Recommended Maximum Pipe Velocities (ft/sec unless noted)	
Saturated Steam greater than 25 psia and superheated steam with less than 25 °F	12,500 fpm (208 fps)
Superheated Steam greater than 25 psia and superheated steam with less than 25 °F superheat when 90° elbows are present	9,000 fpm (150 fps)

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Superheated Steam with a minimum of 25 °F superheat	20,000 fpm (333 fps)
Low pressure wet steam (including saturated steam up to 25 psia)	7,500 fpm (125 fps)
Water, General Service (except minimum flow recycle lines) and Cooling Water	10
Water, minimum flow recycle lines	15
Condensate	
Pump Suction	3-5
Pump Discharge	12
Boiler Feedwater	
Pump Suction	8-12
Pump Discharge	10-18
Other pump suctions	7-10
Potable water	7
Compressed Instrument Air Headers	40
Compressed Air (Branch Lines <50 ft)	100
Compressed Gas (N2, H2, CO2)	40

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Firewater	20
Diesel Oil	10
Chemical Feed	7
Natural gas (fpm)	6000, not to exceed 1/3 sonic

11.2. Design Pressure: The design pressure for piping shall be consistent with conditions established for the design of the associated system. The design pressure of a piping system generally shall be based on either the maximum sustained pressure that may act on the system plus 25 psi or 10 %, whichever is less, or to the relief valve set pressure. Gravity drain lines open to atmospheric design pressure shall equal the total static head of the source fluid. Vacuum systems shall be designed for external pressure with 10% margin added. If a design pressure is specified in the EDR, these margins need not be applied.

11.3. Design Temperature: The design temperature for piping shall be consistent with conditions established for the design of the associated system. The design temperature of a piping system generally shall be based on the maximum sustained temperature which may act on the system plus 10 °F rounded up to the next 5 °F increment. If a design temperature is specified in the EDR, that these margins need not be applied.

11.4. Tolerances: Fabrication tolerances shall meet the requirements of PFI Standard ES-3.

11.5. Allowance: Pipe wall thickness shall be calculated using the following allowances:

a. Carbon Steels (Water Service (Velocity <15 fps)) 0.063 inches
b. Carbon Steels (Water Service (Velocity >15 fps)) 0.125 inches
c. Carbon Steels (Saturated Steam Service) 0.063 inches
d. Carbon Steels (Superheated Steam or Dry Gases) 0.020 inches
e. Carbon Steels (Galvanized Carbon Steel for Air) 0.020 inches
f. Low Alloy Steels (Superheated Steam): 0.020 inches
g. Low Alloy Steels (Water Service): 0.031 inches
h. Creep Strength Enhanced Ferritic Steels: 0.063 inches
i. Stainless Steel and Nickel Alloys: 0.000 inches
j. Plastic or Rubber Lined Piping: 0.000 inches

11.6. Wall Thickness Measurements: Where pipe wall thickness measurements are required, they shall be determined by recording measurements at four equidistant points along the

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pipe's circumference; 0°, 90°, 180°, and 270°. For each pipe, sets of 4 equidistant point measurements shall be recorded along the longitudinal axis according to following criteria:

- Pipe length less than or equal to 5 feet: 1 pipe diameter in length from each pipe end.
- Pipe length greater than 5 feet: 1 pipe diameter in length from each pipe end, and within the middlemost 5-foot section of the pipe.

11.7. Materials: Material selection shall be based on the design pressure, temperature, and service conditions.

11.7.1. PIPE AND TUBE MATERIAL: Piping materials shall be in accordance with applicable ASTM and ANSI standards and local codes under B31.1. Brass with high zinc content shall not be used in the construction of wetted surfaces that will be in contact with chlorinated water. Unless otherwise indicated below, the minimum allowed piping schedule for NPS 2-1/2 nominal size and larger piping is STD WT and for NPS 2 and smaller is schedule 80. Schedules, sizes, and dimensions shall conform to ASME B36.10M or B36.19M, as applicable. Piping materials shall generally be in accordance with the following:

11.7.1.1. Carbon Steel Pipe: Carbon steel piping NPS 2 nominal size and smaller shall be schedule 80 minimum. Carbon steel piping NPS 2-1/2 through DNPS 14 nominal size shall be seamless, non-galvanized, listed material allowed by code. Carbon steel piping with a nominal size of NPS 16 or larger shall be seam welded listed material allowed by code.

11.7.1.1.1. Galvanized Carbon Steel Pipe: The piping shall be hot-dip galvanized. The use of galvanized steel pipe shall be limited to systems where a degree of corrosion resistance is required or where codes require the use of galvanized steel pipe rather than black steel pipe.

11.7.1.2. Stainless Steel Pipe: All stainless steel piping materials shall be fully solution annealed prior to fabrication. Type 316 materials shall be utilized for high resistance to corrosion. Type 316L materials shall be utilized for applications requiring hot working (bending, etc.). Stainless steel piping NPS 2 and smaller shall be schedule 40S minimum. Stainless steel piping NPS 2-1/2 and larger shall be schedule 10S minimum. Threaded pipe/nipples shall be 80s minimum.

11.7.1.2.1. Piping for lubrication services that supply lube oil to a piece of equipment shall be stainless steel, pickled, passivated and solvent cleaned after fabrication. All piping for lubrication services shall be butt welded, including small bore. Piping for lubrication services draining lube oil back to the lube oil reservoir/cleaning skid shall be stainless steel or carbon steel. All lube systems (except field installed) shall be flushed to an acceptable level of cleanliness and laid up for transit and storage prior to shipping.

11.7.1.2.2. Stainless Steel Tubing: Stainless steel tubing shall conform to ASTM A213, Type 316. All stainless steel tubing shall be of the fully annealed type. Wall thickness shall be suitable for the service conditions, but not less than 0.049 inch for 1/2 inch tubing, and 0.035 inch for 3/8 inch tubing. All stainless steel tubing and materials used shall meet all applicable code

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requirements. Stainless steel tubing for use with crimp or bite type tubing fittings shall not exceed Rockwell B80 hardness.

11.7.1.3. Low & Intermediate Alloy Pipe: chromium alloy pipe shall be in accordance with ASTM A335 Grades P11, P22, P91, or P5.

11.7.1.4. Nickel Alloy Pipe: Piping for sulfuric acid service shall be B729 UNS N08020 (Alloy 20). Alloy 20, Cr-Ni-Fe-Mo-Cu-Cb stabilized alloy piping, shall conform to ASTM B464. Materials for other acids/chemicals shall be approved by the Buyer.

11.7.1.5. Rubber Lined Pipe: Lining materials, manufacturers and method of application for rubber lined carbon steel pipe shall be chosen to meet or exceed the service requirements. The lining application, inspection and testing shall be in strict accordance with the rubber and cement manufacturers' current requirements. Thickness specified to be no less than 0.25" and installed and tested in accordance with NACE International SP0298.

11.7.1.5.1. Polypropylene Lined Pipe: Polypropylene lined pipe shall be ASTM A53 or A106 steel pipe with an applied liner of polypropylene.

11.7.1.5.2. Fiberglass Reinforced Plastic Pipe: Fiberglass reinforced plastic pipe shall be chosen in accordance with the specific service requirements and shall be used only with approval of the Buyer. For slurries or fluids containing abrasive materials, a minimum 100 mil abrasion resistant interior liner is required. Plain water containing systems do not require an interior abrasion resistant liner. Minimum wall thickness values shall meet the manufacturer's requirements for the design pressure and temperature of the system.

11.7.1.6. Copper Alloy Pipe: Copper alloy pipe shall conform to ASTM B43, Seamless Red Brass Pipe, or ASTM B88 Type K.

11.7.1.6.1. Copper Tubing: Copper tubing shall not be used for instrument and/or compressed air service. For other services copper tubing shall be used only with approval of the Buyer.

11.7.1.7. Polyvinyl Chloride Pipe: Polyvinyl chloride (PVC) pipe conforming to ASTM D1785 or ASTM D2241, schedule 80 minimum or equal wall thickness, shall be used only with approval of the Buyer. PVC for use outdoors shall be provided with means of UV protection including material additive, coverings, coatings, or insulation. Valves and inline components for use outdoors shall be fully supported on either side of the valve. For higher seismic zones, it is recommended to support under the component itself to avoid localized stress points in the pipe. Pipe shall be supported with supports suited for plastic piping or FRP piping. Use of steel supports or laying on Unistrut is not allowed. Pipe supporting and routing should be in accordance with pipe supplier's recommendations. Expansion joints shall be used on pump inlets and outlets. Seller shall verify that the suitability of the supplied material for the design temperature and pressure as well as ambient conditions in accordance with ASME NM. 1 or approved buyer designated design code.

11.7.1.8. Chlorinated Polyvinyl Chloride Pipe: Chlorinated polyvinyl chloride (CPVC) pipe conforming to ASTM F441 shall be used only with approval of the Buyer. CPVC for use outdoors shall be provided with means of UV protection including material additive, coverings, coatings, or

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insulation. Valves and inline components for use outdoors shall be fully supported on either side of the valve. For higher seismic zones, it is recommended to support under the component itself to avoid localized stress points in the pipe. Pipe shall be supported with supports suited for plastic piping or FRP piping. Use of steel supports or laying on Unistrut is not allowed. Pipe supporting and routing should be in accordance with pipe supplier's recommendations. Expansion joints shall be used on pump inlets and outlets. Seller shall verify that the suitability of the supplied material for the design temperature and pressure as well as ambient conditions in accordance with ASME NM.1 or approved buyer designated code.

11.7.1.9. High Density Polyethylene Pipe (HDPE): High-density polyethylene piping conforming to ASTM D3035 PE 4710 or ASTM F714, SDR 11 maximum, shall be used only with approval of the Buyer. Unless otherwise approved, all polyethylene piping joints shall be made using automatic type welding machines with displayed jointing cycle times and countdown facilities. A flanged joint shall be provided at connections to valves and at such other points in the piping system as necessary to facilitate dismantling of piping and Facility for maintenance purposes. Screwed joints shall not be used for polyethylene piping. Victaulic Couplings are not acceptable in use with HDPE piping.

11.7.1.10. Underground Piping Materials: Buried pipe shall be non-metallic, ductile iron, concrete, or carbon steel. The material selection shall be in accordance with the service requirements. Metallic underground piping shall be wrapped in accordance with AWWA standards.

11.7.2. FITTINGS MATERIAL: Fittings shall be constructed of materials equivalent to the pipe with which they are used, except for polypropylene lined cast iron or ductile iron fittings that shall be used with polypropylene lined steel pipe, and rubber lined cast iron or ductile iron fittings that shall be used with rubber lined steel pipe:

11.7.2.1. Butt Welding Fittings: The wall thickness of butt welding fittings shall be greater than or equal to the pipe wall thickness.

11.7.2.2. Forged Steel Fittings: Forged steel fittings shall be used for socket weld and steel threaded connections and shall conform to ASME B16.11.

11.7.2.3. Steel Flanged Fittings: Steel flanged fittings shall conform to ASME B16.5 or B16.47.

11.7.2.4. Integrally Reinforced Branch Connections: Reducing outlet tees should be used in lieu of specially designed adapters for branch piping 2-1/2inch and larger whenever possible as code allows. Specially designed adapters may be used in lieu of reducing outlet tees if standard reducing outlet tees are not available for the run and branch sizes specified. Branch connections 2 inch and smaller shall be made with special reinforced welding adapters or shall have special welded and drilled pads.

11.7.2.5. Galvanized Pipe Fittings: Fittings for galvanized steel pipe shall be screwed malleable, iron Class 300, conforming to ASTM A197, or grooved in accordance with ASTM A536, or galvanized forged steel.

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11.7.2.6. Rubber Lined Pipe Fittings: Flanged cast iron or ductile iron fittings used with rubber-lined pipe shall be lined with the same materials as the pipe with which they are used.

11.7.2.7. Brass and Bronze Fittings: Screwed brass and bronze pipe fittings shall conform to ASME B16.15. Flanged brass and bronze pipe fittings shall conform to ASME B16.24.

11.7.2.8. Polypropylene Lined Ductile Iron Fittings: Flanged ductile iron fittings used with polypropylene lined steel pipe shall be the ductile iron fittings conforming to ANSI A21.10/AWWA C110 and shall be lined with the same material as the pipe with which they are used.

11.7.2.9. Fiberglass Reinforced Plastic Fittings: Fittings for use with fiberglass reinforced plastic pipe shall be manufactured from material of the same type as the pipe. Joints shall be as required by the application.

11.7.2.10. Polyvinyl Chloride and Chlorinated Polyvinyl Chloride Fittings: PVC and CPVC pipe fittings shall be manufactured from PVC/CPVC material of the same type as the pipe with which they are used. The fittings shall have socket ends with internal shoulders designed for solvent cementing and shall be schedule 80 minimum.

11.7.2.11. Threaded Polyvinyl Chloride and Chlorinated Polyvinyl Chloride Pipe and Fittings: Where PVC or CPVC pipe is approved by the Buyer, drilled and tapped threads in the pipe wall are prohibited for any reason. Fittings shall be used for all branch, drain, vent, instrument, and other lines perpendicular to the pipe run.

11.7.2.12. HDPE Fittings: HDPE fittings shall be manufactured from HDPE materials of the same type as the pipe with which they are used. The fittings shall have butt fusion ends and an SDR no larger to the piping to which it is connected. HDPE fusion shall be in accordance with ASTM F2620.

11.7.2.13. Tubing Fittings: Stainless steel fittings shall be used with stainless steel tubing and shall be limited to 2 inches and smaller. Fittings for use with stainless steel tubing from sizes 1 inch to 2 inches shall be of the socket weld type conforming to ASME B16.11. Fittings for use with stainless steel tubing in sizes 0.75 inch or less shall be of the flareless "compression" type. Fitting material and bursting strength shall be equivalent to the tubing with which they are used.

11.7.2.14. All compression fittings for tubing shall be approved by Buyer.

11.7.2.15. Brass fittings shall be used with copper tubing and shall be of the flareless "compression" type. Braze joint fittings shall be used with ASTM B88, Type K copper tubing and shall be wrought copper, bronze, or brass, conforming to ANSI/ASME B16.22. Copper tubing shall not be used for instrument and/or compressed air service.

11.7.3. FLANGE MATERIAL: The dimensions and drilling of the flanges shall be to ANSI standards. Flanged joints shall be in accordance with the following requirements:

11.7.3.1. Steel flanges should have raised face flange preparation. Flat face flanges may be used where required by the Seller’s or component manufacturer’s design in addition to mating

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with cast iron, ductile iron, fiberglass reinforced plastic, polyvinyl chloride, HDPE or bronze flanges. Flanges should not be raised faced if connecting to a flat face flange, especially if FRP, PVC, DI, etc.

11.7.3.2. Segmented flanges for use in water systems in accordance with AWWA C207 may be used with approval of the Buyer for pipe exceeding a nominal diameter of 24 inch.

11.7.3.3. Flange Selection: Flanges mating with flanges on piping, valves, and Equipment shall be of sizes, drillings, and facings that match the connecting flanges of the piping, valves, and Equipment. Flange class ratings shall be adequate to meet the design pressure and temperature values specified for the piping with which they are used. Flanges shall be constructed of materials equivalent to the pipe with which they are used. Flanges in horizontal piping shall be installed as two-hole based vertically. Flanges in vertical piping shall be installed as two-hole based on plant north.

11.7.3.4. Steel Flanges: Steel flanges shall conform to ASME B16.5 or B16.47. Flanges associated with B16.47 shall be Series A. Flanges conforming to MSS SP-44 may be used where allowed by the governing design code.

11.7.3.5. Steel flanges 2-1/2 inch and larger except for grooved pipe shall be of the weld neck, slip-on type is permitted for Class 150 only, and all steel flanges 2 inch and smaller shall be of the socket type. Slip-on flanges shall generally be used only when the use of weld neck flanges is impractical.

11.7.3.6. Orifice flanges shall be provided with socket welded taps designed to ASME B16.36 requirements. Tap size shall meet the specified piping code and not be less than NPS ½. Buyer approval is required to use threaded taps.

11.7.3.7. Alloy steel and stainless steel flanges shall conform to ASTM A182.

11.7.3.8. Brass and Bronze Flanges: Brass and bronze screwed companion flanges shall be plain faced and shall conform to Class 150 or Class 300 classifications of ASME B16.24.

11.7.3.9. Flange Bolting: Flange bolting shall conform to the following requirements:

11.7.3.9.1. Bolting shall conform to the requirements of ASME B16.5 and ASME B18.31.2.

11.7.3.9.2. Bolted Flange Joint: Bolted flange joint assemblies shall meet the requirements of ASME PCC-1: Guidelines for Pressure Boundary Bolted Flange Joint Assembly

11.7.3.10. If flanges are used in NEC Division 1 gas systems, FM approved flange guards must be provided.

11.7.4. GASKETS MATERIAL:

11.7.4.1. Non-metallic, full faced gaskets shall be used with flat face flanges. For steam, fuel gas, other hazardous fluid applications spiral wound gaskets shall be used with raised face flanges. Gaskets containing asbestos are not acceptable

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11.7.4.2. Compressed Fiber Gaskets: Compressed fiber gaskets shall be in accordance with ASME B16.21, and materials shall meet or exceed the system design pressure and temperature.

11.7.4.3. Spiral Wound Gaskets: Spiral wound gaskets shall be constructed of a continuous stainless steel ribbon wound into a spiral with non-asbestos filler between adjacent coils. The use of alternative ribbon material will be based on fluid compatibility. Spiral wound gaskets shall be in accordance with ASME B16.20.

11.7.4.4. Rubber Gaskets: Rubber gasket materials shall be cloth-inserted sheet and shall be in accordance with ASME B16.21.

11.7.4.5. Teflon Gaskets: Teflon gasket materials shall be glass reinforced PTFE sheet. Teflon gaskets shall be restricted for use with ASME Class 150 and Class 300 systems at temperatures 400 °F and below.

11.8. Piping unions shall be avoided where flanged connections are practical. Unions shall conform to MSS SP-83. Piping unions shall 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 shall be the same as the fittings in the piping systems in which they are installed.

11.9. Control and Instrument Piping and Tubing: Control and instrument piping and tubing shall be in accordance with ASME B31.1, but in no case shall be less than 0.065-inch minimum wall thickness. Tubing for control and instrument air lines shall be 3/8 inch to 1/2 inch outside diameter stainless steel tubing; Type 316, schedule 40S stainless steel pipe shall be used for larger sizes. Instrument lines other than air lines shall be 3/8 inch outside diameter stainless steel tubing. Stainless steel tubing shall meet the requirements as stated within this specification.

11.9.1. Air tubing supplied with pneumatic devices shall be 3/8 to 1/2 inch stainless steel. Tubing supports shall be furnished to minimize vibration. Tubing bends shall be made without reducing the internal diameter of the tubing. All tubing shall be blown clean with dry compressed air after routing, but prior to attachment to devices at either end

11.9.2. Tubing supports shall be hot-dip galvanized Uni-strut, or acceptable equal. Cut or welded surfaces shall be repaired with a cold galvanizing compound.

11.9.3. Each control enclosure requiring a control air supply shall be furnished with the following:

a. A control air header
b. A ball valve to shut off the air supply to the header
c. A blowdown valve at the low point
d. An air supply shutoff valve shall be furnished for each internal airline connection to the control air header.

11.9.4. Piping and tubing within control and instrument enclosures shall be arranged to allow any device to be serviced, disconnected, or removed from the enclosure without

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disconnecting piping or other devices. Tubing for external connections shall be terminated on bulkhead fittings in the bulkhead plate.

11.9.5. Each tubing termination shall have an air supply shutoff valve shall be identified by a metal tag stamped with the identification/tag number for the connected device.

11.9.6. Piping schematic, connection, and interconnection diagrams shall be submitted to the Buyer for acceptance.

11.10. Protection for Shipment: All flange faces, machined surfaces, and threads shall be clean and shall be protected from damage during shipment. Flange faces and machined surfaces shall be protected with wood, plastic, or metal covers. Couplings and threaded openings shall be protected by steel pipe plugs or by plastic protectors. Open ends of piping and tubing shall be cleaned and sealed and taped or supplied with end caps prior to shipping.

11.11. Joints for low pressure steam, water, drain and air services shall be of approved design, in which all coupling together of pipes and valves 2 1/2" and larger, shall be by means of butt welded or flanged joints, unless otherwise specified or approved by Buyer. Flanges shall be square to the pipe. Steel piping 2" and smaller may, in approved locations, be coupled using socket type fittings or with screwed couplings, except in Fuel Gas or Lube Oil piping which may use butt welded connections. Union fittings may also be used. All galvanized pipes shall have screwed joints unless otherwise approved. Threaded connections at Equipment shall be provided with unions or a threaded by plain end nipple and a socket type flange. Threaded pipe connections are permitted on drains that are atmospheric at both ends such as pump base plate drains, silencer drains, etc.

11.11.1. Joints for oil and gas services shall be of flanged or butt-weld construction and shall be of approved design. Screwed fittings shall not be used for natural gas service. Miters are not allowed in gas service.

11.12. PIPE HANGERS AND SUPPORTS: The supports will be designed to all applicable loading scenarios defined in ASME B31.1, Section 101 and in MSS SP-58, Section 6. Code, seismic and safety classifications, and other necessary data are defined herein. For supports specified to be designed in accordance with ASME B31.1, the loads should not be based on increasing the allowable stress level in hanger components by 20%, as allowed by the code. For Covered Piping Systems as defined by ASME B31.1-2024, hangers and supports shall be placed to limit stress due to sustained load (as calculated by B31.1-2024 Eq. 15) to 80% of Code Allowable.

11.12.1. Seller shall provide a bill of material tabulation, indicating weight of support, correct total loading, and any/all other necessary data.

11.12.2. Seller's supports designer shall analyze and determine the piping loads and movements that will exist at any time, including all applicable forces acting simultaneously, and shall design and detail the supports in accordance therewith. The temperature of piping to be used in the design of supports shall be considered. Consideration of piping movements shall not be made before the maximum temperature of such piping is indicated.

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11.12.3. For systems where thermal growth will occur, sufficient clearance shall be provided to prevent interference between supports and surrounding Equipment during this growth.

11.12.4. Clevises, Turnbuckles, Rods: All clevises and turnbuckles shall be forged steel and compatible with the material of rod. Turnbuckles and locknuts shall be provided, if not supplied internally, with constant support and variable spring hangers.

11.12.5. Horizontal Movement: The supporting element units shall be designed so that supporting rods are within 1/2 degree from the vertical in the hot position, unless otherwise noted on the drawings or herein. Pipe clamps or beam connections shall permit the horizontal movement of pipe (when hot) to swing the hanger rod into the vertical position. The maximum vertical offset between pin-to-pin connections when cold shall be four degrees.

11.12.6. Saddles: Saddles shall be provided for any bottom-supported (trapeze) horizontal lines having an insulation thickness over 1 in. Pipe shoes may be used in lieu of saddles when required by the Seller's design. Rod attachments at clamps shall be clear of the insulation.

11.12.7. Riser Clamps: Surfaces bearing against pipe attachments shall be ground so that all parts of pipe attachments will be bearing against clamp surfaces.

11.12.8. Constant-Support-Type Units: Spring-type units shall be of the constant-support type only where the following conditions exist:

a. At locations where it is necessary to minimize the transfer of stresses from one support to another or to Equipment connecting with the supported piping.
b. Where load variations exceed the limitations specified below for variable-type supporting units.

11.12.9. Variable-Support Type Units: Variable-support spring-type units shall be designed for a maximum of Twenty-five percent (25%) variations in support load for the total vertical travel between hot and cold positions.

11.12.10. Where it is necessary for the Contractor to weld to structural steel members in order to carry pipe supports, anchors, etc., the welds for securing the plates to the structural members shall in all cases be parallel to the length and located at web of the structural member.

11.12.11. Pipes shall not be supported from or attached to cable trays, HVAC ducts, conduit or their associated hanger supports. Small bore pipes in steam drains service may be supported from the source header in limited circumstances wherein a formal stress analysis will be conducted to validate stresses and support loads. Small bore instrumentation piping and/or tubing may be supported from the source header using brackets when necessary based on Seller's design. Pipe support rods shall not pass through cable trays or HVAC ducts unless specifically reviewed and accepted by the Buyer's Engineers.

11.12.12. Welding of extension pieces to support rods is prohibited for all size rods.

11.12.13. Supports for Small Piping and Tubing: Acceptable support methods for small diameter piping and tubing (instrument sensing, control air, instrument air and sampling piping

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and tubing; capillary leads; etc.), shall include but are not limited to the pipe or tubing being laid on channels or having continuous supporting means such as Tube Track, Unistrut, or other suspension system. Small diameter piping and tubing may also be supported non-continuously provided that spans are adequate to prevent excessive sag, bending, or shear stresses in the piping in accordance with ASME B31.1. Supporting systems shall be subject to review by the Buyer's Engineers.

11.12.14. Travel Stops and Locks: All constant-support and variable-support units shall be provided with hydrostatic test and erection locks, installed and preset in the cold position on the units before they are shipped. All constant- and variable-support units shall be designed and constructed with the following provisions: Overtravel in either direction is stopped before the spring(s) would be overstressed. Failure of spring(s) would not cause the unit to release the load. The following attachments shall be of the same material as the piping to which they connect:

a. All clips, lugs, plates, saddles, etc., welded to the piping pressure boundary.
b. All straps, ring hangers, clamps, etc., fastened to piping by means other than welding, where design temperature of piping is greater than 500°F.
c. All straps, ring hangers, clamps, etc., fastened to piping by means other than welding may be of carbon steel material where design temperature of piping is 500°F or less.
d. Austenitic stainless steel U-bolts may be used in the supports and shall be solution annealed after hot or cold forming

11.12.15. Anchors, Guides and Restraints: Anchors, guides and restraints shall be designed per ASME B31.1-2024 for the imposed loading by a method of analysis acceptable to Buyer. For non-analyzed support, Seller standard cold support designs will be utilized. The specific means provided shall not interfere with the intended thermal movement of the piping system. Calculations for such items designed by Seller shall be submitted to Buyer for review and/or record.

11.12.16. Galvanizing: All suspension system hardware that may be in contact with un-insulated copper pipe or tubing or other dissimilar metal piping shall be of materials or have a design which will provide protection against galvanic corrosion. Galvanizing shall conform with the applicable requirements set forth in the latest editions of ASTM Standard Specification A 123, A 153, and A 386; and the recommended practice set forth in A 384 and A 385.

11.12.17. Inspection and Testing: Any lug attachments welded to Contractor's auxiliary steel in the shop shall be ultrasonically tested to inspect the full penetration weld. Acceptance criterion shall be AWS D1.1, Section 8.15.

11.12.18. Each spring support and snubber unit shall have a metal nameplate attached in a conspicuous place. Supports shall be oriented such that the nameplate is visible from the nearest platform. The following information shall be clearly stamped thereon:

a. Manufacturer's model and/or catalog number.
b. Manufacturer's serial number.
c. Size

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d. Load (in pounds), as follows:
    1. Calibrated load for snubbers.
    2. Cold and hot loads for variable supports
    3. Operating load for constant supports
e. Seller's identification number
f. Travel (in inches), where applicable
g. "Cation" or "Danger" information

12. VALVES: Valve pressure classes, sizes, types, and body materials shall generally be in accordance with the following requirements. Valve end preparations shall be in accordance with Table 1 at the end of this Section. Valves shall be appropriate for the service intended. Any valve used for modulating/control service shall be specifically designed for such service. Special features and special application valves shall be utilized where required. Valve bodies shall be marked in accordance with MSS SP-25. Valve end to end dimensions shall comply with ANSI B16.10.

12.1. Valves over 2 inch nominal size which are intended for low pressure steam or steam drain services shall have bodies of cast or forged steel those intended for water, water drains or air services shall have cast iron, cast steel, or forged steel bodies; valves of 2 inch nominal bore and under may be of the inside screw type. Valves of 2-inch nominal diameter and below shall have a minimum rating classification of Class 600 for all services. Intermediate or special class valves with weld end preparation may be used for systems above Class 1500.

12.1.1. All valves intended for high pressure steam, feedwater, drain, or any other services subject to high pressure and temperature shall be of approved make and shall have cast or forged steel bodies with covers and glands of approved construction. Approved means shall be provided to prevent any accumulation of pressure between the discs of high-pressure steam or feed-parallel slide valves. In the case of valves with by-passes, the inter-gate space of the main valve shall be connected to the inter-gate space of the by-pass valve.

12.2. All vents, drains, and instrument connections rated ASME B16.5 CL600 or greater shall utilize double block valves. Valve rating is defined in B16.34. Gas services shall have integral bleeds. A double block and bleed configuration shall be provided when piping is penetrating into a confined space.

12.3. All isolating valves shall be capable of being locked in both open and closed positions. All valves shall operate smoothly and steadily in both opening and closing directions. All valves shall be free from flow induced vibration and shall comply with all sound levels when specified. All valves shall be fitted with open/closed indicators that may be readily seen from the operator's level and in the case of those valves fitted with extended spindles (stems); indicators shall be fitted both to the extended spindle and to the valve spindle. Spindles of all valves for use outdoors shall have covers for weatherproof protection. Each valve shall be tagged with a permanent stainless steel tag with the unique number stamped on the tag. Tags shall be visible by operators after installation is complete.

12.3.1. Eyebolts shall be provided where necessary to facilitate handling heavy valves or parts of valves.

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12.4. An arrow shall be clearly displayed on the valve body in the form of castings, stamping or plate indicating the direction of the flow.

12.5. All valves shall be arranged to close when the hand wheel is rotated in a clockwise direction when looking at the hand wheel from the operating position. The direction of rotation to close the valve shall be clearly marked on the face of each hand wheel.

12.6. Valve materials shall be suitable for operation at the design pressure and temperature of the piping to which they are connected in accordance with ASME B16.34. Seats and faces shall be of low friction, wear-resistant materials.

12.7. Valves in throttling service shall be selected with design characteristics and of materials that will resist erosion of the valve seats when the valves are operated partly closed. Throttling valves shall not be allowed to operate below the valve manufacturer's minimum seat protection opening.

12.8. Valves with position stops that limit the travel of each valve in the open or closed position shall have the stops located on the exterior of the valve body to provide clear indication of full open and close positions.

12.9. In general, valves shall be standardized to use the same valve type and manufacturer to the extent possible.

12.10. All steam and water valves operating at less than atmospheric pressure shall have vacuum packing suitable for the design conditions. Where a valve can experience both pressure and vacuum, pressure/vacuum packing shall be provided.

12.11. Valves shall be installed to meet the valve manufacturer’s requirements. For example, if the manufacturer requires a valve to be oriented with the actuator vertical, the actuator shall not be installed in any other way but the valve actuator vertical. Valves shall not be installed in an inverted position unless approved by the Buyer.

12.12. Valves having butt welded, flanged, socket welded, or threaded connections shall have ends prepared in accordance with the applicable ASME standards. Steel flanges shall be raised face type unless otherwise required. Cast iron and bronze flanges shall be flat faced type. Butt weld end connections shall be prepared as stated within this specification.

12.13. Steel body gate, globe, angle, and check valves shall be designed and constructed in accordance with ASME B16.34, as applicable. Valve bodies and bonnets shall be designed to support the valve operators (handwheel, gear, or motor) with the valve in any position without external support. Cast carbon steel, A216 Gr WCB/WCC, valves shall be limited to a maximum system design temperature dictated by the governing design code or 775°F whichever is less. Cast chrome-moly steel valves, A217 Gr. WC6, 1 percent chrome - ½ percent molybdenum material, shall be limited to 950°F. P22, A217 Gr. WC9, 2¼ per cent chrome - 1 per cent molybdenum, materials shall be limited to 1200°F. Forged equivalents may also be used in accordance with ANSI B16.34.

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12.13.1. Steel Body Valves 2 inch and Smaller: Steel body valves 2 inch and smaller will have forged steel bodies unless specified otherwise by the Buyer. Forged steel valves complying with the standards and specifications of ASME B31.1 shall be used within the manufacturer's specified pressure temperature ratings. The use of Class 1500 and 2500 forged steel valves will be limited in accordance with the pressure temperature ratings specified in ASME B16.34 and the criteria established by the Manufacturers Standardization Society (MSS).

12.13.2. Steel Body Valves 2-1/2 inch and Larger: Steel body valves 2-1/2 inch and larger shall have forged or cast steel bodies. The face-to-face and end-to-end dimensions shall conform to ASME B16.10. The use of these valves shall be in accordance with the pressure temperature ratings specified in ASME B16.34, as applicable.

12.14. Gate, globe, and angle valves shall be provided with back seating construction. Gate, globe, and angle valves shall be outside screw and yoke construction. Unless otherwise specified in the Technical Specifications, all gate valves shall follow the table below. All gate valves greater than 2 inch nominal size shall be of the full-port gate type and when in the full open position, the bore of the valve shall not be obstructed by any part of the gate. Globe and angle valves shall be supplied with industry standard conventional ports. Approved means shall be provided to prevent any accumulation of pressure between the discs of high-pressure steam or feed-parallel slide valves. In the case of valves with by-passes, the inter-gate space of the main valve shall be connected to the inter-gate space of the by-pass valve.

NPS	CL	Temp	Type
≥6”	≥600	≥500°F	Parallel
≥6”	<600	≥500°F	Double-disc wedge
≥6”	≥600	<500°F	Double-disc wedge
<6”	All	≥500°F	Double-disc wedge
All others			Flexible wedge

12.15. Check valves used on pump discharge installations, and on other applications in which the valves may be subjected to significant reverse flow water hammer or fluid surges, shall be of the non-slam type and installed in the horizontal. Check valve type shall be per the table below. All check valves shall be designed for installation in either horizontal or vertical piping with upward flow. Stop check valves, where specified, shall be Y-pattern globe type. Bronze check valves 2 inch and smaller shall be Y-pattern swing disc type or guided piston type. The resilient seat material shall be suitable for the operating fluid. Where check valves are installed, examination or replacement of the internal parts shall be possible without removing the check valve from the line.

Design Pressure	Line Size	Check Valve Type
All Pressures	NPS 6 and Smaller	Guided Piston, Swing
All Pressures	Larger than NPS 6	Non-Slam Tilting Disc

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Design Pressure	Line Size	Check Valve Type
< 400 psig (Water and Air)	All Sizes	Butterfly style check valves (twin flappers spring-mounted on a center stem) with resilient seats, Non-Slam Tilting Disc

12.16. Butterfly Valves: Butterfly valves shall be used only where specifically approved by the Buyer, and only in lines NPS 4 and larger. Butterfly valves shall be limited in application to water and air services. Resilient materials in the valve shall be suitable for the fluid being transported. Rubber-seated butterfly valves shall generally conform to the requirements of MSS SP-67, Butterfly Valves, with sealing between the disc and body by a renewable, resilient seat secured to the body. Sealing between the disc and body of butterfly type valves shall be renewable metal to rubber facings secured to the disc and body in an approved manner. Valves of the lugged wafer type shall be designed for installation between two flanges. Wafer type valves with through holes shall not be used without specific approval from the Buyer. Butterfly valves shall be suitable for bi-directional shutoff at rated pressure and allow for the removal of piping on one side while maintaining the pressure boundary on the other side.

12.16.1. Butterfly valves for seawater service shall have nickel-aluminum-bronze discs with resilient seats constructed of Buna N or other suitable synthetic rubber compound. Seats shall be retained in the valve body by mechanical means without retaining rings, segments, or hardware of any kind in the flow stream. Shafts shall be completely isolated from the seawater.

12.17. Bronze and Brass Body Valves: Gate valves shall be inside screw, rising stem type with solid wedge disks. Globe valves shall have renewable seats and disks. Bronze and brass materials shall be limited to a system design pressure of 350 psig and a design temperature of 200°F.

12.17.1. Bronze gate and globe valves 2-1/2 inch and larger shall be of the outside screw rising stem construction. Gate valves shall have either integral or renewable seats. Globe valves shall have renewable seats. The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer and in accordance with the criteria established in MSS SP-80, Bronze Gate, Globe, Angle and Check Valves.

12.18. Plug Valves: Plug valves shall be of the eccentric lubricated, or Teflon sleeve plug type, as required by the service. Plug valve bodies shall conform to the requirements of ASME B16.10 for short pattern dimensions, material thickness, and material specifications. The use of these valves shall be in accordance with the pressure temperature ratings specified by the manufacturer.

12.19. Ball Valves for High Temperature Service: Ball valves for high temperature service shall have metal seats, hardened balls, and shall meet temperature/pressure ratings of ASME B16.34. Valves shall have blowout proof stems.

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12.20. Ball Valves for regular service: All other ball valves shall have full area ports, Teflon seats and seals, and chromium plated carbon steel or stainless steel balls, and shall not require lubrication. Ball valves shall have provisions for locking in-place if used for other than full open or closed service.

12.20.1. Ball valves for natural gas service shall conform to API-607.

12.21. Diaphragm Valves: Diaphragm valves shall be straightway or weir bodies, with flanged ends faced and drilled for installation between flanges, and shall not be used unless approved by the Buyer.

12.22. PVC and CPVC Valves: PVC and CPVC valves will be constructed entirely from polyvinyl chloride, chlorinated polyvinyl chloride, and Teflon. Bodies will be double entry flanged or true union screwed type.

12.23. Branch Isolation Valves: Isolation valves shall be provided in 2 inch and smaller branch lines from main piping headers and equipment.

12.24. Valve Operators: Valves shall be provided with manual or automatic operators as required for the service application and system control philosophy. All operators shall be sized to operate the valve with the valve exposed to the design pressure on one side and atmospheric pressure on the other side.

12.25. Automatic operators shall be motor, piston, or diaphragm type, and shall be provided where required for automated process control or for safety reasons. Air-operated valves shall be provided for modulating service and/or where a valve is required to fail in the open or closed position.

12.25.1. Manual operators shall be lever, handwheel, or gear type, with the use of lever operators to be limited to valves requiring a maximum of 90° stem rotation from full open to full closed position on valve sizes 6 inch and smaller. Lever arm length shall not exceed 12 for any valve unless approved by the Buyer. The direction of operation to close the valve shall be clearly marked on the face of each handwheel. Gear operators shall be supplied for all manually operated valves NPS 8 and larger and on smaller valves when the lever pull of the valve is greater than 50 pounds at the maximum operating torque requirement. Isolation valves installed in areas inaccessible from platforms shall be furnished with chain wheels where approved by Buyer. The operating mechanism for large size valves shall be such as to ensure that a minimum of maintenance is required.

12.25.2. Locking devices shall allow the valve to be locked either opened, closed, or in place (as required) with a standard padlock.

12.25.3. Limit switches, when furnished, shall be provided for the opened and closed position of the valve.

12.26. All valve bonnets for valves with design temperatures of 150 °F or higher shall be provided with bonnet over pressure protection. For vents, drains, and instrument isolation valves, internal drains are an acceptable mean to provide bonnet over pressure protection. All other valves

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shall have external equalizer pipe and equalizer valve to ensure that bi-directional shutoff of the valve may be maintained. Equalizer pipe and equalizer valve shall be located outside of the insulation. The drains shall prevent the bonnets from being exposed to excessive pressure when the bonnet is full of water and the valve is exposed to elevated temperatures.

12.27. Valves shall not be equipped with bypasses unless specifically required.

12.28. Manually Operated Valves: Manual valves that are normally operated during facility operation, and manual block valves required for normal plant start-up and shut-down, shall be located such that they meet the intent of the criteria specified.

12.29. Valves for Oil Services: All valves intended for lubricating oil services shall be of cast or forged steel construction with flanged, butt weld, screwed or socket-welded ends. Weld-on flanges will not be acceptable. All valves intended for fuel oil or lubricating oil services shall be fire safe and shall be provided with suitable features in the valve to ensure electrical continuity between the valve stem and the body of the valve. Valve connections to piping not included in the scope of work shall be flanged. No aluminum or zinc alloys or similar low melting material shall be included in their construction. All valves shall provide reliable tight shut-off and be capable of easy operation after long periods in one position.

12.30. No aluminum or zinc alloys or similar low melting material shall be included in the construction of valves. All isolation valves shall provide reliable tight shut-off and be capable of easy operation after long periods in one position.

12.31. Valves for Air Services: Ball valves limited in size to 2-inch nominal diameter may be used in lieu of gate and globe valves (except for throttling and control purposes) for compressed air systems. Valves above 2-inch nominal diameter shall be of the gate valve type in the compressed air system. The valves shall have provision for locking in-place if used for other than full open or closed service. Ball valves shall be of suitable construction for servicing in position without being removed from liners and shall be top or bottom but not side entry.

12.32. Valves for Hydrogen Services: Gate, angle and globe valves used for hydrogen services shall have a stem sealing feature and disc to seat of a construction suitable for containing the fluid without any leakage.

12.33. Valves for Fire Protection Services: All valving for fire protection and fire safe service shall be of designs specifically for the service and shall be UL Listed or FM Approved.

12.34. Valves for Natural Gas Services: All isolating valves intended for use in natural gas services shall be AGA approved manufacture and shall be full bore, 90° turn, ball or plug valve type, PTFE coated (PTFE is not acceptable for heated fuel gas), with cast or forged steel bodies and butt welded ends in accordance with API 6D. The valves shall be classified as fire resistant, in as much as the valves shall incorporate either a primary or secondary metal to metal seal to ensure negligible external leakage which could contribute to the risk of fire and, when closed, shall minimize through leakage when in a fire. All valves shall be fitted with an anti-static device, which shall ensure electric continuity between the ball stem and the body of the valve. No aluminum or zinc alloys or similar low melting material shall be included in their construction. Valves up to 2 inch in size may be of the non-lubricated type, valves greater than 2 inch in size

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shall incorporate design features that enable lubricant to be injected under pressure between the plug and body whilst the valve is in service. All valves shall incorporate sliding sealing surfaces such that further movement of the closing part is provided after gas shut-off. All valves shall provide reliable tight shut-off and be capable of easy operation after long periods in one position. Where solenoid operated valves are used in conjunction with gas-powered actuators for automatic isolation, the valves shall be generally in accordance with ANSI standards. The solenoid shall be of the normally closed, direct operated type, such that the valve is closed when the coil is de-energized.

12.35. Cast iron material shall be limited to non-shock service, a system design pressure of 200 psig and a design temperature of 200°F. Seller shall submit proposed systems for cast iron for Buyer approval and receive approval prior to use.

12.36. Ductile iron material shall be limited to a system design pressure of 350 psig and a design temperature of 400°F. Seller shall submit proposed systems for ductile iron for Buyer approval and receive approval prior to use.

12.37. Pressure Reducing Valves: All pressure reducing valves shall be perfectly stable, quiet and free from vibration or cavitation in operation when pressure reducing any flow up to the maximum flow, and shall be suitable for continuous use at the operating temperature. Pressure gauges and transmitters downstream of PRVs. A pressure relief valve shall be provided on the downstream (outlet) side of each pressure reducing valve, where the downstream piping system is not designed for the upstream pressure, and shall be capable of exhausting to atmosphere the maximum discharge of the reducing valve without undue build-up of pressure on the low pressure side. The discharge from relief valves in steam services shall be routed to a safe location outside of buildings.

13. CONTROL VALVES: Control valve sizing shall consider valve application and the minimum, normal, and maximum-operating conditions specified to ensure suitable valve capacity, trim, and range-ability. Control valve sizing shall be based on IEC 60534-2-1. All control valves shall have a sufficient overload range. Valve operating range shall be between valve manufacturer minimum and 85% Cv. Valves shall be sized for flow requirements taking into account the appropriate CV factor. Where load fluctuations are excessive, dual split range control valves shall be installed in parallel. One valve handles the start-up condition and the other valve covers normal or higher load operation. Control valve end preparations shall be in accordance with Table 1 at the end of this Section. Butt welding end connections shall be prepared as stated within this specification. All valves required to be operated for normal transient operations shall be actuated.

13.1. Each control valve shall have an upstream and downstream isolation valve with a maintenance drain upstream of the control valve. One (1) globe bypass valve adequate for full flow shall be provided for control valves unless specifically stated otherwise. Bypass valve shall have a Cv as nearly matched to the associated control valve as practical. Critical and/or high-pressure control valve stations shall be provided with manual or inching type motorized bypass valves. Pressure and temperature gauges and transmitters shall be provided upstream and downstream of control valves.

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13.2. Control valves in general shall be of the single seat, cage guided, globe pattern type with bolted bonnets for steam and clean liquid/gas applications. Valves for liquid/gas applications containing suspended solids, and valves that are too small for cage guiding, shall be top guided. Stem and port guided valves are not acceptable for any application. Other valve body pattern types (butterfly, ball, eccentric disc, etc.) may be used if worst-case service conditions are acceptable to the valve manufacturer. Valve body materials shall be based on the design service conditions for use under the governing design code. Valve bodies shall be hydrostatically tested in accordance with ISA 75.19.01. Valve bodies shall be marked in accordance with MSS SP-25.

13.3. Control valve body size shall be no more than two nominal sizes smaller than the line in which the valve is to be installed. Valve body sizes of 1-1/4 inch, 3-1/2 inch and 5 inch shall not be used. Control valves shall conform to the face-to-face or end-to end dimensions of ASME B16.10. All welding performed on valves shall conform to BPVC section IX. All welds shall be nondestructive inspected to the requirements of ASME B31.1. Threaded end valves shall not be used without approval of the Buyer. Cast iron bodies for control valves will not be accepted.

13.4. Control valve noise levels shall meet the requirements specified herein.

13.5. Valve seat leakage class should be minimum ANSI/FCI 70-2 class IV, and valve failure positions shall be determined by process requirements.

13.6. An arrow shall be clearly displayed on the valve body in the form of castings, stamping or plate indicating the direction of the flow.

13.7. On/off valves for combustible fluid valves shall have fire safe seats and seals for valves and actuator where required by applicable codes and regulations. Metal seated ball valves shall be provided for liquid and steam services in automatic on/off service class 300 or greater. Soft seated ball valves shall be provided for air and gas services.

13.8. Control valve actuators shall be the pneumatic-spring diaphragm or piston type. The actuator shall be sized to shut off against at least 110% of the maximum shutoff pressure. Maximum shutoff pressure is difference between the design pressure upstream of the valve, and ambient pressure downstream of the valve. Actuators and associated solenoid valves shall be designed to function with instrument air pressure range as specified herein. Control valve accessories, excluding controllers, shall be mounted on the valve actuator unless severe vibration is expected.

13.9. Control valve trim shall be stainless steel minimum, hardened for erosive service as required by the design conditions. Severe service conditions may dictate consideration of other materials.

13.10. Packing glands shall be equipped with flange-style gland followers, secured by two bolts. No asbestos is permissible.

13.11. Extension bonnets shall be provided on throttling service below -20°F, or in accordance with the manufacturer's recommendation. On-off control valves shall use high temperature packing in lieu of extension bonnets when practicable.

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13.12. Piston actuators shall be furnished with pneumatic trip valve, volume tank, piping, and necessary components to lock-in supply air pressure on loss of supply air pressure to actuator to ensure proper failure position. Limit switches shall be provided at the failure position of the valve to confirm its position.

13.13. Manufacturer's shop test certificates shall be furnished for the hydro-test of control and pressure reducing valve bodies and for the leakage rates across control valve seats.

13.14. Automatic Recirculation Control (ARC) valves are not acceptable for use in pump minimum flow control or any other application.

13.15. MOTOR OPERATED VALVES: Motor operated valves shall be complete in all respects including the motor and the necessary controls for automatically stopping the motor when the valve gate has reached the 'full open' or 'full closed' position. The control gear shall preferably form an integral part of the valve assembly. A clutch mechanism shall be included to prevent damage in the event of jamming. The motor and control gear shall be placed in such a position relative to the valve that there is no possibility of leakage of steam or water from the valve joints or glands blowing on to the motor or control equipment. Hand operation facility shall be provided and be so arranged that the hand-operated mechanism must be disengaged before the operating motor can be energized. Motor operated valves shall be provided with hand wheels having plain polished rims.

13.15.1. Where valves are required to be remotely controlled, a lockable changeover device shall be fitted at the valve local control position. Where valves are required to be automatically controlled, they shall be provided with local controls for maintenance purposes and with a lockable changeover device fitted at the valve local control position.

13.15.2. Where required, limit switches with an approved number (minimum of two) of contacts shall be provided for control and interlocking purposes.

14. SPECIALTIES: Mechanical specialty end preparations shall be in accordance with Table 1 at the end of this Section. Mechanical specialties with butt welded end connections shall be prepared as specified within the contents of this Section, and the articles below.

14.1. High-Pressure Steam Traps (ASME B16.5 Class 600 and above): High-pressure steam traps shall be of disc or inverted bucket type with integral strainers, and steel, chrome moly, or stainless steel bodies as required by design temperature. Traps shall be installed with shutoff valves, bypass valves, and a drain for maintenance.

14.2. Low-Pressure Steam Traps (ASME B16.5 Class 300 and below): Low-pressure steam traps shall be of float or thermostatic type with integral strainer and internal check valve. Traps shall be installed with shutoff and bypass valves.

14.3. Expansion Joints: Expansion joints shall be suitable for the pressure, temperature, and axial/lateral/rotational movements required by the system design. All joints shall be designed for full vacuum. End connections, size, and materials shall be compatible with adjacent piping or equipment.

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14.3.1. Metal expansion joints shall have Type 316 stainless steel bellows and pipe ends of a material compatible with the attaching pipe. Joints shall be supplied with internal liners, protective outer shrouds, and restraining rods. Metal expansion joints shall conform to Expansion Joint Manufacturer's Association (EJMA), ASME, and ANSI standards.

14.3.2. Rubber expansion joints shall be of the open arch design unless otherwise noted and shall be constructed of multiple layers of fabric impregnated with rubber and reinforced with steel as required. Expansion joints shall be furnished with tie rods. Rubber expansion joints shall be in accordance with Rubber Expansion Joint Division of the Fluid Sealing Association.

14.4. Safety and Pressure Relief Valves: Safety and pressure relief valves shall be provided as required to protect piping systems and equipment and as required by Code. The set pressure of the valve shall be a minimum of 10% higher than the maximum operating pressure of the system. The valve type and materials of construction shall be selected based on system pressure and temperature requirements. The valves shall be designed to allow an adjustment range of 10% above and below set pressure. All valves shall be designed to relieve to atmospheric pressure unless a backpressure or differential is required. Safety and pressure relief valve vent stacks for steam service shall be sized to prevent blowback and shall be routed vertically and away from platforms and walkways for personnel safety. Safety relief valves shall be ASME code stamped, factory calibrated, and provided with a certified calibration sheet. A copy of the calibration sheet shall be submitted to the Buyer and included in the Comprehensive Equipment Manual (CEM). Isolating valves shall not be installed on either the inlet or outlet of safety valve piping.

14.4.1. Safety relief valves shall be of the high capacity, flat seated, reactive type attaining full lift on pop and having a maximum blow down of 3% (or as specified by the applicable Code and Standards) of the set gauge pressure. Safety relief valves ASME Class 900 and above or in steam service shall have welded ends at the inlets and flanged outlets. All other safety relief valves shall have welded OR flanged ends at the inlets and flanged outlets. They shall be of the spring loaded or torsion bar, angle valve type. Safety relief valves shall be of the spring loaded or torsion bar, angle valve type, and shall have flanged ends at the inlets and outlets.

14.4.2. Pressure relief valves shall be of the spring loaded, angle valve type. The open spring casing type shall be used for air and saturated steam only. As a minimum, nameplates on safety and relief valves shall indicate manufacturer’s name, model number, size, set pressure, capacity, orifice size, materials, and approving authority stamp symbol.

14.4.3. Valves shall be equipped with lifting levers. Where required, test gags shall be furnished for hydrostatic testing of the system when higher than the valve set pressure. Valves shall be factory set for pressure.

14.4.4. Silencers shall be provided for safety relief valves if necessary to meet noise requirements. Silencers are required for safety relief valves in steam services. Silencers for these relief valves shall be designed not to exceed 110 dBA at the nearest operating platform. For any silencers which are supported by materials not supplied by Seller, the silencers shall include attachment lugs (by Seller) for supporting on steel support framing (by Others). Attachments shall be sized and constructed according to good industry practice with consideration to weight, operation thrust loads. Calculations shall be provided showing the total capacity of the lifting lugs.

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The lugs shall be designed for bolting to the steel support framing. Bolt holes shall be slotted to allow for ease of installation.

15. TANKS AND VESSELS:

15.1. Carbon steel tanks shall have a minimum corrosion allowance of 1/16 inch. Coated pressure vessels shall be avoided.

16. HEAT EXCHANGERS:

16.1. Heat exchangers shall be code stamped in accordance with the applicable requirements of the ASME Section VIII, shall be registered with the National Board and shall be supplied with appropriate relief valves. Requirements of the HEI Standard for Power Plant Heat Exchangers shall apply except where the requirements of this Standard Specification are more stringent.

16.2. All heat exchangers shall be provided with associated pressure relief devices Relief valves shall be of the enclosed-spring type. Relief valves 1-1/2 inch and larger in size shall be provided with a packed stem and lifting levers. All portions of the heat exchanger shall be drainable without breaking piping connections. Skid bars, sealing strips, and support plates that trap liquid shall also be notched for full drainage. Heat exchanger design shall allow nitrogen blanketing for long-term layup.

16.3. Heat exchanger shall be hydrostatically tested.

16.4. A 1/16-inch corrosion allowance shall be added to the minimum wall required by ASME Section VIII for all carbon steel pressure parts, except tubes.

16.5. Nozzle connections shall be suitably reinforced in accordance with ASME Code requirements.

16.6. SHELL AND TUBE: Shell and tube heat exchangers shall be designed per TEMA Class C. Both shell and tube sides shall be provided with vent and drain connections as required. Channel side relief valves shall be 0.75 inch minimum size. The minimum number of tubes required shall include an additional 6% as extra tubes. Maximum and minimum tube velocities at the normal operating temperature for stainless steel, Monel and Inconel shall be 10.0, 9.0 and 3.0 feet per second, respectively.

16.6.1. The heat exchangers shall be so constructed that the channel covers can be removed without disconnecting any piping. With covers removed, all tubes, tube sheets and channel shall be easily accessible for cleaning. One eight-inch steel quick opening hand-hole shall be provided on each channel enclosure. Full-diameter channel access shall be provided for inspection, cleaning, and repair. No man-hole access shall be used.

16.6.2. Tube Materials: Stainless steel tubes shall conform to SA-240, SA-249 or SA-688 and the type and grade shall be suitable for the service. Other tube materials used shall conform to the requirements of the ASME. All U-bends plus six inches of each leg shall receive heat treatment, when required by code.

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16.6.2.1. Forging or plate materials used for tube sheets, water channels, and channel covers, whether of one-piece construction or fabricated, shall be limited to the following materials:

a. ASME SA-105
b. ASME SA-266 Class 2
c. ASME SA-336
d. ASME SA-350 Grade LF1 or LF2
e. ASME SA-515 Grade 70
f. ASME SA-516 Grade 70

16.6.3. Tubes shall be expanded into tube sheets by a roller-type expander or other method not injurious to tubes. For welded tube end construction, tubes shall also be expanded into the tube sheets. Tubes shall be first expanded and then welded into the tube sheet.

16.6.4. Channels shall be designed to avoid erosion of internal parts. Tube entrances at inlet to each pass shall be belled except where weld design will not permit. Channels shall be designed to prevent inter-pass leakage.

16.6.5. Tube holes in support plates shall be drilled to allow a free sliding fit, and holes shall be slightly chamfered on both sides of plate to prevent scoring of tubes. Provide bracket-type supports or saddles capable of safely carrying entire weight of heat exchanger with all spaces flooded.

16.6.6. The lifting attachments on each heat exchanger shall enable the complete exchanger to be handled during erection and for straight tubed exchangers to facilitate access to the tube sheets for maintenance. Lifting attachment details in each case shall conform to good structural practice and shall be constructed to withstand extreme handling conditions that may be encountered without bending or distortion, and shall be attached to the vessel by means of full-penetration welding. Insulation cleats shall be provided if heat exchanger is insulated.

16.6.7. Flanged piping connecting terminals shall be nozzle-neck type. Studded connections to shells or heads shall not be used.

16.6.8. Stainless steel impingement baffles (3/8-inch minimum thickness) shall be furnished where required to prevent tube erosion.

16.7. PLATE AND FRAME: The heat exchangers shall be designed and manufactured in accordance with the ASME Section VIII, Div. 1. The design shall be suitable for cleaning without dismantling, future incorporation of additional 50% heat exchanger area as a minimum, and disassembly/reassembly while retaining leak tightness. Due attention shall be given for ease of maintenance, repair and cleaning. Each plate shall be numbered by indelible ink in sequence, for ease of assembly.

16.7.1. When flammable liquids such as lube oil are used, a fireproof shroud to protect the adjacent equipment and personnel from liquid impingement due to gasket failure shall be provided in accordance with OSHA requirements.

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16.7.2. All nozzles shall be of flanged connection type. Plates shall be packed in a frame consisting of fixed frame plates and movable pressure plates aligned at top and bottom on carrying bars of special inverted "T" section to ensure three dimensional steering and locking. A double seal arrangement shall be provided around ports. The space between the seals shall be vented to atmosphere in order to avoid intermixing of liquids in case of gasket failure.

17. PUMPS:

17.1. All pump materials shall be suitable for safe and satisfactory operation under the operating conditions and under all climatic conditions prevailing at the Project Site. Where there is at least one installed spare pump in the system, it shall start automatically upon failure of the primary operating pump. All pumps shall be provided with a minimum flow protection system.

17.2. All pumps shall be suitable for continuous single pump and/or parallel operation, as applicable, at the specified conditions. In the case of centrifugal pumps, this shall mean from minimum flow to pump run-out flow, without vibration, cavitation and without undue sound under all operating conditions.

17.3. Unless otherwise stated, all pumps shall be furnished with all necessary vents, drains, leak-offs and gauges.

17.4. All pumps shall use cartridge type mechanical seals.

17.5. On pump skids, piping systems connected to the suction and discharge connections of the pumps shall be designed based on the pump manufacturer's allowable nozzle loads.

17.6. Load rated lifting eyebolts, with means for attachment or pad eyes, shall be provided to aid in handling heavy parts.

17.7. Pump motors shall be furnished and mounted by Seller on a common baseplate.

17.8. CENTRIFUGAL PUMPS: Centrifugal pump materials shall be specifically chosen to resist cavitation, erosion, corrosion, seizure or other destructive influences to which a pump may be subjected in service. If the pump impellers and the impeller shaft are of different material, any portion of the impeller shaft that could be in contact with the fluid must be covered by a sleeve of the same material as used in the impeller construction. All materials shall be in accordance with the specified code where such exists, or with other recognized industry standards.

17.8.1. All horizontal centrifugal pumps shall be dynamically and statically balanced to meet the vibration limits of ANSI/HI 9.6.4, AC electric motor driver, common base plate, coupling and base mounted coupling guard, arranged for easy disconnection and re-assembly and designed to withstand all service conditions. Spacer type couplings shall be used in conjunction with end suction pumps to allow impeller removal without moving the motor. Grid type flexible couplings shall be provided for pump less than 100 hp. Gear type couplings shall be provided for pumps 100 hp or greater. All pumps shall be direct drive.

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17.8.2. All vertical centrifugal pumps shall be complete with AC electric motor drive, curb plate for mounting on the pump deck, rigid type adjustable coupling and coupling guard. All pumps shall be pullout type arranged for easy disconnection and reassemble.

17.8.3. Horizontally split pumps shall have the casing split on the horizontal centerline with suction and discharge connections and pump feed cast in the lower half. Complete removal of the bearing housings and rotating assembly shall be possible without requiring disassembly of any lower half connections.

17.8.4. Where end suction pumps are specified or proposed, these shall be of the back pullout design.

17.8.5. The pumps shall be equipped with impellers sized smaller than the maximum allowable for the pump casing such that an additional 5 percent head can be achieved with replacement of a larger impeller.

17.8.6. The rotating assembly shall not have a critical speed within 25% of the pump operating speed. The rotating part of the pump shall be balanced statically and then dynamically at a speed below the first critical speed after its rated speed.

17.8.7. TESTING: A shop performance test shall be performed in accordance with ANSI/HI 14.6 Grade 1U. The more restrictive procedures and acceptance criteria between this specification and ANSI/HI 14.6 Grade 1U will govern. An NPSHR test, vibration test and sound level test shall be performed with the shop performance test. The shop performance test of developed head, efficiency, brake horsepower and NPSHR vs. flow shall be performed at design operating speed.

17.8.8. Seller shall furnish a pump performance test report which, at a minimum, describes the tests performed and provides the results. This report shall also discuss any standard test corrections the Contractor makes to achieve the final results. All tests shall have a minimum of five flow points including the design minimum flow, design flow and runout flow (if applicable, to be assumed as 125% of design flow unless otherwise specified).

17.8.9. Efficiencies and brake horsepower shall be determined preferably by use of a calibrated torque-measuring device. Alternately, a motor furnished for the pumps can be used for the shop tests if the motor performance has been tested and certified by the manufacturer and witnessed by Buyer and Owner. If a certified motor is used to determine pump efficiency and brake horsepower, the tolerances of the electrical instruments used on the pump tests shall be factored into the test readings so that the calculated power input at the pump coupling would be the maximum expected values.

17.8.10. Vibration shall be tested in the radial direction, in two orthogonal positions at each radial bearing and in the axial direction at the thrust bearing. Values shall not exceed the required limits, at the guaranteed rated flow and operating speed.

17.9. POSITIVE DISPLACMENT PUMPS: All positive displacement pumps shall be of the horizontal screw, piston, or gear type. All positive displacement pumps shall be complete with electric motor driver, common base plate, gear type flexible coupling and base mounted coupling

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guard, arranged for easy disconnection and reassemble and designed to withstand all service conditions. The pump/ motor combination shall be non-overloading at 125% of the normal system operating pressure at the maximum pumping viscosity value. Spacer type couplings shall be used if required to allow pump disassembly without moving the motor. All pumps shall be direct drive.

17.10. Pumps of the rotary screw type shall have two or three rotors in accordance with manufacturer's standard. Where the lubricity of the medium being pumped is insufficient to prevent excessive wear of the pump internals, externally lubricated gears and bearings shall be provided.

17.11. Unless specified otherwise, mechanical seals shall be used exclusively. Ample space shall be provided for seal maintenance.

18. GENERAL WELDING REQUIREMENTS: Material shall be supplied and welding shall be performed in accordance with the sections herein.

TEMPORARY SPOOLS: If the Seller provides any temporary piping spools with their scope for the purpose of commissioning/startup activities, the spools shall be designed to the same maximum operating/design and testing conditions as the permanent piping and equipment materials. Under no circumstances is it acceptable for the Seller to de-rate the operating conditions so as to reduce the wall thickness of the temporary spools.

END OF SECTION

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Table 1 - Pipe and Valve Specification Criteria

ASME B16.34/B16.5 Class							
Interface Points	**150**	**300**	**600**	**900**	**1500**	**2500**	**4500**
Small Bore Ends	Flg, SW, BW	Flg, SW	SW	SW	SW	SW	SW
Options (Note 3)	THD	THD, BW	Flg, BW	Flg, BW	Flg, BW	BW	BW
Large Bore Ends	Flg	Flg	Flg, BW	BW	BW	BW	BW
Options (Note 3)	BW	BW	None	Flg	Flg	Flg	None
Pipe	**150**	**300**	**600**	**900**	**1500**	**2500**	**4500**
Small Bore Ends	SW, BW	SW, BW	SW, BW	SW, BW	SW, BW	SW, BW	SW, BW
Options (Note 3)	Flg, THD	Flg	Flg				
Large Bore Ends	Flg, BW	Flg, BW	BW	BW	BW	BW	BW
Options (Note 3)	None	None	Flg	None	None	None	None
Valves	**150**	**300**	**600**	**900**	**1500**	**2500**	**4500**
Small Bore End	N/A	N/A	ASME B16.34: SW Ball Valves: Flg Plug Valve: Flg Butterfly Valve: Lugged Oil Service: BW	ASME B16.34: SW Ball Valves: Flg Plug Valve: Flg Oil Service: BW	ASME B16.34: SW Ball Valves: Flg Plug Valve: Flg Oil Service: BW	ASME B16.34: SW Ball Valves: Flg Plug Valve: Flg Oil Service: BW	ASME B16.34: SW Ball Valves: Flg Plug Valve: Flg Oil Service: BW
Options (Note 3)	N/A	N/A	Butterfly Valve: Wafer	None	None	None	None
Small Bore Bonnet	N/A	N/A	Bltd	PS Plug Valve: Bltd	PS Plug Valve: Bltd	PS Plug Valve: Bltd	PS Plug Valve: Bltd
Options (Note 3)	N/A	N/A	Wldd	Wldd	Wldd	Wldd	Wldd
Large Bore End	ASME B16.34: Flg, BW Bronze: Flg Ball Valve: Flg Plug Valve: Flg Butterfly Valve: Lugged Oil Service: BW	ASME B16.34: Flg, BW Bronze: Flg Ball Valve: Flg Plug Valve: Flg Butterfly Valve: Lugged Oil Service: BW	ASME B16.34: Flg, BW Ball Valve: Flg, BW Plug Valve: Flg, BW Butterfly Valve: Lugged Oil Service: BW	ASME B16.34: BW Ball Valve: BW Plug Valve: BW Oil Service: BW	ASME B16.34: BW Ball Valve: BW Plug Valve: BW Oil Service: BW	ASME B16.34: BW Ball Valve: BW Plug Valve: BW Oil Service: BW	ASME B16.34: BW Ball Valve: BW Plug Valve: BW Oil Service: BW
Options (Note 3)	Butterfly Valve: Wafer	Butterfly Valve: Wafer	Butterfly Valve: Wafer	None	None	None	None
Large Bore Bonnet	Bltd	Bltd	Bltd	PS Plug Valve: Bltd	PS Plug Valve: Bltd	PS Plug Valve: Bltd	PS Plug Valve: Bltd
Options (Note 3)	None	None	None	None	None	None	None

Abbreviations: “SW” = Socket Weld, "BW" = Butt Weld, "Flg" = Flanged, "THD" = Threaded End, “Bltd" = Bolted Bonnet, "Wldd" = Welded Bonnet, "PS" = Pressure Seal Bonnet

Notes:

1. Table above excludes grooved, press fit, fusion, glued, and bell and spigot ends.
2. Table above excludes underground (buried) valves.
3. Optional ends require approval of the Buyer.
4. All Oil Service interface points, pipe and valves shall be BW.

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