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Change 1 - 08/14

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2015

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SECTION 46 76 23.16

RECESSED CHAMBER FILTER PRESSES 02/11

NOTE: This guide specification covers the requirements for recessed chamber filter presses.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: This guide specification provides requirements for both fixed volume and variable volume recessed filter press systems. The fixed volume system involves the use of fixed volume recessed chambered plates. This system is used for applications requiring 690 to 1550 kPa (100 to 225 psi) filtering pressure. The variable volume system involves the use of fixed volume recessed chamber plates equipped with a diaphragm that is inflated with water or air to apply the squeezing force for the filtration cycle. The variable volume system is typically used for applications requiring very dry sludge cake. The variable volume system typically requires a sludge feed filling rate pressure ranging from 350 to 690 kPa (50 to 100 psi) with a diaphragm

squeezing pressure ranging from 690 to 1550 kPa (100 to 225 psi) or greater. For applications requiring diaphragm inflation pressures greater than 1030 kPa (150 psi), only water inflation is recommended to inflate the diaphragms because of the inherent danger of using air for this type of pressurized system.

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI SG03-3 (2002; Suppl 2001-2004; R 2008)
Cold-Formed Steel Design Manual Set

AMERICAN LADDER INSTITUTE (ALI)

ALI A14.3 (2008) Standard for Fixed Ladders and
Safety Requirements

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C110/A21.10 (2012) Ductile-Iron and Gray-Iron Fittings
for Water

AWWA C111/A21.11 (2012) Rubber-Gasket Joints for
Ductile-Iron Pressure Pipe and Fittings

AWWA C115/A21.15 (2011) Flanged Ductile-Iron Pipe With
Ductile-Iron or Gray-Iron Threaded Flanges

AWWA C151/A21.51 (2009) Ductile-Iron Pipe, Centrifugally
Cast, for Water

AWWA C500	(2009) Metal-Seated Gate Valves for Water Supply Service
AWWA C504	(2010) Standard for Rubber-Seated Butterfly Valves
AWWA C509	(2009) Resilient-Seated Gate Valves for Water Supply Service
AWWA D100	(2011) Welded Steel Tanks for Water Storage

AMERICAN WELDING SOCIETY (AWS)

AWS B2.1/B2.1M	(2014) Specification for Welding Procedure and Performance Qualification
AWS D1.1/D1.1M	(2010; Errata 2011) Structural Welding Code - Steel

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.1	(2010) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
ASME B16.11	(2011) Forged Fittings, Socket-Welding and Threaded
ASME B16.21	(2011) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2012) Standard for Factory-Made Wrought Steel Buttwelding Fittings
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC IX	(2010) BPVC Section IX-Welding and Brazing Qualifications

ASTM INTERNATIONAL (ASTM)

ASTM A105/A105M	(2014) Standard Specification for Carbon Steel Forgings for Piping Applications
ASTM A153/A153M	(2009) Standard Specification for Zinc

Coating (Hot-Dip) on Iron and Steel
Hardware

ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A182/A182M	(2014b) Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
ASTM A194/A194M	(2014) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A276	(2013a) Standard Specification for Stainless Steel Bars and Shapes
ASTM A283/A283M	(2013) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A307	(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A312/A312M	(2014b) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A36/A36M	(2012) Standard Specification for Carbon Structural Steel
ASTM A436	(1984; R 2011) Standard Specification for Austenitic Gray Iron Castings
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM C582	(2009) Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment
ASTM D1784	(2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

ASTM D1785	(2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2241	(2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2564	(2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D3139	(1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D3222	(2005; R 2010) Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials
ASTM D3299	(2010) Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
ASTM D3308	(2012) PTFE Resin Skived Tape
ASTM D4097	(2001; R 2010) Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks
ASTM D638	(2010) Standard Test Method for Tensile Properties of Plastics
ASTM D785	(2008) Rockwell Hardness of Plastics and Electrical Insulating Materials
ASTM D790	(2010) Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ANSI/ISA 5.1	(2009) Instrumentation Symbols and Identification
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MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1 (2000; R 2008; E 2010) Standard for
Industrial Control and Systems: General
Requirements

NEMA MG 1 (2011; Errata 2012) Motors and Generators

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE No.3 (2007) Commercial Blast Cleaning

1.2 SUBMITTALS

NOTE: Review submittal description (SD) definitions
in Section 01 33 00 SUBMITTAL PROCEDURES and edit
the following list to reflect only the submittals
required for the project.

The Guide Specification technical editors have
designated those items that require Government
approval, due to their complexity or criticality,
with a "G." Generally, other submittal items can be
reviewed by the Contractor's Quality Control
System. Only add a "G" to an item, if the submittal
is sufficiently important or complex in context of
the project.

For submittals requiring Government approval on Army
projects, a code of up to three characters within
the submittal tags may be used following the "G"
designation to indicate the approving authority.
Codes for Army projects using the Resident
Management System (RMS) are: "AE" for
Architect-Engineer; "DO" for District Office
(Engineering Division or other organization in the
District Office); "AO" for Area Office; "RO" for
Resident Office; and "PO" for Project Office. Codes
following the "G" typically are not used for Navy,
Air Force, and NASA projects.

An "S" following a submittal item indicates that the
submittal is required for the Sustainability
Notebook to fulfill federally mandated sustainable
requirements in accordance with Section 01 33 29
SUSTAINABILITY REPORTING.

Choose the first bracketed item for Navy, Air Force
and NASA projects, or choose the second bracketed
item for Army projects.

Government approval is required for submittals with a "G" designation;
submittals not having a "G" designation are for [Contractor Quality Control
approval.][information only. When used, a designation following the "G"
designation identifies the office that will review the submittal for the
Government.] Submittals with an "S" are for inclusion in the
Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY

REPORTING. Submit the following in accordance with Section 01 33 00
SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Sludge Dewatering Equipment

SD-03 Product Data

Sludge Dewatering Equipment
Spare Parts
Posting Framed Instructions
Welding

SD-06 Test Reports

Factory Tests
Field Tests and Inspections

SD-07 Certificates

Sludge Dewatering Equipment

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions

[Six] [_____] sets, each set permanently bound and have a hard cover. Inscribe the following identification on the covers: the words "OPERATING AND MAINTENANCE INSTRUCTIONS," name and location of the facility, name of the Contractor, and contract number.

1.3 DELIVERY, STORAGE, AND HANDLING

The filter press system shall be delivered completely assembled to the maximum extent possible, and shipped on skids. Equipment delivered and placed in storage shall be stored with protection from the weather, excessive humidity and temperature variations, dirt, dust, or other contaminants as required by the manufacturer.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Each recessed [fixed-volume][variable-volume] chamber filter press unit and accessories shall efficiently dewater sludge for handling as dry cake.

2.1.1 Service Conditions

NOTE: Conditioning agents, such as lime, ferric chloride, or polymers, may be required to enhance filterability. Delete inapplicable conditioning agents.

The characteristics of the sludge to be dewatered are:

Sludge Type [Biological] [Metal Precipitation] [Domestic Wastewater]	[_____]
Filter Feed percent Solids by Weight (Approximate)	[_____]
pH	[_____]
Temperature	[_____]
Elevation (Above Mean Sea Level)	[_____]
Each Conditioning Agent Type	[_____]
Each Conditioner percent Feed Solids	[_____]

2.1.2 Design Criteria

Each filter press unit shall meet or exceed the following criteria:

Type, Recessed Plate	[Fixed-Volume] [Variable-Volume]
Number of Units	[_____]
Unit volume per cycle, cubic meters cubmic feet	[_____]
Filter cake thickness, mm inch	[_____]
Plate size, mm by mm inch by inch	[_____] by [_____]
Expansion percent	[_____]
Maximum Operating Pressure, kPa psig	[690] [1550] [100] [225] [_____]
Feed inlet connection diameter, mm inch	[_____]
Filtrate pipes:	
Number, minimum	[3] [4]
Diameter, mm inch	[_____]

2.2 GENERAL MATERIAL REQUIREMENTS

Materials for common equipment used throughout this specification shall conform to the following requirements. Materials for specific components and accessories shall be as specified. Recyclable materials shall conform to EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

2.2.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that

essentially duplicate items that have been in satisfactory use in similar facilities for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.2.2 Nameplates

Filter presses, pumps, tanks, mixers, panels and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a stainless steel plate permanently secured to the item of equipment.

2.2.3 Protection of Moving Parts

Completely enclose belts, chains, couplings, and other moving parts by guards to prevent accidental personal injury. Guards shall be removable or arranged to allow access to the equipment for maintenance. If equipment is in a lockable housing, no additional guards are necessary.

2.2.4 Special Tools

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

2.3 MATERIALS

2.3.1 Steel Plates, Shapes and Bars

ASTM A36/A36M.

2.3.2 Pipe and Fittings

NOTE: Delete items in paragraph: PIPE AND FITTINGS,
paragraph: PIPE HANGERS AND SUPPORTS, paragraph:
VALVES, and paragraph: OTHER MATERIALS, and
reference Section 40 05 13 PIPELINES, LIQUID PROCESS
PIPING, for specific requirements if that section is
included in the specifications.

[Pipe and fittings shall conform to the requirements specified in Section 40 05 13 PIPELINES, LIQUID PROCESS PIPING.]

2.3.2.1 Steel Pipe

ASTM A53/A53M.

- a. Flanged Fittings: ASTM A105/A105M.
- b. Welded Fittings: ASME B16.9, ASME B16.11.
- c. Bolts and Nuts: ASTM A193/A193M, Grade B5; ASTM A194/A194M.

2.3.2.2 Ductile-Iron Pipe

AWWA C115/A21.15.

- a. Flanged Pipe: AWWA C115/A21.15, with ASME B16.1, Class 125 flanges.

- b. Rubber-Gasket Joints: AWWA C111/A21.11.
- c. Fittings: AWWA C110/A21.10.
- d. Push-On Joints: AWWA C151/A21.51.
- e. Bolts and Nuts: ASTM A307, Grade B.

2.3.2.3 Stainless Steel Pipe

ASTM A312/A312M, Schedule 40, Type 316 or Type 304.

- a. Flanged Pipe: ASTM A182/A182M, Class 150, drilled to ASME B16.5.
- b. Rubber-Gasket Joints: [ASME B16.5] [ASME B16.21].
- c. Threaded Fittings: ASME B16.11.
- d. Bolts: ASTM A193/A193M, Class 1, Grade B8.
- e. Nuts: ASTM A194/A194M, Grade 8.

2.3.2.4 Polyvinyl Chloride (PVC) Pipe and Fittings

PVC pipe and fittings less than 100 mm 4 inch diameter shall be in accordance with ASTM D1785 or ASTM D2241. PVC pipe and fittings 100 mm 4 inches in diameter and larger shall be in accordance with ASTM D2241 and shall have push-on joints.

- a. Push-On Joints: ASTM D3139 or ASTM F477.
- b. Solvent Cement: ASTM D2564.

2.3.3 Pipe Hangers and Supports

NOTE: Coordinate hanger and support requirements
with Section 40 05 13 PIPELINES, LIQUID PROCESS
PIPING, if that section is included in the project,
otherwise use the reference provided.

[Hangers and supports shall conform with the requirements identified in Section 40 05 13 PIPELINES, LIQUID PROCESS PIPING.][MSS SP-58.]

2.3.4 Valves

[Valves shall conform to the requirements specified in Section 40 05 13 PIPELINES, LIQUID PROCESS PIPING.] [Valves shall be rated for a[1.03 MPa 150 psig][[_____] MPa psig service]. Valves shall have steel or cast iron bodies unless otherwise shown or specified.] Threaded or socket welded connections shall conform to ASME B16.11, flanged connections shall conform to [ASME B16.1] [ASME B16.5], and valves for high temperature service shall conform to:

2.3.4.1 Globe and Angle Valves

Globe valves, 80 mm 3 inches and smaller, shall be [angle pattern] [globe

style] valve [and shall have [bronze] [TP316 stainless steel] [_____] bodies,] with [bronze] [brass] [stainless steel] [_____] trim, and [bronze] [brass] [_____] bonnets. Valves shall include [union] [threaded] [OS&Y] bonnets, inside screws, rising stems, [plug] [needle] [conventional] discs constructed of [polytetrafluoroethylene (PTFE)] [butadiene acrylonitrile] [bronze] [stainless steel] [_____] , and [bronze] [brass] [stainless steel] [_____] rings. Valves shall be equipped with [handwheel] [pneumatically actuated] [electrically actuated] [_____] operators.

2.3.4.2 Gate Valves

Valves 50 mm 2 inches and smaller, shall have [bronze] [_____] bodies and stems, [screwed] [union] [bolted] [yoke] bronze [_____] bonnets, single [solid] [split] wedge bronze discs, and [rising] [non-rising] stems. Valves 65 mm 2.5 inches and larger, shall have [iron] [bronze] [Ni-resistant stainless steel] [_____] trim. Valves shall meet the requirements of [AWWA C500] [AWWA C509]. Bonnet shall be a [clamp] [OS&Y Bolted] [NRS Bolted] type. Discs shall be [wedge] [double] type of [iron] [bronze] [ductile iron] [bronze faced iron] [rubber coated ductile iron] [_____] construction, and have [nonrising] [rising] stems [with backseats]. Valves shall be equipped with [handwheel] [pneumatically actuated] [electrically actuated] [_____] operators.

2.3.4.3 Plug Valves

[Nonlubricated] [lubricated] type eccentric valves, 80 mm 3 inches through 1350 mm 54 inches, shall have drip-tight shutoff with pressure from either direction, [and [Ni-resistant] [aluminum] [stainless steel] [nickel] [_____] bodies]. Plugs shall be cast iron with [round] [or] [rectangular] ports of no less than [80] [_____] percent of the connecting pipe area [and coated with] [butadiene acrylonitrile] [chloroprene] [fluoro-elastomer] [hard natural rubber] [_____] . Valves shall have [stainless steel] [nickel] [_____] seats, self-lubricating [stainless steel] [reinforced polytetrafluoroethylene (PTFE)] [_____] stem bearings, and [multiple [V-rings] [U-cups] [O-rings] stem seals] [[nitrile rubber] grit seals on the stems]. [Valves shall be equipped with [handwheel] [pneumatically actuated] [electrically actuated] [_____] operators.] [Valves 150 mm 6 inches and smaller shall have a wrench lever manual operator and valves 200 mm 8 inches and larger shall have a totally enclosed, geared, manual operator with handwheel, 50 mm 2-inch nut, or chain wheel.] [Valves shall conform to ASME B16.34 Class [_____] .]

2.3.4.4 Butterfly Valves

Butterfly valves, 50 mm 2 inch and larger, shall be [[wafer] [lugged] styled]. Valves shall conform to [AWWA C504 Class [125] [150] [_____]] [ASME B16.34 Class [_____]]. Discs shall be contoured [ASTM A436 Type 1 Ni-resist cast iron with maximum lead content of 0.003 percent] [ASTM A536 Grade 65-45-12 ductile iron] [stainless steel] [polyvinylidene fluoride (PVDF) coated ductile iron] [bronze] [_____] . The valve shafts shall be [carbon steel] [stainless steel] [_____] with self-lubricating, corrosion-resistant sleeve type bearings. Valve seats for [600 mm 24 inch] [_____] and smaller valves shall be attached to either the valve body or the disc and shall be constructed of [chloroprene] [_____] . Valves shall have [manual, locking hand lever] [hand wheel] [crank] [chain wheel] [pneumatically actuated] [electrically actuated] [_____] operators.

2.3.4.5 Ball Valves

Ball valves, 50 mm 2 inch and smaller, shall be end entry type with [bronze] [brass] [_____] bodies and [threaded, in accordance with ASME B1.20.2MASME B1.20.1,] [_____] , [full bore] [regular] ports. Valves shall have [polytetrafluoroethylene (PTFE)] [_____] seats and packing, [chrome plated] [brass] [stainless steel] [_____] balls and [hand lever] [tee-handle] [hand wheel] [pneumatically actuated] [electrically actuated] [_____] operators. [A union shall be installed adjacent to the valves to provide access to the seat.] Ball valves, 50 mm 2 inch to 300 mm 12 inches, shall conform to ASME B16.34 Class [_____] , [and have a [bronze] [TP316 stainless steel] [_____] body,] stainless steel ball and stem, polytetrafluoroethylene (PTFE) packing and gasket, and [flanged] [welding] [_____] ends, full port. Valves shall have [hand lever] [pneumatically actuated] [electrically actuated] [_____] operators.

2.3.4.6 Check Valves

Swing check valves, shall have a [bronze] [TP316 stainless steel] [_____] body. Valves 50 mm 2 inches and smaller, shall have a swing type, replaceable [butadiene acrylonitrile] [polytetrafluoroethylene (PTFE)] [_____] disc. Valves 65 mm 2.5 inches through 300 mm 12 inches, shall have a bronze-mounted swing type, [bronze] [ductile iron] [cast iron] [_____] disc, [solid bronze] [ductile iron] [_____] hinges, and stainless steel hinge shaft [with outside lever and [weight] [spring]].

2.3.4.7 Polyvinyl Chloride (PVC) Valves

Thermoplastic valves, 150 mm 6 inches and smaller, shall be rated for [1.03 MPa 150 psig] and have ASTM D1784, Class 12454-B, [polyvinyl chloride (PVC)] [chlorinated polyvinyl chloride (CPVC)] [ASTM D3222 polyvinylidene fluoride (PVDF)] [_____] bodies, and stems. Valves shall be double union design, with [solvent-weld socket] [threaded, in accordance with ASME B1.20.2MASME B1.20.1,] [flanged] [butt] [_____] end connections, [ethylene propylene diene monomer (EPDM)] [fluoro-elastomer] [_____] seats, and [fluoro-elastomer] [polytetrafluoroethylene (PTFE)] [ethylene propylene diene monomer (EPDM)] [_____] O-ring stem seals. Valves shall have [handwheel or lever] [pneumatically actuated] [electrically actuated] [_____] operators where applicable or indicated.

2.3.5 Other Materials

[Joint compound and joint tape shall conform with the requirements identified in Section 40 05 13 PIPELINES, LIQUID PROCESS PIPING.]

2.3.5.1 Joint Compound

Joint compound for threaded joints shall be a stiff mixture of graphite and oil, inert filler and oil, or a graphite compound.

2.3.5.2 Joint Tape

Joint tape for threaded joints shall comply with ASTM D3308.

2.4 MANUFACTURED UNITS - GENERAL REQUIREMENTS

2.4.1 Electrical Products

Electrical products shall be furnished and installed in accordance with the

applicable requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.2 Electric Motors

Motors shall conform to NEMA MG 1. Motors with nameplate horsepower equal to or greater than 380 watt 1/2 hp shall be suitable for 480 volt, 3 phase operating service, unless otherwise specified. Motors equal to or greater than 760 watt 1 hp shall be high efficiency type as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors less than 380 watt 1/2 hp shall be provided with internal thermal overload protection or motor starters suitable for [120] [240] volt, single phase, operating service.

2.4.3 Motor Controls

Controls shall conform to NEMA ICS 1.

2.4.4 Bolts, Nuts, Anchors, and Washers

Bolts, nuts, anchors, and washers shall be steel, galvanized in accordance with ASTM A153/A153M.

2.4.5 Pressure Gauges

Gauge sizes and scale ranges shall be as indicated or as specified. Gauges shall comply with ASME B40.100, Type 2A, as a minimum. Compound gauges shall be provided on the suction side of pumps and standard pressure gauge on the discharge side of pumps. Gauges shall have clear acrylic or shatterproof glass windows and shock-resistant cases. The design operation should be at the midpoint of the graduated scale. Gauge scales shall have a minimum of 5 major and 50 minor divisions. Major divisions shall be equally spaced and shall be in integers. Scale units shall be engraved on the scale face. Pointer travel shall be not less than 200 degrees nor more than 270 degrees arc. Gauge accuracy shall be plus or minus 0.5 percent of span. Each gauge, except those for hydraulic systems, shall have a process shutoff valve.

2.4.6 Valves

**NOTE: "Fire safe" valves are recommended for
pneumatic controls for sludge service, but
non-metallic valves may be acceptable when
non-metallic piping is used.**

2.4.6.1 Automated Valves

Automatic valves used for sludge service shall be pneumatic cylinder operated, [fire safe,] [non-metallic,] full port ball valves. Valves 50 mm 2 inches and larger shall be flanged in accordance with ASME B16.5 Class 150. Cylinder operators shall be sized for operation at sludge pressures up to 1720 kPa 250 psig when supplied by air at 690 kPa 100 psig. Valves shall be equipped with limit switches to indicate full open and full closed positions. Solenoid valves shall be shop piped to the cylinder operators.

2.4.6.2 Manual Valves

Manual valves shall be as defined above except operators and limit switches will not be required.

2.4.7 Tank Requirements

The tanks specified include the filtrate collection and weir, [sludge conditioning,] [precoat,] [acid wash,] [membrane water,] [_____,] and filter media wash tanks. These tanks shall be provided in accordance with the following general requirements, unless otherwise indicated. Additional requirements are also provided in the paragraph that describes the application of each specific type of tank.

2.4.7.1 General Tank Requirements

Each tank shall include flanged fittings for inlet, outlet, overflow and drain. The nozzle size, elevation, and orientation shall be provided in accordance with construction drawings. Hold down lugs shall be provided to anchor the tank to the base. A cover shall be provided with a piano type hinged access door for inspection and cleaning of the tank. Single pole double throw level switches shall be provided. Switch contacts shall be rated 5 amps, 120 volts ac inductive load minimum. Switch leads shall extend to a NEMA 4 junction box located 1.5 m 5 feet above floor level. Leads shall terminate on terminal strips using ring tongue connectors and shall be identified.

2.4.7.2 Tank Construction Materials

NOTE: If carbon steel tanks are specified, include section based on Section 09 97 02 PAINTING, HYDRAULIC STRUCTURES or incorporate applicable provisions in paragraph PAINTING.

The tank construction material shall be compatible with the material stored. Tanks constructed of polyethylene, polypropylene, and fiberglass reinforced plastic (FRP) shall conform to applicable material and construction provisions of ASTM C582, ASTM D3299, and ASTM D4097. Steel tanks shall conform to AWWA D100. Carbon steel tanks shall be ASTM A283/A283M carbon steel Grade C or D and shall be protected with an interior coating system appropriate for the intended service in accordance with Section 09 97 02 PAINTING, HYDRAULIC STRUCTURES. Stainless steel tanks shall be Type 304 stainless steel conforming to ASTM A167 with structural supports conforming to ASTM A276. Exterior painting or coating shall be provided in accordance with paragraph PAINTING.

2.4.7.3 Access Ladders

Access ladders and platforms for access to the tank tops shall conform to ALI A14.3. The ladder shall be fabricated of [fiberglass reinforced plastic shapes] [stainless steel coated with a 3 mm 1/8 inch minimum thickness of reinforced resin]. Rungs shall be serrated or grooved longitudinally to provide a nonslip surface. Splices and connections shall have a smooth transition without projections that are sharp or more extensive than required for joint strength. Rails shall be fitted with brackets for anchorage to structure. The top of the cage shall be extended 1.1 m 3 feet 6 inches above the tank and shall be connected to the tank roof. A minimum of 200 mm 8 inches clearance between the tank wall and the ladder rungs shall be maintained. The last rung of the ladder on top shall be at the same level as the top of the tank.

2.4.7.4 Tubular Glass Gauge Assembly

A tubular glass gauge assembly shall be provided complete with valves and protector to provide local indication of liquid level in the tank. The tube shall be 19 mm 3/4 inch O.D. borosilicate glass and shall provide indication from 0.3 m 1 foot above bottom of tank to the overflow level. The valves shall be offset pattern and of outside screw and yoke design. Valves shall be provided with a floating shank union vessel connection. Valves shall be stainless steel ball checks that seat to prevent loss of tank contents should the glass break. Valves shall be operated by handwheel. A plastic window gauge glass protector shall be installed the entire length of the indication. A yellow board graduated gauge scale shall be attached to the tank behind the glass in [0.30 mm 1/10 foot] [[_____] mm foot] graduation increments for tank gauging.

2.4.7.5 General Mixer Requirements

Mixers shall be in accordance with the following requirements unless otherwise indicated. Each mixer shall be mounted in the center top of the tank and shall be suitable for continuous operation. The tank shall be supplied with baffles as recommended by the mixer manufacturer. Mixers shall be provided with totally enclosed fan cooled electric motors, for an operation service of 480 volt, three phase, 60 hertz. The mixer shaft and turbine blades shall be rubber covered carbon steel. The motor short circuit protective device and magnetic starter shall be remotely located in a motor control center or panels as shown on the drawings. A local disconnect shall be provided at the motor.

2.5 SLUDGE DEWATERING EQUIPMENT

NOTE: Items noted below shall be identified on the drawings. Delete accessories or optional features that are not used.

The sludge dewatering equipment shall consist of the filter press components, including the filter press unit and its ancillary equipment, and accessories required to support the filtration operation. The filter press unit shall consist of a main structural frame, filter press plates, and filter media.

2.5.1 Ancillary Equipment

The ancillary equipment shall include the press closing mechanism, plate shifter, sludge feed and discharge piping, [diaphragm inflation manifold,] [air and core blowdown assembly,] filtrate collection and weir tank, drip trays, [automatic filter media water washer assembly,] [safety options,] a filter press control panel, and dewatering system control panel. The ancillary equipment required for press operation shall be integrally incorporated within each filter press unit and controlled through the filter press control panel and coordinated with control for accessories provided through the dewatering system control panel.

2.5.2 Accessory Systems

The accessory systems shall include a sludge feed pump system, [a raw sludge conditioning system,] [a precoat system,] [an acid wash system,] [membrane water inflation system,] an air compressor system, and a filter

media water wash system.

2.5.2.1 Sludge Feed Pump

The sludge feed pump system shall transfer sludge from the sludge conditioning system to the filter press through an automatic pump control system.

[2.5.2.2 Sludge Conditioning System

The sludge conditioning system shall include a chemical feed (conditioning agent) point and shall receive raw sludge and provide sludge to the filter press feed pump system.

]2.5.2.3 Precoat System

The precoat system shall be provided to precoat the filter media prior to feeding the filter press with conditioned sludge.

]2.5.2.4 Air Compressor System

The air compressor system shall provide compressed air for instrument control and process operations for the filter press.

2.5.2.5 Membrane Water Inflation System

Provide a membrane water inflation system for membrane inflation of the variable-volume recessed plate system.

2.5.2.6 Filter Media Washing

The [manual] [automatic] filter media water wash system and acid wash system shall be provided for filter media washing.

2.5.3 System Technical Data

Submit the following:

- a. Drawings that contain complete electrical interconnecting wiring and schematic diagrams for power, piping, control, and instrumentation circuits to equipment specified; equipment layout and anchorage; process flow diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances and equipment relationship to other parts of the work including clearances required for maintenance and operation.
- b. A complete list of equipment and materials, including manufacturer's descriptive and technical literature; performance charts and curves; catalog cuts; power requirement demand; and installation instructions. As a minimum, the list shall include the following data:
 - (1) Filter Press. Equipment dimensions; materials and details of construction; inlet/outlet sizes and locations; controls; size, make and type of electrical motors; and flow rates.
 - (2) Pumps. Base and pump dimensions; pump type; materials and details of construction; inlet/outlet locations; size, make, and type of electrical motors; and flow rate and pressure capacities.

- (3) Tanks. Dimensions; materials and details of construction; inlet/outlet sizes and locations; and chemical feed pipe and diffuser size, location, and materials.
- (4) Mixers. Identification/location; impeller size, type, and material; shaft size, material, and number of sections; size, make, and type of electrical motors; electrical control equipment type; specifications, details, input and output speeds, exact gear ratio, and service factor (24-hour continuous service) of gear reducers; and connection and mounting details.

2.6 FILTER PRESS COMPONENTS

NOTE: Components for both fixed-volume and variable-volume filter presses are described in this paragraph. Delete components and features that are not required.

Components shall be new, free of defects or mechanical damage and in operating condition.

2.6.1 Main Structural Frame

NOTE: Two types of frames are typically available for filter press applications: a side bar assembly and an overhead and lower tie bar assembly. The overhead bar assembly is primarily for larger recessed plate presses greater than 1220 mm (48 inches) higher pressure installations (i.e. 1550 kPa (225 psi)) and variable volume presses, and for applications with heavy recessed plates such as those constructed of ductile iron.

The filter press shall be designed for [690 kPa 100 psig] [1550 kPa 225 psig] [[_____] kPa psig] service. The filter press frame shall be fabricated of ASTM A36/A36M steel and consist of a fixed head, movable follower head, tail stand, and [side bar] [overhead and lower tie bars] beam assembly.

2.6.1.1 Fixed Head

The fixed head shall be fabricated steel construction with welded ribs and shall provide uniform strength over the entire surface against the filter plate pack. The head shall be free standing with integral attachment points for anchor bolts. The fixed head end shall incorporate connections for [two side bars for the side bar assembly] [the [three] [four] corner tie bars, [one] [two] located above the plates for the overhead beam and two below the plates for overhead bar assembly]. The fixed head end shall contain the necessary connections for the filter feed and discharge. [The fixed head end shall contain one [_____] mm inch center sludge feed connection and four [_____] mm inch corner filtrate discharge connections]. [The fixed head end shall contain one [_____] mm inch corner sludge feed connection and three [_____] mm inch corner filtrate discharge connections.] If variable volume plates are used, an external manifold with individual high pressure hoses for each plate shall be supplied in

accordance with the requirements provided in the paragraph Diaphragm Plate Piping System.

2.6.1.2 Movable Head

The movable follower head shall be fabricated of steel construction with welded ribs and shall provide uniform strength over the entire surface against the filter plate pack. The follower head shall be mounted on supports over the two [side] [overhead] bars for alignment and smooth parallel movement against the plate stack. If the plate stack is in excess of 80 chambers, connections shall be supplied for sludge feed as described for the fixed head. Follower movement shall be transmitted by a double-acting hydraulic cylinder attached to the thrust block on the follower.

2.6.1.3 Tail Stand

The tail stand shall be fabricated steel and shall be free standing with anchor bolt attachment points. The tail stand shall have a sufficient area to provide acceptable load distribution to the filter foundation. The tail stand shall support the press closing mechanism. The tail stand shall also have connections to accept the [two side bars of the side bar assembly] [[three] [four] tie bar/plate supports of the overhead bar assembly].

2.6.1.4 Beam Assembly

The [two side bars of the side bar] [two overhead and two lower tie bars of the overhead] beam assembly shall interconnect the fixed head and tail stand. The beam assembly shall support the weight of the plates and follower, and shall provide tensile strength for maintaining closing pressure. The [two side bar] [four overhead] beams shall be of sufficient width and depth to prevent deflections in excess of 1/900 of the length of the beam assembly when fully loaded. Intermediate supports of the beams will not be acceptable. Beam flanges shall be stainless steel clad or have stainless steel caps to facilitate smooth operation of the filter plate shifter.

2.6.2 Filter Press Plates

NOTE: Polypropylene fabricated plates are typically applicable for sludge applications for pressures of 1550 kPa (225 psi) and less for temperature less than 90 C (200 F). Above this criteria, glass filled polypropylene or nylon constructed plates should be considered. In addition to plates constructed of polypropylene, plates constructed of ductile iron, cast iron, and rubber coated steel are commercially available.

2.6.2.1 Fixed Volume

The fixed-volume recessed type filter plates shall be of the [center] [corner] feed, corner filtrate discharge design for operation at [690 kPa 100 psi] [1550 kPa 225 psi] [[_____] kPa psi] pressure at ambient temperature. The filter plates shall be constructed of polypropylene conforming to ASTM D638, ASTM D785, and ASTM D790. Plates shall be monolithically molded with integral stay bosses. Plates shall be designed

with a short rib quadrant or piped design that maximizes filtrate flow and provides maximum cloth support. Plate sealing surfaces shall be machined to maximum parallel plate tolerance of 0.3 mm 0.01 inch. Chamber recess depth dimensions shall have a tolerance not to exceed 0.5 mm 0.02 inch. Plates for side bar assembly presses shall have handles that are integrally cast and not mechanically fastened or welded in. Plates shall be of the [non-gasketed] [gasketed] design. [Gasketed plates shall have a round bottomed caulking groove machined around the perimeter of each drainfield for installation of filter cloths. Gasketing shall be on the perimeter sealing surface and around each of the corner eyes. Grooves of the dovetail design shall be machined around each corner port and around the cake chamber on the sealing surface for the installation of gasketing.] [Non-gasketed plates shall come completed with five equally spaced cloth dogs along the uppermost edge of the plate for installation of filter cloths.] A head liner plate and follower liner plate shall be provided with a recess on only the side facing the adjacent filter plate. Plates shall be complete with filter media installed.

2.6.2.2 Variable Volume

The variable-volume recessed type filter plates shall be of the [center] [corner] feed, corner filtrate discharge design for filtration operation at [690 kPa 100 psi] [[_____] kPa psi] and diaphragm squeeze operation of [1550 kPa 225 psi] [[_____] kPa psi] pressure at ambient temperatures. The filter press plates shall be constructed of polypropylene conforming to ASTM D638, ASTM D785, and ASTM D790. Plate bodies shall have integrally molded stayboss supports equally spaced on the drain field. Plates shall be of the non-gasketed design. Non-gasketed plates shall come completed with 5 equally spaced cloth dogs along the uppermost edge of the plate for installation of filter cloths. Plates shall be complete with filter media installed. Diaphragms shall be designed for [water inflation] [inflation by air]. Each plate body shall have two flexible diaphragm drain fields made of [polypropylene] [ethylene propylene diene monomer (EPDM)]. Diaphragms shall be [of replaceable construction] [welded to the plate body]. [Plates shall be of the variable-volume diaphragm squeeze design. The headliner and follower liner plate shall be provided with a recess and diaphragm on only the side facing the adjacent plate.] [or] [A quantity of plates equal to one-half of the total number of chambers required shall be of the variable-volume, diaphragm squeeze design, and shall alternate within the filter pack with filter plates of the fixed volume recessed design. End plates shall be of the fixed-volume recessed design.]

2.6.3 Filter Media

One set of filter media shall be provided with each press. A standard filter media constructed of polypropylene, having a multi-filament warp and monofilament (satin) weave, and a porosity of 2.4 L/s 5 cfm, shall be provided, unless justified by the press manufacturer for the intended service. Cloths shall be of the barrel neck design. Neck material shall be of the same or less porous material. [Filter media for non-gasketed plates shall have a series of grommets along three edges. Grommets shall be used to install media on filter plate cloth dogs and shall be used along vertical sides to insert nylon cloth ties to hold media taut on the plate.] [Filter media for gasketed plates shall be held in place on the filter plates by a woven, high density polypropylene cord sewn into the perimeter of the cloth. The filter media shall be pressed or caulked into place on the filter plate and held by an interference fit.]

2.6.4 Closing Mechanism

The closing mechanism shall consist of a hydraulic cylinder and hydraulic power pack.

2.6.4.1 Hydraulic Cylinder

**NOTE: Cylinder sizes, opening pressures, stroke,
and rod diameters are dependent on the size and
operation of each specific filter press.**

Sealing pressure for each press unit shall be provided by a double acting, hydraulic cylinder which opens and closes the press unit. The hydraulic system shall be designed to maintain an adequate force to keep the press closed against the full slurry feed pressure of [690 kPa 100 psi] [1550 kPa 225 psi] [[_____] kPa psi] plus a minimum safety factor of 25 percent. A cylinder with a minimum [_____] mm inch stroke and [_____] mm inch rod diameter shall be mounted on the tail stand and positioned so that the piston and rod movement are horizontal. The piston rod end shall be connected to the follower plate by a ball fit connection to allow limited rotation of the follower head. A minimum stroke of [_____] mm inches shall be provided to permit sufficient movement of the follower plate to allow each plate to be shifted and drop filter cakes, and to provide sufficient space for maintenance between plates. The press manufacturer shall provide the requirements for the cylinder size and stroking speed and a drawing of the cylinder attachment points. The hydraulic cylinder shall be provided with a steel rod with a polished and chrome plated finish fabricated in accordance with ASTM A276 to minimize wear on the rod packing. A neoprene boot shall fit over the piston rod to preclude entry of foreign material.

2.6.4.2 Hydraulic Power Pack

The hydraulic cylinder shall be pressurized by [an electric] [a pneumatic] hydraulic pumping unit. The pumping unit shall provide a nominal 34.5 MPa 5,000 psi oil pressure to maintain closing forces during the filtration cycle. The power pack shall automatically sense the changes due to temperature changes, pressure elongation, and media compression and adjust to maintain closing pressure for extended cycles completely unattended. The power pack shall be equipped complete with a hydraulic pump, valves, fittings, pressure regulators, filters, visible and fully exposed sight glass, and thermal relief valve. [The air driven power pack shall be designed for a maximum of [_____] kPa psig air to generate up to [_____] L/s gpm of oil flow and up to 3.5 MPa 500 psig oil pressure.] [The electric driven power pack shall be a totally enclosed fan cooled motor designed for operation with [480 volt, 3 phase] [240 volt, single phase] service.] The power pack shall be readily detachable from the filter press frame. The power packs shall be free standing and attached to the filter press by hydraulic hoses equipped with integral valves in quick connectors that are readily detachable from the filter press if necessary for maintenance. The oil reservoir shall be equipped with a filter-breather cap, local temperature indicator and switch, oil level indicator and switch and shall be designed so that the oil can be drained from the unit at a point 300 mm 12 inches minimum above the floor and refilled without the use of pumps. The oil reservoir shall be integral to the hydraulic cylinder mount acting as a heat sink to prevent overheating of the hydraulic system.

2.6.5 Plate Shifter

NOTE: Plate shifters can be manually, semiautomatically, or automatically controlled. A semiautomatic type plate shifter is typically optional, but should be provided for presses with plates larger than 800 mm (32 inches).

Plate movement for cake discharge shall be accomplished by means of a [semiautomatic] [automatic] [manual] plate shifter. The [semiautomatic] [automatic] plate shifter shall consist of one shifter carriage, mounted within the beam plate suspension system of the filter press to pick up and transport only one plate at a time. The shifter shall be an electric/hydraulic driven variable speed reciprocating type. Shifting shall be accomplished by the operator opening the follower and shifting the plate shifter into automatic operation. The shifter carriage shall extend and pick up each plate by the plate suspension bracket and pull it to the fully opened position, discharging the plate against the follower. The plate shifting mechanism shall be driven by a variable speed reversing [electric] [hydraulic] motor/gear reducer, totally enclosed fan cooled assembly with [_____] watt hp for an operating service of 480 volts, three phase. The unit shall then reverse and return to pick up the next plate. Plate suspension brackets shall be designed to provide parallel movement of the plates without pendulum movement. The brackets shall have an integral latching system that shall prevent shifting of more than one plate at a time. The exposed portions of the shifter latching mechanisms shall be made from [316 stainless steel] [high density linear polyethylene] with 300 series stainless steel springs actuating the engagement pawls. A pendant or trigger control station shall be provided to allow the operator to interrupt the shifting sequence to inspect, remove cake, clean or otherwise attend to any individual plate. Sufficient extended urethane pneumatic cable shall be provided to allow the operator to manipulate the control from anywhere along the length of the plate stack. The system shall be designed to provide a restart button only from the filter press control panel.

2.6.6 Sludge Feed and Discharge Piping

NOTE: Plastic PVC piping is not recommended for operating pressures greater than 690 kPa (100 psi). Carbon or stainless steel piping is recommended for applications greater than 690 kPa (100 psi) pressure.

Feed and discharge piping shall be fabricated of [PVC] [carbon steel] [[304] [316] stainless steel]. The [_____] mm inch piping shall be provided with connections through the head from the center feed slurry port and corner filtrate discharge ports in the filter pack through the fixed-end head. Threads shall be NPT standard.

2.6.6.1 Air Blowdown Manifold

NOTE: This manifold is only required with the optional air blowdown operation. The air blowdown operation removes entrained filtrate from the filter

**cake by the introduction of compressed air prior to
cake discharge.**

The air blowdown manifold shall be fabricated of [schedule 80 PVC] [carbon steel] [[304] [316] stainless steel] and shall consist of the necessary piping and valves to join the four filtrate discharge ports located on the fixed head into a common discharge pipe. Automatic closing of the valves and introducing air into an upper filtrate port shall force air through the filter cake in each press chamber and result in discharge of excess filtrate to the alternating lower filtrate discharge port. The system shall be rated for a minimum operating pressure of 280 kPa 40 psi. A 0 to 420 kPa 0 to 60 psi air regulator and pressure gauge to control and monitor air blowdown shall be supplied, in accordance with the requirements for pressure regulators presented in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.6.6.2 Core Blow System

**NOTE: This system is only required when the
optional core blow operation is used. The core blow
operation consists of the removal of excess liquid
sludge from the feed eye or core by the introduction
of compressed air prior to cake discharge.**

The core blow system shall consist of an air line and valve fabricated of [schedule 80 PVC] [carbon steel] [[304] [316] stainless steel] and attached to the tail plate. The system shall be rated for a minimum pressure of 550 to 690 kPa 80 to 100 psig to force excess sludge feed in the core of the press back out of the center feed inlet. Closing and opening of valves shall be provided by controls operating the press. This process shall be performed after air blowdown.

2.6.7 Diaphragm Plate Piping System

**NOTE: The diaphragm plate piping system is only
required for variable-volume plate filter press
applications.**

A diaphragm plate piping system header shall be supplied as an integral component of the filter press skeleton. The header shall be fabricated from [_____] mm inch diameter schedule 40, [304 stainless steel] [carbon steel] pipe. The header system shall come complete with header and individual flexible reinforced hoses that are connected to the header and each individual diaphragm filter plate by swivel connectors and mounted so as not to interfere with late shifting, cake discharge, or other ancillary functions. The system shall be rated for a minimum operating pressure of [1550 kPa 225 psi] [_____].

2.6.8 Filtrate Collection and Weir Tank

Each filter shall be provided with a filtrate collection and weir tank to measure and indicate terminal filtrate flow. The weir tank shall be capable of passing the maximum filtrate rates discharged from the filter press filtrate connection. The tank shall be provided with an inlet and outlet connection, an overflow weir extending from wall to wall within the

tank between the inlet and outlet, and a liquid sensing device located on the inlet side of the weir to transmit an electrical signal to the Dewatering System Control Panel when stable terminal flow has been achieved. The tank shall have a capacity of [_____] and shall be constructed of [fiberglass reinforced plastic] [coated steel] and shall include a hinged, vented cover.

2.6.9 Drip Trays

NOTE: Drip trays are optional features recommended for housekeeping purposes when a filter media water washing system is used. If drip trays are not used delete this paragraph.

Each of the cake storage bunkers shall be equipped with a set of bomb-bay type drip trays located in the floor opening. The trays shall consist of two shelf sections to extend from the location of the follower, in its fully extended position, to the tail stand of the filter, and shall be designed to convey water from the trays or from washing operations into a launder. The top tray shall slightly overlap the lower center half at the center line to yield a pitched surface when closed. Trays shall be hydraulically operated by means of a double acting hydraulic cylinder. Power pack controls shall automatically interlock drip tray closure with opening and closing of this press. In the fully closed position, the trays shall be mechanically locked; reliance on hydraulic pressure to ensure full closure will not be acceptable. Limit switches shall be incorporated in the drip tray mechanism, and interlocking shall be incorporated in the system design to ensure against accidental discharge of filter cake when the doors are not in a fully open position. A manual override shall be provided for maintenance purposes. The supporting frame for the drip trays shall be fabricated steel construction. The top surface of the trays shall be [polypropylene] [304 stainless steel]. Each drip tray assembly shall be equipped with a launder extending the length of that assembly. The launders shall be at least 150 mm 6 inches wide, shall be of [polypropylene] [PVC] [304 stainless steel] construction with a minimum material thickness of 16 gauge, and shall terminate in a [_____] mm inch flanged drain outlet.

2.6.10 Sludge Cake Handling and Storage

NOTE: Sludge cake storage and handling depends on the method of ultimate disposal, such as direct discharge into a storage receptacle or conveying or pumping the sludge cake for further processing.

2.6.10.1 Direct Discharge Systems

NOTE: The direct discharge system size depends on the size of the filter press and required sludge cake storage capacity. This paragraph provides two direct discharge system options: a drum system for smaller applications (210 L (55 gallon) drums) and a roll-off box system for larger applications (greater than 210 L (55 gallon) receptacle).

The direct disposal system shall be provided to support the filter press in such a manner and elevation that filter cake discharged from the press is directly deposited into [[1] [_____] 210 L 55 gallon[drum] [drums]] [[1] [_____] cubic meterscubic feet roll-off box] located beneath the press. The direct disposal system shall consist of a platform and disposal [chute] [chutes] that shall direct the sludge cake discharged into the disposal [drum] [drums] [roll-off box]. The platform shall include railing, catwalk, and stairs and shall conform to the design requirements in AISI SG03-3. The platform shall be constructed as indicated to allow an operator adequate access between all sides of the filter press and the safety railing and access to critical components of the press not accessible from the floor. The platform deck and stair treads shall be fabricated of ASTM A36/A36M carbon steel grating 25 mm by 5 mm 1 inch by 3/16 inch bars on 20 mm 13/16 inch centers and shall be constructed so that deflection will not exceed 1/300 of the span, considering dead and live load requirements and applicable safety factors. The platform frame shall be fabricated of ASTM A36/A36M structural steel I-beam, angle and plate shall support all equipment loading plus applicable safety factors. The operator walkways shall have a toe plate of carbon steel and safety rails of 25 mm 1 inch diameter schedule 80 carbon steel pipe. Stairs shall conform to requirements listed in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS. Each disposal chute shall be fabricated of 6 mm 1/4 inch thick ASTM A36/A36M carbon steel sheet and shall be attached to the platform to limit spillage of sludge cake.

[2.6.10.2 Sludge Cake Transport Systems

NOTE: A separate section to address conveying or pumping the sludge cake will be prepared and referenced in this paragraph.

]2.6.11 Blanking Plate

A blanking plate shall be provided which can be vertically inserted at any point in the plate stack to isolate the filter plates between it and the follower head, allowing a partial load to be processed. A movable follower liner which can move with the blanking plate shall be provided to allow filtration in the last cavity. The core blow air line shall move with the blanking and follower plates.

2.6.12 Automatic Filter Media Water Washer Assembly

NOTE: The automatic filter media water washer assembly will be required only if an automatic plate water wash system is used. If a manual system is used, delete this paragraph.

Each of the filters shall be equipped with a fully automated filter media water washer assembly. The washer shall be supported from the beam assembly of the filter and shall normally be stored between the filter follower and tail stand. The washer shall be designed for operation with water at 10 MPa 1500 psig and shall be capable of washing two plate sides at a time using one or multiple passes as required. Controls and

appurtenances shall be provided to allow the washer, once initial settings have been established, to wash each plate in a filter without further operator attention.

2.7 CONTROL SYSTEM

NOTE: Control systems for filter press and dewatering systems are application specific and can range from fully manual control to fully automatic control. The level of control presented in this guide specification is based on a semiautomatic control scheme. The semiautomatic control scheme involves manual operator startup of the sludge dewatering system, automatic control during the filtration cycle, and manual startup and shutdown of supporting sub-cycles such as filter media washing. The filter press components are controlled by a Filter Press Control Panel with control of the accessories by a Dewatering System Control Panel. If more or less control is required the degree of control shall be specified herein or shall be identified on the drawings.

If remote alarm and process variable monitoring is used, a separate paragraph should be added to coordinate with remote systems, such as Supervisory Control and Data Acquisition (SCADA) Systems and annunciators, and to include the method of transmission to remote locations.

A [manual] [semiautomatic] [automatic] complete electrical power, control, and instrumentation system as specified or recommended by the equipment manufacturer for the safe operation and supervision of the filter press units and related equipment shall be provided, except those items specified to be furnished under other sections. Schematics and interconnection wiring diagrams for power, control, instrumentation circuits shall be provided to equipment specified. Terminal blocks (plus 25 percent spare terminals) shall be provided in panels to terminate field and interconnection wiring. Control power transformers, relays, adjustable timers, auxiliary contacts, switches, or additional equipment required to interconnect the filter press package equipment to a remote plant monitoring system, and control circuits as shown on schematic or instrument control system drawings shall be provided. Conduit and wiring between control panels and control devices shall be furnished.

2.7.1 Normal Operation

NOTE: Following are typical normal operation procedures for both the fixed-volume and variable-volume filter presses. These operation procedures are provided for equipment suppliers to design control systems which involve control of filter press components by a Filter Press Control Panel and control of the accessories by a Dewatering System Control Panel. If these procedures are provided on the drawings, or are inapplicable,

delete or revise appropriately.

2.7.1.1 Fixed Volume Operation

The normal operation of a fixed-volume recessed plate and frame press will consist of the following sequence:

- a. The operator shall close filter press with controls at the press.
- b. The drip trays shall be closed from Filter Press Control Panel.
- c. The operator shall manually close valves to filtrate weir tank and valves to slurry feed pump.
- d. The operator shall manually open valves for precoat recycle to filtrate storage tank, precoat tank to pump, and precoat pump to press.
- e. The operator shall start the precoat pumps from the Dewatering System Control Panel.
- f. The precoat system shall operate long enough to complete three cycles through the press while recycling back to the precoat tank.
- g. The operator shall manually open valve from sludge conditioning tank to slurry feed pump.
- h. The operator shall start the slurry feed pumps from the Dewatering System Control Panel.
- i. The operator shall close valve from precoat pump to press while simultaneously opening valve from slurry feed pump to the press.
- j. The operator shall close precoat recycle valve and open valve to filtrate weir tank.
- k. The filter press feed pumping unit shall be operated as recommended by filter press supplier or as indicated.
- l. The filter press shall operate until it is automatically shut down by high filter press inlet pressure, terminal filtrate weir tank flow rate, low level in the sludge conditioning tank, or any additional process or safety related shutdowns recommended by the filter press supplier or as indicated.
- m. After the filter press feed pumping unit is shut off, there shall be a [1] [2] [_____] minute delay before the control system shall automatically: (1) close the filtrate pipe valve, (2) open the valves on the filter press feed line to air/core blowdown tank and open the air supply valve to the air/core blowdown tank, and (3) at completion of air/core blowdown, reposition valves on the filter press feed line to the filter feed position.
- n. After air/core blowdown, the completed filtering operation shall be indicated on the Filter Press Control Panel. The operator shall then open the filter press and initiate plate shifting and discharging of sludge cake from the Filter Press Control Panel.
- o. The drip trays shall be interlocked with the sludge discharge operation

and shall provide an enable/disable interlock for press opening. Internal filter press pressure in the feed port shall not allow press opening.

- p. The plate shifter shall automatically move plates at an adjustable delay of [5 to 10] [_____] seconds between shifts. A trigger control station located at the filter press shall allow interruption of the plate shifting process. The plate shifting process must be reinitiated from the Filter Press Control Panel. When each plate has been shifted the closing mechanism shall remain in the open position until the next press cycle is initiated.

2.7.1.2 Variable Volume Operation

The normal operation of a variable volume (diaphragm) recessed plate and frame filter press will consist of the following sequence:

- a. The operator shall close filter press with controls at the press.
- b. The drip trays shall be closed from Filter Press Control Panel.
- c. The operator shall manually close valves to filtrate weir tank and valves to slurry feed pump.
- d. The operator shall manually open valves for precoat recycle to filtrate storage tank, precoat tank to pump, and precoat pump to press.
- e. The operator shall start the precoat pumps from the Dewatering System Control Panel.
- f. The precoat system shall operate long enough to complete three cycles through the press while recycling back to the precoat tank.
- g. The operator shall manually open valve from sludge conditioning tank to slurry feed pump.
- h. The operator shall start the slurry feed pumps from the Dewatering System Control Panel.
- i. The operator shall close valve from precoat pump to press while simultaneously opening valve from slurry feed pump to the press.
- j. The operator shall close precoat recycle valve and open valve to filtrate weir tank.
- k. The filter press feed pumps shall run until an initial fill cycle has been completed.
- l. After the initial fill cycle is completed the valves to the filter press feed pumps shall close and the pumps shall shut down.
- m. The valves to the diaphragm [water] [air] filling system shall open and the [water] [air] shall be slowly pumped behind the diaphragms causing them to expand and compress the sludge cake.
- n. The diaphragm system shall operate at the maximum diaphragm pressure until the filter press is automatically shutdown by an elapsed compression time, terminal filtrate weir tank flow rate, low level in the sludge conditioning tank, or any additional process or safety

related shutdowns recommended by the filter press supplier or as indicated.

- o. The [water] [air] diaphragm system shall then be depressurized.
- p. After the filter press diaphragm is depressurized, there shall be a [1] [2] [_____] minute delay before the system will automatically: (1) close the filtrate pipe valve, (2) open the valves on the filter press feed line to air/core blowdown tank and open the air supply valve to the air/core blowdown tank, and (3) at completion of air/core blowdown, reposition valves on the filter press feed line to the filter feed position.
- q. After air/core blowdown, the completed filtering operation shall be indicated on the Filter Press Control Panel. The operator shall open the filter press and initiate plate shifting and discharging of sludge cake from the Filter Press Control Panel.
- r. The drip trays shall be interlocked with the sludge discharge operation and shall provide an enable/disable interlock for press opening. Internal filter press pressure in the feed port or diaphragm system shall not allow press opening.
- s. The plate shifter shall automatically move plates at an adjustable delay of [5 to 10] [_____] seconds between shifts. A trigger control station located at the filter press shall allow interruption of the plate shifting process. The plate shifting process shall be reinitiated from the Filter Press Control Panel. When each plate has been shifted the closing mechanism shall remain in the open position until the next press cycle is initiated.

2.7.2 Filter Media Water Wash Operation

NOTE: The filter media water wash operation can be performed either automatically or manually. This paragraph only provides requirements for the automatic operation and will be deleted when a manually operated system.

Filter media water washing will be provided on an as required basis and will consist of the following sequence:

- a. The operator shall open the filter press.
- b. Drip trays shall be closed from the Filter Press Control Panel to collect the wash water.
- c. From the Dewatering System Control Panel the sequence shall be initiated to automatically index through the entire plate stack or an isolated plate until each plate has been washed.
- d. Plates shall be shifted and washed at the rate of one plate per [1] [_____] minute.
- e. Operation of the filter press shall be unimpeded by the washer in the parked position.

- f. The washer shall automatically return to the cylinder end of the plate stack after wash cycle is complete.
- g. After the last plate is washed the filter media water wash system shall automatically shutdown.
- h. In manual mode the filter media water wash pump shall be started from a local hand switch.

2.7.3 Acid Wash Operation

NOTE: An acid wash system is only required when lime conditioning is used. If this system is not used, delete this paragraph.

The acid wash system shall be controlled from the Dewatering System Control Panel. The Dewatering System Control Panel shall have an acid wash local/remote switch and on/off pushbuttons for each filter press. The local/remote switch shall be in the local position, disable the on/off pushbuttons on the Dewatering System Control Panel, and enable the local on/off switch. In the remote position the on/off pushbuttons on the Dewatering System Control Panel are enabled and the local on/off switch is disabled. The acid wash operation shall be initiated and terminated manually. The local on/off push button shall be provided for maintenance purposes. The acid wash pump shall not be allowed to start or continue to operate once started unless the Dewatering System Control Panel indicates the following conditions have been met:

- a. Drip trays closed.
- b. Closing mechanism closed.
- c. Appropriate filtrate drain valves open/closed.
- d. Filter press feed valve in closed position.
- e. Core blow air valves closed.

2.7.4 Filter Press Control Panel

NOTE: The control of filter press components will be provided by a Filter Press Control Panel. If more or less control is required the degree of control will be specified herein or identified on the drawings.

Each filter press unit shall be provided with a control panel mounted on or near the unit to monitor and control pneumatic and hydraulic press parameters during shutdown and maintenance. The panel shall be prewired to the associated press components. The press control panel shall also include, but not be limited to, the following items:

- a. A [handrail] [unit] [floor] mounted NEMA [4X] [4] Control Panel with front accessible door.

- b. Air supply pressure gauge and control.
- c. Hydraulic supply to press cylinder gauge and control.
- d. Hydraulic supply to drip tray gauge and control.
- e. Hydraulic supply to plate shifter gauge and control.
- f. Open-close drip trays.
- g. Open-close plate follower.
- h. Start-Stop plate shifter.
- i. Precoat cycle ON/OFF indication and control.
- j. Filter media washer ON/OFF indication and control.
- k. Air blowdown and core blow cycle indication, including destination of the air and core blown sludge.

2.7.5 Dewatering System Control Panel

NOTE: The control of accessories to the filter press sludge dewatering system shall be provided by a Dewatering System Control Panel. If more or less control is required the degree of control will be specified herein and identified on the drawings.

Each filter press shall be provided with a remotely mounted running and operating control panel as indicated on the drawings. The control panel shall house electrical equipment and accessory items required in the operation of the dewatering equipment as specified. The dewatering system control panel shall include, but not be limited to, the following items:

- a. A [handrail] [unit] [floor] mounted NEMA [4] [4X] enclosure with front access door and nameplate.
- b. ON-OFF selector switch for each press.
- c. A push-pull emergency shutdown push button for each filtration system treatment trains.
- d. Off-Auto selector and start push button shall be furnished for each of the following cycles: filtration cycle, [precoat cycle with timer controls,] [air and core blowdown cycles with timer controls,] [automatic filter media water wash cycle,] [manually operated acid wash cycle].
- e. Pump Controls. Local/remote selector switch and lighted Start-Stop push buttons for the acid wash pump. H-O-A selector switch and lighted Start-Stop push buttons for each filter press feed pump [, filter precoat system feed pump,] [and the filter media water wash pump]. Selection control and operating status of filter press feed pumps.
- f. Valve Controls. Lighted push button controls shall be furnished for each core blow compressed air valve and three way filter feed pump

discharge valve. Lighted OPEN-CLOSE push-button controls shall be furnished for each of the filtrate top drain and the filtrate bottom drain.

- g. Limit switches on each valve shall indicate position on the Dewatering System Control Panel. Switches shall be NEMA 9 or shall be intrinsically safe devices.
- h. Alarms. A filter press filtrate terminal flow switch and a filter press inlet high pressure switch shall be furnished with the filter press package and shall be input to the Dewatering System Control Panel. Either of the conditions shall shut down filter press operation. The filter press feed pumps indicating lights for "low hydraulic pressure" and "end of cycle" due to a full filter press shall be provided on the Dewatering System Control Panel.
- i. Outputs. Isolated dry contact closures shall be furnished for the following remote indications: filter press run status, press equipment malfunction alarm, press feed pump run status.

2.7.6 Power and Instrumentation/Control Signals

A separate electrical power supply to each Filter Press Control Panel as indicated shall be 480 volts, 60 Hz, [20] [_____] amps, three-phase service. The filter press manufacturer shall provide circuit disconnect, protective motor starting, control and step down power transformers, and power and control circuits required for complete operation of the filter press regardless of whether or not they are specified or shown on the drawings. The electrical power supply to the Dewatering System Control Panel as indicated shall be unregulated 120 volts ac, 20 amps, single phase service. Transmitted electronic analog instrument signals shall be 4 to 20 mA dc, unless noted otherwise, and shall be linear with the measured variable. Pneumatic analog instrument signals shall be 20 to 100 kPa 3 to 15 psig. Control and instrument system installations shall conform to applicable requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. An integral 24 volt dc power supply shall be provided as required in the Dewatering System Control Panel for operating instrumentation circuits.

2.7.7 Metering Accuracy

System metering accuracy, as compared to the actual process value, shall be determined from the value read at the principal readout device such as the recorder or totalizer. System requirements shall not preclude any requirements specified herein for individual devices. For systems where the primary measuring device, transmitter, and receiver are furnished under this section, the accuracies shall be within the following limits:

Pressure	1.0 percent of measured span
Level	1.0 percent of measured span
Temperature	1.0 percent of measured span
Position	2.0 percent of maximum travel

2.7.8 Appurtenances

Signal converters, signal boosters, amplifiers, special power supplies, special cable, special grounding, and isolation requirements shall be furnished and installed as required for proper performance of the equipment.

2.7.9 Interchangeability and Appearance

Instruments utilized for the same types of functions and services shall be of the same brand and model line insofar as practicable. Similar components of different new and existing instruments shall be from the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever practical, identical units shall be furnished. Recorders, process indicators, control stations, and similar panel-mounted instruments shall be of the same style and shall be products of the same major instrument manufacturer.

2.7.10 Programming Devices

Programming or system configuring devices, such as hand held programmers and calibrators, shall be provided when required for routine maintenance and troubleshooting of the equipment.

2.7.11 Device Tagging

Devices shall be provided with permanent identification tags. The tag numbers shall agree with the construction drawings and with the supplier's equipment drawings. Stamped stainless steel or engraved plastic tags shall be provided. Hand lettered labels or tape labels are not acceptable.

2.7.12 Panel Fabrication

Controls shall be enclosed in NEMA [4] [4X] control panels. Electrical components shall be prewired and factory tested to the maximum extent possible. The following paragraphs describe general fabrication requirements for panels, consoles, enclosures, and subpanels:

- a. Piping. Pneumatic tubing shall be not less than 6 mm 1/4 inch OD copper with compression fittings. Tubing and fittings shall be specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Tubing shall be run in horizontal and vertical planes, rigidly supported to withstand handling and shipment. Flexible polyethylene tubing shall be used to connect devices mounted on hinged doors. Compression type bulkhead fittings shall be provided near the bottom or top of the panel for field connections. Compression nuts and sleeves shall be provided for the field connections. Indicators, recorders, controllers, and other pneumatic devices shall be provided with plugged test connections and shutoff valves for isolation. Devices shall have separate air supply shutoff valves. Pneumatic instrument panels shall be arranged to be served from a looped air supply header which is common to the panels. A three-valve manifold shall be provided in each instrument panel so that: (1) the looped air supply header may be sectionalized, (2) the panel may be served from either or both sides of the looped header supply, and (3) the looped air supply header may remain open with the supply to the panel shutoff. Power and control air requirements for the pneumatic instruments and devices on, within, and in conjunction with the instrument panel shall be supplied from the panel side of the respective three-valve manifold. Dual pressure regulators shall be provided on each instrument panel for each power or

control pressure level and shall be provided with blocking and shutoff valves so that either may be taken out of service without interrupting the service of the other. The regulators shall be connected to valve header manifolds and arranged to supply each individual pneumatic system through separate lines which branch off and can be isolated with blocking valves so that each system may be isolated and taken out of service independently of another. A bar type bulkhead shall be provided for termination of field piping and shall also provide threaded "T" taps that are plugged but which can be used for connection of test gauges during service and maintenance. Relief valves shall be provided for protection of instruments from high pressure in case of regulator failure. Regulators shall be provided with input and output pressure gauges and with filters and moisture traps.

- b. Wiring. Standard power and control wiring shall be provided in conformance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and analog control wiring shall follow the requirements within this paragraph. Analog circuits shall be routed in dedicated raceway systems. Terminal blocks for external connections shall be suitable for No. 12 AWG wire, and shall be rated 30 amperes at not less than 600 volts. Terminal blocks shall be fabricated complete with marking strip, cover, and pressure connectors. Terminals shall be labeled to agree with identification shown on the supplier's submittal drawings. A terminal shall be provided for each conductor of external circuits plus one ground for each shielded cable. Wiring shall be grouped or cabled and firmly supported to the panel. Not less than 200 mm 8 inches of clearance shall be provided between the terminal strips and the base of vertical panels for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Each control loop or system shall be individually fused, and fuses or circuit breakers shall be clearly labeled and located for easy maintenance. The panel fabricator shall provide such additional circuits as may be indicated on or required by the electrical drawings.
- c. Nameplates. Nameplates shall be provided on the face of each panel and on each individual device as required. Panel nameplates shall have approximate dimensions and legends as indicated and shall be made of laminated phenolic material having engraved letters approximately 5 mm 3/16 inch high extending through the black face into the white layer. Nameplates shall be secured firmly to the panels.
- d. Painting. Panels shall painted in accordance with requirements provided in paragraph PAINTING.

2.7.13 Controls and Interfaces

The filter press shall be controlled and operated with accessories and auxiliary systems, filter press pumps, [sludge conditioning system,] [precoat system,] filter media water wash system, [acid wash system,] [membrane water inflation system], and compressed air system, as one system, as indicated and specified. Filter feed pump, filter press, and valve interlocking relays, timers, and controls shall be provided as required on drawings or as specified.

2.7.14 Alarms

The unit shall be deactivated automatically if a loss of hydraulic pressure is sensed in the filter press. Alarm circuits and fail-safe controls shall be provided to alert the operator of any press equipment malfunction and

shut down the press and auxiliaries, light an alarm light and sound an alarm horn on the Dewatering System Control Panel. A normally open contact which closes under an alarm condition shall be provided for this annunciation. Operation of each filter press system shall be indicated by continuously illuminated lights on the front of the filter press control panels. The alarm circuits shall be reset by an "Alarm-Reset" push button on the front of the Dewatering System control panel.

2.8 SPARE PARTS

Submit spare parts data for materials and for each different item of equipment, after approval of the detail drawings, and not later than [2] [_____] months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

The following spare parts shall be provided with each filter press unit: one complete set of filter media cloth; two plates; two complete sets of each type of bearings and bushings, exclusive of those contained in motors and gear drives; one complete set of seals; two fuses of each type and size used; two light bulbs of each size used, including annunciator; and any other parts considered as "high wear" items unique to the filter press furnished. Spare parts shall be provided in waterproof packages suitable for export service labeled with the description and part numbers. Except for fuses and light bulbs, each item or set of parts expected to be installed at one time shall be in an individual package.

2.9 SAFETY MECHANISMS

NOTE: Safety mechanisms are optional features that are recommended for semiautomatically or automatically operated press applications. Light curtain or safety pullwires primarily preform the same function, thus both features are not required for the same application.

2.9.1 Light Curtain

NOTE: The light curtain shall extend over the minimum length of the horizontal edge of the filter plates.

A light curtain presence sensing device shall be factory mounted to control the complete operation of the filter press. Light curtains shall be furnished for both sides of the filter providing an operator safety depth of [____]. The light curtain shall consist of an [infrared] [visible spectrum] light source transmitter array, a photo transistor receiver array, and a solid state multiplexed controller with electro-mechanical output relay. The light sources shall be mounted in a reflective housing and shall be equipped with a high quality optical lens to properly collimate the emitted light. The receivers shall be mounted in a sealed housing equipped with a glass optical converging lens. The control system shall have a time delay function, adjustable from 0.025 to 5 seconds, which shall continue to de-energize the electronic output for the specified time period after the curtain has been interrupted and then restored.

2.9.2 Safety Pullwires

A double set of shifter or follower movement safety stop lanyards shall be provided on both sides of the filter press for personnel protection. This system shall consist of steel cables and supports with manually reset safety switches on both sides of the press. The system shall provide control contacts to interrupt service until the switch is reset by hand. Switches shall be NEMA 4 enclosures.

2.9.3 Safety Guards

A safety guard shall be mounted on the non-operator side or side opposite from the plate shifter control station of the filter press. The safety guard shall consist of a metal screen or acrylic safety screen. The safety guard shall be equal height to the filter plates and shall run the length of the press.

2.10 FILTER PRESS INSTALLATION EQUIPMENT

An overhead [bridge crane] [monorail] [hoist] shall be provided in accordance with the requirements of Section [41 22 13.13 BRIDGE CRANES][41 22 23.19 MONORAIL HOISTS].

2.11 ACCESSORIES

2.11.1 Filter Press Feed Pumps

NOTE: Several types of pumps, including plunger, progressive cavity, and diaphragm pumps, may be applicable for filter press feed applications. Information on these types of pumps is presented in Section 22 13 29 SANITARY SEWERAGE PUMPS.

Each filter press sludge feed pump shall be a [plunger] [progressive cavity] [diaphragm] type. Each pump shall be completely factory assembled, that is, parts required to operate the pump shall be mounted on a base plate. Pump and drive unit shall be designed for continuous 24 hour per day operation. The specific requirements for this type of pump and associated accessories are provided in Section 22 13 29 SANITARY SEWERAGE PUMPS.

2.11.2 Sludge Conditioning System

NOTE: The sludge conditioning system may be applicable for some applications to increase filterability. If conditioning is not required, delete this paragraph.

A sludge conditioning system shall be supplied consisting of a mixing tank, an air blowdown manifold and sludge receiving tank, and associated valves, appurtenances, and controls.

2.11.2.1 Sludge Conditioning Tank

The sludge conditioning tank shall have a useful capacity of [_____] and be constructed of [fiberglass reinforced plastic (FRP)] [coated steel]. The tank shall be flat bottom, closed flanged top type approximately [_____] diameter and [_____] high. In addition to the tank useful capacity, 300 mm 12 inch extra of sidewall height for pump cut off controls and 300 mm 12 inch extra of sidewall height for freeboard shall be allowed. The tank shall include flanged fittings for drain, sludge outlet, 600 mm 24 inch manway in the shell, sludge inlet, conditioning agent inlets, [core blow tank connection,] vent connection, level switches, mixer mounting flange in the top, and access ladder and platform for top access.

2.11.2.2 Sludge Conditioning Tank Mixer

The sludge conditioning tank mixer shall mix the conditioning tank contents prior to feeding the filter press. The mixer agitator shall be complete with [_____] watt hp motor. [_____] turbine type mixing elements shall each be supplied with [_____] pitch blades.

2.11.2.3 Air Blowdown\Core Blow Sludge Separation Tank

NOTE: The air blowdown\core blow sludge separation tank is only required if those optional features are used.

An air blowdown and core blow sludge separation tank shall be provided to dissipate, by centrifugal action, the energy of the sludge discharged under pressure from the air blowdown and/or core blow operations performed at the end of the dewatering cycle. This tank shall be a cylindrical separator type tank fabricated of coated steel with an overall length of [_____] and diameter of [_____]. This tank shall be mounted on top of the sludge conditioning tank.

2.11.2.4 Chemical Feed System

NOTE: Each type of chemical feed system required for sludge conditioning is application specific. Requirements for several types of liquid chemical feed systems typically required for sludge conditioning are provided in Section 43 32 69 CHEMICAL FEED SYSTEMS. Requirements for any additional types of chemical feed systems will also be added to that section.

Chemical feed systems required for sludge conditioning shall be provided in accordance with requirements in Section 43 32 69 CHEMICAL FEED SYSTEMS.

2.12 PRECOAT SYSTEM

NOTE: A precoat system may not be required for every application. If inapplicable this paragraph shall be deleted.

A precoat system shall provide material to precoat the filter media. The precoat system shall consist of a precoat tank with mixing, precoat pump, chemical feed system, associated valves, appurtenances, and controls.

2.12.1 Precoat Tank

The sludge precoat tank shall have a useful capacity of [_____] and be fabricated of [coated steel] [stainless steel]. The tank shall be flat bottom, closed flanged top type approximately [_____] diameter and [_____] high. In addition to the tank useful capacity 300 mm 12 inch extra in sidewall height for pump cut off controls and 300 mm 12 inch extra in sidewall height for freeboard shall be allowed. The tank shall include flanged fittings for drain, precoat outlet, future connection for precoat material inlet, filtrate water inlet level switches as shown on the construction drawings, mixer mounting flange in the top, and an access ladder and platform for top access.

2.12.2 Precoat Tank Mixer

The precoat tank mixer shall mix the tank contents to feed the filter press. The agitator shall be complete with [_____] watt hp motor. [_____] turbine type mixing elements shall each be supplied with [_____] pitch blades.

2.12.3 Precoat Feed Pump

NOTE: Several types of pumps, including centrifugal and diaphragm pumps, may be used for precoat feeding depending on the type of precoat material used. Information on these types of pumps is presented in Section 22 13 29 SANITARY SEWERAGE PUMPS.

Each precoat pump shall be a [centrifugal] [diaphragm] type. Each pump shall be factory assembled, that is, parts required to operate the pump shall be mounted on a base plate. Pump and drive unit shall be designed for continuous 24 hour per day operation. The specific requirements for this type of pump and associated accessories are provided in Section 22 13 29 SANITARY SEWERAGE PUMPS.

2.12.4 Chemical Feed

NOTE: The type of dry or bulk chemical feed system required will be application specific. Requirements for the dry chemical feed system will be provided in a separate guide specification and referenced in this paragraph.

2.12.5 Compressed Air System

NOTE: The compressed air system described in this paragraph contains equipment for both instrument and plant systems applications. Edit as necessary.

Compressed oil free, dry instrument air is to be supplied at [690 kPa 100 psi] [[_____] kPa psi] and process air is to be supplied at [690 kPa 100 psi] [1550 kPa 225 psi] [[_____] kPa psi]. The air compressor system shall consist of air compressors, an air dryer, instrument air receiver, and a membrane inflation and core blow air receiver.

2.12.5.1 Air Compressors

[Two] [_____] duplex air compressors shall be supplied with the filter press. The air compressors used for the filter press system shall be in accordance with air compressor requirements provided in drawings and in Section 22 00 00 PLUMBING GENERAL PURPOSE.

2.12.5.2 Compressed Air Dryer

A refrigerated type compressed air dryer shall be installed between the compressor aftercoolers/separators and the instrument air receiver. The dryer shall have a minimum operating capacity of [_____] L/s cfm at a pressure of 690 kPa 100 psig. The electrical characteristics of the dryer shall be [_____] watt hp, 208 volts, three phase, 60 Hertz. An adjustable air pressure regulator shall be installed upstream of the air dryer. The regulator shall be capable of handling a maximum inlet pressure of 2.1 MPa 300 psig, have an adjustable range of [_____] to [_____] kPa [_____] to [_____] psig, with a maximum operating temperature of 80 degrees C 175 degrees F and be provided in accordance with any additional applicable requirements in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.12.5.3 Instrument Air Receiver

The instrument air receiver shall store air as delivered from the air dryer. The instrument air receiver used shall be provided in accordance with the air receiver requirements provided in drawings and in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.12.5.4 Core Blow and Membrane Inflation Air Receiver

NOTE: This receiver will only be required for filter press systems using air or core blowing systems or variable volume filter presses requiring diaphragm inflation. This receiver shall be designed with 1720 kPa (250 psi) working pressure which is greater than the 1380 kPa (200 psi) pressure referred to in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

The air receiver shall store air as delivered from the compressor aftercooler. The core blow and membrane inflation air receiver used shall be provided in accordance with the air receiver requirements provided in drawings and in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

2.12.6 Membrane Water Inflation System

NOTE: This system will only be required if a variable volume filter press using a membrane water system is used.

The membrane water inflation system for the variable volume filter press application shall consist of a pump, tank, and appurtenances.

2.12.6.1 Membrane Water Inflation Pump

NOTE: Several types of pumps, including centrifugal, progressive cavity, and diaphragm pumps, may be applicable for membrane water inflation. Information on the applicability and detailed requirements for these types of pumps are presented in Section 22 13 29 SANITARY SEWERAGE PUMPS.

Each membrane water inflation pump shall be a [centrifugal] [air diaphragm] [progressive cavity] type. This type of pump and associated accessories shall be provided in accordance with requirements in Section 22 13 29 SANITARY SEWERAGE PUMPS.

2.12.6.2 Membrane Water Tank

NOTE: If the water is recycled to the filter media water wash tank this paragraph shall be deleted.

The membrane water tank shall have a useful capacity of [_____] and shall be constructed of [polypropylene] [polyethylene] [fiberglass reinforced plastic]. The tank shall be flat bottom, open flanged top type approximately [_____] diameter. The tank shall also be provided with a tubular glass gauge assembly and level controls.

2.12.7 Filter Media Water Wash System

NOTE: Filter media water washing can be performed either manually or automatically. Both types of systems are described in this paragraph. Any equipment not required shall be deleted.

[A manual filter media water wash system shall be provided having 6.9 MPa 1000 psig discharge nozzle pressure to periodically clean the filter media. The wash system shall be cart mounted with sufficient length of hose and power cord. The washer shall consist of a hand held wand with a single fan type nozzle. Washer control shall be contained in the washer cart. The pump shall be powered by a 760 watt 10 hp totally enclosed fan cooled motor mounted on the pump cart.] [An automatic filter media water wash system shall be supplied consisting of a tank, pump, and appurtenances. The system shall provide high pressure water at 10.3 MPa 1500 psig to the filter media water washer assembly.]

2.12.7.1 Filter Media Water Wash Tank

NOTE: If an automatic wash system is not used this paragraph shall be deleted.

The filter media water wash tank shall have a useful capacity of [_____] and be constructed of [polypropylene] [fiberglass reinforced plastic]. The tank shall be flat bottom, open flanged top type approximately [_____] diameter. The tank shall also be equipped with a tubular glass level gauge assembly.

2.12.7.2 Filter Media Water Wash Pump

NOTE: If an automatic wash system is used, the specific requirements listed in this paragraph shall be coordinated or incorporated into Section 22 13 29 SANITARY SEWERAGE PUMPS, as required. If an automatic wash system is not used this paragraph will be deleted.

The plate water wash pump shall be a triplex reciprocating, horizontal piston pump. The pump shall be factory assembled; that is, parts required to operate the pump shall be mounted on a common base plate. The pump shall be rated for a flow of [_____] and a discharge pressure of [_____].

- a. Drive Unit. The pump shall be driven by an electric motor. The motor shall be [_____] watt hp, three phase, 60 Hz, 480 Volt, totally enclosed fan cooled, Class F Insulation, Severe Duty Construction. The motor short circuit protective device and magnetic starter shall be remotely located in a motor control center as shown on the drawings. A local disconnect shall be provided at the motor. The motor shall be directly coupled to the gear reduction unit. The coupling shall be flexible and shall be covered with a guard. The pump shall be equipped with an internal, single reduction gear. Moving gear parts shall be splash lubricated and shall not require any external force lubrication system. The entire gear mechanism shall be totally enclosed and effectively sealed so that dirt or water cannot enter. It shall have an oil sight glass, an oil filling opening and an oil outlet. The pump gear wheel speed shall not exceed 400 rpm. The pinion gear and gear wheels shall be helical type operating in an oil bath. The pump pinion shaft shall be of high strength hardened steel. The pump shall run in sealed anti-friction bearings to prevent oil leakage.
- b. Pumping Unit. Each piston shall be stainless steel with two neoprene U ring seals forming an effective seal with the inside surface of the cylinder liner. The piston shall run in a replaceable stainless steel cylinder liner.
- c. Piping, Valves, and Miscellaneous. The suction and discharge valve shall be housed in a compact, double valve cartridge for easy inspection and replacement. Valves shall be spring loaded plate type in one piece assembly. The valve seats and valve plates shall be hardened stainless steel. The suction and discharge side valve components shall be interchangeable. The pump shall be equipped with a spring loaded discharge pressure relief valve to protect the pump and system from over pressure. The pump shall have a 19 mm 3/4 inch connection and shall be set for 10.7 MPa 1550 psig. The pump shall be equipped with a liquid filled pressure gauge with an isolation valve.

The pump shall have a nitrogen prefilled, bladder type pulsation dampener connected to the discharge side of the pump. The pump shall be mounted on rubber vibration isolation pads and connected to the suction piping with a rubber spool piece. The pump shall be fitted with a fine mesh suction strainer with an exchangeable filter element. The discharge of the pump shall be equipped with a solenoid operated three/two-way bypass valve with a bypass line going directly back to the suction side of the pump. The three/two-way valve shall be spring loaded such that pumpage is directed to the pump suction, unless the solenoid is energized. A loss of power shall cause the three/two way valve to direct pumpage to the pump suction with no back pressure. The pump shall be equipped with a 0.9 meter 3 foot long flexible, high pressure discharge hose and a 38 mm 1-1/2 inch ASME B16.5 Class 600 discharge flange.

d. Materials of Construction. Materials of construction shall consist of:

- (1) Gear Housing: Cast Iron
- (2) Crankshaft/Gear Wheels: Ductile Cast Iron
- (3) Pinion Gear Shaft/Piston: Hardened Steel
- (4) Pump Body: Ductile Cast Iron
- (5) Piston: Stainless Steel w/ U ring seals
- (6) Piston Liner: Stainless Steel
- (7) 3/2 Way Valve: Steel
- (8) Pump Base: Fabricated Steel
- (9) Valve Seats and Plates: Stainless Steel

2.12.8 Acid Wash System

NOTE: Acid wash systems are required only when lime conditioning is used. If this system is not required, delete this paragraph.

An acid wash system shall consist of a drum pump, mixing tank, mixer, and transfer pump that will provide a dilute acid for filter-media cleaning.

2.12.8.1 Acid Storage System

NOTE: Acid storage is provided in its original shipping container. If a different acid storage system is used, revise the following requirements appropriately.

Acid shall be stored in its original shipping container.

2.12.8.2 Acid Transfer Pump

NOTE: Acid pumping for preparation of the acid wash solution is performed by an acid drum pump. If a different pumping system is used, revise the following requirements appropriately.

Transfer of [38] [_____] percent hydrochloric acid from shipping drums to

the acid wash mixing tank shall be provided by a drum pump. The pump tube shall be fabricated of polyvinyl chloride or other compatible non-metallic material, and shall be 1200 mm 47 inches long and designed to fit through the bung of a standard shipping drum. The pump shall have a capacity of approximately [_____] at [_____] of head. The drive motor shall be rated [_____] watts hp, 115 volts, single phase, 60 Hz. An integral circuit breaker with manual reset, and an "On-Off" switch shall be mounted in the pump handle. A [_____] long cord with 3 prong plug shall be included. The pump shall have a 25 mm 1 inch, barbed discharge port for a hose connection. A wall mounting storage bracket and a chemical-resistant drip pan shall be included. The dedicated circuit shall terminate in a dedicated receptacle near the drum location.

2.12.8.3 Acid Wash Tank

The acid wash tank shall be furnished to dilute, mix and hold acid for filter media washing. The tank shall have a useful capacity of [_____] and be constructed of fiberglass reinforced plastic. The tank shall have [_____] diameter conical bottom with supporting legs. The tank shall include flanged fittings for water inlet, acid outlet, acid recirculation, overflow and drain and shall be provided with an access.

2.12.8.4 Acid Wash Tank Mixer

The mixer shall be suitable for continuous operation and shall be driven by a [_____] watt hp, 115 volt, single phase, 60 Hz, totally enclosed fan cooled electric motor. The rotating speed of the mixer shall not exceed 1,750 rpm. The mixer shall be located to provide thorough mixing. The mixer shaft and impellers shall be fabricated of corrosion resistant materials.

2.12.8.5 Acid Wash Pump

NOTE: The specified materials of construction for wetted parts of this pump referenced in Section 43 21 13 PUMPS WATER CENTRIFUGAL will be polypropylene or other suitable non-metallic material.

The acid wash pump shall be furnished to circulate dilute acid through the filter press. The horizontal end suction centrifugal pump shall be provided in accordance with the requirements provided in Section 43 21 13 PUMPS: WATER, CENTRIFUGAL.

2.13 LUBRICATION

An adequate means of lubrication shall be provided for moving parts subject to wear. Except as otherwise specified, lubrication shall be by grease or oil. Grease fittings shall be provided for grease-type bearings. If bearings are not easily accessible, grease tubing shall be provided in a convenient location. Bearings shall be provided with relief ports to prevent build up of pressures which might damage the bearings or seals. Oil reservoirs shall be liberal in size and shall be provided with an opening for filling, an overflow opening at the proper location to prevent overfilling, and a drain opening at the lowest joint. Reservoirs shall be properly vented to prevent pressure build up.

2.14 FACTORY TESTS

Factory tests shall include tank integrity testing, process piping pressure/leak testing, accessory operability testing, and control panel testing. The factory tests shall be performed and the results submitted to the Contracting Officer prior to final approval of the equipment.

2.14.1 Tank Integrity Testing

Tank integrity (hydrostatic) tests shall include, but not be limited to, filling the tanks with potable water for a period of 24 hours and inspecting for leaks.

2.14.2 Process Piping Pressure/Leak Testing

Process piping pressure and leakage testing shall include, but be not limited to, pipe testing for at least 1 hour with no loss of pressure except to compressed air plastic piping, unless recommended by the manufacturer, at 1.5 times the working pressure, but not less than 350 kPa 50 psi with the intended service media.

2.14.3 Accessory Operability Testing

Accessory operability tests shall be performed for the filter feed pump system, [sludge conditioning tank system,] [acid wash system,] filter media water wash system, and air compressor system.

2.14.4 Control Panel Testing

Control panel testing shall be performed by functional tests.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 SLUDGE DEWATERING EQUIPMENT INSTALLATION

Install reinforced concrete, of the size and design indicated, in accordance with Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE.

3.2.1 Welding

Steel piping shall be welded in accordance with AWS D1.1/D1.1M by welders certified to have passed tests using procedures in accordance with AWS B2.1/B2.1M or ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practicable. A copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators.

Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING. Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING PROCESS PIPING.

3.2.2 Pipe and Valve installation

Piping shall be installed with joints tight and with no undue marring of finishes. Installed piping, valves, and fittings shall be free from strain and excessive stresses caused by weight or misalignment. In addition to these requirements, piping shall be installed in accordance with applicable requirements provided in Section 22 00 00 PLUMBING, GENERAL PURPOSE.

3.2.2.1 Flanged Joints

Bolts shall be tightened uniformly to prevent overstressing flanges and misalignment.

3.2.2.2 Screwed Joints

Screwed joints shall be made tight with joint compound, applied to the male threads only, or with joint tape.

3.2.2.3 Push-On Joints

Pipe ends shall be beveled to facilitate assembly. Pipe shall be marked to indicate when the pipe is fully seated. Gaskets shall be lubricated to prevent displacement. The gasket shall remain in proper position in the bell or coupling while joints are made.

3.2.2.4 Solvent-Weld Joints

Joints shall be made in accordance with the manufacturer's written instructions.

3.2.2.5 Valves

Valves shall be installed and located for easy access for operation.

3.2.3 Equipment installation

Equipment installation shall be in accordance with the manufacturer's written instructions.

3.2.4 Electrical Work

Electrical work shall be in accordance with the drawings and applicable requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Equipment shall be suitable for installation in a corrosive environment (NEMA 4X) unless specified otherwise.

3.3 PAINTING

**NOTE: Include Section 09 97 02 PAINTING, HYDRAULIC
STRUCTURES in the project, or incorporate applicable
provisions in this paragraph.**

Painting shall be performed in accordance with applicable requirements provided in Section [_____] and additional requirements provided herein.

3.3.1 General

Metal surfaces, except aluminum, bronze, brass, galvanized steel, and stainless steel shall be painted. Surface preparation and painting shall be performed in the shop or in the field as indicated. Manufactured items, such as motors and switchboards, shall be finished with the manufacturer's standard finish.

3.3.2 Preparation and Application

Ferrous metal surfaces shall be prepared in accordance with SSPC SP 6/NACE No.3 and painted with two or three coats of MIL-DTL-24441 epoxy paint, to achieve a total dry film thickness of 150 microns (6 mils). Master Painter's Institute (MPI) #120 Epoxy, High Build, Self Priming, Low Gloss, is an acceptable replacement to MIL-DTL-24441.

3.3.3 Testing

Coatings shall be examined for flaws and tested for thickness and holidays. Thickness of coatings shall be measured wet and dry using a commercial film thickness gauge. The Contracting Officer shall be notified in advance of any painting. Additional coats shall not be applied until the previous coat has been approved. Repair or additional coatings shall be accomplished at no additional cost to the government.

3.3.4 Coating Repair

If welding is required after application of the coating or if the coating is damaged in any way, repair shall consist of preparing the affected area in compliance with SSPC SP 6/NACE No.3 and reapplying the coating to that area. If holidays are detected or film thickness is insufficient, the surface shall be prepared and additional coats applied in the affected area in compliance with the manufacturer's instructions.

3.4 POSTING FRAMED INSTRUCTIONS

Post the approved wiring and control diagrams showing the complete layout of the entire system, including equipment, piping valves, and control sequence, framed under glass or in approved laminated plastic, where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. Submit proposed diagrams, instructions, and other sheets prior to posting. The framed instructions shall be posted before acceptance testing of the systems.

3.5 FIELD TESTS AND INSPECTIONS

3.5.1 General

Perform the field tests. The Contracting Officer will witness field tests and conduct field inspections. The Contracting Officer shall be notified 7 days prior to the dates and times for acceptance tests. Any deficiencies found shall be rectified and work affected by such deficiencies shall be retested at the Contractor's expense.

Submit test reports in booklet form showing results of the field tests performed to adjust each component following the installation of the system

and the field tests performed to prove compliance with the specified performance criteria. Each test report shall indicate the final position of controls.

3.5.2 Initial Acceptance Test

After completion of the installation and as soon as practical, an operating test of the Filter Press and associated equipment shall be performed to demonstrate that the system functions properly. The initial tests shall include the manufacturer's recommended tests for equipment vibration, horizontal and vertical alignment structural integrity, leaks in piping and seals, correct operation of control systems and equipment, and excessive noise levels. Horsepower shall be checked and verified with the manufacturer's design data for the specified equipment. Tests shall demonstrate that the equipment is not electrically, mechanically, structurally, or otherwise defective; is in safe and satisfactory operating condition; and conforms to the specified operating characteristics. After completion of the tests, the system shall be adjusted for proper operation, in accordance with the manufacturer's written instructions and the operating and maintenance instructions.

3.5.3 Final Acceptance Test

**NOTE: This paragraph only applies to specific
circumstances such as partial installation of the
dewatering system components at different periods of
time. If not applicable, delete this paragraph.**

Six months after completion of the initial acceptance test, conduct a retest of the equipment to verify that the equipment functions as specified under actual operating conditions. Replace or upgrade equipment not capable of performing as specified at no cost to the Government.

3.6 MANUFACTURER'S SERVICES

3.6.1 Installation, Adjustment, and Testing

Provide a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment to supervise the installation, adjustment and testing of the equipment.

3.6.2 Field Training

Conduct a field training course for the designated operating and maintenance staff members. Training shall be provided for a period of [24] [_____] hours of normal working time and shall start after the system is functionally complete, but prior to final acceptance test. The field instructions shall cover the items contained in the Operating and Maintenance Instructions, as well as demonstrations of routine maintenance operations. Prepare a video tape of the field training course for a permanent record for future training use.

3.7 MAINTENANCE

Provide operating and maintenance instructions the step-by-step procedures required for system startup, operation and shutdown, routine maintenance, possible breakdowns and repairs, and troubleshooting. These instructions

shall include the manufacturer's name, model number, service manual, parts list, and brief description of the equipment and their basic operating features. These instructions shall include, but not be limited to, the following:

- a. System layout showing piping, valves, and controls.
- b. Approved wiring and control diagrams prepared in accordance with ANSI/ISA 5.1 including a drawing index, legend and symbols list, and abbreviations and identifiers.
- c. A control sequence describing startup, operation, and shutdown.
- d. Operating and maintenance instructions for each piece of equipment, including lubrication instructions and troubleshooting guide.
- e. Manufacturer's bulletins, cut sheets and descriptive data, parts lists, and recommended spare parts.

-- End of Section --