SP-151133
(Replaces SP-151104)

SPECIAL PROVISIONS
FOR
WAVESHAPERS™ AND GATES

Polk County
EDP-PA26(001)--7Y-77

Effective Date
March 29, 2022

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

151133.01 DESCRIPTION.

A. General.
There shall be designed, furnished, and installed an adjustable Gate (WaveShaper™) to adjust and control the shape of waves in the waterway. This shall also be referred to as a gate. The equipment shall include plates, hinges, actuators, valves, and seals as schematically shown on the plans, hydraulic system, and piping, and all other equipment, systems, and design as required for a fully functional gate system. The hydraulic system including cylinders, valves, reservoir, controls, and hydraulic pump to move the gate is included.

B. Definitions.

1. Actuators: Hydraulic cylinders to move the various panels of the gates.

2. Lip: Downstream end of the most downstream panels.

3. Gate System Supplier: The fabricator of the WaveShaperTM or their authorized representative. (See Article 151133.05, D for additional information on the Gate System Supplier.)

C. Quality Assurance.

1. References: Reference in this Section of a Standard, such as ASTM, AWWA or ACI, is to be interpreted to be the latest revision of that Standard.

2. Industry Standards and Specifications:
- **a.** American Society for Testing and Materials:
  - **1)** A29/A29M: Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished, General Requirements
  - **2)** A36/A36M: Structural Steel
  - **3)** A53: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
  - **4)** A123: Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

5) A153: Zinc Coating (Hot-Dip) on Iron and Steel Hardware
6) A181/A181M: Forgings, Carbon Steel for General Purpose Piping
7) F593: Stainless Steel Bolts, Hex Cap Screws, and Studs
8) A536: Ductile Iron Castings
9) D751: Coated Fabrics, Test Method
10) D1149: Rubber Deterioration – Surface Ozone Cracking in a Chamber (Flat Specimens), Test Method
11) D3350: Polyethylene Plastics Pipe and Fittings Materials
12) D4801: Polyethylene Sheeting in Thickness of 0.25 mm (0.010 in.) and Greater

b. American Institute of Steel Construction (AISC): "Manual of Steel Construction."
c. American Welding Society (AWS): D11 "Structural Welding Code."
d. The Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
e. International Society of Automation (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
f. National Electrical Manufacturers Association (NEMA):
g. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
h. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
i. ICS 2, Industrial Control Devices, Controllers and Assemblies.
j. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
k. Underwriters Laboratories Inc. (UL): 508A, Standards for Safety, Industrial Control Panels.

151133.02 SUBMITTALS.
Submit the following for review according to Article 1105.03 of the Standard Specifications.

A. Gate System Supplier qualifications and experience demonstrating compliance with requirements.

B. Final design drawings, computations, and engineering analysis of Gates prior to commencement of Shop Drawings, fabrication submittals and fabrication of Gates. Design Loads including dead loads, safety factors, etc. are to be included. Drawings, computations, and engineering analysis are to be sealed by a Professional Engineer licensed in the State of Iowa. Shop drawings shall detail all connections, fabrication details, all final dimensions, clearances, tolerances, finishes, etc. An anchor bolt template shall also be shown on the Shop Drawings and shall be furnished unless waived in writing by the Engineer.

C. Product Compliance Certificate, Material Testing Records, and Installation Instructions prior to commencement of installation.

D. Handling and storage plan and requirements, prior to delivery of Gate, and any components to the project site. Written instructions from ~~manufacturer~~ Gate System Supplier will be provided.

E. Work plan and schedule for construction, including foundation work, anchors, concrete forming and steel placement, placement of embeds and anchors, hydraulic lines and sensing/controls piping, special concrete work to fill areas of difficult placement, concrete finishing, and placement, testing of anchor bolts, work area plan for placement, detailed sequential steps of placement, equipment for placement, controls and sensing line installation, and all testing procedures.

F. Specific minimum tolerances required by ~~manufacturer~~ Gate System Supplier for construction of reinforced concrete, painting, torque for anchor bolts and fasteners, pressures, deadbands, dimensions and related construction. ~~Manufacturer's~~ Gate System Supplier's requirements do not supersede other stricter requirements elsewhere in these specifications and on the plans.

G. Written instructions regarding concrete embedded anchor system hardware, to include tolerances, 30 days prior to anticipated delivery of the concrete embedded anchor system hardware.

H. Installation inspection report by Gate System Supplier. This report shall include report from on-site inspection by Gate System Supplier. Inspections will be periodic as required for installation of critical components or at critical times. At least one inspection report approving installation of each Gate prior to running water over the Gate during the construction dewatering phase. The Engineer shall be informed of the date for each inspection at least two weeks prior to all on-site inspections by the Supplier.

I. Hydraulic System Leakage Test Records prior to final inspection by Engineer.

J. Installation Acceptance Certificate with copies of test reports attached, and Warranty Certificate immediately following final inspection by Engineer.

K. Bill of material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of control system.

L. Catalog information on electrical devices furnished with system.

M. Shop Drawings, catalog material, and dimensional layout drawings for control panels and enclosures.

N. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.

O. Complete set of user manuals.

P. Submit ~~manufacturer's~~ Gate System Supplier's standard warranty certificate. ~~Manufacturer's~~ Gate System Supplier's standard warranties for specified products shall be transferred to Polk County Conservation upon acceptance of the project.

151133.03 DESIGN.

A. General:
Rotation of the vane of the WaveShaper(s)™ allows the desired hydraulic jump formation over a wide range of flows. To reliably provide this ability, the WaveShaper shall be designed for long-term low-maintenance operations. The shape, dimensions, some details, range of motions of Gates, and various criteria are as specified on the plans and within this specification. A hydraulic pump and control system like that on various equipment with 3-way hydraulic valves operates the vane of the WaveShaper™. Adjustments can be made during normal operations, however once the tuning phase is completed, steel bars will be fabricated by the Contractor and supplied to the ~~Owner~~ Contracting Authority to allow the WaveShaper™ to be locked into place in the future if desired.

B. Description:
The gate shall consist of a steel vane with welded framing, steel torque tube, pillow blocks, and lever arm assemblies anchored to concrete as shown on the plans. The actuators shall include two hydraulic cylinders mounted in vaults adjacent to gate on concrete foundations with hydraulic lines embedded in the foundation that lead to hydraulic hoses in conduits to a control vault on the riverbank where a hydraulic pump unit, reservoir and valves shall move the vane as shown on plans. The panel, torque tube, and lever arm assembly shall allow the Gate to operate through a range from fully raised to fully lowered and as otherwise shown on the plans. Shims at the pillow blocks shall allow for the Vane to be raised or lowered as required during start-up and tuning.

C. Member Sizes and Dimensions:
The moveable panels that make up the WaveShapers™ and Gates shall be designed to move within the limits shown on the Plans with water flowing in the waterway. The shape and dimensions of the WaveShapers™ vanes are as shown on the plans and the overall dimensions and shape

shall not be changed significantly. Members, connections, and details are shown schematically. Minimum sizes of members and connections are shown on the plans. The Gate System Supplier shall determine if larger members or additional members and connections are required. Dimensions for the components and various members shown on the plans are illustrative only and final dimensions of all members shall be determined by the Gate System Supplier based upon actual member sizes, required clearances, welding, painting, and assembly needs, objectives, and details, etc. Additional members, structural components, reinforcing, welding, connectors, connection details, bolting and fasteners, etc. shall be required and are not shown on the plans.

D. Design Rationale:

The WaveShapers™ design shall be based both on thorough stress analysis and on long term experience with comparable components under similar conditions. Design efforts by the Gate System Supplier, shall include a detailed structural analysis. Any ~~H~~hydraulic modeling completed by the Supplier as part of final design shall be ~~conducted if deemed necessary~~ provided to the Engineer for review. A detailed, working solid 3D model of the WaveShaper(s)™ in a 3D computer application program shall be provided. This shall be fully moveable and readily able to demonstrate the range of motion and verify the absence of interference of the various components and structural members. This model shall be viewable with rotatable vane(s) in at least one common~~ly~~ program/application.

E. Hydraulic Loading:

The Gates/WaveShapers™ including attachments hinges, bearings, and connectors shall be analyzed and designed using the loadings and considerations as described herein. The moveable panels that make up the Gates/WaveShapers™ shall be designed to move within the limits shown on plans with water flowing in the waterway.

The Gates/WaveShaper™(s) will be operating in a rapidly varying flow regime (transition from super critical to sub critical flow) at a hydraulic jump. Depending on the hydraulic jump formation the gate will experience downward or upward (uplift) loading. The Gates/ WaveShapers™ and system components (including actuators) shall be designed to withstand the loads as described herein. The surrounding waters will be very turbulent and all lines, hoses, and other equipment will be designed to accommodate severe turbulent conditions. Loads shown do not include dead loads and do not include a safety factor. Supplier shall assign an appropriate safety factor based on their experience with similar systems. Live downward loads due to hydraulic forces shall be no less than 200 lbs./ft^2 applied across the entire vane. Live upwards loads due to hydraulic pressures under the vane shall be no less than 200 lbs./ft^2 (net upward) applied across the entire vane.

F. Other Loading:

Supplier shall evaluate and include in the design other loads on the system including momentum, impact, shear, dead loads, actuator dynamic loads, loads from a minimum of 2-feet of sediment (sands and gravels) deposition applied to the rack, and others identified by the gates system supplier based on experience with similar systems. Gate system supplier shall also consider operational loadings such as when the waterway is filling or draining during startup and shutdown.

G. Hydraulic System Loading:

Gate system supplier shall size and select a cylinder that meets the load requirements provided above including structural analysis of connections and buckling of extended cylinder/rod. The normal working system hydraulic pressure shall be no more than 2,500 psi and the cylinders shall provide the forces required to overcome the live and dead load forces at the normal working hydraulic pressure. The maximum working system hydraulic pressure shall be 3,000 psi. Unless specifically stated, the system and all components shall have a rated working pressure of at least the maximum working system hydraulic pressure plus safety factor.

H. Loading due to Restricted Movement:

Loading due to the force exerted by the cylinders at maximum operating pressure shall be accounted for when conditions where the vane is prevented from movement due to reaching the

limits of the range of movement, or sediment build up under the vane occurs.

I. Unequal Cylinder Loading:
The Gate(s) including the frame, panels, connections, pivots, and attachments shall be designed to accommodate an unequal loading of any individual cylinder of 50% of its maximum design loading without excessive deflection or stresses of the Gate including the frame, connections, supports, pivots, clevises, etc.

J. ~~Finite Element~~ Engineering Analysis:
An ~~finite element~~ engineering analysis shall be carried out on the WaveShaper(s)™ to calculate the maximum stresses and deformations and to verify the safety of the features. In the analysis of WaveShaper(s)™, all loading conditions needed for design including, but not limited to, the two load cases as described below shall be made and presented:

1. Downward load case: WaveShaper(s)™ vane in the fully raised position with specified hydrostatic head pushing down on the exposed horizontal surfaces of the WaveShaper(s)™ vane.

2. Uplift load case: WaveShaper(s)™ vane in the fully lowered position with the uniform hydrostatic up-lift pressure pushing up on the exposed horizontal desk surfaces of the WaveShaper(s)™ vane.

K. Allowable Stresses:
The allowable stress value shall be as deemed by the gate system supplier but shall be no greater than as determined from AISC Allowable Stress Design (latest edition), based on considering the beams and plate as flexural members. ~~allowable stresses.~~ Allowable stresses shall be provided.

L. Stress Limits:
Stress assessment as carried out by the gate system supplier and as defined below shall ensure the safe operation of the WaveShaper(s)™. The allowable stress defined above shall be compared to the computed von Mises stress. The United States Corps of Engineers' "Design of Hydraulic Steel Structures" (EM-1110-2-2105, 1993) shall be used as a basis in establishing the criteria:

For gates that are subject to severe dynamic hydraulic loading or are normally submerged where maintenance is difficult, the allowable stress shall be 0.75 times that allowed by AISC Allowable Stress Design.

M. Objective and Rationale of Stress Analysis:
Stress analysis shall be performed to prove that stresses in the steel structures as designed ensure safe operation and meet the requirements of the applicable specification. Stress analysis shall be based on mathematical models (analytical or numerical) of the components under investigation.

151133.04 MATERIALS AND EQUIPMENT.

A. Gate System Supplier:
The Gate ~~s~~System ~~s~~Supplier shall complete the final design of all Gates/WaveShapers™ included, supply all components, and supervise installation. Design of ~~T~~the ~~G~~gate system ~~supplier~~ shall ~~have~~ be completed by an Engineer who has previously designed~~, manufactured, and supplied~~ equipment similar in function and size ~~and have at least 15 years of experience~~ or can otherwise demonstrate competence. The Gate ~~s~~System ~~s~~Supplier shall have expertise in the hydraulics of flow that impacts the Gates. ~~The term Gate System Supplier shall also include an authorized representative of the Supplier.~~

B. Gate System Supplier Supplied Components:
The Gate and all necessary ancillary components required to allow successful operation of the Gate shall be provided by Contractor. Design documentation and equipment to be so provided

includes the following.

1. Final design drawings and calculations, shop drawings, structural computer modeling (if conducted) results and engineering analysis of gate system forces prior to commencement of fabrication of the gates.

2. Steel gate panels and associated piping attachments.

3. Steel torque tube, bearing cover, split bushing, lever arm, and all ancillary items.

4. Edge covers with attachment hardware.

5. Gate attachment hardware with anchor bolts, nuts, and washers.

6. Hydraulic system controls including hydraulic pump and reservoir, hydraulic lines, valves and control components.

7. The hydraulic cylinder including all bearings, attachments, pivots, hoses, attachment fittings, clevises, etc.

8. Inclinometers communicating with a 4-20 mA signal to an LCD output display located in a NEMA 4X enclosure.

9. WaveShaper™ Trash Racks

10. All other appurtenances as require to provide a complete and functioning system.

C. Steel Components:

All structural steel, including but not limited to torque tube, attachment straps, vane(s), etc. shall be manufactured from ASTM A36 steel unless otherwise approved by the Engineer.

1. Other non-structural components to be manufactured from ASTM A36 steel or approved equal.

2. All threaded fasteners including anchor bolts and attachment hardware shall be 304 stainless steel or approved equal. (Except that hardware, connectors, etc. related to hydraulic cylinder shall be 316 stainless). Anchor bolt allowable shear and tension stresses for attachment to concrete shall not exceed that recommended by the anchor bolt manufacturer.

3. Stainless steel plates and other stainless items with a grade not otherwise provided, shall be from 304L stainless steel, 3CR12 stainless steel, or approved equal. All embedded steel, connectors, attachment hardware, mounting plates and all other members and items shown on the plans as stainless steel (ss) shall be stainless steel.

4. All attachment hardware shall not protrude above adjacent surfaces. All bolts on exposed faces of steel gate shall be countersunk flush to surface.

D. Edges and Gaps:

Exposed edges on gate shall have a minimum radius of 1 1/2 inches or as shown on the plans. All other exposed edges on all panels, hinge attachments, steel, etc., shall be rounded to no less than 1/4 of an inch and be smooth, free of burs, rough welds, or other rough/sharp areas. Edges of the vane shall have no gaps between gate panels/frames and concrete walls greater than 1/4 of an inch and any gap shall not taper from wider to small in the upstream to downstream direction to prevent fingers or lose articles of clothes from becoming entrapped/tangled.

E. Edge/PE Covers:

Edge covers shall be high density polyethylene (HDPE) sheeting that complies with all ASTM

D4801 requirements for HDPE Sheeting. Minimum thickness and dimension as shown on the plans.

F. Inclinometers/Tilt Gauges:

1. Inclinometers shall be accurate to at least 0.5 degrees, be reliable and suitable for river conditions, and have an IP68 rating with a specified pressures based on anticipated immersion depth. Connector output shall be rated and supplied with IP69K connector cable.

2. All mounting hardware shall be stainless.

3. Output shall ~~be optimal and~~ integrate with ~~distance to~~ the display located in the vault and be suitable for the distance required.

4. Shock: Shall meet EN60068-2-27:1993, 100 g/11 ms, 100 shocks.

5. Vibration: Shall meet EN60068-2-6:1995, 20 g/10 Hz-2 kHz, 10 cycles.

6. Inclinometers shall be supplied by the Gate System Supplier.

7. All tilt gauges and wiring shall be protected from debris, severe turbulence, and abrasion and long enough to avoid splicing.

8. Gauges shall be mounted to facilitate maintenance and replacement

9. Two Inclinometers shall be provided: one on each lever arm.

G. Display:
The Inclinometer shall communicate with a digital display located in a panel within the control vault.

H. Split Bushing:
Materials used to manufacture high density polyethylene bushings at pillow blocks/bearings shall comply with all ASTM D3350 requirements and have a PPI recommended designation of PE 4710. The molecular weight category shall be extra high (250,000 to 1,500,000) as per the Gel Permeation Chromatography determination procedure with a typical value of 330,000.

HDPE pipe manufactured from materials meeting the specification of this section shall have an Environmental Stress Crack Resistance of zero failures when tested to greater than 10,000 hours (ESCR:F_0>10,000) when tested in accordance with ASTM F1248.

Bushing shall be machined to meet thicknesses and dimensions as shown on the Plans.

I. Hydraulic Cylinder and Attachments:
Cylinders shall be double acting and designed to support the entire design hydraulic load and dead loads. Cylinder shall meet the operating ranges including required stroke length as shown on the Plans. The Cylinder and all hardware shall be designed for submerged conditions and for vegetable oil based hydraulic fluid. The cylinder shall have a rated operating pressure of at least the maximum operating pressure specified in Article 151133.03, G above. Cylinder shall have a stainless steel body and a rubber bellow cover to protect the rod seals. All bolts, rods, clevises, rod eyes, pivoting hardware, and all other hardware shall be 316 Stainless Steel. Seals shall be designed for vegetable oil operation and submerged conditions. Cylinder supports, pivots, clevises, etc. shall be designed to allow for inaccuracies in construction, unequal loadings, etc. so as to not put any non-axial loading or moment on the hydraulic cylinder. Both cylinder mounts shall be spherical connections. Cylinder shall be provided with a 5-year manufacturer's warranty.

J. Vane Hydraulic System:

The hydraulic system supplying and controlling the hydraulic cylinder of the Vane Gate shall provide smooth, reliable, and efficient operations of the Vane. The hydraulic system shall be designed so that there is not a loss of hydraulic pressure over time and that the cylinder and the gate panels stay in-place when the system is turned off or un-attended. All systems components shall be suitable for water immersion or damp environments without corrosion. Controls, valves, pumps, motors, piping shall be securely attached to the vault a minimum of 24 inches above the floor.

1. The hydraulic system will be designed to provide the specified design forces with a working pressure of the normal working hydraulic pressure specified above.

2. The hydraulic system will be supplied, and all components designed to operate with vegetable base hydraulic fluid of the supplied viscosity.

3. Hydraulic Fluid: The grade shall be as determined for the application. Hydraulic fluid shall be readily and totally biodegradable, maintain low viscosity at -20°F, and be stable for a period longer than 25 years. Base fluid shall be canola (rapeseed) oil approved by the Engineer and the product shall have been produced and marketed for at least 10 years by major companies and government organizations. Ten gallons of additional fluid for future use shall be supplied. The hydraulic fluid shall meet or exceed the following requirements:
   - **a.** Anti-wear performance: Exceed the requirements for US Steel 126, 136 and 127, load stage 10 in the FZG (DIN 51354), and GM (LS-2).
   - **b.** Federal Specifications A-A-59354 Superseding MIL-H-46001D Specification for machine tool hydraulic systems.
   - **c.** The Environmental Protection Agency (EPA) 2013 Vessel General Permit (VGP) guidelines for Environmentally Acceptable Lubricants (EALs) and should be used in hydraulic systems where LOW TOXICITY, BIODEGRADABILITY and NON-BIOACUMMULATION properties are required.
   - **d.** The acute toxicity (LC-50 / EC-50 >1000 ppm) criteria adopted by the US Fish and Wildlife Service and the US EPA.
   - **e.** Oxidative Stability: Have a Rotary Pressure Vessel Oxidation Test (RPVOT): life over 200 minutes.
   - **f.** Extreme Pressure/Antiwear: When properly formulated, passed FZG stage 12, Shell 4-Ball Wear results (1800 and 1200 rpm, 20 and 40 kg, 1 hour) were 0.30 to 0.40mm.
   - **g.** Meet the Factory Mutual as a less hazardous fluid “Specification Tested” ISO/CD 15029-3 rating HFDU, and ISO/TS 15029-2 Spray Ignition-Ignitability (Class H)

4. Hydraulic Hoses and fittings: Hydraulic hoses shall have stainless steel braid around a Teflon tube and rated for a working pressure of at least 2500 psi with a minimum burst pressure of 8000 psi and a minimum 5 inch bend radius. Hose shall be attached with stainless steel quick connects and stainless-steel fittings. Fittings shall have an equivalent or greater strength than the hose, shall be designed and supplied for use with the supplied hydraulic hose, shall supplied by the supplier of the hydraulic hose and shall be connected to the hose at the shop of the supplier unless otherwise approved by the Engineer.

5. Where not routed in conduits or carrier pipes, hoses shall be fastened at no greater than 4 feet intervals with stainless steel straps, supports, or guides.

6. Heavy Duty Hydraulic Hose Spiral Wrap. All hoses inside and outside of conduits and carrier pipes shall be wrapped with appropriately sized spiral hose wrap. The material shall be HDPE (High-Density Polyethylene) with an operating temperature: -40°F to 280°F and a tensile Strength @Break of 360 kg/cm^2 and be designed specifically for heavy-duty bundling and protection of hydraulic and pneumatic hoses used across various industries. Heavy duty spiral hose wrap shall be Mine Safety and Health Administration (MSHA) certified and UV resistant and protect against damage caused by depreciation, abrasion, regular misuse, poor maintenance, or severe working environments. Hose protector tubing shall have rounded

edges for reduced risk of exposed sharp edges and resist all Hydraulic Fluids including Glycol & Phosphate ester.

7. Stainless Steel Pipe. All hydraulic lines shown as pipe or otherwise embedded shall be stainless steel pipe. Stainless steel pipe shall be installed along paths as generally shown on the plans unless otherwise approved by the Engineer. All fittings and connectors for all hydraulic pipe and hose shall be stainless steel. Hydraulic pipe and fittings shall be ½ -inch O.D, Schedule 10 or higher if welded and Schedule 40 or higher if threaded. All stainless steel pipe shall be Stainless 304L, be seamless, and meet requirements of ASTM A312 / ASME SA312. Each line shall be pressure tested at 1.3 times the maximum operating pressure and show no loss of pressure for four hours.

8. Valves: Ball and check valves shall be stainless steel. Supplier shall design valving scheme to allow raising and lowering of the Vane using the Manual Hydraulic Pump by opening and closing valves to allow extension of the cylinder or retraction of the cylinder. Check or other valves shall be included in the design such that when transitioning from moving the gate up to down or down to up there is no loss of pressure in the system or movement of the vane.

9. Control Valve: Shall be a hydraulic directional control Valve, NFPA Size D03, Lever Operated Operation Type, with closed center position. Valve Ways and Positions shall be 4-Way/3-Position. Max. Flow 22.0 gpm or more as required to meet, Max. Pressure -Hydraulic Valves 5000 psi, Max. Tank Pressure (PSI) 500, Adjustable PSI Range -, Nitrile O-Ring Seal Type.

10. Pressure Relief Valves (PRV) Valves: PRV valves in the hydraulic system of the Wave Shaper Gates shall release pressure so as not to allow over pressuring of any cylinder at any time. PRV valves shall be self-actuated safety valves designed to relieve excess upstream pressure from the line. The PRV valves shall be adjustable from 1000 psi to 3000 psi. The PRV valves shall be connected to a drain valve so that hydraulic fluid is released back to the hydraulic pump reservoir.

11. Electric Hydraulic Pump and Reservoir: The Contractor shall supply a hydraulic pump capable of operating the hydraulic cylinders required to operate the WaveShapers™. The pump shall be single speed with a minimum reservoir capacity equal to at least 2 times the difference between the volume of hydraulic fluid between all cylinders up and all cylinders down plus 10 gallons. It shall have a maximum operating pressure of 3000 psi. The pump shall be capable of moving the Vane Gate through one full range within 5 minutes but no faster than 60 seconds. The pump shall have a pressure regulating valve to adjust the maximum operating outlet pressure from 1000 psi to 3000 psi. The pump shall be designed to work with vegetable based hydraulic fluid.

12. Hydraulic Handpump: A handpump for backup use shall be provided. The pump shall be rated for at least 2800 psi but no more than 5000 psi. The displacement per stroke will be approximately 0.15 cubic inches and shall have a required force of no more the 40 pounds at the handle. The pump shall have an external load release valve and internal pressure-relief valve for overload protection. The pump shall be made of materials and/or painted and otherwise designed for application in damp areas.

13. Pressure Gages: Provide liquid filled pressure gages approved by the Engineer rated per the maximum system operating pressure. Include an isolation valve between gage and hydraulic system. The pressure gauge shall be a rugged, solid-front aluminum case gauge. Dial sizes shall be 6 inches in diameter or larger. All cases shall be coated with black epoxy which will withstand most environmental conditions. The gauge shall have a 0.5% full scale (Grade 2A, ASME B40.100) accuracy, meet IP54 dry case weather protection, have a glass window and a micrometer adjustable pointer. The movement shall be rotary, 400 SS, with a Teflon coated pinion gear and segment.

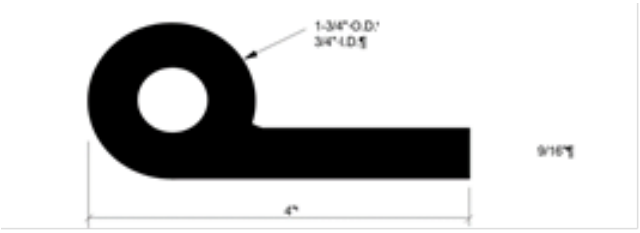
K. Removeable Access Plates:
Removable access plates and all attachment hardware, as shown on the Plans shall be supplied with the Gate. These shall allow access to the pillow blocks, removal, and installation of anchor bolt nuts/washers, and have adequate clearances to allow access below the gate for a 6-inch diameter hose for removal of sediment/debris.

L. Spherical Head Vault Lifting Anchors:
Spherical head anchors for the vault covers shall be forged stainless steel metal anchors. The grade of Stainless steel shall be applicable for repeated use. Embedment options shall be as required to suit casting of the vault covers and edge distances and slenderness of elements etc. Eight provided lifting clutches shall be provided. The anchors may have a T shape (T Anchors) or an "O" shape (Type O) or have a welded-on plate, in the embedded portion and shall be designed for the thickness and loads. Capacities shall be enhanced by the inclusion of additional local reinforcement in the vault covers. Options to weld the reinforcing or anchors to the steel frame may be required. The anchors must be fixed in the mold using recess formers. The recess former retains the anchor securely in position during the concrete placement. The recess former creates a void around the head which corresponds to the clutch. The clutch shall be designed to bear against the concrete during an angled lift and therefore the horizontal load is transferred into the concrete directly. The anchors shall be designed with a safety factor of at least 3.0.

M. J Bulb Seals:
J Bulb seals shall have 1 3/4 inch diameter hollow bulb and be 4 inches wide and made of Hi Tensile Neoprene meeting the following property values requirements.

PROPERTY	VALUES
Tensile Strength	2250 min. PSI
Ultimate Elongation	400 % min.
Shore A Durometer	60 / 70
Specific Gravity	1.4
Compression Set	30% max
Tensile Strength after Oxygen Bomb Aging	80% min.
Ozone Resistance	Good

The cross-section shall be as shown on the following figure.



The J Bulbs shall be installed with a continuous stainless steel support bar that is securely anchored 'to resist deflection or warping of the J bulb.

N. WaveShaper™ Trash Racks:
The WaveShaper™ trash racks shall be of the bar screen style, having a 4 inch or less (as indicated in this Section or on Plans) clear opening between all bars and sides.

1. The trash rack including all connectors will be constructed of A36/A36M structural steel.

2. ~~Pipe shall be Schedule 40 or Schedule 80 as shown on Plans.~~

~~3~~ **2.** The trash racks shall be designed to allow the gates to be rotated down to allow access during maintenance.

~~4~~ **3.** The clearance between the bottom portion of the trash rack frame and foundation shall be 3 1/2 inches or as shown on the plans.

O. Davits:
A portable davit shall be provided to lift the covers of the vaults and miscellaneous equipment in and out of the vaults. The portable davit shall have the capacity and range to lift either of the vault covers and place it on the uphill side. Socket base flush-mount inserts to support the davit shall be provided and located within the foundation walls at locations to permit the removal, installation, and placement beyond the sides of the vaults for all vault covers. Inserts shall be stainless steel, support 1.5 times the maximum load of the provided davit and include covers to prevent sediment accumulation. Davit and location for inserts shall be determined by the Gate System Supplier. Number of inserts shall be determined by the Gate System Supplier and shall be sufficient to allow removal and installation of vault covers. Gate System Supplier shall coordinate and provide any special concrete reinforcing modifications related to the davit inserts. Harness shall be supplied for lifting of all vaults covers. The provided portable davit shall be constructed of materials such as aluminum and carbon fiber to minimize the weight of the davit.

P. Cylinder Bars:
Bars located next to the hydraulic cylinders shall be provided. The set will have a fixed position to provide the ability of lock the WaveShaper™ vanes in place. The set will be fabricated after testing in the startup and tuning phase once the positions and limits are established. The sets of bars and the structure shall be designed so as not to buckle, put excessive point loads or moment on it or the arm, and not to overstress any other member, connector, or bearing of the WaveShaper™ when the cylinders are at 1.5 times the maximum operating pressure.

Q. Adjustable WaveShaperTM Limiters:
Adjustable fixed struts shall limit the lower range of motion of the vanes. The strut and arms shall be designed so as not to buckle, put excessive point loads or moment on it or the arm, and not to overstress any other member, connector, or bearing of the WaveShaper™. when the cylinders are at 1.5 times the maximum operating pressure. If desired, the design of this element maybe incorporated with the Cylinder Bars as they will not be both installed at the same time.

R. Finishes:
Refer to Section 2408 of the Standard Specifications for all steel members other than fasteners, and stainless-steel components. All non-stainless-steel components shall be prepared and coated according to this specification other than as modified herein.

1. The paint system outside of the surfaces on the upper side vane shall be ~~Zink Rich Epoxy~~ zinc rich epoxy meeting Materials I.M. 482.02.

2. One primer coat and two topcoats shall be applied, each having a dry thickness of at least 4 ~~mm~~ mils each.

3. Surfaces of the Vane: All exposed steel on surfaces and edges of the upper side of the vane of the WaveShaper, including but not limited to the vane plate including side panels, shall be coated with a primer and a 1/4 inch thick layer of a two-component, rapid curing, elastomeric pure polyurea lining system. The lining will wrap around the edges and extend several inches along the underside of the steel members before terminating except that its application will not interfere with the movement of the Vane. The lining shall be spray-applied in the shop and create a monolithic, seamless lining which conforms to all shapes and is smooth. Processing characteristics shall include a process pressure of 2000 psi or greater using a spay gun with fusion- air purge or mechanical purge. The liner shall be applied according to manufactures

recommendations. A sample of the coating applied to steel shall be provided to the ~~engineer~~ Engineer for approval prior to coating the WaveShaper vane.

4. Physical Properties of the polyurea lining system shall include:
- **a.** Hardness (Shore D) ASTM D-2240 50±5
- **b.** Tensile Strength (psi)* ASTM D-412 2200 – 2500
- **c.** Elongation (%) * ASTM D-412 300 – 350
- **d.** Tear Resistance (pli) Die C* ASTM D-624 330 – 400
- **e.** Water Absorption (%) - 24 hours ASTM D-570 ≤1.5
- **f.** Dielectric Strength (volts/mil) ASTM D-149 300
- **g.** Volume Resistancy (ohm/inches) ASTM D-257 6 X 10 (12)
- **h.** Dielectric Constant (MHz) ASTM D-150 5.4
- **i.** Dissipation Factor (MHz) ASTM D-150 0.058
- **j.** Cathodic Disbonding ASTM G-8 Pass

The primer shall be supplied by the same manufacturer as the polyurea lining system and shall be applied to the stricter standard of the recommended by the manufacturer or as required in Section 2408 of the Standard Specifications. Primer shall be a two-component, 100% solids (no solvents), flexible, elastomeric polyurethane primer and sealant. It shall have a high resistance to acids, hydrolysis and salt spray and withstands mechanical stresses from impacts. The primer shall have excellent adhesion to a variety of substrates, have good flexibility-withstands mechanical stresses due to impacts. The primer shall meet the following requirements.

PRIMER ADHESION RESULTS* (PSI) AST D-4541-17

	STEEL	**STAINLESS STEEL**	**ALUMINUM**
24 Hours	1174	909	1119
48 Hours	898	835	986
72 Hours	877	888	884

Primer applied 24 / 48 / 72 hours before coating. Plates sandblasted, solvent wiped and primed. Solvent wiped again before coating

CHEMICAL PROPERTIES	**ISOCYANATE**	**RESIN**
Solids by Volume/Weight	100%	100%
Volatile Organic Compounds (VOC)	0 lbs./gal.	0 lbs./gal.
Mix Ratio, Parts per Weight (grams)	10	25=35 grams mix total
	30	75=105 grams mix total
	100	250=350 grams mix total
Cure Time, Minutes	120-240 Minutes @ 60°F	
	45-90 Minutes @ 90°F	
Viscosity	120 cps	12,000 cps
Flash Point	424°F	302°F

Cure times can vary depending on ambient conditions (humidity, temperature etc.).

5. Application:
Surface shall be prepared as required for remainder of WaveShaper™ and solvent wiped

immediately prior to application. Primer shall be sprayed with a HVLP gun with a large tip 2.0 or larger. The minimum thickness shall be 4 mils. Primer must be completely dry before applying product over it. Primer can go up to 72 hours before the primer would have to be lightly abraded and another coat of primer applied. Then completely dried before applying product over it. Ideal surface temperature is no lower than 50°F. The recommended pot-life shall not be exceeded.

S. Block Anodes:

Magnesium anodes shall be supplied and installed on various members of the. WaveShaper™ They shall be secured using stainless steel hardware and shall be appropriate for use in freshwater applications, shall be approximately 4 inches by 8 inches by 8 inches with a 3/4 inch recessed pipe core centered unless otherwise approved by the Engineer. Each shall have an approximate weight of 15 pounds or more. At least ten anodes shall be installed, one on each of the lever arms inside the vaults and the remainder evenly distributed on the underside of the vane on the gussets and end plates. The lower trash rack shall have the greater of at least three 5 pound magnesium anodes attached or at least one 5 pound anode per section if the sections are not physically welded together.

T. Testing Records:

Submit written certificate attesting to product compliance with physical material requirements of this Section prior to installation of the Gate and any related equipment.

U. Warranty:

1. The Gate System Supplier shall provide a 5 year warranty on the Gates commencing at final acceptance of the Work. The warranty shall cover all manufactured and supplied components and parts and include on-site assessment, removal, and replacement.

2. In addition to the general warranty requirements, the equipment warranty shall cover (1) faulty or inadequate design by the ~~equipment manufacturer~~ Gate System Supplier; (2) improper assembly or fabrication; (3) defective workmanship or materials, and (4) leakage, breakage, or other failure. It shall be the Gate System Supplier's responsibility to ascertain the conditions and service under which the equipment will operate and to warrant that operation under those conditions shall be successful. The supplier shall furnish a copy of the warranty to the Contracting Authority as beneficiary. Any defects or failure within the warranty period shall immediately be repaired or replaced by the Gate System Supplier.

V. Delivery, Storage, and Handling of Equipment and Materials:

1. Insofar as is practical, the equipment specified herein shall be factory assembled. The parts and assemblies that are, of necessity, shipped unassembled shall be packaged and tagged in a manner that will protect the equipment from damage and facilitate the final assembly in the field. Generally, machined, and unpainted parts shall be protected from damage by the elements of weather with the application of a strippable protective coating.

2. Box, crate, or otherwise enclose and protect equipment during shipment, handling, storage, and following installation so as to ensure the preservation of the required quality and fitness of all materials and equipment until final acceptance of the project. Keep equipment dry and covered from exposure to weather. Store pumps, motors, electrical equipment, controls, insulation, and equipment having anti-friction or sleeve bearings in weather-tight storage facilities. Lift large equipment items only at the points designated by the manufacturer. Protect factory painted surfaces against impact, abrasion, discoloration, and other damage. Repair damage as directed and approved

151133.05 CONSTRUCTION.

A. Piping, Foundation Slab and Wall General Requirements:

1. The Contractor shall store, protect, and install all manufacturer provided components listed in Article 151133.04.

2. The Contractor shall prepare the foundations for the Gate, including all anchors and embedments.

3. The Contractor shall furnish and install all auxiliary components necessary to make a complete and operational Gate.

4. A lubricating compound approved by the Engineer shall be used for all stainless steel anchor bolts and fasteners. The anti-seize compound shall be applicable to stainless steel, prevent galvanic corrosion, be intended for marine applications, and contain no copper.

5. The reinforcing steel and embeds will be placed in the foundation slab, with careful placement to achieve pull out capacity requirements of anchors as specified by the ~~gate manufacturer~~ Gate System Supplier and structural engineering requirements. Care will be taken such that complete concrete penetration under and around embeds is achieved.

6. A steel trowel finish will be used on the base slabs below and downstream of the gate. Any rough points, edges or other defects will be ground smooth and as directed.

7. The foundation walls will be placed with a tolerance of +/-1/8 inch of the designated vertical plane, with no edges, form ridges or other defects.

8. Embedment plates or other provisions to provide a uniform and low-friction surface may be required at the foundation walls adjacent to the moveable panels of the Vane. These surfaces will be in contact with the Edge Covers (see below).

9. PE cover shall be provided to fill the gap between the Vane panel and the concrete foundation walls. Covers shall be machined and attached to gate to achieve the smallest practical gap between covers and walls not to exceed ¼ inch maximum gap. All exposed edges shall be rounded smooth.

10. All embeds will be cleaned, threads cleaned, and bolts temporarily placed to determine that threads are clean and in good condition. Torque test pull-out resistance as directed.

11. Hydraulic piping shall be run in conduit or in covered raceway as shown on the Plans. Conduits shall have long-radius bends and pull boxes at bends to facilitate pulling hydraulic piping lines through the conduit. Outside of conduits all lines shall be securely fastened with stainless steel connectors to prevent vibration, abrasion and damage and to uniformly support the hydraulic piping.

B. Installation:

1. General Requirements:

a. Installation Plan and Facilities. The ~~contractor~~ Contractor will develop an installation plan describing site storage and work areas, equipment needs and other details in consultation with the Gate ~~manufacturer~~ System Supplier so that the Gate and controls can be installed, tested, and operated.

b. Installation: The Gate will be installed to achieve the requirements of the plans and specifications, and as directed by the manufacturer. All materials and surfaces will be protected against damage. The sequence of construction will be as directed by the Gate ~~manufacturer's~~ System Supplier's technical advisor and to achieve the gate operational characteristics.

c. Testing: The equipment, cylinder, panels, hinges, and controls will be tested in advance and during initial operation. Thereafter, any defects repaired as directed.

2. ~~Manufacturer's~~ Gate System Supplier's Technical Advisor and Engineer's Representative:

a. General: The ~~manufacturer~~ Gate System Supplier shall provide a factory-trained technical advisor to oversee installation of the Gate, startup, and testing of the operating equipment, and to instruct operating personnel. A representative of the Engineer will attend all meetings and installations as may be designated.

b. Pre-installation Meeting: A pre-installation meeting to be attended by the ~~manufacturer's~~ Gate System Supplier's technical advisor, Engineer, and Contractor personnel will be held within two weeks prior to the scheduled installation of any Gate or gate component. The technical advisor shall provide the attendees with information regarding the proper procedures for installing the Gate and related equipment.

c. Pre-installation Inspection: The ~~manufacturer's~~ Gate System Supplier's technical advisor and Engineer shall inspect the concrete foundation with anchoring system hardware and reinforcing steel prior to placement of concrete. The ~~engineer~~ Engineer and ~~manufacturer~~ Gate System Supplier shall receive 10 days advance notice of the scheduled concrete placement.

d. The installation of the hydraulic cylinder and gate panels, including preparatory work, shall be done with the Engineer at the site. The ~~engineer~~ Engineer and the ~~manufacture~~ Gate System Supplier will receive 10 days advance notice of scheduled installation. The technical advisor shall notify the Engineer as soon as possible of any discrepancies discovered in the work which may hinder successful installation of the Gate.

3. Final Testing: The installed systems shall be leak tested, as specified elsewhere, for leakage by the Contractor with the assistance of the Engineer.

4. Final Inspection: A final inspection of the Gate installation and related equipment will be performed by the Engineer with the assistance of the ~~gate manufacturer's~~ Gate System Supplier's technical advisor in conjunction with the final testing.

C. Testing:

1. General: The Contractor shall be responsible for conducting testing of the installed system. Tests shall be conducted in the presence of the Engineer.

All hydraulic hoses shall be tested and accepted before installation of the Gate commences.

Hydraulic hoses shall be tested by pressurizing to 3000 psi. Pressure readings and ambient air temperature shall be recorded at six different times during each test. Any joints or fittings exhibiting leakage during this time shall be repaired or replaced.

After installation of the system the Gate shall be fully raised and lowered three times. The Gate shall operate smoothly with no binding. Vane shall be tested an additional three times, each time varying the position of the lip throughout the range of operation.

After installation of the Gate with hydraulic cylinder, the hydraulic system shall be isolated from the pump system and held at a pressure of 3000 psi for 24 hours. All hydraulic lines and hoses shall have no drop in pressure over a 24 hour period.

2. Adjustments: During the Starting of Systems (Tuning) Phase, the Gate shall be adjusted and tested as ~~Directed~~ directed by Engineer to verify a fully functioning system in the active flow condition. Refer to Special Provisions for Startup and Tuning.

D. Other:

1. Generally, the Gate System Supplier will have previous experience with design and fabrication of gates used for dams, hydroelectric stations, municipal water or wastewater applications, or of flood gates. A list of companies is provided below for reference. Inclusion of a company in the lists below does not constitute pre-qualification of any of the companies as the Gate System Supplier. The lists are not an endorsement of, nor a recommendation to sub-contract with, any of the following Suppliers. The lists are provided solely as a reference for Contractors.

2. Companies that have previously fabricated WaveShaper Gates (listed alphabetically):

- **DBE Manufacturing & Supply**
  4431 5th St
  Greeley, CO 80631.
  Phone: (970) 392-9800
- **Obermeyer Hydro, Inc.**
  303 W Co Rd 74
  Wellington, CO 80549
  Phone: (970) 568-9844
- **SL Green, Inc.**
  331 Co Road 298
  Smiths, AL 36877
  Phone: (334) 448-2488

3. Other companies with design or fabrication capabilities relevant to the WaveShaper (listed alphabetically):

- **Gerace Construction**
  4055 S Saginaw Rd
  Midland, MI 48640
  Phone: 989-496-2440
- **Industrial Metal Fabricators, Midland, GA**
  7007 Flat Rock Rd
  Midland, GA 31820
  Phone: 706-561-1415
- **JCI Industries**
  699 Walnut Street, 4th Floor
  Des Moines, IA 50309
  Phone: 515-414-9006
- **Steel-Fab, Inc.**
  430 Crawford Street
  Fitchburg, MA 01420
  Phone: 978-645-1112
- **Waterman Industries**
  25500 Road 204
  Exeter, CA 93221
  Phone: 800-445-8457

151133.06 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

A. No separate measurement for payment will be made for any labor, equipment, and materials required for the WaveShaper™ System Installation item. The lump sum price will include all of the Contractor's costs. This bid item includes but is not limited to:

A 1. Design, fabrication, and installation of WaveShaper™ system components including fabricated steel gates, rubber bulbs, steel trash racks/grates, hinges, hydraulic system components, embedded items, and any other system components.

~~B~~ **2.** All necessary hardware for erection, attachment, and hydraulic system.

~~C~~ **3.** Furnish and install hydraulic system conduits/embedded piping from controls to gates.

~~D~~ **4.** Testing and Startup to demonstrate a fully functioning WaveShaper™ system.

~~E~~ **5.** Providing all other related and necessary labor, equipment, and materials to complete the work.

B. Lump Sum Payment Adjustment

1. If the total weight of steel in the final approved shop drawings for the WaveShaper™ exceeds the total weight of steel shown on the Plans by more than 5%, lump sum payment for the Waveshaper™ System Installation will be adjusted. Final payment will be calculated by multiplying the lump sum price by the LS Adjustment as defined below.

LS Adjustment = (Weight of steel on Approved Shop Drawings) / (Weight of steel on Plans * 1.05)

2. To receive the LS Adjustment, provide the Engineer detailed calculations of the weight of steel used on the approved shop drawings and weight of steel as shown on the Plans.