

SECTION 46 61 23
GRAVITY FILTER PLASTIC UNDERDRAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Includes:
1. All of the equipment described in this section shall be supplied by a single underdrain manufacturer that regularly engages in that business. All underdrain systems specified in this section will be constructed on HDPE or PVC. This section requires the furnishing and installation of 24 existing filters as shown on the Contract drawings. These 24 filters are across 5 Pumping Stations:
 - a. Davis Pumping Station
 - 1) 4 Filters (2 cells per filter)
 - a) Cell Dimension: 15'-0" x 30'-0"
 - b. Mallory Pumping Station
 - 1) 8 Filters (2 cells per filter)
 - a) Cell Dimension: 12'-6" x 33'-0"
 - c. McCord Pumping Station
 - 1) 4 Filters (2 cells per filter)
 - a) Cell Dimension: 12'-0" x 34'-0"
 - d. Morton Pumping Station
 - 1) 4 Filters (2 cells per filter)
 - a) Cell Dimension: 13'-2" x 39'-6"
 - e. Shaw Pumping Station
 - 1) 4 Filters (2 cells per filter)
 - a) Cell Dimension: 13'-2" x 39'-6"
- B. Related Requirements: Include, but are not necessarily limited to:
1. Section 46 61 13 – Filter Media.
 2. Section 46 61 19 – Wash Water Troughs.

1.2 REFERENCES

- A. Reference Standards: Standards referenced in this section include, but are not necessarily limited to, the following:
1. American Water Works Association (AWWA):
 - a. B100 – Granular Filter Material.
 - b. F101 – Contact-Molded, Fiberglass-Reinforced Plastic Wash-Water Troughs and Launderers.
 - c. F102 – Matched-Die-Molded, Fiberglass-Reinforced Plastic Weir Plates, Scum Baffles, and Mounting Brackets.
 2. NSF International (NSF):
 - a. 61, Drinking Water System Components – Health Effects.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Pre-installation Meeting:
1. A Pre-installation meeting shall occur before any work is started at the facility. This meeting is to review the work schedule and to verify the contractor has all equipment on site to perform the removal and installation of filter underdrains and filter media.
 2. The following parties shall be present at the meeting or have a delegated representative:
 - a. Contractor Site Supervisor.
 - b. Engineer.
 - c. Owner's Representative.

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- B. Sequencing and Scheduling:
 - 1. Only one (1) filter may be removed from service at a pumping station to perform the work contained in the Construction Drawings and Project Manual.
 - a. Mallory Pumping Station can have two (2) filters out of service for work at one time with approval from Owner.
 - 2. A maximum of two (2) filters can be removed from service across the Owner's entire production system at a time to perform the work contained in the Construction Drawings and Project Manual.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Submit to the engineer complete shop drawings showing details of fabrication, materials of construction, installation and leveling data of all items furnished under this section.
 - 2. Details submitted shall include as a minimum, headloss data for air, water and combined air/water backwash, installation details, flow distribution calculations, certification of compatibility of the underdrain system with the filter media specified in Section 46 61 13 – Filter Media, details for installing reinforcing and other items to be embedded in concrete.
 - 3. Testing Procedures: Detailed start-up, hydraulic, and air scour test procedures.
 - 4. Proper documentation showing NSF-61 certification on all underdrain components.
 - 5. Testing Plans, Procedures, and Testing Limitations:
 - a. Testing procedure, apparatus, and limitations of apparatus and procedure, for:
 - 1) Source quality control activities indicated in this Section.
 - 2) Field quality control activities indicated in this Section.

1.5 QUALITY ASSURANCE

- A. Manufacturer: The filter system shall be supplied by one manufacturer that shall assume total responsibility for the parts operating as a whole and shall be manufactured by:
 - 1. Xylem Leopold.
 - 2. Roberts Filter Group.
 - 3. Or approved equal.
- B. Basis of Design (BOD): For the purposes of comparison, the Engineer has established the flowing blocks as the BOD at each of the pumping stations:
 - 1. Davis Pumping Station: Xylem-Leopold Type S
 - 2. Mallory Pumping Station: Xylem-Leopold Type XA
 - 3. McCord Pumping Station: Xylem-Leopold Type XA
 - 4. Morton Pumping Station: Xylem-Leopold Type S
 - 5. Shaw Pumping Station: Xylem-Leopold Type S
- C. Experience: The filter system shall be a standard product of a filter manufacturer who has been actively providing dual-parallel lateral air/water underdrain equipment for at least 15 years. Upon request, the filter manufacturer with provide the Engineer with a list of installations of underdrain which totals not less than 100.
- D. NSF Certification: All materials used in contact with the water and backwash air shall meet National Sanitation Foundation (NSF) Standard 61 Drinking Water System Components – Health Effects.
- E. Underdrain: All materials directly related to the installation of the underdrain system including blocks, special anchorage, grout plates, gaskets, etc. shall be the products of a single manufacturer/supplier.
- F. Hydraulic Demonstration:
 - 1. The filter manufacturer shall, at their own facilities, if requested by the Engineer, set up a test lateral run of equal length to that required by the project and provide an opportunity for the Engineer and/or Owner to visit the facility to witness a full scale demonstration of the headloss and flow distribution during backwash.

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2. Testing shall be run at flows up to 25 GPM/SF.
3. The test facility shall be capable of demonstrating concurrent air and water distribution in a submerged trough and water only distribution on a non-submerged test bench.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. The schedule of work shall be submitted to the Owner for approval prior to commencement of work.
- B. The contractor shall be responsible for coordinating the shipment of supplies of materials and equipment specified herein. Coordination will be required during construction, startup and/or testing.
- C. The contractor shall be responsible for storage of the filter underdrain equipment. Contractor is to coordinate with the Owner for an on-site storage location. If the location is outside, Contractor is responsible for protecting material and equipment from UV exposure, dust, and water damage.

1.7 WARRANTY

- A. Manufacturer's Special or Extended Warranty:
 1. In addition to manufacturer's general, standard printed warranty, furnish manufacturer's special warranty covering underdrain system, including blocks, media retention plates, and any other appurtenances. Special warranty shall remain in effect for a period of 5 years commencing on the date of Substantial Completion for the associated Work.

PART 2 - PRODUCTS

2.1 UNDERDRAIN

- A. Underdrain Design Criteria for Filtration and Backwash:
 1. Air Scour Rate: 3-5 SCFM/ft²
 2. Water Wash Rate, Water Only: 25 gpm/ft²
 3. Water Wash Rate, Concurrent with Air: 6 gpm/ft²
 4. Max Filtration Rate: 5.0 gpm/ft²
- B. The underdrain system for the filters shall be a lateral type with a **slotted** integral media support retainer where feeder and compensating chambers are provided within the cross section of the block. The cross section of the underdrain shall be so arranged that the feeder (primary) chamber is adjacent and connected to the compensating (secondary) chamber through a series of orifices. The orifices shall be located at various elevations and sized to provide uniform distribution of air and water.
- C. Underdrains shall be holes arranged on the top of the blocks to ensure even flow distribution across filter when filtering and while backwashing.
- D. The underdrain shall have a horizontal flat top discharge surface, so that the finished filter bottom is essentially flat, with orifices for uniform energy intensity of air and water coverage which direct flow vertically for effective penetration and cleaning of the media.
- E. The underdrain shall maximize uplift resistance via grout or physical restraint.
 1. Underdrain manufacturer shall documentation to show uplift resistance of the underdrain.
 2. All underdrains shall be capable of 25 psi of uplift resistance/internal pressure.
 3. If using physical restraint is being used, the underdrain manufacturer shall develop and endorse **stamped** design drawings showing the designed restraint system for the underdrain. This information shall be submitted during the submittal process for Engineer review.

2.2 AIR HEADER

- A. Because the proper distribution of air into the underdrain has a significant effect upon operation, the filter manufacturer shall have the responsibility to design and provide the air distribution header for this underdrain.

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- B. Air header is to be fully contained in the flume and underdrain. No air piping in the filter media will be permitted.

2.3 MATERIALS AND CONSTRUCTION

A. Underdrain

- 1. Material: The individual blocks used in the system shall be of impervious high strength completely corrosion-resistant high-density polyethylene (HDPE) or polyvinyl chloride (PVC) material. The blocks shall be resistant to erosion and corrosion and have uniform smooth surfaces.
- 2. Dimensions: The block size and width shall permit ease of handling and installation. Block heights shall be selected to ensure safe velocities of water in the laterals at all times.
~~Additionally, blocks must be of an appropriate height to ensure that 50% expanded media does not come into contact with the wash water troughs.~~
 - a. This height varies from station to station. Reference Construction drawings for more information.
- 3. Block Geometry: The blocks shall be essentially rectangular in shape with dispersion orifices located in the top flat surface. The blocks shall have ridges and pockets for structure rigidity. Blocks shall have features to allow block to key into surrounding grout.
- 4. Lateral Construction: Blocks shall be arranged end-to-end and be mechanically joined to form continuous underdrain laterals approximately equal to the length of the filter cell. One-piece extruded underdrain laterals are also permitted. If the blocks are to be connected, the joints shall be gasketed, bell and spigot type with internal alignment tabs for proper joint alignment. These joints shall be water and air tight. Joints shall be of a snap-lock type so that the blocks are joined with integral interlocking snap lugs and lug receptors for ease of assembly and installation.

- B. Media Retaining Caps: Media retaining caps are permitted to substitute the need for support gravel. Media retaining caps are to be either stainless steel, ~~thermos-plastic or PVC~~. ~~Slot opening shall be small 450 micron or less to prevent~~ the media from obstruction or passing through the underdrain. Media retaining caps shall be attached and sealed to the blocks using 316 stainless steel screws. Sintered bead retaining plates are not permitted.

C. Air Header

- 1. General: The air distribution system shall be generally comprised of a corrosion resistant header specially calibrated to evenly distribute air flow via properly located riser pipes to each lateral. Sufficient relative velocities shall be maintained in both the header and riser pipes to ensure proper distribution of air.
- 2. Material: The air header piping shall be Sch 10, type 316 stainless steel. The anchors and hardware for anchoring shall be type 316 stainless steel.

D. Grout

- 1. Cement: Cement shall be standard brand Portland cement conforming to ASTM C150, Type II for general use. Cement that has become “lumpy” shall not be used.
- 2. Water: Water for mixing and curing shall be clean and clear potable water. The water shall be considered potable if it meets the requirements of the local government agencies. Water with a total dissolved solids of 1000 mg/l or higher or greater than 10 NTU shall not be used.
- 3. Sand: Sand shall be clean and washed masonry sand. When tested in accordance with ASTM D2419, the sand equivalency shall not be less than 90% for an average of three samples, or less than 85% for any individual samples. 100% of sand particles shall pass No. 4 sieve and not more than 4% of sand particles shall pass No. 200 sieve.
- 4. Chemical Admixtures: No chemical admixture is needed in most of the applications. The grout can be mixed in a small batch and used immediately.
- 5. Strength: The group used in installing the blocks shall have a minimum compressive strength of 3000 psi (207 bars) after 30 days of curing. Normally, use a grout with one part Portland cement and two parts clean silica sand properly mixed and wetted to a maximum

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water-cement ration by weight equal to 0.50 to 0.55 for the base grout and 0.61 to 0.67 for the fill grout.

PART 3 - EXECUTION

3.1 PRODUCT HANDLING, STORAGE AND DELIVERY

- A. Place or store underdrain only in designated staging areas that are approved by Engineering and Owner.
- B. Store underdrain and specialties off the ground, under ultraviolet-resistant tarps from time of deliver on-site until final installation of the filters.
- C. Replace, at no charge to Owner, underdrains and specialties damaged during storage and delivery.
- D. Underdrains and specialties are subject to inspection at the Engineer's request if visual evidence of damage is observed.

3.2 INSTALLATION

- A. Filter Underdrain and Air Header
 - 1. The Contractor shall install the filter underdrain system in strict accordance with: (1) the manufacturer's written instructions and recommendations and the manufacturer's installation drawings; (2) the oral and written directions provided by the manufacturer's technical representative who is supervising and observing the work; and (3) any additional requirement specified herein.
 - 2. Floor Preparation
 - a. Care shall be exercised in preparing the filter floor slab and in setting the anchors to assure proper alignment and elevation. Steel anchor rods shall be furnished by the filter manufacturer and set in the floor slab on both sides of the distribution flume in accordance with the manufacturer drawings. The floor slab shall be screeded into a flat level plane and be free of protrusions and depressions, but have a rough, broom finish. Do not trowel or finish the floor to a smooth finish.
 - b. Do not paint the floor or wall area where it will come in contact with the grout surrounding the underdrain. The filter floor and filter wall extending is not to be painted.
 - 3. Underdrain Lateral Installation
 - a. The underdrain laterals shall be set in relatively level rows on a bed of grout over the filter floor slab. Plates for closing the ends of each row of blocks shall be furnished by the filter manufacturer. After joining, aligning and setting the blocks, the bed grout is set-up, as soon as possible, all spaces between the rows of blocks and walls shall be filled with grout so that the entire bed is totally sealed and held firmly in place. Once all grouting is complete, the grout shall be allowed to cure for at least 3 full days before any functional testing.
 - b. Anchor rods, if required to meet the uplift requirement, shall be supplied by the underdrain manufacturer and installed by the Contractor. Installation of the anchor rods shall be in accordance with the Manufacturer's approved installation drawings and instruction manual.
 - c. After the anchor rods have been installed and the epoxy has cured, a non-destructive vertical pull test shall be performed. Testing shall be performed on 100% of the anchor rods. The pull test shall be performed by the underdrain Manufacturer in accordance with the Manufacturer's instruction manual.
 - 4. Cleaning and Protection During Installation, Testing, and Startup
 - a. The Contractor shall take all precautions recommended by the underdrain manufacturer or specified herein to ensure that the filter underdrain system and any piping communicating there with is completely clean and free of any debris, dirt, or other foreign materials which could clog the underdrain system or interfere with flow.

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Backwash air and water piping shall be thoroughly flushed clean. All loose debris and dirt within the filter cell and flume shall be removed by brooming down and vacuuming. Care shall be taken to keep grout from being deposited anywhere where it could interfere with flow. Any grout so deposited shall be removed. As installation progresses, partially completed portions of the Work shall be protected with heavy plastic sheeting or other suitable material to maintain the cleanliness of the underdrain system. Such protection shall be maintained until the underdrain system and filter media is installed.

- b. The Contractor shall also take precautions to prevent any dust, dirt, debris, or other foreign materials from leaving the filter under construction and migrating to the surrounding filters that are in service filtering water.
- c. Any time the underdrain laterals are to be used as a work surface, the underdrain block shall be overlaid with ½” (13 mm) minimum plywood sheeting where necessary, to distribute the load of yard buckets, wheel barrows, ladders, scaffolds, etc., to prevent damage to the underdrain.

3.3 FIELD TESTING

A. Tests:

1. Conduct all specified testing and provide all material, instrumentation, personnel, etc., for the tests specified.
2. All costs for such testing shall be borne by the Contractor, as well as the costs for all work and materials to correct deficiencies revealed during testing and retesting.
3. The Engineer and Owner shall be given sufficient advance notice of the testing to enable the Engineer and Owner to witness these tests.
4. All test set-ups, procedures, and instrumentation shall be designed by the underdrain manufacturer as required to provide data accuracy of plus or minus 2 percent.
5. Perform each test on every filter unless otherwise noted.

B. Preliminary Structural Integrity Test:

1. This test shall performed after a sufficient curing time of 28 days, or as defined by the underdrain manufacturer, has elapsed to permit the installation to develop adequate strength for the dynamic testing and before the placement of any media.
2. Flood the filter cell with approximately one foot of clean water above the underdrain.
3. Backwash each underdrain installation increasing the backwash rate in stages as in 5 gpm/ft² increments as follows (rates shall be held at each stage for sufficient observation):
 - a. 10 gpm/ft²
 - b. 15 gpm/ft²
 - c. Maximum backwash rate
 - d. 110% of maximum backwash rate
4. During this test, flow from each opening as well as any signs of dead spots shall be visually observed. Evidence of flow maldistribution such as water “mound” or “boil” in any area of the filter will constitute a failed test.
5. After this initial test, the filter shall be drained and the underdrain system shall be inspected for any damage or leaks.
6. Follow the underdrain manufacturer’s specific instructions necessary to correct any deficiencies revealed by these tests.
7. Repeat test until deficiencies are corrected at no additional cost to the Owner.
8. Follow underdrain manufacturers specific instructions for repairing damage to the underdrain system caused by test procedure.

C. Underdrain Flow Distribution Test:

1. This test shall be performed after the Preliminary Structural Integrity Test and before the media is placed.
2. The test shall be conducted using methods specified by the manufacturer and approved by the Engineer.

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3. Flood filter cells with clean water approximately 6 inches above the underdrain at the beginning of each test. Sustain test flow rates for approximately 3 minutes while making visual observations.
4. Extend or repeat test when additional time is needed to make observations, as directed by the Engineer or Owner.
5. Tests shall be as follows:
 - a. Test 1 – 4 standard cubic feet per minute per square foot of scour air with no backwash water.
 - b. Test 2 – 4 standard cubic feet per minute per square foot of scour air with 6 gallons per minute per square foot of backwash water.
 - c. Test 3 – 25 gallons per minute per square foot of backwash water with no air scour
6. During each test, the water surface shall present a uniformly turbulent appearance without dead spots or boils.
7. Follow the underdrain manufacturer’s specific instructions necessary to correct any deficiencies revealed by these tests. Any evidence of flow maldistribution will constitute a failed test.
8. Correct and retest underdrain systems that fail to meet the test criteria.
9. Repeat tests until deficiencies are corrected at no additional cost to the Owner.
10. Follow the manufacturer’s specific instructions for repairing any damage to the underdrain system caused by the test procedure.

D. Equal distribution Test of Backwash Water (Manometer Test)

1. This must be completed before the installation of any filter media.
2. It is difficult to determine a bad distribution by measuring the actual speed of the wash water in a flooded filter. Therefore, this test aims to measure the pressure in the plenum during a backwash instead, because pressure is related to flow. To measure the pressure, the Contractor shall install six (6) supplier-provided piezometric adapters in the false floor as indicated on the plans.
3. From the piezometric adapters on the nozzle sleeves, the Contract shall route Supplier-provided transparent vinyl tubing of equal length from the installed piezometric adapters to a Supplier-provided piezometer panel that contains a scale for each sample tube. Contract to adjust the panel and the scales with the water level during backwashing and assist with measurements as directed by the Supplier.
4. The panel shall be installed in a place far from the troughs. Figure 3.24 of “Filter Troubleshooting and Design Handbook” by R.P. Beverly of the AWWA shall serve as a reference for performing this test.
5. Pressure readings representing the pressure drop of the system of false floor are measured as the height of the water in each tube above the wash water level during a backwash. Using the highest and lowest values, the maldistribution can be calculated as follows:
 - a. $Maldistribution (\%) = \left[1 - \sqrt{\frac{P_{Highest}}{P_{Lowest}}} \right] * 100$
6. The test shall demonstrate equal distribution of the backwash water. A deviation of up to 10% between different measurement points is acceptable. If the deviation is found to be greater than 10%, the Contractor must make all corrections required to meet the maximum prescribed deviance. No work will be allowed in any subsequent filters until the problem is corrected.
7. After testing, the Contractor shall remove the piezometric taps and replace with approved nozzles. The Contractor shall also remove the vinyl tubing and manometer board and assist the Supplier for clean-up and storing of the piezometric equipment. The piezometric equipment provided by the Supplier for the testing shall remain the property of the Supplier.
8. The test protocol shall be prepared and submitted to the Engineer.
9. The measurements shall be recorded by the Supplier, and a report shall be submitted to the Engineer for review.

3.4 MANUFACTURER'S SERVICES

- A. Mechanical Filter Equipment Services
1. Install all items in accordance with the filter equipment manufacturer's recommendations. Upon completion of the installation, the technical director for the **filter manufacturer** shall furnish a certificate of compliance detailing that the underdrain has been installed in accordance with the manufacturer's instructions. **Manufacturer will provide suitable representation on-site to achieve the certification.**
 2. At a minimum, the Contractor shall provide the services of the manufacturer's technical representative for not less than **10** working days (8 hours per day) to inspect and supervise the installation and testing of the filter underdrain system in 5 trips (**minimum of** one per pumping station).
 3. Additional supervision for testing or other purposes in excess of that included above shall be made available by the manufacturer with reasonable notice and at the manufacturer's prevailing per diem rate plus living and travel expenses.
 4. The underdrain manufacturer shall retain on its permanent staff, field service representatives with at least 10 years of experience in the placement of underdrains. Such persons shall be available to instruct the Contractor in the proper placement and testing of the underdrain.

3.5 DOCUMENTATION

- A. As a minimum, documentation shall include:
1. Manufacturer's standard instruction bulletins for all functional components.
 2. Final shop drawings indicating filter underdrain systems as installed by Contractor.
 3. Documentation from Manufacturer certifying that underdrain systems have been installed per manufacturer recommendations.
 4. Warranty certificates for filter underdrain system including date of completed for each filter and each filters specific warranty expiration date.

3.6 DISINFECTION

- A. After all work is completed and before the filter is placed in service, the Owner will disinfect the entire filter in accordance with AWWA C653.

3.7 SPARES

- A. Spares shall be provided as follow:
1. Ten (10) underdrain o-rings (If any).
 2. Five (5) Grout bridge pieces.
 3. Five (5) Plastic end caps (If any).

END OF SECTION

SECTION 46 61 23A
GRAVITY FILTER STAINLESS STEEL UNDERDRAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Work Includes:
1. All of the equipment described in this section shall be supplied by a single underdrain manufacturer that regularly engages in that business. All underdrain systems specified in this section will be constructed of Stainless Steel. Stainless Steel underdrains shall be bid as an alternate to the plastic underdrains specified in Section 46 61 23. This section requires the furnishing and installation of 24 existing filters as shown on the Contract drawings. These 24 filters are across 5 Pumping Stations:
 - a. Davis Pumping Station
 - 1) 4 Filters (2 cells per filter)
 - a) Cell Dimension: 15'-0" x 30'-0"
 - b. Mallory Pumping Station
 - 1) 8 Filters (2 cells per filter)
 - a) Cell Dimension: 12'-6" x 33'-0"
 - c. McCord Pumping Station
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1. Section 46 61 13 – Filter Media.
 2. Section 46 61 19 – Wash Water Troughs.

1.2 REFERENCES

- A. Reference Standards: Standards referenced in this section include, but are not necessarily limited to, the following:
1. American Water Works Association (AWWA):
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 - c. F102 – Matched-Die-Molded, Fiberglass-Reinforced Plastic Weir Plates, Scum Baffles, and Mounting Brackets.
 2. NSF International (NSF):
 - a. 61, Drinking Water System Components – Health Effects.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Pre-installation Meeting:
1. A Pre-installation meeting shall occur before any work is started at the facility. This meeting is to review the work schedule and to verify the contractor has all equipment on site to perform the removal and installation of filter underdrains and filter media.
 2. The following parties shall be present at the meeting or have a delegated representative:
 - a. Contractor Site Supervisor.
 - b. Engineer.

- c. Owner's Representative.
- B. Sequencing and Scheduling:
 - 1. Only one (1) filter may be removed from service at a pumping station to perform the work contained in the Construction Drawings and Project Manual.
 - a. Mallory Pumping Station can have two (2) filters out of service for work at one time with approval from Owner.
 - 2. A maximum of two (2) filters can be removed from service across the Owner's entire production system at a time to perform the work contained in the Construction Drawings and Project Manual.

1.4 SUBMITTALS

- A. Action Submittals: Submit the following:
 - 1. Submit to the Engineer complete shop drawings showing details of fabrication, materials of construction, installation and leveling data of all items furnished under this section.
 - 2. Details submitted shall include as a minimum, headloss data for air, water and combined air/water backwash, installation details, flow distribution calculations, certification of compatibility of the underdrain system with the filter media specified in Section 46 61 13 – Filter Media, details for installing reinforcing and other items to be embedded in concrete.
 - 3. Testing Procedures: Detailed start-up, hydraulic, and air scour test procedures.
 - 4. Proper documentation showing NSF-61 certification on all underdrain components.
 - 5. Testing Plans, Procedures, and Testing Limitations:
 - a. Testing procedure, apparatus, and limitations of apparatus and procedure, for:
 - 1) Source quality control activities indicated in this Section.
 - 2) Field quality control activities indicated in this Section.

1.5 QUALITY ASSURANCE

- A. Manufacturer: The filter system shall be supplied by one manufacturer that shall assume total responsibility for the parts operating as a whole and shall be manufactured by:
 - 1. AWI
 - 2. Robert's Filter Group.
 - 3. Or approved equal.
- B. Basis of Design (BOD): For the purposes of comparison, the Engineer has established the flowing blocks as the BOD at each of the pumping stations:
 - 1. All Pumping Stations: AWI Phoenix
- C. Experience: The filter system shall be a standard product of a filter manufacturer who has been actively providing dual-parallel lateral air/water underdrain equipment for at least 15 years. Upon request, the filter manufacturer with provide the Engineer with a list of installations of underdrain which totals not less than 100.
- D. NSF Certification: All materials used in contact with the water and backwash air shall meet National Sanitation Foundation (NSF) Standard 61 Drinking Water System Components – Health Effects.
- E. Underdrain: All materials directly related to the installation of the underdrain system including blocks, special anchorage, grout plates, gaskets, etc. shall be the products of a single manufacturer/supplier.
- F. Hydraulic Demonstration:
 - 1. The filter manufacturer shall, at their own facilities, if requested by the Engineer, set up a test lateral run of equal length to that required by the project and provide an opportunity for the Engineer and/or Owner to visit the facility to witness a full scale demonstration of the headloss and flow distribution during backwash.
 - 2. Testing shall be run at flows up to 25 GPM/SF.
 - 3. The test facility shall be capable of demonstrating concurrent air and water distribution in a submerged trough and water only distribution on a non-submerged test bench.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. The schedule of work shall be submitted to the Owner for approval prior to commencement of work.
- B. The contractor shall be responsible for coordinating the shipment of supplies of materials and equipment specified herein. Coordination will be required during construction, startup and/or testing.
- C. The contractor shall be responsible for storage of the filter underdrain equipment. Contractor is to coordinate with the Owner for an on-site storage location. If the location is outside, Contractor is responsible for protecting material and equipment from UV exposure, dust, and water damage.

1.7 WARRANTY

- A. Manufacturer's Special or Extended Warranty:
 - 1. In addition to manufacturer's general, standard printed warranty, furnish manufacturer's special warranty covering underdrain system, including blocks, media retention plates, and any other appurtenances. Special warranty shall remain in effect for a period of 5 years commencing on the date of Substantial Completion for the associated Work.

PART 2 - PRODUCTS

2.1 UNDERDRAIN

- A. Underdrain Design Criteria for Filtration and Backwash:
 - 1. Air Scour Rate: 3-5 SCFM/ft²
 - 2. Water Wash Rate, Water Only: 25 gpm/ft²
 - 3. Water Wash Rate, Concurrent with Air: 6 gpm/ft²
 - 4. Max Filtration Rate: 5.0 gpm/ft²
- B. The filter underdrain system will support a dual media bed cleaned by water backwash, air scour, or a combination of both water and air.
- C. The underdrain system shall be comprised of a series of laterals. Laterals must compensate for water velocity and momentum changes during backwash operations by varying the size of the orifices along the lateral length.
- D. Lateral height shall be such to accommodate the velocities of water and also ensure that substantial clearance is available between the bottom of the filter troughs and the elevation of the filter media after being expanded 50%.
- E. The underdrain shall maximize uplift resistance via grout or physical restraint.
 - 1. Underdrain manufacturer shall documentation to show uplift resistance of the underdrain.
 - 2. All underdrains shall be capable of 25 psi of uplift resistance/ internal pressure.
- F. The underdrain system shall be designed to allow for efficient repairability. All anchorage and assembly shall be designed so that all aspects of the underdrain system can be removed for cleaning, repair or replacement without damaging any adjacent components of the underdrain system.

2.2 AIR HEADER

- A. Because the proper distribution of air into the underdrain has a significant effect upon operation, the filter manufacturer shall have the responsibility to design and provide the air distribution header for this underdrain.
- B. Air header is to be fully contained in the flume and underdrain. No air piping in the filter media will be permitted.

2.3 MATERIALS AND CONSTRUCTION

A. Underdrain

1. Material: The stainless steel laterals shall be constructed of at least 20 gauge 316L stainless steel.
2. Dimensions: The lateral size and width shall permit ease of handling and installation. Lateral heights shall be selected to ensure safe velocities of water in the laterals at all times. Additionally, laterals must be of an appropriate height to ensure that 50% expanded media does not come into contact with the wash water troughs.
 - a. This height varies from station to station. Reference Construction drawings for more information.
3. Lateral Geometry: The laterals shall be essentially triangular or trapezoidal in shape with dispersion orifices located in the sloped sides of the laterals. Laterals shall have restrained to the filter floor by means of a stainless steel restraining plate secured to an anchor placed in the filter floor. All voids between the laterals shall be filled with gravel, torpedo sand, or filter sand. These areas of sand do not count towards total heights of media specified in the Contract drawings.
4. Lateral Construction: Laterals shall be arranged end-to-end and be mechanically joined to form continuous underdrain laterals approximately equal to the length of the filter cell. One-piece extruded underdrain options are also permitted. If the laterals are to be connected, the joints shall be held together by 316 stainless steel hardware. These joints shall be water and air tight.

B. Air Header

1. General: The air distribution system shall be generally comprised of a corrosion resistant header specially calibrated to evenly distribute air flow via properly located riser pipes to each lateral. Sufficient relative velocities shall be maintained in both the header and riser pipes to ensure proper distribution of air.
2. Material: The air header piping shall be Sch 10, type 316 stainless steel. The anchors and hardware for anchoring shall be type 316 stainless steel.

C. Grout

1. Grout shall only be used for leveling means and not for restraining the underdrain laterals.
2. Cement: Cement shall be standard brand Portland cement conforming to ASTM C150, Type II for general use. Cement that has become “lumpy” shall not be used.
3. Water: Water for mixing and curing shall be clean and clear potable water. The water shall be considered potable if it meets the requirements of the local government agencies. Water with a total dissolved solids of 1000 mg/l or higher or greater than 10 NTU shall not be used.
4. Sand: Sand shall be clean and washed masonry sand. When tested in accordance with ASTM D2419, the sand equivalency shall not be less than 90% for an average of three samples, or less than 85% for any individual samples. 100% of sand particles shall pass No. 4 sieve and not more than 4% of sand particles shall pass No. 200 sieve.
5. Chemical Admixtures: No chemical admixture is needed in most of the applications. The grout can be mixed in a small batch and used immediately.
6. Strength: The grout used in installing the blocks shall have a minimum compressive strength of 3000 psi (207 bars) after 30 days of curing. Normally, use a grout with one part Portland cement and two parts clean silica sand properly mixed and wetted to a maximum water-cement ration by weight equal to 0.50 to 0.55 for the base grout and 0.61 to 0.67 for the fill grout.

PART 3 - EXECUTION

3.1 PRODUCT HANDLING, STORAGE AND DELIVERY

- A. Place or store underdrain only in designated staging areas that are approved by Engineering and Owner.

- B. Store underdrain and specialties off the ground, under ultraviolet-resistant tarps from time of deliver on-site until final installation of the filters.
- C. Replace, at no charge to Owner, underdrains and specialties damaged during storage and delivery.
- D. Underdrains and specialties are subject to inspection at the Engineer's request if visual evidence of damage is observed.

3.2 INSTALLATION

- A. Filter Underdrain and Air Header
 - 1. The Contractor shall install the filter underdrain system in strict accordance with: (1) the manufacturer's written instructions and recommendations and the manufacturer's installation drawings; (2) the oral and written directions provided by the manufacturer's technical representative who is supervising and observing the work; and (3) any additional requirement specified herein.
 - 2. Floor Preparation
 - a. Care shall be exercised in preparing the filter floor slab and in setting the anchors to assure proper alignment and elevation. Steel anchor rods shall be furnished by the filter manufacturer and set in the floor slab on both sides of the distribution flume in accordance with the manufacturer drawings. The floor slab shall be screeded into a flat level plane and be free of protrusions and depressions, but have a rough, broom finish. Do not trowel or finish the floor to a smooth finish.
 - b. Do not paint the floor or wall area where it will come in contact with the grout surrounding the underdrain. The filter floor and filter wall extending is not to be painted.
 - 3. Underdrain Lateral Installation
 - a. The underdrain laterals shall be set out starting from one end of the filter wall. Lay out these locations and closely observe all tolerances.
 - b. Anchors shall then be embedded into the base slab of the filter at locations laid out by the Manufacturer's drawings. All dust and debris shall be cleaned from the filter after all anchors have been installed.
 - c. After all anchors have been installed, install laterals one at a time per Manufacturer shop drawings and Manufacturer recommendations and instructions.
 - 4. Cleaning and Protection During Installation, Testing, and Startup
 - a. The Contractor shall take all precautions recommended by the underdrain manufacturer or specified herein to ensure that the filter underdrain system and any piping communicating there with is completely clean and free of any debris, dirt, or other foreign materials which could clog the underdrain system or interfere with flow. Backwash air and water piping shall be thoroughly flushed clean. All loose debris and dirt within the filter cell and flume shall be removed by brooming down and vacuuming. Care shall be taken to keep grout from being deposited anywhere where it could interfere with flow. Any grout so deposited shall be removed. As installation progresses, partially completed portions of the Work shall be protected with heavy plastic sheeting or other suitable material to maintain the cleanliness of the underdrain system. Such protection shall be maintained until the underdrain system and filter media is installed.
 - b. The Contractor shall also take precautions to prevent any dust, dirt, debris, or other foreign materials from leaving the filter under construction and migrating to the surrounding filters that are in service filtering water.
 - c. Any time the underdrain laterals are to be used as a work surface, the underdrain block shall be overlaid with ½" (13 mm) minimum plywood sheeting where necessary, to distribute the load of yard buckets, wheel barrows, ladders, scaffolds, etc., to prevent damage to the underdrain.

3.3 FIELD TESTING

A. Tests:

1. Conduct all specified testing and provide all material, instrumentation, personnel, etc., for the tests specified.
2. All costs for such testing shall be borne by the Contractor, as well as the costs for all work and materials to correct deficiencies revealed during testing and retesting.
3. The Engineer and Owner shall be given sufficient advance notice of the testing to enable the Engineer and Owner to witness these tests.
4. All test set-ups, procedures, and instrumentation shall be designed by the underdrain manufacturer as required to provide data accuracy of plus or minus 2 percent.
5. Perform each test on every filter unless otherwise noted.
6. Manufacturer's may submit their own testing procedures for review by the Engineer. These tests may be substituted in place of the tests described in this section. Manufacturer's test procedures can only be used after review and approval from the Engineer.

B. Preliminary Structural Integrity Test:

1. This test shall performed after a sufficient curing time of 28 days, or as defined by the underdrain manufacturer, has elapsed to permit the installation to develop adequate strength for the dynamic testing and before the placement of any media.
2. Flood the filter cell with approximately one foot of clean water above the underdrain.
3. Backwash each underdrain installation increasing the backwash rate in stages as in 5 gpm/ft² increments as follows (rates shall be held at each stage for sufficient observation):
 - a. 10 gpm/ft²
 - b. 15 gpm/ft²
 - c. Maximum backwash rate
 - d. 110% of maximum backwash rate
4. During this test, flow from each opening as well as any signs of dead spots shall be visually observed. Evidence of flow maldistribution such as water "mound" or "boil" in any area of the filter will constitute a failed test.
5. After this initial test, the filter shall be drained and the underdrain system shall be inspected for any damage or leaks.
6. Follow the underdrain manufacturer's specific instructions necessary to correct any deficiencies revealed by these tests.
7. Repeat test until deficiencies are corrected at no additional cost to the Owner.
8. Follow underdrain manufacturers specific instructions for repairing damage to the underdrain system caused by test procedure.

C. Underdrain Flow Distribution Test:

1. This test shall be performed after the Preliminary Structural Integrity Test and before the media is placed.
2. The test shall be conducted using methods specified by the manufacturer and approved by the Engineer.
3. Slowly fill filter cells with clean water at a rate of 2 GPM/sq. ft. approximately 6 inches above the underdrain at the beginning of each test to release entrapped air that may be in the underdrain.
4. While the filter is beginning to fill, check all joints for any possible jets indicating possible areas of problem.
5. Once the water surface is approx. 6 inches above the top of the underdrain, increase the backwash rate to 5 GPM/ sq. ft. Inspect and identify any areas that indicate jetting.
6. Drain filter unit and repair any areas of jetting.
7. Repeat steps 3 through 6 until all problem areas have been resolved.
8. Once distribution is acceptable, slowly increase the filter backwash rate to the maximum rate for 5-10 minutes. Once completed, drain the filter bed and inspect for any signs of uplift, loose hardware or any other abnormalities.

9. Follow the underdrain manufacturer's specific instructions necessary to correct any deficiencies revealed by these tests. Any evidence of flow maldistribution will constitute a failed test.
10. Correct and retest underdrain systems that fail to meet the test criteria.
11. Repeat tests until deficiencies are corrected at no additional cost to the Owner.
12. Follow the manufacturer's specific instructions for repairing any damage to the underdrain system caused by the test procedure.

D. Air Distribution Test

1. This test shall only be performed after completion of the Underdrain Flow Distribution Test.
2. Slowly fill the filter with water to a level approximately 6 inches above the top of the filter underdrain.
3. Slowly start the blower and gradually open the air inlet valve to the filter. Air flow should reach 4 SCFM/sq. ft. or a specified rate from the manufacturer.
4. Observe the distribution across the filter for any non-uniform distribution. If distribution is not uniform, adjust the air higher or lower until equal distribution is achieved. For areas where turbulence is observed, drain the area to inspect and repair the joints.
5. Correct and retest until no more turbulent areas are observed.
6. Follow the manufacturer's specific instructions for repairing any damage to the underdrain system caused by the test procedure.

E. Equal Distribution Test of Backwash Water (Box Test)

1. This must be completed before the installation of any filter media.
2. Mount four test boxes to measure the rise rate at 4 predetermined areas of the filter by installing gasket material to ensure a proper seal at the box and lateral interface. Each box shall be fitted with a submersible pressure transducer to continuously measure water pressure in the box. Recordings for four boxes shall be recorded on a Human Machine Interface as well.
3. Once all test boxes and equipment have been installed, slowly fill the filter basin at a rate of 5 GPM/sq. ft. using backwash water until the water level is approximately 6 inches over the top of the underdrains. Observe the water in the filter and verify that all of the air has been released from the laterals. If not, continue filling at a low rate until air has dissipated.
4. Once the air has dissipated, drain the underdrains back down to 6 inches above the underdrain.
5. Begin backwashing, increasing the flow up to the design test backwash flow rate. Increase the rate in increments of 5 GPM/ sq. ft.
6. Once the flow reaches the design test rate and the water level is 6 inches above the anticipated top of media, record the time.
7. Continue washing until the water reaches the bottom of the troughs and record this time. Once the water has reached the bottom of the trough, the test can be stopped.
8. Drain the filter and continue with any further testing.
9. Using the recorded data from the pressure transmitters, calculate the flows from all 4 boxes and compare. Using the minimum and maximum flow rates across the boxes to determine the maldistribution.
 - a. $overall\ \% \ difference = \frac{max\ rate - min\ rate}{((max\ rate + min\ rate)/2)} * 100$
 - b. Divide by 2 to find the +/- distribution from the average.
10. The measurements shall be recorded by the Manufacturer, and a report shall be submitted to the Engineer for review.

3.4 MANUFACTURER'S SERVICES

A. Mechanical Filter Equipment Services

1. Install all items in accordance with the filter equipment manufacturer's recommendations. Upon completion of the installation, the technical director shall furnish a certificate of compliance detailing that the filtering materials have been installed in accordance with the

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manufacturer's instructions. **Manufacturer will provide suitable representation on-site to achieve the certification.**

2. The Contractor shall provide the services of the manufacturer's technical representative for not less than 10 working days (8 hours per day) to inspect and supervise the installation and testing of the filter underdrain system in 5 trips (minimum one per pumping station).
3. Additional supervision for testing or other purposes in excess of that included above shall be made available by the manufacturer with reasonable notice and at the manufacturer's prevailing per diem rate plus living and travel expenses.
4. The underdrain manufacturer shall retain on its permanent staff, field service representatives with at least 10 years of experience in the placement of underdrains. Such persons shall be available on a fee-paid basis to instruct the Contractor in the proper placement and testing of the underdrain.

3.5 DOCUMENTATION

- A. As a minimum, documentation shall include:
 1. Manufacturer's standard instruction bulletins for all functional components.
 2. Final shop drawings indicating filter underdrain systems as installed by Contractor.
 3. Documentation from Manufacturer certifying that underdrain systems have been installed per manufacturer recommendations.
 4. Warranty certificates for filter underdrain system including date of completed for each filter and each filters specific warranty expiration date.

3.6 DISINFECTION

- A. After all work is completed and before the filter is placed in service, the Owner will disinfect the entire filter in accordance with AWWA C653.

3.7 SPARES

- A. Spares shall be provided as follow:
 1. 2% more anchor bolts for each pumping station than the quantity shown on the manufacturer's drawings.
 2. 2% more assembly bolts for each pumping station than the quantity shows on the manufacturer's drawings.
 3. 2% more sealant than is needed for installation at each pumping station as shown on the manufacturer's drawings.
 4. 2% more gasket material for each pumping station than is shown on the manufacturer's drawings.

END OF SECTION