
USACE / NAVFAC / AFCEC / NASA UFGS-43 31 14 (April 2006)
Change 1 - 11/14

Preparing Activity: USACE Superseding
UFGS-43 31 14 (August 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2016

SECTION TABLE OF CONTENTS

DIVISION 43 - PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE
EQUIPMENT

SECTION 43 31 14

TRICKLING FILTER

04/06

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 EXTRA MATERIALS

PART 2 PRODUCTS

- 2.1 SYSTEM DESCRIPTION
- 2.2 MATERIALS AND EQUIPMENT
 - 2.2.1 Standard Products
 - 2.2.2 Materials Protection
 - 2.2.3 Rotary Distributor
 - 2.2.3.1 Design and Operating Requirements
 - 2.2.3.2 Center Column
 - 2.2.3.3 Distributor Arms
 - 2.2.3.4 Center Pier Supply Fittings
- 2.3 FILTER BLOCKS
- 2.4 FILTER MEDIA
 - 2.4.1 Quality
 - 2.4.2 Size and Grading

PART 3 EXECUTION

- 3.1 INSTALLATION AND CONSTRUCTION
 - 3.1.1 Placing Rotary Distributor
 - 3.1.2 Placing Filter Block
 - 3.1.3 Placing Filter Media
- 3.2 FIELD TESTS AND INSPECTIONS
- 3.3 CLOSEOUT ACTIVITIES

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEC / NASA UFGS-43 31 14 (April 2006)
Change 1 - 11/14

Preparing Activity: USACE Superseding
UFGS-43 31 14 (August 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2016

SECTION 43 31 14

TRICKLING FILTER 04/06

NOTE: This guide specification covers the requirements for a trickling filter for use in sewage treatment plants normally handling domestic sewage.

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

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

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

PART 1 GENERAL

NOTE: Special consideration must be given to sewage carrying industrial wastes containing components detrimental to biodegrading microorganisms. The following information should be shown on the project drawings or provided by the project designer:

- a. Dimensions of filter tank and elevation of base slab.
- b. Design flows and loading rate.
- c. Available head.

- d. Depth of filter bed.
- e. Size of inlet piping.
- f. Location of vent stack pipes.
- g. Design loads for wind and ice where applicable.
- h. Clearance of arms above filter surface.
- i. Number of distribution arms.
- j. Type(s) of filter media to be allowed.
- k. Type of filter blocks.

1.1 REFERENCES

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

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

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

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

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

- | | |
|---------|--|
| ABMA 11 | (2014) Load Ratings and Fatigue Life for Roller Bearings |
| ABMA 9 | (2015) Load Ratings and Fatigue Life for Ball Bearings |

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

- | | |
|----------|---|
| AISC 360 | (2010) Specification for Structural Steel Buildings |
|----------|---|

AMERICAN WATER WORKS ASSOCIATION (AWWA)

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

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2013) Standard Specification for Zinc
(Hot-Dip Galvanized) Coatings on Iron and
Steel Products

ASTM A153/A153M (2009) Standard Specification for Zinc
Coating (Hot-Dip) on Iron and Steel
Hardware

ASTM A36/A36M (2014) Standard Specification for Carbon
Structural Steel

ASTM A475 (2003; R 2014) Standard Specification for
Zinc-Coated Steel Wire Strand

ASTM A48/A48M (2003; R 2012) Standard Specification for
Gray Iron Castings

ASTM A53/A53M (2012) Standard Specification for Pipe,
Steel, Black and Hot-Dipped, Zinc-Coated,
Welded and Seamless

ASTM B209 (2014) Standard Specification for Aluminum
and Aluminum-Alloy Sheet and Plate

ASTM B209M (2014) Standard Specification for Aluminum
and Aluminum-Alloy Sheet and Plate (Metric)

ASTM B429/B429M (2010; E 2012) Standard Specification for
Aluminum-Alloy Extruded Structural Pipe
and Tube

ASTM C144 (2011) Standard Specification for
Aggregate for Masonry Mortar

ASTM C150/C150M (2015) Standard Specification for Portland
Cement

ASTM C159 (2006; R 2011) Standard Specification for
Vitrified Clay Filter Blocks

ASTM C700 (2013) Standard Specification for
Vitrified Clay Pipe, Extra Strength,
Standard Strength, and Perforated

ASTM C88 (2013) Standard Test Method for Soundness
of Aggregates by Use of Sodium Sulfate or
Magnesium Sulfate

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 8 (1982; E 2004) Pickling

1.2 SUBMITTALS

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

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

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

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

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

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.][information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Rotary Distributor; G[, [_____]]

SD-03 Product Data

Rotary Distributor; G[, [_____]]

Spare Parts

Submit spare parts data after approval of the detail drawings and not later than [_____] months prior to the date of beneficial occupancy.

SD-10 Operation and Maintenance Data

Operating and Maintenance Manuals; G[, [_____]]

1.3 EXTRA MATERIALS

All standard spare parts shall be provided as recommended in the manufacturer's instruction manuals for each component of the equipment. Submit spare parts data for the rotary distributor. Include a complete list of parts and supplies, with current unit prices and source of supply.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The trickling filter shall include a rotary distributor, reinforced concrete walls and base, filter media, filter block underdrainage system, and all other components indicated or necessary for proper operation.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Standard Products

Unless otherwise specified, provide materials and equipment which are standard commercial products in regular production by the manufacturer and suitable for the required service. Structural steel shall conform to ASTM A36/A36M. Steel pipe for structural members and distributor arms shall conform to ASTM A53/A53M. Steel members which will be in contact with sewage, completely or intermittently, during normal operation of the equipment shall have a minimum thickness of 6 mm 1/4 inch. All cast iron shall conform to ASTM A48/A48M, Class 30. Aluminum alloy used for structural members and pipe shall conform to ASTM B209M ASTM B209 (3003-H14) and ASTM B429/B429M (6063-T6), respectively.

2.2.2 Materials Protection

All ferrous metal surfaces shall be pickled in accordance with SSPC SP 8. All ferrous metal surfaces, including rotating assembly, distributor arms, supports, and attachments shall be zinc coated in accordance with ASTM A123/A123M or ASTM A153/A153M, as applicable. The interior and exterior of all fabricated ferrous metal components shall be pickled and galvanized after fabrication. To prevent corrosive action, insulating components such as gaskets, couplings, or bushings, of a dielectric-type which will prevent corrosion of bimetallic-type contacts, shall be used at connections between dissimilar metals.

2.2.3 Rotary Distributor

The rotary distributor shall be suitable for the uniform distribution of sewage over the filter bed at the rates of flow and operating conditions specified herein. The rotary distributor shall include distributor arms, center column, and other appurtenances necessary for proper operation. The rotary distributor shall rotate solely from the reaction of sewage flowing through jets or nozzles in the distributor arms and shall operate freely

and effectively over the entire range of operation. Submit detail drawings of rotary distributor and installation instructions. Detail drawings shall contain equipment layout and anchorage, and sufficient details to demonstrate that the rotary distributor will properly function as a unit.

2.2.3.1 Design and Operating Requirements

NOTE: Delete ice coating requirements in warm climates.

The rotary distributor shall be designed for a filter bed of [_____] mm feet inside diameter. Design flows shall range from a minimum of [_____] L/second gpm to a maximum of [_____] L/second gpm, and the average design loading shall be [_____] L/second gpm. The total head available at the inlet (above the media surface) shall be [_____] at the maximum rate of flow. The maximum velocity in the arms shall not exceed 1.22 m/second 4.0 fps. The rotary distributor and each of its component parts shall be designed to withstand all structural and mechanical stresses brought about by the following loadings: weight of equipment plus liquid; wind loading; and a live load of [_____] N pounds at any point on the arm; and an ice coating of [_____] mm inch thick. Safety factor for the foregoing shall be a minimum of 1.6 based on the yield point of the steel. The anchorage of concrete center pier shall be designed to resist, with a 2.0 minimum safety factor, a maximum overturning moment brought about when arms on one side of the distributor are filled with water and those on the other side are empty. Vertical deflections at the end of the distributor arms shall not exceed 100 mm 4 inches and arms shall have a clearance above the surface of filter bed as indicated. The rotary distributor shall be designed for continuous 24-hour service under design load without excessive wear, damage, or failure. Stresses developed under the aforementioned operating conditions and loads shall not exceed the stresses allowed under AISC 360.

2.2.3.2 Center Column

NOTE: Delete bracketed wording pertaining to weirs or dependent on the provisions of weirs when distributors have less than four arms, except when two-compartment arms are used.

The trickling filter tank should be constructed in accordance with Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE. Walls should have standard finish. Horizontal surfaces should have screed finish. Insert the following requirements in the appropriate place: "The hollow concrete center pier, including installation of anchor bolts, shall be constructed in accordance with the recommendations of the manufacturer of the rotary distributor, as approved by the Contracting Officer."

Type IIA cement normally will be specified, but Type V cement will be specified when the soils contain in excess of 0.2 percent water soluble sulfate as SO(4), or waste water contains in excess of 1,000 parts per million sulfates. Alkali reactive aggregates require use of a cement containing less

than 0.60 percent alkalis. Type I cement may be permitted when it can be assured that the water soluble sulfates in the soil will be less than 0.1 percent and the waste water will contain less than 150 parts per million sulfates over the design life of the project. Air entrainment admixtures will be used in all types of concrete.

The center column shall be mast-type or turntable-type and shall include a stationary assembly, rotating assembly, seal, bearing assembly, lubricating fittings, and anchor bolts. Ample port areas or openings shall be provided to permit unrestricted flow of sewage from inlet in stationary assembly through rotating assembly into distributor arms.

- a. Stationary Assembly: Elements of the stationary assembly shall be of cast iron, structural steel, steel pipe, or aluminum alloy. The stationary assembly shall have a [_____] mm inch diameter inlet and be designed for anchorage to the hollow concrete center pier by anchor bolts.
- b. Rotating Assembly: Elements of the rotating assembly shall be of cast iron, structural steel, or aluminum alloy, except as otherwise specified herein. Turntable, when provided, shall be of cast iron only. Steel for nonstructural applications shall have a minimum yield point of 207 MPa 30,000 psi. [An adjustable weir shall be provided to divide the flow between the primary and secondary arms so that only primary arms will operate at minimum flow and that all arms will discharge uniformly at maximum flow. The weir shall be accessible for adjustment without dismantling the equipment. The weir shall be in the rotating assembly, unless provided in each secondary arm as specified hereinafter.] Rotating assembly shall have machined surfaces suitable for installation of distributor arms and shall be of a height that provides suitable anchorage for distributor arm supports.
- c. Seal: A mechanical seal or an air gap shall be provided to prevent the leakage of water between the stationary and rotating assemblies at the maximum hydraulic head. Any type of seal employing mercury as the sealing element will not be allowed.
 - (1) Mechanical Seal: The mechanical seal, if selected, shall be designed to withstand the full hydraulic head in the rotating assembly. Seals shall have an annular ring of replaceable grease-resistant neoprene or tetrafluoroethylene with a low coefficient of friction. Seals between horizontal surfaces shall be maintained against the seal plate by annular steel weight strips and steel seal clamps. Seals between vertical surfaces shall be spring loaded in steel retainer rings attached to the rotating assembly.
 - (2) Air Gap: An air gap, if selected, shall be provided to prevent the liquid from entering the rotor bearing and shall require no auxiliary equipment to maintain the air gap between the fixed feeder pipe or column and the rotating sleeve and/or drum. Means shall be provided to prevent the liquid level in the rotating equipment from rising positively to the elevation of the air gap. The relief device provided to prevent this shall be constructed to force any overflow to discharge on the surface of the filter, visible to the operator and at a point above or apart from normal

distribution outlets.

- d. Bearings: The radial and axial loads of the rotating assembly and distributor arms shall be transmitted to the stationary assembly by an anti-friction thrust bearing of the ball or roller type. Guide or steady bearings shall be provided where necessary to maintain alignment. Bearings shall be designed so that the rotating assembly will maintain its alignment, start freely, and operate satisfactorily at the minimum head at all conditions of wind and temperature. Bearings shall be designed for the vertical thrust of the machine full of water and the horizontal thrust due to eccentric loads on the arms. Bearings shall have a minimum rated life expectancy of 100,000 hours (L-10). When equipment is operating continuously under specified loading conditions, load rating and fatigue life shall be based on ABMA 9 and ABMA 11, as applicable.
- e. Lubrication Fittings: All moving parts subject to wear and all bearings shall be provided with adequate means for lubrication. Lubrication shall be by grease or oil, as suitable. Greased bearings shall be provided with fittings for grease gun service. If not easily accessible, the bearing lubrication fittings shall be provided with grease tubing extended to convenient locations. The grease fittings shall prevent over-lubrication and pressure build-up injurious to bearings. Each oil reservoir shall be liberal in size and be provided with an opening for filling, an overflow opening at the proper location to prevent overfilling, an oil-level sight glass, and a drain at the lowest point. Provide the manufacturer's recommended lubricant sufficient for 6 months of normal operation.
- f. Anchor Bolts: Anchor bolts, with necessary hex nuts and washers, shall be Type 304 stainless steel. Anchor bolts and accessories shall be provided to secure the stationary assembly to the hollow concrete center pier.

2.2.3.3 Distributor Arms

The distributor arms shall be attached to the rotating assembly by flanged or screwed connections. The arms shall be of steel pipe, structural steel with minimum wall thickness of 6 mm 1/4 inch, or aluminum alloy. [When the adjustable flow division weir specified in paragraph Rotating Assembly, is not provided in the rotating assembly, one adjustable, accessible overflow weir shall be provided in each secondary arm to cut off flow to that arm at minimum flow and to allow uniform flow of all arms at maximum flow.] The end of each arm shall be provided with a quick-opening shear gate for flushing. Arms shall be supported from the rotating assembly by cables, steel tie rods with turnbuckles, or a steel truss. Wire strand for cables shall conform to ASTM A475. Arm supports shall be designed to support the design loads. Arms shall be laterally braced by means of horizontal steel tie rods with turnbuckles. Each arm shall have openings spaced to distribute the flow uniformly over the filter bed. Nozzles and spreaders shall be provided at each opening and shall be of corrosion-resistant nonferrous material. Nozzles shall be designed to provide maximum reactive force with minimum head loss. Spreaders shall be designed to disperse the flow evenly from each opening. Each spreader shall be easily removable for cleaning and shall be equipped with replaceable orifices permitting variation of flow capacity with different orifices. Rectangular-arm distributors shall have orifices in the spreaders. Orifices and openings shall be of nonclogging design.

2.2.3.4 Center Pier Supply Fittings

The [_____] mm inch supply inlet line junction fitting shall be a [base tee and riser pipe] [base-plate with short riser pipe and flange] suitable for the rotary distributor center column attachment. The construction shall be ductile iron, or steel conforming to AWWA C151/A21.51 or ASTM A53/A53M, respectively.

2.3 FILTER BLOCKS

The underdrain system shall include rectangular and cut tile blocks, cover blocks for drainage channels, and vent blocks. All blocks shall conform to ASTM C159, Type I-H, except cover blocks shall not have apertures and vent blocks shall have openings to accommodate vent stacks. Cut or angle blocks shall be cut on an angle to conform approximately to the wall curvature. Filter underdrain blocks shall have semicircular inverts or equivalent section and shall cover the entire floor of the filter. Vent stack pipes shall be of extra strength vitrified clay pipe conforming to ASTM C700 and shall be provided as indicated.

2.4 FILTER MEDIA

2.4.1 Quality

**NOTE: When plastic media is to be used exclusively,
delete all requirements for and reference to other
materials.**

The media shall be [crushed stone or crushed slag][or][plastic]. The top 460 mm 18 inches of media shall have a loss by the 20-cycle sodium sulfate soundness test of ASTM C88 of not more than 10 percent by weight; the balance of the media shall pass a 10-cycle test using the same criteria. Plastic media shall be random-dumped ring type or stacked modular type. Random-dumped ring type shall be of long term heat aging, rigid polypropylene plastic specially manufactured as trickling filter media, with a minimum void volume of 90 percent, and a minimum surface area per cubic meter feet volume of 82 square meters 25-square feet. Plastic stacked modular type shall be of saran, polyvinyl chloride (PVC), fiberglass reinforced resins, or plastic equally resistant to oxidation, ozone aging or effects of ultraviolet exposure, and shall have minimum void volume and surface area per cubic meters feet volume as required for random-dumped ring type media. The media shall provide a minimum projected life of 25 years in the intended service. Projected life shall be based on case history or simulated aging tests as performed by an independent testing laboratory acceptable to the Contracting Officer. Such tests shall be substantiated by certified and notarized test reports. Installed media shall provide support for the weight of two workmen working together on any part of the surface of the filter without damage or displacement of the media.

2.4.2 Size and Grading

[Stone or slag media shall conform to the following size distribution and grading and mechanical graded over a vibrating screen with square opening: 100 percent passing 5.0 inch sieve; 95-100 percent by weight retained on 3.0 inch sieve; 2 percent by weight passing the 2.0 inch sieve; and 1 percent by weight passing the 1.0 inch sieve.][Plastic media shall be the

manufacturer's standard as approved by the Contracting Officer.]

PART 3 EXECUTION

3.1 INSTALLATION AND CONSTRUCTION

3.1.1 Placing Rotary Distributor

**NOTE: Delete bracketed wording pertaining to weirs
or dependent on the provisions of weirs when
distributors have less than four arms, except when
two-compartment arms are used. Coordinate with
paragraph CENTER COLUMN.**

The rotary distributor shall be installed in accordance with the recommendations of the manufacturer and by workmen experienced in the installation of this type of equipment. All components with galvanized or other corrosion-protective coating shall be carefully checked and any damaged or abraded areas shall be restored to the original or an equivalent coating. Proper alignment of all equipment shall be provided. The anchor bolts shall be set in place and the nuts tightened against the shims. After the foundation alignments have been approved, the stationary assembly shall be securely bolted in place. The alignment of equipment shall be further checked after securing to the foundations and, after confirming all alignments, the stationary assembly shall be finally grouted in place. Equipment shall be aligned with associated piping and under no circumstances will "pipe springing" be allowed. [The weirs shall be set in accordance with the directions of the manufacturer, based on anticipated flows.]

3.1.2 Placing Filter Block

Filter underdrain blocks shall be laid in a dry mortar bed. The mortar shall contain one part cement conforming to ASTM C150/C150M, Type II, and 4 parts sand conforming to ASTM C144, except a 1:3 cement-sand mortar bed for the first course of blocks where cover blocks are used. After the blocks are laid and before the stone is placed, the dry mortar bed shall be dampened by sprinkling. Filter blocks shall be installed providing an uninterrupted flow through the drainage channels in the blocks to the effluent channel. Blocks shall be laid in true alignment, with cross joints staggered in longitudinal rows at right angles to the center drains. The rows of blocks shall start at the edge of the drainage channel and end at a sufficient distance from the filter wall to provide an air passage around the inside periphery of the filter. Air ducts comprised of either blocks or stacks shall be provided for venting air to the atmosphere as shown on the drawings. A plan layout of filter block units shall be provided by the manufacturer.

3.1.3 Placing Filter Media

[Stone or slag media delivered to the filter site shall be stored on wood planks or other approved clean hard surface areas. Stone and slag shall not be dumped directly into the filter. The media shall be rescreened or forked at the filter site to remove all fines before placement in the filter. Material shall be placed by hand to a depth of 300 mm 12 inches above the filter blocks and all material shall be placed without damaging or displacing the underdrains. The remainder of the material may be placed

by means of belt conveyors, wheelbarrows, or other approved equipment. The media shall be placed in layers not exceeding 450 mm 18 inches in depth. Filter media shall be placed as near as practicable in final position to avoid excessive rehandling; special care shall be taken to avoid breakage or segregation of different size particles. Dumping the filter media directly from trucks into the filter, dropping the filter media from heights exceeding 1 m 3 feet or throwing the media into the filter will not be permitted. If it is determined that an excessive amount of fractured stone or dust is passing into the underdrains, the Contractor may be required to remove and rescreen the filter media at a location outside the filter walls. There shall be no walkways or runways over the filter except for the purpose of installing materials or equipment for the filter. Storing materials, such as cement or sand, or placing heavy construction equipment within the filter walls will not be permitted. Concrete, sand, dirt, or other materials deleterious to the filter shall not be passed over the filter by any means. No material shall be dropped from a height greater than 1 m 3 feet. Trucks, tractors, or other heavy equipment shall not be driven over the filter during or after construction.] [Installation of plastic filter media shall be made in accordance with the recommendations of the media manufacturer.]

3.2 FIELD TESTS AND INSPECTIONS

Perform all field tests. Provide all labor, equipment, and incidentals required for the tests, except that water required for the field tests will be supplied as set forth in the CONTRACT CLAUSES. The Contracting Officer will witness all field tests and conduct all field inspections. Give the Contracting Officer [_____] days prior notice for dates and times for acceptance tests. Any deficiencies found shall be rectified and work affected by such deficiencies shall be completely retested at the Contractor's expense. The distributor mechanism shall be tested to demonstrate correct alignment, smooth operation, and uniformity of flow distribution over the filter media.

3.3 CLOSEOUT ACTIVITIES

After acceptance and before contract closing, submit operating and maintenance manuals. The operation volume outlining the step-by-step procedures required for system startup, operation and shutdown. The maintenance volume listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The manuals shall include the manufacturer's name, model number, service manual, parts list, brief description of all equipment and their basic operating features, and simplified wiring diagrams for the system as installed.

-- End of Section --