

SECTION 43 22 56.02
VERTICAL MIXERS

EQUIPMENT AND COMPONENT NUMBER(S)

MXR-8111: Digester Mixer 1.
MXR-8112: Digester Mixer 2.
MXR-8211: Digester Mixer 3.
MXR-8212: Digester Mixer 4.

PART 1 GENERAL

1.01 WORK OF THIS SECTION

- A. The Work of this section includes providing mixer/aerators for mixing and aerating two intermittently aerated, sequencing batch reactor aerobic digesters with variable water level. There will be two mixer/aerators in each aerobic digester. The equipment shall include, but not be limited to, motor, gear reducer, base plate, impeller shaft, impeller, and air sparger.

1.02 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Bearing Manufacturer's Association (ABMA):
 - a. Standard 9, Load Ratings and Fatigue Life for Ball Bearings.
 - b. Standard 11, Load and Fatigue Life for Roller Bearings.
 2. American Gear Manufacturer's Association (AGMA):
 - a. 250.04, Lubrication of Industrial Enclosed Drives.
 - b. 297.02, Sound for Enclosed Helical, Herringbone, and Spiral Bevel Gear Drives.
 - c. 390.03a, Gear Classification, Materials, and Measuring Methods for Bevel, Hypoid, Fine Pitch Worm Gearing and Racks Only as Unassembled Gears.
 - d. 6010-E, Spur, Helical, Herringbone, and Bevel Enclosed Drives.
 - e. 9002-A, Bores and Keyways for Flexible Couplings.
 3. American Iron and Steel Institute (AISI): Pocketbook of AISI Standard Steels.
 4. American Society of Civil Engineers (ASCE): 2, Measurement of Oxygen Transfer in Clean Water.
 5. Deutsches Institut für Normung/International Organization for Standardization (DIN-ISO).

1.03 DEFINITIONS

- A. Adequate Mixing: Variation in mixed liquor suspended solids of less than 10 percent between the mean value of samples taken at any two depths along any vertical line extending between water surface and floor.
- B. Aeration System Backpressure: Air pressure at the point of connection necessary to satisfy air supply and distribution requirements. Account for all pressure losses incurred by the aeration system when new.
- C. Standard Airflow: Airflow at standard conditions, expressed as standard cubic feet per minute (scfm).
- D. Standard Conditions for Air: 68 degrees F, 14.7 pounds per square in absolute (psia), and 36 percent relative humidity.
- E. Standard Conditions for Oxygen Transfer: Tap water at 20 degrees C, zero residual dissolved oxygen (DO), 1,000 mg/L total dissolved solids (TDS), and barometric pressure of 760 millimeters mercury (mm Hg) (dry air).
- F. Standard Oxygen Transfer Rate (SOTR): Mass of oxygen per unit time dissolved in a volume of water by an oxygen transfer system operating under standard conditions for oxygen transfer.
- G. Virtual Wall: Hydraulic boundary between two mixers created by opposing flow patterns from the mixers. The virtual wall approximates two completely mixed stirred-tank reactors in series.

1.04 SUBMITTALS

- A. Action Submittals:
 - 1. Manufacturer's product literature, dimensioned drawings of mixer layout, anchorage and base details, impeller diameter and details, shaft diameter and speed, and materials of construction.
 - 2. Computational fluid dynamic (CFD) analysis of the proposed mixers and the tank geometries indicated.
 - a. Include average annual daily forward flow and recycle flows as defined in the Hydraulic Profile sheet on the Drawings.
 - b. The analysis shall show velocity contours at 1 foot, 6 feet, 12 feet, and 18 feet above the basin floor.
 - c. CFD shall show velocity contours at cross sections cut for each mixer selection.
 - d. Demonstrate virtual wall between mixer pairs.
 - 3. Motor submittals in conformance with Section 26 20 00, Low-Voltage AC Induction Motors.

4. A statement by a licensed mechanical engineer indicating shaft-impeller critical speed, shaft stress, impeller stress, and horsepower are in compliance with the requirements specified.
5. Mixer weights and loads transmitted to the supporting structure.
6. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
7. Clean water oxygen transfer efficiency test plan, if results of a minimum of five full-scale clean water oxygen transfer tests per ASCE 2 of manufacturer's mixer/aerator equipment.
8. Mixing performance test plan.

B. Informational Submittals:

1. Applicable operation and maintenance information as specified in Section 01 78 23, Operation and Maintenance Data.
2. Manufacturer's Certificate of Proper Installation as specified in Section 01 79 00, Demonstration and Training.
3. Manufacturer's installation instructions.
4. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
5. Design calculations by a registered engineer demonstrating that the equipment performance requirements are met.
6. Test Reports:
 - a. Source Quality Control Factory Tests.
 - b. Field Quality Control Functional Tests.
 - c. Field Quality Control Performance Tests.
7. Clean water oxygen transfer efficiency results for five full-scale clean water oxygen transfer tests per ASCE 2.

1.05 EXTRA MATERIALS

A. Furnish the following tools and spare parts:

1. Special Tools: One set of special tools, if required for normal operation and maintenance, shall be furnished with the equipment.
2. For Each Model Mixer:
 - a. One gearbox.
 - b. One shaft holder.
 - c. Rubber buffers.
 - d. Bottom guide system (for mixer/aerator).

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 67 00, Product Requirements.

1.07 PERFORMANCE REQUIREMENTS

- A. Maintain adequate mixing over full range of depth (16 feet to 22 feet).
- B. The entire system shall be hydraulically and dynamically stable during fluctuations in liquid levels commonly associated with turbulent mixing and with variations in process flow perpendicular to the shaft-impeller system.
- C. Pairs of mixers not separated by a physical wall shall hydraulically establish a virtual wall.
- D. Mixer/Aerator Requirements: See Data Sheet Supplement.

1.08 SERVICE CONDITIONS

- A. Fluid: Mixed Liquor and aerobically digested waste activated sludge. Upstream physical processes include screens, fine screens, and grit removal.
- B. See Data Sheet Supplement.

PART 2 PRODUCTS

2.01 GENERAL

- A. Mixer shall be top-entering type and furnished complete with heavy-duty gear speed reducer, drive motor, support members, anchor bolts, shaft, and impeller mounted on a common base plate.
- B. Mixers will be installed outdoors on a concrete deck over the aerobic digesters as shown on the Drawings.
- C. The full load operating noise levels of the mixer drives shall meet current OSHA occupational noise standards, and/or AGMA 299.1, and shall not exceed 85 dBA at 3 feet from any part of the drive assembly.

2.02 SUPPLEMENTS

- A. Some specific requirements are attached to this section as supplements.

2.03 PHYSICAL CHARACTERISTICS

- A. General: The mixer shall be a nonragging, vertical shaft, hyperboloid-body type. The gear box output shaft shall be separate from the impeller shaft. Submerged material shall be Type 316 stainless steel or FRP.
- B. Gear Reducer:
 - 1. The gear drive shall comply with AGMA 6010-E or DIN-ISO equivalent. Stamp the AGMA or DIN-ISO equivalent calculated drive horsepower rating and service factor on the drive nameplate. The gear box service factor shall be 2.0. Base the gear drive's minimum AGMA or DIN-ISO equivalent service factor on the motor's nameplate horsepower.
 - 2. All gear reducers shall be parallel shaft and use helical gears.
 - a. Drive gearing shall be quality 10 or better as specified by AGMA 390.03a or DIN-ISO equivalent.
 - b. Gear reducers shall be double or triple reduction as required.
 - c. Use of gear motors and multiple, independent reducers will not be accepted.
 - 3. The mixer gear drive shall be designed with an output shaft system suitable for the loadings imposed by the specified duty and shall be supported by two adaptor-type anti-friction bearings.
 - 4. The gear reducer shall be splash lubricated from a common oil sump by a combination of oil slinger and gears immersed in oil. Units requiring an external oil cooling system will not be accepted. A dipstick and/or a sight glass to measure oil level shall be provided. Oil leakage down the impeller shaft shall be prevented by a dry well feature or equivalent triple lip seal. All oil fill and drain lines, and grease fittings, shall be easily accessible.
 - 5. All bearings within the reducer shall be of the anti-friction ball or roller type.
 - 6. General maintenance including, but not limited to, motor changes and the oil system maintenance shall not require removal of the speed reducer housing from its foundation. Speed reducer shall be provided with eyebolts or lifting lugs.
- C. Motor and Drive Unit: The motor shall be a vertical TEFC, as specified in Section 26 20 00, Low-Voltage AC Induction Motors, and within this section.
- D. Impeller Shaft:
 - 1. The impeller shaft shall be of overhung design.
 - 2. The use of underwater steady bearing is only permitted for mixer/aerator units.

3. Connect the impeller mixer shaft to the upper, or drive output shaft, by means of a hollow shaft connection.
4. Impeller shaft straightness, rigid coupling squareness, and output shaft accuracy must be such that the maximum total indicated runout at the lower end of the shaft does not exceed 1/8 inch for every 10 feet of overhang, as measured when turning over by hand.

E. Impeller:

1. A single impeller shall be used on each mixer and an additional upper impeller is not permitted.
2. Provide removable, engineered impellers, streamlined stress-free body.
3. Hyperboloid shape (continuous shape) with integral shear ribs on the top surface to create the appropriate swirling motion.
4. Mixer body shall have a polished surface.
5. Flanged connection of impeller to shaft.

F. Mixer/Aerator:

1. Ring Sparger:
 - a. Non-clogging and made of Type 316 stainless steel.
 - b. Point of connection 5 feet from the center of the mixer/aerator with a 6-inch flange. Flange shall be Type 316 stainless steel flange with bolt pattern per ASME B16.5 Class 150.
 - c. Mount on basin floor.

G. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: Type 316 stainless steel as specified in Section 05 50 00, Metal Fabrications.

H. Factory Finishing: Prepare and prime and finish coat outdoor exposed ferrous metal components in accordance with Section 09 90 00, Painting and Coating. System No. 4. Submerged metallic components to be uncoated Type 316 stainless steel.

2.04 FUNCTIONAL CHARACTERISTICS

A. Gear Reducer:

1. Routine maintenance on the speed reducer shall not require removal of the motor or lifting the mixer.

2. The thermal rating of the gear reducer must exceed the design mechanical rating.
- B. Mixer Mount: Mount shall hold the mixer rigidly in place, without excessive vibration when operating at maximum design loads.
- C. Mixer/Aerator:
 1. Provide two operating modes:
 - a. Aeration Mode: Air is supplied through a ring sparger and the impeller is used to disperse the air into fine bubbles to meet mixing and aeration performance requirements.
 - b. Mixing Mode: Impeller is operated at a reduced speed to meet mixing performance requirements.
- D. Ring Sparger: Size for maximum airflow identified in the Data Sheet Supplement.

2.05 PERFORMANCE CHARACTERISTICS

- A. See supplement.
- B. Impeller Shaft: Impeller shaft maximum stress shall not exceed 9,000 psi under maximum operating loads. The shaft-impeller system design shall not exceed 70 percent of first critical speed. The use of stabilizing rings or fins shall not influence this limitation.

2.06 SOURCE QUALITY CONTROL

- A. Factory Tests: Manufacturer's standard quality control.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install the equipment in strict conformance with the manufacturer's printed instructions.
- B. Verify installed shaft meets specified deflection tolerances.
- C. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

- A. Touchup damaged coatings on motor, gearbox, and baseplate in accordance with Section 09 90 00, Painting and Coating.

3.03 FIELD TESTING AND FACILITY STARTUP

- A. Field Testing and Facility Startup shall be in accordance with the requirements of Section 01 91 14, Equipment Testing and Facility Startup.
- B. Facility startup specifies the order and prerequisites for the following tests of the equipment:
 - 1. Field functional testing.
 - 2. Software operational testing.
 - 3. Performance testing.
 - 4. Demonstration testing.
- C. All Field Testing and Facility Startup shall be performed using a qualified representative provided by the Manufacturer as specified in Section 01 91 14, Equipment Testing and Facility Startup, Section 01 43 33, Manufacturers' Field Services, and as elaborated upon in this section.

3.04 FIELD QUALITY CONTROL

- A. In addition to any testing herein, perform all testing for each mixer consistent with the requirements of Section 01 79 00, Demonstration and Training, the applicable codes, and the manufacturers' current Quality Assurance program.
- B. Functional Test: Conduct on each mixer.
 - 1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
 - 2. Clean Water Test: A factory-trained representative shall test the installed equipment at full load and full speed for a minimum of 4 hours after oil temperature has stabilized. Water will be at normal operating level. Check reducer housing and shaft seals for leaks. Any leaks shall be corrected and the test repeated at the Contractor's expense. Record oil temperature at intervals of no greater than 15 minutes.
- C. Performance Tests:
 - 1. Oxygen Transfer Test:
 - a. Provide results of a minimum of five valid full-scale clean water oxygen transfer tests of manufacturer's mixer/aerator equipment. If the manufacturer is unable to provide said results, the manufacturer must perform full-scale clean water oxygen transfer performance tests onsite for two Digester Mixer/Aerators according to the following procedure outlined in ASCE 2:
 - 1) Oxygen Transfer Performance Field Testing Procedure: In accordance with ASCE 2. Contracting Officer must approve

specific details of test procedure and any deviation from requirements stated below.

- a) Non steady-state reaeration tests shall be performed for the mixer/aerators. For each mixer/aerator tested, perform a minimum of three reaeration test runs at the airflow conditions listed on the attached data sheet supplements.
 - b) SOTR for each airflow condition shall be average of SOTRs obtained for multiple reaeration tests.
 - c) SOTR results shall be normalized to 1,000 mg/L TDS using the exponential equation in ASCE 2, Annex G, Commentary B.
- 2) If proposed equipment fails to meet requirements, it shall be modified such that it meets all requirements. Such modifications include any structural or piping modifications necessary to accommodate the modified equipment. All modifications shall be made at no cost to Government. After modification, diffused aeration equipment shall be retested at no cost to Government.
2. Wastewater Mixing Test:
- a. Submit the mixer performance testing protocol a minimum of 15 days prior to the test. Testing can only be conducted following approval of plan. The performance test plan shall at minimum include the exact locations, depths, transects, sampling protocol, analytical methods, and any modeling, calculation, or analyses to be conducted by the equipment manufacturer in support of the performance testing.
 - b. Conduct on a minimum of one anoxic mixer. Test mixer/aerator in mixing mode.
 - c. Perform mixing test with 1500 mg/L, plus or minus 1,000 mg/L digested sludge, or as agreed with plant operations. Stop all forward and recycle flow through basin during test.
 - d. Select two vertical lines and three depths in each basin. Depths shall be at 1 foot, 6 feet, 12 feet, and 18 feet above the basin floor.
 - e. Take three Samples at each depth along each vertical line using a Van Doren sampler or a sample pump.
 - f. Independent testing laboratory approved by Contracting Officer will perform residue test on each Sample using Standard Method 2540D. Mean value of total residue for three Samples at each depth will be used to determine conformance with adequate mixing requirements. Adequate mixing is defined as the standard deviation of all samples taken no greater than 10 percent.
 - g. All testing and sampling shall conform to procedures established in latest edition of Standard Methods for Examination of Water and Wastewater.

- h. A digital total suspended solids sensor may be used to measure the suspended solids concentration at each location in place of taking samples.

3.05 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

- 1. Present at Site or classroom designated by Contracting Officer, for minimum person-days listed below, travel time excluded:
 - a. 4 person-days for installation assistance and inspection.
 - b. 4 person-days for functional and performance testing, completion of Manufacturer's Certificate of Proper Installation, and startup.
 - c. 1 person-day for prestartup classroom or Site training.

B. See Section 01 79 00, Demonstration and Training.

3.06 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

- 1. Digester Mixers 1, 2, 3, and 4 Data Sheet.
- 2. Digester Mixers 1, 2, 3, and 4 Induction Motor Data Sheet.

END OF SECTION

DIGESTER MIXERS 1, 2, 3, AND 4 DATA SHEET	
Project: <u>South Rim Wastewater Treatment Plant – Site Improvements</u> Owner: <u>National Park Service</u> Service: <u>Digester Mixing/Aerator</u> Mixer Name: <u>Digester Mixers 1, 2, 3, and 4</u> Equip. Tag Number(s): <u>MXR-8111, -8112, -8211, -8212</u> No. Mixers Required: <u>3</u>	Mixer A Mfr.: <u>Invent Env. Tech, Inc</u> Model: <u>HCMA/2500-36-30 hp</u> Mixer B Mfr.: <u>Or equal</u> Model: _____ Mixer C Mfr.: _____ Model: _____
LIQUID MIXED AND SERVICE CONDITIONS Name: <u>Digested Sludge</u> Liquid Temperature (°F): Normal: <u>60</u> Max: <u>85</u> Min: <u>50</u> Specific Gravity @ 60°F: <u>1</u> Viscosity Range (CP) @ 60°F: _____ Liquid pH: <u>6-8</u> TSS (mg/L): <u>less than 15,000 mg/L (2%)</u> Erosion/Abrasion/Corrosion: ☐ Yes ☒ No Caused by: _____ Scale Buildup: ☐ Yes ☒ No Caused by: _____ Altitude (ft above MSL): <u>7,000</u> Area Classification: <u>Class 1, Div 2</u> Available Aeration System: Standard Airflow (scfm per unit): <u>650</u> Backpressure (psig): <u>9.5</u>	MIXER DESIGN AND MATERIALS Gear Housing: Material: <u>Fabricated steel or cast iron</u> Impeller: Type: <u>Hyperboloid</u> Material: <u>FRP, Type 316 SST, and/or marine grade aluminum</u> Shaft: Material: <u>FRP, Type 316 SST, and/or marine grade aluminum</u> Coupling Material: <u>Type 316 SST</u> Miscellaneous Wetted Parts: Material: <u>Type 316 SST</u> Bearing: ABMA L-10 Life (hrs.): <u>100,000</u> Lubrication: ☐ Grease ☒ Oil Baseplate Plate: Material: <u>Fabricated steel or cast iron</u> Drive Type: ☐ Direct-Coupled ☐ Belt ☐ Adjustable Speed ☒ Gear Reducer ☐ Other: _____ Lubrication: <u>Synthetic oil</u>
BASIN GEOMETRY Cell Length by Width (ft): <u>36 x 36, see the Drawings.</u> Baffles: <u>None</u> Side Water Depth (ft): <u>16-22</u> Freeboard (ft): <u>4</u>	
PERFORMANCE REQUIREMENTS Mixing Requirement: <u>Adeq. mix. Solids conc. +/- 10% standard deviation of average of samples taken.</u> Aeration Mode Max SOTR Req (lbs O ₂ /hr per unit): <u>150</u> Max Impeller Speed (rpm): <u>36</u> ☐ Constant ☒ Adjustable	
Remarks: _____ _____ _____	

**DIGESTER MIXERS 1, 2, 3, AND 4
INDUCTION MOTOR DATA SHEET**

Project: South Rim Wastewater Treatment Plant

Owner: National Park Service

Equipment Name: Digester Mixers 1, 2, 3, and 4

Equipment Tag Number(s): MXR-8111, -8112, -8211, -8212

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 30

Guaranteed Minimum Efficiency at Full Load: _____ percent

Voltage: 460

Guaranteed Minimum Power Factor at Full Load: _____ percent

Phase: 3

Service Factor (@ rated max. amb. temp.): ☒ 1.0 ☐ 1.15

Frequency: 60

Enclosure Type: ☐ DIP ☐ EXP ☐ ODP ☒ TEFC

Synchronous Speed (rpm): 1,800

☐ CISD-TEFC ☐ TENV ☐ WPI ☐ WPII ☐ SUBM

Inverter Duty: ☒ Yes ☐ No

☐ Multispeed, Two-Speed: _____ / _____ rpm

☐ Thermal Protection: _____

Winding: ☐ One ☐ Two

☐ Space Heater: _____ volts,
single-phase

Mounting Type: ☐ Horizontal ☒ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☒ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ min to: _____ max

☒ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 26 20 00, Low-Voltage AC Induction Motors.

Special Features:

Combined motor gearbox is acceptable.

