SECTION 11243 - FINE BUBBLE DIFFUSER SYSTEM

City of San Diego, CWP Guidelines

PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

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NTS: In the paragraph below, define the terms "comparable size and complexity" for the equipment or system specified. Requiring experience of more than one successful project requires sound justification and prior written approval from the City Project Manager.

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A. The WORK of this Section includes providing a fine bubble diffuser system for the aeration tanks as indicated. All equipment shall be provided complete with all accessories, connections, supports and controls necessary for a workable system and shall conform to all applicable codes and standards. The fine bubble diffuser system shall be defined as starting from the main air header on top of the tanks, excluding the air header itself, through the individual diffusers.

B. The WORK also requires that one manufacturer be made responsible for the WORK of this Section including drop pipes, differential pressure measuring system, distribution pipes, bleed valves and pipes, diffusers, and other accessories as indicated, but without altering or modifying the CONTRACTOR'S responsibilities under the CONTRACT DOCUMENTS.

C. The WORK additionally requires that the one responsible manufacturer shall manufacture the principal elements and components including, as a minimum, the diffuser assemblies and its support system. The manufacturer shall be experienced, reputable and qualified in the manufacture of the equipment to be supplied and must have supplied at least one system of comparable size and complexity in the United States in the recent past. Equipment of comparable size and complexity shall have the following characteristics: [ ].

1.2 RELATED SECTIONS

A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

1. Section 02644 Small PVC Nonpressure Pipe
2. Section 11000 Equipment General Provisions

1.3 SPECIFICATIONS AND STANDARDS

A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

1. ASTM A 240 Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, and strip for Pressure Vessels

2.	ASTM D 1784	Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
3.	ASTM D 1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
4.	ASTM D 1869	Rubber Rings for Asbestos-Cement Pipe
5.	ASTM D 2241	Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
6.	ASTM D 2466	Polyvinyl Chloride (PVC) Plastic Pipe and Fittings, Schedule 40
7.	ASTM D 2564	Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
8	ASTM D 3034	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipes and Fittings
9.	ASTM D 2855	Practice for Making solvent Cemented Joint with Polyvinyl Chloride (PVC) Pipe and Fittings
10.	ANSI B 16.5	Pipe Flanges and Flanged Fittings

1.4 SHOP DRAWINGS AND SAMPLES

A. Prior to release for manufacture of equipment, the CONTRACTOR shall submit shop drawings of all equipment in accordance with Section 01300. The submittal shall include the following:

1. A complete system description.

2. The number of complete diffuser assemblies.

3. A complete materials list and dimensions of all parts of the diffuser assemblies.

4. The dry permeability rating of the diffuser (without the flow control orifice) for ceramic diffusers only.

5. The number and size of the orifices in the flow control device.

6. The recommended minimum, design and maximum air flows per diffuser.

7. A curve showing headloss versus air flow rate for components of the diffuser assembly (orifice, diffuser disk, and complete diffuser assembly) over the full range of operation.

8. A complete materials list and details of the air distribution system including moisture blowoff piping, fittings, valves and pipe supports. Fabrication details shall be included.

9. A layout of the diffuser system including the baseplates, fittings, valves, pipe supports as well as the moisture blowoff piping.

10. A complete shop welding procedure for stainless steel pipe.

11. The equipment manufacturer's recommended installation procedures including level test, uniformity and leakage test, and oxygen transfer test.

12. Descriptive literature and dimensional drawings showing the proposed method of compensation for thermal expansion and contraction in the aeration system.

13. A testing plan designed to ensure consistently good quality and uniformity of the diffuser assemblies, including a sampling plan. The plan shall specify the number of diffuser elements to be tested from each batch, quality control test procedures, and the credentials of the agency conducting the tests.

14. A curve showing the oxygen transfer efficiency of the proposed system at different air flow rates in the design range (efficiency versus air flow rate at proposed depth).

[15. A sample diffuser assembly.]

16. Information on at least one successfully performing installation of comparable size and complexity constructed in the recent past, including contact name, telephone number, and address.

1.5 OWNER'S MANUAL

A. In addition to the requirements of Section 11000, the following shall be submitted in the OWNER'S MANUAL in compliance with Section 01300:

1. A list of special tools.

2. An instruction manual, parts list and maintenance instructions for the diffusion equipment.

1.6 FACTORY TESTING

A. **Product Testing**: Diffusers shall be inspected and tested at the factory.

1. Permeability Tests: Ceramic diffusers shall have a design mean permeability rating of 14 scfm per 9 inch diffusers when used without flow control device, and shall be permeable over their active surface. The permeability rating is defined as the number of cubic feet of air per minute at 70 degrees plus or minus 2 degrees F and 10 to 25 percent relative humidity which will pass through one diffuser under a differential pressure equivalent to 2 inches of water column. Diffusers must be tested in a room maintained at 70 degrees plus or minus 5 degrees F and 10 to 50 percent relative humidity. EPDM diffusers do not need to be tested for permeability.

2. Uniformity Test: All diffusers selected for permeability testing shall be randomly sampled to ensure uniformity. Uniformity is defined as substantially even distribution of air bubbles when the diffuser is submerged and operating at [0.5] [ ] scfm. [ ] diffuser(s) from each 100 tested for permeability shall be tested for uniformity. Same percent of EPDM diffusers shall be tested for uniformity.

3. Strength Test: Diffusers sampled for permeability shall also be strength-tested as a part of quality control plan. Adequate strength shall be defined as the ability of the sampled diffuser to withstand a vertical load of 1000 pounds applied to the center one-inch diameter (0.78 square inch) of the diffuser when the diffuser is properly supported

in a fixture similar to the diffuser element holder.] Same percent of EPDM diffusers shall be tested for strength.

4. Dynamic Wet Pressure Test: All diffusers tested for uniformity shall also be tested for dynamic wet pressure in accordance with an approved testing procedure. The dynamic wet pressure is the pressure drop across a wetted diffuser element (disk only) at a given air flow rate.

5. A test plan designed to meet the above requirements shall be submitted by the CONTRACTOR for the CONSTRUCTION MANAGER's review. [Five] [Ten] percent of the diffusers shall be tested. Ninety-five percent of diffusers tested shall fall within 15 percent of the indicated permeability. If this condition is not met, however, all elements to be shipped to the job site shall be tested. In any case, all diffuser elements not satisfying the test requirements shall be rejected. The remaining elements, which meet the requirements, shall be accepted in regard to the given test parameter.

6. Defects: All diffuser elements shall be visually inspected for defects. Those with appreciable warping of surfaces or irregularity of corners, showing cracks, soft spots, chipping or other defects, or not free from adhering foreign material, dirt, oil or clogging material, shall be rejected and removed from the job site.

B. **Witnesses**: The OWNER and the CONSTRUCTION MANGER (at the option of either) reserve the right to witness factory testing.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide complete diffuser systems for the aeration basins as indicated. For all systems, there shall be provided all necessary drop pipes, header pipes, distribution pipes, supports, air diffusers, hold-downs and accessories.

2.2 DESIGN CRITERIA

A. **General:** The aeration equipment shall have the following: a minimum oxygen dissolution capacity of not less than [[ ] lb/hr] of atmospheric oxygen at a submergence of [ ] feet under standard conditions in tap water; and a minimum oxygen dissolution capacity of [[ ] lb/hr] of atmospheric oxygen in mixed liquor [(up to 3000 mg/L solids)] at the above stated depth but corresponding to at least [2 mg/L] dissolved oxygen in the mixed liquor. Further, the aeration equipment shall have the ability to maintain suspension of all mixed liquor solids at air flow rates as low as [[ ] scfm per diffuser element]. Oxygen transfer efficiency in tap water under standard conditions and above stated depth shall not be less than [ ] percent at flow rates from [ ] scfm to [ ] scfm per diffuser, with the corresponding minimum efficiency of [ ] percent at [2 mg/L] of dissolved oxygen in mixed liquor. Differential pressure manometers with a gauge mounted on the handrail shall be provided to measure headloss across the diffuser element at a minimum of [ ] locations in each aeration tank, one provided for each individual grid system.

B. **Criteria**:

Number of aeration tanks [ ]

Area of each aeration tank (sq ft) [ ]

Number of grid assembles per tank [ ]

CFM per diffuser
(minimum) [ ]
(average) [ ]
(maximum) [ ]

Tank depth (ft)-(in) [ ]

Water depth (ft)-(in) [ ]

Submergence to top of diffusers (ft)-(in [ ]

Max. allowable pressure loss through diffusers (in) [ ]

Max allowable pressure loss through system (from top of tank to diffuser outlet) (in) [ ]

[ ] scfm per diffuser

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NTS: Specifier shall provide additional information, as appropriate, specifying number of aeration zones, number of diffusers in each zone, air flow in each zone, etc.

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2.3 DROP PIPE AND MANIFOLD

A. Each drop pipe shall extend from the air main piping system at the top of the tank above the water surface to the submerged air manifold.

B. **Expansion and Contraction:** The submerged air manifold shall include an expansion-contraction system consisting of fixed supports, intermediate supports and expansion joints. Fixed supports shall anchor the manifold against longitudinal and lateral movement at the support. Intermediate supports shall allow longitudinal movement through the support. Expansion joints shall allow for longitudinal expansion and contraction within the joint. The entire system shall allow for expansion and contraction over a range of 125 degrees F.

C. **Supports:** Each section of the submerged air manifold shall have a minimum of 3 supports. Maximum support spacing shall be 10 feet. Manifold supports shall meet the expansion-contraction system requirements as indicated.

D. Manifold supports shall include manifold hold-down, adjusting and locking mechanism, cradle, cross, tee, and supporting structure as needed and indicated. Cinch type anchor bolts shall secure the stainless steel stand to the tank floor.

E. Each manifold support shall have a cradle with a bearing surface contoured to fit a minimum of the bottom 90 degrees of the air distribution manifold. The cradle surface shall be a minimum of 2 inches wide. All supports shall include a mechanism to provide for a

minimum of ±2 inches vertical and ±0.5-inch lateral adjustment for alignment of the manifold. One support for each manifold section shall include an integral device for longitudinal rotational adjustment of the manifold. All adjusting devices and mechanisms shall lock to maintain the manifold in position after the final adjustments have been made.

F. **Special Connections:** Special expansion connections or couplings shall be provided along the bottom centerline of the submerged air manifold for connection to the air distribution headers. These special couplings shall prevent stress concentrations in unplasticized polyvinyl chloride (UPVC) distribution piping.

G. **Welded Parts:** All welded parts and assemblies including drop pipes, (all but bottom 3 ft) fabricated supports, flanged joints and expansion joints shall be fabricated from sheets and plates of Type 304L stainless steel with a 2D finish conforming to AISI Type 304L and ASTM A 240. All submerged air manifolds and bottom 3 ft of drop pipes shall be Schedule 40 UPVC Type 1120 pipe conforming to ASTM D 1785. Other non-welded parts and pieces such as nuts, bolts, washers, and follower flanges shall be made of Type 304 stainless steel. All anchor bolts shall be Type 304 stainless steel. Cleaning connections for ceramic diffusers shall be provided on UPVC portion of drop leg. The connection shall be minimum ¾ inch diameter. Threaded nipple reinforced with a Class 63 saddle Tee. The connection shall be extended to the top of the tank and capped.

H. **Welding:** All welding shall be completed in the factory. Field welding shall not be permitted. All welding shall be by the shielded arc, inert gas, MIG or TIG method. Filler wire shall be added to all welds to provide for a cross section of weld metal equal to, or greater than, the parent metal. Butt welds shall have full penetration to the interior surface and gas shielding shall be provided to the interior and exterior of the joint.

I. Interior weld beads shall be smooth, evenly distributed with an interior projection not exceeding 0.0625-inch beyond the ID of the air header or fitting.

J. **Cleaning:** The outside weld area shall be wire brushed. Brushes shall be of stainless steel and used only on stainless steel. All discoloration and deposits left by welding shall be removed by pickling.

K. **Pickling:** After fabrication, all stainless steel assemblies and parts shall be passivated by immersion in a pickling solution of 6 percent nitric acid and 3 percent hydrofluoric acid at 140 degrees F for a minimum of 15 minutes. Parts shall be free of iron particles or other foreign material. A complete neutralizing operation shall be required by immersion in a tri-sodium phosphate rinse.

2.4 DISTRIBUTION SYSTEM

A. **General:** The distribution headers shall include header piping support stands, factory installed diffuser element holders, joints, expansion joints, drainage system and anchor bolts.

B. **Distribution Headers:** The distribution headers shall connect to the bottom centerline of the manifold at the special couplings provided for that purpose. The headers shall be fabricated in sections not to exceed 20 feet in length. Joints between sections shall be of the expansion joint type and shall permit rotation of each header section independently of adjacent header sections.

C. **Supports:** Each header section shall be held in place by one anchor support. Intermediate supports shall allow longitudinal and rotational movement of the header section. The distribution header supports shall be spaced at a maximum of 6.5-foot intervals. Stands shall be adjustable to permit leveling up to 6 inches and rotating of the distribution header with the header in place. All adjusting devices shall lock in place after the headers have been installed and leveled. Each support shall be secured to the tank floor by means of a Type 316 stainless steel cinch type anchor bolt designed for 10 times the calculated normal uplift forces. All header supports shall have a vertical adjustment of ±6 inches.

D. **Expansion and Contraction:** The UPVC air distribution system shall include a means for expansion-contraction of the system and shall include expansion joints, fixed supports and intermediate sliding supports. The expansion-contraction joint shall be designed to allow for a total movement of 3 inches over a temperature range of 125 degrees F.

E. **Header Supports**: The fixed supports shall be designed to anchor the UPVC header against longitudinal movement at the support. The fixed support shall be attached to the header in such a manner to prevent movement at this point. The supports shall be located at the expansion joints and at the ends of the header pipe. Any expansion-contraction must take place in the expansion joints. The CONTRACTOR shall provide calculations demonstrating the adequacy of its support system for both uplift and expansion/contraction.

F. **Diffuser Assemblies:** Diffuser assemblies shall be installed along the distribution header. Each diffuser assembly shall consist of a [crystalline fused alumina diffuser disk, baseplate, flow control device, retainer ring and O-ring for a diffuser disk] [EPDM membrane diffuser with integral O-ring, a PVC retainer ring and a diffuser support piece].

G. **Air Distribution:** Air shall enter the diffuser assembly from the distribution header through the orifice control. The orifice control shall be of a size to insure adequate air distribution throughout the system and the air release of the orifice shall be designed such that air entering the diffuser assembly shall be distributed under the surface of the diffuser element. For EPDM diffusers, center one inch diameter shall not be perforated. The non-perforated center of the EPDM diffuser shall provide the necessary sealing capabilities and back flow prevention when air supply to the diffuser is interrupted. The EPDM diffuser cross section shall be thickened at the center and at the periphery near the O-ring to resist stretching.

H. **Diffuser Element:** The diffuser element shall be a [porous ceramic disk] [EPDM] and shall diffuse the air in a fine bubble form into the mixed liquor. EPDM diffuser material shall have durometer of 55 ± 5 Shore A with a minimum tensile strength of 1375 psi, and a minimum elongation of 500 percent at break point.

I. **Purge System:** An air lift moisture blowoff system shall be provided with each aeration grid and shall be provided as indicated. The system shall be properly supported (at maximum intervals of 4 feet) and shall be provided with any expansion joints necessary to allow expansion and contraction of the piping over a temperature range of 125 degrees F without a stress buildup in the piping. The valve in the blowoff piping shall be located in an easily accessible location above the water surface adjacent to the wall. The valve shall be a socket end type, PVC ball valve. Pipes in the purge system shall be at least 1-1/2-inch diameter.

J. **Pipe Material:** Distribution headers, expansion joints, vertical purge system piping, diffuser holders and retainer rings shall be manufactured of UPVC with a minimum of 2 percent $Ti0_2$ added for ultraviolet protection.

K. Headers shall be nominal four inch diameter Schedule 40 UPVC Type 1120 pipe and shall conform to ASTM D 1785. Expansion joints, diffuser holders, and retaining rings shall have a minimum wall thickness of 0.125 inches. Header sections shall not exceed 18 feet in length and a minimum nominal wall thickness of 0.23 inches. Expansion joints and diffuser element holder shall be factory installed on the distribution header. No field solvent welding shall be permitted. Supports shall be of Type 316 stainless steel and shall meet the material requirements indicated for manifold supports. Each support shall be tested to a margin of safety of 10 for buoyant uplift force, or 300 lb, whichever is greater.

L. **Diffuser Gaskets:** [Diffuser element gaskets shall be polyisoprene or neoprene and shall meet the requirements of ASTM D 1869 except that elongation shall be 500 percent minimum. Water absorption shall be 5 percent maximum. Oven age tensile strength shall be -10 percent and oven age elongation shall be -15 percent. The specific gasket material shall be submitted with the shop drawing submittal for approval.

2.5 DIFFUSER ELEMENTS [CERAMIC]

A. The diffuser element shall be [ceramic bonded fused alumina; overall diameter of 9-1/4 inches and a diameter exposed to process water of 8-5/8 inches (±1/8 inch) and thickness of 3/4 inches (±1/16 inch).

[The dry permeability rating of each alumina diffuser disk in a retainer assembly but without the flow control orifice shall be 14 scfm. Similarly, the dynamic wet pressure of the diffuser disk at a flux rate of 1.5 scfm/ft^2 shall be 6.5 inches of H_2O. All disks shall be designed to withstand a minimum temperature of variation of 30EF to 110EF. They shall be substantially free from any materials soluble in sewage carrying household or industrial wastes of any character and from any adhering foreign material, such as dirt or oil, that may affect their normal and proper operation. All disks shall be strong, substantially free of cracks, soft spots, chipping, spalling, warpage, or other structural defects. All disks shall be substantially uniform at any given horizontal cross section and shall be free from holes and impervious material which may cause unequal air distribution. The diffuser disks shall have substantially constant and uniform distribution of the emergent diffused air bubbles across their entire horizontal section.]

B. [Each diffuser assembly in alumina diffuser disk system shall incorporate an appropriate metering orifice for even distribution of flow. The flow control device shall be UPVC. All hold-down bolts shall be Type 316 stainless steel. Each disk diffuser shall incorporate a removable UPVC orifice assembly mounted at the holder centerline. Baseplate to hold diffuser disk shall be made of UPVC conforming with ASTM D 1784 and shall be factory welded to the piping. A threaded PVC retainer ring shall be used to secure the diffuser disk to the baseplate. The diffuser disk O-ring shall be polyisoprene and shall meet the requirements of ASTM D 1869, except that elongation shall be 500 percent minimum. The O-ring shall form a seal between the diffuser disk, baseplate and the retainer ring. The diffuser flow control device shall be sized to provide equal air distribution throughout the system. Should a diffuser disk break, the flow control device shall be capable of maintaining a fairly uniform distribution of air throughout the system. The device shall consist of a simple 13/64-inch orifice.]

C. **Diffuser Elements [EPDM]**

Diffuser assemblies shall consist of a nominal 9-inch diameter, EPDM membrane diffuser with integral O-ring, a PVC retainer ring and a diffuser support piece. Diffusers shall be

composed of EPDM elastomer and shall be resistant to attack by common municipal wastewater. EPDM material shall meet the requirements of ASTM D 573.
Diffusers shall be free of voids, tears, bubbles, creases or other structural defects.

Diffusers shall have a uniform distribution of air release across the entire surface area of the diffuser except for the center one inch diameter which shall not be perforated. The non-perforated center of the diffuser shall provide the necessary sealing capabilities and back flow prevention when air supply to the diffuser is interrupted. The center shall be thickened to prevent ballooning and air abrasion where the air is released under the diffuser.

Diffuser shall be disc-shaped with a 9-inch diameter and an integral O-ring seal molded into the diffuser assembly. The diffuser cross-section shall be thickened at the center as noted above and at the periphery near the O-ring to resist stretching.

Diffuser material shall have a durometer of 55 ± 5 Shore A, with a minimum tensile strength of 1375 psi, and a minimum elongation of 500 percent at break point.

After 48 hours of oven age testing the diffuser shall be 50 Shore A, tensile strength of 1200 psi and elongation of 500 percent. Compression set shall be 18 percent.

The diffuser shall be perforated with uniform slits of a shape and size to prevent tearing or lengthening of the slits during operation.

The diffuser shall exhibit uniform distribution of air across the entire surface area when submerged and operating at 1.0 cfm per diffuser.

Dynamic wet pressure of the diffuser element shall be between 9.0 and 10.0 inches of water column over the normal range of diffuser operation (0.5 - 4.0 scfm).

D. **Retainer Ring**

1. The retainer ring shall be made of PVC with a minimum of 1 -12% TiO_2 added for ultra-violet protection. The retainer ring shall have a minimum of 2½ complete threads for effective sealing. The threads shall be buttress-type for maximum holding strength and to minimize stress concentration.

E. **Diffuser Baseplates**

The diffuser baseplates shall be factory solvent welded to the PVC diffuser lateral and shall be manufactured of PVC with 1.50% TiO_2 added for ultra-violet protection. The welding contact area between the baseplate and the distribution lateral shall be a minimum of 24 square inches to provide a structurally sound connection.

Angular variation of all the baseplates on a distribution lateral shall not exceed ± 1.0 degree.

The baseplate shall be centered on the crown of the pipe.

Each baseplate shall incorporate a factory-drilled orifice sized to give minimum headloss while assuring uniform air distribution. The control orifice shall be factory drilled. Designs requiring field drilling of the orifice shall not be acceptable. The air release of the orifice shall be designed to provide even air distribution under the horizontal surface of the diffuser element.

F. Elastomeric Gaskets

The following gaskets shall be provided for the aeration system.

1. Expansion joint gaskets - 4.5 inches inside diameter.

   Expansion joints shall be composed of solid neoprene rubber and shall conform to ASTM D 2000. Gaskets shall be suitable for withstanding the effects of wastewater and for temperatures up to 250°F.

2.6 NAMEPLATES, TOOLS AND SPARE PARTS

A. **Tools**: The CONTRACTOR shall supply one complete set of special wrenches or other special tools necessary for the assembly, adjustment and dismantling of the equipment. All tools shall be furnished in labeled tool boxes of suitable design.

B. **Spare Parts**: The CONTRACTOR shall provide [ ] gaskets, [ ] O-rings, [ ] diffuser elements and [ ] retainer rings.

2.7 MANUFACTURERS

A. Products of the type indicated shall be manufactured by one of the following (or equal):

1. Diffuser element:

   Sanitaire
   Parkson
   Aercor

PART 3 -- EXECUTION

3.1 INSTALLATION AND CHECKOUT

A. The fine bubble aeration diffusion system shall be installed in accordance with approved procedures submitted with the shop drawings and as indicated, unless otherwise approved.

All unplasticized polyvinyl chloride (UPVC) components of the fine bubble aeration system stored on site shall be adequately protected from prolonged exposure to direct sunlight and extreme temperature change. The material shall be stored in a manner which prevents physical damage to the system components. Installation of UPVC aeration system components shall be scheduled during periods of the day and year when temperatures are not at extremes, hot or cold, to prevent damage due to thermal expansion. Upon the completion of installation of all UPVC aeration system components in the aeration tanks, the tanks shall be filled with clean water to a depth above the highest UPVC component to protect the system from sunlight and extreme temperature changes. The CONTRACTOR shall be responsible for controlling the quality of the water in the aeration tanks and shall take appropriate action to control biological growth, such as algae, which may damage the fine bubble aeration system. The CONTRACTOR shall, similarly, store diffusers properly to prevent them from getting dirty and/or plugged and damaged from elements.

Diffuser retainer rings shall be initially installed by hand tightening only. After hand tightening, the CONTRACTOR shall fill the tanks with water to approximately 6 inches above the

diffuser disks. Air shall then be supplied to the system. All retainer rings shall then be final tightened in accordance with the approved installation procedure, but no power tools of any kind shall be used.

B. **Inverts:** The invert elevation of the submerged air manifold shall be the same throughout the tank. Changes in diameter shall be accomplished with eccentric reducers. Each end of the submerged air manifold shall have a flanged welded end cap.

C. **Pipe Connections:** Connections between sections of the submerged manifold shall be flanged joints or Type 304 stainless steel band couplings. These joints shall be installed such that individual manifold sections can be rotated independently of adjacent manifold sections for alignment purposes. Once the pipe is properly aligned, the flanges shall be solvent welded onto the two adjacent pipe sections. Flanged joints shall have solvent welded flanges with 304 stainless steel bolts.

D. **Leveling:** The entire system shall be designed, manufactured, and installed in such a manner that all the diffuser elements are within ±0.125-inch of a common horizontal plane. Air distribution shall be uniform throughout the entire system and shall be uniform over the entire horizontal projected surface of each diffuser element.

3.2 FIELD TESTS

A. At least 14 days prior to the performance of field tests, the CONTRACTOR shall notify the CONSTRUCTION MANAGER in writing when these tests are to be performed. The CONTRACTOR and CONSTRUCTION MANAGER shall agree upon the actual time the tests are to be performed. The CONTRACTOR shall furnish all labor, equipment, and materials required to perform the tests. All defects shall be corrected by the CONTRACTOR and all required retesting shall be performed by the CONTRACTOR at no additional cost to the OWNER.

1. Level Test: Each aeration tank shall be flooded with potable water to the tops of the ceramic dome diffusers. The level of the domes shall then be checked to insure that they are at the same elevation within [±0.125-inch]. The elevations of the diffuser assemblies shall be adjusted as necessary.

2. Uniformity and Leakage Tests: Each aeration tank shall be flooded with potable water to a depth of approximately one foot above the tops of the ceramic dome diffusers. Process air shall be supplied evenly to all headers in each tank. The surface of the water above the diffusers shall then be visually inspected for leaks and to ensure that air flow is uniformly distributed across the tank. Any leaks discovered shall be repaired to full satisfaction of the CONSTRUCTION MANAGER.

3. Clean Water Oxygen Transfer Test: The CONTRACTOR shall arrange to run this test through an independent testing laboratory approved by the CONSTRUCTION MANAGER, at the manufacturer's manufacturing facility or at the premises of the above independent testing laboratory, showing the performance of the diffusers in clean water under standard conditions. A tank, at least 20 feet long by 20 feet wide, and water depth equal to the actual water depth in the full-scale aeration basin, shall be used for this test. The density, type of the diffusers and all other accessories comprising the diffuser assembly shall be the same as that in the full-scale aeration basin.

The CONTRACTOR shall supply all the necessary materials and labor to perform this test, including all the air diffusion assemblies, diffuser grid piping, expansion joints, pipe supports, source of air, sampling and testing equipment and test chemicals. The test shall be run per the following procedure unless otherwise approved. The OWNER and the CONSTRUCTION MANAGER shall be notified of the place, date and time of the test at least two weeks in advance to enable them to witness the test if they so desire. Four copies of the test report shall be provided to the CONSTRUCTION MANAGER within no later than three weeks of the completion of the test.

a. Tank Preparation: The test tank shall be thoroughly cleaned and filled to the indicated depth with potable water. Care shall be taken to avoid any contamination of the test water with the chemicals used for tank cleaning. The temperature of the test water shall be as close to 68 degrees F (20 degrees C) as possible.

b. Sample Pumps: Submersible sample pumps shall be installed at three operating depths, bottom, mid-depth, and top water level, at a minimum of four sample locations in the tank (12 sample pumps).

c. Catalyst: A catalyst, cobalt chloride, or sulfate is then dissolved in the tank contents, with the diffusers operating to insure mixing to a concentration not greater than [0.5] mg/1. During this mixing period, the process air flow rate to the tank shall be adjusted and stabilized at the test value of [ ] (±5 percent) cfm per diffuser. The aeration system shall be allowed to operate until it is in physical equilibrium, but for a period of not less than 30 minutes, prior to initiating the oxygen transfer test. Immediately prior to beginning the oxygen transfer test, all significant contributing variables, including process air flow rate; process air pressure; process air temperature; barometric pressure; and, test liquid temperature shall be measured and recorded.

d. Testing and Sampling: To initiate the test a 10 percent by weight solution of sodium sulfite (Na_2SO_3 - technical grade) shall be added to the tank in sufficient volume to reduce the dissolved oxygen concentration to zero and maintain this oxygen depleted condition for approximately one minute. Stoichiometrically, approximately 75 pounds of 96 percent pure sodium sulfite will be required per million gallons to deplete the oxygen concentration by 1 mg/l. Approximately 150 percent of the stoichiometric requirements are usually necessary to maintain 0 conditions for one minute. Precisely timed (and recorded) samples shall be taken from the sample locations in the tank at time intervals so spaced to assure that a minimum of eighteen (6 from each depth) samples are collected at each sample location as the dissolved oxygen concentration in the test water increases from 10 to 80 percent of oxygen saturation. Each sample shall be analyzed for dissolved oxygen concentration using the Azide Modification of the Winkler method as outlined in the latest edition of "Standard Methods for the Examination of Water and Wastewater." A dissolved oxygen probe may be used for these measurements, provided the probe is calibrated against the modified Winkler Method before and after the test. At the end of the test, again measure and record the operating parameters described above.

e. Oxygen Saturation Concentration: The equilibrium concentration of oxygen saturation at standard conditions (C_s) shall be determined based on the average dissolved oxygen concentration at each of the twelve sample points after continuous aeration of the tank for a period of not less than 2 hours after

completion of the oxygen transfer test. Convert this value to standard conditions (C_s).

f. Mass Transfer Coefficient Determination: The overall mass transfer coefficient at temperature T (K_La_T) shall be determined experimentally for each sample point (12 determinations required) by the semi-log plot of the dissolved oxygen deficit (C_s - C_t) versus time (in hours). The negative slope of the line so generated (K_La_T) shall be calculated as follows:

$$K_La_T = \text{Log}_e \frac{(C_s - C_1)}{(C_s - C_2)} \div (t_2 - t_1)$$

Where: K_La_T = Overall mass transfer coefficient at temperature T (degrees C)

C_s = Oxygen saturation at test temperature, mg/l

C_t = Oxygen concentration at time (t), mg/l

C_1, C_2 = Oxygen concentration at time 1 (t_1) and time 2 (t_2), mg/l, respectively

K_La_T shall be corrected to standard temperature (20 degrees C) using the expression:

$$K_La_{20} = K_La_T\ (A)^{20-T}$$

Where T = Test temperature (degrees C)

A = 1.01 @ T greater than 20 degrees C
= 1.03 @ T less than 20 degrees C

K_La_{20} values (12 values) obtained above shall be averaged to obtain the final K_La_{20} used to calculate oxygen transfer efficiency, as indicated below.

Standard Oxygen Transfer Rate (SOTR) = $K_La_{20}\ C_s\ V$

where V = volume of water in the test tank

$$\text{Standard Oxygen Transfer Efficiency (SOTE)} = \frac{\text{SORT x 100}}{\text{mass of air supplied}}$$

where mass of air supplied = $Y_r\ q_s$

and Y_r = density of oxygen at actual temperature and pressure

q_s = volumetric air flow rate

g. Accuracy of Data: To assure valid results and insure good mixing using this test technique, the dissolved oxygen concentration in the test basin should be increased from 10 to 80 percent of saturation within a period of ten to thirty minutes. K_La_T values for each sample point shall not vary more than ±5 percent

from the average value for the test. Greater variation shall indicate incomplete mixing and invalidate the test.

h. Adjustments and Retesting: Should the aeration system fail to produce the indicated oxygenation capacity and oxygen transfer efficiency, the test procedure shall be repeated. If the indicated performance is not demonstrated after two test repetitions, the CONTRACTOR shall modify the aeration system by increasing the number of diffusers and/or by replacing the defective items, and repeat the test procedure described herein until the test results are satisfactory. This shall be done at no additional cost to the OWNER.

3.3 DIFFUSER SYSTEM EVALUATION

A. The CONTRACTOR shall provide a lump sum bid price to install all of the following alternate aeration systems specified as Bid Alternatives A, B, and C. To be responsive, bid price for all alternate aeration systems shall be provided.

1. Ceramic Disk Diffusers

2. EPDM Disk Diffusers

3. Parkson Aeration Panels

For Parkson Aeration Panels, as specified, it is expected less air would be required than the other two aeration alternatives; however, higher head may be required for Parkson Aeration Panels because of slightly higher head loss across the panels than the other systems. In addition, submergence of aeration panels is somewhat higher, which will further increase the head requirement, The CONTRACTOR can therefore adjust the blower sizes accordingly for Parkson aeration panels, although the number of blowers and size of piping from the blowers to the aeration tanks shall not be changed. This information shall be supplied with the bid.

The CONSTRUCTION MANAGER and/or the OWNER intends to use the criteria summarized in a table for comparison of bids for the three alternate aeration systems.

Since the capital costs associated with these systems are likely to be different, the OWNER can select any system it chooses and its decision will be final.

** END OF SECTION **