SECTION 11398 - DISSOLVED AIR FLOTATION THICKENERS

City of San Diego, CWP Guidelines

PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

A. The WORK of this Section includes providing equipment for dissolved air flotation thickener (DAFT) units for the concentration of mixed primary and secondary sludges and scums as follows: float and sludge collection equipment suitable for a circular tank, drive equipment, access bridge, float troughs, air dissolution equipment including tank and backpressure valve, air compressors, pressurization pumps, tank covers and miscellaneous appurtenances. Equipment shall be suitable for installation in a circular concrete tank with the applied solids stream entering at the bottom of the tank.

B. The WORK also requires that one manufacturer accept responsibility for furnishing the WORK as indicated but without altering or modifying the CONTRACTOR'S responsibilities under the Contract Documents.

C. The WORK additionally requires that the one manufacturer who accepts the indicated responsibilities shall, as a minimum, manufacture the sludge collection mechanism.

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NTS: This Specification is written for units 25 feet in diameter or larger. Specifications for smaller DAFTs should be based on manufacturer's standard equipment because the size does not justify the special features incorporated into the Specifications.

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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 06610 Glass Fiber and Resin Fabrications, General

2. Section 11000 Equipment General Provisions

[3. Section 11032 Variable Frequency Drives]

4. Section 11175 Pumps, General

5. Section 11370 Blowers, Compressors, and Vacuum Pumps, General

6. Section 13206 Pressurized Steel Tanks

1.3 SPECIFICATIONS AND STANDARDS

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

[1.	AA-30	Specifications for Aluminum Structures]
[2.	AA-45	Aluminum Association Standard Designation System for Aluminum Finishes]
3.	AFBMA-9	Load Ratings and Fatigue Life for Ball Bearings
4.	AGMA 908-B	Geometry Factors for Determining the Pitting Resistance and Bending Strength of Spur, Helical and Herringbone Gear Teeth
5.	AGMA 2001-B	Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth
6.	AGMA 6010-E	Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives
7.	AGMA 6034-A	Practice for Enclosed Cylindrical Wormgear Speed Reducers and Gearmotors
8.	AGMA 6019-E	Gearmotors Using Spur, Helical, Herringbone, Straight Bevel, or Spiral Bevel Gears
9.	AISC-M011	Manual of Steel Construction, 9th Edition
10.	AISI	Pocketbook of AISI Standard Steels
11.	ASME Section VIII	Boiler and Pressure Vessel Code; Pressure Vessels, Division I
12.	ASTM A 36	Specifications for Structural Steel
13.	ASTM A 48	Specifications for Gray Iron Castings
14.	ASTM A 536	Specifications for Ductile Iron Castings
15.	ASTM B 308	Specification for Aluminum-Alloy 6061-TS Standard Structural Shapes, Rolled or Extruded
16.	ASTM E 18	Test Method for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
17.	AWS D1.1	American Welding Society, Welding Handbook
18.	NEMA 250	Enclosures for Electrical Equipment (1,000 Volts Maximum)

B. **Structural Standards**:

1. Structural Steel and Welds: All structural steel used for equipment fabrication shall conform to the requirement of the Standard Specifications for Steel for Bridges and Buildings and ASTM A 36. All welding shall conform to the latest standards of the American Welding Society (AWS).

2. Structural Design: All steel structural components shall be so designed that the stresses developed under the indicated conditions will not exceed the allowable stresses defined by the AISC standards and the aforementioned standards.

1.4 DEFINITIONS

A. The following definitions apply to this Section:

1. Continuous Operating Torque: The continuous operating torque is defined as the AGMA design torque which is the torque load that is assumed to be continuously applied on the drive system through a 24-hour operating period, 365 days per year for a 20-year life.

2. Alarm Torque: The torque at which an alarm sounds to serve as a warning of increased torque loading. The alarm torque is defined to be equal to 110 percent of the continuous operating torque.

3. Cutout Torque: The torque load at which a motor cutout switch is activated to shut down the unit. The cutout torque is defined to be 120 percent of the continuous operating design torque.

4. Momentary Peak Torque: The maximum or peak torque of the drive unit assumed to be equal to twice the calculated AGMA torque rating of the spur gear set or 3 times the calculated AGMA torque rating of the worm gear set, whichever is lower.

1.5 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Complete certified equipment drawings and details, showing all dimensions, weights, materials of construction, structural members, float and sludge collection members, beach assembly, welds, torque ratings, and gears.

2. Materials of construction list for all machinery and structural components.

3. Foundation, installation, and grouting plans.

4. Anchor bolt placement measured from construction joints in the concrete structure. Anchor bolt details shall include projections from concrete.

5. Type and size of structural details, float and sludge drawoff pipes, including method of return sludge flow control, and all pipe connection details and supports.

6. Walkway construction details and dead load deflection computations by a registered professional engineer.

7. Air dissolution tank information, including air control panel details, materials of construction, mounting details, dimensions, location of all accessories, and details of fittings.

8. Pressurization pump information, including manufacturer's literature, head-capacity curve, materials of construction, and mounting details.

9. Air compressor details, including performance curve, dimensions, and mounting details.

10. Backpressure regulating valve details including performance data over the indicated flow range.

11. Specifications, detail drawings and information for the drive mechanism including type, input and output speeds, exact gear ratios, service factor and efficiency of gear reducer units and drive assembly.

12. Bearing manufacturer and model and bearing life data.

13. Size, make, type designation and mounting details of all electric motors indicated in this Specification.

14. Details and description of the overload protection assembly and alarms. Details submitted shall clearly demonstrate the adequacy of the overload protection provided by the assembly proposed.

15. A copy of the Contract Document control diagrams and process and instrumentation diagrams, with addenda updates, that apply to the equipment in this Section marked to show specific changes necessary for the supplied equipment. If no changes are required, the drawing shall be marked "no changes required."

16. Drawings for the DAFT covers.

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

18. Field torque testing procedures as indicated in paragraph 3.2.

19. A certificate of design, signed by a Registered Professional Engineer, shall be submitted prior to the manufacture of the equipment. The certificate shall include the following information:

    a. Codes and Specifications followed in the design.

    b. Type and strength of materials for members.

    c. Loading conditions used for the design.

    d. Certification that equipment is designed to withstand maximum continuous running torque and momentary peak torque indicated.

1.6 OWNER'S MANUAL

A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:

1. Calculations substantiating the output torque rating of the drive selected, including gears and pinions. The calculations shall clearly specify the values used for the following design parameters for surface durability and strength ratings:

   Number of Pinions
   Actual Face Width
   Tooth Geometry Factor (I and J Factors)
   Load Distribution Factor
   Allowable Contact Stress
   Allowable Bending Stress
   Pinion Pitch Diameter
   Tooth Diametral Pitch
   Hardness Ratio Factor
   Elastic Coefficient
   Life Factor

   The load distribution factor shall be determined as described in the referenced AGMA standards. The net face width for surface durability calculations shall not exceed 90 percent of the actual face width of the narrowest of the two mating gears. For parameters which are material dependent, such as allowable contact stress, the calculations shall include a full description of the materials and heat treatments used.

2. Calculations showing the related stresses developed in the drive cage and sludge collection arms at 200 percent of the continuous operating torque per paragraph [2.4C].

3. Design computations for the cover in accordance with paragraph [2.4L].

1.7 SERVICES OF THE MANUFACTURER

A. **Instruction of OWNER'S Personnel**: The authorized service representative of the manufacturer shall instruct the OWNER'S personnel in accordance with Section 11000 for not less than [5] days. The instruction work shall include both classroom and field instruction and shall include:

1. Startup procedures
2. Shutdown procedures
3. Troubleshooting
4. Selection of proper polymer types and dosages
5. Backpressure control valve adjustment
6. Operating adjustments for performance optimization
7. Preventive maintenance
8. Maintenance procedures
9. Emergency procedures
10. Records keeping

B. The manufacturer shall submit a written training program to the CONSTRUCTION MANAGER for approval. Training shall not commence until 20 days after written approval by the CONSTRUCTION MANAGER. All trainees, minimum of [5] shall receive a training manual specific to their trade as follows:

1. Mechanics
2. Electricians
3. Instrument Mechanics
4. Operators

The training manuals will be retained by the trainees, and not returned to the manufacturer.

1.8 QUALIFICATIONS

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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. **Manufacturer:** The manufacturer shall be a company specializing in circular, center-feed DAFT equipment of the type and size indicated, with a minimum of one successfully performing installation of comparable size and complexity constructed in the recent past. Equipment of comparable size and complexity shall have the following characteristics: [ ].

PART 2 -- PRODUCTS

2.1 GENERAL

A. The following equipment shall be included with the dissolved air flotation thickener system:

Quantity	Equipment	I.D. No.
[ ]	Drive unit	[ ]
[ ]	Sludge and float collector mechanism	[ ]
[ ]	Pressurization pumps	[ ]
[ ]	Air dissolution tank (s)	[ ]
[ ]	Dissolution tank solenoid (s)	[ ]
[ ]	Dissolution tank level controller (s)	[ ]
[ ]	Air compressors	[ ]
[ ]	Backpressure control valves	[ ]
[ ]	Torque switch (shutdown)	[ ]

[ ] Torque switch (alarm) [ ]

[ ] Non-rotation switch (alarm) [ ]

2.2 DESIGN AND PERFORMANCE REQUIREMENTS

A. **Performance Requirements**: The system shall be designed to perform under the following conditions:

1. Solids and Hydraulic Loads:

	Flow Condition (Peak)	Flow Condition (Average)
Solids loading, lb/day:		
Primary sludge (includes scum)	[ ]	[ ]
Biological sludge (includes scum)	[ ]	[ ]
Total Loading, lbs/day	[ ]	[ ]
Surface loading rate, lb/sq ft/day (Note 1)	[ ]	[ ]
Hydraulic loading rate, gpm/sq ft (Note 2)	[ ]	[ ]
Pressurized flow, gpm (Note 3)	[ ]	[ ]

2. Influent characteristics:

Solids concentration, mg/l	[ ]
Sludge temperature, degrees F	[ ]

Note 1: Surface loading rate is defined as the average loading based on the total loading with [one] tank out of service.

Note 2: Hydraulic loading rate includes pressurized flow and feed sludge at [ ] to [ ] percent solids concentration.

Note 3: Pressurized flow is based on one pressurization pump in operation per air saturation system at given loading.

B. **Design Criteria**: The following shall be used for design of the equipment provided under this Section:

1. Tank Dimensions:

Diameter, feet	[	]
Sidewater depth, feet at wall	[	]
Floor slope	[1:12	]
[Submerged launder, internal diameter, feet	[	]]

2. Center Column:

Internal diameter, minimum, inches	[	30	]
Maximum headloss through inlet ports, feet	[	0.3	]
Distribution feedwell diameter, feet	[		]
Pressurized flow pipes:			
Number	[	1	]
Internal diameter, inches	[	6	]
Carrier pipe, internal diameter, minimum inches	[	24	]
Polyelectrolyte piping, diameter, inches (Note 4)	[		]

3. Sludge and Float Collectors:

Float collector flights, number	[	16	]
Bottom sludge collectors, number	[	2	]
Float troughs			
Number	[	2	]
Length	[		]
Collector mechanism tip speed, feet per minute			
Minimum	[	0.25	]
Maximum	[	5.0	]
Continuous maximum operating torque, ft-lb	[		]
Drive unit motor, minimum horsepower	[		]

4. Air Dissolution System:

Operating pressure, psig			
Maximum	[	75	]
Minimum	[	55	]
Tank pressure rating	[	125	]
Design flow per dissolution tank, gpm	[		]
Air supply pressure, psig			
Maximum	[	100	]
Minimum	[	80	]
Air/solids ratio, minimum	[	.03	]
Minimum air saturation efficiency, percent (Note 5)	[	85	]
Dissolution tank detention time, minimum minutes (Note 6)	[	0.75	]

5. Pressurization Pumps:

NPSH available (ft)	[		]
Minimum pump efficiency at design point (percent)	[		]
Pump speed, rpm	[		]
Maximum motor speed	[	1800	]
Minimum motor horsepower	[		]
Suction flange, min inches	[	4	]
Discharge flange, min inches	[	4	]

6. DAFT Covers:

Live load			
Uniform, lb/sq ft	[	50	]
Concentrated, point load, lbs	[	400	]

Note 4: The system shall be designed to permit the use of polymers as a flocculating aid. However, the design shall be based upon operation under average conditions without chemicals. Polymer, prepared in diluted liquid form elsewhere in the plant, may be pumped to DAFTs by positive displacement pumps.

Note 5: Saturation efficiency is defined as the ratio of the actual amount of air dissolved in the full pressurization flow to the theoretical amount that could be dissolved in the pressurization flow at the design pressure and test temperature.

Note 6: Dissolution tank detention time is defined as the pressurized flow detention time in a volume equivalent to the volume of air space above the controlled liquid level in the tank.

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NTS: Design Consultant shall specify additional requirements for the covers, such as unbalanced loading and wind loading, as necessary based on type of dome used and geographical area of the project.

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2.3 MATERIALS

A. The equipment shall be provided with the indicated feature and materials as follows:

Steel plate, structural steel shapes, steel tube	ASTM, A 36 steel, 1/4-inch minimum if submerged
Center column, center column access cover plates, drive cage, influent distribution well, float trough, sludge and float removal arms and carrier pipe.	ASTM, A 36 steel, 1/4-inch minimum
Main spur gear	
Ductile iron	ASTM A 536, 80-55-06 or 80-60-03
Cast iron	ASTM A 48, minimum Class 50A
Forged Steel	AISI 4130, 4135, 4140, 4150, or 4340
Worm	Flame-hardened AISI 41L50 or 4140/42H alloy steel
Worm gear	Manganese, bronze alloy, centrifugal casting
Pinion	AISI 4140, 4150, or 4340 heat treated to 220-260 Brinell

Main bearings	Hardened alloy steel, vacuum degassed
Main bearing races	AISI 4140 alloy steel 38-46 HRC per ASTM E18
Access cover plate support and fastening hardware	AISI Type 316 stainless steel
Collector hardware	AISI Type 316 stainless steel hardware
Float wiper blades	Neoprene
Flights (bottom sludge)	1/4-inch, ASTM A 36, steel blade flights with adjustable 20-gauge, AISI type 316 stainless steel squeegees
Distribution weir	Fiberglass, per Section 06610
Distribution weir hardware	AISI Type 316 stainless steel
Access bridge	
Frame	ASTM A 36 steel
Grating and handrail	[Aluminum]
Air dissolution tank	Steel designed per ASME Code, Section VIII, Division 1, for 125 psig design working pressure
Air dissolution tank nozzle, impingement plate and fastening hardware	AISI Type 316 stainless steel
Backpressure control valve and associated fastening hardware and control shaft	Stainless steel, Type 316
Pressurization pumps	
Casing	Cast iron or ductile iron
Impeller	Stainless steel, Type 316
Wear ring	Stainless steel
Shaft and shaft sleeve	Stainless steel
DAFT cover structural supports	[ASTM B 308 aluminum, 6061-T6 or 6063-T6 alloy]
DAFT cover panels	[ASTM B 308 aluminum, 3003-H16 alloy]
DAFT cover hardware	AISI Type 316 stainless steel

2.4 EQUIPMENT

A. **Influent Structure**: The tank influent structure shall consist of the center column and influent distribution well, with adjustable influent distribution weir plate.

1. Center Column: The center column shall be a hollow steel cylinder with its base flanged for anchor bolting to the concrete floor of the tank. Its top shall be flanged and stiffened for supporting the drive cage and collector mechanisms, influent distribution well, drive mechanism, and carrier pipe for the pressurized flow and polymer pipes, and equipment access bridge beams. The drive cage, the influent distribution well and weir, the bottom sludge collection system, and the float collection skimmer system shall be supported from the moving part of the drive mechanism. No vertical thrust shall be imposed on any underwater bearing. The center column shall have two 18-inch diameter, or rectangular, access plates, 180 degrees apart, which align with the access ports on the carrier pipe skirt, to allow access to the backpressure control devices. Center column access port covers shall attach with stainless steel hardware, provide a waterproof seal, and be curved to conform to the curve of the center column.

   Six to eight equally-spaced ports shall be provided in the center column for discharging liquid from within the column into the distribution well. The ports shall be sized by the DAFT equipment manufacturer to minimize head loss at this location. [Under no circumstances shall the ports be submerged at any flow. An allowance of at least 6 inches shall be provided between the free water surface in the center column and the top of the ports.] [A deflector plate shall be located in the influent center column as indicated to direct sludge flow out of the center column ports into the tank. A seal between the deflector plate and carrier pipe housing shall be provided to prevent water and foam from entering the center column above the ports. The seal shall consist of the rubber boot and mechanical fastener which can be secured around the carrier pipe from outside the center column. The influent center column shall have ports that shall be below the tank minimum water surface elevation.]

2. Carrier Pipe: The carrier pipe, which shall contain the pressurized flow and polymer pipe shall be removable and designed as a stiffened structural member projecting down the center column to near the tank bottom. The carrier pipe shall resist all forces that result from release of the pressurization flow and its encounter with the incoming sludge flow. The pipe shall be designed to bolt securely to the top of the center column and to bolt to intermediate supports attached within the center column and located above the water surface in an area not exposed to sludge. Access to these attachments shall be provided by two openings in the center column, minimum 18 inches in diameter, located above the operating water surface; associated covers shall be attached with stainless steel hardware. No spiders, stiffeners, or other structural attachments or obstructions will be permitted in the annular space between the carrier pipe and center column in the path of the mixed sludge and pressurization recycle flow. The drive unit configuration shall be designed such that, with the worm gear housing removed, the entire carrier pipe assembly, with the skirt removed, can be removed from the center column through the drive unit.

3. Carrier Pipe Skirt: The bottom of the carrier pipe shall have a bolt on two piece removable skirt. The skirt shall extend one foot below the backpressure control devices and shall be securely fastened to the carrier pipe with stainless steel hardware and rubber seal that allows the skirt to be dismantled and removed from the center column through access ports. The skirt shall have two access ports with covers, attached with stainless steel hardware, which will allow inspection and repair of the backpressure control devices from outside the center column.

4. Pressurized Flow Pipes: The pressurized flow pipes shall extend just beyond the terminus of the carrier pipe such that the backpressure devices are located within the

skirt and release pressurized flow within the skirt. The top and bottom of the carrier pipe shall be sealed around the pressurized flow and polymer pipelines with welded steel cover plates to prevent the accumulation of debris within the carrier pipe. A polymer diffuser system shall be provided, as indicated, to distribute polymer uniformly and efficiently to the incoming waste stream. Polymer piping will be contained within the carrier pipe housing. A polymer sparge ring for polymer injection into the annular space between the carrier pipe and center column shall be located in the carrier pipe housing one-foot above where it connects with the skirt.

5. Distribution Well and Weir: The distribution well and weir shall be arranged to promote uniform distribution of the influent flow radially over the entire surface of the DAFT by inducing a slight headloss over a submerged weir. The influent distribution well and weir shall be supported from the drive cage and shall rotate therewith. A seal shall be provided at the bottom of the well between the rotating floor and the stationary center column to prevent the passage of liquid into the DAFT at this point. The well shall be designed and supported to preclude distortion and deflection of the weir when the well is full and the tank empty and vice versa.

   The influent distribution weir shall be mounted on the outside of the influent distribution well as indicated. The weir shall be adjustable to allow overflow depth to vary from a minimum of 3 inches to a maximum of 12 inches from the liquid level indicated, and be designed to allow for expansion and contraction. The interface between the weir and distribution well shall be sealed with a neoprene gasket. The overflow depth shall initially be set for [7.5] inches.

[B. **Submerged Subnatant Collection Launders**: Fabricated submerged collection launders shall be supported from the inside of the tank wall and shall be fabricated of steel pipe with regularly spaced orifices. The number, size, and construction details of the orifices and launder supports shall be as indicated.]

[B. **Effluent Weirs and Baffles**: The effluent weirs shall be mounted on the inside PVC lined concrete periphery of the tank and shall be fabricated of 1/4-inch thick close-fitting injection molded fiberglass which complies with Section 06610. Rectangular notches, 1-1/4 inches in width shall be provided as indicated. Weir plate anchor bolts shall be 316 stainless steel located as indicated. The weirs shall be slotted to permit not less than 6 inches of adjustment.

The effluent baffle shall be fabricated of continuous steel and shall extend completely around the tank approximately 10 inches in from the effluent weir. Baffle mounting and width shall be as indicated. A positive seal shall be provided where the weir intersects the float troughs.]

C. **Drive Cage**: Torque shall be transmitted from the drive unit to the rotating components of the mechanism by a drive cage. The drive cage shall encompass the center column and shall be fabricated of structural steel shapes of sufficient strength to transmit and/or carry all loads and stresses associated with 200 percent of the continuous operating torque without deflection or distortion. The rotating drive cage shall be designed to maintain the minimum wiper clearance above the operating water surface without conflict with the tank cover. The drive cage shall be designed to allow access to both cover plates in the center column at the same time. Means shall be provided at the connection to the main gear to permit vertical alignment of the cage in the field.

D. **Bottom Sludge Collectors**: The bottom sludge collectors shall be of the plow type. Arms shall be of truss construction, rigidly braced, and connected to the drive cage. The arms shall have steel raking blades and adjustable stainless steel squeegees. The blades shall be designed to move the settled sludge along the tank bottom to the sludge hopper at the center column. The entire tank bottom shall be raked twice per revolution. The finished installation of the bottom sludge collector shall be such that the squeegees are located not less than 1/2-inch nor more than 3/4-inch from the finished floor at any location in the tank. Calculations shall be provided showing the related stresses developed in the sludge collection arms at 200 percent of the continuous operating torque.

E. **Float Collectors**:

1. General: The float collector shall consist of float collector flights supported by a pinwheel-type structure in a manner conforming to that indicated. The primary structural member shall extend radially from the center drive cage to wheels that ride on the outer rail. Pairs of secondary supports shall be placed as chords between each primary member. Operation of the float collection system shall be smooth and without sudden motion [at all speeds within the indicated range]. Skidding, jerking, stalling, bumping, deflection of the primary radial members, or any interruption to the smooth motion of the collector will not be acceptable.

2. Flights: The flights shall be supported on axles that span the chords in a manner which will leave the flight wipers radial when their tips are 6 inches below the float trough lip on the collection box. The float collector flights shall be equally spaced and shall be designed to move the float up the collection beach and into the flat trough with less than 1 inch of horizontal deflection when the flight moves vertically 3 inches in either direction from the above referenced radial setting. No portion of the collector mechanism other than the wiper blades shall be allowed to engage or enter the liquid contents.

   The float sludge collector flights shall be suspended from above by bearings on a fixed shaft or fixed to a shaft mounted in bearings on the secondary supports. The bearings shall be of the self-aligning, permanently lubricated, sealed type. The attachment between the flights and chords shall allow the flight to deflect toward the center of the tank as it tips up above the water surface while passing over the beach and float trough. This connection shall also allow individual flights to be taken out of service by rotating up and securing to the carousel, without the flight interfering with the tank wall and cover while in this position. In normal operation, the outboard-side flight wiper blade shall firmly contact the peripheral tank wall. This shall be accomplished by spring or other apparatus made from Type 316L stainless steel with adjustable tension, such that the flights move smoothly throughout rotation and do not bind when passing over the float trough. The inboard-side of the flight wiper blade shall maintain sufficient contact with the beach inboard curb to minimize leakage of captured float back into the tank.

   The method used for attachment of wipers to the wiper suspension system shall permit at least 3 inches of vertical adjustment of wiper position (in 1-inch increments) above and below the liquid elevation indicated. Adjustments shall be achieved using permanently fixed carriage bolts, lockwashers, and wing nuts not less than 1/2-inch nominal diameter. Adjustment of wiper blades and liquid level within the range indicated shall not result in other members dragging in the liquid and stirring the tank contents.

Each flight shall be designed to be compatible with the float trough and approach beaches provided. To provide proper wiping action, blades shall be attached to the bottom and extend out the sides of each flight. The blade shall have a support backing for stability. Blades shall extend 6 inches below their support.

Each flight shall have two 1-inch holes by which it can be secured in a raised position when out of service. The holes shall be placed for minimum lateral deviation from underneath the chord supports as the flight travels around the tank. The ties between the flight and the chord supports shall be stainless steel chain. Stainless steel fasteners shall be provided at the flight and at the chords. Fasteners at the chords shall allow easy adjustment of length of tie.

3. Support Wheels and Rails: The wheels for the primary structural members shall be designed to support the full load of all attached structural components and shall have enough width to account for all of the rail eccentricity. Transverse movement of the axles will not be permitted. Wheels shall have permanently lubricated, sealed bearings and shall be mounted on the primary structural member in a manner which will accommodate the radius of the support rail. Casters, if furnished, shall also have permanently lubricated and sealed bearings. All bearings shall be specifically designed to provide not less than 5 years' continuous duty in a moist atmosphere where gritty materials may be present.

   The rail or similar steel section on which the primary support arms ride shall be attached with brackets to the peripheral concrete wall of the tank. The rail shall be curved (±1/4 inch tolerance) to match the curvature of the tank at the point of support. The rail shall have supports (such as a rolled channel underneath the rail) to prevent deformation by arm loading. The rail shall be level and meet a ±0.01-foot tolerance in elevation. Provisions shall be made to allow adjustment of rail level at each support.

F. **Float Troughs**: The trough assembly shall be fabricated as indicated and shall consist of a collection beach, the float trough, and a trailing ramp. The leading ramp and trailing ramp shall be constructed to provide continuous contact between the entire length of the wiping blades and the ramp surfaces throughout the duration of contact. The trough length shall be a minimum of 4 feet. The beach shall be vertically adjustable.

The underside of the trough shall be shaped to avoid flat or concave surfaces which could trap float. At the CONTRACTOR'S option, inner spaces within the troughs may be filled with polyurethane foam to prevent the spaces from filling with liquid. The troughs shall be supported by cantilevered brackets attached to the tank wall. The trough, including the skimming beach, shall be fitted with braces and otherwise stiffened and supported to prevent movement when the tank is being filled with liquid and when the skimming arm passes over the trough. Movement (tank empty to tank full) shall not exceed plus or minus 1/8 inch.

G. **Drive Mechanisms**:

1. General: The drive assembly shall include an [electric gear motor,] [variable speed drive,] worm gear and worm gear reducer, pinion gear, turntable type main spur gear, drive base, shear pin hub coupling, steel roller drive chain, torque overload protection system and non-rotation detection system. Gears shall be AGMA Quality 8 or better. The driving and driven gears shall be designed in accordance with AGMA 6034-A for a service factor of 1.25 applied to the continuous operating torque; AGMA 908-B and

2001-B for 24-hour continuous duty, uniform loading, and 20-year design life based on the continuous operating torque and maximum collector speed; and AGMA 6010-E.

The drive assembly shall be firmly mounted to a cast iron turntable base with a minimum wall thickness of 1/2-inch. The drive base shall be mounted on the center column and be provided with a positive leveling feature. The drive mechanism shall be mounted on the influent column with the top of the spur gear housing capable of supporting the total access bridge load by means of equally loaded, removable bridge supports. Drive mechanism components shall be designed for the rated torque indicated in paragraph [2.2.A.] All drive equipment, including gears, bearings, motor and variable speed drive shall be located above the cover and accessible from the bridge.

[2. Drive and Primary Reduction, Variable Speed: The electric motor for the drive shall be suitable for operation under all weather conditions and shall be provided with a sealed conduit box. The motor shall be the heavy duty type per Section 16040. A 12-gauge steel belt guard, hot-dip galvanized after fabrication, shall be provided.

The variable speed drive shall be V-belt driven and shall be a hydrostatic type, positive displacement unit designed to transmit a constant output torque over a 27 to 1 variable output speed range. The hydraulic drive shall be fitted with a flange-mounted reduction gear and modified to obtain only the collector rotational speed range indicated. The drive shall be compact, self-contained, and totally enclosed in a cast iron housing suitable for outdoor service. Oil fill and drain plugs and level indicators shall be provided and shall be easily accessible. The drain shall be at the lowest point of the oil reservoir. Speed control shall be through a manual indicating mechanism capable of adjusting speed with the drive speed within 0.5 percent of the indicated speed over the full range of out put loads. Oil temperature rise shall not exceed 60 degrees C at maximum rated load at a maximum ambient temperature of 50 degrees C. Drive efficiency shall be at least 70 percent at full speed and 65 percent at half speed.]

[2. Drive and Primary Reduction, Variable Speed: The collector mechanism shall be capable of operation through the speed range specified through the adjustment of a variable frequency drive. The variable frequency drive shall conform to the requirements of Section 11032 and shall be specifically selected to provide continuous (24 hour) smooth, steady operation at the torques indicated with the speed range specified. The variable frequency drive shall be located as indicated in the motor control center serving the DAFT.]

[2. Gear Motor: The drive motor shall be an 1800 RPM heavy duty motor in accordance with Section 16040. The gear motor shall be designed for continuous duty, Class II applications in accordance with AGMA 6019-E.]

The [variable speed drive] [motor] shall be directly coupled to a primary gear reducer. The gear reducer shall be self-contained and enclosed in a cast iron housing and provided with oil fill and drain plugs. Gear reducers shall be designed in accordance with AGMA 6010-E with a minimum safety factor of 1.5 or greater.

Power transmission between the primary gear reducer and the intermediate gear reducer shall be made through a roller chain and sprocket drive assembly. Chain shall be permanently lubricated "O"-ring type chain. Sprockets shall be hub type, plain bore, steel or cast iron. The drive sprocket shall be fitted with a shear pin designed for

manual adjustment of chain tension. A 12-gauge steel chain guard, galvanized after fabrication, shall be provided, with stainless steel fastening hardware.]

3. Intermediate Gear Reducer: The intermediate gear reducer shall be a worm gear type specifically designed for this service. The assembly shall consist of a ground worm and a centrifugally cast worm gear. The worm gear assembly shall be self-contained and enclosed in a cast iron gear case and with oil fill, level, and drain fittings and a sight gauge. The drain shall be at the lowest point of the oil reservoir and shall be accessible. Oil fill and level indicators shall be easily accessible. The worm shall be integral with the worm shaft. The worm gear torque capacity shall be determined according to AGMA 6034-A for service factor of 1.50 applied to the continuous operating torque.

4. Spur Gear Assembly: The pinion and pinion shaft which drive the internal spur gear shall be made as an integral unit from forged alloy steel. The pinion shall be rigidly supported by bearings located above and below the pinion gear. Overhung pinions shall not be acceptable.

   The spur gear shall be AGMA Quality 5 and shall be designed and rated in accordance with AGMA 908-B and 2001-B with a service factor of 1.5 or greater applied to the continuous operating torque. If the spur gear is of a split gear design, the two halves shall be furnished with precision mating surfaces with self-registered and indexed fits.

   The spur gear housing shall be cast iron. A felt or neoprene seal and dust shield shall be included with each spur gear housing in two locations; a lower seal located between the stationary drive base and main gear, and an upper seal located between the main gear and stationary drive cover. The gear case shall have oil fill and drain plugs and an oil level indicator pipe. The drain shall be at the lowest point of the gear case and shall be accessible. Oil fill and level indicators shall be readily accessible. The spur gear housing shall be designed to allow 75 percent submergence of the gear face in the oil bath. The drain line, suitable for removing condensate, shall be located at the lowest point in the oil reservoir and shall be accessible.

   To permit inspection and maintenance of the interior of the center column, each spur gear shall have an access opening of not less than [30] inches in diameter. A reinforced fabricated [aluminum] cover plate with lifting holes securely attached shall be provided for the cover plate.

5. Main Bearing: The entire float and sludge collector mechanism shall be suspended from the turntable which in turn shall be supported on a ball bearing assembly that uses large-diameter hardened vacuum degassed alloy steel bearing balls. The bearing balls shall run in an oil bath on replaceable carbon corrected steel liners and placed in annular raceways in the gear and turntable base. A minimum 75 percent of the gear face shall be submerged in oil. A cross-contact or four-point angle contact ball bearing arrangement is prohibited. Bearings shall be designed for an L-10 life of at least 375,000 revolutions.

6. Torque Overload Protection: The drive mechanism shall be provided with an overload protection system (consisting of an electro mechanical overload device and a backup shear pin) and an overload alarm system. The overload device shall be designed to measure thrust of the worm gear shaft and be provided with an indicator showing the load on the mechanism. The indicator shall be visible from the access bridge, shall

read in ft-lbs torque or percent continuous operating torque and shall cover the range of torques indicated up to the momentary peak torque.

The overload device shall include two switches; the first is to activate a remote alarm at continuous maximum operating torque, and the second is to shut down the unit at shut off torque. The device shall be factory calibrated to activate the alarm switch (normally open) when the torque load on the mechanism reaches the alarm torque and activate the main cutout switch (normally closed) at the cutout torque. The overload device shall be enclosed in watertight cast iron or aluminum housing. The switches shall be double pole, double throw (DPDT), housed in a NEMA 4X enclosure, and rated at 5 amps at [120] [240] volts AC and shall be arranged to open on alarm.

The drive mechanism shall be equipped with a non-rotation detection device to sense lack of shaft rotation on the intermediate work gear reducer input shaft, when the drive motor is running. The device shall be an active magnetic pickup type with zero speed switch and normally closed contact for remote indication of non-rotation and alarm.

A backup shear pin shall be provided in a shear pin hub mounted on the output shaft of the [gear motor] [variable speed drive]. The shear pin shall be selected to break when the load on the mechanism achieves 140 percent of the continuous operating torque indicated. A NEMA 4X limit switch shall be provided to activate an alarm when the shear pin breaks.

H. **Bridges**:

1. Access Bridge: The bridge shall have a 48-inch wide walkway and an access platform around the drive unit, and shall include [aluminum] grating, structural steel support members, and handrailing as indicated. The bridge and access platform shall be supported on the main spur gear housing which, in turn, shall be supported by the center column. Minimum clearance around the drive mechanism shall be 24 inches. All walkway surfaces shall be at the same elevation.

I. **Air Dissolution Equipment**:

1. General: Air dissolution equipment includes the dissolution tank with liquid level controls, air control panel, and pressurized flow system with backpressure control valve(s), and all associated instrumentation and accessories. The dissolution system shall be suitable for using either recycled thickener effluent or [reclaimed water]. Thickener effluent may contain fine solids, small grit particles, and small amounts of grease. [Reclaimed water may contain up to 15 mg/l of chlorine.]

   The DAFT equipment supplier shall be responsible for the design of the dissolution system to achieve the performance indicated. Pipe sizes and fittings and accessories indicated and the pressurization pump's characteristics indicated shall be verified.

2. Air Dissolution Tank: The tank shall be vertical, cylindrical welded steel sized by the manufacturer for efficient air dissolution (saturation of the pressurized flow with air) and large bubble removal required to achieve the indicated performance. The tank shall be designed in accordance with ASME Code, Section VIII, Division 1, for the pressure rating indicated. The tank shall bear an ASME inspector's stamp, complete with design working pressure, and date and place of manufacture. The liquid level control system for the dissolution tank shall be of excess air bleed-off type and shall maintain a

constant liquid level in the tank. The external diameter of the pressure vessel, excluding piping and appurtenances, shall not be larger than [3.5] feet. The height of pressure vessel, including support legs, a 4-inch high concrete equipment pedestal, appurtenances and all connected piping, shall not exceed [12] feet.

The internal arrangement of the static air dissolution tank shall be the responsibility of the manufacturer to achieve the saturation efficiency indicated at the indicated rated pressure and maximum fluid temperature without the aid of mixers, internal diffusers or internal baffles. Internal packing, secondary recycle pumps, and mixers will not be allowed. The pressurized dissolution flow nozzle(s) shall have a minimum discharge velocity of 20 feet per second. Nozzle(s) shall discharge onto a replaceable stainless steel target baffle(s) and shall not impinge directly upon the pressure vessel.

The tank shall be fitted with the following:

a. Pressure manhole.

b. Flanged full skirt support suitable for anchor bolting. The supports shall have access holes for access to the drain.

c. A bottom 2-inch diameter drain and valve.

d. A 1-inch safety valve bearing the ASME seal set for 80 psig stamped by an ASME inspector.

e. A 24-inch armored sight gauge fitted with gauge valves visible from the air control panel.

f. A level control device with a monel float-actuated mercury switch which controls the operation of the air bleed-off solenoid valve. The float shall be mounted in cast iron chamber, external to the dissolution tank, with Type 316 stainless steel internal trim, Type 400 stainless steel magnetic sleeve, and brass inner liner. The chamber shall be attached to the dissolution tank with two 1-inch ball valve connections and shall have a 1-inch ball valve drain. The level control device shall have a NEMA 4X switch enclosure and a hand-off-auto switch, for selection of air bleed off control modes. A control panel for the controls shall be provided. The control panel external wiring shall be as indicated. The panel enclosure shall be NEMA 4X.

g. A pressure gauge mounted on a 1/2-inch NPT valve connection. Pressure gauges shall be as indicated. Range shall be 0 to 100 psig.

h. High-low water level switches, SPDT in a NEMA 4X enclosure. Upon high or low level in the dissolution tank, the switches shall close a common set of contacts to trigger a single alarm. The switches shall be attached to the dissolution tank with two 3/4-inch ball valve connections.

i. [6-inch] flanged pressurized flow inlet and outlet connections.

j. A 3/4-inch diameter air inlet.

k. A 3/4-inch diameter air bleed off connection and 3/4-inch solenoid valve.

l. Internal dissolution nozzle(s) with replaceable stainless steel target baffle(s).

m. A constant gas purge system, consisting of a 1/2-inch needle valve, rotameter, and silencer to permit continuous, adjustable venting of the gas space. The gas purge system shall be piped from the top of the saturation tank to the air control panel.

The tank shall be fitted with plate baffles and the entrance to the pressurized flow outlet pipe shall be sized and located to prevent the formation of vortices and the ingestion of bubbles from the tank gas space.

Fittings shall be provided so that the sight glass, the level control valve float chamber, and instrumentation connections can be purged with high-pressure plant water without draining the dissolution tank.

3. Air Control Panel: The air supply regulation system shall be wall mounted on a corrosion-resistant panel with a removable cover, through which components are operable and pressure and flow indications are visible, or shall be mounted directly to the dissolution tank. Components of the air control panel shall be 3/4-inch line size and shall include an air filter, a pressure regulating valve, a calibrated [0-25] scfm direct-reading rotameter with a Type 316 stainless steel float, safety shield and needle valve, a check valve, a pressure indicator (0 to 100 psig), and all other valves and fittings as indicated.

4. Pressurized Flow System: The manufacturer shall provide the portion of the pressurized flow piping system indicated, including the backpressure control valve, so that during equipment commissioning the proper backpressure setting can be selected to achieve the indicated system parameters. The backpressure control valve shall be designed to balance total head loss of the system against the pressurization pump characteristics.

Backpressure control valve shall be suitable for operation at all pressure differentials between 40 and 100 psig. The backpressure control valve shall be an extended shaft cone valve, connected to a vertical shaft for operation. Flat disc or plug type valves will not be acceptable. This shaft shall extend from the backpressure valve, internally through the pressurized flow pipe to the top of the access bridge, where a manual (hand wheel) operator shall be located. The manual operator shall permit changing flow and pressure while the system is in operation. The unit shall be designed so that no leakage from the pressurization pipe occurs. Steady bearings shall be provided for the shaft, within the pressurized flow pipe, to maintain proper position of the backpressure control valve and prevent deflection and vibration. The backpressure control valve shall be attached to the vertical shaft such that it can be removed for maintenance or can be replaced from the bottom of the shaft. The face of the backpressure control valve, the base of the pressurized flow pipe, and the last 3 inches of the interior of the pressurized flow pipe, shall be hard faced with No. 6 Satellite to a hardness of 45 Rockwell C.

5. Corrosion Protection: The inside of the pressurized flow pipes and the inside of the air dissolution tank shall be coated with two shop coats of [coal tar epoxy] [vinylester] [alphatic polyurethane] conforming to Section 09800.

J. **Air Compressors**: Air compressors, receiver, and control shall be skid mounted. The air compressors shall be air-cooled reciprocating type, 2-stage, receiver mounted units, rated

to deliver at least [ ] scfm free air at 100 psig discharge pressure, with an operating range of [80 to 120] psig, complete with suction valve unloaders, intake air filter and silencer, after cooler, automatic start-stop control, V-belt drive and rubber cushion mounted [ ]-hp, 1750-RPM heavy-duty motor, and other items indicated. The receiver shall be mounted on an [80-gallon] ASME [horizontal] [vertical] tank in accordance with Section 13206. Tanks shall be fitted with a safety valve, drain cock, and pressure gauge. Controls shall include pressure switches to automatically maintain pressure in the receiver tank, a low oil supply, and a high temperature cut-out. The compressors shall be interlocked so that, in normal operation, one will be 100 percent stand-by for the other, and failure of one will bring the other into service automatically, and the failure will be indicated and alarmed at the control panel. Equipment shall meet the requirements of Section 11370.

K. **Pressurization Pumps**: Pressurization pumps shall be frame-mounted, centrifugal, continuous duty, horizontal end suction pumps, conforming to ANSI B 73 standard. Pumps shall be grease lubricated and provided with mechanical seals and heavy duty flexible shaft couplings. Casing shall be foot-mounted, with gauge and drain connections. Backhead shall be designed to permit removal of impeller, shaft, and bearings, without disturbing piping. The pump shall be driven [through a V-belt] by a constant speed [1200] [1800] RPM heavy duty motor. Pump and motor shall be provided on a common baseplate with drain pan of cast iron or steel with drain connection and pipe. The inlet losses at the inlet to the dissolution tank shall be included in the required pump discharge head. Pumps shall meet the requirements of Section 11175.

L. **DAFT Tank Covers**: [Aluminum] fixed tank covers shall be constructed as indicated with an [aluminum] frame. [Aluminum dome components shall be anodized to M12-C22-A41 in accordance with Aluminum Association Standard 45.] [Aluminum dome components shall have a clear satin anodized architectural Class I finish of minimum 0.7 mil thickness.]

[Cover frame shall be designed in accordance with the AA-30.] The physical configuration, as well as the strength of the dome, shall be designed to provide for all thermal stresses, both in expansion and contraction. Additionally, the design shall incorporate the full dead load plus the indicated live load conditions.

Design computations, utilizing the design criteria indicated herein, shall be submitted with the Owner's Manual. The computations shall include analysis of all structural members and appurtenances, and shall be prepared by or under the direct supervision of a registered professional engineer. The engineer responsible for the design computations shall provide an engineer's certificate stating that the dome covers meet the design criteria indicated herein.

[The cover shall be an aluminum semi-spherical structure designed to fit between the wall of the thickener and the thickener center column, but below the access bridge and walkway. The cover shall conform to the overall dimensions indicated. The structure shall include the following items: extruded aluminum frame, aluminum tension ring, aluminum gussets, expansion base shoes, stainless steel anchor bolts, all fasteners, base flashing, seal hatches, observation hatches, air inlet and exhaust openings, access hatches providing full access to the float trough and beach areas, two access hatches at the center column and sealant. Non-skid walkways and ladders shall be provided for access to the hatches from both the thickener wall and the bridge.

The exterior panels shall be non-corrugated flat panels, having a minimum thickness of 16 gauge. The use of steel shall be minimal, but when it is necessary, it shall be stainless steel.

In the construction of the cover itself, as well as in the immediate vicinity of its placement onto the structure, galvanic corrosion shall be prevented by proper coating of the affected dome surface. All sealants shall be Dow 781, or equal, installed in accordance with the manufacturer's specifications.]

In addition, the cover shall meet the following:

1. The cover shall be sealed at the DAFT tank wall.

2. The roof shall be clear span and self-supporting from the circular periphery of the reinforced concrete thickener tank.

3. An opening of the dimensions indicated shall be provided at the bridge access platform.

4. Access shall be provided for maintenance for the two float collection troughs, including their leading and trailing ramps, the wheels of all primary radial arms, and the influent distribution well. Access shall be provided for removal of equipment from the tank and for general access to the thickener collectors and interior. Access shall be a minimum of [6 feet by 8 feet], clear. Those areas where access is required and the nominal dimensions for the desired openings are indicated in a general nature. These shall be coordinated with the actual location in the manufacturer's final design of the equipment. These dimensions may be adjusted to accommodate the roof framing plan. However, the final arrangement shall not unduly hamper access to the equipment.

5. All openings and hatches shall have a finished appearance, set in frames, edges rolled or rounded.

[6. The dome panels shall be attached by means of clamping bars which engage the panels in an interlocking joint. The use of panel attachment fasteners which penetrate both the panel and the flange of the structural member is expressly prohibited.]

[7. The dome structural members shall be attached to the gusset plates by means of bolts connecting the flanges of the structural members to the gusset plates. A minimum of four bolts per flange shall be used.]

8. The cover shall be designed by a structural engineer, registered to practice in the State of California. All drawings associated with the cover shall bear the engineer's registration stamp and seal.

$# _____

NTS: Cover material and specifications shall be coordinated with the architect and structural engineer to be consistent throughout the plant.

_____ #$

M. **Protective Coatings**: All items shall be coated in accordance with Section 09800 unless otherwise indicated. The inside of the pressurized flow pipes and the inside of the dissolution tanks shall be coated with System 103, Coal Tar Epoxy.

2.5 SPARE PARTS

A. As a minimum, the following spare parts shall be provided:

1. 1 set - all bearings and bearing seal rings for drive unit, except the main turntable bearing
2. 1 set - all gaskets for drive unit
3. 1 set - spur gear seal and replaceable bearing races
4. 1 set - shear pins
5. 1 set - nozzles (if required) and impingement plates for dissolution tank
6. 1 - backpressure regulating valve assembly included shaft, positioner, and disc
7. 1 - carrier pipe skirt

2.6 MANUFACTURERS

A. Products shall be supplied by one of the following (or equal):

1. Sludge and float collector and dissolution system:

a. Eimco
b. Envirex (a Rexnord Division)
c. Walker Process Corporation
d. Komline-Sanderson
e. Westech

2. Pressurization pumps:

a. Allis-Chalmers
b. Fairbanks Morse
c. Goulds

3. Compressors:

a. Gardner-Denver
b. Kellogg-American
c. Quincy (Colt Industries)

PART 3 -- EXECUTION

3.1 INSTALLATION

A. **General:** Products and equipment shall be installed in accordance with the manufacturer's written installation instructions.

3.2 FIELD TESTING

A. Products shall be field-tested for compliance with the indicated requirements. All testing shall be conducted under the supervision of factory-trained representatives furnished by the manufacturer. If the equipment should fail to successfully complete the testing program, this will be sufficient cause for the CONSTRUCTION MANAGER to require that the equipment be replaced or reconstructed and retested.

1. Torque Tests: As part of the test and inspection program, the entire sludge removal mechanism shall be load tested by the CONTRACTOR by anchoring bottom sludge

collector arms individually. In successive tests, attempts will be made to demonstrate capability of the sludge removal mechanism (including drive unit, cage, gears, and structures) to withstand the cutoff torque. Sketches and calculations shall be submitted illustrating the test procedure and indicating how the torque will be applied to satisfy this requirement. Testing shall include calibration of the torque overload and backup shear pin systems and testing of the non-rotation device.

2. Freshwater Test: As part of the testing program, the DAFT tanks shall be filled with fresh water to their operating level and the mechanism operated continuously at its maximum speed for a period of not less than 48 hours. Following the maximum speed test, the mechanism will be operated at 25, 50, and 75 percent speeds for continuous periods of not less than 6 hours. At no time during the operating tests shall the equipment fail on torque overload or exhibit indications of binding or uneven operation. The CONTRACTOR shall record torque values registered on the drive mechanism torque indicator and motor amperage (all three phases) at 3-hour intervals.

   If the mechanism should fail on torque overload or exhibit indications of binding or improper adjustment, the CONTRACTOR shall immediately stop the tests and remedy the problem. After completion of necessary repairs or adjustments, the freshwater tests shall be repeated. Failure to successfully complete the tests in six attempts shall be considered sufficient cause for rejection of the equipment.

3. Air Saturation Tests: Prior to startup of the equipment and operation on sludge, each air dissolution system shall be operated with fresh water to demonstrate that the indicated design requirements for air dissolution saturation efficiency have been satisfied. Testing shall include operation of both one and two pressurization pumps, dissolution systems, and backpressure control devices at one time. Saturation efficiency shall be determined based upon the average of the data points recorded after discarding the highest and lowest observed dissolution efficiencies for each system.

   Dissolution efficiency shall be defined as the ratio of the actual amount of air dissolved in the full pressurization flow to the theoretical amount of air that could be dissolved in the pressurization flow at the design pressure and test temperature. Representative samples shall be withdrawn from the discharge line of the dissolution tank at design pressure with pump on at design rate. At least five samples shall be taken from each system over a 6-hour run. The following steps shall be performed for each sample:

   a. Release sample to atmospheric pressure capturing and recording volume of all excess gas.

   b. Correct the volume of gas for temperature differences between the gas sample and the pressurization flow and for water vapor pressure.

   c. Determine the dissolved oxygen (DO) content in the sample liquid immediately and after 2 hours. DO may be measured with an electronic probe provided the CONTRACTOR documents the probe's calibration to barometric pressure, and verifies the probe's accuracy using the azide modification of the Winkler titration (Standard Methods, latest edition).

   d. Calculate the dissolved nitrogen content in the sample liquid and correct for supersaturation, assuming the same degree as for dissolved oxygen (ratio of DO immediately to DO after 2 hours).

e. Calculate the actual air content by summing the corrected gas sample volume and the oxygen and nitrogen content in the liquid sample.

f. Calculate the theoretical air solubility in the pressurized sample at test temperature and at system pressure corrected for local atmospheric pressure and water vapor pressure.

g. Calculate the dissolution efficiency by dividing the actual air content in the sample by the theoretical air content in the pressurized sample.

3.3 TEST REPORTS

A. [Six] copies of the test reports shall be submitted which will include the results of all field tests conducted in Section 3.2.

** END OF SECTION **