PROFESSIONAL SERVICES GROUP, INC.

THE OPERABILITY REVIEW PROCESS

For Use in the Design Review of Wastewater

Treatment Plants

Includes Recommended Criteria To Be Considered
In Designing For Operability and Maintainability
During the Various Design Phases

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TABLE OF CONTENTS

INTRODUCTION

The following material describes the operability review process and the procedures used in conducting an operability review session. Methods of prioritizing the recommendations that result from the review session are also presented.

This presentation also includes operability and maintainability recommendations developed by operation and maintenance professionals in the PSG Consulting Services Divisions. This group has had extensive experience in the Operation and Maintenance field. These recommendations cover a broad range of elements that must be considered in the design of a wastewater treatment facility. There is no attempt to claim that they are a complete or comprehensive compilation of all important operation and maintenance recommendations. However, the incorporation of many of these ideas will result in the design and construction of a plant that will have a high degree of operability and maintainability incorporated into it, insuring cost effective and reliable plant performance.

These recommendations were developed primarily for the review of large plant facilities, but many are universal and can be applied equally well to smaller plant designs. The recommendations are generally for a conventional activated sludge plant with main sewage pumping, preliminary treatment, primary treatment, aeration, final settling, chlorination, sludge thickening and sludge digestion. The recommendations concentrate on the operation and maintenance of plant components and are not intended to be used for process control recommendations and strategies. The ideas are based on the experience and preferences of the individuals who participated and your experience in some instances may sharply contrasts the views presented. However, P.S.G. is confident that you will find the majority of these recommendations to be practical and valuable in reviewing proposed plant designs. You may also find in a few instances that a recommendation may be repeated in several sections and in similar wording with respect to different components. Although some of this redundancy could be eliminated, many of these recommendations are very important and the redundancy helps to reinforce the significance of the recommendation.

The operability review process should not be an adversarial one between the operability review team and the design engineer. The purpose of the review is to make the designer aware of commonly observed pitfalls and omissions that the review team has observed in there experience. Ignoring these pitfalls and omissions has resulted in designs that are inefficient from an operation and maintenance prospective. The designer should be receptive to the important recommendations that will enhance the design. On the other hand, the review team must be cognizant of the fact that the designer is generally working under very strict time constraints and that significant increases in design costs may preclude the incorporation of excellent recommendations. As a result, the recommendations have to be carefully categorized so that the essential ones are clearly pointed out and prioritized before they are given to the design engineer.

In conclusion, a properly conducted operability review session can result in a very efficient plant design from an operability and maintainability viewpoint and in a plant that meets regulatory requirements for effluent quality on a consistent, long term basis.

I - DEFINITION OF AN OPERABILITY REVIEW

An operability review is an intensive project analysis in which specialized operations and maintenance expertise is used to insure that quality and reliability from an operating and maintenance perspective are provided in a wastewater project design.

Elements of the design that could result in the inefficient, unreliable operation and maintenance of the facility or that could create unsafe conditions are identified. This results in a set of recommendations to the design engineer to modify the design for a better final project.

Typically for large projects, up to three review sessions are provided during the design phases; Conceptual (10 %), Preliminary (20 to 45 %) and Final Design (60 to 90 %), with a bacchic review at 100%. For smaller projects fewer sessions are usually provided. We recommend that at least one session be provided for smaller projects, in a simplified form, to identify potential problem areas.

An operability review can also be useful in the facilities planning stage, prior to the design phase, in which alternative treatment and disposal systems are developed and analyzed. An operability review insures quality and reliability from an operating and maintenance perspective at this important early stage of a project. This can aid the designer in the selection of the proper system, as well as assisting with other important technical, economic, environmental and financial factors to be considered in selecting a cost effective plan.

The operability review team members are generally senior O & M professionals who are not involved in the design and have substantial practical experience in the operation and maintenance of wastewater treatment facilities. The team will generally have practical experts in process operation, equipment maintenance, electrical systems operation and maintenance, instrumentation, and possibly in the plumbing, constructibility, HVAC, architectural, civil and structural fields. Typically the team has four to six members experienced in the various disciplines previously indicated.

II - THE OPERABILITY REVIEW PROCESS

An operability review will commonly involve a period of one to two week. An example schedule for a large project follows:

1st day- Monday: The design engineer presents a comprehensive, detailed overview of the project to the team. The designer presents pertinent plans and specifications for the facility or portion of the facility which is the subject of the operability review. Initial team questions are answered or noted for future response.

2nd day- Tuesday: The team determines the best approach to the review: Usually this involves either reviewing the project with the entire team as one group or reviewing the design in smaller groups. The size of the facility and the review team composition are two factors in determining the approach to the review. An intensive and systematic review of the design is then conducted and preliminary concerns are developed. To facilitate this review a system is developed to prioritize the recommendations and identify to the designer those that the team believes are critical to the proper functioning of the facility. Several alternative systems used to prioritize comments are described following this discussion of the Operability Review process.

3rd day- Wednesday: Continue preliminary review and begin to develop and prioritize questions and issues.

4th Day- Thursday: Complete preliminary review and prioritization of questions and issues.

5th Day- Friday: Finalize recommendations. Review, modify and categorize suggestions. This categorization must include the development of a rating system, as described previously and in the next section, to indicate the seriousness of the concern. A preliminary presentation is then made to the designer.

Following the working sessions return comments back from the designer are reviewed and incorporated into the final document which is then presented to the client for action about one week after the review session.

For smaller projects, the review period as well as the size of the review team may be reduced commensurate with the size and scope of the project.

III - <u>SYSTEMS USED TO PRIORITIZE OPERABILITY REVIEW RECOMMENDATIONS</u>

SYSTEM NO. 1

1. "A" items, which the review team determines either will not work as designed or are essential to future plant operation.

2."B" items, which are highly desirable, the plant will work without them, but less efficiently and/or at a higher cost.

3."C" items, which would be nice to have.

4. "D" items, Soft issues which are procedural and editorial in nature (e.g. drawing errors,technological enhancements, etc.).

SYSTEM NO. 2

A. Issues critical to the successful operation of the facility. Without these items the plant will not function as necessary to meet permit in a safe and efficient manner. These items must be addressed to ensure the integrity of the facility.

B. Issues of high operational\maintenance importance. These items are important to the operational and maintenance related integrity of the facility, but will not in essence prevent the facility from operating as designed.

S. Issues important to plant operation and maintenance safety concerns. These items involve safety concerns, representing conditions or situations which will endanger the welfare of personnel as they perform their duties. Critical safety concerns must be addressed by the designer.

DS. Design suggestions for improved plant operation and maintenance. These are items that will make the plant run more smoothly and efficiently and in some cases more cost effectively, but will not prevent the plant from operating as designed. Design changes to incorporate these ideas, particularly at a late stage of design, can add design expenses and cause delays that offset the advantages presented. If not included in the design these suggestions may be incorporated by the plant in the future.

SYSTEM NO. 3

A. Critical- plant will not work unless recommendation is incorporated into the design.

B. Important- plant will work if idea is not incorporated into the design, but either less efficiently, less cost effectively or in a less safe manner.

C. Minor- Items that are nice to have or conveniences, but have low impact on the efficiency and cost effectiveness of operation and maintenance.

D. Housekeeping Issues- minor editorial errors in details of drawings and specifications for the designers review and resolution as required.

Although these systems have categories that are quite similar, each has some differences that may suit the needs of a particular review team. If none of these systems meets the needs of the team, they can be used for guidance in developing a more applicable system.

IV - CRITERIA TO BE CONSIDERED DURING THE VARIOUS DESIGN PHASES

1. FACILITY PLANNING PHASE

- **SYSTEM COMPLEXITY**

  Is the proposed treatment system very complex or relatively simple. The system should be as simple as possible to meet the effluent criteria for the facility, provided that there is reasonable operational and staffing cost effectiveness. Systems with complex equipment and instrumentation should only be considered if facility goals can be achieved only through their use. The availability of skilled labor and the need for costly contract maintenance for specialized equipment and systems must be carefully weighed before choosing a process alternative.

- **DESIGN SYMMETRY**

  Design symmetry should be emphasized so that wherever feasible, even numbers of process units are provided. If multiple batteries are used, mirrored images are desirable. This generally results in superior plant hydraulics and simplified process operation.

- **SITE LAYOUT**

  Is the site layout efficient, allowing for ease of operation and maintenance? Would alternative processes lead to better utilization of available space?

- **PROCESS FLEXIBILITY**

  Is a similar, high level of process flexibility provided in any alternative designs being evaluated? Can more flexibility be added to enhance process strategies?

- **EQUIPMENT REDUNDANCY**

  Ensure that redundant equipment is furnished to prevent maintenance and emergency downtime. The same level of equipment redundancy should be provided in each design alternative so that reliable process operation will result with any alternative, this will also result in an unbiased cost comparison.

- **PROPRIETARY SYSTEMS**

  If proprietary systems are being considered, do they have a history of reliable operation and reasonable maintenance requirements.

- **ODOR CONTROL**

  Has the need for odor control been adequately addressed to allow the operator to properly respond to problems and complaints from the public? The reliability and flexibility of the odor control processes under consideration must be analyzed.

- **CORROSIVE CHEMICALS**

  The use of corrosive and toxic chemicals should be minimized consistent with required goals and cost effectiveness considerations. Where they are used provisions for the safety of the operation and maintenance staff must be carefully considered.

- **BUFFER ZONE**

  Proper buffer zones should be provided between the facility and the surrounding community to minimize the impact of the facility on the public. This will allow the operator to concentrate on the process operation and maintenance of the facility, without being burdened with unreasonable attention to public relations. Where natural buffer area is not available artificial means of isolation must be used.

- **PROVISIONS FOR FUTURE EXPANSIONS**

  Have provisions for future expansions been made so that future construction activities don't interfere with ongoing plant operation? Examples include valve isolation at blind flanges, etc.

2. CONCEPTUAL DESIGN PHASE (10 %)

- **CONFINED SPACES AND EXPLOSION PROOF AREAS**

  Every effort should be made to minimize confined spaces and the need for explosion proof areas to maximize worker safety at the facility. Where confined spaces exist safe operation and maintenance access and egress should be facilitated in the design.

- **FLEXIBILITY OF OPERATION**

  Increased flexibility of operation can usually be provided in the valving, piping and I & C for minimal additions in cost. This flexibility is vital in maintaining stable plant operations and meeting regulatory requirements. Many times Value Engineering reviews mistakenly eliminate valuable flexibility considerations for the sake of small incremental cost savings.

- **EQUIPMENT REDUNDANCY**

  The selected design should be reviewed thoroughly to insure that the critical systems in the plant have been provided with adequate redundancy to allow for equipment failure and downtime for maintenance activities. These systems include main sewage pumping, process air blowers, sludge pumping systems (primary, waste, return); any system that can impact on meeting regulatory or permit requirements must have adequate redundancy. Also included are support systems such as instrument air compressors, process water, and cooling water that can impact on the operation of many of the essential systems. Generally, for any critical system (pumping, blower, compressor, etc.) at least three units should be provided. When only two units are provided, an emergency condition can easily be created if the second unit fails while the other unit has been taken out for maintenance activities.

- **ACCESS TO EQUIPMENT, VALVING, PIPING, CONTROLS, FLOWMETERS, SWITCHES, FILTERS AND OTHER COMPONENTS**

  The design must give careful consideration to accessing equipment so that both maintenance and operation procedures can readily be performed. Clearances between pieces of equipment, between walkways and equipment, between valves, operators and piping must all be correctly laid out to facilitate equipment operation and surveillance, as well as removal. In most cases the contract design should admonish the contractor to ensure adequate access during equipment installation.

- **REMOVAL OF EQUIPMENT FOR MAINTENANCE**

  In addition to access around equipment for maintenance, properly laid out lifting equipment including cranes, hoists (permanent or portable) and eyehooks must be included in the design. Transportation to the maintenance shop must also be considered. Where ceiling hooks are furnished , offset hooks should be provided to allow straight lifts and offset laydown.

- **CONCRETE FLOORS IN OPERATING AREAS**

  Concrete floors in operating galleries where wastewater, scum, screenings or sludges are handled must be roughened. Smoothly troweled floors should never be used. Special non-slip coatings should be considered. In areas handling polymers nonslip gratings should be used throughout areas where potential polymer spills are possible.

- **PROCESS AND EQUIPMENT LAYOUT**

1. Series vs Parallel layouts

Generally series layouts of the major process units are more cost effective and lend themselves to more efficient use of personnel for operation and maintenance, as compared to parallel layouts which can result in more interconnecting piping and a poor flow of personnel for operation.

2. Residuals Handling

The location where residuals (e.g. grit, screenings and scum) are removed from the plant should be as close to the point of removal from the flow stream as possible. This allows for efficient use of personnel and avoids the need for extensive conveyor systems or mobile equipment to bring the residual to the disposal point. Extra equipment and distance would result in unnecessary operation and maintenance requirements. If possible all residuals (e.g. grit, scum and screenings) should be handled in one area.

3. Sludge Piping

The length of primary sludge, thickened sludge and scum lines should be as short as possible. The plant layout should be given very careful attention with regard to this matter. Close proximity of the primary tanks to the sludge treatment facility and close proximity of the thickening systems to sludge treatment facilities are extremely important, as long lines for the conveyance of these grease-laden sludges can be problematical. Suction lines should be as short as possible for all primary settling tanks and sludge thickening units.

4. Digester Shapes

The shape of digestion and storage tanks should be such that they can be easily cleaned. The design should provide effective tank geometry and properly sloped floors, directed to pump suctions. For smaller facilities, square or rectangular tanks with a sloped floor to a pump sump can be very effective, as compared to a round tank. This is because of short pump suction lines at the wall of the tank, where round tanks must take center

4. Digester Shapes (continued)

suction requiring longer suction lines and potentially increases in pipe clogging and blockages. In addition, a rectangular or square tank with a sloped floor to the pump suction can readily be cleaned. A square tank is also simpler and less costly to build and can provide for a more efficient plant layout.

5. Support Buildings

Support buildings for plant energy, process water, cooling water, instrument compressors, etc. should be as close to the end use as possible to avoid unnecessarily long service and return lines. Short piping and power runs provide cost effective operation and maintenance. Maintenance buildings should be located as conveniently as possible to the areas containing the most complex equipment.

6. Gravity Drains for All Process Units

All process units should be laid out so they can be drained by gravity for both operational and maintenance activities. This avoids the need for unnecessary pumping systems, either permanent or portable. Careful consideration of the plant hydraulics is necessary to ensure gravity drainage. Provide sufficient flow capacity for drainage of individual units within an 8 hour period (one shift, if possible).

7. Interconnecting Tunnels

Whenever feasible use interconnecting tunnel systems throughout the plant with direct access from grade by ramp for all-weather ease of operation and maintenance activity accessibility. Utility trenches or chases should also be considered for ease of access for maintenance. If tunnels are not provided, elevators or properly sized hatchways with portable hoists are required.

8. Equipment Areas Prone to Flooding

Avoid placing major pieces of equipment in areas that are potentially prone to flooding (i.e blowers, boilers, hydraulic systems). Only equipment absolutely necessary for process operation should be installed in these areas.

9. Gallery Drainage Systems

In galleries, floor drainage should be provided by using sloped floors to drainage channels at the walls, and pitching floors toward sump pump locations. Embedded floor drains should be avoided,if possible; particularly in process areas, embedded floor drain traps should be prohibited.

3. PRELIMINARY AND FINAL DESIGN PHASES (30 TO 90 %)

MAIN PUMPING STATION

- **Wetwell** - The amount of equipment located in the wetwell, which is normally a confined space area, should be limited so that entry into this area is rarely required. Stop logs should not be used in the wetwell because of their cumbersome nature and difficulty in handling. Sluice gates, sump pumps, hydraulic systems or other equipment that will require regular maintenance should be minimized; first because of the safety aspects and secondly because of the corrosive atmosphere that normally exists in this area. A backup wetwell elevation system should be considered for reliability in the main pumping operation.

- **Drywell** - The amount of equipment in the drywell (a classic confined space) should be also be limited to only that equipment that must be placed at this level. Hydraulic and electrical systems should be located at higher levels, free from potential flooding. Hydraulic lines or electrical conduits can be run from the upper levels down to the pump room floor as required.

- **Pump Discharge Piping** - The piping on the pump discharge side of the main pumps should always discharge into the side of the forcemain and should always be angled into the forcemain so that the discharge of one pump does not "fight" the discharge from another pump, limiting discharge flow and increasing power costs. Pump check valves should always be placed on a horizontal run

- **Redundant Pumping Equipment** - Good design should call for a conservative policy with respect to redundancy for this critical operation. In a typical case, six pumping units would be provided; with four required to handle peak design flow, with one pump out for maintenance and one pump available for backup, so that permit conditions with respect to plant flow can be met at all times.

- **Sample Pump** - If a sample pump is provided to sample the influent flow it should be located so as to take suction from a well mixed and turbulent area in the wetwell to ensure a representative sample. The suction line should be as short as possible to minimize the potential for clogging. High pressure air and water should be available near sampling connections to blow and flush out suction and discharge lines.

- **Main Influent Gates** - Controls should be on a balcony or at grade level, not on screening chamber or drywell floor. Gates should be visible from the control point. Emergency closing should be provided for power failures or explosive detection. Closure should be swift, approximately 30 seconds. Provisions should be made to close main gates by gravity in case of failure of the hydraulic system.

SCREENING CHANNEL DESIGN AND SCREENINGS HANDLING

- **Sluice Gates** - Influent and effluent sluice gates should be provided for isolation of each screening channel to permit maintenance activities. The sluice gates should be supplemented with stop log grooves before the influent gate and after the effluent gate so the channels can be isolated if the gates fail so they can be repaired.

- **Hydraulic Design** - A notable flaw in many designs is that little attention is paid to the hydraulic distribution to the screening channels. Generally the interceptor is aligned with the screening chamber and the flow comes directly into the common screening chamber influent with little thought of baffling or other means to direct flow evenly to the channels. As a result most of the screening load goes to one screen and the others are underutilized. In addition, during high flow periods, with one screen taking most of the load, shortcircuiting through the screen is likely, as well as increased risk of screen breakdown. To preclude such results, energy dissipation methods and baffling should be carefully considered. Some alternatives for energy dissipation include; a forebay gate prior to the screenings forebay; allowing the flow to enter the plant at 90 degrees to the screening channels. If two interceptors are provided letting them meet in opposite directions at 90 degrees to the screening channel inlets

- **Hydraulic Design (Continued)**

  dissipates energy improving distribution to the screen channels. Energy dissipation and baffling insures good screening channel distribution.

- **Downstream Channel Velocity Control** - Motor operated velocity control devices such as proportional weirs or curtain gates can be provided after each screen to distribute flow effectively to each screen in service.

- **Distance of Screen From Main Influent Gate** - In many instances inadequate distance from the influent gate to the screen causes shooting velocities through the screen and poor screen performance; distance provisions should be carefully reviewed.

- **Bar spacing** - 3\4 to 7\8 of an inch spacing between bars is recommended.

- **Automatic timers** - Timers with a manual operation backup should be provided with a differential bubbler system on either side of the screen as a backup to prevent channel elevations from becoming too high. The timer cycle should be adjustable to allow a mat to form on the screen, maximizing screening removal efficiency.

- **Channel width** - The channel should be widened at the screen to slow velocity through the screen, enhancing capture.

- **Stabilizing Screenings** - Lime dispensing equipment should be considered for dosing both screenings grit and scum materials removed from the sewage.

- **Storage** - All storage facilities and containers should be placed indoors. If the facility is close to the public, storage areas must be odor controlled

- **Screening Compactor** - Compactors should also be considered to remove water and provide easier screenings handling during disposal.

- **Drive Units** - Mechanical units should be located at floor level. If not a platform or ladder arrangement should be provided to insure safe access for maintenance.

- **Access** - Enough room must be provided between bar screen mechanisms to allow men and equipment access between the units.

- **Secondary Screens** - The provision of secondary screening facilities is recommended to screen primary sludge and possibly waste sludge flow streams before going to sludge treatment facilities. This helps to insure proper operation of the sludge handling facilities by minimizing equipment clogging with screening materials in the sludge handling area.

GRIT HANDLING

- **Direct Discharge to Container** - To minimize handling direct discharge from a grit washer into the container used for removal is preferred. If this is not possible smaller satellite containers are recommended; the use of conveyor systems are recommended only if these other alternatives are not feasible. If a conveyor is necessary a backup system should be provided in case of conveyor failure.

- **Discharge Chutes** - Chutes must be properly designed and installed to prevent splashing of product.

- **Sump Pumps** - Sump pumps in this area should be specially designed for the abrasive service of grit runoff. Floor drains in the grit area should not go to sump pits in other areas.

- **Storage** - All storage facilities and containers should be placed indoors. If the facility is close to the public areas it must be odor-controlled

- **Flooring** - Flooring in this area should be concrete, designed to resist abrasion. Asphalt should not be used in areas handling grit containers.

- **Hot and Cold water** - Sufficient hot and cold water should be provided in grit handling areas for housekeeping and equipment flushing.

SCUM REMOVAL AND HANDLING

- **Influent Channels** - Provisions should be made to remove scum and grease from influent channels throughout the plant. Down-opening gates discharging into the process units located at proper elevation and location can be adequate, if feasible.

- **Scum Pumping** - If possible systems should be designed to avoid the pumping of concentrated scum. If the pumping of concentrated scum is necessary, lines should be as short as possible and heated. However, normally scum should be pumped using high volumes of sewage (for dilution) to a scum concentrator at the disposal point. Concentrated scum should be removed from the concentrator using a heated trough discharging directly into the disposal container.

- **Hot and Cold Water and Steam Jenny** - Housekeeping services such as hot and cold water along with a steam jenny and adequate electrical outlets at critical locations to power the steam jenny are required.

- **Grease Removal Rectangular Tanks** - Flight and Chain systems used to remove scum from the surface of settling tanks should convey the scum as close as possible to the collector trough before submerging avoiding unnecessary buildup on the units.

- **Aeration Basins and Chlorine Contact Tanks** - An effective high volume system is essential for froth removal from the aeration systems. Grease removal from the chlorine contact tanks should be considered.

- **Storage** - All storage facilities and containers should be placed indoors. If the facility is close to the public areas it must be odor controlled

PRIMARY TANKS (RECTANGULAR DESIGN)

- **High Pressure Air and Water to Unclog Piping**- Primary sludge pumps should have quick connect fittings on the suction piping so that high pressure air and/or water can be used to blow back lines.

- **Heavy Duty Positive Displacement Pump** - These pumps should be provided at least for every five primary tanks with interconnections. The purpose is to provide a means of unclogging blocked primary sludge lines, both suction and discharge. The pump piping system should be flexible, allowing the pump to take suction from primary tank sumps and effluent water systems to dislodge blockages.

- **Redundancy** - Good practice is to provide three primary sludge pumps for every two primary tanks (one for each tank and one common spare).

- **Controls for Pump and Collector** - These controls should be interlocked in such a manner that the collector mechanism trips and sends an alarm when the pump malfunctions. This is to prevent heavy sludge buildup in the collector pit.

- **Tank Dump Valves** - Provide rising stem sluice gate dump valves in the sump pit, no less than 12" size.

- **Sump Pit Access** - A large grated opening should be provided on the primary tank deck over the collector sump pit for operation and maintenance personnel access. If the units are covered for odor control a hinged cover over the cross collector sump should be provided.

- **Target and Distribution Baffles** - These baffles should be installed to provide proper distribution of flow within a unit.

- **Shear Pin** - The design should provide for trouble free replacement; in lieu of a shear pin consider a trip clutch, which can be reset without pin replacement.

- **Drive Mechanism** - There should be separate drives and motors for the longitudinal and cross collector flights in lieu of using a single right angle drives to operate both.

- **Portable Davit Units** - These units necessary to raise and lower personnel and\or equipment into the tanks,should be provided. Provisions should be made to install an attachment for the unit at a convenient access point at each bay of each primary settling tank. Personnel lifts are an important part of confined space entry procedures.

- **Tank Lighting** - Provide sufficient local lighting at the drive equipment. Equipment lighting should be activated by a local switch, not by automatic controls. Pole lights for security and walkway lighting should be designed to provide easy access for servicing. Security lighting in each area should be controlled by a single accessible photocell unit with a timer as a backup.

- **Electrical Outlets** - Sufficient outlets should be provided on the primary settling tanks to facilitate tank maintenance work. Provide sufficient 220 and 440 volt, 30 to 60 amp. circuits and receptacles for welding and submersible pump service. All outlets should incorporate ground fault protection.

PRIMARY TANKS (CIRCULAR)

- **Drive Units** - Units must be easily accessible at the center of the tank walkway for monitoring and maintenance.

- **Main Gear Lubrication** - Lubrication for the main gear should be piped from a central application point to the lube points on the gear.

- **Drive Mechanism Clutch** - A clutch with an alarm which can manually be reset is preferred over shear pins and trip mechanisms.

- **Full Radius Ducking Scum Skimmer** - A full radius ducking skimmer with a sequenced-timer controlled tip tube is generally preferred over circumferential skimmimgs collection; however in colder climates, freezing can be more of a problem with the full-radius skimmers. If full-radius skimmers are furnished, tip duration and skim revolution should be adjustable, operator chosen set points.

- **Primary Sludge Pumps (Dewatering)** - Primary sludge pumps should be installed and plumbed such that they can be used to dewater the tank. If this is not feasible dewatering must be furnished by either gravity or pump from the clarifier center well.

- **Tank Flushing Water** - High pressure flushing water should be furnished at four points around the tank for hosing the weirs and effluent troughs, as well as for flushing out the scum collection tube.

- **Blanket Depth Measurement** - Instrumentation or access for the measurement of blanket depth must be provided.

- **Sludge Pumping Regulation** - The use of sweep drive torque signal or sludge density sensing to regulate sludge pumping is recommended.

- **Tank Lighting and Electrical Requirements** - Similar to Rectangular Settling Tanks.

AERATION TANKS (CONVENTIONAL)

- **Drainage Channel** - Provide center drainage trough in floor of each pass to facilitate hosing out of tank. Ensure that the tank is pitched to the drain trough or sump.

- **Froth Control** - Provide the capability of rapid wasting of froth buildup when it occurs

- **Return Sludge Discharge to Aeration** - If odor control is not necessary we recommend a visible discharge of the return sludge flows to each aerator through a weir box for control and simplicity of operation.

- **Sampling Considerations** - Provide access for D.O profiles, process control samples. This is particularly important if the tank is to be covered for odor control.

- **Foam Control** - The provision of a foam control system may be useful. However, insure the ability to isolate and drain the spray water system from outside of the tank for maintenance and in colder climates to protect against the effects of freezing when the system is out of service.

- **Diffused Air Headers (Access)** - Insure that a proper system is in place for access to and removal of the diffusers and the air header system.

- **Tank Cleaning** - Provisions for hosing and cleaning of the tank floors, walls and weirs must be provided.

- **Mechanical Mixer Systems** - Access for maintenance must be provided along with satisfactory alarms and protective devices for overload or failure.

FINAL SETTLING TANKS (RECTANGULAR)

- **Gravity Overflow** - Use hydrostatic lifts (Telescoping Bell Weirs) to remove sludge from final settling tanks. Adjustable motor operated units with the level of the overflow indicated are recommended. The discharge should flow to the return sludge pump suction well. The alternative system using direct pump suction from each tank, requires extensive pumping equipment and metering for control resulting in increased operating and maintenance personnel requirements. The visible ability to check flow from the tank results in a much simpler and more effective return sludge pumping system, which is easier to control.

- **Chlorination of Return Sludge** - The ability to chlorinate return sludge to control sphaerotilus and other undesirable organisms should be provided.

- **Return Sludge Channels** - Channels should be aerated and grease removal should be provided.

- **Waste System** - A visible discharge of flows entering a wastewell to the waste sludge pumps should be provided. Where feasible each flow should be metered through a Parshall Flume or V-notch weir to allow easy and accurate flow measurement. This system is more reliable and requires minimal operator attention as compared to those dependent on in-pipeline meters. In-line venturi, differential pressure meters should not be used for sludge application.

- **Portable Davit Units** - These units necessary to raise and lower personnel and\or equipment into the tanks,should be provided. Provisions should be made to install an attachment for the unit at a convenient access point at each bay of each final settling tank. Personnel lifts are an important part of confined space entry procedures.

- **Controls for Pump and Collector** - Controls should be interlocked in such a manner that the collector mechanism stops when the pump malfunctions. This is to prevent heavy sludge buildup in the collector pit. In addition an alarm should be sounded to immediately alert personnel to the problem.

- **Tank Dump Valves** - Provide rising stem sluice gate dump valves in the sump pit no less than 12" size.

- **Chain Guards** - Guards have historically been heavy bulky units that are frequently removed during the first servicing of equipment and never reinstalled. Guards should be light weight, expanded metal mesh or plastic and permit visual inspection of the shear pin hub without having to remove the guard. The guard should be hinged so that the entire guard can be swung away for maintenance or made in sections so that part of the guard can easily be removed to work on the shear pin assembly. This requirement should be included in the contract specifications.

- **Collector Interlock** - The longitudinal collector and the cross collector should be interlocked, such that if the cross collector fails, the longitudinal collector will also trip out. If a pump is provided on each final tank it should also be interlocked with the collector mechanism to prevent sludge buildup in the cross collector upon failure. Each condition should be alarmed to a control center for immediate action.

- **Tank Lighting** - Provide sufficient local lighting at the drive equipment. Equipment lighting should be activated by a local switch, not by automatic controls. Pole lights for security and walkway lighting should be designed to provide easy access for servicing. Security lighting should be controlled by a single accessible photocell unit with a timer as a backup.

- **Electrical Outlets** - Sufficient outlets should be provided on the final settling tanks to facilitate tank maintenance work. Provide sufficient 220 and 440 volt, 30 to 60 amp. circuits and receptacles for welding and submersible pump service. All outlets should incorporate ground fault protection.

- **Target and Distribution Baffles** - Baffles should be installed to provide proper distribution of flow within a unit.

- **Shear Pin** - The design should provide for trouble free replacement; in lieu of a shear pin consider a trip clutch, which can be reset without pin replacement.

- **Drive Mechanism** - There should be separate drive and motor for the longitudinal and cross collector flights in lieu of using right angle drives to operate both.

FINAL SETTLING TANKS (CIRCULAR)

- **Drive Units** - Units must be easily accessible at the center of the tank walkway for monitoring and maintenance.

- **Main Gear Lubrication** - Lubrication for the main gear should be piped from a central application point to the lube points on the gear.

- **Drive Mechanism Clutch** - A clutch with an alarm which can manually be reset is preferred over shear pins and trip mechanisms.

- **Full Radius Ducking Scum Skimmer** - A full radius ducking skimmer with a sequenced-timer controlled tip tube is generally preferred over circumferential skimmimgs collection; however in colder climates, freezing can be more of a problem with the full-radius skimmers. If full-radius skimmers are furnished, tip duration and skim revolution should be adjustable, operator chosen set points.

- **Waste Sludge Pumps (Dewatering)** - Waste sludge pumps should be installed and plumbed such that they can be used to dewater the tank. If this is not feasible dewatering must be furnished by either gravity or pump from the clarifier center well.

- **Tank Flushing Water** - High pressure flushing water should be furnished at four points around the tank for hosing the weirs and effluent troughs, as well as for flushing out the scum collection tube.

- **Tank Lighting and Electrical Requirements** - Similar to Rectangular Settling Tanks.

- **Blanket Depth Measurement** - Instrumentation or access for the measurement of blanket depth must be provided.

- **Gear Reducer Cover** - The cover over the motor and gear reducer unit may be part of the walkway, but provisions should be included to remove or tie back the covers, as well as to place a guard chain across the walkway at the opening

- **Chain Drive Guard** - The guard over the chain drive or shear pin mechanism should be easily removed and replaced, preferably with flip type latches rather than with bolts.

- **Sludge Collection** - Multiple draft tube central sludge collection is preferred over center well collection, particularly for larger diameter tanks (over about 40 feet), provided that the tank is operated within the design flow parameters (low flows tend to result in draft tube clogging). Draft tube height should be easily adjustable, as collection rate relies on the head differential between the draft tube and the tank surface. Waste sludge can be taken from the return sludge line or directly from the clarifier bottom center sump.

- **Foam Control Center Well Area** - Spray nozzles for foam control are often helpful in the center well areas and should be considered. If spray nozzles and headers are installed a method should be furnished to drain the headers during downtime or cold weather

CHLORINE CONTACT TANKS

- **Number of Tanks** - At least two tanks should be provided, each capable of providing the necessary contact time while the other tank is out of service for cleaning.

- **Motor operated sluice gates** - Sluice gates should be provided for the chlorine contact chambers. Stop logs should not be used, except for isolation for sluice gate repairs.

- **Cleaning of Tank** - The floor should be pitched and contain drainage trenches for ease of cleaning.

- **Baffling and Tank Vanes** - Sufficient baffling and turning vanes should be provided to prevent short-circuiting and tank dead spots. Inlet baffles should be provided to promote good mixing.

- **Automatic Sampling** - Two sampling locations must be provided; one approximately one third of the distance down the first pass (for control of the chlorination process) and one at the tank outlet to record the residual leaving the tank for record-keeping and regulatory requirements. Complete backup for both systems is required in the event of failures to maintain continuous operation. Provisions for backflushing the sampling system should be provided.

- **Effluent Foaming** - This common problem at many locations may be caused by turbulence due to effluent splashing down into the outfall, or due to tidal or design conditions. Careful consideration must be given to minimize these effects by creative designs that can control and minimize outfall turbulence and with proper process control operation. Provide sprays to control foaming if it is unavoidable in design.

- **Hydrants** - A sufficient number of hydrants around the contact tanks should be provided for cleaning (one every 50′ as a starting point). Enough water pressure and volume should be provided to flush solids off the tank floor. Secondary effluent should be used as a source of flushing water.

THICKENERS

- **Splitter Box** - A splitter box of sufficient hydraulic capacity to distribute flow evenly to all thickeners should be provided. In addition, adjustable V-notch weirs should be provided to distribute and measure flow to each unit.

- **Dump Valves** - Should be provided at the top of the thickener cone floor and at the bottom of the sump. Some locations only have a dump valve at the top of the cone and rely on the pump alone to dewater the cone. This can be a problem if the pump fails or loses prime at low levels.

- **Enclosed Units** - Covering of units is not desirable but may be necessary for odor control. Enclosed structures should be well lit. Skylights are desirable. Tank covers should be high enough to allow normal personnel entry for operation and maintenance tasks. If not, abundant access hatches must be provided for observation and to allow for maintenance activities.

- **Shear Pin** - Should be provided as a backup to torque switch. Consider the use of mechanical clutch in lieu of shear pins.

- **Pump Timers** - Should be provided for operation according to the amount of sludge in the tank.

- **Programmable Logic Controllers** - Consider the use of programmable logic controllers for multiple timer\sequencing functions.

- **Pump Location** - The pump should be located as close to the bottom of the thickener as possible to minimize the length of suction piping. The pump should be at an elevation that guarantees a flooded pump suction line.

- **Piping** - The suction and discharge piping should contain as few bends as possible. Lines should be swept with no sharp 90 degree turns.

- **Cleanouts** - The suction and discharge piping should be provided with sufficient clean out and blowback capability to allow easy cleaning of pipelines and pumps.

- **Pressure Gauges** - Both suction and discharge gauges should be provided on each pump (must be diaphram isolated).

- **Valves** - Valves should be full port opening and should be operated by lever operators for quick opening and closing. Valves should be located for ease of operation. Valves above reach (approximately 6'6") must be furnished with a easy method of operation from the floor.

DIGESTION TANKS

- **Overflow Box** - All digesters should be connected to a common overflow box. The overflow box should be configured for completely flexible operation. The gravity overflow from the digesters should be able to go to any secondary digester (if provided), to any storage tank, to the aeration system, to the thickener system, to other digesters, and through a separate emergency overflow line to the aeration system. The splitter box should be set up so that varying amounts of sludge can be sent to all or any of the locations spelled out above. V-notch adjustable weirs should be supplied for this purpose. The height of the overflow pipes should be adjustable. Use adjustable bell weirs or telescoping valves for this purpose. If odor control measures required enclosing the overflow box, safety concerns must be properly addressed.

- **Hot Digested Sludge Loop** - A loop should be provided to bring digested sludge back to the thickener pump suction and discharge lines that feed the particular digester. This loop prevents the buildup of grease in the system lines. Hot loops should be valved so that any thickener can feed any digester.

- **Circular Digester Access Covers** - At least two 30 inch access covers should be located at the periphery of the digester cover. The number of periphery access manholes will depend on the size of the unit. One 48 inch opening at the center of the digester should be included. Two side access plates (side by side) at the basement pumping level above the cone should be supplied. These openings should be 36 to 48 inches. Another access cover at the top of the cone should also be provided. These openings are essential for digester cleaning and equipment and piping maintenance within each unit.

- **View Ports** - Ports are usually not useful and should not be provided unless needed for some special purpose.

- **Decanting Lines** - Decanting of sludge supernatant can be helpful in reducing sludge volume. Some form of decanting should be provided in secondary digesters and storage tanks. Because the clear supernatant is often at intermediate levels the ability to decant from any of several levels in the tank is desirable.

DIGESTER GAS SYSTEMS

- **Vacuum\Pressure Reliefs with Flame Arrestor** - All digester roofs must be equipped with these safety devices. Two are recommended with one out for maintenance. The units must be valved in such away that one is always active (consider an interlocked valve system).

- **Gas Withdrawal** - Digester gas should always be withdrawn from the highest point on the digester roof to reduce the possibility of foam clogging the line. Flame arrestors used on the gas line should not be placed close to the withdrawal point where they could clog if foaming occurs. Fittings for flushing the line when foaming occurs should be placed at strategic locations in the gas withdrawal line.

- **Digester Mixing** - Gas mixing or high volume pump mixing are normally preferred over mechanical mixers. Some high volume, low maintenance gas mixing systems currently on the market look promising.

- **Buried Pipe** - Buried pipes should be avoided. Gas piping should be readily accessible.

- **Indoor Gas Piping** - Piping runs indoors in operating areas should be avoided to minimize explosion proof wiring requirements and to maximize safety.

- **Gas Piping** - All lines should be adequately pitched and have no inaccessible low spots. Large drip pots should be located before and after all gas meters. Properly sized drip pots should be located at all low spots after the gas meter.

- **Sampling Cock** - Spring loaded sampling cocks should be installed on the gas line from each digester to permit safe and easy sampling for gas quality.

- **Waste Gas Burners** - Natural gas or propane are recommended for pilot ignition of the burner. The severe conditions in the waste gas burner system require ignition systems to be of the most rugged available design to withstand the burner temperatures during prolonged burner operation and to operate the burners intermittently on a short term basis, as is normally the case.

- **Gas Compressors** - Gas compressors should be hermetically sealed. Externally packed stuffing boxes should be avoided.

- **Gas Compressor Discharge Header** - Compressor discharge piping should provide flexibility of operation and should not be dedicated to any one piece of equipment (i.e. boiler, engine).

- **Compressor Location** - All compressors should be installed in a separate, well-lit and ventilated room with appropriate safety devices and alarms.

- **Gas Scrubber** - All digester gas systems should be provided with a gas scrubber system to protect equipment utilizing the digester gas.

V - DESIGN ELEMENTS COMMONLY OMITTED OR NOT ADDRESSED PROPERLY

MECHANICAL EQUIPMENT (GENERAL)

- Design should include devices and accommodation for lifting equipment from the working location to a point where transport methods can be used for equipment removal to the maintenance shop.

SUMP PUMPS

- Duplex sump pump units should always be provided.
- They should be provided optimally every 100 ft. apart, if larger sump pits are possible, a greater distance between sump pump installations can be considered, dependent on floor pitch.
- In galleries, sloped floors and gutters are preferred to floor drain systems for ease of maintenance.
- Hose stations should be provided every 50 ft. with 50' of hose. This allows reasonable overlap.
- Sump pumps should have a free discharge into an open channel and should only discharge into a pressure line if free discharge is not possible.
- Provide audio\visual alarms signaling pump failure, floor flooding conditions and high water level in sump.
- Discharge pipe runs should be as short as possible.
- Eyehooks and\or other lifting devices should be installed over the pumps for lifting and servicing the pump. Ease of access should be provided for cleaning the sump.

MOTOR CONTROL CENTERS

- Must always be located above potential flood levels and never below conduits or machinery carrying liquids.
- Specify safety mats at all panels and motor control centers.
- Metering- all motor control centers should be provided with voltage, amperage, watthour, and run time meters.
- Alternate sequential critical equipment components in different motor control centers in case one motor control center is not available due to failure, fire or shorting out. For

example, if there are four main influent pumps, place the controls for two pumps in one MCC and the controls for the other two pumps in another MCC. This applies to lighting panels as well.

SAFETY SHOWERS

- Eyewash and cleanup sinks - In addition to providing showers and eyewash at chemical handling areas, eyewash and cleanup sinks must be provided in all areas that handle sludge, grit, scum, and screenings. For long galleries or large areas, more than one location should be considered.

CHEMICAL DRAINS

- Chemical drains must be of chemical resistant material and should pass through neutralization prior to discharge into any common drain
- Separate drain systems and neutralization tanks should be provided for acidic and basic chemicals when both are used in a plant.

CHEMICAL LINES

- Provide adequate protection for chemical lines so that if they rupture they will not spray on personnel, equipment, piping, or electrical conduit. Lines routed through the facility should be placed in recessed troughs in concrete floors and adequately covered with secured and sealed noncorrosive plates. Run off from this trough should be directed to chemical sump pumps. Doubled-walled pipe with leak detection should be used if lines must be run near or over personnel or equipment.

PUMP MAINTENANCE

- The unit must be readily removed to the shop. There must be ease of access around equipment to facilitate corrective and preventive maintenance and operational activities. Suitable seal water drains must be provided so seal water runs to gutters, sumps or floor drains. Valves and fittings must be provided to conveniently catch oil drained from pump bearing housings or gear reducer, so it does not go on floor during preventive maintenance activities. Hot water for

PUMP MAINTENANCE (CONTINUED)

cleanup must be provided for pumps handling sludge, scum or grit. The floor must be pitched properly to drains or gutters. The pump must be on a personnel working-level pedestal for ease of maintenance and to prevent damage during washdown activities. Lighting must be adequate to facilitate corrective and preventive maintenance as well as operational activities.

PROCESS AND WATER PIPING REQUIREMENTS (GENERAL)

- All process and water piping should contain isolation valving at all tees, wyes, branches, etc. to preclude a system shutdown requirement during repairs on only one branch. Each piece of process equipment must be valved for isolation such that work on the one piece does not require the shutdown of an entire bank or system.

SPECIFICATIONS

- Ensure that adequate but not superfluous spare parts are provided.
- Ensure that adequate provisions are made for fitting out the facility with maintenance and support vehicles, tools, lubricants, supplies, maintenance equipment, operation support equipment (i.e drain cleaning equipment, portable pumps, steam gennies).
- Specifications for comprehensive vendor O & M manuals must be provided.
- Specifications for comprehensive vendor training must be provided.
- Adequate safety equipment and supplies must be provided, so that operations can safely begin immediately on occupancy.
- Adequate equipment for building maintenance must be provided, including floor washing machines, window washing equipment etc., and for landscaping including mowers, trimmers, snow removal gear, sweepers, etc.
- Laboratory equipment, furniture and supplies should be specified.
- Furniture and office supplies should be specified for the facility.

MAINTENANCE ACCESS PLATFORM

- Where there is equipment that requires routine access at a high level off the ground for both operational and maintenance activities (e.g. grit and scum equipment, conveyors, large pumps and motors, flowmeters, storage hoppers, activated carbon units) maintenance platforms must be provided.

AIR DRIVEN TOOLS AND EQUIPMENT

- A facility wide air source should be considered for the operation of air driven tools and equipment. Use of air driven tools can make maintenance activities in wet or explosion-proof areas safer, simpler, and more efficient

PIPING

- Provide a valve and a blind flange at any locations where future connections (as for expansion) may be necessary.
- Sludge, grit and scum pipelines must be laid out to minimize turns and bends.
- Tees, double tees and blind flanges on grit, scum and sludge lines and suction and discharge piping should be fitted with gate valves to allow access for flushing, ridding or sampling and inspections.
- As a rule, scum and grit piping should not be less than 4" in pressure conduits and no less than 8" for gravity lines. Sludge piping (primary, thickened or digested sludge) should be no less than 6" for pressure conduits and no less than 8" for gravity lines.
- Sludge, scum and grit lines should be as short as possible. If this is not possible pigging stations and\or high pressure hot or cold water flushing connections should be considered.
- Venting systems should be provided for gravity lines, particularly at all low spots.

FLOW DISTRIBUTION SPLITTER BOXES

- Because they split flow simply, efficiently and accurately, the use of flow distribution boxes is recommended throughout the plant, even though some energy may be sacrificed to provide adequate head. The boxes should be fitted with v adjustable weirs (preferably V-notch for greater accuracy in flow splitting). This will insure consistent distribution and loading for all process units with minimal operator attention required. Unit isolation and maintenance access must be include in the design.

FLOW METERING

- The use of visible flow measuring metering devices should be maximized for simplicity of plant operations. Flat and V- notch weirs and Parshall Flumes should be used wherever possible in open channels. These devices must be easily accessed to facilitate the checking of flow readings by manual measurements. More complex flow devices should only be used where a high degree of accuracy is necessary (e.g. Main Sewage Flow).

POTABLE WATER

- If low water pressure is anticipated in area servicing the plant, booster pumps should be installed to provide the required pressure and volume necessary throughout the plant. Make-up tanks and emergency storage tanks should also be considered.
- Where possible two separate water mains from two different supply sources are recommended.
- The potable water system should be a loop system containing sectional isolation valves arranged in a manner that permits tie-in and cross feeding flexibility.
- It is desirable to have water meters on all branches coming off the loop. This is important for monitoring water use during drought conditions.
- Water meters should be located within a building,if possible. If this is not feasible, easily-accessed meter chambers should be provided. These pits should be well lit, ventilated and have a convenient means of drainage.

POTABLE WATER (CONTINUED)

- As indicated elsewhere in this document, sufficient numbers of hose stations for tank washdown and housekeeping purposes are required.
- Convenient hose stations with hot and cold water should be provided at all pump stations (e.g grit, screening, grease and, sludge handling locations).
- Hose stations for washdown purposes throughout the plant should be well thought out in the design so that personnel can perform both operation and maintenance tasks in an efficient manner (e.g. a hose station for tank washdown should be located close by the cross collector sumps, other examples can be found previously throughout this text).
- A water conditioning system most be provided for heating systems and boiler make up systems to control corrosion.
- Potable water should be used for equipment seal water; well-screened plant effluent water is acceptable only as a backup during drought or emergency conditions.
- Dual reduced pressure type backflow preventers (to insure source protection during backflow device maintenance) are to be provided to meet code requirements. The pressure loss across a backflow preventer must be considered in the design.
- All piping subject to freezing should be insulated and heat traced. Piping should be jacketed in all interior areas to prevent sweating and provide protection from accidental impact.

PLANT EFFLUENT WATER

- Plant effluent water may be used for various applications, including main sewage pump ring flush, aeration and scum spray water, process dilution water (i.e. chlorination), air conditioning and for flushing out and cleaning pipelines and major process units and tanks.
- Plant effluent water should never be used for a source of washdown water in an enclosed area such as a pump gallery for health and safety reasons. Potable water should be used exclusively for this purpose.
- During periods of primary-only treatment, emergencies and construction potable water should be available as a backup supply source.

PLANT EFFLUENT WATER (CONTINUED)

- Duplex basket strainers should be provided to strain final effluent. The basket element should be No. 316 Stainless Steel and the strainer constructed for severe service. If a single strainer is provided, a bypass is necessary.
- "Self Cleaning" strainers are strongly recommended. Automatic, self cleaning strainers will greatly reduce the labor required to keep strainers flowing and in service.
- The strainer should be located in a well lit, easily accessible area and a means of servicing and dismantling the strainer should be provided.
- Where possible do not exceed a strainer size of 12" for ease of handling during maintenance and operation. When more than one strainer is required, provide a battery of 12" strainers. If this is not possible then provide the larger duplex strainer.
- It is desirable to provide pressure gauges on the inlet and outlet of the effluent water strainers.