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PLANT SOLID WASTE TREATMENT AND DISPOSAL SYSTEMS

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Project Standards and Specifications cover the minimum requirements for the process design and engineering of plant solid waste treatment and disposal facilities in Oil and Gas Processing Industries. This Engineering Standard does not deal with the disposal systems and treatment facilities pertaining to the air pollution aspects and covers only the water pollution features.

As far as Environmental Regulations are concerned, extent of application of all systems, facilities and/or methods as outlined in this Standard Specification shall be instructed by the Company for each project.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

<u>Text Book</u> : “Waste Water Engineering, Treatment And reuse” 4th Ed. 2003 METCALF & EDDY, INC.

DEFINITIONS AND TERMINOLOGY

For definition of the particular terms/words of this Standard Specification, reference should be made to the latest revision of the following tandards/publications:

API Vol. 1, "Manual on Disposal of Refinery Wastes, Volume on Liquid Wastes"

SYMBOLS AND ABBREVIATIONS

SYMBOL/ABBREVIATION	DESCRIPTION
BOD_5	The 5 Day Biochemical Oxygen Demand at 20°C.
BS&W	Basic Sediment and Water.
COD	Chemical Oxygen Demand.

DN	Diameter Nominal, (mm).
DO	Dissolved Oxygen.
EPA	Environmental Protection Agency.
l/s	Liter per second.
m	Meter.
OGP	Oil, Gas and Petrochemical.
PFRP	Process to Further Reduce Pathogens.
ppmm	Parts per million by mass, (mg/kg) and/or (mg/l) in case of water.
PSRP	Process to Significantly Reduce Pathogens.
r/min (rpm)	Rotations per minute.
SS	Suspended Solids.
TDS	Total Dissolved Solids.
TS	Total Solids.

UNITS

This Standard is based on International System of Units (SI) except where otherwise specified.

BASIC CONSIDERATIONS

Classification

Solid wastes include those suspended in liquids and are classified in the following categories in the order of increasing difficulty in disposal:

a. Inert dry solids, e.g., trash, silt, spent cracking catalyst.
b. Combustible dry solids, e.g., trash, waste paper, scrap lumber.
c. Sludges containing water and solids, e.g., water softener sludges, sanitary sludges
d. Sludges containing oil, e.g., spent clays.
e. Sludges containing oil, water, and solids, e.g., tank bottoms, oil-water separator bottoms.

Methodology

For proper evaluation and selection of solid waste disposal the following procedures shall be performed:

a. Tabulation of sources
b. Sludge production rates and quantities.
c. Physical characteristics such as pumpability, concentration factor, etc.
d. Analyses for water, oil and solids contents, volatiles, and ash.
e. Analyses of the water component for pH, sulfide, acidity or alkalinity, lead, and other constituents having potentially significant effects on water pollution.
f. Analyses of the solids component for combustible and non-combustible content and for size distribution of the dry solids.
g. Heating value of sludge (on dry basis).

Sources

1. Solids in the crude oil supply

   All crude oils contain some basic sediment and water (BS &W) which is generally composed of a mixture of water, iron rust, iron sulfides, clay, sand, and so forth produced with the crude oil or picked up in transit. Part of the BS &W is charged to the crude oil Unit and may settle out in the desalter, entering the oily water sewer system along with the desalter effluent. The balance will settle out in storage tanks, resulting in eventual tank-cleaning problems.

2. Solids from surface water

   Process waters and all other special drainages throughout the plant/refinery shall be isolated from surface run-off. The surface drainage shall be collected in a dedicated and separate clean storm water sewer system. Extensive efforts shall be made to the segregation of the surface drainages and avoiding the contamination or mixing with the oily water sewers.

3. Solids in the water supply

   Silt may enter in the water supply. Depending on the source of the supplied water to the plant/refinery and the characteristics and impurities, provision of sedimentation before the water is used shall be investigated. Special attention shall be made to the reducing of deposition of solids in cooling tower basins, heat exchangers and other consumers and, also to prevent these solids from entering oily water sewers.

4. Sanitary solid wastes

   Sanitary wastes should be segregated from all other types of drainage systems.

5. Solids and sludges in waste water systems

   According to the type of plant and the method of plant operation, the sources of solids in a waste water treatment plant can be realized. The principal sources of solids and sludge and the types generated in a conventional waste water treatment plant is demonstrated in Table A.1 of Appendix A. Solids may also be formed by interaction of waste streams in the sewer. Wastewaters contain metal ions, such as iron, aluminum, copper; magnesium and etc. from corrosion of the process equipment, chemicals used in treating cooling water, salts in the water intake, and chemicals used in processing. Insoluble metal hydroxide floc may be formed when alkaline wastes are discharged and raise the pH of waste water above neutral. The wastes containing a considerable concentrations of phenols, sulfides, emulsifying agents and alkalines shall be segregated. In general discharging of any material to the oily sewer system or other drainage systems should be investigated for the final waste treatment and disposal targets.

6. Catalytic processes catalysts

   Catalyst can be appeared in the sewer systems in the plants with catalytic processes applications. Means shall be provided to minimize catalyst disposal. Hopper trucks or covered portable containers shall be provided to prevent catalyst fines from becoming airborne. In some cases spent catalyst is slurred with water and pumped directly to ponds where the solids are settled. Spent solid catalysts which contain, platinum or other valuable metals shall be returned to the manufacturer for recovery.

7. Solids from coking operations

   a. Coke fines

      Water used to remove coke from coke chambers in delayed coking Units shall be recirculated through a settling basin to remove entrained coke fines. The basin can be located near the coke storage pile so that storm water will drain through the basin to recover coke washed from the storage area. To clean the basin, coke can be transferred directly to the storage pile with appropriate equipment.

b. Wax tailings

   Wax tailings from coking processes present a very difficult disposal problem in the sewer systems. Wax tailings disposal to the oily sewer system shall be avoided. Wax deposits may form to clog the oily water sewer or to reduce the capacity of the oil water separators. In some cases, the wax tailings will rise and be partially absorbed in the oil layer, causing slop oil treating problems. Investigations shall be made to provide facilities to remove wax tailings before discharging to the sewer system. The coker blowdown system may include a scrubber in which a light oil, such as light cycle oil is recirculated to dissolve wax tailings and remove them from the water. When the API gravity of the light oil has reached a certain point, the oil shall be returned to the hot-oil system via the fractionator and be replaced by a new charge.

8. Particulate matter and fly ash

   Particulate matter from collectors is sometimes commercially valuable either directly or after further treatment. Therefore, special attention shall be made to collect the particles for reuse purposes such as:
   - Addition to concrete in small amount;
   - Using as constituent of clay bricks;
   - Using as a soil conditioner.

9. Cleanout wastes

   Solids from cleanout operations contain normally a considerable amounts of various metals and should not be sent to the oily water system.

10. Other sources

   Other sources of the solid wastes such as the following shall be taken into consideration:
   - Storage tank drains.
   - Process Unit drains.
   - Catalyst contaminated streams.
   - Others.

Characteristics

The characteristics vary depending on the origin of the solids and sludge, the amount of aging that has taken place, and the type of processing to which they have been subjected. Some of the physical characteristics of sludges are summarized in Tables B.1, B.2, and B.3 of Appendix B.

Quantities

The quantity of solids entering the waste water treatment plant is fluctuated over a wide range. To ensure capacity capable of handling these variations, the following factors shall be taken into consideration:

a. The average and maximum rates of sludge production.
b. The potential storage capacity of the treatment Units within the plant.
c. Capabilities to dump short-term peak loads (e.g., by sufficient capacity of equalization basin).

Data on the quantities of sludge produced from various processes and operations and also sludge concentrations are shown in Table C.1 of Appendix C

SLUDGE HANDLING, TREATMENT AND REUSE

General

In selecting the appropriate methods of sludge processing, reuse, and disposal, special consideration must be given to the regulations controlling the disposal of sludge from waste water treatment plants. The following main disposal targets shall be investigated :

- Application of sludge to agricultural and non-agricultural land;
- Distribution and marketing;
- Monofilling;
- Surface disposal;
- Incineration

The sludge processing and disposal methods are listed in Table 1(for more detail refer to Waste water Engineering Treatment Disposal, and Ruse). Thickening (concentration), conditioning, dewatering, and drying are used primarily to remove moisture from sludge; digestion, composting, incineration, wet air oxidation, and vertical tube reactors are used primarily to treat or stabilize the organic material in the sludge.

Sludge and Scum Pumping

Sludge produced in waste water treatment plants must be conveyed from one plant point to another in conditions ranging from a watery sludge or scum to a thick sludge.

For each type of sludge and pumping application, a different type of pump may be needed. The application and selection of the various types of sludge pumps are summarized below

Table 1 - Sludge-Processing and Disposal Methods

UNIT OPERATION, UNIT PROCESS, OR TREATMENT METHOD	FUNCTION
Pumping	Transport of sludge and liquid biosolids
Preliminary operations	
Grinding operations	Particle Size reduction
Screening operations	Removal of fibrous materials
Degritting operations	Grit removal
Blending operations	Homogenization of solids stream
Storage operations	Flow equalization
Thickening operations	
Gravity thickening	Volume reduction
Flotation thickening	Volume reduction
Centrifugation	Volume reduction
Gravity belt thickening	Volume reduction
Rotary drum thickening	Volume reduction
Stabilization	
alkaline stabilization	Stabilization
Anaerobic digestion	Stabilization, mass reduction
Aerobic digestion	Stabilization, mass reduction
Composting	Stabilization, product recovery
Conditioning	
Chemical conditioning	Improve dewaterability
Other conditioning methods	Improve dewaterability
Dewatering	
Centrifuge	Volume reduction
Belt-filter press	Volume reduction
Filter press	Volume reduction
Sludge drying beds	Volume reduction
Reed beds Reed	Storage, volume reduction
Lagoons	Storage, volume reduction
Heat Drying	
Direct dryers	Weight and volume reduction
Indirect dryers	Weight and volume reduction
Incineration:	
Multiple-hearth incineration	Volume reduction, resource recovery
Fluidized-bed incieneration	Volume reduction
Coincineration with solid wastes	Volume reduction
Application of biosolids to land:	
Land application	Beneficial use, disposal
Dedicated land disposal	Disposal, land reclamation
Landfilling	Disposal
Conveyance and storage	Solid transport and storage

1. Types and selection

   a. Plunger pump

      Plunger pumps have been used frequently and, if rugged enough for the service, have proved to be quite satisfactory. The advantages of plunger pumps are as follows:

      i) Pulsating action of simplex and duplex pumps tends to concentrate the sludge in the hoppers ahead of the pumps and resuspend solids in pipelines when pumping at low velocities.
      ii) They are suitable for suction lifts up to 3 m and are self priming.
      iii) Low pumping rates can be used with large port openings.
      iv) Positive delivery is provided, unless some object prevents the ball check valves from seating.
      v) They have constant but adjustable capacity, regardless of large variations in pumping head.
      vi) High discharge heads may be provided.
      vii) Heavy solids concentrations may be pumped if the equipment is designed for the load conditions.

      The range of plunger pumps capacities are from 2.5 to 3.8 L/s per plunger and they are supplied with one, two, or three plungers (called simplex, duplex, or triplex units).

      Pump speeds should be between 40 and 50 r/min (rpm). The pumps should be designed for a minimum head of 24 m in small plants and 35 m or more in large plants because of accumulations of grease in sludge lines cause a progressive increase in head with use.

   b. Progressive cavity pumps

      The progressive cavity pumps are normally used for all types of sludges. The pump is selfpriming at suction lifts up to 8.5 m, but it must not be operated dry because it will burn out the rubber stator. It is available in capacities up to 75 L/s and may be operated at discharge heads of 137 m on sludge. For primary sludges, a grinder normally precedes these pumps. The pumps are expensive to maintain because of wear on the rotors and the stators, particularly in primary sludge-pumping applications where grit is present. Advantages of these pumps are:

      - Easily controlled flow rates;
      - Minimum pulsation; and,
      - Relatively simple operation.

c. Centrifugal pumps

Centrifugal pumps of non-clog design are commonly used. The selected pumps must have sufficient clearance to pass the solids without clogging and have a small enough capacity to avoid pumping a sludge diluted by large quantities of waste water overlying the sludge blanket. Throttling the discharge to reduce the capacity is impractical because of frequent stoppages; hence, it is absolutely essential that these pumps be equipped with variable-speed drivers. For pumping primary sludge in large plants, centrifugal pumps of special design-torque flow, screw feed and bladeless should be used. Screw feed and bladeless pumps have not be used very much in recent applications because of the successful use of torque-flow pumps.

Torque-flow pumps have fully recessed impellers and are very effective in conveying sludge. The size of particles that can be handled is limited only by the diameter of the suction or discharge openings. Pumps used in sludge service should have nickel or chrome abrasion resistant volute and impellers. The pumps can operate only over a narrow head range at a given speed, so the system operating conditions must be evaluated carefully. Variable speed control should be used where the pumps are expected to operate over a wide range of head conditions. For high pressure applications, multiple pumps may be used and connected together in series. For returning activated sludge to the aeration tanks, slow speed centrifugal, mixed flow pumps and screw pumps are commonly used.

d. Diaphragm pumps

Diaphragm pumps are relatively low capacity and low head

e. High pressure piston pumps

High pressure piston pumps are used in high pressure applications such as pumping sludge long distances and are very expensive. Several types of piston pumps have been developed for high pressure applications and are similar in action to plunger pumps. Advantages of these types of pumps are:

- They can pump relatively small flowrates at high pressures, up to 13800 kPa (ga),
- Large solids up to the discharge pipe diameter can be passed,
- A range of solids concentrations can be handled, and,
- The pumping can be accomplished in a single stage.

f. Rotary-lobe pumps

Rotary-lobe pumps are positive displacement pumps in which two rotating, synchronous lobes push the fluid through the pump. Rotational speed and shearing stresses are low. For sludge pumping, lobe shall be made of ard metal or hard rubber. The advantage is that lobe replacement is less costly than rotor and stator replacement for progressive cavity pumps. Rotary-lobe pumps, like other positive isplacement pumps, must be protected against pipeline obstructions**.**

2. Application of pumps to types of sludge

Types of sludge that are pumped include primary, chemical, and trickling-filter sludges and activated, thickened, and digested sludges. Scum that accumulates at various points at a treatment plant must also be pumped. The application of pumps to types of sludge is summarized in Table 2 (for more detail refer to Waste water Engineering Treatment Disposal, and Ruse).

Table 2 - Application of Pumps to Types of Sludge

TYPE OF SLUDGE OR SOLIDS	APPLICABLE PUMP	COMMENT
Ground screenings	Pumping screenings should be avoided	Pneumatic/steam ejectors may be used.
Grit	Torque-flow centrifugal	The abrasive character of grit and the presence of rags make grit difficult to handle. Hardened casings and impellers should be used for torque-flow pumps. Pneumatic/steam ejectors may also be used.
Scum	Plunger; progressive cavity; diaphragm; centrifugal	Scum is often pumped by the sludge pumps; valves are manipulated in the scum and sludge lines to permit this. In larger plants, separate scum pumps are used. Scum mixers are often used to ensure homogeneity prior to pumping. Pneumatic/steam ejectors may also be used.
Primary sludge	Plunger; centrifugal; torque-flow diaphragm; progressive cavity; rotary-lobe; copper; hose	In most cases, it is desirable to obtain as concentrated a sludge as practicable from primary sedimentation tanks, usually by collecting the solid in hoppers and pumping intermittently, allowing the solid to collect and consolidate between pumping periods. The character of untreated primary solid will vary considerably, depending on the characteristics of the solids in the wastewater and the types of treatment Units and their efficiency. Where biological treatment follows, the quantity of solids from: 1) Waste activated sludge, 2) humus sludge from settling tanks following trickling filters, 3) overflow liquors from digestion tanks, and, 4) Centrate or filtrate return from dewatering operations will also affect the sludge characteristics. In many cases, the character of the sludge is not suitable for the use of conventional nonclog centrifugal pumps. Where sludge contains rags, chopper pumps may be used.
sludge from Chemical Precipitation	Same as for primary sludge	May contain a large amount of inorganic constituents depending on the type and amount of chemicals used.
Trickling-filter humus	Nonclog and torque-flow centrifugal; progressive cavity; plunger; diaphragm	Humus is usually of homogeneous character and can be easily pumped.
Return or waste activated sludge	Nonclog and torque-flow centrifugal; progressive cavity; diaphragm	Sludge is dilute and contains only fine solids so that nonclog pumps may be used. For nonclog pumps, slow speeds are recommended to minimize the breakup of flocculant particles.
Thickened or concentrated sludge	Plunger, progressive cavity; diaphragm; high-pressure piston; rotary-lobe; hose	Positive displacement pumps are most applicable for concentrated sludge because of their ability to generate movement of the sludge mass. Torque-flow pumps may be used but may require the ddition of flushing or dilution facilities.
Digested biosolids	Plunger; torque-flow; centrifugal; progressive cavity; diaphragm; high-pressure piston; rotary-lobe	Well-digested biosides are homogeneous, containing 5 to 8% solids and a quantity of gas bubbles, but may contain up to 12% solids. Poorly digested sludge may be difficult to handle. If good screening and grit removal is provided, nonclogy centrifugal pumps may be considered.

Sludge Piping

1. In treatment plants, conventional sludge piping should not be smaller than DN 150 (6 inch), although smaller diameter glass-lined pipes have been used successfully.
2. Pipe sizes need not be larger than DN 200 (8 inch) unless the velocity exceeds 1.5 to 1.8 m/s, in which case, the pipe shall be sized to maintain the velocity. Gravity sludge withdrawal lines should not be less than DN 200 (8 inch) in diameter.
3. A number of cleanouts in the form ofplugged tees or crosses instead of elbows shall be installed so that the lines can be rodded if necessary.
4. Pump connections should not be smaller than DN 100 (4 inch) in diameter
5. Pump selection shall consider build-up ofhead due to grease accumulations at the inside of piping. In some plants provisions may also be made for melting the grease by circulating hot water, steam or digester supernatant through the main sludge lines.
6. In the design of long sludge lines, special design features should be considered including:
   a. Providing two pipes unless a single pipe can be shut-down for several days without causing problems;
   b. providing for external corrosion and pipe loads;
   c. adding facilities for applying dilution water for flushing the line;
   d. providing means to insert a pipe cleaner at the treatment plant;
   e. including provisions for steam injections;
   f. providing air relief and blow-off valves for the high and low points, respectively; and,
   g. considering the potential effects of waterhammer.

Preliminary Operation Facilities

Sludge grinding, degritting, blending, and storage are necessary to provide a relatively constant, homogeneous feed to sludge processing facilities. Blending and storage can be accomplished either in a single Unit designed to do both or separately in other plant components.

1. Sludge grinding

   Some of the processes that must be precededby sludge grinders for the purpose of preventing clogging are

   a. Pumping with progressive cavity pumps;
   b. Solid bowl centrifuges ;
   c. Belt-filter press;

   Slow speed, more durable and reliable grinders shall be applied. The design shall include mproved bearings and seals, hardened steel cutters, overload sensors, and mechanisms that reverse the cutter rotation to clear obstructions or shutdown the Unit if the obstruction can not be cleared.

2. Sludge screening

   Because row wastewater screens can allowsignificant of solids to pass through, sludge screening is alternative to grinding. Screening is advantageous in that nuisance material is removed from the solid stream. Types of screens are:

   a. Step screens can be used for the removal of fine solids from septage, primary sludge, or biosolids. Screen openings normally range from 3 to 6 mm (0.12 to .24 in), although openings up to 10mm (0.4 in) can be used.
   b. In-line screen that can be installed in a pipeline. The screen removes material by passing the flow screen through a screen with 5 mm (0.2 in) openings.

3. Sludge degritting

   In some plants where separate grit removal facilities are not used ahead of the primary sedimentation tanks or where the grit removal facilities are not adequate to handle peak flows and peak grit loads, the grit removal facilities should be provided before further processing of the sludge. Where further thickening of the primary sludge is desired, a practical consideration is sludge degritting. The most effective method of degritting is through the application of centrifugal forces in a flowing system to achieve separation of grit particles from the organic sludge. Such separation is achieved through the use of cyclone degritters, which have no moving parts. The efficiency of the cyclone degritter is affected by pressure and by the concentration of the organic in the sludge. To obtain effective grit separation, the sludge must be relatively dilute. As the sludge concentration increases, the particle size that can be removed decreases.