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03 October 2019
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UNIFIED FACILITIES CRITERIA (UFC)

OPERATION AND MAINTENANCE (O&M): WASTEWATER TREATMENT

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Indicate the preparing activity beside the Service responsible for preparing the document.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location
1	01 April 2024	Updated non-unified references and added sewer inspecting and cleaning guidance in Appendix A.

This UFC supersedes UFC 3-240-03N, dated January 2004.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale may be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide website https://www.wbdg.org/ffc/dod.

Refer to UFC 1-200-01, *DoD Building Code (General Building Requirements)*, for implementation of new issuances on projects.

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UNIFIED FACILITIES CRITERIA (UFC)
REVISION SUMMARY SHEET

Document: UFC 3-240-03, *Operation and Maintenance (O&M) Wastewater Treatment*

Superseding: UFC 3-240-03N, Wastewater Treatment System Augmenting Handbook Operation and Maintenance, dated January 2004

Description: UFC 3-240-03 provides technical requirements and guidance for the operation and maintenance of wastewater treatment systems.

Reasons for Document:

- The new UFC updates technical requirements and increases the use of industry standards.
- The majority of existing criteria was outdated and needed a major revision.

Impact:

- This update revises an existing Navy only UFC and unifies wastewater treatment operation and maintenance criteria across DoD. This operation and maintenance criteria will assist owners and operators with maintenance and operation of wastewater treatment systems and provide increased guidance.

Unification Issues:

AIR FORCE

- AFH 32-1290 provides additional requirements for cathodic protection systems.
- **\1** AFMAN 32-1062 provides additional requirements for electrical systems, power plants, and generators. **/1/**
- **\1\ /1/**
- **\1** AFMAN 32-1067 provides further guidance water and fuel systems requirements and reporting. **/1/**
- **\1** AFMAN **/1/** 32-1068 provides further guidance on boiler personnel schedule requirements.
- **\1\ /1/**
- AFI 32-7001 provides further guidance on reporting requirements.

ARMY

- AR 420-1 provides additional operating data requirements.

- PWTB 200-1-142 provides additional requirements for water reuse.
- TM 5-682 provides additional requirements for electrical facilities safety.
- TM 5-683 provides additional requirements for electrical interior facilities.
- TM 5-684 provides additional requirements for electrical exterior facilities.
- TM 5-685 provides additional requirements for operation, maintenance, and repair of auxiliary generators.
- PWTB 420-49-29 provides additional requirements for cathodic protection systems.
- TM 5-814-3 provides additional requirements for cold weather operation.

NAVY

- OPNAVINST 5090.1D provides Navy only requirements.
- OPNAVINST 5100.23G provides Navy only safety requirements.
- MCO P5090.2A provides Marine Corps only requirements.

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This UFC provides technical guidance and procedures for operations and maintenance (O&M) of wastewater treatment facilities.

1-2 APPLICABILITY.

This UFC applies to all service elements and contractors involved in the operation and maintenance of permanent DoD wastewater treatment plants worldwide.

1-3 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, DoD Building Code (General Building Requirements). UFC 1-200-01 provides applicability of model building codes and government-unique criteria for typical design disciplines and building systems, accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

1-4 CYBERSECURITY.

All control systems (including systems separate from an energy management control system) must be planned, designed, acquired, executed, and maintained in accordance with UFC 4-010-06, and as required by individual Service Implementation Policy.

1-5 GLOSSARY.

Appendix B contains acronyms and definition of terms.

1-6 REFERENCES.

Appendix C contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

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CHAPTER 2 REGULATORY COMPLIANCE AND MONITORING

2-1 OPERATION AND MAINTENANCE CRITERIA.

DoD wastewater systems must achieve, maintain, and monitor compliance with applicable environmental requirements and monitor these environmental requirements worldwide. Operate and maintain wastewater treatment systems in accordance with the requirements of applicable federal, state and local government agencies or overseas equivalent.

2-1.1 Within the United States.

For Installations located in the United States and its territories and possessions the wastewater system must comply with the following criteria precedence:

a. State wastewater or local regulations for the project location;

b. DoDI 4715.06;

c. Navy Only: OPNAVINST 5090.1D and MCO P5090.2A;

d. Additions to the above criteria as indicated in this UFC;

e. IPSDC;

f. WEF MOP 11; and

g. Refer to Appendix A for guidance.

2-1.2 Foreign Countries.

For Installations located outside of the United States and its territories and possessions the wastewater system must comply with the following criteria precedence:

a. The Forward of this UFC (All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA));

b. Final Governing Standards (FGS);

c. DoDI 4715.05 and DoD 4715.05-G, Overseas Environmental Baseline Guidance Document

d. Navy Only: OPNAVINST 5090.1D and MCO P5090.2A;

e. Additions to the above criteria as indicated in this UFC;

f. IPSDC;

g. WEF MOP 11; and

h. Refer to Appendix A for guidance.

2-2 FOREIGN COUNTRIES.

DoD 4715.05-G, *Overseas Environmental Baseline Guideline Document* (OEBGD), applies when there are no Final Governing Standards (FGS) in place. Therefore, in foreign countries this UFC will be used for DoD projects to the extent that it is allowed by and does not conflict with the applicable international agreements and the applicable FGS or OEBGD.

2-2.1 Wastewater Quality Standards.

DoD wastewater systems must achieve, maintain, and monitor compliance with applicable environmental requirements and monitor these environmental requirements worldwide.

2-3 SAFETY.

All DoD facilities must comply with DoDI 6055.1, DoDI 4715.1E, and applicable Occupational Safety and Health Administration safety and health standards.

For the Navy, also use OPNAVINST 5100.23G.

2-4 PLUMBING.

UFC 3-420-01 adopted the use of the International Plumbing Code (IPC) to comply with Public Law 104-113. Refer to UFC 3-420-01 for modifications to the IPC.

2-5 OPERATING REQUIREMENTS.

Wastewater treatment plant systems must operate within their approved permits and with federal, state, and local requirements or overseas equivalent. Operations and management staff at wastewater treatment plants (WWTP) are expected to understand, comply with these requirements and inform the Installation Environmental Program staff of any problems that may affect compliance.

2-5.1 Recordkeeping.

Equipment maintenance and repairs records are used for maintenance planning and scheduling to ensure that each piece of equipment is properly maintained to ensure it is reliable for the wastewater treatment process. All maintenance and repairs for each piece of equipment must be captured in a formal method to allow for an operator in the future to review the equipment history. The most common and effective way is to use a computerized maintenance management system.

The records for each piece of equipment can be used to make decisions on the repairs and replacement of the equipment. Such decisions look at the age of the equipment, the amount of time spent maintaining and repairing the equipment, and the cost of repairing and maintaining the equipment.

2-6 PERMITS.

Permits are issued for the construction, modification, discharge of treated effluent, discharge of stormwater runoff, and solids management practices. These permits may be issued by the Environmental Protection Agency (EPA), state, and local governments. In some cases, permits may be required from all three levels of government. Coordinate with the Installation Environmental Program staff during the permitting process.

2-6.1 Federal Permit Requirements.

Permits under Part 503.3(a), the requirements in Part 503 may be implemented through:

a. permits issued to treatment works treating domestic sewage by EPA or by states with an EPA approved solids management program; and

b. permits issued under Subtitle C of the Solid Waste Disposal Act; Part C of the Safe Drinking Water Act; the Marine Protection, Research, and Sanctuaries Act of 1972; or the Clean Air Act.

Treatment works treating domestic sewage submit a permit application to the approved state program, or, if there is no such program, to the EPA Regional Sludge Coordinator. Direct Enforceability under Part 503.3(b), the requirements of Part 503 automatically apply and are directly enforceable even when no permit has been issued.

2-6.2 National Pollutant Discharge Elimination System.

Code of Federal Regulations (CFR), Section 40, Part 122 describes the National Pollutant Discharge Elimination System (NPDES) permitting program. The NPDES permit program has separate regulations found in 40 CFR 125, 40 CFR 129, 40 CFR 133, 40 CFR 136, 40 CFR 400 through 460, and 40 CFR 503. When the EPA has designated authority to an individual state, Federal law allows these individual states to have more stringent requirements. WWTP owners or owner’s designated representative needs to know if the EPA has delegated permitting authority to their state.

2-6.2.1 NPDES Permit Compliance.

Failing to comply with the NPDES permit may result in fines and other penalties. In some cases, it may even result in criminal prosecution. Since the NPDES program relies on self-reporting for implementation, EPA places special emphasis on timely and complete reporting. Enforcement actions are often swift and severe for being late with the monthly operating reports or for failing to report violations.

Exceedance of water quality limits will also draw regulatory attention and possible enforcement action. However, proactive planning prior to beginning the permit renewal process can reduce the likelihood of enforcement actions. In most states, the permitting agency may establish water parameters that the WWTP is not currently meeting. The permitting agency and WWTP owner or owner's designated representative should work together to determine a date when the parameter becomes effective in the future. This allows the WWTP time to upgrade or change the process to meet the parameters.

2-6.2.1.1 Negotiation of Effluent Limits.

Careful review by the discharger of the specific basis used for the water quality-based effluent limits is advisable. In many cases, the basis used in the development of the effluent limits is open to negotiation. Address effluent limits during the permit renewal process.

2-6.2.2 NPDES Permit Renewal.

NPDES permits require periodic renewal. The application and renewal of the permit is to be completed by the Installation as they may have different departments applying for permits. Permits may be modified by regulators prior to the normal permit renewal periods. Permit renewal applications need to be submitted 180 days (about 6 months) before the expiration date. If the existing permit is being violated regularly, the WWTP may need to develop a Wastewater Master Plan with a list of plant improvements and costs to bring the WWTP back into compliance with the discharge permit limits or as required by the permitting agency.

2-6.3 Operating NPDES Permit.

An operating NPDES permit is required before a WWTP can begin operating. An operating NPDES permit may include topics such as identifying the owner, describing the treatment process, describing the discharge location, frequency, and limits, and contain specific and general conditions. The owner is required to meet the discharge limits stated in the operating NPDES permit. The WWTP operator is responsible for keeping a copy of the permit on file at the WWTP. An operating NPDES permit is typically combined to contain the Federal, state, and local regulations and standards in a single document for the WWTP. In addition to treated wastewater, operating NPDES permits may address stormwater and other disposal options. When the EPA has designated authority, the state also may establish groundwater monitoring or discharge requirements. For example, disposal of treated effluent to the subsurface will require an Underground Injection Control permit from the state as required by the Safe Drinking Water Act.

Note: For the Army, AR 420-1 provides additional operating data requirements.

Note: For the Air Force, AFI 32-7001 and **\1** AFMAN **/1/** 32-1067 provide further guidance on reporting requirements.

2-6.3.1 Licensing and Staff Requirements.

The operating NPDES permit and applicable regulatory requirements determine the licensing and staffing requirements. Many states require that the chief operator be certified to complete the reports that are necessary to comply with state and federal water pollution control laws and regulations. Some facilities are required to have a certified operator on shift work when the chief operator is not on site. In some locations, all operators may require certification for the operation of a treatment plant. The EPA has stated that it would like to have all plants operated by qualified personnel; certification is a method of demonstrating an operator's level of qualification. Failure to have the correct number and level of certified operators can be considered a compliance violation.

2-6.3.2 WWTP Modifications.

An operating NPDES permit is not a construction permit. The EPA requires a modification to the operating NPDES permit when there is a significant change in the operation of the WWTP. In some states, an owner may construct or modify a facility, but it is a violation to place the modified facility in operation until a valid operating permit is obtained. Other states limit all construction activities until the changes or modifications are approved. Coordinate permit requirements with the Installation Environmental Program staff.

2-6.4 Disposal Permit Options.

Each Installation is responsible for disposal of waste such as solids, screenings, and grit in accordance with the approved WWTP permits. Treated effluent that is entirely disposed into the groundwater or onto land application sites does not need an operating NPDES permit from EPA to discharge, but it may be subject to NPDES permits for stormwater or solids.

2-6.5 Solids NPDES Permit.

Residual solids management has received special attention under 40 CFR 503. Solids management is typically addressed as part of the operating NPDES permit. However, a solids NPDES permit may still be required.

2-6.6 Stormwater NPDES Permit.

Each Installation is responsible for stormwater state management per the applicable permits. WWTPs that treat more than 1 million gallons per day (mgd) or are equal to or larger than 5 acres are included in the stormwater NPDES permitting program as a categorical industrial facility. Although stormwater could be included in the operating permit described above, many facilities obtain a general stormwater NPDES permit. This permit is maintained separately from the operating permit.

2-7 EMERGENCY REPORTING.

Emergency failures or spills typically require that the appropriate agencies be notified within 24 hours. Emergency reporting requirements should be included in the WWTP Operation and Maintenance Manual and displayed in obvious locations. Federal, State and Local governments may be involved with reporting emergency failures or spills.

2-7.1 Spill Prevention and Response Plan.

A stormwater NPDES permit typically requires best management practices and includes a spill prevention and response plan.

2-8 FACILITY OPERATION AND MAINTENANCE MANUAL.

The WWTP develops and updates the facility operations and maintenance manual. This manual includes a sapling and testing procedures required for day-to-day operations, reporting requirements, license requirements, and operating instructions (both normal operation and emergency operation). The operating instructions include single line drawings as applicable. Include maintenance and regulatory compliance requirements.

Retain shop drawings, catalogue cut sheets, and any other equipment information.

2-9 SAMPLING OF WASTEWATER.

A sampling and analysis program needs to be conducted as required by the NPDES operating permit. Typically, if a well-executed sampling plan is implemented, the process monitoring, and control program is more effective. Sampling is conducted for compliance with legal requirements, process monitoring and control, and historical data collection.

The NPDES operating permit’s effluent limits are evaluated and monitored for compliance by sampling. Each permit specifies the sampling location, type, and frequency; analyses to be performed at each sample location; and frequency of reporting the results to the regulatory agency.

2-10 REPORTS.

The WWTP owner is responsible for ensuring all reporting requirements are completed by the chief operator or designated certified operator.

2-10.1 Capacity Analysis Report.

The Capacity Analysis Report documents the predicted future flows and loads within the treatment facility and evaluates the capacity of existing unit processes to reliably treat those loads for the next permitting cycle. The historical flows and the treatment performance of the preceding 5 years need to be analyzed. The carbonaceous biochemical oxygen demand (CBOD) and total suspended solids (TSS) loading (in pounds per day) also need to be verified. Population, flow, and load projections are then made to estimate what future loads will be, based on historical growth trends. The capacity of each unit process needs to be determined. These capacity assessments may already have been done for past renewals. However, the capacity rating of each process needs to be checked against the latest loadings and flow.

Use a 5-year period for future projections. Include future projects and realignment decisions when making future projections. If the plant is undersized, an expansion needs to be initiated and a Preliminary Engineering Report for improvements developed. Higher discharge rates also will precipitate additional permit application requirements to address anti-degradation issues.

2-10.2 Operation and Maintenance Report.

The Operation and Maintenance Report reviews plant operations data over the last permit cycle to evaluate needed improvements to the facility. Any upsets or spills need to be reviewed to determine the cause and possible solution. Some water quality exceedances may be a result of operation practices and need to be reviewed. The condition of the facilities is evaluated, such as the need for painting and other routine maintenance. Some needs may require changes to the process or construction approval. However, not every maintenance item needs to be reported to the agencies. Confirmation from the agency on which items need permitting is recommended after the Operation and Maintenance Report is completed.

2-10.3 Preliminary Engineering or Feasibility Report.

Use the Preliminary Engineering or Feasibility Report when modifications to the WWTP are required. This is a preliminary design study that will outline what changes are required to attain or maintain compliance. Typically, this report will contain a summary of the future flows and loads to be treated from the Capacity Analysis Report, a review of any alternative evaluations used to select the appropriate treatment technologies, and a conceptual-level design for upgraded facilities. A professional engineer sizes and plans for appropriate process changes. The Preliminary Engineering Report is submitted as part of the permit application renewal. Some states may require final construction drawings and specifications before approving the changes, whereas others may issue a construction permit based solely on the Preliminary Engineering Report.

2-11 REPORTING REQUIREMENTS FOR SEWAGE SOLIDS.

Reporting requirements for these solids are found in Part 503.18 for land application and Part 503.28 for surface disposal. These requirements apply to Class I solids management facilities and to WWTPs with a design flow rate equal to or greater than 1 mgd or that serve 10,000 or more people. Submit to the permitting authority the records they are required to keep as “preparers” of biosolids, owner of surface disposal sites. There are no reporting requirements associated with the use or disposal of domestic septage.

2-12 OPERATOR CERTIFICATION.

Operator certification is a process by which an individual is awarded a certificate from the state water quality regulatory agency for meeting specific criteria associated with the operation of wastewater treatment plants. Most states require that the responsible wastewater treatment plant operator possess a current state operator certification for the plant to meet the state's operating permit requirements. This certification process varies from state to state. Most states have different levels of certification that depend upon plant complexity and size or individual expertise. Certification requirements are usually contained in the permit or in state regulations. Certified operators demonstrate a specific level of proficiency in their selected field.

2-12.1 Training for Certification.

Additionally, operators may be required to attend classes or obtain a required amount of training prior to obtaining certification. Operators may contact state agencies to obtain specific information about training requirements for their certification.

Note: For the Air Force, **\1** AFMAN **/1/** 32-1067 provides additional requirements regarding operator training and certification.

2-12.2 Obtaining Certification.

Each state regulatory agency has a program for achieving certification. Operators should contact the state agency where the WWTP is located to obtain specific information about requirements and reciprocity programs. Although reciprocity exists between many states, certifications may not be transferable between some states. A certified operator may be able to apply for certification in other states that have reciprocity with the state issuing an operator certification. State regulatory agencies can help with reciprocity of certifications.

2-12.3 Training for Renewal of Certification.

States may require continual training by the operator to maintain their certification. Operators are required to review and complete the required amount of training to maintain their certification in the time periods set by their state regulations.

2-13 WASTEWATER REUSE.

Several states and communities are promoting the reuse of wastewater as a beneficial way of reducing both drinking water demands and wastewater discharge to the environment. The most common reuse projects involve using treated wastewater for irrigation purposes (e.g., golf courses). Other uses of water may include residential irrigation, fire protection, landscape features (e.g., ponds and fountains), and industrial supply. Generally, a project is only considered a reuse project if the reclaimed effluent replaces drinking water demand. Groundwater discharge is sometimes referred to as "groundwater recharge" and may be considered reuse if it is used to replenish the drinking water supply. However, contamination of the drinking water supply is a concern, and the discharge may have as many disincentives as incentives. Most land application projects that rely on groundwater infiltration for effluent disposal would be considered disposal projects, not reuse projects. Any disposal to natural surface waters will be considered an NPDES discharge and will be subject to all applicable rules.

2-13.1 Reuse Feasibility Study.

An engineering study is required to determine the actual water usage for a given reuse project. For example, an irrigator will not need water in wet periods or winter. The WWTP may therefore need to dispose of all its effluent for extended periods of time. The permit requirements need to be flexible to accommodate such seasonal effects. The objective of the engineering study is to determine a conceptual reuse system, including customers, available capacity, the size of the pipeline, pumps, and storage. This study is not a design-level project. Further design and permitting is required to implement a project.

2-13.2 Reuse Treatment Facilities.

Additional treatment processes may be needed to provide reuse-quality water. If there is a possibility of public contact with the water, provide high-level disinfection (<20 most probable number per 100 milliliters [mL]) for the effluent. Filtration before disinfection or discharge to an irrigation system also would be likely. If only a portion of the effluent flow is used for reuse, then these additional facilities would need to be sized accordingly and would treat only a side stream. An engineering feasibility study would need to determine the size and layout of these treatment facilities.

Note: For the Army, PWTB 200-1-142 provides additional requirements for water reuse.

2-13.3 Sludge Reuse.

Biosolids have beneficial plant nutrients and soil-conditioning properties. However, biosolids also may contain heavy metals, bacteria, viruses, protozoa, parasites, and other microorganisms that cause disease. If improperly treated and applied, they may also attract nuisance vectors such as insects and rodents. EPA actively promotes management practices that provide for the beneficial reuse of biosolids while maintaining or improving environmental quality and protecting human health. However, while the Part 503 regulations encourage the beneficial reuse of biosolids, they do not mandate it; traditional disposal methods, such as landfilling, may still be selected.

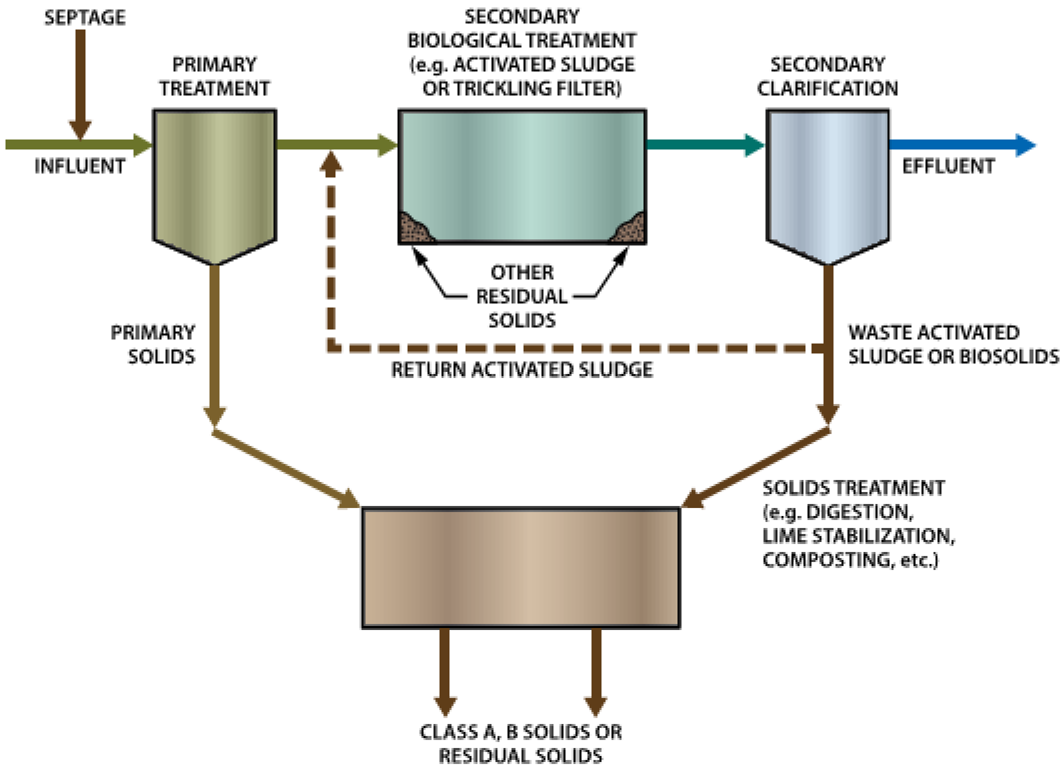
The use and disposal of biosolids, including domestic septage, are regulated under 40 CFR 503. This regulation, promulgated on February 19, 1993, was issued under the authority of the Clean Water Act, as amended in 1977, and the 1976 Resource Conservation and Recovery Act. For additional guidance on the Part 503 regulations, refer to EPA/625/R-92/013.

2-13.4 Solids Definition.

The Part 503 regulations promulgated the word “sludge” to describe a variety of solids residuals from wastewater treatment processes. The wastewater treatment industry and regulatory agencies have recently tried to minimize the use of the word “sludge” because the term is too general, and its negative connotations do not accurately reflect the industry’s goal: to promote the beneficial reuse of properly treated wastewater solids as useful soil amendments for agricultural users and the general population. In keeping with current industry practices, this document avoids the word sludge except when directly referred to in Part 503 regulations or a widely accepted process name, such as the “activated sludge process.” Figure 2-1 shows a secondary wastewater treatment plant and identifies the terminology used by industry and this document to replace the word sludge.

The primary solids referred to in Figure 2-1 are those derived from primary treatment processes. Solids drawn from the secondary treatment system are referred to as “waste activated sludge” or “biosolids.” The word biosolids refers to the residual treatment bacteria and inert solids contained in the biological treatment process. Solids that have undergone treatment for beneficial reuse generally are referred to as “residual solids” or classified according to their level of treatment, such as “Class A Solids.” In some cases, treatment facilities do not further treat primary or secondary solids and dispose of these in a permitted landfill; in this case, the residuals are referred to as “sludge,” meaning the product has not received treatment to reduce pathogens or vector attraction. The phrase “other residual solids” refers to the dense, grit-like solids that accumulate in process tanks and are removed when the tanks are periodically emptied and cleaned.

Figure 2-1 Residual Solids



2-14 PROTECTION OF PUBLIC HEALTH AND THE ENVIRONMENT.

In the judgment of the EPA administrator, Part 503 protects public health and the environment through requirements designed to reduce the potential for contact with the disease-bearing microorganisms (pathogens) and heavy metals in biosolids applied to the land or placed on a surface disposal site. These requirements are divided into the following categories:

- Requirements designed to control and reduce pathogens in solids
- Requirements designed to reduce the ability of the solids to attract vectors (rodents, birds, insects, and other living organisms that can transport solids pathogens away from the land application or surface disposal site)
- Requirements designed to limit the amount of heavy metals in solids applied to land or placed on a surface disposal site

Subpart D of Part 503 includes both performance- and technology-based requirements that aim to reduce pathogens and vector attraction. It is designed to provide a more flexible approach than Part 257, which required solids to be treated by specific listed or approved treatment technologies. Under Part 503, treatment works may continue to use the same processes they used under Part 257, but they can modify conditions and combine processes with each other if the treated solids meet the applicable requirements.

2-14.2 Pathogen and Vector Attraction Reduction.

Part 503.15 covers the applicability of the pathogen and vector attraction reduction requirements. The Subpart D requirements apply to solids (both bulk solids and solids that are sold or given away in a bag or other container for application to the land) and domestic septage applied to the land or placed on a surface disposal site. The regulated community includes anyone who generates or prepares solids for application to the land, as well as those who apply it to the land, including anyone who:

- Generates solids that are land-applied or placed on a surface disposal site
- Derives a material from solids
- Applies solids to the land
- Owns or operates a surface disposal site

2-15 LAND APPLICATION OR DISPOSAL.

Solids cannot be applied to land or placed on a surface disposal site unless they have met the two basic types of requirements in Subpart D: pathogen and vector attraction reduction requirements. These two types of requirements are separated in Part 503, which allows flexibility in how they are achieved. Demonstrate compliance with both types of requirements separately. Therefore, demonstration that a requirement for reduced vector attraction has been met does not imply that a pathogen reduction requirement also has been met, and vice versa.

2-16 PATHOGEN REDUCTION.

Sewage Sludge [503.32(a) and (b)]. The pathogen reduction requirements for sewage sludge are divided into two categories: Class A and Class B. These requirements use a combination of technological and microbiological requirements to ensure reduction of pathogens. The implicit goal of the Class A requirements is to reduce the pathogens in sewage sludge (including enteric viruses, pathogenic bacteria, and viable helminth ova) to below detectable levels. The implicit goal of the Class B requirements is to ensure that pathogens have been reduced to levels that are unlikely to pose a threat to public health and the environment under the specific-use conditions. For Class B solids that are applied to land, site restrictions are imposed to minimize the potential for human and animal contact for a period of time following land application until environmental factors have further reduced pathogens. Class B solids cannot be sold or given away in bags or other containers for application to the land. There are no site restrictions for Class A solids.

Domestic Septage [503.32(c)]. Domestic septage is a form of sewage sludge. Domestic septage is a liquid or solid material that is removed from a septic tank, cesspool, portable toilet, type III marine sanitation device, or similar system that only receives domestic septage (household, noncommercial, and non-industrial sewage). The requirements for domestic septage vary, depending on how it is used or disposed. Domestic septage applied to a public contact site, lawn, or home garden must meet the same requirements as other forms of sewage sludge. Separate, less complicated requirements for pathogen reduction apply to domestic septage applied to agricultural land, forests, or reclamation sites. These requirements include site restrictions to reduce the potential for human contact and to allow for environmental attenuation or pH adjustment with site restrictions only on harvesting crops. No pathogen requirements apply if domestic septage is placed on a surface disposal site.

2-17 VECTOR ATTRACTION REDUCTION.

Subpart D specifies 12 options to demonstrate reduced vector attraction. Eight of the options apply to sewage sludges that have been treated in some way to reduce vector attraction (e.g., aerobic or anaerobic digestion, composting, alkali addition, and drying). These options consist of operating conditions or tests to demonstrate that vector attraction has been reduced in the treated solids. Three options cover methods for injection or incorporating solids into the soil to reduce vector attraction.

One option is a requirement to demonstrate reduced vector attraction in domestic septage through elevated pH. This option applies only to domestic septage.

2-18 FREQUENCY OF MONITORING.

Sewage Sludge [503.16(a) and 503.26(a)]. The Class A and Class B pathogen requirements and the first eight vector attraction reduction options (the treatment-related methods) all involve some form of monitoring. The minimum frequency of monitoring for these requirements is given in Part 503.16(a) for land application and Part 503.26(a) for surface disposal. The frequency depends on the amount of solids used or disposed of annually. The larger the amount used or disposed of, the more frequently monitoring is required.

Domestic Septage [503.16(b) and 503.26(b)]. One of the options that can be used for demonstrating both pathogen reduction and vector attraction reduction in domestic septage is to elevate pH to >12 for 30 minutes without the addition of more alkali. When this option is used, monitor each container of domestic septage (e.g., each tank truck load) applied to the land or placed on a surface disposal site for pH.

2-19 RECORDKEEPING REQUIREMENTS.

Recordkeeping requirements are covered in Part 503.17 for land application and Part 503.27 for surface disposal. Records are required for both sewage sludge and domestic septage. Retain all records for 5 years except when the cumulative pollutant loading rates in Part 503 Subpart B (Land Application) are used. In that case, keep certain records indefinitely. Some records must be reported to the permitting authority.

- Land Application: Keep records to confirm that the solids meet the applicable pollutant limits, management practices, one of the pathogen requirements, one of the vector attraction reduction requirements, and where applicable, the site restrictions associated with land application of Class B biosolids. When bulk solids are applied to land, both the person preparing the solids for land application and the person applying them must keep records. The person applying solids that are sold or given away does not have to keep records.
- Surface Disposal: When solids are placed on a surface disposal site, the owner of the surface disposal site must keep records. In the case of domestic septage applied to agricultural land, forest, or a reclamation site or placed on a surface disposal site, the person applying the domestic septage. The owner of the surface disposal site may be subject to pathogen-related recordkeeping requirements, depending on which vector attraction reduction option was used.

Certification Statement: In every case, recordkeeping involves signing a certification statement that the requirement has been met. Parts 503.17 and 503.37 of the regulation contain the required certification language.

CHAPTER 3 WASTEWATER TREATMENT

3-1 INTRODUCTION.

For an operator to understand a wastewater treatment plant, it is important to have an accurate characterization of the wastewater influent. The wastewater characterization provides the operator with information to control the wastewater treatment processes. There are typically two types of influent water: domestic and industrial. Domestic wastewater comes from residential units such as single-family households, condominiums, apartments, cottages, or resorts. Industrial wastewater comes from non-residential sources such as institutional, commercial, or industrial facilities.

3-2 MAINTENANCE.

The maintenance requirements for preliminary treatment varies, depending on the type of equipment used. Recommended maintenance should be completed by operators and maintenance staff to maintain all warranties and performance guarantees. Refer to the equipment manufacturers operation manual and operate preliminary treatment equipment in accordance with manufacturers recommendations and all NPDES permits.

3-3 WASTEWATER INFLUENT CHARACTERISTICS.

Nonresidential sources vary, depending on the type of establishment. There are differences in waste-generating sources present, water usage rates, and other considerations. The characteristics for existing nonresidential buildings are characterized by sampling and metering the discharge wastewater. For new nonresidential establishments, use available characterization data from similar facilities. Refer to EPA/625/R-00/008 for typical loadings and concentrations.

Higher than typical ammonia influent levels may occur at some WWTPs because of water conservation programs. Higher than normal influent ammonia levels will require operational adjustments and additional process control monitoring.

3-4 PRELIMINARY TREATMENT METHODS.

The preliminary treatment processes are intended to remove large solids and abrasive material from the influent wastewater prior to damaging equipment or clogging piping. The failure of any of these units will affect downstream processes in the wastewater treatment plant. Therefore, it is important to keep the preliminary treatment units working as effectively as possible.

Refer to *Operation of Wastewater Treatment Plants*, Volume 1, Chapter 4 for additional guidance on preliminary treatment.

3-4.1 Preliminary Screening.

The screening system at a wastewater treatment plant is a system that is either machine run or a completely manual operation. The purpose of the screening system is to remove material that can damage equipment and clog piping in the wastewater treatment plant.

1-1.1.1 Screening Operation.

Manual bar screens and mechanical bars screens both operate in a manner to remove large material. Both come with different spacing between the screen's bars. The smaller the spacing between the screen bars the more material that will be captured by the screen.

3-4.1.1.1 Manual Bar Screens.

Inspect the manual bar screen for spacing between bars, damage to the bars, and any loose fasteners. Manual bar screens are manually cleaned with a tool that allows the operator to pull the captured material off the bar screen.

3-4.1.1.2 Mechanical Screens.

Mechanical screens normally operate in a fully automatic mode. Some newer designs of mechanical screens function with the differential level as the primary means of starting the mechanical screen with the timer as a backup. Determine the correct differential level for the mechanical screen and timers to prevent surging flow through the mechanical screen and wastewater treatment plant.

3-4.1.2 Screening Maintenance.

The maintenance for manual bar screens and mechanical screens are widely different due to the simplicity of manual bar screens and the complexity of mechanical screens.

3-4.1.2.1 Manual Bar Screens.

The maintenance requirements for manual bars screens is limited to periodic inspections of the bar screen with the channel drained and cleaned.

3-4.2 Grit Removal.

Wastewater flow contains material of fine, discrete, non-biodegradable particles called grit. The sources of grit include sand, cinders, rocks, coffee grounds, and cigarette filter tips. The purpose of a grit system is to remove material that can damage equipment and clog piping in the wastewater treatment plant. If grit is not removed during preliminary treatment the grit will accumulate in the bottom of aeration tanks, digesters, and sludge holding tanks which reduces the usable volume in the tanks. Typical grit parameters can be found in WEF MOP11, Table 18.1.

In an aerated grit removal system, the amount of air can also be changed. These changes impact the amount of grit that is removed. If the air to the aerated grit chamber is decreased, the amount of grit captured will increase, but the amount of organics captured also will increase.

3-4.2.1 Grit System Operation.

Grit is removed during preliminary treatment manually or by mechanical equipment. Perform periodic inspections of the grit removal system and inspect for wear and damage.

3-4.2.1.1 Manual Grit Removal.

Manual grit removal is the simplest form of grit removal. The manual grit removal system consists of one or more tanks. Multiple tanks allow a decrease in stream velocity so that grit particles may be allowed to settle out.

3-4.2.1.2 Mechanical Grit Removal Systems.

A mechanical grit removal system is a grit tank that includes a mechanical scrapper or a chain-flight system that pushes the grit to a sump. The grit is removed from the sump by a grit elevator or grit pumps where it is cleaned by a grit washer or grit classifier.

Normal operation is for the mechanical scrapper or chain-flight equipment to be operating continuously. To prevent clogging the grit pump suction or damaging the grit elevator, the operator determines the amount of time that the grit elevator or grit pump runs. The operator inspects the grit collected daily for the amount collected and the effectiveness of the grit washing.

3-4.2.1.3 Aerated Grit Removal Systems.

Aerated grit removal systems consist of one or more tanks that use compressed air to remove organics from the grit as it settles to the bottom of the grit tank. At the bottom of the tank, a longitudinal screw moves the grit to a sump where a grit pump takes suction and pumps the grit slurry to a grit classifier or grit washer to be cleaned. The grit also can be removed by a grit elevator that lifts the grit slurry to a grit classifier or grit washer.

Operators monitor the flow to ensure that the aerated grit removal system does not exceed its designed detention time. Normal operation is for the aerated grit chamber to have the aeration blower continuously running. To prevent clogging the grit pump suction or damaging the grit elevator, the operator determines the amount of time the grit elevator or grit pump runs. The operator inspects the grit collected daily for the amount collected and the effectiveness of the grit washing.

3-4.2.1.4 Vortex Grit Removal Systems.

Vortex grit removal systems spin the wastewater in a chamber to force the grit to be forced to the outer walls of the grit chamber. The grit then slides to the center of the grit chamber where it is removed by a grit pump. The grit slurry is pumped to a grit classifier or grit washer where it is cleaned and dried.

The vortex grit removal system requires the centrifugal force from the spinning of the wastewater to remove the grit. All the vortex grit removal systems have a minimum and maximum flow for which the system is designed. Ensure that the minimum and maximum flows are not exceeded in multiple vortex grit removal tanks. Some vortex grit removal systems have a mixer in the center to help induce the spinning action of the wastewater in the vortex grit chamber. Run the mixer continuously to ensure the vortex grit removal system is operating correctly. To prevent clogging the grit pump suction, the operator determines the amount of time that the grit pump runs. The operator inspects the grit collected daily for the amount collected and the effectiveness of the grit washing.

3-5 PRIMARY TREATMENT.

Primary treatment removes settleable and non-settleable materials. Settleable solids are typically inorganic materials such as grit. Non-settleable materials such as organic materials. The volume of settleable solids collected during primary treatment is typically reduced by the proper operation of the preliminary treatment system. The solids that are removed in the primary treatment process can reduce the treatment in the biological process by 25 to 30%.

Refer to *Operation of Wastewater Treatment Plants*, Volume 1, Chapter 5 for additional guidance on primary treatment.

3-5.1 Operation.

When a primary treatment tank is in operation, a mechanical scraper or a chain-flight system pushes the primary sludge to a sump. The sludge is removed from the sump by a pump and is then pumped to either a thickening process or a digester. In some cases, the primary treatment tank also acts as a gravity thickener for the primary sludge. The floatable material (known as scum) is pushed to a collection point. The scum is then removed from the primary treatment tank via a scum trough where the scum flows to a collection point where it is pumped to be removed from the wastewater treatment plant. In some WWTP processes, the scum is pumped to the digester for processing.

3-5.1.1 Process Control.

The various processes in the wastewater treatment plant vary based on wastewater flow and the environment in which the treatment plant operates. Adjust the number of primary treatment tanks in service to optimum detention time. The optimum detention time is 6 hours. Typically, there is minimal benefit with longer detention times.

The operator determines the best time to pump sludge out of the primary treatment tank, prevent sludge from going septic and maintain the required sludge thickness as required by downstream processes such as digesters and thickening. If the wastewater treatment plant sends WAS to the primary treatment process (co-settles), operators must ensure that the primary treatment pumping is enough to prevent denitrification from occurring in the primary treatment tanks and causing the sludge blanket from being carried into the biological treatment process.

3-5.1.1.1 Mean Cell Retention Time and Sludge Retention Time.

Determine a method of controlling the amount of mixed liquor (WAS) removed from the activated sludge system based on daily operating temperatures. The two common methods are mean cell residence time (MCRT) and Solids Retention Time (SRT_a). MCRT and SRT_a are similar, except for how they are calculated.

MCRT can be as low as 4 days during warm weather periods, and keep nitrification, but without any buffer to counteract an upset such as a slightly low pH. Wastewater treatment plants operation may vary between 4 days in warm weather and 10 days or more in cold weather.

Equation 3-1. Mean Cell Retention Time

$$MCRT = \frac{MLSS_{Total} + TSS_{Clarifier}}{TSS_{WAS} + TSS_{eff}}$$

Where:
MCRT = mean cell residence time (days)
$MLSS_{Total}$ = total activated sludge tanks mixed liquor (lb)
TSS_{WAS} = wasted mixed liquor (lb)
$TSS_{Clarifier}$ = clarifier total suspended solids (lb)
TSS_{Eff} = clarifier effluent total suspended solids (lb)

Equation 3-2. Aerobic Solids Retention Time

$$SRT_a = \frac{MLSS_a}{TSS_{WAS} + TSS_{eff}}$$

Where:
SRT_a = aerobic solids retention time (days)
$MLSS_a$ = aeration tank mixed liquor (lb)
TSS_{WAS} = wasted mixed liquor (lb)
TSS_{Eff} = clarifier effluent total suspended solids (lb)

3-5.1.1.2 Food to Mass Ratio.

Another item to consider when determining MCRT or SRT_a is the food to mass ratio (F:M). This is the ratio of the amount of BOD_5 to the mass of microorganisms in the total activated sludge tanks.

Equation 3-3. Food to Mass Ratio

$$F/M = \frac{BOD_{PE}}{MLSS_{Total}}$$

Where:
F:M = food to mass ratio
BOD_{PE} = BOD_5 *in primary effluent (lb)*
$MLSS_{Total}$ = *total activated sludge tanks mixed liquor (lb)*

Refer to WEF MOP 11, Table 20.1 for typical range of F:M parameters. Individual wastewater treatment plants may operate outside of the ranges listed below. Reference the F:M ratio as a check to see if it is relatively consistent. Investigate the F:M ratio if there are changes. This can indicate that the amount of WAS is incorrect or that there are significant changes to the wastewater flow constituents.

3-5.1.1.3 Alkalinity Adjustment.

Operators can adjust for alkalinity if the raw wastewater does not contain enough. Alkalinity is not lost in any process of the wastewater treatment plant unless coagulants are used to remove phosphorus. Monitor and adjust the alkalinity feed to maintain enough alkalinity in the wastewater to ensure complete nitrification is possible and to maintain at least a 75-mg/L residual in the effluent unless there is a required limit in the wastewater treatment plant NPDES permit.

3-6 BIOLOGICAL TREATMENT.

Most wastewater treatment occurs through biological treatment. Biological treatment occurs by creating an environment in the wastewater treatment tanks that allows a targeted type of bacteria to thrive and treat a specific constituent in the wastewater prior to the treated water being released to the environment. Constituents that are normally removed in the wastewater are biochemical oxygen demand (BOD_5) and CBOD, ammonia, nitrate, and phosphorus.

Refer to *Operation of Wastewater Treatment Plants*, Volume 1, Chapters 6, 7, 8, 9, and 10; *Operation of Wastewater Treatment Plants*, Volume 2, Chapter 11; *Advanced Waste Treatment*, Chapter 2 for additional guidance on biological treatment.

3-6.1 Biological Treatment Methods.

There are multiple methods of containing the bacteria (microbiology) in a space to treat the wastewater. These methods include activated sludge that uses large tanks, trickling filter which the wastewater flows through a tank with media, rotating biological contactors (RBCs), in which wastewater flows through a tank that contains a big wheel that rotates in the tank, and natural biological treatment (such as a lagoon). In all cases, there are biological-chemical reactions that occur. The most common biological-chemical reactions are nitrification (the conversion of ammonia to nitrates by bacteria) and denitrification (the conversion of nitrates to nitrogen gas by bacteria). Refer to *Advanced Waste Treatment* for various constituent removal requirements.

3-7 ACTIVATED SLUDGE.

The activated sludge process is a process in which wastewater treatment plants have one or more tanks filled with the microbiology in suspension with water. The bacteria water mixture is known as mixed liquor suspended solids (MLSS) and flows through the tanks to a clarifier, where it settles at the bottom and thickens slightly. The settled solids are then collected and pumped back to the biological process tanks. After the settled solids are pumped and returned to the process, its name is changed to return activated sludge (RAS). A portion of the settled solids is removed from the process and thickened or dewatered for disposal. The portion of the settled solids that is removed is called waste activated sludge (WAS).

Some treatment plants use two or more tanks in which all the activated sludge is processed. These tanks are called sequencing batch reactors (SBRs). SBRs allow a portion of the wastewater flow to enter them and then run all the activated sludge process on the single tank while another tank is filling. When the process is complete, the SBR drains the supernatant (treated water) before filling again to repeat the process.

3-7.1 Activated Sludge Operation.

The operation of the activated sludge process is complex and requires the most monitoring and adjustment in the wastewater treatment process. Any changes that are made in the activated sludge system take long periods of time (days to weeks) to see the full effect of any changes due to the growth rates of the microbiology in the activated sludge process. Operators must make small changes to the activated sludge system and wait some amount of time prior to making another change to see the effects of the change before making another. The amount of time that the operator will wait depends on the change made and hydraulic, organic, and nutrient loading. Changes, such as dissolved oxygen (DO) levels, can be seen within 1 hour of the change, whereas a change to the amount of WAS removed can take weeks to see the full effect of the change.

Refer to *Advanced Waste Treatment*, Chapters 5 and 6 for additional guidance on phosphorus and nitrogen removal.

3-7.2 Activated Sludge Process Control.

Process control in the activated sludge process is done to maintain and maximize the treatment of the wastewater to remove the various constituents as efficiently as possible. The removal of BOD_5 and nitrogen from the wastewater are only accomplished by the microbiology, whereas the phosphorus can be removed by both the microbiology and chemicals. Water temperature is an important factor to monitor and adjust in the wastewater treatment plant. As temperature decreases, the biological activity of the mixed liquor also decreases. Inversely, as the temperature increases, so does the biological activity of the mixed liquor. Nitrifying bacteria are only active between 4 and 40 ˚C.

3-7.2.1 SBR Process Control.

Review the timers for the process to ensure that the treatment goals are met. There may be adjustments that operators can make to the timers to improve the process, but this may affect the amount of wastewater that the facility can treat per day.

3-7.2.2 Chlorination.

It may become necessary to chlorinate the activated sludge to control unwanted microorganisms, such as filamentous organisms, and for sludge bulking events. In general, the range of dosage is 2 to 3 mg/L of chlorine per 1,000 mg/L of mixed liquor volatile suspended solids (MLVSS) in the aeration tanks. In severe cases, dosages up to 8 to 10 mg/L of chlorine per 1,000 mg/L of MLVSS in the aeration tanks have been required to be effective in controlling the bulking. The result of chlorination is often a turbid effluent since the nitrifiers are particularly affected by the chlorination. It is common for the chlorination of the activated sludge to last several weeks. Complete a daily microscopic exam during chlorination. Once the filamentous growth begins to decrease, gradually reduce the amount of chlorine feed to reduce the toxicity to the nitrifiers and re-establish the effluent quality.

3-7.2.3 Return Activated Sludge Pump.

Run the RAS pump (pump out of the clarifier) to keep the sludge blanket (thickened mixed liquor) between 1 and 2 feet in thickness in the clarifiers. This allows the RAS to be a thicker concentration. If the WAS is removed from the RAS, it reduces the amount of polymer needed for sludge thickening and keeps the sludge blanket low enough to prevent a hydraulic surge from washing it out in the effluent. The normal flow rate of the RAS pump is between 40 and 60% of influent flow on conventional activated sludge systems and 100 to 150% on extended aeration systems.

3-8 AEROBIC AND ANAEROBIC ZONE TREATMENT.

Every activated sludge wastewater treatment plant has an aerobic tank DO above 1.0 milligrams per liter [mg/L] in which oxygen is introduced by a mechanical aerator or a blower pushing air through air diffusers at the bottom of the tank. To remove BOD_5 and convert ammonia to nitrate, the DO level must be between 1.0 and 2.0 mg/L to ensure that enough oxygen is being provided to allow for the complete oxidation of the ammonia and BOD_5. This tank or portion of the tank is known to be “aerobic.” The size, detention time, temperature, and sludge age are the key factors in determining if an aerobic zone will oxidize BOD_5 and nitrify ammonia. If the wastewater treatment plant is designed to remove nitrogen, the plant will contain a pump near the end of the aerobic tank to pump MLSS that contains nitrates to the anoxic zone, which is normally at the beginning of the activated sludge process. In the portion of the tank where nitrate is being converted to nitrogen gas, the DO level must be below 0.5 mg/L, with sufficient BOD_5 and alkalinity available to complete the conversion. This tank or portion of the tank is known to be “anoxic.” In some wastewater treatment plants, there may be two anoxic zones. The first is where a majority of the denitrification occurs, but the second, which is after the aerobic zone, is used to remove any remaining nitrates to get to low total nitrogen levels. It is common to have to feed a supplemental carbon source into the second anoxic zone. This carbon source can be methanol, a glycerin product, or another preparatory substance. Review and understand the amount of BOD_5 that is in the carbon source and dose it appropriately to remove the nitrates without exceeding the operating NPDES permit requirements for BOD_5.

In some wastewater treatment plants, there is a tank or portion of a tank that is “anaerobic.” Anaerobic means that there are no nitrates in the portion of the tank and that DO is very close to 0.0 mg/L. In treatment plants that have an anaerobic zone, the activated sludge has certain bacteria in it that release phosphorus in the anaerobic zone but absorb more than they release in the aerobic zone. This allows for biological removal of phosphorus from the wastewater.

3-8.1 Mixer Operation.

In both the anoxic and anaerobic zones of the biological process, there are mixers that must be in operation at times to keep the MLSS from settling to the bottom of the tank. The mixers also allow the MLSS to move throughout the water, encountering various constituents and thus improving the biological process efficiency.

3-8.2 Clarifier Operation.

The MLSS flows out of the biological tanks into a clarifier. The clarifier is a tank that includes a continuously running mechanical scraper or chain-flight system that pushes the settled solids to a sump. The settled solids are continuously removed from the sump by the RAS pumps and pumped back to the biological tanks. The clarifiers also collect any remaining scum from the surface of the water. Collect and disposed of to prevent it from flowing out of the clarifier and into the clarifier’s effluent where it may cause an Operating NPDES permit violation by interfering with the disinfection process or by changing a water characteristic above the allowable limits. In some WWTP processes, the scum is sent to the digester for processing.

Periodically remove some of the settled solids from the process as WAS. By removing some of the mixed liquor from the biological tanks, the operator can promote growth in the biological tanks and remove old and unhealthy microbiology and any non-organic materials from biological process.

3-8.3 Nitrogen Removal Process.

In the clarifiers and the aerobic portion of the biological tank, there are pumps (internal recycle) that are used to help in the nitrogen removal process. These pumps and the

RAS pump return nitrates to the anoxic zone to allow denitrification to occur. Run the internal recycle pumps the design portion of the influent wastewater flow. A total recycle flow for denitrification of around 400% of influent provides the most denitrification with the lowest energy usage. After 400% recycle flow, the amount of nitrogen removed is significantly reduced.

3-8.4 Trickling Filters and Rotating Biological Contactors.

Trickling filters and RBCs operate similarly to each other to treat the wastewater. Trickling filters spray the wastewater over the surface of the media where the biological mass grows to treat the wastewater, whereas the RBC rotates large wheels of media with the biological mass on it into the wastewater flow to treat the wastewater. In trickling filters, the media can be either natural (such as stone or coal) or plastic, whereas the RBC media are always plastic. After either a trickling filter or RBC, a clarifier is used to capture any of the biological mass that is removed from the media.

Refer to *Operation of Wastewater Treatment Plants*, Volume 1, Chapters 6 and 7 for additional guidance.

3-8.4.1 Operation.

Trickling filters and RBCs are relatively simple in their operation. Run the trickling filters and RBCs at their design hydraulic and organics loading. Failure to do so will overload the trickling filter or RBC and cause the biomass to be scoured off the media and possibly cause an NPDES permit violation. The clarifiers that follow both the trickling filters and RBCs must periodically have the sludge pumped out for disposal.

Trickling filters do not normally have any mechanical equipment to make the distribution arm move as this is accomplished by the force of the wastewater exiting the distribution arm on to the media. To improve performance, trickling filters may have aeration blowers that either blow air into the bottom of the media or draw air through the top to aid in providing oxygen to the biomass.

3-8.4.1.1 Rotating Biological Contactor.

RBCs must always have their drive shaft running to turn the media to provide treatment to the wastewater. RBCs may have additional aeration to increase the efficiency of the wastewater treatment process.

3-8.4.2 Process Control.

There is little process control in trickling filters. RBCs have some adjustments that can be made to improve the treatment of the wastewater. RBCs can have their zone sizes changed, or wastewater can be step fed into different zones, which can allow increased treatment of the wastewater. RBCs also may be able to increase the speed and/or direction of the drive shaft to allow more oxygen to be introduced into the zones for increased treatment. Additional aeration can be used to increase the treatment efficiency of the units. The aeration system provides additional oxygen to the biomass to treat the wastewater.

3-9 NATURAL BIOLOGICAL SYSTEMS.

Natural biological systems include ponds (also known as lagoons) and land application. In both situations, the constituents in the wastewater are removed by natural occurring bacteria and require little to no operator intervention to maintain the treatment process.

Refer to *Operation of Wastewater Treatment Plants*, Volume 1, Chapter 9 for additional guidance.

3-9.1 Pond Operation.

Ponds have many factors that can affect their operation. Refer to *Operation of Wastewater Treatment Plants*, Volume I for additional guidance.

3-9.1.1 Oxygen Introduction.

Ponds use algae to provide oxygen to the bacteria in the pond through photosynthesis. Along with the algae, wind and waves also introduce oxygen to the pond to promote the growth of bacteria to treat the wastewater. In every pond, there are locations with little DO. Do not try to aerate every portion of a natural pond.

In some ponds, there is a mechanical method of providing the air to the pond, thus, increasing the amount of DO to the pond. Operate the aeration equipment as long as possible to achieve the best treatment results.

3-9.1.2 Operating Level and Testing.

Keep ponds at the same operating level to ensure that the level of treatment is adequate throughout the year. The level must be high enough to ensure that vegetation will only grow on the edge of the pond, typically 3 feet (900 mm). When allowing wastewater into ponds, the amount of water released into each pond in operation must be equal to ensure that no single pond is overloaded. If the pond is designed to work in a batch operation, the pond must be allowed to discharge only when it has the highest quality effluent.

Test the pond for DO, pH, and temperature at least twice per week to determine if any action is needed to improve the pond’s effectiveness and comply with operating NPDES permit requirements.

3-9.2 Land Application.

Land application of wastewater is a simple method of treating the wastewater with little operator action. The amount of wastewater pumped on the land is determined by the soil properties. Ensure that the amount of wastewater pumped on to the land does not exceed the permitted amount, as this may cause contamination of the groundwater.

3-10 DISINFECTION.

Provide disinfection of the treated effluent from wastewater treatment facilities to reduce the risk of human exposure to pathogens into receiving water bodies. Human pathogens of greatest concern are bacteria, viruses, and parasites. The most prevalent methods of disinfection include ultraviolet and chlorine disinfection. Additional methods, such as peracetic acid (PAA) and ozone addition, are used less frequently but are also discussed.

Refer to *Operation of Wastewater Treatment Plants*, Volume 1, Chapter 10 for additional guidance.

3-10.1 Disinfection Operation.

The operation of the disinfection system is to either kill or inactivate pathogens while minimizing cost and protecting the environment. The ultraviolet and chlorine disinfection systems operate very differently to achieve the disinfection of the treated water.

Evaluate bulk chemical purchases and onsite storage chlorine disinfection and dechlorination products for "shelf-life degradation" for the proper onsite storage size to be selected. This will optimize the expected shelf life of these types of products.

Maintain an adequate amount of chemicals in the storage tanks to ensure that pump suctions remain flooded. Order the bulk storage tanks chemicals in time to ensure that the bulk tanks are not drained before the delivery occurs. The amount of advanced time depends on delivery lead time and includes additional time for a short delay in delivery. Determine the chemical usage rate such that at the end of the season there is little chemical left and/or test the chemical prior to use to determine the actual concentration if using the chemical during the next season.

3-10.2 Ultraviolet.

The use of ultraviolet (UV) light for disinfection arose from concerns over the storage, handling, and water quality impacts of traditional chlorine disinfection. Ultraviolet light is a form of invisible light radiation. The use of UV light on pathogens in the wastewater stream will inactivate them, making it impossible to replicate. The intensity of the UV radiation is measured at a wavelength of 253.7 nanometers. The flow, UV transmittance (UVT), and UV intensity are continuously monitored to ensure that the correct dose is achieved.

Monitor process control parameters to ensure the effectiveness of the UV light disinfection, include UVT, design dose, wastewater quality, age of the UV lamps, and iron concentration. The UVT, which is impacted by both suspended and dissolved matter, is measured by the percentage of UV light intensity not absorbed after passing through 1 centimeter (cm) of water column. The lower the UVT, the lower the intensity of the light reaching the pathogens, which will result in less effective disinfection. The presence of suspended solids can negatively impact UVT as the solids can bind with the pathogens and provide a barrier between them and the UV light. Run the UV system in automatic control. This will allow the UV system to adjust the number of UV lamps and their intensity to account for changes in the wastewater flow and the changing UVT of the treated wastewater. The equation to determine the UV dose is shown below.

Equation 3-4. UV Dose

$$UV_{dose} = (I_{UV}) \times t$$

Where:
UV_{dose} = UV dose (millijoules/cm^2)
I_{UV} = UV intensity ((milliwatts)/*cm^2)*
t = time (seconds [sec])

3-10.2.1 Impact of Ferrous Salts and UV Lamp Age.

The use of ferrous salts in wastewater treatment may also impact the performance of UV disinfection. Ferrous salts, which are often used for enhanced coagulation and sedimentation, can absorb invisible UV light, lessoning the effectiveness of UV disinfection. The age of the UV lamp has an influence on the intensity of the UV radiation. Monitor lamp output to determine lamp age. Store an adequate supply of backup lamps the facility if an older lamp needs to be changed out or in the case of lamp breakage.

3-10.3 Chlorination.

In chlorine disinfection, a chlorine solution is fed into the wastewater stream at a known flow rate. The solution is then mixed thoroughly for a predetermined contact time. The mechanism of disinfection through chlorination is the oxidation of the cellular material. Chlorination compounds include chlorine gas, liquid hypochlorites, and chlorine dioxide, which is used less commonly in wastewater applications.

These reactions are both temperature and pH dependent. The hypochlorite solutions form a weak hypochlorous acid, which dissociates to form an equilibrium of hypochlorous acid and hypochlorite ion. When pH is above 8.5, the equilibrium approaches 100% dissociation, and when the pH is below 6.0, the solution approaches 100% HOCl. Between pH of 2.0 and 6.0, chlorine exists predominately at HOCl. Chlorine gas is predominate in pH below 2.0. At pH above 7.8, hypochlorite ions persist.

3-10.3.1 Chlorine Dosing Equipment.

Run the chlorine dosing and dechlorination equipment in automatic control based on a desired free chlorine residual in the chlorine contact basin. This will allow the controls system to adjust the chlorine feed to maintain the setpoint based on changes in flow and water quality. Check the chemical feed pump's actual stroke volume against the displayed setting for volumetric accuracy.

3-10.3.2 Process Controls.

Important process controls that play an important role in any chlorination method include detention or contact time, chlorine residual, oxidation reduction potential, indicator bacteria results, and handling of the chlorine containers or cylinders. The actual amount of chlorine present in each chlorine disinfection solution will vary. Bulk delivery sodium hypochlorite is typically commercially available in a solution containing 15 grams per liter (g/L) (15%) as available chlorine. As sodium hypochlorite ages, its solution strength goes down and will stabilize at around 5 g/L (5%). Factors that affect the speed at which sodium hypochlorite degrades are sunlight, temperature, and atmospheric pressure. Due to this degrading property of sodium hypochlorite, operators must check the strength of the solution to determine the correct feed rate.

In systems that use sodium hypochlorite or calcium hypochlorite, operators must rotate pumps regularly to ensure pump operation and to remove any chlorine gas that has degassed from solution. As part of the pump operation, run the pumps at various speeds to ensure that the pumps are not gas bound.

3-10.3.3 Chlorine Residual.

Chlorine residual is comprised of free, combined, and total chlorine. Free and total chlorine are often the two parameters that are monitored in the effluent line. Combined chlorine consists of both chloramines as well as other chloro-organic compounds that form by the reaction of chlorine with ammonia and organic compounds present in the effluent. A chlorine demand exists in all wastewater effluent. The chlorine demand is defined by the amount of chlorine that is consumed or converted to other less active forms of chlorine by matter present in the wastewater. Examples of substances in wastewater that may consume chlorine include ammonia compounds, organic materials, ferrous iron and some sulfur compounds. Free chlorine residual is what exists after the breakpoint has been achieved. The total chlorine residual includes both the combined and free chlorine present in the effluent, but always test chlorine concentration for process quality assurance.

3-10.3.4 Dechlorination.

The presence of chlorine in high enough concentrations can be toxic to fish and other aquatic life. Common chemicals used for dechlorination include sulfur dioxide (SO_2), sodium metabisulfite ($Na_2S_2O_5$), and sodium bisulfite ($NaHSO_3$). Proper dosage is critical to produce a non- detectable chlorine residual. On a mass basis, 0.9 parts sulfur dioxide (or 1.46 parts $NaHSO_3$ or 1.34 parts $Na_2S_2O_5$) is required to dechlorinate 1.0 part residual chlorine. In practice, approximately a one- to-one ratio is used.

Three of the most important parameters that must be monitored and controlled for adequate dechlorination to occur are mixing efficiency, chlorine residual, and contact time. Mixing allows the chlorine to get mixed thoroughly into the water column to disinfect the water prior to discharge, whereas the contract time is required to provide adequate time to allow the chlorine to disinfect the water.

3-10.4 Ozone.

Ozone can be used to disinfect the treated wastewater. Ozone disinfects by destruction of the cell wall, reaction of radical byproducts of ozone decomposition, and damage to the nucleic acids inside the cells, thus, preventing cell replication. Ozone is provided in concentrations of 1 to 4% using dry air and 3 to 10% using pure oxygen. Ozone is created on site. Ozone has the same operating requirements as chlorine in that it requires mixing into the water column and detention time.

Collect ozone samples to determine the ozone percentage sufficient to treat the wastewater effluent. To prevent equipment damage, inspect the ozone cooling water system to ensure that it is operating correctly.

3-10.5 Bromine Chloride and Chlorine Dioxide.

Bromine chloride and chlorine dioxide can also be used for disinfection as they perform the disinfection in the same methods as ozone. The bromine chloride is fed as a gas into the wastewater, whereas the chlorine dioxide is created on site and fed into the treated wastewater flow as a liquid. Bromine chloride and chlorine dioxide have the same operating requirements as chlorine in that they require mixing into the water column and detention time.

3-10.6 Peracetic Acid.

PAA is a liquid solution of acetic acid and hydrogen peroxide. PAA is normally between 12 and 15% solution strength and has a long shelf life; therefore, it does not change solution strength as quickly as sodium hypochlorite. PAA is normally dosed under 4 mg/L, which meets most bacteria effluent limits and has a residual of less than 1 mg/L, which is the EPA established limit.

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CHAPTER 4 SOLIDS MANAGEMENT

4-1 INTRODUCTION.

The treatment of wastewater creates sludge. This sludge contains organic material, inorganic material, and various types of bacteria, which when mixed are called solids. All this material is usually treated at the same location as the wastewater treatment plant. To aid, in the storage, transportation, and method of disposal wastewater treatment plants thicken, reduce the amount, and dewater the solids prior to being removed from the wastewater treatment plant.

Refer to *Operation of Wastewater Treatment Plants*, Volume 2, Chapter 12 for additional guidance.

4-2 MAINTENANCE.

The maintenance requirements for solids treatment varies, depending on the type of equipment used. Recommended maintenance should be completed by operators and maintenance staff to maintain all warranties and performance guarantees. Refer to the equipment manufacturers operation manual and operate solids treatment equipment in accordance with manufacturers recommendations and all NPDES permits.

4-3 DIGESTER OPERATING CHARACTERISTICS.

Refer to WEF MOP 11, Table 30.7 for typical characteristics of an aerobic digester. The values represent operating parameters that will be monitored at the plant. They will be able to monitor trends and predict potential digester upsets.

4-4 SLUDGE VOLUME REDUCTION.

Sludge volume reduction is intended to remove water from waste solids or biosolids and is also known as thickening or dewatering. It is desirable to thicken/dewater the sludge to reduce the process volume and therefore the costs associated with pumping, equipment sizes, and disposal.

4-4.1 Operation.

There are multiple methods to reduce the sludge volume, including, gravity thickening, mechanical thickening, mechanical dewatering, and natural dewatering. The difference between thickening and dewatering is the amount of water that is removed from the sludge. Thickened sludge normally contains between 1 and 8% solids, whereas dewatered sludge normally contains between 15 and 30% solids. Due to the variation in the different systems components and operations, operators must refer to the vendor equipment manual for proper operation of their system.

4-4.1.1 Gravity Thickening.

Sedimentation is the driving force for gravity thickeners through the acceleration of gravity. Gravity thickeners are typically circular but may also be rectangular. Depending on the solid being thickened, the nature of the flocculent and concentration of the solid will vary.

The rake or scraper mechanism is used to deposit the thickened sludge to the underflow. The drag is created between the thickened sludge and the rakes to generate a load on the raker drive. If this load becomes too high, an alarm notifies the operator of an overload caused by the sludge being too thick or a jam in the rake. The underflow rate is then increased to mitigate the problem, although this reduces the cake blanket.

4-4.1.1.1 Sludge Septicity.

A common potential problem with gravity thickeners is the sludge septicity. This is a problem if the sludge is floating, solids are being carried to the overflow, and/or there are foul odors and reduced sludge outflow concentrations. Sludge septicity is caused from storing the sludge too long in the thickener, either because the thickened sludge pumping rate is too low or the thickener overflow is too low. Depending on the cause of the problem, increase the pumping rate, increase the influent flow to the thickener, or incorporate dissolved oxygen via aeration. The addition of chlorine or hydrogen peroxide can temporarily solve septicity.

4-4.1.1.2 Sludge Pumping Rate.

Determine and monitor the pumping rate of the thickened sludge. If the wastewater treatment plant pumps WAS to the primary clarifiers and/or to the gravity thickeners, increase the amount of pumping to prevent the sludge from denitrifying in the gravity thickener or allowing it to stay in the gravity thickener so long as to allow for microorganisms to release phosphorus into the supernatant. If the sludge denitrifies in the gravity thickener, the nitrogen bubbles can cause the sludge blanket to rise to the surface and be washed out with the supernatant, which will cause an increased organic loading to the biological treatment system. If the sludge is allowed to settle in the gravity thickener and phosphorus is released, this can cause an increase phosphorus loading on the biological system and/or increase the amount of chemical usage to precipitate the phosphorus in the wastewater treatment plant. If either of these occur, it is possible the operating NPDES permit may be violated.

4-4.1.2 Mechanical Thickening.

Mechanical thickening systems include dissolved air flotation, gravity belt, centrifuge, and rotary drum thickening. These thickening methods require two or more pieces of equipment to accomplish the thickening process.

4-4.1.2.1 Dissolved Air Flotation Thickening.

Dissolved air flotation (DAF) thickeners are comprised of a flotation unit and a saturator. The flotation unit is utilized to divide the solid phase from the liquid phase and the saturator dissolves air into the compressed water. A reducing valve allows the pressure-saturated water to flow into the flotation unit and become supersaturated with the air. The wastewater feed is introduced downstream of the reducing valve. Small bubbles from the saturated feed are formed and attached to the wastewater particles, forming bubble-particle agglomerates. Then, mixing occurs to make sure chemical dispersion occurs. The buoyancy in the flotation unit causes the agglomerates to float and accumulate at the water level. The solids are removed by scrapping, and the solids concentration is increased from draining the interstitial water from the float.

Typically, DAF units are operated continuously but may be operated with short shutdown periods or only during certain hours of the day. When the units are not running continuously, a feed sludge holding and mixing tank can be utilized. Minimize the entrance velocity to the flotation unit to avoid shearing of flocculated sludge particles. The float skimmers are placed above the water level and the speed is set to maximize the solids concentration. Set the controlling pressure at the lowest value that allows optimal operation but not below 50 pounds per square inch (psi). There are three typical parameters that are monitored for DAF units: solids and hydraulic loading rates, air-to-solids ratio, and air volume and pressure.

- The solids loading rate is the weight of solids added (including recycle flow) to the unit divided by the flotation surface area. The efficiency of the DAF will decrease if the solids loading rate is exceeded. The typical values for WAS conditioned with polymer is 2 to 4 lb/square foot (ft^2) per hour (h). The hydraulic loading rate is the solids feed rate and recirculation rate divided by the flotation surface area. The rise rate, subnatant solids concentration, and overall efficiency are affected by the hydraulic loading rate. The peak hydraulic loading rate of WAS using polymer is 2.5 gallons per minute (gpm)/ft^2.
- The air-to-solids ratio is the mass of air divided by the mass of solids added to the DAF. As the air-to-solids rate increases, the float concentration increases. The typical range of air-to-solids ratio is 0.02 to 0.04 lb/lb.
- The air pressure in the DAF unit determines the size of air bubbles. The air pressure is an indicator of whether the DAF has good “float.” If the pressure is increased, the rise rate of solids decreases. An air flotation test can be conducted to monitor conditions in the DAF such as recycle rate, solids loading rate, air pressure and others.

4-4.1.2.2 Gravity Belt Thickeners.

Gravity belt thickeners take conditioned sludge and release additional water, utilizing gravity drainage on a porous belt that is typically horizontal. To separate the solids from the free water, chemical conditioning occurs, often by injecting the chemical through an injection ring into the sludge. The sludge is then collected in a retention tank where the velocity is reduced to allow solids to float to the top and flow by gravity to the moving belt. As the sludge moves along the belt, plows are used to turn over the solids and allow filtrate to drain. The sludge accumulates at the end of the belt before discharging to a dam or adjustable ramp, allowing further water removal. The belt is cleaned by a scrapper and high-pressure wash water spray system.

Many factors affect the functioning of the gravity belt thickeners. The proper polymer needs to be selected to achieve optimal thickening. The recommended solution range for polymers to condition sludge is 0.05 to 2% by weight for dry polymers, 0.1 to 0.5% by volume for emulsion/dispersion polymers, and 1 to 3% by volume for mannich polymers. If the concentration of polymer is above this range, it could cause the polymer to not mix properly and deteriorate the thickening process. Sludge that settles more easily (higher percent solids) will require less polymer. Only inject the minimum amount of polymer required to thicken the sludge because the extra will go out the drain. The retention time is the amount of time required for the polymer to react with the sludge and flocculate. The ideal retention time is ideally 15 to 20 seconds. If too much time is allowed, the flocs will be too large, and with a short time, the flocs will be too small. The belt speed can be adjusted to go slower or faster and adjusted in the field to reach the optimal speed. When the belt is traveling slower, there is more time for the cake to dry. When the belt is traveling faster, there is a larger amount of throughput or a quicker process time.

4-4.1.2.3 Centrifuge Thickening.

Centrifuges can thicken and dewater sludge through the same piece of equipment by only changing the weir setting. The solids are separated from the liquid through sedimentation because of the differences in density. The centrifuge generates thousands of times the acceleration of gravity through centrifugal force to separate the solids even further.

Centrifuges rely on constant feed to quality. This can be achieved by taking centrifuges on or offline as the production increases or decreases. Typical problems occur from varying primary and secondary sludge concentrations or septic feed. Centrifuges are designed for flow conditions of 25 to 1,500 gpm. The bowl speed is set by the manufacturer and rarely changed. The speed can be adjusted to determine if the set speed is operating optimally.

4-4.1.2.4 Rotary Drum Thickening.

Rotary drum thickening consists of drums of varying sizes with wedge wires, perforated holes, stainless steel fabric, or a combination of stainless steel and synthetic fabric to obtain the solids. The drum is rotated at 5 to 20 revolutions per minute by a variable-speed drive unit. Sludge enters the drum, and the water is drained through openings in the drum to an underdrain. The sludge is transported through the drum by a continuous internal screw or diverted angle to a discharge chute. The drum is periodically cleaned by wash water to ensure the high solids capture and dewatering efficiency.

Four process variables are utilized for effective thickening: sludge feed rate, polymer feed rate, pond depth, and drum speed. The pond depth is controlled by the angle of the drum, which can be adjusted to up to 6˚ from the horizontal. A typical starting range is between 2 to 3˚. If the incline increased, the solids are dryer but the capacity of the drum decreases. If the incline is decreased, the capacity increases but the solids are wetter.

4-4.1.3 Mechanical Dewatering.

Mechanical dewatering includes belt filter presses, centrifuges, and vacuum and pressure filters.

These processes may require polymer to enhance the dewatering of the solids from the liquid. The polymer dosage determines the amount of polymer needed per amount of feed solids. The polymer dosage equation is below.

Equation 4-1. Polymer Dosing

$$Dose_{polymer} = \frac{C_{polymer}}{C_{feed}} \times \frac{Q_{polymer}}{Q_{feed}} \times 2000 \frac{lb}{ton}$$

Where:
$Dose_{polymer}$ = polymer dose (lb/ton)
$C_{polymer}$= polymer concentration (%)
C_{feed} = sludge feed solids concentration (%)
$Q_{polymer}$ = polymer feed rate (gpm)
Q_{feed} = sludge feed rate (gpm)

1-1.1.1.1 Belt Filter Press.

The operation of a belt filter press occurs in three zones: the gravity drainage zone, low-pressure zone, and high-pressure zone. The gravity drainage zone is where the sludge is thickened from the water draining out through movement on a porous belt. Then, low-pressure is applied to the feed to remove more water and create a biosolids matrix. This matrix is then passed through decreasing rollers to create a high-pressure zone to further filter the water.

The capture rate for the belt filter press must be 95% or higher and is therefore not a parameter that can be changed. Cake dryness, loading, and polymer dosage directly affect each other, and changing one variable affects the performance of the other. For example, if dryer cake is desired, the polymer dosage rate is increased, or the loading rate is decreased. Most belt filter presses have an inline mixing system to inject the polymer. The amount of polymer and intensity of mixing is adjusted based on the sludge and polymer being used.

4-4.1.3.2 Centrifuge Dewatering.

A dewatering centrifuge works like a thickening centrifuge. The capture rate for the centrifuges must be 95% or higher and is therefore not a parameter that can be changed. Cake dryness, loading, and polymer dosage directly affect each other, and changing one variable affects the performance of the other. For example, if dryer cake is desired, the polymer dosage rate is increased, or the loading rate is decreased. Centrifuges prefer warmer temperatures of up to 60 ˚F to operate most efficiently. The hydraulic loading rate is not as limited for centrifuges compared to filtration devices because thinner feed sludge does not impact the performance as much. The solids loading with more biosolids will have a lower residence time and wetter solids. The conveyor torque and speed, the bowl speed, the weir setting, and the polymer addition are additional mechanical variables that affect the operation. The conveyor differential speed is adjusted to control the cake removal rate. Decreasing the speed causes the cake to become dryer because the sludge blanket in the centrifuge builds up. Increasing the speed causes a lower height of the sludge blanket and increases the biosolids removal. The conveyor torque increases as the cake becomes drier because the viscosity increases. The speed is controlled automatically and keeps a constant torque value. The bowl speed is directly related to the process performance with an increase in speed equal to an increase in process performance. However, centrifuges are typically operated at lower speeds to avoid excessive wear, vibration, and noise. Evaluate the weir setting every 2 years to determine if it is still at the optimal setting.

4-4.1.3.3 Vacuum and Pressure Filters.

Vacuum and pressure filters utilize inorganic chemical conditioning with, most commonly, lime and ferric chloride. These chemicals are used to increase the ability to filter the sludge and remove the sludge from the filter media. Lime has a larger range of effective dosage than polymers. The solids capture rate is ideally 99% for a conventional filter press. The feed pressure falls between one of the two ranges: 95 to 130 psi or 200 to 250 psi. The filter media varies, depending on the application. Typically for dewatering organic biosolids, polypropylene filaments are used with 2.3 to 3.4 cubic meters (m^3)/min porosity. Refer to Appendix A for the typical conditioning doses of ferric chloride and lime.

The filter press needs to be checked periodically prior to initiation of the automatic filter cycle. Once sufficient feed stock has accumulated and the chemical solution is prepared, a high feed rate is initially required to completely fill in the press in a short time until the system reaches 55 psi. Then, only a small high-pressure pump is used to continue feeding to a maximum pressure of 95 to 130 psi. The cycle stops once a set cake concentration is obtained.

4-4.1.4 Natural Dewatering.

Natural dewatering occurs through air-drying by natural evaporation or induced drainage. Typically, anaerobic or aerobic digestions are utilized to stabilize the biosolids prior to air-drying. Air-drying may be more energy-efficient, and the systems are less complex compared to mechanical dewatering. Although, they can require a large amount of land and more labor to remove the cake. The natural systems are most common for small and rural treatment facilities where there is warm weather. There are multiple types of beds, including, reed beds, sand beds, vacuum-assisted beds, wedge-wire beds, and paved beds. They all have similar process variables such as being affected by the weather, chemical conditioning, feed solids, system design, and residence time. Since all depend on the weather, backup storage or treatment needs to be provided during low production. Multiple beds are required because cleaning requires the beds to be taken out of service.

4-5 SLUDGE DIGESTION.

Sludge digestion is a biological process intended to decompose organic solids into stable substances to reduce the amount of sludge and decrease the number of disease-causing microorganisms. Digester failure can make it harder to dewater the digested sludge and cause the plant to not meet sludge disposal requirements. Therefore, it is important to keep the sludge digestion processes functioning as effectively as possible.

4-5.1 Sludge Digestion Operations.

Sludge digestion at a wastewater treatment plant occurs by aerobic or anaerobic digestion. Both require a source of elemental oxygen, but anaerobic digesters prevent gaseous oxygen from entering the system.

4-5.1.1 Aerobic Digestion.

For effective operation, uniformity and consistency of the incoming sludge is important; otherwise, the digester performance may be inhibited and lead to foaming. It is ideal to feed the digester continuously, 24 hours per day, but if this is not possible, develop a consistent feeding plan.

4-5.1.1.1 Short Circuiting.

To prevent short circuiting, the withdrawal of solids occurs immediately after feeding raw sludge. Solids are withdrawn concurrently with the inflow if there is a surface overflow. At least once per day, withdraw solids from the digester to avoid a drop in the active microorganism population.

4-5.1.1.2 Mixing System.

Scum can accumulate on the digester liquid surface if the mixing system is not properly operating. A properly designed and operated mixing system keeps the scum mixed with the digester contents.

4-5.1.1.3 Addition of Oxygen.

Add oxygen to the digester while feeding and mixing the aerobic digester to promote the digestion process of the sludge. Target DO in the digester to a range of 0.3 to 3.0 mg/L.

The digestion process lowers the vector attraction of pathogens. EPA requires a 1.5 mg/L/g standard oxygen uptake rate at 20 ˚C for adequate vector reduction in vector attraction.

4-5.1.1.4 Temperature Requirements.

Aerobic digesters require warm weather to complete the digestion process. Normally, aerobic digesters are not provided heat from any other source other than the environment. If the digester temperature drops below 10 ˚C, digestion will not occur.

4-5.1.2 Anaerobic Digestion.

Anaerobic digestion works to stabilize organic material through a multistage biochemical process. The anaerobic digestion process requires mixing, heating, removing sludge, and feeding raw sludge. Proper mixing of the sludge will create the optimal environmental conditions. The mixing system typically runs continuously.

4-5.1.2.1 Digester Mixing.

There are two types of mixing systems: unmixed digestion and mixed digestion. In unmixed digesters, there is a top layer of scum on the liquid surface and bottom layer of stabilized biosolids and grit with a small area for mixing in between. Unmixed digestion is used for low-rate and standard-rate digesters at small facilities less than 1 mgd.

In mixed digestion, high rate digestion and higher loading rates are achieved by controlled mixing and heating, uniform feed rates, and thickening of digester feed. There are two common types of mixed digestion: mechanical and gas mixing systems. Mechanical mixing includes pumped and impeller-type mixing. Pumped mixing systems have pumps installed outside of the tank, and the mixing nozzles are installed inside the tank to create a flow pattern for complete mixing. Impeller mixing consists of a draft tube containing the impeller with a discharge nozzle into the tank at an angle to cause mixing of the sludge. An impeller, a drive shaft, and a drive are provided with the mixing systems. Most often, the drive shaft is reversible to allow for clearing blockages. Gas mixing systems consist of bottom diffusers, lances, bubble guns, and gas lifters. The central component is the compressor where the moisture and sediment from the gas needs to be removed upstream of the compressor. Flow-balancing manifolds may be required to evenly partition the flow to mixer inside the digester. To prevent a vacuum from being created in the digester when there is low pressure, monitor the pressure with a low-pressure regulator. When the compressor discharge surpasses a set level, the high-pressure regulating valves bypass gas to the suction of the compressor or to storage.

4-5.1.2.2 Digester Feeding.

It is ideal for digesters to be fed continuously 24 hours per day. If this is not possible, keep the feeding schedule continuous and uniform. Feed the digesters a mixture of feeds, such as waste activated sludge and primary sludge. To prevent short circuiting, the withdrawal of solids occurs immediately after feeding raw sludge. Solids are withdrawn concurrently with the inflow if there is a surface overflow. At least once per day, withdraw solids from the digester to avoid a drop in the active microorganism population.

4-5.1.2.3 Digester Covers.

Digester covers, specifically fixed covers, need to be monitored. When sludge is fed or withdrawn, and the tank is full, the inflow and outflow must be equal, or the tank could overpressure and push the cover from its mountings. If sludge is withdrawn without adding more sludge, a vacuum can be created. These obstacles can be prevented by installing safety relief valves, which often develop gas leaks.

4-5.1.2.4 Secondary Digesters.

Secondary digesters are typically utilized at medium and large wastewater plants. The primary digester is used to optimize digestion and is where most of the gas production occurs. The secondary digester may or may not be mixed and/or heated. It may be designed to be mixed and heated when the primary digester is out of service. Secondary digesters without heating can be used as a storage tank, standby primary tank, and a source of seed sludge. For storage vessels, floating or membrane covers work best because they allow for drawdown without creating a vacuum under the cover, which can damage the digester cover and tank walls.

4-5.1.2.5 Digestion Temperature Ranges.

Most anaerobic digestion occurs in mesophilic conditions (32 to 38 ˚C). The biochemical process occurs in one tank and typically as a high-rate process because it is more stable and has a shorter detention time. Volatile solids are reduced by 40% to 60% in the digester to create stable conditions.

Thermophilic digestion is operated at thermophilic temperatures (55 ˚C or higher) and conducted in one or more stages. The goal of thermophilic digestion is to reach greater pathogen destruction, which causes higher volatile solids destruction and lowers retention times. More energy is required compared to mesophilic digestion; therefore, it is important to utilize heat recovery techniques.

4-5.1.2.6 Volatile Solids Reduction.

The following equation can be used to calculation the volatile solids reduction based on the volatile solids in the feed and digester discharge:

Equation 4-2. Volatile Solids Reduction

$$\boldsymbol{VSR, percent} = \left(\frac{\boldsymbol{VS_{feed} - VS_{digested\ sludge}}}{\boldsymbol{VS_{feed}}}\right) \times \mathbf{100}$$

Where:
VSR = volatile solids reduction (%)
VS_{feed} = volatile solids in feed sludge (lb)

$VS_{digested\ sludge}$ = volatile solids in digested sludge (lb)

If the digesters do not have significant grit accumulation, the Van Kleeck equation may be used to calculate volatile solids reduction.

Equation 4-3. Van Kleeck

$$VSR, percent = \left(\frac{VS_{feed} - VS_{digested\ sludge}}{VS_{feed} - (VS_{feed} \times VS_{digested\ sludge})}\right) \times 100$$

Where:

VSR = volatile solids reduction (%)

VS_{feed} = volatile solids in feed sludge (lb)

$VS_{digested\ sludge}$ = volatile solids in digested sludge (lb)

4-5.1.2.7 Digester Gas.

The gas from digesters can be utilized as it contains methane. The digester gas can be used by a boiler that is designed to use the digester gas after it has been conditioned (hydrogen sulfide removed) or on unconditioned digester gas. Digester gas can be used to create power through a turbine, but the gas must be conditioned to ensure that all impurities are removed from the digester gas to prevent damage to the turbines. The digester gas can also be directly burned to the atmosphere through a flare. In general, digester gas systems will always have a flare to ensure that the digester gas is properly disposed of, and it may have one or more other components to transform the digester gas into a useful energy source.

Note: For the Army, AR 420-1 provides further guidance on boiler operations.

Note: For the Air Force, **\1** AFMAN **/1/** 32-1068 provides further guidance on boiler personnel schedule requirements.

4-6 OTHER SLUDGE STABILIZATION METHODS.

In addition to anaerobic and aerobic digestion, there are other conventional ways to stabilize sludge such as composting, lime stabilization, thermal treatment, heat drying, and incineration. These methods are commonly used to reach Class A or Class B levels for beneficial reuse and disposal. These methods are critical to reduce odors or nuisances, reduce level of pathogens, and facilitate efficient disposal or reuse of the product.

4-6.1 Composting.

The most common use of composting is to stabilize raw sludge. Composting is also commonly used to further stabilize digested sludge. For compositing to work, the initial solids content must be between 40 and 50% solids. To obtain this solids level and to raise the carbon to nitrogen ratio, a bulking agent is normally added. The desired carbon to nitrogen ratio is between 26:1 and 31:1. Composting heats the compost pile to 50 to 70 ˚C to destroy most pathogenic organisms.

In a windrow system, the compost piles are turned over daily to aerate the compost pile. This occurs for at least 3 weeks, which must include 3 days at 55 ˚C after which the windrow is then considered ready for use as compost. In systems that the windrow is not turned over, a blower either pulls or pushes air through the windrow to provide oxygen to the interior portion of the windrow.

4-6.2 Lime Stabilization.

Lime stabilization is the process of adding lime to sludge to a pH of 12.0 or more for at least 2 hours. Lime stabilization destroys or inhibits pathogens and microorganisms in the sludge. Lime stabilization can occur on raw primary sludge, WAS, and anaerobically digested sludge. The lime can be added to the sludges either before or after dewatering, although before dewatering is more typical of lime addition. When shutting down the lime system, empty all lime to prevent issues during startup.

In addition to monitoring the pH, the operator must take biological samples every quarter or as required by the operating NPDES permit. Include the organisms as required on the operating NPDES permit for the samples. If none are stated, use indicator organisms, such as fecal coliforms and fecal streptococci.

4-6.3 Thermal Stabilization.

Thermal stabilization kills the microorganisms by breaking apart the cells and releasing the water inside of the cell. Thermal treatment uses heat and steam to raise the temperature and pressure of the sludge.

Note: For the Army, AR 420-1 provides further guidance on thermal processes for sludge.

4-6.4 Sludge Drying.

Sludge drying is used to reduce the volume of sludge being hauled and reduces the number of pathogenic organisms. The sludge is dried by exposing it to hot gases from a furnace. Variables that affect the sludge drying process are:

- Percent solids in the feed sludge
- Ratio of wet sludge to dry sludge
- System operating temperature
- Amount of hot gases that can be used for drying

Note: For the Army, AR 420-1 provides further guidance on thermal processes for sludge.

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CHAPTER 5 CHEMICAL TREATMENT

5-1 INTRODUCTION.

Various chemicals are used at wastewater treatment plants. Chemicals range from sodium hypochlorite which is used for disinfection of the treated wastewater, to polymers, which are used for solids capture in a clarifier or for solids capture on a thickening or dewatering machine. Chemicals can come in gas form (such as chlorine), liquid form (such as sodium hydroxide), or solid form (such as soda ash). Operators must review their facility's O&M manual and the various equipment manuals to fully understand what each chemical is and how it is used at their wastewater treatment plant. Operators must also maintain and review the safety data sheet for each chemical used on site. The safety data sheet provides health and safety requirements for the specific chemical along with the chemical's physical properties and actions to complete if a spill occurs.

Degrees Baumé is used in the chemical industry to measure density of various liquids when ordering onsite chemicals. The Baumé scale is a pair of hydrometer scales with one for liquids with densities heavier than water and one for liquids with densities lighter than water. If the degrees Baumé of a chemical is known, the specific gravity can be calculated. Then, the specific gravity of the chemical can be used to find the actual chemical concentration.

5-2 MAINTENANCE.

The maintenance requirements for chemical treatment varies, depending on the type of chemicals and equipment used. Recommended maintenance should be completed by operators and maintenance staff to maintain all warranties and performance guarantees. Refer to the equipment manufacturers operation manual and operate solids treatment equipment in accordance with manufacturers recommendations and all NPDES permits.

5-3 OPERATIONAL REQUIREMENTS.

Store chemicals in accordance with UFC 3-600-01 and applicable National Fire Protection Association codes and standards. The operation of each chemical system is specific to the individual wastewater treatment plant. At some plants, a chemical, such as a polymer, can be delivered in a liquid ready for use, whereas at larger wastewater treatment plants, the polymer can be delivered in a dry powder, which requires the polymer to be added to water and mixed prior to use. Operators must review their facility's O&M manual and the various equipment manuals to understand how each piece of equipment works to add the chemical to the wastewater treatment process. Several industrial associations, including The Chlorine Institute, The National Lime Association, and The American Chemistry Council provide guidance for operators that can be used for the storage and use of the chemicals.

When loading bulk chemicals, follow the requirements in the spill control plan and applicable standard operating procedures to prevent spills and addition of the chemicals to the wrong chemical storage tank. Use the chemical usage rate and storage volume to determine the amount of the chemical remaining in storage and to see if there is any possible indication of a leak. Report any indications of leaks to the Installation Environmental Program staff. The chemical may be tested prior to use to determine the actual concentration. Chemical that has been stored for use during the next season should be tested to confirm chemical concentrations.

5-3.1 pH Adjustment.

Normally, at wastewater treatment plants, pH is not in need of adjustment for the biological process to occur. The high and low pH chemicals are used for cleaning items such as membranes, UV lamps, and for adjusting pH for chemical odor control systems. The common bulk pH-adjusting chemicals used at wastewater plants are citric acid and sodium hydroxide (caustic soda).

Citric acid can be delivered in either dry or liquid form. Normally, when citric acid is delivered in dry form, it is for small batches where the operator adds the dry acid to a tank to achieve a desired pH. Liquid citric acid is used to create large batch of low pH cleaning solutions. Sodium hydroxide is always delivered as liquid, but it can vary in solution strength of either 25 or 50%.

5-3.2 Indoor Chemical Storage.

Chemical storage rooms may have Heating, Ventilation, and Air Conditioning (HVAC) systems installed. Operators must ensure that all HVAC equipment is operating, to maintain a safe environment and preserve chemical quality. HVAC equipment may maintain temperature, humidity, and ventilation requirements for the chemicals being stored. HVAC systems can also be used to limit the amount of corrosion caused by the chemical vapors in the chemical storage room.

5-3.3 Outdoor Chemical Storage.

Outdoor chemical storage tanks may have tank heaters that are used to prevent freezing. Operators should inspect chemical storage heaters to ensure they are operating during cold weather to maintain the bulk chemical quality and prevent the chemicals from freezing in the storage tank.

Freezing of chemicals can damage equipment and piping, causing chemical leaks. A chemical of specific concern is a solution of 50% sodium hydroxide. The 50% sodium hydroxide solution will freeze at 59 ˚F (15 ˚C).

5-3.4 Cleaning Considerations.

After cleaning with an acid, do not add the low pH cleaning byproduct directly to the biological process as it will have a significant effect on the biological process. Neutralize the acid with a base (to a pH of around 7.0) or dilute the acid with water prior to disposing of it through the wastewater treatment plant. If neither option is possible, add the acidic solution to the wastewater flow slowly, taking long periods of time to add it, thus allowing the influent wastewater flow to dilute it prior to entering the biological process.

5-3.5 Alkalinity Adjustment.

Alkalinity adjustment is typical at wastewater treatment plants. The alkalinity is normally increased in the wastewater to support the nitrification of ammonia in the wastewater. Additionally, alkalinity may need to be adjusted to support the use of chemicals for phosphorus removal.

Alkalinity addition chemicals can come in liquid and dry powder form. The two liquid chemicals used are 50% sodium hydroxide and 62% magnesium hydroxide. Chemicals in solid form are typically dissolved in water to make a slurry. The slurry can then be pumped into the wastewater flow to increase its alkalinity. Lime and soda ash are the two most common chemicals.

5-3.5.1 Chemicals Used for Alkalinity.

Each chemical has specific operating procedures that operators must ensure are correct. The 50% sodium hydroxide solution must remain above 15 ˚C to prevent the chemical from freezing, which will damage equipment and piping. The location where the sodium hydroxide is stored must have its heating system checked regularly. If a tank heater and heat tracing are used on the piping, they must be checked for proper operation. Adjust the carrier water (motive water) to reduce the sodium hydroxide concentration in the carrier piping and to ensure that water velocity is fast enough to minimize the possibility of freezing.

Mix magnesium hydroxide and both soda ash and lime slurries. Magnesium hydroxide must remain constantly mixed to prevent the chemical pump suction from becoming clogged. Soda ash and lime must be mixed into the water to become a slurry.

5-3.6 Coagulants and Phosphorus Removal.

To remove phosphorus by chemical precipitation, various chemicals can be used. These chemicals can also be used to coagulate the suspended solids in the wastewater to increase the clarity of the water. The addition of these chemicals will increase the amount of sludge that is created at the wastewater treatment plant. The common chemicals that are used for phosphorus removal are aluminum and ferric salts.

Refer to *Advanced Waste Treatment*, Chapter 5 for additional guidance on phosphorus removal.

5-3.7 Aluminum Salts.

The aluminum salts come from three chemicals: aluminum sulfide (known as alum), aluminum chloride, and sodium aluminate. Sodium aluminate is the only aluminum salt that comes in a solid and must be dissolved on site. Alum consumes about 0.55 mg/L of alkalinity per every 1.0 mg/L of solution added, whereas aluminum chloride and sodium aluminate do not affect the water alkalinity. The theoretical amount of aluminum needed to remove phosphorus is 2:1 as a molar ratio. Below is the general equation for aluminum reaction to remove phosphorus.

Equation 5-1. Aluminum Phosphorus Removal

$$Al^{+3} + H_nPO_{-4}^{n+3} \leftrightarrow AlPO_4 + nH^+$$

5-3.8 Iron Salts.

The most common iron salt is ferric chloride (known as ferric), which is normally in a liquid form. Other ferrous salts can be used, but they require a pH higher than 8.5 or must be combined with chlorine to change the ferrous iron to ferric iron. Ferric consumes 0.93 mg/L of alkalinity per 1.0 mg/L of ferric added. The theoretical amount of iron ranges from 15 up to 30 mg/L (45 to 90 mg/L of ferric chloride) for every 1 mole of phosphorus. Below is the general equation for ferric reaction to remove phosphorus.

Equation 5-2. Ferric Phosphorus Removal

$$Fe^{+3} + H_nPO_{-4}^{n+3} \leftrightarrow FePO_4 + nH^+$$

On all the coagulants, they start to crystalize at 0 ˚C. Operators must check tank heaters and heat tracing on all the coagulant chemical system to ensure that no equipment damage occurs.

5-3.9 Polymers.

Polymers come in liquid and dry form. They are used for thickening and dewatering sludge but can be used to improve solids capture in a clarifier. Polymers range from cation (positive charge) to non-charge (neutral) and to anionic (negative charge). Some manufacturers also produce polymers that contain both cation and anion in the polymer. Keep liquid polymers in a cool dry location. Liquid polymer will degrade at temperatures higher than 50 ˚C. Keep dry polymers in a dry location to prevent clumping and clogging of piping after being introduced into the dilution water.

Conduct bench testing with a polymer manufacturer to determine the correct polymer and its dosing. As part of the bench testing, determine the correct solution strength to make the polymer, aging of the polymer, and mixing requirements of the polymer. In general, mix the dry polymer for at least 30 minutes at a low speed to allow the polymer to uncoil prior to use.

5-3.10 Oxidizers.

At wastewater treatment plants, oxidizers are used for odor control and control of hydrogen sulfide. The two most common oxidizers used are hydrogen peroxide and potassium permanganate. These chemicals normally are only used during warm weather to reduce odors and prevent the formation of hydrogen sulfide in the pipes and process of the wastewater treatment plant.

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CHAPTER 6 ODOR CONTROL

6-1 MAINTENANCE.

The maintenance requirements for odor control systems varies depending on the type of chemical and biological odor control systems used. Recommended maintenance should be completed by operators and maintenance staff to maintain all warranties and performance guarantees. Refer to the equipment manufacturers operation manual and operate solids treatment equipment in accordance with manufacturers recommendations and all NPDES permits.

6-2 ODOR CONTROL SYSTEMS.

Wastewater, whether it is being collected, treated, or disposed, emits strong odors and potentially other air containments. Odor control is also implemented because of public concern for health and safety and/or intolerable odors. Odors can be treated with microbiology, which uses compounds in the odorous air for an energy source, or with chemicals, which react with the compounds in the odorous air and change the compounds into a non-odorous compound. Some compounds can be adsorbed into activated carbon as the air passes by it.

Refer to *Advanced Waste Treatment*, Chapter 1 for additional guidance on odor control.

6-3 OPERATION.

The operation of both chemical and biological odor control systems are different in their requirements. In both cases, sampling may be used to verify proper operation and verify performance to ensure that the treated air meets applicable permit requirements.

Record all operating data and evaluate any changes and trends in the data collected for each type of odor control system.

6-3.1 Chemical Odor Control Systems.

Operate chemical odor control equipment in accordance with the manufacturer's operation manual. Common setpoints may include pH, oxidation reduction potential, and free chlorine. Operators must ensure that the amount of makeup water supplied to the odor control system is enough to ensure proper operation of the odor control system without wasting a large amount of water. Refer to *Advanced Waste Treatment* for typical oxidant dosages for a chemical odor control system.

For an odor control system that contains activated carbon, monitor activated carbon performance. If the activated carbon shows signs of breakthrough, it must be replaced.

6-3.2 Biological Odor Control Systems.

Maintain the moisture content in the biological odor control media. The amount of water required to be applied to the media is dependent on the location of the biological odor control system and time of year. Times of dry weather and when the atmosphere contains dry air generally will require more water to be applied to the media than times of the year when there is precipitation and humidity in the air. Generally, biological odor control system media must be kept between 50 and 60% moisture content. Some biological odor control systems may have a system to increase the humidity in the odorous air prior to entering the media. Adjust the amount of water to raise the odorous air humidity to the manufacturers recommended humidity level.

Biological odor control system may have a nutrient addition system. Operate the nutrient addition system per the manufacturer requirements to ensure that the microorganisms have sufficient nutrients to allow them to grow and maintain treatment of the odorous air.

CHAPTER 7 COLD WEATHER OPERATION

7-1 INTRODUCTION.

Cold weather can affect every aspect of the wastewater treatment plant operation. Items to consider for cold weather operation for each process at the wastewater treatment plant follow.

7-2 MAINTENANCE.

Recommended maintenance should be completed by operators and maintenance staff to maintain all warranties and performance guarantees. Refer to the equipment manufacturers operation manual and operate equipment in accordance with manufacturers recommendations and all NPDES permits.

7-3 SCREENINGS.

Clean screens more frequently during cold weather, either automatically on timers or manually, because the screenings will freeze to the metal bars. Once this occurs, removing screenings from the bars is difficult. Mechanical mechanisms may also become jammed and inoperable. Weatherproofing or enclosing the area and providing heat may be desirable. Be aware of the potential for combustible materials entering with the wastewater. Provide proper ventilation and equipment to prevent explosive conditions.

Screenings may freeze to the sides and bottom of containers; prevent this from happening if possible. Grinders may bind because of ice if they are not run often enough. Consider operating the grinders continually or often enough to prevent ice buildup. Covering channels with rigid insulating materials may contain enough heat from the wastewater within the channel to prevent ice buildup on the grinder. Gear oil viscosity will be affected by freezing weather. Condensation also will occur in the gear boxes of this equipment, adversely affecting the gear oil. Check the oil routinely (twice monthly) in the winter.

7-4 GRIT REMOVAL.

Operation of grit-handling facilities may be difficult during extremely cold weather. The grit that is collected and transported will freeze easily in the equipment used to clean and move it to the holding container. Temporary enclosures may assist in keeping the process warm. If this process is to be enclosed, choose the materials carefully to prevent dangerous or explosive conditions. Heat-tracing the metal equipment may help prevent ice buildup. Heat-tracing involves wrapping an electrified wire loop around the equipment. Running warm water across cleaning areas also may prevent freezing, depending upon local conditions.

7-5 PRIMARY TREATMENT.

Clarifiers are affected in several ways by the decrease in seasonal temperatures. The density of water changes with temperature, and this change affects the settling characteristics of the solids. Materials at the surface of these quiescent basins will tend to freeze. Weirs and launders may also freeze, depending upon the ambient and wastewater temperature.

Settling characteristics change when temperatures lower; solids settle at a slower rate in colder (near freezing) waters. Stoke's Law governs the physics of settling in primary clarifiers, and it is affected by temperature. For example, when the temperature drops from 68 ˚F (20 ˚C) to 38 ˚F (3 ˚C), the settling time for a particle increases 64%. Under these conditions, additional clarifiers may facilitate the process. The use of additional clarifiers may result in lower water temperatures and a higher risk of freezing. Evaluate the use of additional clarifiers and the risk of freezing. If the solids loading is high (above 2,000 mg/L), Stoke's Law does not apply.

7-5.1 Inspection.

Inspect the aerobic digester for ice on the primary treatment surface and around the sludge flight and chain or the scum skimmer when cold weather occurs. If any ice is found, the operator must break up or remove the ice before it damages the primary treatment equipment.

7-5.2 Biological Treatment.

Cold weather affects the biological systems in the same way, in that the microbiology process slows down. But, the cold weather affects the mechanical equipment to each of the various types of biological system differently and thus each system is described below.

7-5.3 Activated Sludge.

Cold weather does not affect conventional activated sludge systems with a detention time of 4 to 6 hours as significantly as systems with longer detention times. Extended aeration systems having detention times of 10 to 24 hours will experience a temperature decrease that will affect the biological process Systems that use diffused air for oxygen transfer will add heat to the system in the air flow; conversely, mechanical mixing systems will have significant temperature decreases across the aeration basin as cold air is mixed into the activated sludge. Operators must take these temperature changes into consideration when selecting or changing aeration methods in a cold climate. Avoid ice buildup across the surface of the basins. The ice buildup will limit the oxygen transfer and may interfere with mixing equipment. Removing floating scum before winter will help prevent this extra material from freezing in the aeration basin.

7-5.3.1 Maintenance.

When a tank is offline and drained, protect equipment from cold weather and damage. Refer to the equipment manufacturers operating and storage instructions for storage and follow the recommended practices.

7-5.4 Biological Reaction Rates.

Biological reaction rates depend upon temperature. A reduction in temperature of 18 ˚F (10 ˚C) decreases the reaction rates by one-half. In cases where the temperature is affecting the process, changes to the process control are required. Process adjustments would include increases to the MCRT, aerobic Solids Retention Time (SRT_a), or a decrease in the food-to-microorganism ratio to maintain the same process performance and loading rates.

7-5.5 Aeration Equipment.

Ice buildup around mechanical aeration equipment will also affect safety and may overload equipment if it attaches to equipment surfaces. Continuous operation of mechanical mixers at low speed or intermittent operation will reduce the oxygen transfer and reduce ice buildup. Monitor oxygen concentration closely if this method is attempted. Heat tracing the components also may be helpful.

7-5.6 Clarifiers.

The most serious problems associated with clarifiers is freezing on the surface, surface scum, and ice buildup on the scum beach plate. These problems damage skimming mechanisms and may even cause the clarifier rake mechanism to jam or fail. Removing the skimming arm in winter may prevent this problem; however, the problems of scum freezing and removal remain. Hot water sprays, heat tape, and enclosed lamps may help in addressing these problems. Many times, ice must be carefully chopped off the surface of the tanks and removed to the launders. Covering clarifiers will typically help eliminate these potential problems. When designing covers, consider snow loads, weatherproofing of electrical controls, and the possibility of humidity within the covers. Torque limits on the rake mechanism need to be properly set to ensure proper operation if ice affects the collector.

7-5.6.1 Maintenance.

Routinely check torque limits on the rake mechanism and repair them if necessary.

7-5.7 Trickling Filters and Rotating Biological Contactors.

In trickling filter plants, the potential for icing is high. In the winter, turn off the draft in forced-draft systems unless a source of warm air is available to prevent ice from forming in the filter. The forced draft systems are used primarily when the outside air is less than 5 ˚F (3 ˚C) above or below the process liquid temperature. If ice forms within the unit, flood it to melt the ice. Take care when flooding the media and be cautious of structural loading as well as leaking and overloaded pumping systems, gates, and valves. Ice can form on the top of the media, which may affect the distributor arm. Covers are advised in extremely cold areas to prevent this situation. RBCs are usually covered to control odors but keep the covers in good condition to keep the heat within the wastewater. If the RBCs do not already have covers, install them to keep the media from freezing and affecting the shaft with additional loading and potential failure.

7-5.8 Natural Biological System.

Aerated lagoons will typically freeze during the winter. Remove mechanical mixers to prevent them from becoming covered with ice and turning over or sinking. Remove any baffles or be prepared to repair them in the spring. Because the ice will affect the depth of the lagoon, run winter operations at the highest liquid levels possible to increase lagoon volume. Because of the ice coverage, little to no algae activity will occur under the ice and snow. Adding the lower water temperature to the situation, lagoon performance in the winter may be marginal. With the rise in spring temperatures, the lagoons will have a liquid turnover, with a possible washout of solids.

7-5.9 Aerobic Digester.

While aerobic digesters are not normally in locations that experience long periods of cold weather, they can experience short spells of cold weather that can damage equipment. Inspect the aerobic digester for ice on the digester surface and around the mixing equipment when cold weather occurs. If any ice is found, the operator must break up or remove the ice before it damages the digester equipment. If an extended period of cold weather is experienced, consider building a temporary shelter around the digester to limit the amount of ice that forms on the digester.

Aerobic digesters operate at lower efficiencies. Longer detention times are required to obtain the needed levels of stabilization. Increase digester solids concentrations to accommodate these changes. Thus, decanting the digesters may take longer because of increases in viscosity.

7-5.10 Anaerobic Digester.

It will take more energy to keep the contents up to the processing temperature because of the lower feed temperature. Tank insulation (dome and sides) will need to be inspected in the fall of each year and repaired as needed.

7-6 ODOR CONTROL SYSTEM.

Both the chemical and biological odor control systems have heat traced and insulated water piping, which must remain full of water and is exposed to the cold weather. This will prevent freezing of the piping, which may cause equipment damage. Chemical piping in the chemical odor control system should be heat traced and insulated to prevent the chemicals from freezing or crystalizing in the piping.

To drain the biological odor control system, isolate the irrigation water system and drain to prevent equipment damage. To fully drain the system, consider using compressed air to remove all possible water. Inspect the odor control air duct for condensation in the interior piping by opening all water drain ports to remove water and then shutting them once all water has been drained out.

7-7 UTILITIES.

In electrical panels, frost may arc across some electrical circuits. A small warm-air fan in the vent of the electrical panel will keep the internal components warm and dry if this is a local issue.

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Note: For the Army, TM 5-814-3 provides additional requirements for cold weather operation.

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CHAPTER 8 WET WEATHER FLOW OPERATION.

Due to the infiltration of groundwater and use of combined sewers, the operation of a wastewater treatment plant must change when a large amount of precipitation is expected.

8-1 SCREENING PROCESS.

The increase in raw wastewater influent will increase the amount of material that it carries with it. Run mechanical screens more often by either reducing the differential level for the screen to start or reducing the timer to make the mechanical screen start. For manual bar screens, increase the number of times the screen is cleaned during a storm.

For both the mechanical screen and manual bar screen the increased removal of material will minimize the possibility of a sewer overflow in the collections system. The increased frequency of removing the materials also will minimize the surging of water flow through the wastewater treatment plant, thus, maintaining a high level of treatment for all water that flows through it.

8-2 GRIT REMOVAL PROCESS.

The increase in wastewater flow can increase the amount of grit that it contains due to velocity of the water flowing through the collection system. Prior to a wet weather event, it is recommended that the amount of time that the grit removal equipment runs to remove grit from the grit chamber be increased to remove the increased grit load.

8-3 BIOLOGICAL PROCESS.

Each of the biological systems are affected by wet weather. The increased flow can cause NPDES permit violations if operators do not take action. Below are recommended actions for the various biological process to maintain permit compliance during a wet weather event.

8-4 ACTIVATED SLUDGE.

When wet weather occurs, the constituent loading on the biological system may slightly increase, but the major increase will be the hydraulic loading on the activated sludge process. The increased flow will decrease detention times for treatment of the wastewater and settling of the mixed liquor in the clarifier. Prior to a major wet weather event, if possible, increase the amount of mixed liquor and increase the amount of tankage available to treat the wastewater. Additionally, increase the number of clarifiers in service to allow as much settling of the mixed liquor from the treated wastewater prior to it flowing out to the environment. Consider increasing how much RAS they return from each clarifier to minimize the possibility of washing out any mixed liquor from the bottom of the clarifiers.

8-5 TRICKLING FILTERS AND ROTATING BIOLOGICAL CONTACTORS.

As with activated sludge, the constituent loading on the biological system may slightly increase, but the major increase will be the hydraulic loading when a wet weather event occurs. If possible during a wet weather event, start up another trickling filter or RBC and increase the recirculation rate of the units. This will provide more time to allow treatment, and if the trickling filter and RBC do not have a biomass, the recirculation will seed the units to start growing the biomass on the media.

CHAPTER 9 UTILITIES.

A wastewater treatment plant cannot perform its function without the support of other utilities such as electrical distribution and natural gas. All the utilities have required operation and maintenance requirements that operators must be aware of and follow to ensure that proper treatment of wastewater continues without interruption to the treatment process.

9-1 ELECTRICAL DISTRIBUTION.

The electrical distribution system is typically required to have two independent power sources. Normally, the second power source is provided by emergency generators, but it can be provided by a second electrical power supply line that independent of the first electrical power supply. The electrical distribution system normally contains various voltages within it. These voltages are supplied by the power provider or emergency generators.

An electrical distribution has at least one power supply line that provides power the wastewater treatment plant. The power is then distributed to motor control centers, or to other power panel and lighting panels.

9-1.1 Operation and Maintenance.

Use UFC 3-540-07, UFC 3-550-07 and UFC 3-560-01 for additional operation and maintenance requirements. The operation of the electrical distribution system is limited to backup generators. Operators should inspect, test and store fuel in accordance with written standard operating procedures to maintain the operational integrity of backup generators. Any other operation of the electrical distribution must be completed by a qualified person to ensure personnel and equipment safety.

Note: For the Air Force, **\1** AFMAN **/1/** 32-1062 provides additional requirements for generators.

Note: For the Army, TM 5-682 provides additional requirements for electrical facilities safety. TM 5-683 provides additional requirements for electrical interior facilities, TM 5-684 provides additional requirements for electrical exterior facilities, and TM 5-685 and AR 420-1 provide additional requirements for operation, maintenance, and repair of auxiliary generators.

9-2 POTABLE WATER.

Potable water is used throughout the wastewater treatment plant for various uses. These uses include drinking water, seal water for pumps, chemical carrier water, fire protection, and equipment wash water.

9-2.1 Operational and Maintenance.

Use UFC 3-230-02 for operation and maintenance of water supply systems. Potable water supply systems are required to be protected from backflow by an approved backflow prevention device. Use UFC 3-230-01, UFC 3-420-01 and UFC 3-600-01 for backflow protection and cross control. Verify Installation specific requirements and testing frequency with the Installation Environmental Program staff.

Potable water may be piped to a hydropneumatic tank or a tank with an air gap to prevent any possibility of contaminating the potable water system with chemicals, sludge, or wastewater. Operate the hydropneumatic tanks per the manufacturer's operating instructions to prevent damage to the equipment and protect the potable water system.

Note: For the Air Force, **\1** AFMAN **/1/** 32-1067 provides additional requirements regarding potable water.

9-3 NATURAL GAS.

Natural gas may be used at wastewater treatment plants as a fuel source for a heating unit, a hot water heater, a sludge incinerator, or an emergency generator.

9-3.1 Operational and Maintenance.

Operators at a wastewater treatment plant typically do not have any operational requirements for the natural gas service up to and including the gas meter. Contact the natural gas utility provider for any emergency or service related questions. Post the natural gas service providers emergency contact information on-site.

Call the local utility marking service prior to any digging or excavation and obtain a permit or clearance to dig from the utility marking service.

9-4 CATHODIC PROTECTION.

Cathodic protection provides additional corrosion protection, supplementing the normal protection offered by protective coating systems. Use UFC 3-570-06 for operation and maintenance of cathodic protection systems.

Note: For the Army, PWTB 420-49-29 provides additional requirements for cathodic protection systems.

Note: For the Air Force, AFH 32-1290 provides additional requirements for cathodic protection systems.

9-5 HEATING, VENTILATION, AND AIR CONDITIONING.

The heating, ventilation, and air conditioning (HVAC) system is comprised of various pieces of equipment that are used to maintain the desired atmosphere inside a single room or the entire building. The atmosphere of the room or building includes temperature and humidity of the room or building.

The HVAC system is also used to maintain the number of air exchanges that occur in a room to reduce the potential for health effects on an operator when they enter the room and the potential hazard of fire or explosion from the accumulation of sewer gases. The HVAC system can also be used to maintain differential pressure in various locations in a building to prevent the migration of odors from sludge and other wastewater processes. The HVAC system may also work in conjunction with the odor control system to remove odors from a space or building.

9-5.1 Heating, Ventilation, and Air Conditioning Equipment.

The HVAC systems are comprised of some equipment that is simplistic in its function, whereas other pieces of equipment are complex and perform various functions for the HVAC system.

9-5.1.1 Heating Equipment.

The heating of air can be accomplished by various pieces of equipment. Unit heaters are industrial electric heaters, whereas gas unit heaters use natural gas to heat the air. Both unit and gas unit heaters are simple heaters that operate independently of any control system. Rooftop units can provide both heating and cooling of a space, but they require a control system to determine when the heat or cooling system of the rooftop unit will be used. The rooftop unit can use electricity or natural gas as its fuel source to heat the air.

9-5.1.2 Ventilating Equipment.

Ventilation is accomplished by fans and rooftop units. Fans can either supply air (push air into a space) or exhaust air (draw suction on a space). This method of supplying and exhausting the same amount of air is the simplest method of cooling a space, and it also can be used to provide air exchanges to maintain the atmosphere in the space. If the amount of air differs, then a pressure differential is created between the space and the outside atmosphere. Rooftop units normally provide air into a space; thus, if they are the only method of ventilation, the space will be pressurized, which will push out of the building into the outside atmosphere.

9-5.1.3 Air Conditioning Equipment.

Air conditioning of a space or building is accomplished by rooftop air conditioning units. These air conditioning units run to maintain the temperature setpoint in the control system. In addition, the air conditioning unit can run to maintain a humidity setpoint in the control system.

9-5.2 Operational Requirements.

The HVAC system must have all components operating as designed to maintain a safe environment. Operators must review all setpoints entered into the HVAC control system to ensure the temperature setpoints are correct and all times for occupancy are correct for the work day.

When entering a space, operators must turn on or ensure that the HVAC equipment is operating correctly. When operators exit a space, they must turn off the HVAC system if applicable.

Note: For the Army, AR 420-1 provides further guidance on boiler operations.

Note: For the Air Force, **\1** AFMAN **/1/** 32-1068 provides further guidance on boiler personnel schedule requirements.

9-6 FIRE PROTECTION SYSTEMS.

Use UFC 3-600-02 for the inspection, testing and maintenance of fire protection systems.

CHAPTER 10 SEPTIC SYSTEMS, GREASE TRAPS, AND OIL-WATER SEPARATORS

10-1 INTRODUCTION.

Septic sewer systems collect and treat wastewater where it is not feasible to provide a wastewater collection and treatment system. The majority of septic systems collect and treat domestic wastewater. Food-service operations typically use grease traps to prevent excessive discharge of grease and oil into the wastewater collection and treatment system. Refer to EPA/625/R-00/008 for additional guidance.

10-2 MAINTENANCE.

The maintenance requirements for septic system, grease traps and oil-water separators varies depending on user operating procedures and the type of equipment used. Recommended maintenance should be completed by operators and maintenance staff to maintain all warranties and performance guarantees. Refer to the equipment manufacturer's operation manual and operate equipment in accordance with manufacturer's recommendations and all NPDES permits.

10-3 SEPTIC TREATMENT AND DISPOSAL SYSTEM.

Septic systems are used when collection of wastewater by a centralized wastewater collection and treatment system cannot be provided. Septic systems collect domestic septage, provide treatment and dispose of the treated effluent on-site. A state or local permit may be required to construct, operate or modify a septic system.

Septic systems collect domestic wastewater flows from the building into the septic tank through a sewer pipe. In the tank, bacteria attack and digest organic matter by anaerobic digestion. The wastewater itself provides the bacteria for this process. The anaerobic digestion process changes the waste into gas, biosolids (residual organic and inorganic material), and treated effluent. The gas escapes into the air, the treated effluent is discharged to the leaching system, and the residual solids remain in the tank. The treated effluent is discharged into the soil through the perforated or open-jointed pipes in the drain field. Soil bacteria destroy remaining organic material in the effluent. Use IPSDC for septic treatment and disposal system requirements. Use EPA 932-F-99-068 and *Maintaining Your Septic System - A Guide for Homeowners*, for additional guidance on maintaining septic systems.

10-3.1 Domestic Wastewater Characteristics.

There are many factors that influence septage characteristics such as climate, user habits, septic tank size, design, pumping frequency, water supply characteristics, piping material, and use of water-conservation fixtures, garbage disposals, household chemicals, and water softeners. Refer to EPA 932-F-99-068 for domestic wastewater characteristics.

10-3.2 Monitoring Waste Discharged to System.

Because the septic tank treatment system is a biological process, it is particularly important that toxic or hazardous chemicals are not discharged into it. These chemicals would kill the bacteria used for treatment of the wastewater. Discharge of industrial wastewater to septic tanks violates the underground injection provisions of the SDWA. In addition, do not discharge grease and non-biodegradable into the system. The system is not designed to treat these products, and they can cause clogging in the system components. Use household cleaners, such as bleach, disinfectants, and drain and toilet bowl cleaners, in moderation and only in accordance with product labels. Overuse of these products can harm the septic tank system.

10-3.3 Water Conservation.

Water conservation is critical for proper operation of the drain field. Continual saturation of the soil in the drain field can significantly reduce the ability of the soil to naturally remove toxins, bacteria, viruses, and other pollutants from the wastewater. In addition to conserving water discharged to the septic tank and drain field, try to restrict water from roof drains, sump pumps, and other sources from draining into the area of the drain field.

10-3.4 Septic System Components.

10-3.4.1 Tank.

The size of the septic tank depends on the number of people using the building or the volume and type of waste. Figure 10-1 depicts a two-compartment septic tank system.

10-3.4.1.1 Septic Tank Maintenance.

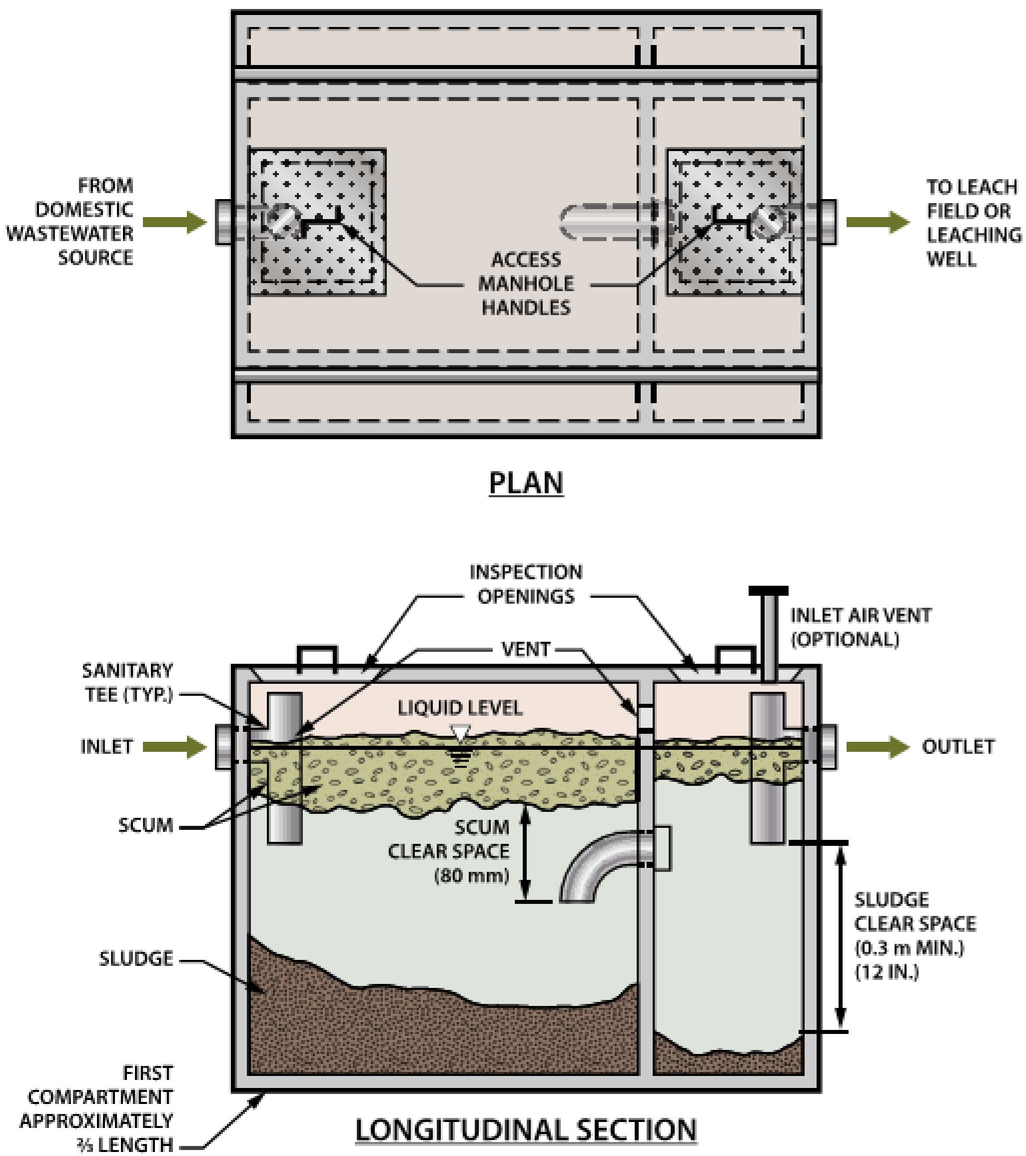
The primary maintenance requirement for the septic tank system is periodic removal of scum and settleable solids. It is not necessary to add yeast or bacteria to the system as a maintenance procedure. If human and kitchen wastes are being discharged to the system, there will be sufficient bacteria in the tank for treatment. Table 10-1 shows the estimated tank pumping frequencies, based on tank size and household size.

10-3.4.1.2 Inspecting the Septic Tank.

Inspect the septic tank every 1 to 5 years to determine if solids need to be removed. If garbage disposals discharge to the septic tank should be inspected annually.

Exercise extreme care when inspecting the septic tank as inhalation of toxic gases have been known to cause sickness or death. Never enter or inspect a septic tank alone. Toxic gases are produced by the natural treatment processes in septic tanks and special precautions need to be used to prevent inhaling these toxic gases. Contact the Installation Safety Officer to obtain a confined space permit if entry is required. Guidance on confined space entry requirements can found in *Operation of Wastewater Treatment Plants*, Volume 2, Chapter 14.

Figure 10-1 Typical Two-Compartment Septic Tank



10-3.4.1.3 Measuring Solids and Scum Inside the Tank.

There are two frequently used methods for measuring the scum layers inside the tank.

a. A hollow clear plastic tube is pushed through the different layers to the bottom of the tank. When the tube is brought back up it retains a sample showing a cross-section of the inside of the tank.

b. The layers can also be measured using a long stick. To measure the scum layer using a stick, a 3 in. (8 cm) piece of wood is attached across the end of the stick to form a "foot," and the stick is pushed down through the scum to the liquid layer. When the stick is moved up, the foot meets resistance on the bottom of the scum layer. The stick is marked at the top of the layer. The distance between the mark and the foot on the end of the stick can be measured to determine the total thickness of the scum layer.

The solids layer can be measured by wrapping cloth around the bottom of the stick and lowering it to the bottom of the tank. Insert the stick either through a hole in the scum layer or through the baffle or tee, if possible, avoid getting scum on the cloth. Estimate the solids depth by the length of solids sticking to the cloth.

Table 10-1 Estimated Septic Tank Pumping Frequencies in Years

	Household Size (number of people)					
Tank Size (gallons)	**1**	**2**	**3**	**4**	**5**	**6**
500	5.8	2.6	1.5	1.0	0.7	0.4
750	9.1	4.2	2.6	1.8	1.3	1.0
900	11.0	5.2	3.3	2.3	1.7	1.3
1,000	12.4	5.9	3.7	2.6	2.0	1.5
1,250	15.6	7.5	4.8	3.4	2.6	2.0
1,500	18.9	9.1	5.9	4.2	3.3	2.6
1,750	22.1	10.7	6.9	5.0	3.9	3.1
2,000	25.4	12.4	8.0	5.9	4.5	3.7
2,250	28.6	14.0	9.1	6.7	5.2	4.2
2,500	31.9	15.6	10.2	7.5	5.9	4.8

(1) These figures assume no garbage disposal is in use.

Source: *Maintaining Your Septic System - A Guide for Homeowners*

10-3.4.1.4 Removal of Settleable Solids.

Pump solids out of the tank when the depth of solids is one-third or more of the liquid depth. When pumping the tank, remove all contents, including scum, liquid, and solids. Use only the access ports on the tank for cleaning; do not pump out the tank through the distribution box. Do not use toxic or hazardous chemicals for cleaning the tank and do not use organic chemical solvents or petroleum products for degreasing or declogging the system. These chemicals and products are harmful to the system and to the groundwater near the system.

10-3.4.1.5 Removal of Scum.

The tee shaped outlet prevents the scum from leaving the tank. Pump the tank whenever the bottom of the floating scum layer is within 6 inches (150 mm) of the bottom of the outlet tee or the top of the floating scum layer is within 12 inches (300 mm) of the outlet tee.

10-3.4.2 Effluent Disposal Systems.

Soil absorption systems, pressure distribution systems, mound systems, and holding tanks are used to dispose or store treated effluent. Do not allow vehicles to drive over effluent disposal systems. Do not plant trees, shrubs, or similar plants over the effluent disposal systems.

10-3.4.2.1 Soil Absorption System.

A gravity effluent leaching system consists of a distribution box or header pipe and a drain field. The drain field is a system of open-jointed or perforated piping that allows the wastewater effluent to be evenly distributed into the soil. Where groundwater levels are high, the elevation may be insufficient for a soil absorption system and an alternative system is used to dispose of treated effluent.

10-3.4.2.2 Soil Absorption System Maintenance.

Replacement is the only remedy for a leachate system that is not functioning. There are no conclusive data to support the premise that enzymes and chemical treatment can revitalize a drain field.

10-3.4.2.3 Mound Systems

Mound systems are generally used in areas with high groundwater levels or a minimum soil depth to bedrock. Mound systems are prohibited in flood hazard areas. Mound systems require a pump to deliver the effluent to the elevated leaching system. Electric controls and a power supply are required to operate the pump.

10-3.4.3 Effluent Screens.

Effluent screens enhance solids removal and clarify the septic tank effluent. Typically, effluent screens are attached to the outlet pipe inside the septic tank. In some cases, effluent screens may be placed in a filter chamber located outside of the septic tank on the outlet side of the septic tank. Effluent screens can assist in preventing blockages that could damage the drain field. In some cases, a biolayer may build up on the screen. The biolayer can help with the removal of viruses and pathogens. Review the state requirements for your location to see if an effluent screen is required. Refer to EPA 832-F-03-023 for additional guidance on effluent screens.

10-3.4.3.1 Effluent Screen Maintenance.

Effluent screens require regular cleaning to keep them operating efficiently and to prevent plugging. The frequency of cleaning depends on many factors, such as, environmental conditions, the material entering the septic tank, and the size of the screen. Some states require the use effluent screens.

10-3.5 Septic System Failures.

Several warning signs can indicate that a septic tank system is failing and that more than cleaning of the system is necessary:

- Obnoxious odors around the system or inside the building
- Soft ground or low spots around the system
- Grass growing faster or greener around the system
- Gurgling sounds in the plumbing or plumbing backups
- Sluggishness in the toilet when flushed
- Plumbing backups
- Tests showing the presence of bacteria in nearby well water

Table 10-2 shows possible causes of septic tank system failures and suggests remedial procedures.

Note: For the Air Force, **\1** AFMAN **/1/** 32-1067 provides additional requirements for septic systems.

10-4 GREASE TRAPS.

If grease traps are not properly maintained, slug loads of grease will interfere with the performance of both the collection and treatment system. There are two general types of grease traps, with the largest being inground grease traps that are usually located outside the food-service establishment in an underground tank with ground-level access. The second type is an under-sink unit. The under-sink units can be either passive, which captures the grease and requires an operator to remove the grease periodically or an automatic system that removes the grease as set by a timer to a separate container that the operator must empty periodically. Under-sink units are not recommended because they generally do not provide adequate grease removal. Where under-sink units are used, proper maintenance is especially critical because of the higher potential for release of slug loads of grease into the wastewater system.

10-4.1 Configuration.

Grease traps usually consist of an underground, watertight concrete tank with inlet and outlet piping. The outlet pipe has a tee that allows the internal discharge to be located within 12 in. (300 mm) of the tank bottom. The size of the grease trap depends on the anticipated flow rate, water temperature, and grease concentration. Access to the tank is typically through one or two manhole rings and covers.

10-4.2 Location.

Grease traps are located outside food-service buildings in an accessible location for inspection and maintenance.

Table 10-2 Septic System Failures

Possible Causes of Failure	Possible Remedial Procedures
Underdesign	
• Tank size insufficient for wastewater flow quantity and/or characteristics • Drain field too small	• Replace septic tank or add additional septic tank(s) in parallel. • Replace septic tank or add additional septic tank(s) in parallel.
Faulty Drain Field Installation	
• Plugged pipes • Insufficient stone in trenches • Uneven grades	• For plugged pipes, insufficient stone, and uneven grades, install a new drain field on top of existing field.
Poor Soil Conditions	
• High groundwater • Insufficient distance below drain field to bedrock • Relatively impervious soils	• Improve surface drainage, install curtain drains, elevate field, and/or reduce water consumption. • Elevate drain field and/or reduce water consumption. • Elevate drain field and/or reduce water consumption.
Overload	
• Excessive wastewater loading • Poor stormwater drainage away from system • Leaking plumbing fixtures • Wastewater flow quantity and/or characteristics greater than anticipated in design due to changes in use of building, garbage grinders, etc.	• Increase tank size or reduce water consumption. • Improve surface drainage. • Repair plumbing fixtures. • Remove garbage grinders; increase drain field.

Possible Causes of Failure	Possible Remedial Procedures
Lack of Tank Maintenance	
• Septic tanks not pumped out at sufficient intervals, causing solids to be discharged to drain field	• Pump out tank, construct new drain field on top of existing drain field, relieve drain field by draining into a pit and pumping out, and let field rest for a month.

Source: Adapted from *Wastewater Engineering Design for Unsewered Areas*

10-4.3 Discharges to Grease Traps.

Grease traps do not perform effectively if they receive discharges with elevated temperatures or high solids concentrations. It is not recommended for grease traps to receive discharges from garbage grinders or produce -preparation sinks. Discharges from mechanical dishwashers are also not recommended. However, the preflush or prescraping sinks that serve mechanical dishwashers may be connected to the grease trap, provided no garbage grinders are used at these sinks.

10-4.4 Maintenance Procedures.

The critical maintenance procedure for all grease traps is periodic removal of accumulated waste. If the responsibility and procedures for cleaning grease traps are not clearly identified and implemented, the traps are ineffective. It is recommended that waste be pumped out of the grease traps rather than dissolved with solvents. Grease and solvents may have a negative impact on the wastewater collection and treatment system. Recovered oil and grease from food-service operations typically can be sold to a local recycling company. If proper maintenance cannot be maintained, consider removing the grease trap and having the user separate the grease before discharging wastewater to the sanitary system.

Note: For the Army, AR 420-1 provides further guidance on grease trap maintenance.

10-4.4.1 Pump-Out Frequency.

The recommended pump-out frequency ranges depending on the waste characteristics of the establishment and the size of the grease trap. The necessary pump-out frequency can be determined by checking the grease retention capacity in the grease trap. Remove grease and accumulated wastes as often as necessary to maintain at least 50% of the grease retention capacity.

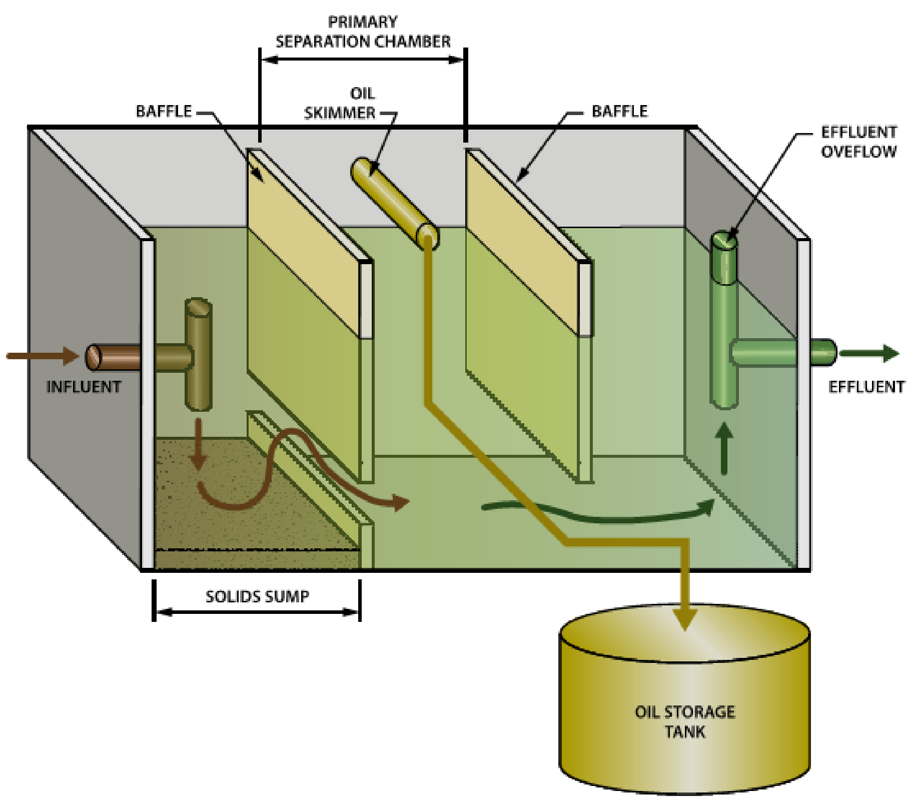
10-5 OIL/WATER SEPARATORS.

Oil-water separators are devices commonly used to separate oily waste products from wastewater streams. They are typically installed in industrial and maintenance areas to receive and separate oils at low concentrations from wastewater generated during industrial processes such as maintaining and washing aircrafts and vehicles. There are three predominant types of oil-water separators: conventional gravity separators, corrugated plate gravity separators, and flotation separators. Most oil-water separators used are conventional gravity separators. Most units, regardless of the type, are purchased as proprietary equipment from vendors.

10-5.1 Gravity Separators.

The process relies on the different densities of oil, water, and solids for successful operation. The wastewater is fed to a vessel sized to provide a quiescent zone of sufficient retention time to allow the oil to float to the top and the solids to settle to the bottom. Gravity oil-water separators come in two configurations: conventional gravity separators, such as those designed in accordance with guidelines established by the American Petroleum Institute (API) and corrugated plate interceptors (CPIs).

Conventional gravity separators are typically rectangular in-ground or above-ground tanks with maximum widths of 20 ft (6 m). A diagram of a typical conventional gravity separator is presented in Figure 10-3. Influent and effluent channels are normally located on opposite ends of the separator. The influent typically passes an inlet section that contains a slotted baffle to distribute influent evenly throughout the depth of the separator. For units without sludge collectors, there may also be a bottom baffle in the separator; this retains settled solids in the front part of the separator to reduce cleaning requirements. Other separators may have automatic sludge removal equipment that will rake accumulated sludge to a sludge hopper where it is pumped from the tank periodically.

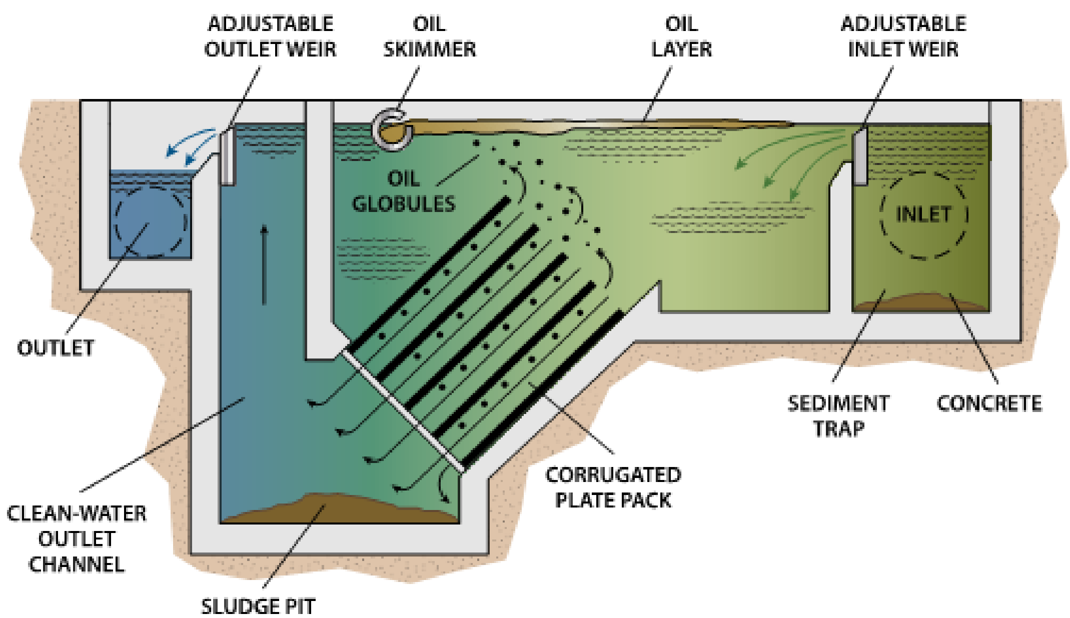


10-5.1.1 Sludge Level.

Monitor the sludge level routinely and remove sludge when it occupies 10% or more of the separator volume. All conventional gravity separators have a surface baffle at the Conventional Gravity Separator outlet end to retain floating oil and grease. The grease is removed by pumping or by activating a rotary drum or slotted pipe that allows the surface material to drain to a drum or oil holding tank. Regularly check the depth of the surface oil layer and conduct routine surface skimming. Experience gained from operating a conventional gravity separator in a specific application will indicate the required intervals for checking and skimming the oil layer. For example, although the oil layer might need to be checked and skimmed daily, this interval could range from several times per day to several times per month, depending on the rate of oil accumulation on the separator surface.

One criterion to use is monitoring the oil layer and skimming as often as necessary to prevent an excess amount of oil from being flushed through the separator by an unexpected hydraulic surge (e.g., rainfall). Thus, the frequency may also depend on the sensitivity of downstream processes to increased oil loading. The frequency will have to be determined by experience, but it likely will be such that the floating oil layer does not exceed about 2 in. (50 mm); some operators prefer that there be no floating oil layer on the separator.

Figure 10-2 Process Schematic of CPI Separator

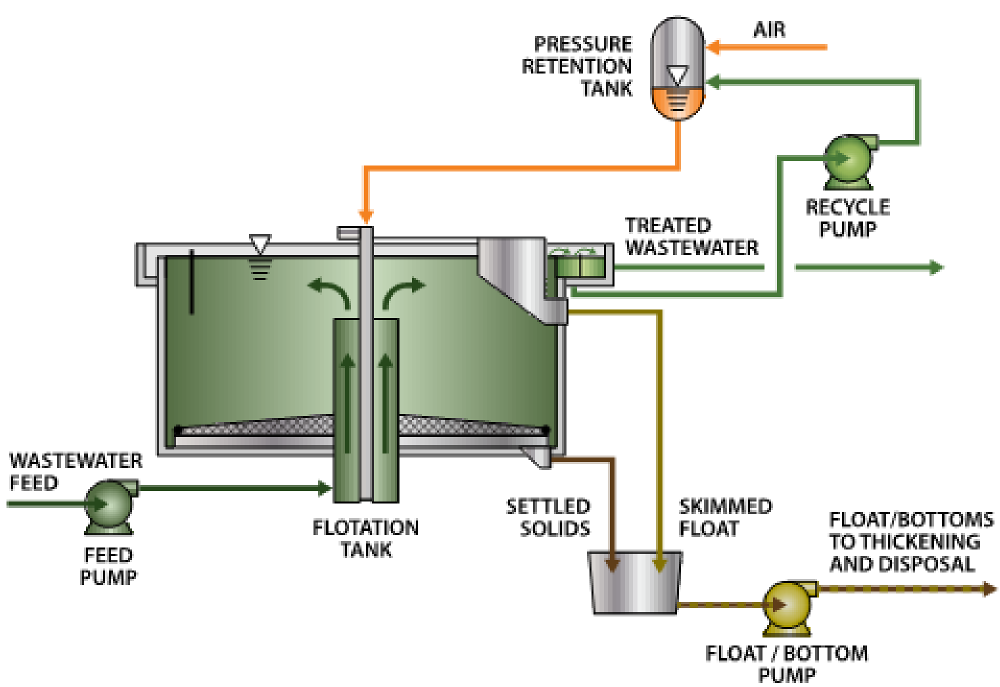


10-5.2 Corrugated Plate Interceptors.

CPIs are typically supplied by vendors and based on proprietary designs. A CPI consists of a tank containing parallel corrugated plates mounted from 0.8 to 1.6 in. (20 to 40 mm) apart and inclined at an angle to the horizontal. A diagram of a typical CPI is presented in Figure 10-4. Wastewater may flow either downward or upward between the plates. In the configuration shown, wastewater flows downward through the plates. As this happens, the oil droplets float upward and collect on the underside of adjacent plates where they coalesce. The coalesced oil droplets move up the plates and are retained in the separator to form a floating layer that is skimmed from the surface of the tank. Settled solids from the wastewater collect on the top side of adjacent plates, migrating down the plates and dropping into the bottom of the CPI vessel. In the diagram shown, treated water flows down through the plates and over a weir into an effluent flume. Some manufacturers use different configurations than the one shown.

CPI separators are smaller and easier to cover for controlling atmospheric emissions, and they may be less expensive than API-type separators. In practice, however, the smaller size has sometimes been a disadvantage because it may not provide sufficient volume to accommodate slugs of oil and it may not provide sufficient detention time for breaking emulsions. In some cases, the plate packs have become severely fouled. CPIs are usually drained and hosed down routinely to clean the plates. Operating experience over time will dictate how often this occurs, but a minimum interval of every 6 months is appropriate.

Figure 10-3 Process Schematic of Dissolved Air Flotation



10-5.3 Dissolved Air Flotation.

DAF is commonly used to remove oil, grease, and suspended solids from industrial wastewaters. A diagram of a typical DAF is presented on Figure 10-4. Typically, gravity oil-water separators are used in front of flotation units to remove the major fraction of free or floating oils; thus, flotation units usually are considered polishing units. The air bubbles can be added to the wastewater by a variety of means. Diffused air flotation and induced air flotation are the two most common types of DAF units. Both types incorporate a flotation vessel with a baffle to retain floated oil, an oil-skimming mechanism, and sometimes a bottom-scraping mechanism to remove heavy particles that do not float.

Significant mechanical equipment is associated with these systems and must be maintained according to manufacturer's directions. Flotation vessel surface skimming generally is continuous but settled sludge must be drawn off manually. The draw-off frequency will have to be determined by experience but could range from once daily to twice monthly, with weekly being a reasonable starting point.

10-5.4 Emulsified Oils.

The most common military applications seldom involve simple oil-and-water mixtures. Waste streams generated from military applications frequently contain significant quantities of dirt, cleaning aids (detergents, solvents), fuels, floatable debris, and various other items common to military equipment and activities. Oil-water separators are not designed to separate these other products. Improper use can result in oil passing through the oil-water separator. Misuse of these systems can upset treatment plants and exceed discharge requirements.

The following factors directly affect the efficiency, use, and management of oil-water separators: frequency and intensity of influent flow, design capacity, emulsifying agents, periodic maintenance practices, type of separator system, and other contaminants contained in the waste stream. Installation personnel must be familiar with these factors so they can operate and maintain these systems. A separator that is being used improperly must be reported to the environmental office.

10-5.4.1 Emulsifying Agents.

Emulsifying Agents, detergents, and soaps designed to remove oily grime from dirty weapon systems, vehicles, or other components can adversely affect oil-water separator operation. These agents are designed to increase solvency of oily grime in water. Hence, the oil droplets take longer to separate from water, reducing separation efficiency. Overzealous use of detergents can degrade efficiency by completely emulsifying oil in the wastewater stream, thus, allowing the oil to pass through an oil-water separator unaffected.

10-5.5 Frequency and Intensity of Flow.

The longer the residence time of the waste stream in the oil-water separator, the more efficient it will be at separating oil. Contaminated water enters a receiving chamber of the separator where the flow velocity of the wastewater is reduced, thereby allowing heavy solids to settle while larger oil droplets float to the top of the compartment. Further separation continues in a separation chamber where smaller droplets of oil separate from the water and join the larger droplets previously separated. The oil layer that has accumulated on the top of the water spills over an oil skimmer into a holding area; the wastewater then flows, or is pumped, to the stormwater or sanitary sewer system.

A longer separation time increases the efficiency of the oil-water separator by allowing a greater amount of oil to rise to the top of the wastewater. Therefore, restricting the wastewater to design flow rates will improve the efficiency of the separator.

10-5.6 Design Capacity.

An oil-water separator has a finite capacity for storing oils and sludges accumulated during its operation. Quite often, the oil-water separator holding compartments can become saturated or full of oils and sludges, allowing contamination to flow freely into the wastewater effluent exiting the separator system. Ensuring that the separator capacity meets the needs of the process will aid separation efficiency.

10-5.7 Operational Changes.

An oil-water separator designed and installed to a past mission requirement may not be suitable for a new mission. For example, a wash rack with an oil-water separator designed to capture contaminants from a small fighter aircraft will not handle larger wastewater volumes from a larger aircraft. Additionally, changes in mission can affect the effluent characteristics of the wastewater being discharged to an oil-water separator (i.e., wastewater with solvents or emulsions versus free floating oil). As missions evolve, the oil-water separator use must be re-evaluated to confirm continued suitability.

Mission conversions can necessitate modifying stormwater or wastewater drainage systems. Oil-water separators that do not have a stormwater diversion system can suffer from reduced removals from the hydraulic loading of stormwater that does not need to be treated. Thus, separator collection systems also must be reviewed for excessive stormwater flows.

10-5.8 Contaminants in Wastewater Stream.

Particulate heavy metals and solids in the wastewater will settle into the sludge at the bottom of the oil-water separator receiving compartments. The sludge could be regulated as a hazardous waste if levels exceed RCRA or state hazardous waste levels. Solvents or fuels also may be retained in oil-water separator sludge.

10-5.9 Evaluation of Need for Oil-Water Separators.

An oil-water separator may not be needed to meet pretreatment or discharge permit limits, coordinate with the Installation Environmental Program staff to see if the oil-water separator may be eliminated, see Figure 10-4. Operators should assist by knowing what is discharged to separators, educating others whose activities are generating the wastewater, and alerting Installation Environmental Program staff of any problems. Vehicle and equipment washrack wastewater typically contains oil and grease but have a relatively small amount of solids. Exterior washing of vehicles and equipment, particularly after field training exercises, can discharge large quantities of solids. At many installations, central vehicle wash racks are provided specifically for exterior washing.

Operators should assist Installation Environmental Program staff in evaluating the need for and effectiveness of existing oil-water separators. Consider the potential for emulsified oil. Example: Are high-pressure water or detergents being used. These practices increase emulsification and allow smaller oil droplets to pass through the oil-water separator.

10-5.10 Operation and Maintenance.

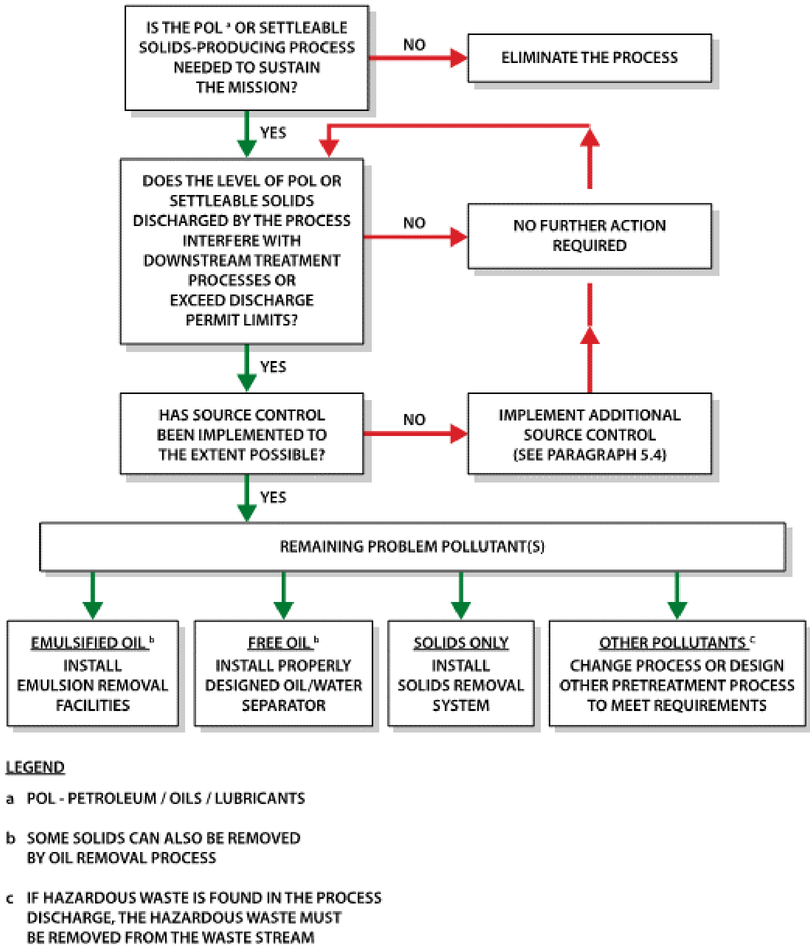
The ability of oil-water separators to function properly depends on the application of required routine service and maintenance.

Personnel using and maintaining the system are expected to understand the separation process and the components of the specific oil-water separator. Maintenance personnel are expected to be familiar with the piping and configuration of each separator for which they are responsible. Periodically inspect all parts of the separator and its draining system to prevent failures caused by operations, breaks, and mechanical settings. Items suggested for inspection and a recommended frequency for inspection are listed in Table 10-3. To determine requirements for periodic draining and cleaning, system users must be familiar with the capacity of the separator and holding tanks, uses of the system, and its potential misuses. Separator performance can be an important indicator of the mechanical condition of the device. Performance can be tracked by regular influent and effluent sampling and analysis.

Note: For the Air Force, **\1** AFMAN **/1/** 32-1067 provides additional requirements for oil-water separators.

Note: For the Army, PWTB 200-1-142 provides additional requirements for oil-water separators.

Figure 10-4 Decision Tree for Pretreatment of Oily Waste



10-5.10.1 Periodic Maintenance Practices.

Sludges and oils that are not periodically pumped from separator holding tanks can render the separator inoperative. Additionally, leaks from oil-water separators can result in environmental pollution that could require investigative studies and extensive cleanup. Regular equipment inspections and a preventive maintenance plan can prevent contaminated discharges from the oil-water separator system. Depending on the wastewater characteristics (e.g., low pH), what material the separator is made of, and the age of the facility, perform visual equipment inspections from once per week to once per month. Conduct more rigorous inspections two to four times per year. Focus inspections on areas below the water line, equipment construction joints, piping connections and interfaces, and other areas prone to wear, spills, or leaks.

Table 10-3 Recommended Inspection Frequency for Oil-Water Separators

Item	Suggested Frequency
Conventional Gravity Separator	
Flight mechanism: flights, chains, sprockets, rails, drive	Visual weekly; detailed annually
Sludge hopper valves: open/close freely, close tight	Weekly
Oil skimmer mechanism: moves freely, level, not plugged	Weekly
Skimming pump(s)	Weekly
Sludge pump(s)	Weekly
CPI Separator	
Parallel plates: fouling	Weekly
Skimmer weir: level	Annually
Skimming pump(s)	Weekly
Sludge pump(s)	Weekly
Flotation	
Surface skimmer mechanism: drive, flight, roller, beach	Visual weekly; detailed annually
Bottom rake: flight	Annually
Pressurization pump and tank	Weekly
Back pressure valve: holds recommended back pressure	Weekly
Sludge valve: operates freely, closes tightly	Weekly
Skimming/bottoms pump(s)	Weekly

10-5.10.2 Parameters of Concern.

Parameters of concern are those that would be expected to be removed or reduced across the separator: oil, grease, and TSS. Data may be plotted to help identify trends showing both influent and effluent concentrations. Compare effluent concentrations with influent concentrations to detect performance deterioration and with discharge permit limits obtained from the Installation Environmental Program staff to assess permit compliance. Frequency of separator effluent sampling is as required by the discharge permit. Influent sample frequency must be the same as effluent sampling frequency. At a minimum, twice monthly is recommended.

APPENDIX A BEST PRACTICES

A-1 PERMITS.

Coordinate with the Installation Environmental Program staff for permit renewal or changes. NPDES permit forms will vary, depending upon the primary agency, EPA or state, and the characteristics of the discharge. The EPA delegates permits to states with approved permitting programs. State and local agencies may have more stringent requirements. Permit forms may require historical plant operation data and much of the same information required for the Capacity Analysis and Operation and Maintenance reports. There is no fee required from the federal government, but state and local agencies may assess fees to process applications.

As part of the operating NPDES permit, WWTPs may be required to periodically submit operating data to the agency that issued the permit, including data to verify the WWTP is operating in accordance with its operating NPDES permit. This may include providing nutrient results of the wastewater treatment plant, sludge sample results and other items such as various flow meter calibration.

A-2 STORMWATER NPDES PERMITS.

Stormwater NPDES permits typically involve developing a stormwater pollution prevention plan, and routinely inspecting the stormwater system, monitoring runoff, and maintaining records on site.

A-3 CURRENT TRENDS AFFECTING WWTP OPERATIONS.

The regulatory agencies responsible for the issuance of discharge permits are implementing more comprehensive programs to ensure protection of the water quality standards of the state's streams.

A-3.1 Water Quality-Based Effluent Limits.

Effluent limits contained in operating NPDES permits are developed by the permit writer and based on state water quality standards for the receiving stream. These effluent limits are called water quality-based effluent limits. Each stream in the state is classified in the water quality standards according to its existing or potential uses. Specific and general standards apply to each classification.

The inclusion of water quality-based effluent limits in the permit is based on a review of the effluent characterization presented in the discharger's operating NPDES permit application. This review, conducted by the permit writer, assesses the presence of compounds that have the potential to violate the water quality standards.

A-3.2 Waste Load Allocation.

Most operating NPDES permits include limits on oxygen-demanding substances (such as CBOD and ammonia). Development of these limits typically is based on a waste load allocation for the receiving stream. Stream modeling is used to assess the assimilative capacity of the stream based on the applicable dissolved oxygen standard. This capacity is then allocated among all the dischargers in the area. Generally, some portion of the stream's capacity is reserved for future dischargers.

Waste load allocation modeling typically consists of a desk-top effort for small discharges and a calibrated and verified model based on field measurements for larger discharges. Modeling is performed by the discharger or by the state agency. Regardless of who performs the modeling, the results receive a detailed review by both the state and EPA. Typically, these results are put out for public comment. In many cases, the public comment period is concurrent with the public notice for the NPDES permit.

A-3.3 Chemical-Specific Criteria.

Water quality-based effluent limits is based on chemical-specific criteria from the water quality standards (such as for metals or toxics) or on general narrative criteria. Specific criteria are used in the development of effluent limits, and in many cases, an allowance for dilution in the receiving stream is provided.

Typically, some portion of the 7Q10 low-flow for the receiving stream is used for dilution purposes. 7Q10 is a hydrogeological determination of the lowest average flow over 7 consecutive days with an average recurrence frequency of once in 10 years. Consider background concentrations in the receiving stream when performing dilution calculations. Where the 7Q10 low-flow is zero, the criteria will apply at the point of discharge, prior to any dilution.

A-3.4 Aquatic Life Criteria.

For aquatic life criteria, acute or chronic values apply. The application of acute versus chronic criteria is dependent on many items, including the use classification and the available dilution in the receiving stream. Generally, if the available dilution is greater than 100 to 1, then the acute criteria apply.

A-3.5 General Narrative Criteria.

To address these narrative criteria, most states apply a whole-effluent toxicity requirement in the permit. The whole-effluent approach to toxics control for the protection of aquatic life involves the use of acute and/or chronic toxicity tests to measure the toxicity of wastewaters. The acute test assesses the lethality of the wastewater to the test organisms and is conducted based on the regulatory agencies' requirements. The chronic test assesses growth and reproduction in addition to lethality and is conducted based on the regulatory agencies' requirements. Whole-effluent toxicity tests use standardized surrogate freshwater or marine plants, invertebrates, and vertebrates. The test is run at the same dilution as is allowed for the wastewater in the receiving stream. Failure to meet the criteria results in the need to conduct a toxicity reduction evaluation on the discharge. If the plant is not yet built, the effluent standards are determined by using effluent standards from a similar type of facility. Additionally, permits consider the standards of the receiving stream.

Example of general narrative criteria:

Toxic substances must not be present in receiving waters, after mixing, in such quantities as to be toxic to human, animal, plant, or aquatic life or to interfere with the normal propagation, growth, and survival of the indigenous aquatic biota.

A-4 COLD WEATHER OPERATION.

Consider Tables A-1 for treatment process components subject to freezing problems.

Table A-1 Treatment Process Components Subject to Freezing Problems

Preliminary Treatment	Clarifiers	Biological Reactors	Solids Management	Disinfection
Pumping	Primary	Activated sludge	Digestion	Chlorination
Screens	Secondary	Extended aeration	Dewatering	
Grinders	Polishing ponds	Oxidation ditches	Disposal	
Grit chamber	Air flotation	Trickling filters		
Flow measurement	Thickeners	Rotary biological contactors		
Flow equalization		Aerated lagoons		
		Facultative lagoons		

Source: SR 85-11.

Consider Table A-2 for winter problems associated with preliminary treatment.

Table A-2 Winter Problems with Preliminary Treatment

Problem	Solution
Ice buildup in headworks area	Keep building heated above 50 ˚F (10 ˚C).
Icing of bar racks	Cover inlet channel. Flush with warm water. Weather-strip channels to reduce cold air entry into building. Clean by hand frequently.
Septage pumping lines freeze	Use heat tape on lines and valves. Use proper flushing after pumping truck. Use manhole to directly dump into plant. Do not handle septage in winter. Drain all lines.
Septage freezing in truck	Pass engine exhaust through truck tank to prevent freezing. Drain truck tank pipings and valves.
Collected grit freezes	Store dumpsters in heated building before emptying. Store truck inside. Remove no grit in winter.
Icing of grit dewatering equipment	Duct kerosene heater into area.
Grit machine freezes	Enclose unit.
Screened rags freeze	Remove regularly by hand.
Spiral lift pumps freeze	Run water on ice to reduce buildup.
Screw pumps freeze	Install timer to “bump” screw once per hour.
Valves and hoses freeze	Drain lines. Keep hoses on.

Automatic sampler freezes	Place sampler inside building. Do not use in severe cold. Build insulated structure heated with light bulb. Insulate suction lines. Purge lines after sample taken. Move sampler location to decrease exposure. Install suction lines to give a straight fall.
Flow measurement device freezes	Use heat tape and glass fiber insulation on flow transmitter. Insulate chamber and heat with one light bulb. Put heat tape on Parshall flume linkage.
Float for flow measurement freezes	Heat with light bulb and insulate. Add antifreeze to float box.
Grit removal bypass channel freezes	Temporarily switch flow to bypass channel, 30 minutes/day or more often if needed.
Water freezing at comminutor	Build Plexiglas structure to keep influent warm.
Doors frozen shut on screening enclosure because of condensation	Put heat tape around door enclosure.
Stairs above screw pumps are slippery from icing condensation	Plant policy requires all operators to keep one hand free at all times to use rails.

Source: SR 85-11.

Consider Table A-3 for winter problems associated with clarifiers.

Table A-3 Winter Problems with Clarifiers

Problem	Solution
Scum line freezes	Flush out with hot water. Use sewer bag to free blockages. Install automatic flushing mechanism.
Scum trough freezes	Cover exterior trough. Break ice into pieces and remove by hand. Install automatic flushing mechanism.
Scum freezes on beaching plate	Flush off with hot water. Discontinue scum removal in winter. Shovel and hose down by hand. If adjustable, decrease exposed plate area.
Ice on beaching plate hangs up collector arm and damages mechanism	Remove skimmer during winter. Remove ice by hand.
Scum freezes on outside ring of peripheral feed clarifier	Cover clarifier.
Scum solidifies, will not flow	Use warm water to flush.
Scum freezes at center feed	Install a warm water sprayer to keep scum moving toward skimmer.
Surface icing	Remove secondary arms to prevent damage. Keep clarifiers on 24 hours/day. Remove thick ice with long- armed backhoe. Shorten detention times.
Icing in idle units	Pump units dry routinely.
Icing in gear units	Install heat tapes on drain line. Drain water in bullgear after rain and when temperature rises.

Hoses and hydrants freeze	Leave lines on. Drain lines after use.
Traveling bridge controls ice-up	Build enclosure over controls.
Icing of bus bar for bridges	Install heat guns or warm air blower.
Switches on monorakes freeze	Shut off units in snow and ice to prevent freezing.
Accumulation of snow on monorake rails stops wheels	Shut down rake during snowstorms and remove snow.
Automatic sampler freezes	Build insulated boxes heated with a 100-watt light bulb.
Waste activated sludge lines freeze	Locate lines deeper. Install proper drainage.

Source: SR 85-11.

Consider Table A-4 for winter problems associated with biological systems.

Table A-4 Winter Problems with Biological Systems

Problem	Solution
Ice buildup on surface area	Remove by hand. Run on high speed for 15 minutes. Turn off for ½ hour, allow mixed liquor to warm aerator, and turn on high speed. Steam ice off. Bump aerator on and off carefully.
Impeller icing causing ponding on fixed shroud	Remove shroud. Ice will still build up, but aerator will not be damaged.
Ice buildup on supporting columns causing rotating shroud to pond on columns	Shorten detention times; run aerators on timers.
Cooling of mixed liquor	Install timers on aerators. Use diffused air instead of surface aeration. Remove some aerator blades.
Icing in idle tank damaging structure	Fill tank 1 foot above baffle. Install small sump pump to keep surface free of ice. Exercise units regularly during sunny days. Care must be taken not to damage units. Use inner tubes to absorb ice expansion. Bubble air to prevent freezing.
Ice buildup on splash guard, electrical conduit, and walkways	Use good snow and ice removal procedures, salt. Plant policy requires operators to keep one hand free to hold railing.
Decreased removal efficiencies	Increase MCRT, decrease food-to-microorganism ratio.

Source: SR 85-11.

Consider Table A-5 for winter problems associated with disinfection problems.

Table A-5 Winter Disinfection Problems

Problem	Solution
Feed lines freeze	Enclose all storage and pumping facilities in a heated building.
Hypochlorite solution crystallizes in pumps and pipes	Keep in heated room above 65 ˚F (18 ˚C).
Surface contact chamber freezes	Cover and insulate tanks.

Source: SR 85-11.

A-5 ODOR CONTROL SYSTEMS.

Each of the odor control systems require maintenance that is based on the air flow, constituents in the odorous air streams, and site conditions. These individual factors have effect on the amount and type of maintenance that each system requires.

A-6 CHEMICAL ODOR CONTROL SYSTEM.

Based on the data collected on the operation of the chemical odor control system, cleaning the plastic media in the system may be required. The media may be replaced or acid washed. Seven to 10 years is the normal expected frequency of cleaning or replacing the media.

A-7 BIOLOGICAL ODOR CONTROL SYSTEM.

Based on the data collected on the operation of the biological odor control system, replacing media in the biological odor control system may be required. Depending on the type of media, the expected life will vary. If the media are made of natural items (e.g., soil, wood chips), the media will need to be replaced every 2 to 3 years. If the media are manmade products, the media are expected to last 7 to 10 years.

A-8 MAINTENANCE.

While maintenance requirements for all the equipment is be completed as detailed in the manufacturer’s equipment manual, there are other tests and observations an operator can complete to identify problems or extend the periodicity of the maintenance requirements.

Consider Table A-6 for winter problems associated with solids management.

Table A-6 Winter Problems with Solids Management

Problem	Solution
Unable to use solids drying beds in winter; beds freeze	Cover beds.
Not able to apply solids to land in winter	Stockpile solids in winter months.
Aerobic digester freezes if blower is shut off to allow thickening by decanting	Cover tank. Decant smaller amounts more often.
Solids mixture freezes in tank	Run mechanical agitator overnight.
Ice forms on digesters	Insulate better.
Icing in gravity thickener	Run final effluent to keep hydraulic loading higher.
Solids holding tank freezes	Take offline during winter.
Solids freeze on truck	Use truck body heated with exhaust gases.
Solids lines freeze; valves freeze	Drain lines correctly. Dismantle and thaw valve. Put heat tape on lines. Increase return rates.
Holding tanks too small to last winter	Use spare clarifier of oxidation ditch.
Extensive heat loss from anaerobic digester	Improve insulation.
Operating temperature could not be reached in a new compost pile	Cover pile and insulate. Mix solids and wood chips with hot compost. Blow hot exhaust from working pile into new pile.

Source: SR 85-11.

A-8.1 Predictive Maintenance.

Predictive maintenance is maintenance completed on a periodic basis. The results of predictive maintenance are used to determine (predict) when a piece of equipment is going to fail or to discover a problem in a piece of equipment before a failure occurs. Most predictive maintenance requires that the piece of equipment be running at its design point before testing starts and during testing.

The periodicity will need to be determined by the operator based on the criticality of the component to the wastewater treatment process, ease of completing the test, treatment plant operations, and budget. As an example, an influent pump cannot have vibration testing and thermal imaging completed during the summer when the pump will not run at full deign speed for long periods of time.

A-8.2 Vibration Testing.

Vibration testing is conducted on mechanical equipment to determine bearing failure. Vibration testing is conducted on both the machine bearings and its motor bearings. The results of the test can provide operators with information on bearing wear and allow the operator to replace or repair bearings prior to the bearing failing. If the bearing were to fail, it may cause equipment damage and result in a violation to the NPDES permit. Conduct vibration testing by a qualified person to ensure that the results are accurate and the test is done consistently each time.

Measure vibration displacement in inches or millimeters. In all cases, the vibration is the measure of the amplitude of the motion from the piece of machinery. If one of the values is known, it can be converted to another using one of the two equations below:

Equation A-1. Vibration Velocity

$$v = 2 * \pi * f * d$$

Where:
v = peak velocity (m/sec or in/sec)
f = cycles per second (hertz)
d = peak displacement (mm or in.)

Equation A-2. Vibration Acceleration

$$a = 2 * \pi * f * v$$

Where:

a = acceleration (g [m/sec^2] or in./sec^2)
f = cycles per second (hertz)
v = peak velocity (m/sec or in./sec)

A-8.3 Lubrication and Wear Particle Analysis.

Lubrication and wear particle analysis is a test that provides information about the condition of the lubricant itself that is provided by a testing laboratory. The analysis provides information on the amount of chemical contamination of the lubricant, the state of the lubricant additives, the molecular condition of the lubricant, and the amount of dissolve elements in the lubricant. The analysis also provides the amount of, makeup, shape, and size of the particles in the lubricant that come from the wear of the internal machinery components being lubricated.

The results of the lubrication and wear particle analysis can help operators adjust their lubrication schedule from the manufacturer's recommendations.

A-8.4 Thermographic Imaging.

Thermographic imaging is the measure of either the temperature or the difference in temperature of both mechanical and electrical components. When thermographic imaging is used, the equipment being checked must be operated at its designed operating point. Thermographic imaging can identify poor lubrication practices on pieces of equipment and poor alignment of the equipment. In electrical equipment, thermographic imaging can identify when equipment is overloaded, there are loose electrical fittings or poor electrical connections, and other potential failures.

A-8.5 Ultrasonic Analysis.

Ultrasonic analysis is used on bearings to determine when it must be greased and how much grease to add. Ultrasonic analysis must be done several times on a piece of equipment with normal lubrication conditions to establish a baseline sound signature, which is measured in decibels (dB). When the bearings sound signature changes by more than 8 dB from its baseline signature, correct the bearing by adding grease to it. If the bearings sound signature changes by more than 12 dB, the bearing is showing an indication of deterioration.

A-8.6 Electrical Surge Testing.

Electrical surge testing is the only testing that can be done on a motor to determine if the motor is deteriorating and may possibly fail. The testing tests the motor's winding for weakness in the turn to turn, coil to coil, and phase to phase insulation. The electrical surge testing looks for faults in the motor windings themselves. A megohm test also known as "meggering" can be performed on the motor windings. The megohm test only examines the motor windings insulation quality.

A-8.7 Motor Current Signature Analysis.

Motor signature analysis is used to detect both mechanical and electrical issues in equipment. This test uses the electrical amperage draw of the motor as load changes over time to provide an early warning of equipment or motor deterioration. Start the motor current signature when the piece of equipment is new to allow for a baseline signature to be developed. Compare the motor current signature to the base line and trend to identify the deterioration of the piece of equipment.

A-8.8 Bearing Greasing.

Bearings are required to be greased on a regular basis and measure the amount of grease added in ounces or grams. Measure the grease to be pumped in as each grease gun dispenses different amounts of grease per pump. Some larger bearings require periodic cleaning out of the bearing and repacking it with grease based on the bearing manufacturer's requirements.

It is common for equipment manufacturers to direct the operator to grease the motor bearings at set intervals. Review the motor greasing frequency. Consider the following items to determine the frequency of motor greasing:

- Motor frame size
- Motor speed
- Severity of service

A-8.9 Severity of Service.

Factors that affect the severity of service are the motor's daily hours of operation, the ambient temperature of the atmosphere around the motor, and the amount of dust in the atmosphere around the motor. In general, motors that are in warmer and dustier locations require greasing more often than motors operating inside a clean and cool room.

A-8.10 Lubricants.

Lubricants come with different options and have different operating ranges. Use the lubricant that is specified in the manufacturer's equipment manual. If the operator decides to change the lubricant type, consult a lubrication engineer and the equipment manufacturer to ensure the equipment is properly lubricated to prevent equipment damage.

The viscosity of lubricating oils will change because of freezing temperatures. The operator can either change the oil to suit the expected temperature range or use heat tape or immersion-type heaters to maintain higher oil temperatures. Sometimes multi-viscosity year-round synthetic oils may be appropriate. Gear boxes tend to collect moisture and condensate, which may either degrade lubrication oil or cause corrosion.

A-8.11 Painting and Coatings.

Maintenance of coating systems in wastewater treatment plants depends upon a number of factors:

- Knowing the specific coating systems that currently exist within the plant
- Implementing an active inspection program
- Providing a good maintenance painting program

Maintenance painting operations are different than new construction painting operations. With a proper maintenance painting program, total recoating is generally atypical rather than normal. In saltwater or coastal environments, painting frequency may need to be increased.

A-8.11.1 Inspection.

Routinely inspect all coating surfaces and be observant for the first signs of coating breakdown such as rust staining and streaking, blistering of coating, peeling of coating, and other signs of deterioration. Coatings on steel substrates generally will show the first signs of failure at sharp edges such as edges of structural steel, adjacent to welds, and around threads of bolts and edges of nuts. Failures on flat surfaces take longer to develop.

In immersion service, coating failures also develop first at edges but can also develop on flat surfaces because of imperfection/s and defects. Linings in tanks and vessels are especially critical.

A-8.11.2 Chemical Storage Areas.

Most chemical storage areas will have concrete containment walls to contain potential spills of the tank. Coat containment surfaces with a suitable coating system capable of withstanding the spilled chemical. Most monolithic (bonded) coatings will mirror any cracks that may develop in the concrete. Visually inspect these areas to detect any leaks or spills through the concrete.

A-8.11.3 Material Selection.

Much of a typical wastewater treatment plant consists of cast-in-place concrete structures. With a few exceptions, concrete performs well in the environments associated with wastewater treatment plants. Other common construction materials also do well but require careful selection and maintenance to achieve long-term service life. The wastewater associated with the wastewater treatment plants is usually not extremely aggressive unless the facility receives wastewater from certain industrial operations.

Hydrogen sulfide is ever present and must be recognized, especially in the vapor areas above the wastewater surface. Where the wastewater is agitated or falls over weirs, hydrogen sulfide is released. Any condensate formed will be acidic and therefore aggressive to concrete and unprotected carbon steel.

A-8.12 Corrosion.

Perform regular inspection of the concrete and steel surfaces in these aggressive areas and take appropriate action when significant corrosion becomes evident. Corrosion of metal surfaces usually occurs faster than on concrete surfaces. Take corrective action as soon as possible.

UFC 3-190-06 contains requirements for painting and coating various components in a wastewater treatment plant.

A-8.13 Maintenance Scheduling.

Follow the manufacturer's maintenance requirements at the recommended periodicities; however, each Installation should review their periodicities and adjust based on specific Installation requirements, experiences, or other considerations such as predictive maintenance results. If the Installation cannot complete all maintenance items, consider a tiered approach in which designated higher tier maintenance items are completed first. A recommended tiered approach would include the following levels:

- Operator-level maintenance
- Tier I
- Tier II
- Tier III
- Tier IV

If a maintenance item is in a lower tier and not completed over multiple cycles, failure to complete the maintenance may cause the piece of equipment to fail. Over time, lack of completion of lower-tier maintenance items will require that those items move up on the tier list. Failure to reassign maintenance completion priority may result in the system not operating as required to meet the wastewater treatment plant's permit requirements.

A-8.13.1 Operator-Level Maintenance.

The operator-level maintenance tier comprises maintenance items that are non-intrusive and normally take little time to complete. Examples of operator-level maintenance include:

- Instrumentation cleaning
- Monitoring equipment for abnormal noise, vibration, and lubricant leakage
- Equipment performance testing

A-8.13.2 Tier I Maintenance.

Tier I maintenance includes maintenance items that must be completed as required by the various operating permits of the wastewater treatment plant. Examples of Tier I maintenance items include:

- Flow meter calibration
- Laboratory instrumentation calibration
- Maintenance items required by the NPDES permit, equipment and system warranties, and performance guarantees

A-8.13.3 Tier II Maintenance.

The Tier II maintenance level includes maintenance items that are completed to keep the equipment running or to check equipment health. Examples of Tier II maintenance items include:

- Checking or changing oil in gearboxes
- Predictive maintenance on equipment
- Changing air filters for HVAC units

A-8.13.4 Tier III Maintenance.

The Tier III maintenance level includes maintenance items that result in major changes to the wastewater treatment process or require a large amount of manpower to complete. Examples of Tier III maintenance items include:

- Cleaning aeration grid air diffusers
- Most electrical system maintenance
- Checking and replacing wear part clearances

A-8.13.5 Tier IV Maintenance.

Tier IV maintenance level includes maintenance items that are required to be completed at infrequent intervals of the equipment's operation life. Examples of Tier IV maintenance items include:

- Rebuilding a pump or blower
- Cleaning or replacing media in an odor control system
- Replacing clarifier scrappers **\1**

A-8.14 Wastewater Collection.

Cleaning and inspecting sewers assists in maintaining sewer capacity and identifying repairs that may be needed. A site-specific maintenance plan for cleaning and inspecting wastewater collection systems should be prepared to assist in maintaining sewers. Include options and procedures for cleaning and inspecting sewers in the maintenance plan. The Installation should determine cleaning and inspection schedules based on the age of the sewer, sewer condition and availability of funding. Use WEF MOP FD-6 and EPA 832-F-99-031 for sewer cleaning and inspection guidance. **/1/**

A-9 O&M GUIDANCE DOCUMENTS.

The Sacramento series are the primary technical guidance references for the operation and maintenance of wastewater treatment systems. These references provide valuable training, operating, maintenance and troubleshooting techniques. These best practice references should be available to personnel operating and maintaining the WWTP.

A-10 OPERATOR TRAINING.

There are various methods of obtaining training for certification. State regulatory agencies or Association of Boards of Certification can help. The required training can be obtained from the following locations:

- The California State University, Sacramento, has correspondence courses available that provide the basics for most state examinations and certification processes.
- Water Environment Federation has wastewater courses both in printed and computer CD-ROM formats.
- Local, state, and national trade shows may have forums that can help meet the required training for the operator certification.
- Local and state classes for operator certification
- College level classes
- Approved equipment manufactures operation and maintenance training
- Approved consultant provided training

A-11 OPERATIONS OF EQUIPMENT AND SYSTEMS.

Consider the following items as part of equipment and system operations.

A-11.1 Starting, Stopping, and Changing Equipment.

Starting, stopping, and changing equipment and wastewater treatment plant processes should be done using site-specific O&M manuals, equipment manufacturer O&M manuals, and standard operating procedures.

A-11.2 Emergency Operating Requirements.

Make emergency generators available and always fueled to above the 75% level. There needs to be enough pumps and tankage available to meet design flow. Complete repairs to equipment that prevent meeting design flow/loads as soon as possible.

There will be specific emergency operating requirements for individual WWTPs. These specific requirements should be identified in the site-specific O&M manual.

A-11.3 Equipment Calibration and Field Checking.

Conduct instrument calibration frequently to have accuracy across readings. Take measurements, flows, and concentrations twice to check the accuracy of the measuring device.

It is useful to have portable field equipment to double-check the values/readings from permanently mounted monitoring instruments as a quality check for data and treatment process control.

A-11.4 Sampling and Process Data Review.

Review sampling and process data to identify trends. These trends can be utilized by the operators to improve the operation of the WWTP. Review plant-operating parameters that includes but is not limited to DO, RAS flow, and influent flow.

A-12 BEST PRACTICE REFERENCES

ENVIRONMENTAL PROTECTION AGENCY

https://www.epa.gov/

EPA/625/R-00/008, *Onsite Wastewater Treatment Systems Manual*, February 2002

EPA/625/R-92/013, *Control of Pathogens and Vector Attraction in Sludge*, July 2003

EPA 832-F-03-023, *Decentralized Systems Technology Fact Sheet; Septic Tank Effluent Screens*, September 2003

EPA 932-F-99-068, *Decentralized Systems Technology Fact Sheet; Septage Treatment/Disposal*, September 1999

NATIONAL SMALL FLOWS CLEARINGHOUSE

http://www.nesc.wvu.edu/pdf/ww/septic/pl_fall04.pdf

Maintaining Your Septic System - A Guide for Homeowners

OFFICE OF WATER PROGRAMS, CALIFORNIA STATE UNIVERSITY, SACRAMENTO, 3020 STATE UNIVERSITY DRIVE, MODOC HALL SUITE 1001, SACRAMENTO, CA 95819. 916-278-6142.

http://www.owp.csus.edu/courses/wastewater.php

Operation of Wastewater Treatment Plants, Volume 1, 2008

Operation of Wastewater Treatment Plants, Volume 2, 2007

Advanced Waste Treatment, 2006

APPENDIX B GLOSSARY

B-1 ACRONYMS

BOD_5	biochemical oxygen demand
CBOD	carbonaceous biochemical oxygen demand
CFR	Code of Federal Regulations
CPI	corrugated plate interceptor
DAF	dissolved air flotation
DoD	Department of Defense
EPA	Environmental Protection Agency
F:M	food to mass ratio
FGS	Final Governing Standards
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HNFA	Host Nation Funded Construction Agreement
HVAC	heating, ventilation, and air conditioning
MCRT	mean cell residence time
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
NAVFAC	Naval Facilities Engineering Command
NPDES	National Pollutant Discharge Elimination System
OEBGD	Overseas Environmental Baseline Guideline Document
O&M	operations and maintenance
PAA	peracetic acid
RAS	return activated sludge
SBR	single batch reactor

SOFA	Status of Forces Agreement
SRT_a	aerobic solids retention time
TSS	total suspended solids
UFC	Unified Facilities Criteria
U.S.	United States
UV	ultraviolet
UVT	UV transmittance
WAS	waste activated sludge
WWTP	wastewater treatment plant

B-2 DEFINITION OF TERMS

Use WEF MOP 11 or the applicable industry standard for definition of terms.

APPENDIX C REFERENCES

DEPARTMENT OF THE AIR FORCE, AIR FORCE PUBLICATIONS DISTRIBUTION CENTER, 2800 EASTERN BOULEVARD, BALTIMORE, MD 21220-2896

http://www.wbdg.org/ffc/af-afcec/instructions-afi/.

AIR FORCE HANDBOOK

AFH 32-1290, *Cathodic Protection Field Testing*, 01 February 1999

AIR FORCE INSTRUCTION

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\1 AFMAN **/1/** 32-1062*, Electrical Systems, Power Plants and Generators,* 15 January 2015

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\1 AFMAN **/1/** 32-1067, *Water and Fuel Systems,* 04 February 2015

\1 AFMAN **/1/** 32-1068, *Heating Systems and Unfired Pressure Vessels,* 08 February 2017

AFI 32-7001, *Civil Engineering Environmental Management,* 23 August 2019

DEPARTMENT OF THE ARMY, U.S. ARMY CORPS OF ENGINEERS, 441 G STREET, NW, WASHINGTON, DC 20314-1000

https://www.wbdg.org

COLD REGIONS RESEARCH AND ENGINEERING LABORATORY

SR 85-11, Special Report, Prevention of Freezing and Other Cold Weather Problems at Wastewater Treatment Facilities, 1985

PUBLIC WORKS TECHNICAL BULLETIN

PWTB 200-1-142, *Application Guidelines for Water Reuse at Army Installations,* 30 June 2014

PWTB 420-49-29, *Operation and Maintenance of Cathodic Protection Systems,* 2 December 1999

TECHNICAL MANUAL

TM 5-682, *Facilities Engineering Electrical Facilities Safety*, 08 November 1999

TM 5-683, *Facilities Engineering Electrical Interior Facilities*, 30 November 1999

TM 5-684, *Facilities Engineering Electrical Exterior Facilities, 29 November 1996*

TM 5-685, *Operation, Maintenance and Repair of Auxiliary Generators*, 26 August 1996

TM 5-814-3*, Domestic Wastewater Treatment,* 31 August 1988

DEPARTMENT OF DEFENSE

http://www.dtic.mil/whs/directives/

DoD 4715.05-G, Overseas Environmental Baseline Guideline Document

DEPARTMENT OF DEFENSE INSTRUCTION

DoDI 4715.05, Environmental Compliance at Installations Outside the United States

DoDI 4715.06, Environmental Compliance in the United States

DoDI 4715.1E, Environment, Safety, and Occupational Health (ESOH)

DoDI 6055.1, DoD Safety and Occupational Health, 14 October 2014

DEPARTMENT OF THE NAVY, OFFICE OF THE CHIEF OF NAVAL OPERATIONS, 1200 NAVY PENTAGON, WASHINGTON, DC 20350-1200

http://www.public.navy.mil

OPNAVINST 5090.1D, *Environmental Readiness Program,* 10 January 2014

OPNAVINST 5100.23G, *Navy Occupational Safety and Health Program*

INTERNATIONAL CODE COUNCIL, 500 NEW JERSEY AVENUE, NW, 6TH FLOOR, WASHINGTON, DC 20001-2070

https://www.iccsafe.org/

IPC, International Plumbing Code

IPSDC, International Private Sewage Disposal Code

MARINE CORPS ORDER

MCO P5090.2A, *Environmental Compliance and Protection Manual*, 26 August 2013.

TECHNOMIC PUBLISHING CO INC, LANCASTER, PENNSYLVANIA

Wastewater Engineering Design for Unsewered Areas, by Rein Laak, 1986,

UNIFIED FACILITIES CRITERIA

https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

UFC 1-200-01, DoD Building Code (General Building Requirements)

UFC 3-190-06, Protective Coatings and Paints

UFC 3-230-01, Water Storage and Distribution

UFC 3-230-02, Operation and Maintenance (O&M): Water Supply Systems

UFC 3-420-01, Plumbing Systems

UFC 3-540-07, Operation and Maintenance (O&M): Generators

UFC 3-550-07, Operation and Maintenance (O&M): Exterior Power Distribution Systems

UFC 3-560-01, Operation and Maintenance: Electrical Safety

UFC 3-570-06, O&M: Cathodic Protection Systems

UFC 3-600-01, Fire Protection Engineering for Facilities

UFC 3-600-02, Operations and Maintenance: Inspection, Testing, and Maintenance of Fire Protection Systems

UFC 4-010-06, Cybersecurity of Facility-Related Control Systems

WATER ENVIRONMENT FEDERATION
MCGRAW-HILL, TWO PENN PLAZA, NEW YORK, NY 10121-2298

WEF MOP 11*, Operation of Water Resources Recovery Facilities,* Manual of Practice No. 11, Seventh Edition, 2017