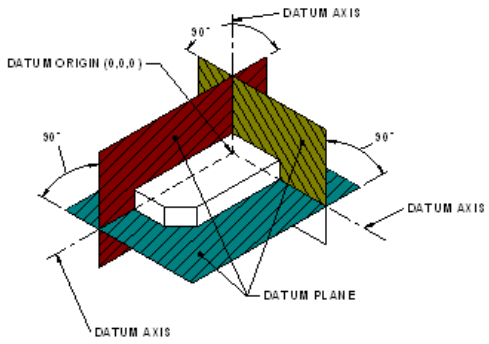
510 N. Crosslane Rd.
Monroe, Georgia 30656
(770) 266-6915 fax
(678) 643-1758

Engineers Edge, LLC
PDH & Professional Training



An Introduction to Water Supply Systems Operation and Maintenance

J. Paul Guyer, P.E., R.A.

Paul Guyer is a registered civil engineer, mechanical engineer, fire protection engineer, and architect with over 35 years of experience in the design of buildings and related infrastructure. For an additional 9 years he was a senior advisor to the California Legislature on infrastructure and capital outlay issues. He is a graduate of Stanford University and has held numerous national, state and local positions with the American Society of Civil Engineers and National Society of Professional Engineers.

CONTENTS

1. INTRODUCTION

2. MAINTENANCE INSPECTIONS

3. ELECTRICAL EQUIPMENT

4. MECHANICAL EQUIPMENT

5. LUBRICATION

6. INTERNAL COMBUSTION ENGINES

7. CHEMICAL STORAGE AND FEEDERS

8. TANKS AND RESERVOIRS

9. PIPELINES

10 CHAIN DRIVES

11. TOOLS AND EQUIPMENT

(This publication is adapted from the *Unified Facilities Criteria* of the United States government which are in the public domain, have been authorized for unlimited distribution, and are not copyrighted.

(Figures, tables and formulas in this publication may at times be a little difficult to read, but they are the best available. **DO NOT PURCHASE THIS PUBLICATION IF THIS LIMITATION IS UNACCEPTABLE TO YOU.)**

1. INTRODUCTION This publication deals with maintenance inspections and general maintenance services required at domestic water supply systems. In addition, this section contains tables specifying tools and equipment, lubricants, and materials and supplies required to perform general and specific equipment maintenance tasks.

2. MAINTENANCE INSPECTIONS.

2.1 TYPES OF INSPECTION AND REPAIR. Water supply system personnel are concerned with three categories of inspection and, to some degree, with overhaul and repair.

2.1.1 OPERATOR'S INSPECTION. Regular inspection of equipment is part of an operator's routine duties to ensure proper functioning of the system. Such inspection includes lubrication, minor adjustments, and renewal of parts that do not require major overhaul or repairs. The operator's inspection also entails detecting and reporting (to the proper authority) any abnormal conditions (appearance, leaks, unusual noises, etc.).

2.1.2 PREVENTIVE MAINTENANCE INSPECTION. Cleaning, lubricating, adjusting, and renewing parts that do not require major overhaul and repairs, plus detecting and reporting (to the proper authority) any abnormal conditions (appearance, leaks, unusual noises, etc.) also comprise preventive maintenance inspection. Such inspections may be conducted by personnel who have been assigned specific areas of inspection responsibility or by personnel operating a particular piece of equipment or system.

2.1.3 CONTROL INSPECTION. Scheduled examinations or tests of public works and public utilities are made to determine their physical conditions. These examinations are termed control inspections and are performed jointly by engineering and operating personnel. Control inspection includes electrical, mechanical, and structural.

2.1.4 MAJOR OVERHAUL AND REPAIRS. As a rule, major overhaul and repairs are not made by operating personnel. This work is usually performed under contract.

2.2 PERSONNEL. It is generally best if well-trained personnel perform inspections, repairs, and preventive maintenance tasks. Personnel assigned to these tasks should

possess a thorough knowledge of the functions and operations of the equipment and the procedures for servicing it safely.

2.3 MAINTENANCE INFORMATION. Water supply system personnel need ready access to equipment O&M information. Keep this information on file and update it as necessary. The best sources of maintenance information are the manufacturers' instruction manuals provided with each piece of equipment. This material should be bound and organized according to equipment type and be kept in good order for quick reference. The following information is typically included in these manuals: descriptive literature (catalog cuts and data sheets); parts lists; instructions for installation, operation, maintenance, and repair; performance data (i.e., pump performance curves); electrical diagrams; and schedules of required lubricants and chemicals. It is normally recommended that operating personnel be familiar with each piece of equipment through careful examination of these instruction manuals. The material contained here is designed as a general overview of maintenance requirements and may not contain answers for specific maintenance questions. Consult the manufacturers' instruction manuals for specific maintenance information. The specifications, shop drawings, and as-built drawings, which should also be kept on file, show dimensions of each piece of equipment and provide information on pipe sizes and materials, valve types, equipment types, etc. They are available to plant personnel if the schematic drawings and valve and equipment schedules in this manual do not provide sufficient information.

2.4 MAINTENANCE MANAGEMENT SYSTEM. Regularly scheduled preventive maintenance is essential for keeping equipment in good running order. Daily tasks may be incorporated into the sampling and laboratory testing routine to make the most efficient use of the operator's time. If possible, perform routine tasks on the same day of the week or month to avoid confusion about when they were last performed. For example, each Monday can be set aside for performing weekly tasks, and the first Tuesday of the month can be set aside for monthly tasks. Annual lubrication can be performed during January. Since operating personnel cannot be expected to remember

the service requirements for every piece of equipment, a system of preventive maintenance is essential. To ensure the system is successfully implemented and maintained, it should be relatively simple to operate, producing maximum output for minimum input. The following paragraphs describe the components of a good maintenance system.

2.4.1 GOALS. An effective maintenance management system is designed to achieve the following goals:

- Provide periodic, timely, standardized, and complete equipment maintenance
- Prevent excessive maintenance, such as over greasing bearings
- Increase system reliability by preventing or providing early detection of equipment malfunction
- Improve the efficiency of equipment operation
- Extend equipment life
- Improve safety by reducing unexpected breakdowns and by providing safety precautions along with maintenance and service procedures
- Reduce overall maintenance costs
- Provide a complete record system covering equipment history, maintenance costs, and workloads.

2.4.2 COMPONENTS. The following components are necessary for a maintenance management system:

- Complete equipment records and maintenance history
- Preventive maintenance scheduling
- Corrective maintenance cost reporting
- Standardized preventive maintenance procedures
- Management reports on maintenance costs, overdue tasks, and employee utilization.

2.4.3 MAINTENANCE PERSONNEL. Another component of an effective maintenance management system is efficient organization of maintenance personnel. This includes providing adequate staffing, developing job descriptions and an organizational chart, providing maintenance training programs, and holding periodic staff meetings. Job descriptions are often developed for use in assessing the skill level required to perform particular tasks in a maintenance program. Depending on the size of the facility, complexity of equipment, and size of the maintenance department, various skill levels may be required (for example, Operator I and II, Mechanic, Electrician, etc.). In many facilities, specialized equipment maintenance may require the use of outside contractors.

2.5 SPARE PARTS AND STOCK CONTROL. Keep sufficient types and quantities of materials and stock on hand to ensure practical, economical, and continuous service. A review of the equipment and the manufacturers' recommendations will aid in determining which spare parts and miscellaneous supplies should be included in the inventory.

2.5.1 EXPENDABLE STOCK. Stock levels for expendable items used at a fairly uniform rate (such as pump packing, treatment chemicals, and laboratory reagents) are based on maintenance experience and operating reports. However, levels may be modified for reasons of economy. Thus, savings can sometimes result if treatment chemicals are bought in large quantities.

2.5.2 STANDBY ITEMS. Seldom-used materials needed to safeguard health, ensure uninterrupted operation of installation facilities, or prevent destruction of property are classed as standby items. Typical examples are chlorinator parts, such as a spare flowmeter, auxiliary chlorine valves, and cylinder connections. Hold materials to be stocked as standby items to a minimum, based on a detailed study of the water supply system. Consider these issues in setting up stocks of standby items:

- Non-critical parts immediately available from nearby installations, municipalities, or supply houses are not stocked. Critical parts are stocked.
- Much repair work at pumping stations and treatment plants can be anticipated, and parts for these repairs can be secured when needed.
- Only major sizes of pipe and fittings are stocked in large amounts.
- If the plant has several similar units, parts that are interchangeable need not be stocked for each unit.
- As soon as an item is drawn from standby stock, a replacement is ordered.

2.5.3 SUPPLY OF MATERIAL. Watch stock levels closely and order essential materials far enough in advance to ensure continuous service. It is recommended that supervisors be familiar with normal and alternate sources of supply and the time each source usually needs to make delivery. Supervisors generally will follow up orders and help supply personnel find alternate supply sources if delivery is delayed. Supplies will be obtained according to normal supply procedures.

2.6 REMOVING EQUIPMENT FROM SERVICE

2.6.1 SHORT PERIOD. Take precautions to prevent damage to equipment removed from service for a short time. Factors to be considered and precautions to be taken depend on the type of equipment and outside conditions. If the outage is likely to last more than a week, test operate the equipment once a week during that time.

2.6.2 PROTRACTED PERIOD. Special precautions are necessary for equipment that is to be out of service for long periods. Failure to retire or adequately protect equipment may cause serious damage during idleness or on resumption of operation. When it is known that the outage will be protracted, dismantle the equipment, if practical, and protect it against corrosion and other damage with suitable greases, oils, and rust-preventative compounds or coverings.

2.7 OPERATING UNDER WINTER CONDITIONS. Protecting operating and standby equipment against damage is especially important in cold climates. Make sure lubricants are changed to winter grades. Drain equipment that is temporarily out of use or on standby service, or provide proper antifreeze coolant to prevent units (such as the housings of pumps, radiators, piping and similar items) from freezing or bursting.

3. ELECTRICAL EQUIPMENT. The following maintenance instructions are general. Perform maintenance of individual pieces of equipment according to the recommendations of the manufacturer. Operating procedures and ambient conditions, such as dirt and vibration, may dictate maintenance schedules different from those recommended here.

3.1 GENERAL. Major electrical equipment is best maintained by qualified, experienced electricians and in accordance with the manufacturer's recommendations. Water system personnel may perform some inspections, lubrication, and simple routine maintenance. In general, do not open an electrical control panel unless the job requires it. De-energize electrical equipment at the motor control center and at the equipment itself before working on it. Always tag the open breaker and, if possible, lock it in the "open" position.

3.2 ROUTINE INSPECTIONS. Visually inspect electrical equipment every day. Keep area clean. Look for the source of any leaks or unusual heat, noise, or odors. On rotating equipment with sleeve bearings, check the oil level and see that oil rings turn with the shaft. On rotating equipment with slip rings or commutators, check for excessive sparking. Inspect motors on rotating equipment weekly. Be sure that the shaft is free of oil and/or grease from the bearings and start the motor to make sure it comes up to speed in normal time. Check the bearings for excessive heat or noise. Check slip rings and commutators for excessive sparking during starting. Lubricate bearings according to the manufacturer's recommendations. Do not lubricate excessively; lubrication on insulating surfaces will deteriorate the insulation and gather dirt, which decreases the effectiveness of the insulation.

3.3 SWITCH GEAR. Perform the following work items in accordance with the manufacturer's instructions, but not less than once per year. Perform the work more often if the equipment is exposed to excessive dirt or vibration. These maintenance procedures apply to all electrical equipment that has contact-making devices (circuit

breakers, contactors, switches, relays, etc.), electrical coils (transformers, reactors, solenoids, etc.), electrical terminations, insulators, or accessible electrical wiring or busses.

- Open equipment panel and wipe insulators and busses with clean, soft, lint-free rags. Clean interior with soft brushes or a vacuum cleaner.
- Check all accessible electrical terminations and connections, including terminations of power and control cables, bolted bus connections, and all accessible ground connections. Taped connections need not be checked. Check visually and tighten loose connections with a screwdriver or wrench.
- Record the voltage at the secondary terminal of each power and distribution transformer, both loaded and unloaded. Compare this reading with previous readings. Change taps or contact the power company if the voltage is more than 5 percent high or low.
- Inspect contacts on switches, contactors, circuit breakers, disconnects, and relays if the contacts are accessible. Dress or replace contacts if they are pitted or burned. Replace contacts in pairs, not singly.

3.4 ELECTRIC MOTORS. Perform the following work items in accordance with the manufacturer's instructions, but not less than once per year. Perform the work more often if the equipment is exposed to excessive dirt or vibration.

- Blow dirt from the windings. Clean out magnetic particles that may be hanging on poles.
- Drain, wash, and renew oil in sleeve bearings. Clean and renew grease in ball-and-roller bearings. Check air gaps. Inspect bearings for excessive wear.
- Check end play. Under load, machines without thrust bearings should have the rotor within the end play. That is, the rotor should not be riding against the thrust collar of either bearing. This condition can cause heating and failure of the

bearing; it can be corrected by shifting the rotor on the shaft or by shifting the laminations. Consult the manufacturer.

- On rotating equipment with commutators or slip rings, check brush tension and brush wear. Make sure brushes are free in the brush holder. Replace brushes as required. Sand-in new brushes. Check commutators and slip rings for wear, scratches, or pitting. Dress as required.
- Megger low-voltage rotating equipment using a 500-volt megger. Megger reading should be 1 megohm at minimum, but readings should be compared with previous readings, since a decreasing megger reading indicates deteriorating insulation or excessive dirt or moisture.
- Check foot bolts, end shield bolts, pulleys, couplings, gear and journal set screws, and keys. Ensure that all covers and guards for pulleys and couplings are in good condition and securely fastened. Observe operation during starting and running.

3.5 STANDBY POWER GENERATORS. Operate emergency generators once a week, if possible, to ensure they will work properly when needed. Operate the generators in accordance with the manufacturer's instruction (operation at full load for at least 1 hour is commonly recommended). Normal power sources must be disconnected to operate standby power at full load. Engine generators should comply with all applicable regulations regarding exhaust emissions.

3.6 INSTRUMENTATION AND CONTROLS. The following paragraphs address maintenance and calibration issues.

3.6.1 REGULAR MAINTENANCE. If kept in the proper environment, modern electronic equipment requires only periodic cleanings. Every 3 months, instruments should be opened or withdrawn from their cases, inspected, and cleaned with a soft brush. Instruments with moving parts should be lightly lubricated in accordance with the manufacturers' instructions. Do not over-lubricate. Check for interferences between

moving parts. Fill ink wells on recorders as needed. Look for source of unusual heat, sound, or odors.

3.6.2 CALIBRATION. Check calibration annually on instruments, gages, and pressure switches. If possible, calibrate equipment in place using the piping, wiring, and fluids of the processes and calibrate a whole subsystem at once. Since this method does not require removing the instrument, it avoids errors such as bad connections and leaks on reinstallation. The disadvantages are that in-place calibration may disrupt the process, and it may be difficult to get sufficient accuracy and range. Calibrate pressure gages and pressure switches by connecting them to a pressure header with a bleed valve and a pressure valve connected to an air tank. Use a gage of known accuracy and recent calibration for a reference. Check set points of pressure switches on increasing or decreasing pressure. Gages and pressure switches should be checked annually.

3.7 TOOLS AND EQUIPMENT. In order to maintain, repair, and troubleshoot electrical equipment and circuits, the proper tools are required. In addition to a normal complement of small hand tools, a voltage tester with sufficient range to measure the highest voltage expected, a clamp-on type ammeter, a megger (a device for checking the insulation resistance), and an ohmmeter or circuit tester are required.

4. MECHANICAL EQUIPMENT. The following maintenance instructions are general. Maintain individual pieces of equipment according to the recommendations of the manufacturer. Operating procedures and ambient conditions, such as dirt and vibration, may dictate maintenance schedules different from those recommended here.

4.1 AERATORS. Maintenance frequencies for aeration equipment are summarized in Table 1.

4.2 RAPID-MIX BASINS AND EQUIPMENT. Because rapid-mix devices revolve at great speed, do not attempt to check the rotation of the mixer paddles during operation, except by visual observation. When the mixing basin is empty, check the condition of the paddles, bearings, drive shaft, and motor. Then clean, lubricate, and paint as necessary. Table 2 presents a summary of maintenance procedures for rapid-mix basins.

4.3 FLOCCULATORS. Table 2 covers flocculator maintenance.

4.4 SEDIMENTATION BASINS AND CLARIFIERS. All types of settling basins require the same basic maintenance (lubrication, cleaning, flushing, and painting). Maintain basins that incorporate proprietary mechanisms or devices according to the manufacturer's instructions. Table 2 presents a summary of maintenance procedures for sedimentation basins.

4.4.1 NON-MECHANICALLY CLEANED SEDIMENTATION BASINS. Clean these sedimentation basins at about 3-month intervals, or when development of an odor or rising floc particles indicates development of septic sludge conditions. Basins with mechanical equipment for removing settled sludge usually clean themselves satisfactorily during normal operations. However, it may be necessary at times to drain them and to clean the tank and mechanism with a high-pressure water hose.

Inspection	Action	Frequency (1), (2)
Waterfall type aerators (cascade)	Inspect aerator surfaces; remove algae; clean.	D
Waterfall type aerators (tray)	Clean and repair trays; clean coke or replace.	SA
Waterfall type aerators (cascade)	Repair or replace surfaces as necessary.	A
Packed tower aerators (strippers)	Inspect packing for scale buildup.	W
Packed tower aerators (strippers)	Clean with acid. (3)	Biweekly or as required
Diffuser type aerators		
Porous ceramic plate or tube	Check discharge pressure. If clogging is evident, dewater tank and clean diffusers.	V
Porous ceramic plate or tube	Drain aeration tank. Check for joint leaks, broken diffusers, and clogging. (4)	SA
Water side of ceramic diffusers	Clean with acid in place or remove and soak in acid. (3)	SA
Air side of ceramic diffusers	If plates are clogged with iron oxide, treat with 30% HCl; if clogged with dust, soot, oil, etc., remove diffusers and burn off extraneous material in a furnace following the manufacturer's instructions.	SA
Porous saran-wound tube diffusers	Inspect and clean as required. (5)	SA
Injection nozzles	Inspect and clean.	SA

Table 1

Maintenance Checklist for Aeration Equipment

Inspection	Action	Frequency (1), (2)
Spray nozzle aerators		
Nozzles	Check for clogging. Clean	W
Manifolds		
Spray fer		
Blowers and equipment		
Comp		
Air filt		
Comp		

(1) D-Daily
V-Varia
(2) The fre
comma
(3) Caution
or chro
will cau
the app
or othe
(4) Note: C
helps h
50 perc
use chr
acid). F
(5) As the
diffuser
(6) Do not

local

ulfuric acid y on emist

ions

acid; lfuric ys. ub the

To view the remainder of the course material and complete the quiz and get PDH credit and certificate, you must purchase the course.

*First, close this window and click "**Create an Account**" or "**Login**" located on the **right side of the webpage** then select the link at the bottom of the webpage:*

"Send payment via PayPal or Credit Card"