

**Hands-On Water/Wastewater
Equipment Maintenance Vol.1**

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VOLUME 1

Hands-on Water/ Wastewater Equipment Maintenance

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Equipment Maintenance Consultant



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Preface

The subject of water or wastewater plant equipment maintenance is so broad and wide-ranging that it is virtually impossible to describe in any written text the maintenance requirements of all of the varieties of equipment that are manufactured. Also, a text written about specific pieces of equipment would not be of much value to any one plant. However, when equipment operation is the subject, one must keep in mind that an equipment breakdown occurs as a result of the failure of one or more small individual components and not the entire unit.

To properly address the topic of equipment maintenance, this text is structured to explain the design, operation, and maintenance of a number of different pieces of equipment (motors, pumps, aeration blowers, mixers, etc.). More importantly, the text discusses the individual components (bearings, couplings, chain drives, seals, etc.) that are an inherent part of a larger piece of equipment. It is the author's belief (supported by practical experience) that if a person knows and understands the design and operating characteristics and limitations of these individual components, major breakdowns can be avoided by correcting minor problems at an early stage.

A number of the chapters contain a certain amount of theoretical and engineering knowledge. This information has been included to reinforce the design and operating conditions or limitations of the various components. Also, this text is intended to be both a reference source as well as a teaching

tool. The theory and engineering information provides basic data that can be supplemented by other more inclusive texts to help solve components' failure problems. The detailed description of the operation of the individual components can be useful when trying to explain the difference between similar pieces during a discussion or training session.

The information that is contained in the various chapters about the construction and operating characteristics of the individual components is of the greatest importance to the reader. A large number of the components described in the text may not be used in your specific plant and might even be foreign to you. However, they have been included to give you a broader understanding of how similar types of equipment can be used for different applications. It is the author's belief that the more knowledge that a person has, the easier it is to make an informed judgment regarding proper equipment operation.

The maintenance and repair techniques presented in the various chapters will serve as a basis for developing a maintenance program. It is anticipated that the text, combined with any manufacturer's literature or instruction manuals will provide the information necessary to keep your plant running at peak efficiency. A smooth running plant, properly maintained (including good housekeeping practices) and operating at peak efficiency, should be a source of pride to all operating personnel.

Acknowledgments

The development of this book has not been without the aid and assistance of many persons and companies. The companies that have permitted use of their illustrations in this text are only a small number of those that have provided reference literature for the author's use. Generally, the illustrations that are used were selected for their quality and descriptive content.

The author wishes to thank all of those companies that supplied catalogs and other literature for his use.

Additionally, the author thanks all of those persons who have urged, supported, and driven him to complete this text, especially his wife for her patience during the many hours of development and writing that have gone into this first volume.

List of Abbreviations

A-C	Alternating current 5.42	NEMA	National Electrical Manufacturers Association 6.38
AGMA	American Gear Manufacturers Association 3.27	NO	Normally open 7.46
ASTM	American Society for Testing and Materials 3.27	OL	Overload 7.48
ATS	Automatic transfer switch 6.32, 7.17	OSHA	Occupational Safety and Health Act 6.74
BT	Backspin timer 7.92	PD	Pitch diameter 10.18
D-C	Direct current 5.08	PLC	Programmable logic controls 8.27
EMF	Electromotive force 5.05	PN	Positive-negative 5.18
HOA	Hand/off/auto 7.50	PTFE	Polytetrafluoroethylene—teflon 11.17, 11.36
IGBT	Insulated gate bipolar transistor 8.23	PWM	Pulse width modulation 8.11
ISO	Industrial Standards Organization 3.28	SAE	Society of Automotive Engineers 3.25
MCC	Motor Control Center 6.31, 7.10	SCR	Silicon-controlled rectifier 5.20, 8.23
M-G	Motor-generator 5.13	SSU/SUS	Saybolt Seconds Universal 3.26
NC	Normally closed 7.45	UL	Underwriters Laboratories 7.104
NEC	National Electrical Code 6.39	UV	Under voltage 7.82
		VI	Viscosity Index 3.29

Table of Contents

Preface xi

Acknowledgments xiii

List of Abbreviations xv

1. INTRODUCTION TO MAINTENANCE 1

 The Need for Maintenance 1

 The Keys to Good Maintenance 1

 Scope of the Maintenance Program 1

2. ESTABLISHING A MAINTENANCE PROGRAM 3

 Approach to Plant Maintenance 3

 Types of Maintenance 3

 Establishing a Preventive Maintenance Program 4

 Setting up the Maintenance Program 4

 Equipment Records 6

 Establishing the Maintenance Schedule 8

 Following the Schedule 9

3. LUBRICATION 11

 Reasons for Lubrication 11

 Types of Lubricants 12

 Selection of a Lubricant 12

 Lubricant Subgroups by Source 14

 Oil Lubricants 14

 Oil Additives 15

 Applying Oil Lubricants 16

 Grease Lubricants 16

 Properties of a Grease 19

 Types of Greases 20

 Other Compounded Greases 21

4. BEARINGS 25

 Rotating Components 25

 Bearing Functions 26

Bearing Categories 26

Design Considerations 26

Load Capacity 27

Speed 27

Life 27

Fatigue 27

Types of Bearings 28

Ball Bearings 28

Single Row 29

Angular Contact 29

Double Row 29

Cylindrical Rollers 31

Spherical Rollers 31

Tapered Rollers 31

Thrust Bearings 33

Needle Bearings 33

Bearing Seals 33

Antifriction Bearing Removal 33

Using a Puller 33

Using an Arbor Press 37

Antifriction Bearing Installation 38

Force Installation 39

Thermal Expansion or Contraction 39

Pillow Block Bearings 40

Bearing Failures 40

Cleaning and Greasing 41

Plain Bearings 42

Plain Bearing Installation 42

Wall-Mounted Plain Bearings 43

Bushings 43

Bushing Installation 45

5. D-C AND SINGLE-PHASE MOTORS 47

Electrical Power 47

Direct Current 47

D-C Power Supply 49

D-C Motors 50

Shunt Wound Motors 51

Series Wound Motors 52

Compound Wound Motors 52

D-C Motor Maintenance 53

Alternating Current 53

Single-Phase Power Supply 54

Single-Phase Motors 54

Single-Phase Motor Types 55

Split-Phase Motors 56

Two-Speed Split-Phase Motors 56

Capacitor Motors 56

Capacitor Start Motors 57

Capacitor Start, Capacitor Run Motors 57

Permanent-Split Capacitor Motors 57

Shaded Pole Motors 57

Other Single-Phase Motors 58

A-C Motor Maintenance 58

6. THREE-PHASE MOTORS	61
Three-Phase Power	61
Three-Phase Alternator Connections	61
Transformers	63
A-C Power Distribution	65
Three-Phase Motor Construction	66
Three-Phase Motor Characteristics	67
Three-Phase Motor Operation	68
Motor Torque	68
Synchronous Motors	70
Dual Voltage Motors	71
A-C Motor Maintenance	71
7. THREE-PHASE MOTOR CONTROLS	75
System Protection and Control	75
Switchgear and Switchboards	75
Motor Control Centers	76
Panel Boards and Load Centers	76
Transfer Switches	76
Fuses	80
Disconnect Switches	81
Circuit Breakers	81
Motor Starters and Controllers	85
Manual Starters	85
Contacting Starters and Controllers	86
Duplex Controllers	87
Reversing Controllers	88
Multispeed Controllers	88
Reduced Voltage Starting	88
Solid-State Reduced Voltage Starting	93
Motor Protection	93
Overload Protection	93
Voltage Monitoring	94
Ground Fault Detection	96
Control Relays	96
Plug-In Relays	97
Timing Relays	98
Motor Control Alternators	99
Other Relays and Switches	100
Motor Control Enclosures	102
Motor Controller Maintenance	102
Checking Out a Circuit	105
8. VARIABLE SPEED DRIVES	107
Variable Speed Applications	107
Electric Drives	107
Direct Current Drives	107
Eddy-Current Drives	108
Alternating Current Drives	110
Converting A-C Power	111
Variable Speed Motors	111
Mechanical Drives	112
Belt Drives	114
Hydraulic Drives	116

9. COUPLINGS 121

Coupling Requirements 121

Shaft Misalignment 121

Coupling Design 122

Solid Couplings 122

Jaw Couplings 122

Flexible Jaw Couplings 124

Pin Couplings 124

Molded Insert Couplings 124

Grid Couplings 126

Gear Couplings 126

Chain Couplings 127

Metal Disc Couplings 128

Universal Joint Couplings 128

Coupling Modifications 129

Shear Pin Couplings 129

Torque-Limiting Couplings 130

Centrifugal Couplings or Clutches 130

Other Coupling Devices 132

Coupling Installation Procedures 132

Basic Procedures 133

Dial Indicator Technique 134

Optical Techniques 135

Reverse Alignment Technique 135

Coupling Maintenance 137

10. BELT AND CHAIN DRIVES 139

Belt Drives 139

V-Belts 139

Modified V-Belts 140

Flat Belts 140

Timing Drive Belts 142

V-Belt Drive Sheaves 142

Fixed V-Belt Sheaves 144

Adjustable V-Belt Sheaves 144

Flat Belt Drive Sheaves 144

Timing Belt Sprockets 146

Drive Belt Installation 146

Drive Belt Storage 148

Chain Drives 149

Roller Chain 149

Extended Pitch Chain 149

Silent Chain Drives 149

Fabricated Drive Chain 150

Cast Drive Chain 150

Nonmetallic Drive Chains 152

Cast or Molded Conveying Chains 152

Fabricated Conveying Chains 154

Sprocket Hubs and Bodies 154

Sprocket Teeth 155

Other Sprocket Modifications 156

Chain Installation 157

11. SEALS AND PACKING 159

Purposes of Seals 159

Open Seals	159
Oil Seals	160
Seal Construction	160
Seal Replacement	162
Seal Removal or Installation	162
Other Sealing Devices	162
O-Rings	162
Preformed Packings	167
Cup Packing	167
Packing	169
Packing Materials	169
Stuffing Boxes	169
Stuffing Box Design	169
Pump Packing Maintenance	170
Excessive Shaft or Sleeve Wear	172
Gaskets	172
Mechanical Pump Seals	173
Mechanical Seal Elements	173
Internal Seal Variations	173
Dual Seals	175
External Seal Variations	175
Seal Removal and Installation	176

12. CENTRIFUGAL PUMPS 179

System Hydraulics	179
Suction Side	179
Discharge Side	180
Other Head Conditions	180
Pump Components	181
Casing	181
Shafts	184
Impellers	184
Wear Rings	185
End Suction Pump Maintenance	186
Double-Suction Pump Maintenance	187
Sewage and Slurry Pumps	189
Other Centrifugal or Velocity Pumps	190
Vertical Turbine Pumps	190
Vertical Turbine Pump Drives	192
Vertical Turbine Pump Maintenance	192
Axial Flow Pumps	193
Axial Flow Pump Maintenance	194
Regenerative Turbine Pumps	194
Regenerative Turbine Pump Maintenance	195

13. GEARS AND REDUCERS 197

Gears	197
Spur Gears	197
Helical Gears	199
Herringbone Gears	199
Miter and Bevel Gears	199
Worm Gears	200
Speed Reducers	201
Horsepower Rating	202
Torque Rating	202

Thermal Horsepower	202
Overload Capacity	203
Overhung Load	203
Service Factor	203
Speed Reduction	204
Reducer Classification	205
In-Line Reducers	205
Parallel Shaft Reducers	206
Right Angle Reducers	207
Shaft-Mounted Reducers	207
Worm Gear Reducers	208
Reducer Installation Procedures	209
Reducer Maintenance Procedures	209

Index	211
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Introduction to Maintenance

THE NEED FOR MAINTENANCE

1.01 Maintenance is a part of everyday life, although little thought is given to some of the more routine “chores,” such as car and home repairs, lawn and shrubbery care, painting, and many other items. However, even though these chores are considered the preservation of property or equipment, they are a form of maintenance. And when you look at the bottom line, maintenance really is the preservation of property.

1.02 The importance of water/wastewater plant maintenance has been discussed and written about for many years. It is a well-known fact that many plants suffer severe operating problems because of poor maintenance. When the topic is discussed, much attention is given to maintenance concepts and the overall program, but the basic fundamentals and details are overlooked or ignored. Following good basic maintenance procedures is like keeping your vehicle filled with fuel. Without fuel the vehicle will stop. Without proper maintenance, the equipment and your plant will shut down.

1.03 The maintenance program for water/wastewater plants should include not only the items that make the plant run efficiently but look good as well. Your plant is often judged by its appearance and not by how you treat the water. Maintenance procedures should be given a high priority in the daily work schedule, because making sure that the plant equipment functions properly is an important factor in achieving the proper water discharge quality. If the equipment does not operate properly, water quality standards cannot be met.

1.04 The need for a good maintenance program and the knowledge of how each component functions and should be maintained cannot be emphasized enough. By properly maintaining plant equipment, an operator can extend its operating life by at least 25 percent. The extended equipment life means less capital replacement expenses, better plant operation, and even better public relations. It should be a source of pride for both the employees and management.

THE KEYS TO GOOD MAINTENANCE

1.05 The performance of maintenance duties or tasks is only a small part of the maintenance function. Although it is important that you understand how to repair a piece of equipment, it is also important that you understand how the component performs its operation as well as some of its design, engineering, and construction features. Understanding the more “technical” aspects of various equipment components should help you gain knowledge of why breakdowns and failures occur. This extra knowledge should help you improve your maintenance program, increase equipment life, and make your job easier.

1.06 Waste or wastewater operators are usually very professional in the manner in which they run their plants. Setting up a maintenance program and performing routine maintenance are just other steps in operating the plant. There is nothing special that is required to set up a maintenance program or to see that the one you have works well. If you do not have the time to develop your own program, there are a number of “packaged” programs available, including manual and computer-driven types. Chapter 2 explains more on establishing a maintenance program.

SCOPE OF THE MAINTENANCE PROGRAM

1.07 All water or wastewater plants have different maintenance requirements. Location, size, staff, and funding all determine how a maintenance program should be set up. Although many design engineers recommend maintenance procedures, only plant personnel can determine what sort of program best suits their individual needs. However, to be effective and efficient, the program should be all-inclusive and not be limited to only the major plant components. The items listed in Figure 1.1 should be used as a guide to establishing a complete maintenance program.

1.08 You must consider not only how broad your maintenance

Treatment Equipment
Lift Stations
Wells
Disinfection Equipment
Emergency Pumps and Generators
Portable Tools
Vehicles
Buildings and Grounds
Security Systems
SCADA and Telemetry Equipment
Battery Systems
Instrumentation Equipment

Figure 1.1. Partial list of items that require maintenance.

nance program will be but also who is going to perform all of the work. For many plants, the maintenance functions, including landscaping, vehicles, water drainage or retention, buildings, and/or storage facilities, are within the scope of the plant staff. For other facilities only the internal equipment or machinery is all the staff maintains, whereas small operations with limited staff may perform only limited or even no maintenance on their equipment. In fact, equipment maintenance is performed by outside contractors or vendors for some small utilities. The important key is to make sure that a maintenance program exists. If your maintenance work is performed under contract by an outside source or by personnel from different utility divisions, make sure that you have input into the maintenance program.

1.09 Whatever approach you use to establish your maintenance program, make sure that it is "flexible" and can ac-

commodate all of your needs while you still can accomplish your other necessary work. Maintenance frequency should be adjusted periodically on the basis of operating or running time and seasonal conditions. For example, if a pump runs only a few months a year, the maintenance frequency cycle should be extended to accommodate this, as opposed to a pump that runs 24 hours a day for weeks on end. Using hours of operation instead of calendar time has always proved to be the most efficient method of scheduling maintenance.

1.10 If you purchase a "packaged" maintenance program (card file, bulletin board, software, etc.), make sure that it is "operator-friendly" and can be modified or adjusted to your specific application or situation. A program that has a lot of options but cannot be modified has limited effectiveness and causes more problems than it solves. Generally, most "packaged" maintenance programs are computer-type programs. Although these programs are helpful, they often require someone to put in and retrieve data. They also generate a lot of paper, some of which can be helpful when properly used. For medium or large utilities, this could mean the hiring of additional administrative staff or assigning one person to run the program. For small utilities, it can take away from performing other duties.

1.11 If you have recently been employed by a utility that has an existing program and you have to make sure that the maintenance is performed, take a good look at the program rather than accept what presently exists. Many times, plant conditions change or have been modified. Under these conditions, the level of maintenance must also change to accommodate different equipment.

Establishing a Maintenance Program

APPROACH TO PLANT MAINTENANCE

2.01 As you know, some sort of maintenance must be carried out to keep a plant functioning smoothly and in good repair. The approaches to plant maintenance vary from total neglect, to emergency repairs only, through minor lubrication, up to computer-driven fully operational programs. Unfortunately, the operators who believe they are saving money by not performing maintenance really pay more for repairs when the equipment finally breaks down.

2.02 Many plant personnel think that maintenance requires a complex program and a lot of involvement and time. However, all that is required for a smooth running maintenance program is that the operator keep an eye on the daily operations of his equipment and perform the necessary maintenance tasks on a routine schedule. Maintenance tasks range from simple lubrication, to minor adjustments, to complete overhaul, depending on the piece of equipment and the situation. The important thing, however, is to perform some sort of maintenance on a regular basis as determined by the plant personnel and the equipment manufacturer. This may sound overly simple, but regularly performed maintenance becomes a normal way of running the plant and requires little or no extra effort.

2.03 Painting, housekeeping, landscaping, building repairs, and even vehicle upkeep are all forms of plant maintenance. They are no less important than equipment maintenance, because these items are what the public sees and judges your performance on. However, this book primarily deals with equipment maintenance. Maintenance of the buildings, grounds, and vehicle maintenance is left up to you.

TYPES OF MAINTENANCE

2.04 There are many words used to describe equipment maintenance. The newest and latest are proactive and predictive maintenance. Proactive, in most instances, only refers to

setting up and implementing an active maintenance program. Predictive maintenance, on the other hand, deals primarily with planning or scheduling maintenance around operating time and the expected life of a piece of equipment. Because of the adverse conditions in which water or wastewater plants operate, the more flexible and proper terms used to describe equipment maintenance are:

- breakdown maintenance
- preventive maintenance

Most of this chapter will be directed to preventive maintenance, because this is the best way to control breakdown maintenance.

2.05 It should be acknowledged that some amount of breakdown maintenance will take place at any plant. Even plants that have a strong preventive maintenance program always have the possibility that something will go wrong and that equipment will unexpectedly break down. However, a good preventive maintenance program will keep the number of breakdowns to small or infrequent occurrences that will not affect the plant operation.

2.06 Even equipment breakdowns can be handled as a nonemergency if you do some preplanning and maintain spare parts and other needed items. Preplanning in the form of maintenance instructions and alternate plans for operating are as important as spare parts. Having an emergency operating plan and spare parts will save you from making a lot of telephone calls or doing a lot of unnecessary chasing around looking for equipment components on short notice.

2.07 There are many situations where manufacturers *do not* maintain a stock of all spare parts (especially noncritical parts), necessary to keep their equipment running. In these situations, critical parts would have to be manufactured from "scratch," necessitating the shutdown of the affected piece of equipment until the parts are available. In some cases, this lack of spare parts could force you to shut down the entire plant. All of this can be avoided with a small amount of timely preplanning.

2.08 Preventive maintenance, on the other hand, relates to the scheduling and performing of regular maintenance functions from inspections through overhaul or replacement. It also should be considered a part of your normal daily work routine and something that is necessary to keep the plant operating at full capacity. In almost all plants, especially the smaller ones, preventive maintenance is in the form of inspections and tests that are performed every day. Preventive maintenance can further be broken down into two categories:

- planned maintenance
- routine maintenance

2.09 Planned maintenance is defined as the periodic scheduled removal of equipment from service for the disassembly and inspection of the internal working parts. This periodic inspection provides you with a visual look at the physical condition of the individual components and should alert you to any potential major equipment problems caused by normal or abnormal wear. Planned maintenance is most beneficial because it permits you to evaluate the life of the equipment and plan overhaul or reconditioning intervals.

2.10 Routine maintenance, on the other hand, is best described as the daily general inspections and tests, including regular lubrication, that are performed as a part of the regular operation of the plant. The daily routine and checking of the plant equipment will make you more aware of minor problems that occur and permit you to make corrections and adjustments necessary to prevent a major breakdown or other costly repairs.

ESTABLISHING A PREVENTIVE MAINTENANCE PROGRAM

2.11 There are several methods used to establish a total preventive maintenance program. Any program should include the frequency of planned maintenance, the amount of routine maintenance to be accomplished on a daily, weekly, or monthly basis, and allowances for emergency repairs. The amount of planning required to set up a preventive maintenance program depends on the size of the plant, as well as how much and what type of equipment it contains. For example, a simple well and water storage tank has few of the problems or maintenance requirements that a water treatment plant has.

2.12 The guidelines presented in this chapter will set up some minimum maintenance procedures and will be able to be modified by any plant operator to fit his particular needs. Remember, the more basic, simple, and less structured the program is, the more easily it can be adapted to fit your system and the easier it will be to perform maintenance tasks on the equipment. The more detailed or com-

plex the program, the harder it will be to carry out the maintenance function.

SETTING UP THE MAINTENANCE PROGRAM

2.13 Many plant operators using purchased maintenance card systems and computer-driven programs have established preventive maintenance programs. Not all plants, however, require a large maintenance program. The preventive maintenance program for your plant may be only a list of equipment on a sheet of paper that is posted on the wall as a reminder of what has to be maintained at certain periods of time.

2.14 Many operators are confident that they understand their equipment and its maintenance requirements. However, keep in mind that you might not always be around and that the person who will follow you may not have the same training. Setting up a preventive maintenance schedule becomes a constant reminder of work to be accomplished, both for yourself and for anyone else who works for or with you. The maintenance schedule also tells other operators how well you run your plant.

2.15 If you do not have an established preventive maintenance program, one can be easily started with a plain sheet of paper. The first and easiest step toward setting up the program is to make a list of all of the items in your plant that require maintenance. This inventory list serves several purposes, but it is a foundation for all of the other data and records that you need for a comprehensive maintenance program. The inventory list also serves as both a record of all capital equipment and a basis of financial expenditures and equipment depreciation. A sample inventory list is shown in Figure 2.1. Your plant operating manual may also contain a partial inventory list.

2.16 The next step in the development of your preventive maintenance program is to identify each major component on the inventory and make a list of each of its subassemblies that will require maintenance. For example, a clarifier will have a drive motor, speed reducer, additional drive gears (or chain and sprockets), and some sort of support-bearing mechanism. The sample subassembly listing in Figure 2.2 shows that each of the items requires a different amount of maintenance at a different time. The advantage of identifying each of the subassemblies will enable you to form groups of all similar components (motors, reducers, drive belts, etc.). Having similar components grouped together will help you establish a more efficient preventive maintenance program for the entire plant.

2.17 A preventive maintenance program can be set up in any of several ways, depending on the plant size and layout. It can be set up for specific types of equipment, such as motors, or it can be done by individual units, or it can be a combination of both. Doing preventive maintenance in a small