Certification Examination

Study Guide

Plant Maintenance Mechanical Technologist

Grade II

CALIFORNIA WATER ENVIRONMENT ASSOCIATION

California Water Environment Association

Grade II
Plant Maintenance Mechanical Technologist
Study Guide

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Important Notice: CWEA is pleased that you have purchased this book. We want to remind you that this book is one of many resources available to assist you and encourage you to identify and utilize the other resources in preparing for your next test.

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Grade II Plant Maintenance Mechanical Technologist Study Guide

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Section 1

Introduction

The California Water Environment Association (CWEA) Technical Certification Program (TCP) is voluntary; its purpose is to educate, prepare, and test an individual's knowledge within six vocations.

- Plant Maintenance (with two parallel specialties of Electrical/ Instrumentation, and Mechanical Technologist)
- Laboratory Analyst
- Collection System Maintenance
- Environmental Compliance Inspector
- Industrial Waste Treatment Plant Operator
- Biosolids Land Application Management

CWEA also assists in educating and training wastewater treatment plant operators for the State of California Operator Certification Tests. Upon qualifying and successfully completing a test, an individual is certified in that specialty at one of the grade levels. Levels within a specialty designate technical knowledge for the apprentice, journey, and management levels. Tests are designed to demonstrate minimum competence for a particular grade.

The purpose of this study guide is to provide a description of the knowledge, skills, and abilities (KSA) needed to pass the test. Also included are questions designed to assess a candidate's strengths and weaknesses relative to their present KSA. Finally, the study guide provides references used to refresh subject knowledge, or to learn more about particular subject areas not completely understood.

Typically there are two to five primary references for each specialty area which need to be read and understood. Test questions are generally based on information contained in these references. Secondary references give more information and often provide a different approach to a subject making it easier to understand.

This study guide is not a compendium of all that may be on the test, so successfully answering questions contained in this guide does not guarantee passing. To successfully pass the Grade II Plant Maintenance Mechanical Technologist test, the reference materials presented in this study guide should be thoroughly understood.

This study guide can best be used to help identify strengths and weaknesses and to identifymaterial that may need further study. Comments and suggestions to improve the study guide are always welcome and appreciated. Good luck on the test!

Section 2

Certification Program Information and Policies

CWEA's mission is to enhance the education and effectiveness of California wastewater professionals through training, certification, dissemination of technical information, and promotion of sound policies to benefit society through protection and enhancement of the water environment.

CWEA is a California Nonprofit Corporation, a Member Association of the Water Environment Federation (WEF), and a member of the National Organization for Competency Assurance (NOCA).

Technical Certification Program History

TCP was created to offer multilevel technical certification for individuals employed in the water quality field. Tests are written by vocational specialists and administered throughout the year in six different disciplines: Plant Maintenance Technology (with two parallel specialties in Electrical/Instrumentation and Mechanical Technology), Laboratory Analysis, Collection System Maintenance Technology, Environmental Compliance Inspection, Industrial Waste Treatment Plant Operation, and Biosolids Land Application Management.

CWEA first offered a certification program for wastewater treatment plant operators in 1937. The program was administered by CWEA until 1973 when the State of California assumed responsibility. During those 36 years, CWEA awarded 3,915 operator certificates.

The first committees were formed in 1975 to establish a voluntary certification program for water quality professionals specializing in disciplines other than plant operation. The Voluntary Certification Program (VCP) emerged with specialized certificate programs for Collection System Maintenance, Plant Maintenance, Environmental Compliance Inspection, and Laboratory Analysis with certifications first issued in April 1976. In the 1980s, two more disciplines were added: Electrical/Instrumentation and Industrial Waste Treatment Plant Operator.

Today, CWEA offers certification in six vocational programs with a total of 22 individual certifications. About 2,000 applications are processed annually and currently over 5,500 certificates are held by individuals in California and neighboring states.

Certification Process

To become certified, *all applicants* must complete the Application for Technical Certification, pay the application fee, have suitable experience and education, and pass the written test. Application instructions and fee schedules are listed on the application. After applications are received at the CWEA office, applicant information is compiled in a database, and reviewed by CWEA staff and Subject Matter experts for the respective vocation applied for. If approved, the applicant will receive an eligibility letter. If the application is rejected, the applicant will be notified and asked to supply more information if warranted.

After completing the test, applicants are sent offical results. Those who pass the exam, are mailed certificates and wallet cards.

Test Administration

Test Dates and Sites

Tests are given throughout the year in California, Michigan, and Alaska (see Application for Technical Certification for test schedule). Applicants who are eligible to test will be mailed an acceptance letter and instructions on how to schedule their exam.

Test Site Admission

Certificate candidates are required to show at least one valid government issued photo identification (State driver's license or identification, or passport). Only after positive identification has been made by the proctor may a candidate's test booklet be distributed. Candidates are not required to show their eligibility letters to enter the test site.

Test Security

All tests are computer-based. No reference material, laptop computers, or cameras are allowed in the test site. Candidates will have access to an onscreen calculator, however, you they are welcome to bring their own pre-approved calculator (visit www.cwea.org/cert). Candidates are not allowed to take any notes from the test site. Candidates who violate test site rules may be asked to leave the site and may be disqualified from that test. All violations of test security will be investigated by CWEA and appropriate action will be taken.

Test Reschedule and Cancellation

To postpone your application you must submit a written request (a letter stating that you wish to postpone), to postpone to the adjacent testing window. You may only reschedule your application once without a fee. Additional postponement will require a $40 reschedule fee. There are no exceptions to this policy. If you have a scheduled exam with our testing administrator, Pearson Vue, you must contact them 24 hours in advance to avoid losing your exam fee.

To cancel your application you must submit a written request (a letter stating you wish to cancel your application) to CWEA. The written request must be received at the CWEA office no later than two (2) weeks after the approved testing window. Full refunds, less the $40 administrative fee, will be made within 4 weeks after the scheduled test date. There are no exceptions to this policy.

Test Result Notification

Test results are routinely mailed to certificate candidates approximately two weeks after the test date. Results are never given over the phone. All results are confidential and are only released to the certificate candidate. There are no exceptions to this policy.

Issue of Certificate/Wallet Card

Certificates and wallet cards are issued to all candidates who pass the test. Certificates and wallet cards are mailed about two to three weeks after result notifications are mailed.

Certificate Renewal

All certificates are renewed annually. The first renewal is due one year from the last day of the month in which the certification test was held. Certificate renewals less than one year past due are subject to the

renewal fee plus a penalty fee of 100 percent of the renewal fee. Certificate holders more than one year past due will need to retest to regain certification. Renewal notices are mailed to certificate holders two months before the due date. It is the responsibility of certificate holders to ensure the certificate(s) remains valid.

Accommodations for Physical or Learning Disabilities

In compliance with the Americans with Disabilities Act, special accommodations will be provided for those individuals who provide CWEA with a physician's certificate, or its equivalent, documenting a physical or psychological disability that may affect an individual's ability to successfully complete the certification test. Written requests for special accommodations must be made with the test application along with all supporting documents of disability.

Test Design and Format

Test Design

All certification tests are designed to test knowledge and abilities required to perform the Essential Duties listed at the end of the section with minimal acceptable competence.

The Essential Duties and Test Content Areas for each certification were determined by a job analysis and meta-analysis of job specifications by two independent psychometric consulting firms. The studies gathered data from on-site visits of over 31 water and wastewater agencies, interviews with 110 water and wastewater professionals, and analysis of more than 300 job specifications. All research was conducted under the guidance of the TCP Committee, vocational sub-committees, and CWEA staff. All test questions are designed to measure at least one area of knowledge or ability that is required to perform an essential duty.

Test Delivery Mechanism

All tests are computer-based format and are written in the English language only.

Test Format

All TCP tests are in multiple choice format (see the sample test questions in this booklet for an example). The multiple choice format is considered the most effective for use in standardized tests. This objective format allows a greater content coverage for a given amount of testing time and improves competency measurement reliability. Multiple choice questions range in complexity from simple recall of knowledge to the synthesis and evaluation of the subject matter.

Test Pass Point

The basic minimum score required to pass all tests is 75 percent of possible total points. However, the score may be adjusted downward depending on test complexity. It should be assumed that the passing score is 75 percent and candidates should try to score as high as possible on their test (in other words, always try for 100 percent). The pass point for each vocation and grade level is set independently. Also, each version, or form of a test will have its own pass point. Different versions are given each time the certification test is administered.

How Pass Points are Set

A modified *Angoff Method* is used to determine the pass point for each version of each test. The modified *Angoff Method* uses expert judgments to determine the test difficulty. The

easier the test, the higher the pass point; similarly the more difficult the test, the lower the pass point.

The following is an outline of the modified *Angoff Method* (some details have been omitted):

1. A group of Subject Matter Experts (SMEs) independently rate each test question within a given test. The ratings are defined as the probability that an acceptably (minimally) competent person with the requisite education and experience will answer the question correctly. An acceptably (minimally) competent person is defined as someone who safely and adequately performs all job functions and requires no further training to do so.
2. The SMEs review each test question as a group. A consensus is reached for the rating of each test question. The SMEs also review comments submitted in writing by test-takers. Any test question that is judged to be ambiguous, has more than one correct answer, or has no correct answers is eliminated from the scoring process for that test. These test questions are then revised for future use, re-classified, or deleted from the test item bank.
3. After the data are refined, the final step is to calculate the mean, or average, of all the test question ratings. This becomes the overall pass point estimation.

Why Use Modified Angoff?

Each version of a given certification test uses questions from a test item bank. Each of these questions vary in difficulty. Because a different mix of questions is used in each test, the overall difficulty level is not fixed. Thus, it is important to make sure that the varying difficulty level is reflected in the pass point of each test to ensure that test results are reliable. Test reliability is concerned with the reproducibility of results for each version of a given test. In other words, for a test to be reliable it must yield the same result (pass or fail) for the same individual under very similar circumstances. For example, imagine taking a certain grade level test and passing it. Immediately after completing this test, a different version of the same grade level test is taken. If the test is reliable, the same result will be achieved: pass. If a passing grade is not achieved, it is likely that the test is not a reliable measure of acceptable (minimal) competency.

By taking into consideration the difficulty of the test, the modified *Angoff Method* significantly increases the reliability of the test. Also, since each test is adjusted for difficulty level, each test version has the same standard for passing. Thus, test-takers are treated equitably and fairly, even if a different version of the test is taken.

There are other methods for setting pass points. However, for the type of tests administered by CWEA, the modified *Angoff Method* is the best and most widely used.

Test Scoring

All tests are electronically scored by CWEA. Most test items are valued at one point. Some test items requiring calculations are worth multiple points varying from two to five (possibly more). After tests are scored, total points are compiled and an overall score is calculated as the sum of all points earned on the test. If the overall score is equal to, or greater than the established pass point, the candidate has passed the test. Total points possible for each test varies, but the average is 100 points plus or minus 25.

Item Appeals

Candidates who wish to appeal a specific test item must do so by completing the Candidate Feedback review screen at the end of the exam. Candidate feedbackss will be evaluated and appropriate adjustments will be made to the test content. Candidtates submitting feedback will not be contacted in regards to the appeal.

Qualifying for the Test

Eligibility criteria are summarized in Table 2-1. You may qualify by meeting either Education/Experience Combination A, B, C, or D. If you do not meet any of the combinations of experience and education, then you do not qualify for Grade II.

Table 2-1 Eligibility Criteria for Grade II Plant Maintenance Mechanical Technologist

Combination	Education and Certificates	+ Experience
A	None	4 full-time years in plant maintenance mechanical technology
B	Hold a Grade I Plant Maintenance Certificate for 1 year	2 full-time years in plant maintenance mechanical technology
C	Hold an AA/AS degree in a related field	2 full-time years in plant maintenance mechanical technology
D	Hold a BA/BS, or higher, degree in a related field	1 full-time year in plant maintenance mechanical technology

It is recommended that Grade II candidates have at least one-year full-time experience as a Plant Maintenance Technologist performing the *Essential Duties* listed below. Many of the candidates without the recommended experience have difficulty successfully completing the written test.

Essential Duties

Grade II duties include the essential duties identified in the Study Guide for Grade I. In addition, the Grade II Plant Maintenance Mechanical Technologist essential duties include:

- Repairs, maintains, installs, inspects, troubleshoots, and adjusts a variety of mechanical equipment at treatment facilities. Equipment
- Maintains, installs, inspects, and repairs a variety of pumps, such as centrifugal, positive displacement, and screw; services, lubricates, and adjusts chemical feed and processing equipment; determines excess wear and pump efficiencies; and follows preventive and predictive maintenance practices.
- Performs horizontal and vertical welding, fabricating, silver soldering, hard facing, and braising using acetylene, arc, mig, and tig welder on most ferrous and nonferrous metals; makes specialized cuts and complex angles using a band saw; and performs blacksmithing and parts fabrication.
- Maintains, installs, inspects, and repairs piping systems of pvc, black and cast iron, stainless steel, and copper tubing; installs, removes, and repairs larger pipes and valves; draws minor new designs; modifies existing piping systems and welded steel pipe, such as nozzles and saddles; and taps, cuts, and threads pipes.

- Performs complex maintenance and repair tasks on a wide variety of internal combusion engines; adjustsvalves and carburetors; and repairs and maintains exhaust systems.
- Performs regularly scheduled maintenance, inspection, and repair tasks on comminuting and grinding devices; overhauls equipment, such as cutters, bearings, chains, mechanical seals, gear reducers; performs close tolerance checking and testing.
- Performs basic to complex maintenance, inspection, and repair or overhauling tasks on drive components, such as right angle drive gears, reduction drives, variable speed and belt and chain drives.
- Overhauls, maintains, installs, adjusts, inspects, and repairs a variety of hydraulic and pneumatic systems and compressors.
- Properly uses and cares for hand and power tools such as grinders, saws, jacks, hydraulic presses and pullers, and pipe threaders, inspects, tests, and measures equipment and material using precision instruments such as scales, height and depth gauges, calipers, verniers, and micrometers of various types.
- Plans tasks, keeps records of work performed and makes estimates of labor and material necessary for the performance of the work.
- Follows proper safety practices, precautions, and procedures, such as confined space entry, storing, handling, and transporting gases, using correct lockout and tagout procedures, using flash protection when welding, and assisting in using safe rigging and welding practices.

Section 3

Skill Sets

The following sections give a concise description of the practical skills that Grade II Plant Maintenance Mechanical Technologists must possess to successfully pass the certification exam.

Table 3-1, presented at the end of this section, cross-references each skill set with a specific chapter, section, or page of applicable references to assist the candidate to better understand the subject matter.

Skill Set 1 Safety

1.1 General

To successfully achieve a Grade II classification, Technologists should have the ability to recognize and identify hazards and hazardous situations encountered above and below ground in plant maintenance and operations. A full knowledge of safety procedures and prevention techniques is also needed. Technologists should be able to identify any potential safety problems and report them appropriately to supervision.

Additionally, it is necessary to be familiar with, understand and know how to apply safety laws, rules, and regulations as they apply to Technologists, their co-workers and the public. The ability to interpret and understand the worker right-to-know law is also necessary.

Technologists must have knowledge of the techniques used in protecting their health and the health of those around them. This includes items such as: lifting and back safety, ergonomics, noise hazards, industrial housekeeping, working with heights, ladders and scaffolds safety, and traffic safety.

1.2 Confined Space

It is important to define what a confined space is and understand its definition. Technologists should know how to determine if a confined space is "permit required" or not. A strong knowledge of the confined space permit process, entry procedures and rescue operations, as well as terminology, is necessary. It is important for Technologists to be able to evaluate a confined space and make recommendations to supervision regarding entry requirements.

Knowledge and understanding of confined space safety rules, requirements, and regulations, as well as accident/injury prevention techniques is important. It is necessary to be aware of and understand the hazards and effects of working in confined spaces and what the responsibilities in these situations are. Technologists need to be able to recognize and evaluate confined space safety equipment, their components, understand their proper function and operation and determine the use based on the situation.

1.3 Chemical and Biological Hazards

There are numerous chemical and biological hazards within the plant maintenance field that may be encountered on a daily basis. A knowledge of these substances, and understanding their potential for hazard should be obtained. Technologists should have knowledge of the policies and procedures for prevention of, and protection from these hazards. The ability to understand and identify the types of proper use of personal protection equipment is required.

1.4 Material Safety Data Sheets (MSDS)

Any hazardous chemical product used within the plant maintenance field has an MSDS. These MSDSs will provide valuable information about potentially hazardous chemicals used on the job. Technologists should know what MSDSs are and understand their use. Technologists should know the laws governing the MSDS and how to obtain one, when necessary.

1.5 Lock Out/Tag Out (LO/TO)

It is necessary that all personnel working in plant maintenance have a strong understanding of LO/TO. It is important to know the policies and procedures set forth by CAL-OSHA. A working knowledge of LO/TO written requirements, application rules and regulations, removal requirements, and the terminology of LO/TO is required. Technologists should also have the ability to evaluate a LO/TO procedure for accuracy and safety. They should be able to respond to problems and/or questions from entry-level personnel.

1.6 Personal Protective Equipment (PPE)

Technologists need to be aware of the physical and chemical hazards not found in other fields and the PPE required to protect themselves from these hazards. Technologists need to be able to identify the different type of PPE available to them, understand how to properly use the PPE, and be able to evaluate a job for PPE required depending upon the work being accomplished and the associated hazards. Technologists should know how to obtain, distribute, use, care for, and properly store PPE.

1.7 Tool Safety

Technologists should be able to understand the safety hazards associated with the hand and power tools used in plant maintenance. Technologists should be able to identify needs of and train entry-level staff. Some of the hazards they would be expected to know are: when a tool is being used incorrectly, how to identify a defective tool, when someone is using the wrong tool for the job, how to identify an improperly maintained tool and incorrect body positioning when using a tool.

1.8 Safety Working With and Around Machinery

Technologists should have a strong understanding of the safety hazards and precautions associated with working with and around machinery. Technologists should be knowledgeable of the policies and procedures for prevention of, and protection from these hazards.

Technologists need to have knowledge of the safety items associated with machinery, why they are there and their proper use. Technologists should be familiar enough with the specifics of the safety features and procedures associated with the equipment found in a WWTP&CS as to be able to train entry-level staff and make decisions based on this knowledge. Some of these would include: safety guards, interlocking guards, controls, feeding and extracting tools, LO/TO, automatically starting equipment precautions and rotating equipment precautions.

Skill Set 2 Tools and Equipment

2.1 Hand Tools and Equipment

Technologists should be able to correctly identify, select, know the proper use of and be able to train entry-level personnel on the various hand tools and small equipment used in plant maintenance. It is important to understand the characteristics and operation of various tools and equipment as they apply to the plant maintenance field. Technologists should be able to identify the various parts of the tools and equipment used in plant maintenance. Technologists must have the ability to recognize and understand inherent hazards, exercise caution, and know the proper use of hand tools.

Some of the tools that the technologist should know are:

Measuring—tape measures steel rules, calipers, vernier calipers, micrometers, thread gage and squares.

Pipefitting—pipe wrenches, saws, strap and chain wrenches, pipe vise, pipe cutters, tap and dies sets, reamers and tube flaring tools.

Plumbing—propane torch, tubes benders, cast iron pipe snapper and line clearing tools.

Electrician's—EMT benders, knockout punches, fish tape, various special pliers, circuit testers, meggers, multi-meters and amp meters.

Woodworking—Saws, planes, scrapers, bits, chisels, levels, plumb bobs, hammers and nails.

Metalworking—Layout tools, rivets and riveting tools, metal cutting chisels, hammers, metal-cutting snips, notchers, forming tools, hacksaws, vises, files, tap and die sets and reamers.

Hoisting and pulling—rope, wire rope, slings, sling hitches, block and tackle, chain falls and machine part pullers.

2.2 Power Tools and Light Equipment

It is important to correctly identify, select, know the proper use of and train entry-level personnel on the various power tools and light equipment used in plant maintenance. Technologists should have a full understanding of the characteristics and proper application of the various power tools and light equipment used in the plant maintenance field. Technologists should also have the ability to recognize and understand inherent hazards and exercise caution and proper use of power tools. Some of the power tools, (many are available in both electric and pneumatic, and light equipment) that Technologists should be familiar with are: drills, saws, hammers, light plants, screwdrivers, nutrunners, wrenches, routers, planes, sanders, grinders, shears and concrete cutting and coring.

Technologists should also know how to perform basic field repair on their power equipment and know when basic field repair will not suffice.

2.3 Heavy Equipment

It is important to correctly identify the various types of heavy equipment used in plant maintenance. There should be an understanding of the unique function and application of the heavy equipment used. Comprehension of the hazards associated with operation of heavy equipment is important. Technologists should have a good working knowledge and the skills to apply proper rigging techniques to the heavy equipment commonly found in a WTP&CS.

2.4 Vehicles

It is important for Technologists to correctly identify and properly operate the various vehicles used in wastewater plant maintenance. Technologists should understand the characteristics and functions of vehicles used in the plant maintenance field.

Skill Set 3 Maintenance, Repair, Construction, and Inspection

3.1 Wastewater Plant Maintenance Fundamentals

Technologists should understand the principles and purposes of the equipment found in a wastewater treatment plant and collection system (WWTP&CS). Also necessary, is the ability to understand the characteristics and mechanical theory behind the equipment commonly found in a WWTP&CS.

Technologists should be able to perform equipment maintenance and repair on the equipment in a WWTP&CS including equipment installation, lubrication, adjustments, preventative and proactive maintenance. Technologists are required to have a working knowledge of and/or the skills to accomplish maintenance on or with bearings, carpentry, mechanical power transmission systems and components, hydraulics and pneumatics, fasteners, packing and seals, lubrication, piping systems, tubing, alignment, gears, pumps, blowers, fans, screens, boilers, HVAC units, engines, motors and electrical systems

3.2 Drawings and Prints

Technologists should be able to read, understand, interpret and work from mechanical drawings, plans, specifications, sketches and blueprints. The technologist should be able to readily identify the schematic symbols, abbreviations and terminology used in prints and drawings. The technologist should be able to understand the difference between and know when to use the different types of drawings and prints including single line, double line, isometric, and orthographic. Technologists should be able to create shop drawings that are of such a nature that others will be able to determine exactly what is in place after the installation or modification.

3.3 Shop Math

It is important to be able to perform the basic shop math necessary in the performance of the duties of Technologists in a WWTP&CS. Technologists should be familiar with the principals of and the basic formulas associated with the mechanical and electrical maintenance including unit conversion, percentage, ohms law, power formulas,

linear calculations, area, volume, basic geometry, volume-weight, flow rate, ratios, horsepower, thermal expansion and manpower.

3.4 Metalworking

Technologists should possess the knowledge and skills to fabricate items out of metal and work on metal items associated with a WWTP&CS. Technologists should understand the principals of, tools used on and how to work with structural steel and sheet metal.

Technologists should be able to design patterns and fabricate by cutting, forming, fastening, etc., simple projects out of sheet metal, using widely recognized methods and practices. They should be familiar with the different metals and alloys available and the terminology associated with metalworking including heat transfer capabilities, resistance and susceptibility to different types of corrosion and which metals are and are not compatible.

3.5 Machinery Installation

It is important for Technologists to be able to install the machinery and equipment associated with a WWTP&CS. Technologists should be familiar with the term, principals, tools, methods, hardware and specifications used in establishing a proper foundation for the installation. Technologists should know how to properly and safely rig the equipment into place. Technologists need to know proper alignment techniques, when and how to field balance, what pipe strain is, how to check for pipe strain and how to alleviate pipe strain.

3.6 Welding

Technologists need to have strong understanding of the four common welding practices; SMAW, GMAW, GTAW and OAW. Technologists should understand the dangers and hazards associated with the different types of welding and how to accomplish the tasks safely. Technologists should be able to use at least one of the above mentioned welding practices. Technologists should be able to evaluate a job to determine which welding practice is best.

3.7 Troubleshooting

It is important for Technologists to be able to diagnose the root cause of the normal problems associated with the equipment common to a WWTP&CS. Using operational parameters, Technologists must be able to trouble shoot both mechanical and operational problems of the equipment and systems associated with a WWTP&CS. They also must have the skills to troubleshoot a piece of equipment once it has been removed from service for maintenance. Some of the troubleshooting techniques Technologists should be able to use are understanding how different type of equipment failure/s influence operational parameters, how to use equipment parameters to evaluate the condition of the equipment and possible pending failure modes, reading the wear patterns on bearings, reading the effect of pressures and temperature on the equipment, reading the faces of mechanical seals and understanding how to use the information on a pump curve.

3.8 Carpentry

Technologists should know the terminology, tools, techniques and capabilities of the carpentry trade. Technologists should have the knowledge and skills necessary to manufacture rudimentary forms and structures out of timber and lumber. Technologists must have the ability to understand the inherent hazards, exercise caution and know how to safely accomplish tasks involving carpentry safely.

3.9 Piping Systems

Technologists should have the knowledge of how to maintain, install, inspect and repair piping systems. They should know and understand the terminology, tools, techniques and typical uses of the common types of piping materials, valves and fittings used in a WWTP&CS such as: PVC, cast iron, steel and ABS for materials; gate, globe, ball, butterfly, reducing, sustaining and knife for valves; ells, tees, reducers, unions, couplings, and wyes for fittings. They should be able to calculate offset and roll for piping system installation or modification.

Skill Set 4 Communications, Customer Service, and Interpersonal Relationships

4.1 General

It is important to maintain effective communications with customers, co-workers, and supervisors. The ability to follow written and verbal instructions from supervisor(s) is necessary. Technologists should know when to provide answers to questions or refer certain questions to a supervisor and should be able to read, speak, and write in the English language at a high school education level.

Technologists should be able to establish and maintain effective working relationships with the various personnel with whom they are required to interact, this includes the knowledge of and ability to use the theories of workplace interpersonal relations.

4.2 Technical Direction, Support, and Training

It is important that Technologists be able to assist their supervisor in job preparation by estimating time, manpower and materials required to accomplish most routine maintenance actions. Technologists should have the ability to use and understand the different maintenance record keeping systems including CMMS (Computerized Maintenance Management System). Technologists need to be able to give technical direction and basic training to entry-level personnel.

Table 3-1 Grade II Plant Maintenance Technologist						
Primary References[a]						
No.	Skill Set	Millwrights and Mechanics Guide 4th Edition	Maintaining Wastewater Equipment Book 383	Industrial Health and Safety Book 109.1	Using Hand Tools Book 107	Confined Space Entry
1	Safety					
1.1	**General**			Lessons 2, 3, 6, 11 and 12		
1.2	**Confined Spaces**					All
1.3	**Chemical**			Lesson 4		
1.4	**MSDS**			Lesson 1		
1.5	**LO/TO**			Lesson 7		
1.6	**PPE**			Lesson 3		
1.7	**Tool**			Lessons 3 and 5		
1.8	**Machinery**	Chapter 21	Lessons 1, 2 and 4	Lesson 7		
2	Tools and Equipment					
2.1	**Hand Tools**	Chapters 17 and 28			All	
2.2	**Power Tools**	Chapters 17 and 27				
3	Maintenance, Repair, Construction and Inspection					
3.1	**Machinery Indentification and Maintenance**	Chapters 24 and 25	Lesson 1, 2, 3, 4 and 5			
3.1.a	**Bearings**	Chapter 10				
3.1.b	**Fasteners**	Chapters 12 and 13				
3.1.c	**Mechanical Power Transmission**	Chapters 3, 4, 5, 6, 7 and 8				
3.1.d	**Gears**	Chapter 6				

a. Complete reference information given in Section 6

Table 3-1 Grade II Plant Maintenance Technologist						
Primary References[a]						
No.	Skill Set	Millwrights and Mechanics Guide 4th Edition	Maintaining Wastewater Equipment Book 383	Industrial Health and Safety Book 109.1	Using Hand Tools Book 107	Confined Space Entry
3	Maintenance, Repair, Construction and Inspection (continued)					
3.1.e	**Hydraulics and Pneumatics**	Chapter 26				
3.1.f	**Packing and Seals**	Chapter 9				
3.2	**Drawings and Prints**	Chapter 1				
3.3	**Shop Math**	Chapters 2, 6, 16, 24, 26 and 28				
3.4	**Metalworking**	Chapters 19 and 20				
3.5	**Machinery Installation**	Chapter 2 Chapter 8 Pages 217–231 Chapter 21				
3.6	**Welding**	Chapter 23				
3.7	**Trouble-shooting**	Chapter 3 Pages 122–123 Chapter 21 Page 734 Chapter 24 Pages 871–872 Chapter 25 Pages 910–915	Lessons 1, 2, 3, 4 and 5			
3.8	**Carpentry**	Chapter 16				
3.9	**Piping Systems**	Chapters 14 and 15				
3.10	**Electricity**	Chapter 22				
4	Communications, Customer Service and Interpersonal References					
4.0	**Communica-tions, Customer Service and Interpersonal Relationships**	Chapters[b] 6, 7 and 8				

b. Refer to *Utility Management* in Section 6, Secondary References

Section 4

Test Preparation

This section provides tips on how candidates should prepare for the test, information on questions that will be on the test, and solutions to math problems. Information included on the test, as well as a table of units and sample math problems are attached.

Basic Study Strategy

To prepare adequately for the test, candidates need to employ discipline and develop good study habits. Ample time to prepare for the examination should be allowed. Candidates should establish a study schedule and stick to it. One or two nights a week for one or two months should be sufficient in most cases. Spend one or more hours studying in quiet surroundings or in small groups of two or three serious candidates. Efforts should be directed to the subject areas of the examination that are not being performed on a day-to-day basis.

While using this study guide, be sure to understand the answers to all the questions. Discuss test questions with others. Not only is this a good study technique, it is also an excellent way to learn.

Candidates should study at the certification level being sought after. There is no advantage to spending time studying material that will not be on the examination. Refer to Section 3, Skill Set for a list of topics that will be covered on the test.

It is not necessary to memorize all formulas and conversion factors. A sheet is provided with the examination to assist in this area (see Table 4-1).

Candidates should obtain the primary reference and training material listed in Section 6, References. Any material not available at their workplace can be obtained from the sources listed in Section 6.

Multiple Choice Questions

The test is written entirely in the objective (multiple-choice) format. At first glance, the multiple-choice problem may seem easy to solve because so much information is given, but that is where the problem lies. The best answer must be chosen from the information given. Here are some tips that may help solve multiple-choice problems.

1. Read the question completely and closely to determine what is being asked.

2. Read all the choices before selecting an answer.

3. Look for key words or phrases that often, but not always, tip off correct or incorrect answers:

   Absolute Words

   (Suspect as a wrong choice)

Always	Never	None
Totally	All	

   Limiting Words

   (Often a correct choice)

Few	Occasionally
Some	Generally
Often	Usually
Many	Possible

4. Never make a choice based on the frequency of the previous answer. If the last ten questions have not had a “b” answer, don’t arbitrarily select “b”. Instead use logic and reasoning to increase the chances of choosing the best answer.

Table 4-1 Plant Maintenance Mechanical Technologist

Equivalents and Formulas

1 cubic foot = 1,728 cubic inches
1 cubic foot = 7.48 gallons

1 cubic foot of water weighs 62.43 pounds
1 gallon of water weighs 8.34 pounds

1 day = 1,440 minutes

1 cubic foot/second = 449 gallons/minute
1 MGD = 694 gallons/minute
1 MGD = 1.55 cubic feet/second

1 psi = 2.31 feet of water

1 horsepower = 746 watts
1 horsepower = 42.45 BTU/minute
1 horsepower = 33,000 foot-pounds/minute

Coefficients of thermal expansion
= 0.00000633/°F for steel
= 0.00001/°F for brass

1 BTU = 778 foot-pounds
1 watt = 3.412 BTU/hour
1 kilowatt = 1000 watts
1 therm = 100,000 BTU

π = 3.14159

Perimeter

rectangle = 2 x (length + width)

Circumference

circle = π x diameter

Area

rectangle = base x height
triangle = $\frac{1}{2}$(base x height)
circle = π x radius^2
circle = .7854 x diameter^2

Volume

rectangular solid = length x width x height
triangular solid = $\frac{1}{2}$(base x height x length)
cylinder = π x radius^2 x height
cylinder = .7854 x diameter^2 x height

$$\frac{\text{Big}}{\text{Little}} = \frac{\text{Fast}}{\text{Slow}}$$

Water horsepower = Flow x total head x specific gravity 3960

Brake horsepower = Flow x head x specific gravity 3960 x efficiency

Hydrostatic force = column area x column height x fluid density

Thermal expansion = coefficient of thermal expansion x length x ΔT

Energy = power x time

$$\text{Efficiency} = \frac{\text{work output}}{\text{work input}}$$

Flowing quantity = area x velocity

$$\text{Power costs} = \frac{(\text{Quantity x watts x hours})}{1000\ \text{watts/kilowatt}} \text{ x cost/kilowatt x time}$$

5. Reject answers that are obviously not right and choose from remaining answers.

   Example

   The straight line distance from the center of a circle to the outer edge is called the:

   a. diameter
   b. circumference
   c. chord
   d. radius

   It is possible to reason out the answer by having some knowledge of geometry, studying the questions and the four provided answers. The question is asking for the name of a line or distance that is inside of the circle. Circumference is the distance around the "outside" of the circle so this is an obvious incorrect answer.

6. Make an educated guess.

   Never reconsider a choice that has already been eliminated. This means that answer "d" should not be considered. Look for key phrases or words that gives a clue to the right answer. Answer "c," chord refers to a straight line inside of the circle, but it does not necessarily go through the center of the circle so this answer can be eliminated.

   Answers "a" and "c" are distances that are measured as straight lines and either start or go through the center of a circle. The diameter goes through the center rather than starting from the center. Radius, answer "c" is the correct answer and is defined as the straight line distance from the center to the outer edge of a circle.

7. Skip over questions that are troublesome. Mark these questions for later review.

8. When finished with the test, return to the questions skipped. Now think! Make inferences. With a little thought and the information given, the correct answer can be reasoned out.

9. Under no circumstances leave any question unanswered. There is no penalty for incorrect answers. However, credit is given only for correct answers.

   NO ANSWER=WRONG ANSWER

10. Keep a steady pace. Check the time periodically.

11. Remember to read all questions carefully. They are not intended to be "trick questions", however the intent is to test candidates' knowledge of and ability to understand the written languages of this chosen profession.

Math Problems

Math problems on the certification tests are meant to reflect the type of work encountered in Plant Maintenance Mechanical Technology. Although there is no specific math section on the test, many questions will require some calculations such as area, volume, ratios, and conversion of units. By far, the greatest number of applicants that fail the certification examinations do so by failing to complete the math problems. Completing the math problems will be greatly simplified by using a calculator and the approach suggested in the following paragraphs.

Calculators

A scientific calculator may be used during the test; however, a four-function (add, subtract, multiply and divide) calculator is adequate for completing any of the certification tests. Additional functions (i.e. square root) are not necessary, but may be helpful in some situations. The most important factor in effectively using a calculator is the candidates' familiarity with its use prior to the time of the examination. Confidence in the calculator and a full understanding of how to properly operate it are a must. The best way to gain confidence is to obtain the calculator early and use it frequently.

Completing the worksheets in this section as well as the sample problems at the various grade levels will improve proficiency. Additional use will also help. For example, calculate the gas mileage when filling a vehicle's tank each time. Check the sales tax calculation on each purchase. Balance a checkbook, or check a paycheck. The calculator chosen should have large enough keys so that the wrong keys are not accidentally punched. Be certain there are new batteries in the calculator, or use a solar powered calculator with battery back up.

Approach

The solution to any problem requires understanding of the information given, understanding of what is being requested, and proper application of the information along with the appropriate equations to obtain an answer. Any math problem can be organized as follows:

Given or Known
All information provided in the problem statement that will be used to get the correct answer.

Find
A description of the answer that is being requested.

Sketch
If possible, sketch the situation described in the problem statement showing size and shape (dimensions).

Equation
This is where the equation or equations that will be used to generate the answers are listed.

Assumption(s)
Stated assumptions of key information needed to answer a math problem with missing information. This occurs frequently on higher-grade tests.

Answer
This is where the answer is clearly identified.

Advantages to using this approach to organize math problems are that it helps to organize thoughts, breaks the problem solution into a series of smaller steps, reducing chances of making an error.

Solutions

Solutions to math problems are like driving routes from Los Angeles to San Francisco: there are many different routes that can be taken. Some routes are shorter or less complicated than others. Only certain routes end up in San Francisco.

Solutions to sample problems given in this study guide are the most common solutions. If a solution that is different, but arrives at the correct answer is found, then that solution can be used.

Equivalents/Formulas

A sample of the equivalents and formulas sheet from the examination is included in Table 4-1. Familiarity with each of the equivalents (conversion factors) and each of the formulas is important. Pay special attention to the units of measure that are used in the formulas. A correct answer will not be obtained unless the correct units of measure are used.

Check the units, arithmetic, and answer. So that:

1. The units agree.
2. The answer is the same when the arithmetic is repeated.
3. The answer is reasonable and makes sense.

Dimensional Analysis

When setting up an equation to solve a math problem, the trick is to have clearly in mind what units the answer should be in. Once the units have been determined, work backwards using the facts given and the conversion factors known or given. This is known as dimensional analysis, using conversion factors and units to derive the correct answer.

Remember, multiplying conversion factors can be likened to multiplying fractions. The denominator (the number on the bottom of the fraction) and the numerator (the number on the top of the fraction) cancel each other out if they are the same, leaving the units being sought after.

Example

If a company runs a discharge pump rated at 50 gallons per minute all day, every day for a year, what is the discharge for the year in millions of gallons per year (MGY)?

Given: pump rating = $50 \frac{\text{gal}}{\text{min}}$

Find: discharge = __?__ MGY

Calculations
Convert gal/min to million gal/yr, convert gallons to million gallons, and minutes to years.

What is known about minutes and years? There are 60 minutes in an hour, 24 hours in a day, and 365 days in a year. Put that into an equation, and multiply each conversion factor so the unneeded units are cancelled out:

$$50 \frac{\cancel{\text{gal}}}{\cancel{\text{min}}} \times 60 \frac{\cancel{\text{min}}}{\cancel{\text{hr}}} \times 24 \frac{\cancel{\text{hr}}}{\cancel{\text{day}}} \times 365 \frac{\cancel{\text{days}}}{\text{yr}} \times 1 \frac{\text{MG}}{1{,}000{,}000 \cancel{\text{gal}}} = 26.28 \text{ MGY}$$

Sample Questions

The following sample math problems are intended to demonstrate unit conversion techniques. Although they are general wastewater problems, the questions may not be specific to any vocation.

1. How many gallons of water will it take to fill a 3 cubic foot container?

   $3\ \cancel{\text{cubic feet}} \times 7.48\ \frac{\text{gallons}}{\cancel{\text{cubic feet}}} = 22.4\ \text{gallons}$

2. If a gallon of gasoline weighs 7.0 pounds, what would be the weight of a 350 gallon tank full of gasoline?

   $350\ \cancel{\text{gallons}} \times 7.0\ \frac{\text{pounds}}{\text{gallon}} = 2{,}450\ \text{pounds}$

3. The rated capacity of a pump is 500 gallons per minute (GPM). Convert this capacity to million gallons per day (MGD).

   $500\ \cancel{\text{GPM}} \times 1\ \frac{\text{MGD}}{694\ \cancel{\text{GPM}}} = 0.72\ \text{MGD}$

4. A chemical feed pump is calibrated to deliver 50 gallons per day (GPD). What is the calibrated chemical feed in gallons per minute (GPM)?

   $\frac{50\ \text{gal}}{\cancel{\text{day}}} \times \frac{1\ \cancel{\text{day}}}{24\ \cancel{\text{hr}}} \times \frac{1\ \cancel{\text{hr}}}{60\ \text{min}} = 0.035\ \text{GPM}$

5. A chemical feed pump delivers 50 mL per minute (mL/min). Determine the chemical feed in gallons per day (gpd).

   $\frac{50\ \cancel{\text{mL}}}{\cancel{\text{min}}} \times \frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}} \times \frac{1\ \text{gallon}}{3.785\ \cancel{\text{L}}} \times \frac{60\ \cancel{\text{min}}}{\cancel{\text{hr}}} \times \frac{24\ \cancel{\text{hr}}}{\text{day}}$

   =19gpd

6. A cyanide destruction process is designed to treat 30 pounds of cyanide per 24-hour operational day. How many pounds of cyanide can be treated during an 8-hour shift?

   $\frac{30\ \text{lbs CN}}{\cancel{\text{day}}} \times \frac{8\ \cancel{\text{hr}}}{24\ \cancel{\text{hr}}} \times \frac{1\ \cancel{\text{day}}}{\text{shift}} = 10\ \text{lbs CN/shift}$

Math Skills

Successful candidates must be skilled in arithmetic, plane geometry and basic algebra. Candidates must also be able to apply these skills to make calculations for work related tasks, such as calculating flow rates, volumetric calculations, solving problems that involve volume and weight, simple ratio problems, basic electrical calculations using Ohm's Law and the power formula, and any other job related math skill may fall within the Skill Sets listed in Section 4. A thorough review of the types of mathematics required for the exam is beyond the scope of this book. If you are unfamiliar with any of these specific math skills you should consult an appropriate math textbook. (See section 6 for a suggested math textbook.) Appendix A provides general strategies for approaching math-related problems, math anxiety and resources for remedial math.

Arithmetic Skills

You should be able to perform and understand the following calculations, either manually or with a calculator:

1. Addition and subtraction of whole numbers.
2. Multiplication and division of whole numbers.

Algebra Skills

You should be able to perform basic applied algebra for solving calculations, such as solving for one unknown in one equation. Remember that when solving for the unknown, there are two basic rules that apply. They are:

1. The unknown must be in the numerator (on the top of the fraction, if one exists).
2. The unknown must be by itself (on one side of the equation away from all other parts of the equation).

These two basic steps should be performed in the order that they appear above.

Example

Y = 2Z x T, solve for Z.

In this problem Z is the unknown.

Step 1
As you can see, Z is already in the numerator (on top).

Step 2

$Y = 2Z \times T$

In a problem that only involves multiplication and division you can move terms from one side of the equation to the other by what is referred to as diagonal movement. This means that if the term you want to move is in the numerator (top) on one side of the equation you can move it to the denominator (bottom) of the other side of the equation and vise versa.

So first you can move the T from the top of one side to the bottom of the other side.

$$\frac{Y}{T} = 2Z$$

Then you can move the 2 from the top of one side to bottom of the other side.

$$\frac{Y}{2T} = Z$$

Now you have solved for the unknown Z. The unknown is on top and by itself on one side of the equation.

Geometry Skills

You should be able to calculate circumference, find the area of a triangle, rectangle and circle, and find the volume of a rectangular solid and a right cylinder. You should be able to apply the skills to work related problems.

Example

What is the volume of a digester that has a diameter of 150 feet and a height of 50 feet? Express your answer in gallons.

First, write the formula from the formula sheet.

Volume = .7854 x diameter^2 x height

Now put in values.

Vol = .7854 x (150 feet)^2 x 50 feet

Now multiply the diameter squared by the height and .7854.

Vol = 883,750 feet^3

Now, using the equivalent given, convert feet^3 to gallons.

883,750 feet^3 x 7.48 gallons/cubic foot
= 6,610,450 gallons

Section 5

Diagnostic Test

Introduction

This section provides a diagnostic exam for those studying for their Grade II Plant Maintenance Mechanical Certification to help determine their current knowledge level of safety; tools and equipment; maintenance, repair, construction, and inspection of a wastewater treatment plant and collection systems; and communications, customer service, and interpersonal relationships.

These questions represent the type of knowledge that may be required to successfully pass the CWEA Plant Maintenance Mechanical Certification Exam. Test questions are generally based on the information contained in the references (See Section 6 for a list of references). However, passing the example questions is not a guarantee of passing the exam, as the exam writers do not prepare the questions. Answers for this practice test and tips on where to find the answers in this text are located at the end of the exam.

Skill Set 1 Safety

1. A carbon dioxide (CO_2) fire extinguisher is intended for use on:
   a. Class A and Class B fires.
   b. Class B and Class C fires.
   c. Class C and Class D fires.
   d. Class D and Class A fires.

2. A SCBA is usually used for what kind of work?
   a. Escape and rescue.
   b. Spray painting.
   c. Underwater diving.
   d. Welding and cutting.

3. A confined space is described by CAL-OSHA as:
   a. large enough to bodily enter and perform work, has limited or restricted means of entry or exit and contains, or has the potential to contain, a hazardous atmosphere.
   b. limited or restricted means of entry or exit, contains, or has the potential to contain, a hazardous atmosphere and is not designed for continuous human occupancy.
   c. limited or restricted means of entry or exit, large enough to bodily enter and perform work and is not designed for continuous human occupancy.
   d. large enough to bodily enter and perform work, is not designed for continuous human occupancy, and contains, or has the potential to contain, a hazardous atmosphere.

4. On a MSDS the section that gives the safe exposure limits, based on OSHA guidelines, is:
   a. chemical identity.
   b. control measures.
   c. safety precautions.
   d. hazardous information and ingredients.

5. A piece of equipment is considered to be LO/TO and safe to work on when:
   a. the main breaker is LO/TO.
   b. all switches and valves have been LO/TO.
   c. your supervisor confirms your procedure.
   d. when you have brought the machine to zero energy state using LO/TO.

6. The only prescription eyeglasses that can be worn in an industrial setting are those approved by:
   a. ANSI.
   b. OSHA.
   c. ISA.
   d. EPA.

7. Many power tools have a device that cuts off power when released. This device is called:
   a. a quick release.
   b. a deadman switch.
   c. a trigger switch.
   d. a cutout.

8. The tool rest on a grinder should be positioned within _____ of the wheel surface to prevent stock from getting caught.
   a. 1/8 inch
   b. 1/4 inch
   c. 1/2 inch
   d. 3/4 inch

Skill Set 2 Tools and Equipment

1. The type of saw designed to cut wood with the grain is called a:
   a. crosscut saw.
   b. backsaw.
   c. coping saw.
   d. ripsaw.

2. Each pneumatic tool should be equipped with:
   a. a pneumatic handle.
   b. an air line lubricator.
   c. a chuck key.
   d. cushioned handles.

Skill Set 3 Maintenance, Repair, Construction, and Inspection

1. Which type of bearing is specifically designed to support axial loads?
   a. Journal bearings.
   b. Split bearings.
   c. Solid bearings.
   d. Thrust bearings.

2. What is the purpose of the cage in an anti-friction bearing?
   a. Keep the grease next to the rolling elements.
   b. Hold the rolling elements in the races during assembly.
   c. Hold the rolling elements in the races during operation.
   d. Properly space the rolling elements and guide them through the load zone.

3. What are the two primary types of anti-friction bearings?
   a. Ball and needle.
   b. Ball and roller.
   c. Ball and tapered.
   d. Ball and deep grooved.

4. The reducer located on the suction side of a horizontally mounted centrifugal pump should be:
   a. flanged.
   b. eccentric.
   c. concentric.
   d. a minimum double reduction.

5. Positive-displacement air compressors can all be placed into two types. These are:
   a. reciprocating and gear.
   b. reciprocating and lobe.
   c. reciprocating and rotary.
   d. reciprocating and dynamic.

6. The purpose of a shaft sleeve is to:
   a. lengthen the pump shaft.
   b. protect the pump casing.
   c. reduce leakage.
   d. protect the pump shaft.

7. What is the purpose of surface-skimming sprays?
   a. Influent dispersion.
   b. Scum collection.
   c. Scum removal.
   d. Sludge removal.

8. When aligning a piece of equipment it is best to:
   a. complete the horizontal part of the alignment first.
   b. complete the vertical part of the alignment first.
   c. do both the horizontal and vertical at the same time.
   d. align the driven to the driver.

9. When dealing with screw threads, the symbol UNC stands for:
   a. unified nominal coarse.
   b. unified national coarse.
   c. united nominal coarse.
   d. united national coarse.

10. Backlash on a gear is defined as:
   a. the wear on the backside of a gear tooth.
   b. the difference in RPM between two mating gears.
   c. another name for gear mesh frequency.
   d. the play between gears that prevents binding.

11. Alternating current (AC) is described as:
   a. the movement of electrons commonly referred to as the flow of electricity.
   b. the electromotive force in an electrical system.
   c. the quantity and rate of flow in an electrical system.
   d. current flow that is continuously reversing in direction.

12. The area on a centrifugal that holds the packing is called the:
   a. packing gland.
   b. packing box.
   c. stuffing gland.
   d. stuffing box.

13. In a drawing a dashed line as shown here (- - - - - - -) would indicate:
   a. a border.
   b. a hidden line.
   c. an extension line.
   d. a break line.

14. A fence is to be installed on the perimeter of a sewer lift station. The sides of the pump station measure 235 feet, 366 feet, 266 feet and 298 feet. If a 20 foot gate is to be installed in the 266 foot section, how many linear feet of fence will be required?
   a. 1,464
   b. 1,145
   c. 1,165
   d. 1,185

15. A circle has a circumference of 393 feet. What is its diameter?
   a. 3.14
   b. 393
   c. 125
   d. 1234

16. A circuit has 120 volts applied across a resistance of 6 ohms. What is the current?
   a. 20
   b. 120
   c. 720
   d. 0.05

17. The training room at your plant needs new carpet. If the room is rectangular in shape and measures 30 feet by 54 feet, how much carpet is needed? Answer in both square feet and square yards.
   a. 168 ft^2, 18.7 yd^2
   b. 180 ft^2, 1620 yd^2
   c. 1620 ft^2, 180 yd^2
   d. 1620 ft^2, 60 yd^2

18. A digester has a radius of 75 feet. What is the surface area of the sludge in the digester, in square feet?
    a. 235.5
    b. 471
    c. 5,625
    d. 17,672

19. You are required to paint the walls of a room that is 20 feet wide, 30 feet long and 8 feet high. If the paint you are using covers 200 square feet per gallon, how many gallons of paint will you need?
    a. 1
    b. 2
    c. 3
    d. 4

20. When ordering sheet steel, you should designate the thickness by:
    a. a fraction of an inch.
    b. decimal parts of an inch.
    c. gauge number.
    d. weight per square foot.

21. The initial step in preparation for installation of machinery is:
    a. check the balance of the equipment.
    b. set the foundation.
    c. locate the baselines.
    d. align the equipment.

22. The most popular welding process in use today is:
    a. Gas tungsten-arc.
    b. Shielded metal-arc.
    c. Oxyacetylene.
    d. Gas metal-arc.

23. You have been informed that your centrifugal pump was discharging properly and suddenly stopped discharging. Which of the following could be the problem?
    a. Misalignment.
    b. Stuffing box too tight.
    c. Air or vapor in liquid.
    d. Pump not primed.

24. To lay out a large square and ensure that the corners are square, carpenters mark points on two legs at 6 feet and 8 feet from the corner. They then measure the straight-line distance (hypotenuse) between these two points. This distance must be:
    a. 10 feet.
    b. 12 feet.
    c. 14 feet.
    d. 16 feet.

25. The most widely used of all pipe valves, in the smaller sizes, is the:
    a. gate valve.
    b. butterfly valve.
    c. globe valve.
    d. cone valve.

Skill Set 4 — Communications, Customer Service, and Interpersonal Relationships

1. Sexual harassment is not a workplace issue when the:
    a. harasser is a female.
    b. behavior occurs off the work site.
    c. behavior is welcome.
    d. subordinate is harassing a supervisor.

2. If you have been given written instructions that you do not understand:
    a. do what you think is best.
    b. ask a co-worker.
    c. ask your supervisor.
    d. ask the author.

3. You should never be _____ when communicating with the public by telephone.
    a. courteous
    b. understanding
    c. rude
    d. decisive

Test Answer Key

The following tables show the correct answers for the test questions included in this study guide. The tables below show what section the answers are for, the correct answer, and the subsection the question refers to. If you marked a wrong answer to any of the diagnostic test questions, refer to the subsection listed and you will be able to find the correct reference material to study to help you correctly answer the question.

Skill Set 1 Safety

No.	Answer	Skill Set
1	b	1.1
2	a	1.2
3	c	1.2
4	d	1.4
5	d	1.5
6	a	1.6
7	b	1.7
8	a	1.8

Skill Set 2 Tools and Equipment

No.	Answer	Skill Set
1	d	2.1
2	b	2.2

Skill Set 3 Maintenance, Repair, Construction, and Inspection

No.	Answer	Skill Set
1	d	3.1.a
2	d	3.1.a
3	b	3.1.a
4	b	3.1
5	c	3.1.e
6	d	3.1
7	b	3.1
8	b	3.1.c
9	b	3.1.b
10	d	3.1.d
11	d	3.10
12	d	3.1.f
13	b	3.2
14	b	3.3
15	b	3.3
16	a	3.3
17	c	3.3
18	d	3.3
19	d	3.3
20	c	3.4
21	c	3.5
22	b	3.6
23	c	3.7
24	a	3.8
25	c	3.9

Skill Set 4 Communications, Customer Service, and Interpersonal Relationships

No.	Answer	Skill Set
1	c	4.1
2	d	4.1
3	c	4.1

Selected Problem Solutions

Skill Set 3 — Maintenance, Repair, Construction, and Inspection

14. A fence is to be installed on the perimeter of a sewer lift station. The sides of the pump station measure 235 feet, 366 feet, 266 feet and 298 feet. If a 20 foot gate is to be installed in the 266 foot section, how many linear feet of fence will be required?

Solution

The perimeter of this form is equal to the sum of the sides.

The linear feet of fence required is equal to the perimeter minus the width of the gate.

Perimeter = 298 feet + 266 feet + 366 feet + 235 feet = 1,165 feet

Feet of fence = 1,165 feet - 20 feet

15. A circle has a circumference of 393 feet. What is its diameter?

Solution

Circumference = π x diameter

393 feet = 3.14159 x diameter

$\frac{393 \text{ feet}}{3.14159}$ = diameter

125 feet = diameter

16. A circuit has 120 volts applied across a resistance of 6 ohms. What is the current?

Solution

E=IR or Voltage = Current x Resistance

120 volts = Current x 6 ohms

$\frac{120 \text{ volts}}{6 \text{ ohms}}$ = Current (amps)

20 amps = Current

17. The training room at your plant needs new carpet. If the room is rectangular in shape and measures 30 feet by 54 feet, how much carpet is needed? Answer in both square feet and square yards.

Solution

This is an area problem and the shape is a rectangle.

Area of a rectangle = base x height

Area = 54 feet x 30 feet

Area = 1,620 ft^2

Area = 1,620 ft^2 x $\frac{1 \text{ yd}^2}{9 \text{ ft}^2}$

Area = 180 yd^2

18. A digester has a radius of 75 feet. What is the surface area of the sludge in the digester, in square feet?

Solution

This is an area problem and the shape is a circle.

Diameter = 2 x radius

Diameter = 2 x 75 feet

Diameter = 150 feet

Area of a circle = 0.7854 x $diameter^2$

Area = 0.7854 x $(150 \text{ feet})^2$

Area = 0.7854 x 22,500 ft^2

Area = 17,672 ft^2

19. You are required to paint the walls of a room that is 20 feet wide, 30 feet long and 8 feet high. If the paint you are using covers 200 square feet per gallon, how many gallons of paint will you need?

Solution

The question is, how many gallons will be needed. You are given a conversion from area (square feet) to gallons, "the paint covers 200 square feet per gallon."

Therefore, 200 ft^2 = 1 gallon.

So, all you have to do is find the total area to be painted and convert from area to gallons.

Area of a wall = width x height

Total area = area wall 1 + area wall 2 + area wall 3 + area wall 4

Total area = (30 ft x 8 ft) + (20 ft x 8ft) + (30 ft x 8 ft) + (20 ft x 8 ft)

Total area = 800 ft^2

Gallons needed = 800 ft^2 x $\frac{1 \text{ gallon}}{200 \text{ ft}^2}$

Gallons needed = 4 gallons

Section 6

References

Book knowledge can never replace the knowledge and skills acquired by hands-on training, but many Technologists forget that it was book knowledge put to work that got them "up to speed" in the first place. Reviewing the magazines and referring to the professional books help to refresh the memory and keep up with changes in the field. Changes in mechanical technology are happening so fast that constant review of information is needed to stay current in the field. References for Grade II Technologists include the references for Grade I Technologists, as well as the primary and secondary references listed below:

Primary References

Millwrights and Mechanics Guide, 4th Edition
Carl A. Nelson
ISBN 002588591X
Pub. Date: July 1989
Available online through various booksellers

Maintaining Wastewater Equipment, Book 383
TPC Training Systems
750 Lake Cook Road
Buffalo Grove, IL 60089
800/837-8872

Industrial Safety and Health, Book 109.1
TPC Training Systems
750 Lake Cook Road
Buffalo Grove, IL 60089
800/837-8872

Hand Tools, Book 107
TPC Training Systems
750 Lake Cook Road
Buffalo Grove, IL 60089
800/837-8872

Confined Space Entry, 1998 Edition
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314-1994
800/666-0206
www.wef.org

Secondary References

References listed in this study guide are designed to give the candidate the bare minimum information required. It is advised that all candidates read as much about the maintenance field as possible. There are many other great sources of information for the Plant Maintenance Professional available. Some of these are:

- Equipment Operation and Maintenance Manuals
- Vendor Repair Manuals
- Classes and Seminars
- Other reference books
- Trade Magazines, both paid for and free

Free trade magazines with good information for Technologists include:

- *Maintenance Technology*
- *Plant Services*
- *Pumps and Systems*
- *Reliability Magazine*
- *Valve Magazine*
- *Practicing Oil Analysis*

Additional recommended books for the library of Technologists include:

- *Applied Math for Wastewater Plant Operators*
  CRC Press
  800/272-7737
  www.crcpress.com

Section 6: References

Utility Management
Office of Water Programs
California State University Sacramento
6000 J Street
Sacramento, CA 95819-6025
916/278-6142
www.owp.csus.edu

Pump Handbook, 3rd Edition
Igor Karassik, Joseph Messina, Paul Cooper and Charles Heald
ISBN 0070340323
Pub. Date: September 2000
McGraw-Hill Professional Publishing Group
800/262-4729
www.books.mcgraw-hill.com

Piping Handbook, 7th Edition
Mohinder Nayyar
ISBN 0070471061
Pub. Date: October 1999
McGraw-Hill Professional Publishing Group
800-262-4729
www.books.mcgraw-hill.com

Centrifugal Pump Sourcebook
John W. Dufour and W. Ed Nelson
ISBN 00701803334
Pub. Date: 1992
The McGraw-Hill Companies
(Out of print, but can be found online through various booksellers)

Pumps and Pumping, 7th Edition
Skeet Arasmith
ACR Publications
1298 Elm Street SW
Albany, OR 97321
800/433-8150
www.acrp.com

Supervisor's Guide to Safety and Health Programs
Water Environment Federation
601 Wythe Street
Alexandria, VA 22314
800/666-0206
www.wef.org

Machinery Failure Analysis and Troubleshooting, Volume 2
Heinz Bloch
ISBN: 088415662
Gulf Publishing Company
2 Greenway Plaza, Ste 1020
Houston, TX 77046
713/529-4301 Fax: 713/520-4433
www.gulfpub.com

Appendix A

You and Wastewater Math

by Cheryl Ooten, Mathematics Professor, Santa Ana College, ooten-cheryl@rsccd.org

Example math problems found in Appendix A are representative of general wastewater math and are designed to illustrate a math problem solving strategy, not specific math skills. Examples given in this appendix may not be like the problems given on the test for your discipline. However, the problems are typical of types of problems you may encounter, including, but not limited to, basic algebra (solving one equation for one unknown), story problems, and plane and solid geometry, (area and volume problems). For specific kinds of math skills and problems you may encounter on the Grade II Plant Maintenance Technologist certification test, please review Sections 3, 4, and 5 of this study guide.

Introduction

Now is the time for you to begin preparation for the math portion of your technical certification exam. This Appendix provides suggestions to take charge of:

- Your math skills
- Your attitudes toward math
- Your test-taking skills

By doing this, you can improve your performance in successfully completing the math questions on the certification exam.

Two Facts to Consider

First, since early childhood, you have used math mostly without giving it a second thought. Knowing your age, counting, comparing sizes and shapes, adding your money, and subtracting to get change are math skills.

You drive the streets judging distances, speeds, and times. You estimate if you can afford a vacation or a car and when you can retire. You compare volumes and areas as you build and do jobs around the work site. You even measure volume in putting toothpaste on your toothbrush. You use statistics as you watch sports and consider things like RBIs in baseball or field goal percentages in basketball. All of these are mathematical skills many people take for granted.

Second, if you think math is hard, please know that math becomes hard for *everyone* at some point. You are not alone. There are math problems that have been unsolved for hundreds of years even though they have been attempted by competent, well-informed mathematicians who may work at them for decades. Those are not the problems you need to work unless you are curious. When you work at your appropriate level, you find a combination of easy ideas and hard ideas.

You may get discouraged comparing your speed and understanding in math with others. Those people who appear to do math easily have, most likely, done those specific problems, or ones like them, many, many times.

You will want to study and progress at your "growing edge"—the skill level where you have a bit of discomfort with new material, but where you are not totally overwhelmed. You can expect challenges that trouble you, but that can be overcome. Instead of saying "I cannot do math," decide now to begin learning enough math to make work and test-taking easier.

Move Beyond the Math You Know

To move beyond your routine skill level in math, consider the following points:

You Have Skills.
You already have many math skills and can build on that base. It is best and easiest to build on what you already know.

Basics are Important.
Going back over the basics of what you know will build confidence and help you progress and add new math skills to your ability to solve math problems.

Math Progresses Logically.
There are many different areas of math and each builds on itself as well as on the others. If you cannot do a particular problem, it may be because you have missed something basic to that one area along the way. Working your way up slowly and cumulatively in math is the fastest way to gain skills.

Words Count.
Each and every word and symbol in math means something. You need to find out those meanings and then practice them. If you do not know what "mgd" or "psi" means, or which units measure "flow", it is harder to do problems involving them. It can seem like a foreign language.

Brains are Unique.
Each individual brain is wired differently, causing each person to think and learn differently. The more you know about the way you as a specific individual learn, the more you will permit yourself to do what it takes to learn math. Some people need to do many written repetitions. Some need to walk or move around as they do math. Some need to talk out loud. Others need to draw pictures. Some need to work problems with other people. Some need to use words and some need to use symbols. In order to focus on how to move forward, think about what works for you or where learning has been difficult for you.

If you are an independent learner, you might find a basic math book at your library to work through on your own. You may be able to study with your own children to learn some math together or with your friends and colleagues. You may have an old math book you used a long time ago that could be helpful, and you may come to remember what you learned from it.

Assessment Helps.
Assess your skill level honestly. Math placement tests are available at your local college and through private educational agencies to help you determine where your skills are and where you can best get help to make comfortable progress.

You are Not Alone.
No one promises that math will always be easy or interesting for you. For most people, working on math is a challenge. Persevering and pushing personal limits allows you to experience the satisfaction of success.

Get help when you get discouraged or experience confusion. Remember this is just a momentary problem in a sequence of ideas that you are confronting. Do not buy into the myth that you have to do math alone. Do not believe it is demeaning for you to admit you do not understand. You can have fun if you lighten up as you progress. Working with others is an outstanding way to improve math skills.

Questions are Essential.
Make a list of people with whom you feel comfortable discussing your math questions. They may be your colleagues, teachers, fellow students, friends, or family members—even your children. Do not ask just anybody; pick people who are helpful and positive or non-judgmental about your questions.

Mistakes Happen.
Expect mistakes up front. As you learn anything new, you will make errors. Do not blame your mistakes on math itself! In any new endeavor you need to allow yourself to crawl before you can walk. Successful people in all fields know this. Trial and error is the basis of all learning.

You can learn more from your mistakes than from repeated successes. Making errors gives you feedback by showing you what you do not understand. Learn to value and accept those errors and use them to find out what areas of your learning need more work. Correct them and then move on with new knowledge.

Learning Math is Not a Competitive Game.
Physicist Albert Einstein, politician Winston Churchill, and inventor Thomas Edison were all considered slow in school. Musical composer Ludwig Van Beethoven and scientist Louis Pasteur probably had learning disabilities. What all five certainly had was determination and patience to persevere. Only compete with yourself, pushing yourself forward, in learning math.

There is Hope for Those with Learning Disabilities.
If you really have a hard time learning, you might ask your local college or a private learning specialist to assess you for a learning disability. Many colleges and universities do free testing and training for their students. You can also purchase this kind of assistance from private consultants. Much is now known about learning disabilities and how to help people who have them. Learning

disabilities often become just learning differences as students learn to honor and use their own thinking and learning styles.

Math Success and Test-Taking Success are Not the Same.
Many math students understand and can work math problems, but have difficulty in test-taking situations. It is possible to know math and still fail exams. These people may find Section 4 "Test-Taking Strategies" very helpful. Conscious practice of both math skills and test-taking skills can make a big difference in your score.

Resources are Available.
Resources exist for all types of math. You will need to decide whether you will work on your math skills independently or with the help of some structure such as a math course or a tutor. Different strategies may work better at different stages in your progress.

Your local community college has inexpensive math courses. Some colleges even have math courses specifically for water and wastewater professionals. Professional organizations sponsor training conferences and seminars which include math courses specific to the field. Many agencies can provide in-house training and many agencies will provide individual help with all aspects of test taking.

Community Colleges
Community colleges offer several types of services including:

- Math Placement Testing
- Math Courses
- Water Utility Science Courses
- Math Anxiety Reduction Courses
- Testing and Training for those with Learning Disabilities

Professional Organizations
Organizations such as the California Water Environment Association (CWEA), American Water Works Association, and American Public Works Association also provide opportunities to practice your math skills and network with others:

- Technical Certification Training Classes and Annual Conferences
- CWEA Northern and Southern Regional Training Conferences
- CWEA Study Manuals

At Work
Ask for help and suggestions from others who have taken math courses or are skilled in the work area similar to the one you are trying to prepare or improve. Ask your supervisor for advice on how to prepare and how much time on the job you can have to prepare. Ask your supervisor to provide training classes for the areas that you are wanting to improve. Ask those managing other departments, agencies, or local professional organizations for help in the training you need.

Materials
Any basic math book or instructional manual that you can beg, borrow, or buy, including:

- Courses from Ken Kerri, Office of Waste Programs, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819
- Price, Joanne Kirkpatrick. *Basic Math Concepts for Water and Wastewater Plant Operators.* Lancaster, Pennsylvania: Technomic, 1991.
- Smith, Richard Manning. *Mastering Mathematics: How to Be a Great Math Student,* 3rd Ed. Pacific Grove, CA: Brooks/Cole, 1998.
- Zaslavsky, Claudia. *Fear of Math.* New Brunswick, NJ: Rutger University Press, 1994.

Practice Problem Solving Strategies

Wastewater math deals with only a handful of basic types of problems that involve moving liquids and semi-solids from place to place, and manipulating, storing, and treating these substances along the way.

So basically, understanding area, volume, slope, rates, concentrations, costs, and time elements that occur in wastewater treatment 24 hours per day, 365 days per year, pretty much covers what you need to know.

Units and Arithmetic

All wastewater math problems can be solved by simple arithmetic—adding, subtracting, multiplying, and dividing. You can become proficient with wastewater math by paying careful attention to

the units in the problems as you write down your strategies, and then using a calculator to do the needed arithmetic.

Units

Units such as cubic feet, gallons, gpm, and mgd are important in wastewater math problems. Paying attention to the units will tell you whether to multiply or divide. Also, the units will often help you know what numbers to multiply or divide.

Notice in each example that doing math operations on the units produces the correct units in the answer. Many people do the math on the units first to figure out the correct procedure before they ever do the math on the numbers.

Multiplying

Multiplying is important. There are several symbols for multiplication. They are •, x, and ()().

For example,

$2 \bullet 3 = 2 \times 3 = (2)(3) = 6$

Dividing

Dividing is important to wastewater math because units often used such as mgd, cfs, ppm, gpm, psi, mg/L, gpd/sq.ft., and % are really division problems.

"Per" stands for "divided by."

$$\text{Mgd} = \frac{\text{millions gallons}}{\text{day}}$$

$$\text{cfs} = \frac{\text{cubic feet}}{\text{second}}$$

$$\text{ppm} = \frac{\text{parts}}{\text{million}}$$

$$\text{gpm} = \frac{\text{gallons}}{\text{minute}}$$

$$\text{psi} = \frac{\text{pounds}}{\text{square inch}}$$

$$\text{mg/L} = \frac{\text{milligrams}}{\text{Liter}}$$

$$\text{gpd/square foot} = \frac{\text{gallons/day}}{\text{square foot}}$$

$$10\% = \text{ten percent} = \frac{10}{100}$$

Example Problems

Example 1

Plant No. 1 measured a flow of 3.5 million gallons in half a day. If the peak flow (hydraulic) capacity of the plant is 8 mgd, is there need for concern?

Using the conversion factor

$$\text{mgd} = \frac{\text{million gallons}}{\text{day}}$$

divide 3.5 million gallons by half a day.

$$\text{mgd} = \frac{3.5 \text{ million gallons}}{.5 \text{ day}} = 7 \text{ mgd}$$

7 mgd is less than the peak flow capacity, 8 mgd. There is no need for concern yet.

Example 2

a. Find the number of gallons in 10 cubic feet.

Since we can pour 7.48 gallons into a 1 cubic foot container, that means that 7.48 gallons = 1 cubic foot. We can use either factor:

$$\frac{7.48 \text{ gal}}{1 \text{ cu ft}} \text{ or } \frac{1 \text{ cu ft}}{7.48 \text{ gal}}$$

to convert cubic feet units into gallons or vice versa

$$\frac{10 \cancel{\text{cu ft}}}{1} \times \frac{7.48 \text{ gal}}{1 \cancel{\text{cu ft}}} = \frac{(10 \cancel{\text{cu ft}})(7.48 \text{ gal})}{1 \cancel{\text{cu ft}}}$$

$= 74.8$ gal

Notice that using the first factor allows the unit "cu ft" to cancel out leaving the answer in gallons.

b. Find the number of cubic feet in 10 gallons. Notice that using the second factor allows the unit "gal" to cancel out leaving the answer in cubic feet.

$$\frac{10 \cancel{\text{gal}}}{1} \times \frac{1 \text{ cu ft}}{7.48 \cancel{\text{gal}}} = \frac{(10 \cancel{\text{gal}})(1 \text{ cu ft})}{7.48 \cancel{\text{gal}}}$$

$= 1.34$ cu ft

You will notice how important it was in these examples to consider the units in deciding whether to multiply or divide by 7.48.

Example 3

a. Find the detention time for a basin with 675,460 gal if the flow is 1,000,000 gal/day.

Flow is always a rate which is division. Units like gpd or cfs are both division.

The formula for the basin detention time is:

$$Dt = \frac{\text{volume}}{\text{flow}}$$

$$Dt = \frac{675{,}460\ \cancel{\text{gal}}}{1{,}000{,}000\ \cancel{\text{gal}}/\text{day}}$$

$$= \frac{675{,}460\ \cancel{\text{gal}}}{1} \times \frac{\text{day}}{1{,}000{,}000\ \cancel{\text{gal}}} = 0.675 \text{ days}$$

b. Find the detention time for a 426 cubic foot basin if the flow is 1,000 cfs.

$$Dt = \frac{426 \text{ cu ft}}{1{,}000 \text{ cfs}} = \frac{426\ \cancel{\text{cu ft}}}{1{,}000 \text{ cu ft/sec}}$$

$$= \frac{426\ \cancel{\text{cu ft}}}{1} \times \frac{\text{sec}}{1{,}000\ \cancel{\text{cu ft}}} = 0.426 \text{ sec}$$

Example 4

Find the number of gallons of an 11% polymer needed to produce 100 gal of a 0.75% solution.

Use the formula $C_1V_1=C_2V_2$ where C=concentration or % and V=volume.

You can let the volume you are looking for (i.e. the number of gal of 11% polymer) be represented by V_1. Then C_1=11% or 0.11, C_2=0.75% or 0.0075, and V_2=100 gal.

Using the formula $C_1V_1=C_2V_2$, you have $(0.11)(V_1) = (0.0075)(100)$

Notice to find V_1, you do the opposite of multiplying (i.e. dividing) by 0.11 on both sides. You then have

$$\frac{(\cancel{0.11})(V_1)}{\cancel{0.11}} = \frac{(0.0075)(100)}{0.11}$$

and using a calculator, V_1=6.82. So, the amount needed is 6.82 gal.

Example 5

How many hours will it take to empty a 43,000 cubic foot tank if it empties at a rate of 2.7 cubic feet per second?

Notice that dividing 43,000 cubic feet by 2.7 cubic feet per second would make the cubic feet unit cancel out. This would give us the time in seconds. To convert seconds into hours, use the factors

$$\frac{1 \text{ min}}{60 \text{ sec}} \text{ and } \frac{1 \text{ hr}}{60 \text{ min}}$$

The work is given below. Notice how the units cancel out leaving the answer in hours.

$$\text{Time} = \frac{43{,}000\ \cancel{\text{cu ft}}}{2.7\ \cancel{\text{cu ft/sec}}} \times \frac{1\ \cancel{\text{min}}}{60\ \cancel{\text{sec}}} \times \frac{1 \text{ hr}}{60\ \cancel{\text{min}}}$$

= 4.42 hr

Example 6

Find the number of gallons of water in a rectangular basin 200 ft long, 50 ft wide, and 12 ft deep.

First, find the volume of the rectangular basin by multiplying length by width by height. Volume = (200 ft)(50 ft)(12 ft) = 120,000 cubic feet or cu ft or ft^3.

You now have a problem similar to Example 2. How many gallons are there in 120,000 cubic feet? Use the factor

$$\frac{7.48 \text{ gal}}{1 \text{ cu ft}}$$

to convert cubic feet into gallons.

$$\text{Volume} = \frac{120{,}000\ \cancel{\text{cu ft}}}{1} \times \frac{7.48}{1\ \cancel{\text{cu ft}}}$$

= 897,600 gal

Example 7

A cylindrical tank is full to 3 feet below the top at 10 a.m. and empty at 4 p.m. If the tank is 50 ft tall with a diameter of 70 ft, find the volume (in gal) of the liquid at 10 a.m. and the rate of flow from the tank in gal per minute.

For a math problem with many words, I recommend always first writing down what you are trying to find:

(1) First, find the number of gal of water in the tank at 10 a.m.

(2) Second, find the rate of flow in gal/min.

Drawing a sketch helps some people understand the problem and helps to keep track of the data.

I also like to write down and interpret the details that are given to me like:

Full to 3 ft below the top at 10 a.m.

Empty at 4 p.m.

Takes 6 hours to empty

a. First, to find the volume in gal at 10 a.m., use the formula for volume of a cylindrical tank which is V=(area of the base) times (height).

To find the area of the base of the tank which is a circle, multiply 0.785 times the diameter squared.

So, the area of the base = $0.785(70^2)$
= 3,846.5 sq ft.

The height at 10 a.m. is 47 ft because the tank is filled to 3 ft below the top.

Volume = (area of the base)(height)
= $(3846.5 \text{ ft}^2)(47 \text{ ft}) = 180{,}785.5 \text{ ft}^3$

However, you want the volume in gal so use the factor

$$\frac{7.48 \text{ gal}}{1 \text{ cu ft}}$$

to convert.

$$\text{Volume in gallons} = 180{,}785.5 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3}$$

= 1,352,275.54 gal

b. Second, to determine the rate of flow in gallons per minute, divide the number of gallons by the number of minutes it took the tank to empty. It took 6 hours to empty. To convert 6 hours to minutes, use 60 min = 1 hr or factors

$$\frac{60 \text{ min}}{1 \text{ hr}} \text{ or } \frac{1 \text{ hr}}{60 \text{ min}}$$

to convert. You want the hour unit to cancel out, so you will use the first factor. The time becomes:

$$\frac{6 \text{ hrs}}{1} \times \frac{60 \text{ min}}{1 \text{ hr}} = 360 \text{ min}$$

Rate of flow in gal per minute =

$$\frac{1{,}352{,}275.54 \text{ gal}}{360 \text{ min}} = 3{,}756.32 \text{ gal per min}$$

Take Charge of Your Success

The key to progress with math is to consciously take charge of your thoughts and actions. Then, instead of letting math control you, you control math and you take charge of your success.

Recommendations

Ask Questions.
Be active and assertive. Learning is not a spectator sport. You cannot learn well from the sidelines. Get involved. Work problems and keep asking questions until they become clear. In classes and seminars, ask questions on confusing procedures.

Take It Easy.
When you get stuck working problems, hang in for a while and then take a break. Go back later, begin at the beginning with a clean sheet of paper and a different point of view. Just because you do not understand at first does not mean understanding will not come. Math learning requires time to settle into your brain. Being able to live with uncertainty for a while is a good math skill to have.

Keep a List.
Write down your resources (books, tutors, people to answer questions, people who understand) so that you can consult them when you get discouraged. You are not alone. Find helpful people with whom you are comfortable. Form a network with others working toward the same goals as you.

Find Yourself.
Discover your own unique ways of learning. Experiment with new ones. If a method does not work, find others. Ask different people how they learn math or do a problem. They will often feel honored and pleased that you asked them and you might get a breakthrough idea.

Be Positive.
Listen to what you say to yourself inside your head. It is difficult to work well if you are saying, "I will never get this" or "I cannot do math." Change those negative messages to neutral ones like "I have not learned this *yet*" or "I cannot do this particular problem *yet*."

Reward Yourself.
Acknowledge your progress—every little bit! Pat yourself on the back for each and every problem you work. Notice what you know now that is new that you did not know two weeks ago. Maybe even write it down to document your growth.

Learn From Mistakes.
Remember that errors are part of the learning process. Pay attention to them and figure out where they happened and how to fix them.

Keep It Real.
Be realistic with your expectations of yourself—your math level, your life commitments, and your time constraints. Do not beat yourself up for being a human being.

Use Technology.
Learn to use a calculator and use it appropriately for calculations with large numbers and decimals. Each brand of calculator is different so keep your manual for reference. Take spare batteries to exams.

Start Easy.
Practice the easier math problems to warm up each time you begin your math study. This builds confidence and strengthens those math pathways in your brain.

Use Paper.
Keep scratch paper available and expect to use it for your math work. You need empty space on paper to think and do calculations.

Promote Emotional Well Being.
Patience, self-care, and humor will make your math work so much easier. Your brain will work better too.

Be Healthy.
You are making new connections in your brain as you practice math so sufficient sleep and healthy foods are important. Having fresh drinking water available and breathing fresh air also helps you think better.

Test-Taking Strategies

There are many actions you can take before, during, and after exams that will improve your test-taking performance and outlook. Remember that math skills and test-taking skills are different from each other. This section will help you become conscious of your thoughts and actions regarding test preparation. Use these suggestions to take charge and approach your test confidently.

If you find yourself thinking negative thoughts about your coming exam, skip to the last section and read "Negative Thinking about Exams" first.

Before the Exam

Work Problems.
Diligently prepare and practice. Repeat solving problems to gain speed and confidence. This takes work and time—sometimes many hours, even days. Going in to an exam with the knowledge that you have worked lots of problems boosts confidence. Prep time is invaluable.

Relax.
Practice relaxation daily for about at least ten minutes using breathing. Sitting or lying comfortably, breathe slowly in through your nose counting to five and then out through your mouth counting to ten. If you feel dizzy, breathe normally for a while. Deep breathing activates chemicals in your body that help you relax and feel better. Any type of regular meditation, yoga, or slow stretching while breathing deeply can help facilitate your relaxation response. Practicing daily will help you control your adrenaline level during your exam. Using relaxation consciously during an exam frees up the thinking part of your brain. (Do not practice these deep breathing exercises while you are driving.)

Stay Active.
Daily walks or biking or whatever aerobic exercise you use consistently prepares your body for your exam by relieving stress and keeping your state of mind positive. Your mind and your body are connected so tightly that they are nearly the same.

Rehearse.
Do a dress rehearsal for your exam. Write or have someone assist you in writing a practice test with problems and questions that you think might be on the real exam. Use questions from the diagnostic test in Section 5 of this study guide. Give yourself this practice test in an environment as close to your testing situation and schedule as possible. Time it and then correct it to learn from your errors.

Plan Ahead.
Plan ahead carefully so that you will get to the exam early—do not be in a rush. Know exactly how to get there and what you will wear so that you are comfortable. You might want to wear your "lucky" shirt or bring a photograph of people who care about you and believe in you. WHATEVER you can do to increase your sense of comfort and security, do it. Ahead of time, pack a Testing-Taking Kit with sharp pencils, pens, a ruler, erasers, tissues or handkerchief, a bottle of water, extra calculator batteries, and anything else you think you might need that is allowed at the test.

Care For Your Body.
Optimal food and rest are individual preferences. Plan these ahead of time. Some research has shown that a brisk walk before an exam has raised test results. Some research has shown that eating a few candies (not chocolate) right before an exam has raised test results. Protein appears to be essential for clear thinking. Be in charge of what happens to you before the exam. Do not let outside influences take charge of you for this little time before your test.

At the Exam

Do a Data Dump.
Bring a short list of formulas or facts you find difficult to remember. Look at them before the test. Visualize them going into a holding tank in your brain. Practice making them subject to recall. If you are not allowed to use notes on the exam, be sure to put the list away so that your honesty is not questioned. When you receive your test, quickly write these formulas or facts on your exam paper. Now you do not have to expend any energy trying to recall them later when you need them.

Ignore Others.
Ignore all of the other people at the exam—before, during, and maybe even after. Different people have different ways of dealing with their anxiety during tests. Some people get a little hyper and try to rub off their anxiety on everyone else. Do not take on someone else's anxiety. Your test is not a competition so what other people do will not affect your score. Often the first person to leave an exam gets a very low score, while the last person to leave gets a very high score. Take your time. Pay no attention to other people's behavior.

Breathe.
When you feel stuck or tense, take a deep breath. Let it all go as you expel the air. (The more you have practiced relaxation and deep breathing before the exam, the more you will relax during the test.)

Take Time Out.
Take short breaks during the exam to close your eyes, breathe deeply, and stretch your neck and arms. Massaging your temples, scalp, and the back of your neck will increase blood flow with oxygen to your brain to help you think better. A few isometric exercises can release tension too.

Use Your Subconscious Mind.
If a problem makes no sense, read it and go on. Ideas will come to you as the problem sinks into your subconscious mind while you continue with the test.

Trust.
Let each question reach into your mind for the answer. Remind yourself that you know everything you need to know for now.

Strategize.
Do the easy problems and questions first. Make pencil marks by the questions to which you want to return.

Use Time Wisely.
Do not work on one problem for a long time. Often a question further into the exam will act as a "key" to unlock a previous problem. Tell yourself that you have all of the time you need. Let go of the rest of your life during the exam. You can deal with all that later.

After the Exam, Let the Results Go.
You have used a lot of energy and may be low and off balance. You may wish to pass up discussing the exam with others so you can take care of yourself. Going to the bathroom, drinking some water, and eating something can help you feel normal again. You may have set much of your life aside to prepare for this exam. Refresh yourself and get your life back. You can deal with the test results later when your priorities are in order again.

Negative Thinking About Exams

Here are negative thoughts math students often think before test-taking. Put a check mark by the examples familiar to you. Recognizing the distorted thinking in each example can help you change negative thoughts to neutral or positive ones. If you need more assistance with overwhelming negative thoughts, I recommend the book *Feeling Good* by David Burns (WholeCare, 1999).

"I Will Fail."
Unless you have a crystal ball and can see into the future OR unless you have made a definite plan NOT to prepare for the test OR unless you plan to "freeze up" during the exam, you have no way of knowing whether you will fail or not. Worrying about the future only takes energy from today.

"I Will Panic During the Test."
It is not uncommon to be excited. An exam is a process during which you will experience many thoughts, feelings, and body sensations. Actors get nervous, yet they still perform. If you do panic, let panic leave you. It will. No one dies from panicking during an exam.

Preparation by practicing problems, asking questions, and reviewing gives you confidence and skills that you need. Taking a dress rehearsal test and trying to panic can help you practice dealing with out-of-control feelings. Learning some relaxation techniques to use before and during the exam calms you and aids clear thinking. The more you prepare yourself ahead, the more you are in charge and feel relaxed.

"I Cannot Do Math."
Math is a very broad subject involving many different skills. If you can recognize shapes, tell time, and know where the front and back of a classroom are, you can already do math. There are many more math skills that you have and many that you do not have YET. There are also many that you will never choose to acquire. Instead of thinking so absolutely about math, find areas where you can grow and learn new skills instead of paralyzing yourself with this broad generalization.

"I Am Stupid."
Name calling is seldom productive. Occasionally you may feel stupid because you do not know something or you mess up. What really is happening is that you are being human and humans are not stupid. Educators recognize the need to change how everyone thinks about intelligence. They recognize that there are many different kinds of intelligence including:

- bodily/kinesthetic
- verbal/linguistic
- naturalist
- logical/mathematical
- visual/spatial
- interpersonal
- intrapersonal
- musical/rhythmic

This comes from the work of Howard Gardner. (Gardner, Howard. *Multiple Intelligences: The Theory in Practice.* New York: Basic Books, 1993.)

You are a wonderful combination of these talents—not just an IQ number. IQ Tests are limited because they only measure a few types of intelligence and ignore the rest. We are not all the same and cannot possibly know all there is to know in every situation. Between now and the exam, there are many questions you can get answered as well as many new skills you can practice and master if you use the skills and intelligence that you have.

"I Will Forget Everything."
Forgetting does not mean something is gone from your mind forever. The right cue will often help you remember what you need to know. Your exam will be filled with cues—words and symbols—that will trigger formulas and ideas you have practiced.

Expecting to forget "everything" is foretelling the future and making a broad generalization. Even most people with amnesia caused by illness or injury do not forget "everything." If you are extremely worried about your memory, *The Great Memory Book* by Karen Markowitz and Eric Jensen (The Brain Store, 1999) can be of assistance to you.

"Math Tests Are Tricky."
Math students who rely on memorizing the material rather than understanding it are usually the ones who think tests are tricky. You will use your memory to add to your understanding of how to do the math. Your math problems will contain many units such as mgd or ft^3 or psi. Learning how to skillfully convert back and forth between units of measure will take a lot of the trickiness away from your test problems. Practicing using your calculator will help too.

"There Is So Much I Do Not Know."
This will always be the case the rest of your life. It is the human condition. Taking a deep breath and finding the level where you can begin to learn will improve your feelings and your confidence.

Appendix B

Glossary

Absolute Viscosity: A measurement of the internal resistance, to shear, in a fluid.

Accumulator: A container in which fluid is stored under pressure as a source of fluid power.

Alloy Steel: Steel that owes its distinctive properties to elements other than carbon.

Alternating Current (AC): Electric current that periodically reverses its direction, rising from zero to maximum and returning to zero, then repeating the sequence in the opposite direction.

Ambient Temperature: The temperature of the surrounding medium, usually to referred to as the temperature of the air surrounding a structure or operating device.

Angular Misalignment: Shafts with the axis concentric but not parallel.

Assembly: The joining together of two or more piping components by bolting, welding, caulking, brazing, soldering, cementing or threading into their installed location as specified by the engineering design.

Ball Joint: A joint that permits universal rotational movement in a piping or mechanical or mechanical system.

Base Metal: The metal to be welded, brazed, soldered or cut. It is also referred to as the parent material.

Bearings: A bearing, in the mechanical terms used by millwrights and mechanics, is a support for a rotating shaft.

Bearing, Guide (Sleeve): The primary function of a guide bearing is to support and align members having sliding or reciprocating motion.

Bearing, Radial: The function of radial bearings is to support loads that act radially. These are loads acting at right angles to the shaft centerline.

Bearing, Thrust: The thrust bearing supports or resists loads that act axially. They may be termed endwise loads because they act parallel to the centerline, towards the shaft ends.

Blank Flange: A flange that is not drilled but is otherwise complete.

Blind Flange: A drilled flange used to close the end of a pipe. It is also know as a *dead end.*

Brazing: A metal joining process wherein coalescence is produced by the use of a nonferrous filler material having a melting point above 800°F but lower than that of the parent material. The filler metal is melted, distributed between closely fitted surfaces of a joint by capillary action and adheres to the parent materials forming the weld.

Clean Water Act (CWA): The federal Clean Water Act sets the framework for the imposition of industrial wastewater control programs on municipalities and the regulation of industrial users. Sections 307(b) and (c) of the CWA sets for the authority for U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to POTWs.

Calipers: Adjustable instruments composed of two straight or curved legs joined at the top by a hinge. They are used to transfer measurements from a measuring tool to the work piece or from the work piece to the measuring tool.

Caliper, Vernier: The vernier caliper is designed to measure with greater accuracy than an ordinary caliper. The greater accuracy is possible because of the special vernier scale attached to the index line. It can measure with an accuracy of 0.001 of an inch and has separate scales, one for inside measurements and one for outside measurements.

Cast Iron: A generic term used for the family of high carbon-silicon-iron casting alloys including gray, white and ductile iron.

Cavitation: The forming and collapsing of vapor bubbles from a low pressure to high pressure in a pumped fluid. This causes noise and may cause damage. Vapor bubbles are formed when the liquid falls below its vapor pressure at ambient temperature.

Celsius: The international name for the centigrade scale of temperature, on which the freezing point of water is 0°C and the boiling point is 100°.

Centrifugal Force: The force that cause rotating bodies to move away from the center of rotation.

Centrifugal Pump: A pump consisting of an impeller on a rotating shaft that is in a casing having a suction connection and a discharge connection. The rotating impeller creates pressure by the velocity derived from centrifugal force.

Circuit Breaker: A switch device that allows manual or automatic interruption of electrical current by tripping a switch to isolate a circuit or electrical equipment from the power source.

Conductor: Any material that will transmit electric current readily, such as wire or cable, busbar, liquid electrolyte, etc.

Coupling (piping): A sleeve used to connect two pipes.

Coupling (pump): A mechanical device usually fabricated of synthetic material, used to connect the ends of the motor shaft and the pump shaft.

Critical Speed: The speed of a rotating element at which resonance (natural frequency) occurs. It can destroy the rotating mass as the uncontrolled vibration level increases.

Density: The density of a substance is defined as the mass of the substance per unit volume. It is expressed in a variety of units.

Efficiency: The ratio between useful work performed and the energy expended in producing it. It is the ratio of output power divided by the input power.

End-suction Pump: A centrifugal pump with the suction and discharge ports located at right angles to each other.

Expansion Joint: A flexible piping component that absorbs thermal and/or terminal movements.

Fahrenheit: A temperature scale in which 32° marks the freezing point and 212° the boiling point of water.

Fatigue: The tendency for any material to fail structurally due to repeated cyclic stress at considerably less than its design strength.

Filter: A device which removes solid material from a liquid.

Filter Efficiency: The ability, expressed as a percent, of a filter to remove a specified artificial contaminant at a given concentration under specified test conditions.

Flash point: The temperature at which a liquid must be heated under specified conditions of the test method to give off sufficient vapor to form a mixture with air that can be ignited momentarily by a specified flame.

Flow: The movement of a stream of water or other fluid from place to place.

Flow Rate: The volume, mass or weight of a fluid passing through any conductor per unit of time.

Flux: A material used to dissolve, prevent accumulation of, or facilitate removal of oxides and other undesirable substances during welding, brazing or soldering.

Frequency: The number of cycles in a time period (usually one second). Alternating current frequency is expressed in cycles per second, termed Hertz (Hz).

Friction: The resistance to motion between two surfaces in contact.

Friction Head: The pressure expressed in pounds per square inch or feet of liquid needed to overcome the resistance to flow in the pipe and fittings.

Galvanizing: A process by which the surface of iron or steel is covered with a layer of zinc.

Gas Metal Arc Welding (GMAW): An arc welding process that employs a continuous solid filler metal (consumable) electrode. Shielding is obtained entirely from an eternal supplied gas or gas mixture. (Some methods of this process have been called MIG or CO_2 welding.)

Gas Tungsten Arc Welding (GTAW): An arc welding process that employs a tungsten (non-consumable) electrode. Shielding is obtained from a gas or gas mixture. Pressure may or may not be used and filler metal may or may not be used. (This process has sometimes been called TIG welding. When shielding is obtained by the use of an inert gas such as helium or argon, this process is called *inert-gas tungsten arc* welding.

Gauge, Pressure: A device for registering the pressure of solids, liquids or gases. It may be graduated to register pressure in any units desired.

Gearbox or Reducer: A machine of different diameter gears; connects the prime mover drive shaft to a driven piece of equipment and reduces the speed of the driven unit.

GPD: The rate of flow of a fluid measured in U.S. gallons per day.

GPM: The rate of flow of a fluid measured in U.S. gallons per minute.

Hazardous Waste: Any waste material that is potentially damaging to environmental health due to toxicity, ignitability, corrosivity, chemical reactivity or other reasons.

Head: The height of a column or body of fluid above a given point expressed in linear units. Head is often used to indicate gauge pressure. Pressure is equal to the height times the density of the fluid.

Head Loss: The decrease in pressure of a fluid flowing through a passage (pipe, for example), attributable to the friction between the fluid and the passage walls.

Header: A pipe or fitting to which a number of branch pipes are connected.

Heat Exchanger: A device that transfers heat through a conducting wall from one fluid to another.

Horsepower: A unit for measuring the power of motors or the rate of doing work. One horsepower equals 33,000 foot-pounds of work per minute (550 foot-pounds per second) or 746 watts.

Hot Taps: Branch piping connections made to operating pipelines, mains or other facilities while they are in operation.

Hydrogen Sulfide(H_2S): A toxic and lethal gas produced in sewers and digesters by anaerobic decomposition. Detectable in low concentrations (%) by its characteristic "rotten egg" odor. It deadens the sense of smell in higher concentrations or after prolonged exposure. Respiratory paralysis and death may occur at concentrations as low as 0.07% by volume of air.

Hypochlorination: The use of sodium hypochlorite ($NaOCl_2$) for disinfection.

Impact Test: A test to determine the behavior of materials when subjected to high rates of loading, usually in bending, tension or torsion. The quantity measured is the energy absorbed in breaking the specimen by a single blow, as in Charpy or Izod tests.

Impeller: A rotating set of vanes designed to impel rotation of a mass of fluid.

Instrumentation: The use of technology to control, monitor or analyze physical, chemical or biological parameters.

Kinematic Viscosity: The ratio of the absolute viscosity to the mass density. In the metric system, kinematic viscosity is measured in stokes or square centimeter per second.

Lantern Ring: A ring in line with a port in a stuffing box which provides sealing fluid. The sealing fluid also lubricates and cools the packing.

Manifold: A conductor that provides multiple connection ports.

Manometer: An instrument for measuring pressure. It usually consists of a U-shaped tube containing a liquid, the surface of which moves proportionally in one end of the tube with changes in pressure in the liquid in the other end.

Mechanical Seal: A seal placed on the pump shaft to prevent air from entering the pump and water from leaking from the pump along the shaft.

Megger: An extended ohmmeter used to measure the electrical resistance of motor insulation.

Meter: An instrument for measuring some quantity, such as the rate of flow of liquids, gases or electric currents.

Methane (CH_4): A colorless, odorless, flammable, gaseous hydrocarbon present in natural gas and formed by the anaerobic decomposition of organic matter, or produced artificially by heating carbon monoxide and hydrogen over a nickel catalyst.

MGD: The rate of flow of a fluid measured as one million U.S. gallons per day.

Micrometer: A micrometer is a type of caliper that is used for accurate measurements to 0.0001 inch. It works by keeping track of the advance of a fine-pitch screw through any number of complete turns or a fraction of a turn.

NPDES Permit: National Pollutant Discharge Elimination System permit is the regulatory agency document issued by either a federal or state agency which is designed to control all discharges of pollutants from point sources into U.S. waterways. NPDES permits regulate discharges into navigable waters from all point sources of pollution, including industries, municipal wastewater treatment plants, sanitary landfills, large agricultural feedlots and return irrigation flows.

Nipple: A piece of pipe less than 12 inches in length which may be threaded on both ends or one end and provided with ends suitable for welding or a mechanical joint. Pipe over 12 inches long is considered cut pipe.

Nondestructive Examination or Inspection: Inspection by methods which do not destroy the item, part or component to determine its suitability for use.

NPSH: Net positive suction head is a measure of the pressure at the suction side of the pump, including atmospheric pressure and vapor pressure of the liquid being pumped.

Orifice: An opening with a closed perimeter in a plate, wall or partition through which water may flow; generally used for the purpose of measurement or control of such water.

Orifice Plate: A plate containing an orifice. In pipes, the plate is usually inserted between a pair of flanges and the orifice is smaller in area than the cross section of the pipe.

Packing: Specially prepared material placed in a stuffing box around the pump shaft. The packing prevents air from entering the pump and water from leaking from the pump along the shaft.

Parallel Misalignment: Shafts with the axis parallel but not concentric.

Parts per million (PPM): The number of weight or volume units of a minor constituent present with each 1 million units of a solution or mixture.

Pipe: A closed conduit which diverts or conducts a fluid or gas from one location to another.

Pipe Diameter: The nominal or commercially designed inside diameter of a pipe.

Pressure: The force per unit area, usually expressed in pounds per square inch.

Pressure, Atmospheric: Pressure exerted by the atmosphere at any specific location. Sea level pressure is approximately 14.7 pounds per square inch absolute.

Pressure, Differential: The difference in pressure between any two points of a system or component.

Pump: A mechanical device for causing flow, for raising or lifting water or other fluid or for applying pressure to fluids.

Pump Curve: A curve or curves showing the interrelationship of speed, dynamic head, capacity, brake horsepower and efficiency of a pump.

Pump Efficiency: The ratio of energy converted to useful work to the energy applied to the pump shaft, or the energy difference in the water at the discharge and suction nozzles divided by the power input at the pump shaft.

Pumping Head: The sum of the static head and friction head on a pump discharging a given quantity of water.

RPM: Revolutions per minute; the means of measuring the rotational speed of machinery.

Spatter: In arc and gas welding, the metal particles expelled during welding that do not form part of the weld.

Specific Gravity: The ratio of the weight of a given volume of material or liquid to the weight of an equal volume of water.

Stainless Steel: An alloy of steel having unusual corrosion-resisting properties, usually imparted by nickel and chromium.

Static Head: The difference in distance from the surface of the suction level to the surface of the discharge level, generally given in feet.

Static Suction Head: The vertical distance from the source of supply, when its level is above the pump, to the centerline of the pump.

Suction Head: The head at the inlet to a pump: or the head below atmospheric pressure in a piping system.

Stuffing Box: A cavity and closure for a sealing device.

Tack Weld: A small weld made to hold parts of a weldment in proper alignment until the final welds are made.

Tolerance: The amount by which any characteristic (dimensional, electrical, physical or mechanical) may vary from that specified.

Torque: The rotating force produced by a motor. The units of torque may be expressed as foot-pounds, inch-pounds (English system) or newton-meter (metric system).

Total Dynamic Head: A measure of the energy a pump must supply to move the desired amount of water (in feet).

Vacuum: Pressure less than atmospheric pressure. It is usually expressed in inches of mercury (in.Hg) as referred to the existing atmospheric pressure.

Valve: A device which controls fluid flow direction, pressure or flow rate.

Valve Actuator: The valve part(s) through which force is applied to move or position flow-directing elements.

Vertical Turbine Pump: A centrifugal pump, commonly a multistage diffuser, in which the pump shaft is mounted vertically.

Viscosity: In flowing liquids, the internal friction or internal resistance to relative motion of the fluid particles with respect to each other.

Water Hammer: A banging or hammering noise caused by a pressure wave oscillating in a closed conduit and rebounding off the closures at each end.

Wear Ring: A replaceable cylindrical ring usually made of bronze and pressed into the pump casing between the high- and low-pressure sides of the rotating impeller.

Appendix C

Common Acronyms and Abbreviations

AA	atomic absorption
AC Power	alternating current
AC	acre
AF	acre-feet
AF	acre-foot (feet)
AFY	acre-foot per year
AMSA	Association of Metropolitan Sewerage Agencies
ANSI	American National Standard Institute
APHA	American Public Health Association
AS	activated sludge
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWT	advanced wastewater treatment
AWWA	American Water Works Association
BECP	Business Emergency and Contingency Plan
BNR	biological nutrient removal
BOD5	biochemical oxygen demand after 5 days
BTU	British thermal unit
C	Celsius
Cal OSHA	California Occupational Safety and Health Act
CalEPA	California Environmental Protection Administration
CBOD	carbonaceous biochemical oxygen demand
CCE	carbon chloroform extract
CCR	California Code of Regulations
cf	cubic feet (foot)
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH4	Methane
CIU	Categorical Industrial User
CM	common mode
CMOM	Capacity Management, Operations, and Maintenance
COD	chemical oxygen demand
CPU	central processing
CRWA	California Rural Water Association
CSP	confined-space permit
CT	current transformer
CWA	Clean Water Act
CWEA	California Water Environment Association
DAF	dissolved air flotation
DO	dissolved oxygen
DOHS	California Department of Health Services
DV/DT	($\Delta V/\Delta T$) The change in voltage per change in time.
DWF	dry weather flow
DWR	Department of Water Resources
EIS	Environmental Impact Statement
EMF	electromotive force or voltage
EPA	U.S. Environmental Protection Agency
F	Fahrenheit
F/M	food to microorganism ratio
ft	feet (foot)
ft^2	square foot
ft^3	cubic feet
FTU	formazin turbidity unit
GAC	granular activated carbon

Appendix C: Common Acronyms and Abbreviations

gal	gallon
GFI	ground fault interrupter
GPD	gallons per day
GPM	gallons per minute
GTAW	gas tungsten arc welding
H_2S	hydrogen sulfide
HCP&ERP	Hazard Communications Program and Emergency Response Plan
hp	horsepower
HPLC	high-performance liquid chromatography
Hz	Hertz
IC	ion chromatograph
ICP	inductively coupled plasma
IEEE	Institute of Electrical and Electronics Engineers
IIPP	Injury and Illness Prevention Plan
IML	Interface Management Language
JTU	Jackson Turbidity Unit
K	Kilo, a prefix meaning 1000
KVA	kilovolt amperes
kw	kilowatt
kwh	kilowatt hour
L	liter
lb	pound
M	Mega, a metric prefix meaning 1,000,000
m	meter
M	mole or molar
MA	millamps
MBAS	methylene blue active substance
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCRT	mean cell residence time
MDL	method detection limit
MG	million gallons
mg	milligram
mg/L	milligrams per liter
mgd	million gallons per day
min	minute
MIS	Manufacturing Information System
mL	milliliter
MLSS	mixed liquor suspended solids
MLVSS	mixed liquor volatile suspended solids
MMI	Man Machine Interface
MOP	Manual of Practice
MPN	most probably number
MS	mass spectrometer
MSDS	Material Safety Data Sheets
N	normal
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NM	Normal Mode
NOCA	National Organization for Competency Assurance
NOD	nitrogenous oxygen demand
NPDES	National Pollutant Discharge Elimination System
NPSH	net positive suction head
NTU	nephelometric turbidity unit(s)
O&M	operation and maintenance
OCT	Operator Certification Test (State of California)
OMR	operations, maintenance, and replacement
OOC	Office of Operator Certification (SWRCB)
OSHA	Occupational Safety and Health Administration/Act
OTE	oxygen transfer efficiency
P	Pico, a metric prefix meaning one millionth of a millionth, or one trillionth (10^{-12})
PC	personal computer
PCB	polychlorinated biphenyls
pH	potential of hydrogen

PI&D	piping and instrumentation diagram
PID	proportional gain, integral action time and derivative action time
PLC	Programmable Logic Controller
POTW	Publicly Owned Treatment Works
PPB	parts per billion
PPE	Personal Protective Equipment
PPM	parts per million
prct	percent
psi	pound per square inch
PSIA	pounds per square inch absolute
PSID	pounds per square inch differential
PSIG	pounds per square inch gage
PVC	polyvinyl chloride (pipe)
QA/QC	quality assurance/quality control
RAS	return activated sludge
RBC	rotating biological contactor
RCP	reinforced concrete pipe
RFI	Radio Frequency Interference
RMS	root mean square
RTD	resistance temperature device
RWQCB	Regional Water Quality Control Board (State of California)
SCADA	supervisory control and data acquisition
SCR	semiconductor, or silicon controlled rectifier
SD	standard deviation
SDI	sludge volume index
sec	second
SI	System Internationale D'Unites (metric units)
SS	suspended solids
SSO	sanitary sewer overflow
SVI	sludge volume index
SVR	sludge volume ratio
SWRCB	(California) State Water Resources Control Board
TAC	Technical Advisory Committee
TC	total carbon
TCP	Technical Certification Program
TDS	total dissolved solids
TF	trickling filter
THD	total harmonic distortion
TIC	total inorganic carbon
TMDL	total maximum daily load
TOC	total organic carbon
TOD	total oxygen demand
TS	total solids
TSS	total suspended solids
TU	turbidity unit
U	micro, a metric prefix meaning one millionth
UPS	uninterruptible power supply
USB	universal serial bus
USEPA	United States Environmental Protection Agency
V	volt
VAC	volts of alternating current
VCP	vitrified clay pipe
VFD	variable frequency drive
VOC	volatile organic chemicals
VOM	volt Ohm meter
VSR	volatile solids reduction
VSS	volatile suspended solids
W	watt
WAN	wide area network
WEF	Water Environment Federation
WRP	water reclamation plant
WWF	wet weather flow
WWTF	wastewater treatment facility
WWTP	wastewater treatment plant (same as POTW)
yr	year

CWEA is pleased that you have purchased this book.

We want to remind you that this book is one of many resources available to assist you, and we encourage you to identify and utilize the other resources in preparing for your next test.

Your comments, questions, and suggestions are welcome.

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