Study Guide

Certification Examination

New 2nd Edition

• Revised for 2015 tests.
• New KSA descriptions including KSA weighting.
• Expanded practice test and solutions.
• Searchable text optimized for electronic reading.

Mechanical Technologist
Grade III
2nd Edition

California Water Environment Association
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Appendix A: You and Wastewater Math
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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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What to Expect From This Study Guide
The purpose of this study guide is to help certificate candidates understand what is expected of them on the certification test and to help them identify resources to assist in preparation for the test. It is not a comprehensive text on the wide variety of topics covered on the certification test. Successful candidates should expect to spend significant time reading and reviewing additional materials listed in this study guide along with any other materials available that can help them understand the subject matter of the test. In addition, successful preparation strategies include attending study sessions, participating in study groups, and completing relevant vocational and college courses. Ultimately, the amount of preparation required to pass the test depends on a candidate’s education, training, and work experience. After reviewing this study guide, you should be able to determine what you need to do to prepare for the test and how much time you will need (months are often required).

About the CWEA Certification Program
The California Water Environment Association (CWEA) Technical Certification Program (TCP) is either required or encouraged by many wastewater employers. Its purpose is to set a standard of the essential requirements for an individual to perform a given job safely and effectively, and to provide a measure of competency through certification testing. The certification test focuses on the Knowledge, Skills, and Abilities (KSAs) an individual must master to perform their job safely and effectively.

CWEA certifies personnel in six vocations:

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

Upon qualifying and successfully completing the certification test, an individual becomes certified in that specialty at that grade level. Grade levels within a vocation designate technical knowledge for the entry-level, apprentice, journey, and management levels. More information about minimum qualifications can be found in the Candidate Handbook for your vocation available at www.cwea.org/cert or calling 510-382-7800.

Much of the CWEA mission is dedicated to providing education and training in all aspects of the wastewater industry including the KSAs of each certification vocation. CWEA is careful to separate its education and training activities from its certification activities to ensure that the educational focus is on the KSAs wastewater professional need to know to perform their jobs rather than being narrowly focused on just passing the certification test.
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 Institute of Credentialing Excellence (ICE).

**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 year round in six different vocations: Collection System Maintenance, Environmental Compliance Inspection, Laboratory Analysis, Plant Maintenance (Electrical/Instrumentation and Mechanical Technologist), 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.

CWEA established its Line Maintenance certification program in 1964. Eventually that would become the Collection System Maintenance certification program. In 1974 the first committees were formed to establish a voluntary certification program for water quality professionals specializing in disciplines other than plant operation. The following year the State Water Resources Control Board suggested that CWEA implement an industrial waste pretreatment certification program. TCP, then known as the Voluntary Certification Program or VCP, emerged in 1976 with specialized certificate programs for 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 vocational programs with a total of 23 individual certifications. About 2,000 applications are processed annually and currently over 5,500 certificates are held by individuals primarily in California. CWEA also partners with other WEF Member Associations to offer certification in Michigan, Hawaii, and Missouri.

**Certification Process**

To become certified, all applicants must complete the Application for Technical Certification, pay the application fee, meet minimum qualifications regarding professional experience and education, and pass the computer-based 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 experts in the field. If timing permits, staff will work with the applicant to resolve any incomplete applications. When approved, the applicant will receive an acceptance letter and test registration and scheduling instructions.
Immediately after completion of the computer-based test, a preliminary score and result will be given at the testing center. Occasionally, the official results may be adjusted from the preliminary results to resolve scoring issues. Official results are mailed to candidates. Those who pass the test are mailed certificates and blue wallet cards (also known simply as “blue cards”).

**Test Administration**

**Test Dates and Sites**

Tests are given throughout the year within four quarterly windows (see Application for Technical Certification for test schedule). Applicants who are eligible to take the test are mailed an acceptance letter with 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 testing proctor can a candidate be allowed to take a CWEA cert test. Be sure the name on your acceptance letter matches your identification or you could be turned away at the test center. If your name does not match, contact the CWEA office immediately. 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, cameras or other personal items are allowed in the test site (see the test site policy at www.cwea.org/cbt). Candidates will have access to an on-screen calculator. However, candidates are welcome to bring their own calculator as long as it is on the list of approved calculators (visit www.cwea.org/cbt). Candidates are not permitted to take any notes from the test site. Candidates who violate test site rules will 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 Rescheduling and Cancellation**

To reschedule your application, you must submit a written request stating that you wish to postpone to the adjacent testing window. You may only reschedule your application to the adjacent window once without a fee. Additional postponement will require a reschedule fee. There are no exceptions to this policy.

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

If you already have a scheduled exam with our testing partner, Pearson VUE, and need to cancel your appointment, you must contact them two business days in advance to avoid losing your exam fee.

**Test Result Notification**

Official test results are routinely mailed to certificate candidates approximately two weeks after the test date. Results are never given over the phone, via fax or email. All results are confidential and are only released to the certificate candidate.
Issue of Certificate/ Blue Wallet Card

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

Certificate Renewal

All certificates are renewable 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 $25 late fee. Certificates more than two years past due are only renewable through retesting. 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.

Every other year, certificates holders are required to submit 12 contact hours of education or training relevant to the certificate held. Continuing Education is required to help ensure that individuals certified by CWEA continue to be knowledgeable of technological advancements and regulatory requirements in the wastewater fields. Continuing education enhances the operation, maintenance and management skills of the certificate holders, and ensures the quality of wastewater treatment. This ultimately increases the ability and confidence of certificate holders and the credibility of the wastewater professions certified by CWEA.

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. Applicants requesting accommodations are encouraged to apply as early as possible to ensure sufficient time to process the request.

Test Design and Format

Test Design

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

The KSAs were determined by a job analysis and meta-analysis of job specifications by experts in the filed under the guidance of test development specialists. 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 subcommittees, 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 available in the English language only. Tests are delivered at Pearson VUE testing centers.

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

Test Pass Point

The minimum score required to pass varies depending on the test and possible total points. The score may be adjusted downward depending on test complexity. It should be assumed that if the passing score is 75 percent 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 judgements 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, reclassified, 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 Pearson VUE pending approval 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 during the test by completing the Candidate Comment Review Section during the exam. Item appeals will be evaluated and appropriate adjustments will be made to the test content. Candidates submitting comments will not be contacted in regards to the appeal.
Understanding The KSAs

The key to success on the CWEA certification test is understanding the KSAs and having adequate training, education, and experience in those KSAs. Each KSA describes the competencies required of an individual to successfully perform the essential duties of the job at grade level. Although the KSAs do not correspond precisely to every individual Grade I position description, they do reflect the core competencies and essential duties required of any Grade I Electrical/Instrumentation Technologist. The KSAs are developed from a job analysis that includes research of the essential duties at a representative cross-section of systems and facilities throughout California and other participating states.

This section outlines each KSA and includes descriptions of the general competencies, math competencies, and suggested reading for that KSA. Candidates are expected to understand the competencies described in this section and seek further educational opportunities to address those KSAs that have not been mastered. Although each candidate is encouraged to find educational opportunities that suit his or her needs best, typical educational opportunities include:

- On the job training
- Print or online training materials
- Manuals of practice, technical documents, regulations, etc.
- Mentoring
- Trade, vocational, or college courses
- Professional education sessions and seminar

Candidates seeking Environmental Compliance Inspector IV certification should review the KSAs presented in this section and seek to understand how they apply to everyday duties and responsibilities.

KSA Weight

KSA Weight is the approximate percent of the test content covered by a KSA. For example, a KSA with a weighting of 7% will have about 7% of all questions (or points) dedicated to that KSA, or 7% of the test is about that KSA. The KSA weight is approximate and shows the relative importance of a KSA compared to the other KSAs. The KSA weight on the actual certification test may vary slightly.

General Competencies and Math Competencies

Each KSA includes an expanded description of the competencies, tasks, and duties expected of certificate holders. Math Competencies describe the math, analytical, or calculation knowledge and skills that are expected of certificate holders. There are no specific “math” questions on the test, but questions in some KSAs require computational skills to complete. Like all other questions on the test, questions requiring math or computational skills are randomly distributed throughout the test.

Suggested Reading

The Suggested Reading lists some materials that are representative of each KSA. Each reference includes chapters, sections, or pages that are representative of the KSA. This is not an exhaustive list of sources relevant to the KSA and candidates are strongly encouraged to seek additional material that covers each KSA especially in those KSAs where the candidate is not adequately prepared.
KSA 301

**Perform fabrication and design to maintain facilities and equipment using the following methods:**

- multi-position welding with acetylene and arc welders
- heating, cutting and bending materials
- proficient use of materials and tools
- material estimation

**KSA301 General Competencies**

A journey level Mechanical Technologist is expected to have extensive experience with metal fabrication tools, including:

- oxy-acetylene torches
- welders
- various hand and power tools used in the trade.

This experience will include:

- fabricating replacement parts
- improving upon existing design to adapt existing equipment to updated tasks
- training subordinates
- materials estimation
- safe material handling
- safe operation of all equipment and tools.

**KSA301 Math Competencies**

Journey level Mechanical Technologists must have excellent mathematical skills and be able to:

- perform calculations of dimensions to fabricate equipment parts to fit in limited spaces
- determine material required for a job
- determine strength requirements of fabricated parts
- estimate time to complete a job
- safely operate material handling equipment such as cranes, and other lifting equipment.

**KSA301 Suggested Reading**

- [Millwrights and Mechanics Guide](#)
KSA 302

Oversee engine repair and maintenance program including:

- verifying troubleshooting and corrections techniques
- ensuring compliance of air quality regulations
- proficient in the knowledge of engines

KSA302 General Competencies

A journey level Mechanical Technologist is expected to have extensive experience with:

- engine repair and maintenance
- overhaul/rebuilding
- tuning
- repairs
- training subordinates
- safe operation of all equipment and tools.

The Technologist will also have extensive experience dealing with:

- regulatory agencies responsible for the permitting of engines
- the equipment associated with the engines including regional air quality boards for engine discharges
- water boards for fuel handling and storage.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- Professional trade related agencies.

KSA302 Math Competencies

There is no specific math competency required however, the incumbent will be expected to:

- perform basic calculations to determine if an engine may be suitable or sized correctly to run a specific piece of equipment
- take measurements when fabricating equipment parts

KSA302 Suggested Reading

- Operation of Wastewater Treatment Plants; Volume 1; Pg. 41
KSA 303

**Manage routine operations of the maintenance management program including oversight of:**

- planning and scheduling
- maintenance management system and related documentation
- outside contractors
- management of vendors, purchasing, and inventory
- work and project management

KSA303 General Competencies

A journey level Mechanical Technologist is expected to monitor the performance of others engaged in:

- operation
- maintenance
- repair of mechanical equipment.

This may include tracking status of operation and maintenance activities by utilizing a variety of sources such as:

- daily work logs
- computerized work management programs
- agency specific computerized maintenance management programs.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA303 Math Competencies

Journey level Mechanical Technologists must:

- have excellent mathematical skills
- be able to perform calculations to determine percentage of work completed
- individual performance by crew as compared to established standards
- determine number of work hours/days required to complete required tasks
- develop work schedules based on established performance levels.

KSA303 Suggested Reading

- [Operation of Wastewater Treatment Plants](#); Volume 1; Pg. 41
KSA 304

Manage maintenance records with an understanding of:

- documentation requirements and record retention
- knowledge base of equipment and product research
- state and local regulations safety training compliance record keeping requirements

**KSA304 General Competencies**

A journey level Mechanical Technologist is expected to be able to:

- document the work of subordinates
- have detailed knowledge of all equipment they work on
- have working knowledge of all pertinent regulations regarding safety training, record keeping and document retention policies

The Technologist is also expected to have the ability to conduct research on:

- machinery and equipment
- comparing features
- costs
- expected life cycles
- maintenance requirements
- other parameters to provide field-level input into upgrades or replacement projects.

This knowledge is usually gained through:

- trade schools
- advanced in-house training
- professional trade related agencies.

**KSA304 Math Competencies**

While there are no complex math calculations for this competency, journey level Mechanical Technologists are expected to have an understanding of the basic math required to calculate elapsed time (as it applies to record retention requirements) and scheduling intervals.

**KSA304 Suggested Reading**

- *Maintenance Manager's Standard Manual*
  - Part V Equipment Records and Preventative Maintenance
  - Chapter 18: How to Set-up and Maintain Equipment Records; Page 208 & 210
  - Chapter 19: How to Establish a Six Step Preventative Maintenance Program; Page 211
KSA 305

Weight 4%

Train and mentor staff and assess learning outcomes using the following techniques:

- on the job and hands on training
- tailgate training
- document training
- teaching principles of the operation and maintenance of equipment such as pumps, engines, and electrical systems related to mechanical systems
- independent study
- application of internal training program

KSA305 General Competencies

A journey level Mechanical Technologist is expected to:

- be proficient in the operation, maintenance and repair of mechanical equipment under their purview
- be able to assess the abilities of, and provide mentoring and detailed training (on-the-job training, tailgate training and classroom study) to subordinate and new staff on any aspect of the trade from basic operating principles to detailed procedures.

The Technologist will be required to possess the competency to:

- monitor and document the progress of those being trained
- adjust the training to deal with personal learning styles
- always set a positive example for the students under their tutelage.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA305 Math Competencies

Journey level Mechanical Technologists must:

- have excellent mathematical skills
- be able to perform calculations to demonstrate and teach principles of the trade, including:
  - dimensions
  - weights
  - volumes
  - and other more complex calculations such as
    - electrical formulas, pump horsepower calculations, gear reduction ratios
- impart this knowledge on subordinate and new employees the Technologist is assigned to mentor and train.

KSA305 Suggested Reading

- *Operation of Wastewater Treatment Plants*; Vol. II; 7th Edition; Administration, Page 697; Training and Certification
KSA 306

Apply journey level pumping principles and techniques in the repair and maintenance of centrifugal, positive displacement, and vacuum pumps such as:

- servicing, lubricating, adjusting, maintaining and rebuilding pumps
- reading and interpreting pump curves and efficiencies
- performing alignment techniques
- applying in-depth understanding of predictive maintenance techniques such as thermography, vibration analysis, oil analysis (tribology) and equipment trending
- troubleshooting and applying corrections
- repairing and maintaining pump hydraulics
- installation and removal techniques
- root cause analysis

KSA306 General Competencies

A journey level Mechanical Technologist is expected to:

- be proficient in all maintenance and repair of equipment under their purview
- be able to assess equipment condition
- be familiar with all maintenance practices including:
  - lubrication schedules
  - aligning pumps and motors
- conducting predictive maintenance activities such as:
  - thermology
  - vibration analysis
  - oil analysis
- monitor equipment trending utilizing maintenance and repair records.
- interpret pump curves
- assist in recommending replacement equipment
- troubleshoot systems and apply corrective actions
- determine the cause of failures and correct these conditions
- be proficient in:
  - servicing, lubricating, adjusting, maintaining and rebuilding pumps
  - repairing hydraulic systems, equipment installation and removal techniques
  - record keeping for equipment maintenance and repair

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.
KSA 306 Continued

KSA306 Math Competencies

Journey level Mechanical Technologists must:

- have excellent mathematical skills
- be able to perform calculations of dimensions to fabricate equipment parts to fit in limited spaces:
  - determine material required for a job
  - determine strength requirements of fabricated parts
  - estimate time to complete a job
  - safely operate material handling equipment such as cranes and other lifting equipment
  - have the ability to compare measurements taken to determine alignment
  - have the ability to determine the difference between readings taken and recommended values
  - make adjustments to correct any deficiencies

KSA306 Suggested Reading

- There are no specific suggested references for this KSA.
KSA 307

Perform journey level maintenance and repair on pipelines and valves such as:

- proficiency in pipe layout
- piping systems
- cutting and threading pipes
- pipe inspection and repair
- modification to existing piping systems
- proficiency in applications of valve, actuators types and associated repairs
- piping support systems
- expansion systems

KSA307 General Competencies

A journey level Mechanical Technologist is expected to be proficient in all:

- repair
- maintenance
- inspection
- modification of pipe and piping systems including:
  - valves
  - pipe supports
  - expansion joints

The Technologist must have the knowledge of valve actuators and their application, pipeline inspection and pipeline expansion joints and support systems. They will also be proficient in:

- servicing, lubricating, adjusting, maintaining and rebuilding pumps
- repairing hydraulic systems
- equipment installation and removal techniques
- all record keeping for equipment maintenance and repair

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA307 Math Competencies

Journey level Mechanical Technologists must:

- have excellent mathematical skills
- be able to perform calculations of dimensions to lay out piping systems
- fabricate equipment parts to fit in limited spaces
- determine material required for a job
- determine strength requirements of fabricated parts
- estimate time to complete a job
- fabricate threaded pipe fittings
- determine thermal expansion
- have the ability to determine ratios for valve actuators gear reduction drives

KSA307 Suggested Reading

KSA 308

Maintain and repair compressors, turbines and blowers with journey level knowledge and skill of:

- lubrication
- air receivers and tanks
- types of valves
- principles of cooling systems
- troubleshooting and corrections
- purpose of control systems
- filtration systems

KSA308 General Competencies

A journey level Mechanical Technologist is expected to:

- be proficient in the maintenance and repair of all equipment under their purview
- be able to assess equipment condition and be familiar with all maintenance practices including:
  - lubrication schedules
  - aligning drive and driven ends of equipment
  - maintenance practices including permitting for air receivers and tanks
- be able to interpret pump curves
- assist in recommending replacement equipment
- troubleshoot systems and apply corrective actions
- determine the cause of failures and correct those conditions

Other responsibilities Mechanical Technicians are required to be familiar with is:

- troubleshooting and diagnosing cooling systems
- filtration systems
- lubrication and fuel systems
- valves of all types
- control systems

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA308 Math Competencies

Journey level Mechanical Technologists must:

- have excellent mathematical skills
- be able to perform calculations of dimensions to fabricate equipment parts to fit in limited spaces
- determine material required for a job
- determine strength requirements of fabricated parts
- estimate time to complete a job
- safely operate material handling equipment such as cranes, and other lifting equipment
- have the ability to calculate thermal expansion
- determine rations for valve actuators gear reduction drives
- compare measurements taken to determine alignment
- determine the difference between readings taken and recommend values
- make adjustments to correct any deficiencies
KSA308 Continued

KSA308 Suggested Reading

- Valve & Actuator Technology
- Operation of Wastewater Treatment Plants
KSA 309

Journey level ability to maintain and repair processing equipment such as:
- chemical feed systems and effects on treatment process and associated equipment
- solids removal systems
- conveyance systems
- digesters and associated systems
- odor control systems
- aeration systems
- disinfection and de-chlorination
- filtration systems
- settling basins
- storage systems

KSA309 General Competencies

A journey level Mechanical Technologist is expected to have in-depth knowledge of all aspects of the treatment process, and the effects these processes can have on all equipment, including:
- chemical feed
- solids removal
- digesters and associated equipment
- odor control
- aeration
- disinfection and de-chlorination
- filtration and settling basins and clarifiers

This knowledge is usually gained through:
- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA309 Math Competencies

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform calculations to determine detention time, flow rates, solids loading rates, chlorination dosages, filter loading rates and chemical feed rates as well as basic dimension and volume calculations.

KSA309 Suggested Reading

- AWWA Wastewater Operator Field Guide
- Operation of Municipal Wastewater Treatment Plants; MOP 11, Page 109
**KSA 310**

Utilize routine shop mathematics and techniques to calculate or determine the following:

- efficiency of pumps and motors
- horsepower (brake and motor)
- flow rates
- volumes and area
- precision measurements (using calipers, micrometers, etc.)
- drive ratios
- estimating staffing levels and scheduling
- materials estimation
- pressure

---

**KSA310 General Competencies**

To spec pumps for given applications, a journey level Mechanical Technologist is expected to have the ability to make complex calculations to determine:

- pump and motor efficiency
- pump horsepower
- motor brake horsepower
- flow rates
- volumes
- areas
- reduction ratios
- pressure

The Technologist is also expected to be able to use various measuring devices (calipers, micrometers, tape measures, and other equipment) to determine lengths, depths, widths and volumes. Additionally they may be required to schedule work, determine staffing requirements, and estimate materials for work.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

---

**KSA310 Math Competencies**

The Technologist will be required to perform complex equations to determine flow rates, volumes, areas, costs for materials, manpower estimates, and pump and motor horsepower and efficiency.

**KSA310 Suggested Reading**

- There are no specific suggested references for this KSA.
KSA 311

Weight 2%

Safely and effectively repair and maintain equipment with a journey level knowledge and understanding of electrical principles and practices including:

- Ohms Law
- voltage rating
- motor identification
- battery principles

KSA311 General Competencies

Journey level Mechanical Technologists are required to have working knowledge of:

- electrical theory including Ohms Law
- voltage and current determination
- motor identification
- battery principles

They will have the ability to work safely around electricity and electrical equipment and train subordinate staff to safely work around this equipment.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA311 Math Competencies

The Technologist will be required to perform complex equations to determine voltage, resistance and current.

KSA311 Suggested Reading

- There are no specific suggested references for this KSA.
KSA 312

Repair and maintain mechanical systems while adhering to industry safety standards and regulations with a journey level knowledge and practical application pertaining to CCR Title 8 or equivalent state regulations:

- lock tag verification (LTV)
- confined space
- slip, trip and fall
- proper lifting
- trench safety
- crane safety
- forklift safety
- vehicle safety
- tool safety
- stored energy
- electrical safety
- chemical safety
- fire safety
- Safety Data Sheet (MSDS)
- gas detection systems
- proper use of PPE (Personal Protective Equipment)
- traffic control
- rigging safety
- NFPA 70E (National Fire Protection Association)
- IIP (Injury Illness Prevention)

KSA312 General Competencies

Journey level Mechanical Technologists are required to be familiar with, and have in depth knowledge of:

- all industry safety regulations as they relate to the maintenance and repair of treatment plant equipment
- Lock Out/Tag Out
- Confined Space Entry
- crane safety
- vehicle safety
- electrical safety
- Personal Protective Equipment
- traffic safety
- Injury and Illness Prevention Programs
- fire safety
- general safety requirements including slip, trip and fall, lifting, trench safety, forklift safety and any other safety regulations that may affect them.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses

KSA312 Math Competencies

This Technologist shall possess the knowledge of basic to intermediate math to calculate lifting loads, electrical voltage and current, distances and speeds.

KSA312 Suggested Reading

- There are no specific suggested references for this KSA.
KSA 313

**Weight 5%**

Participate in the lifting and moving of heavy machinery or equipment with a journey level knowledge and understanding of:

- directing a qualified crane operator
- rigging and lifting
- proper operation of forklifts
- coordinate communications and personnel involved in the lift
- proper use of chain falls/come along (cable or chain puller)

**KSA313 General Competencies**

Journey level Mechanical Technologists are required to be familiar with, and have in depth knowledge of all industry safety regulations as they relate to the operation of equipment used in the lifting and moving of heavy machinery or equipment, such as:

- cranes
- hoists
- fork lifts and other lifting equipment.

The Technician will be familiar with:

- training of subordinate staff rigging and directing crane operations
- operation of cranes
- communication practices when guiding crane operators and use of chain-falls, come-alongs and other cable puller type equipment.

They will also be knowledgeable of licensing requirements and inspection frequencies for lifting equipment and all safety requirements applicable to lifting and hoisting equipment.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

**KSA313 Math Competencies**

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of dimensions, calculate distances, speed lifting loads, and leverage.

**KSA313 Suggested Reading**

- There are no specific suggested references for this KSA.
Proficiently apply and train personnel on the use of tools such as:

- hand tools
- power tools
- machine/shop tools and equipment
- hydraulic/pneumatic tools
- measurement tools
- computers and systems
- ultra sonic preventative maintenance equipment

### KSA314 General Competencies

Journey level Mechanical Technologists are expected to train subordinates in the use of:

- hand tools
- power tools
- machine shop tools and equipment
- hydraulic and pneumatic tools
- measuring tools
- computers and computer systems used in the maintenance trades
- ultrasonic and laser measuring equipment and alignment
- precision measurement tools

The Technologist will be required to possess the competency to monitor and document the progress of those being trained, adjust the training to deal with personal learning styles, and always set a positive example for the students under their tutelage.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

### KSA314 Math Competencies

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of:

- weights, volumes, flows
- dimensions
- conversions
- distances
- angles
- speeds
- lifting loads
- leverages

### KSA314 Suggested Reading

- There are no specific suggested references for this KSA.
KSA 315

Apply appropriate knowledge of facility maintenance, construction methods and materials, to perform journey-level maintenance such as:

- pipe fitting
- framing
- concrete forming, pouring, grouting, and finishing
- painting/coating
- heating and cooling systems
- plumbing and drain
- lighting and electrical
- job and materials estimation
- paving

KSA 315 General Competencies

A Journey level Mechanical Technologists is expected to be proficient in all construction practices, including:

- pipe fittings
- framing
- concrete forming
- pouring
- grouting and finishing
- painting and coating
- heating and cooling systems
- plumbing and drainage systems
- lighting and electrical paving
- metal, plastic and wood fabrication
- job estimating
- materials estimating and ordering manpower allocation
- documentation of work and recordkeeping for equipment maintenance and repair

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA 315 Math Competencies

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of:

- weights
- volumes
- flows
- dimensions
- conversions
- distances
**KSA315 Math Competencies continued**

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of:

- angles
- speed lifting loads
- areas
- leverage
- distances and speeds
- percentage of work completed
- individual performance by crew as compared to established standards
- determine number of work hours/day required to complete tasks
- develop work schedules based on established performance levels

**KSA315 Suggested Reading**

- *AWWA Wastewater Operator Field Guide*
KSA 316

Perform journey level maintenance and repair by interpreting, applying, or developing:

- designs and sketches
- written and verbal design instructions
- equipment specifications
- operation and maintenance service manuals
- diagrams
- schematics
- pump curves

KSA316 General Competencies

A Journey level Mechanical Technologist is expected to be proficient using all reference sources for maintenance and repair of equipment including:

- working from sketches
- improvement plans
- written and verbal instructions
- equipment manufacturer specifications
- O&M manuals
- diagrams
- schematics
- pump curves

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA316 Math Competencies

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of:

- weights
- volumes
- flows
- dimensions
- conversions
- distances
- angles
- speeds lifting loads
- leverage

KSA316 Suggested Reading

- Autocad electrical symbols
- Affinity laws
- Mechanical Trades Pocket Manual, 4th Edition.; Mechanical Drawing; Page 58 & Sketching; Page 72
KSA 317

Establish and maintain effective working relationships with every person encountered in the workplace to help incorporate the concept of teamwork.

- effectively build and lead a team
- positively promote the concept of teamwork
- plan, schedule, implement work with other teams, departments, and contractors
- promote and enforce the agency’s core values

**KSA317 General Competencies**

Journey level Mechanical Technologists are expected to have the ability to effectively:

- build and lead teams
- promote the concept of teamwork
- promote and enforce the agency’s core values in a positive manner

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

**KSA317 Math Competencies**

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of:

- percentage of work completed
- individual performance by crew as compared to established standards
- determine number of work hours/days required to complete required
- develop work schedules based on established performance levels

**KSA317 Suggested Reading**

- There are no specific suggested references for this KSA.
KSA 318

Communicate clearly and concisely in English, both verbally and in writing with respect to:

- completing and accepting work orders
- purchase requests
- warehouse requisition
- accident reporting
- radio and telephone communication
- maintaining written and computerized records
- handling public contacts with tact and diplomacy

KSA318 General Competencies

Journey level Mechanical Technologists are expected to have the ability to be effective team administrators, providing the tools and training to their staff for:

- material procurement
- accident reporting
- communications
- completing work orders and purchase requests
- record keeping to their groups

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA318 Math Competencies

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of percentage of work completed, individual performance by crew as compared to established standards, determine number of work hours/days required to complete required tasks and develop work schedules based on established performance levels.

KSA318 Suggested Reading

- [Operation of Wastewater Treatment Plants](#), Volume II; 7th Edition; Administration, Page 708, 711 & 741
- Your agency’s in-house manual
KSA 319

Weight 6%

Perform maintenance and repair with a journey level understanding of power transmission equipment and techniques such as:

- various types of drives
- gear and pulley ratios
- machine guards
- shafts
- alignment
- vibration analysis
- infrared thermography
- types of couplings
- joints
- gear reduction systems

KSA319 General Competencies

A journey level Mechanical Technologist is expected to be proficient in the use of:

- hand tools
- power tools
- machine shop tools and equipment
- hydraulic and pneumatic tools
- gear and pulley ratios
- machine guards
- measuring tools
- computers and computer systems used in the maintenance trades.

They will also be experienced in the use of vibration analysis, infrared thermography, ultrasonic and laser measuring equipment and alignment and precision measurement tools.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

KSA319 Math Competencies

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of percentage of work completed, individual performance by crew as compared to established standards, determine number of work hours/days required to complete required tasks and develop work schedules based on established performance levels.

KSA319 Suggested Reading

- There are no specific suggested references for this KSA.
KSA 320

**Assist in the development of, and execution of existing response plans for contingencies and emergency conditions such as natural disasters and catastrophic equipment failures including:**

- supervising equipment roll-out and personnel activation
- training staff in emergency response plans procedures
- amending plans to address any deficiencies discovered during training evolutions

**KSA320 General Competencies**

Journey level Mechanical Technologists will be familiar with plans for emergency conditions and contingencies, and be able to lead response activities to natural disasters, catastrophic equipment failures and all emergency conditions, including:

- training staff in emergency response activities
- assisting in the development and amending of response plans
- planning and leading emergency response training evolutions
- identifying and rectifying deficiencies in plans discovered during training exercises.

This knowledge is usually gained through:

- trade schools
- military schools
- advanced in-house training
- college level courses
- vendors
- Regional Occupation Programs
- professional trade related agencies.

**KSA320 Math Competencies**

Journey level Mechanical Technologists must have excellent mathematical skills and be able to perform intermediate to advanced calculations of:

- weights
- volumes
- flows
- dimensions
- conversions
- distances
- angles
- speeds lifting loads
- leverage
- distances and speeds

**KSA320 Suggested Reading**

- *Water, Wastewater and Stormwater Infrastructure Management*
This section provides tips on how candidates should prepare, information provided with the test, the types of questions likely to be on the test, and solutions to typical math problems.

**Basic Study Strategy**

To prepare adequately, candidates need to employ discipline and develop good study habits. Ample time to prepare for the test should be allowed. Candidates should establish and maintain a study schedule. 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 test subject areas that are not being performed on a day-to-day basis.

While using this study guide, be sure to understand the KSAs and answers to all 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 test. Refer to Section 3 for a description of the KSAs and reading assignments that cover the topics on the test.

It is not necessary, but certainly helpful, to memorize all formulas and conversion factors. A formula table is provided on the test to assist in this area. Tables 4-1 give the same formulas and conversion factors as those given on the test.

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

**Multiple Choice Questions**

All test questions are written in 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 provided. Here are some tips that may help solve multiple-choice questions.

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)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>All</td>
<td>Never</td>
</tr>
<tr>
<td>Always</td>
<td>None</td>
</tr>
<tr>
<td>Totally</td>
<td>Completely</td>
</tr>
</tbody>
</table>

Limiting Words
(Often a correct choice)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Few</td>
<td>Occasionally</td>
</tr>
<tr>
<td>Some</td>
<td>Generally</td>
</tr>
<tr>
<td>Often</td>
<td>Usually</td>
</tr>
<tr>
<td>Many</td>
<td>Possible</td>
</tr>
</tbody>
</table>

4. Never make a choice based on the frequency of previous answers. 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.

5. Reject answers that are obviously incorrect and choose from the remaining answers. For example, in the multiple-choice question, “Why are gasoline and volatile solvents objectionable when present in a sewer?”

   a. They produce an explosion hazard.
   b. They tend to cause solids to vaporize.
   c. They will coagulate floatables and cause stoppages.
   d. Because they float, the substances flow to plant headworks quicker.”

   In reviewing physical and chemical characteristics of gasoline and volatile solvents, the specific gravities of these substances are generally less than water and float to the surface. They are solvents for other similar industrial organic chemicals. Therefore, answer “b”, that proposes gasoline and volatile solvents cause solids such as sand, and grit to vaporize, is obviously an incorrect answer.

6. Make an educated guess. Never reconsider a choice that has already been eliminated. That means in the example above, answer “b” is out.

   Look for “key” phrases or words that give a clue to the right answer. For the example above, choices “c” and “d” discuss floatables and are potentially good answers. For answer “c”, chemical interaction of gasoline with floatables is not likely unless they are oil and grease. In such case, the solvent may disperse the oil and grease and reduce stoppages.

   Answer “a” and “d” remain and are both reasonable choices. However, the best answer must be selected. Answer “d” is true, but without knowing the explosive nature of gasoline and volatile solvents, the answer is only a fact. An explosive material in wastewater creates a condition that endangers the public, a potential loss of expensive facilities, and a hazard to operations and maintenance personnel. The best answer is “a”, they produce an explosion hazard.

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 an incorrect answer. 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 profession.

**Math Problems**

Math problems on the certification tests are meant to reflect the type of work encountered in Collection System Maintenance. 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. Although math is important on the test, do not neglect other parts of the KSAs and focus too much time on the math. Completing the math problems will be greatly simplified by using a calculator and the approach suggested in the following paragraphs.

**Calculators**

Approved calculators may be used during the test. See the approved calculator list at www.cwea.org/cbt. A screen calculator will also be available on the test similar to the standard calculator found on computers running Windows. 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 a calculator from the approved calculator list 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).
Section 4: Test Preparation

Equation. The equation or equations that will be used to generate the listed answers.

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)?

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

\[
\frac{50\ \text{gal}}{\text{min}} \times \frac{60\ \text{min}}{\text{hr}} \times \frac{24\ \text{hr}}{\text{day}} \times \frac{365\ \text{days}}{\text{yr}} \times \frac{1\ \text{MG}}{1,000,000\ \text{gal}} = 26.28\ \text{mg}y
\]

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?

\[
3\ \text{cubic feet} \times 7.48\ \frac{\text{gallons}}{\text{cubic feet}} = 22.4\ \text{gallons}
\]

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

\[
350\ \text{gallons} \times 7.0\ \frac{\text{pounds}}{\text{gallon}} = 2,450\ \text{pounds}
\]

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

\[
500\ \text{gpm} \times \frac{1\ \text{MGD}}{694\ \text{gpm}} = 0.72\ \text{MGD}
\]

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)?

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

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

\[
\frac{30 \text{ lbs CN}}{\text{day}} \times \frac{8 \text{ hr}}{\text{shift}} \times \frac{1 \text{ day}}{24 \text{ hr}} = 10 \text{ lbs CN per shift}
\]

**Math Skills**

Successful candidates must be skilled in arithmetic and geometry. Candidates must be able to apply these skills to make calculations for work-related tasks such as excavation, stationing, pumping, determining flow rate, cost estimation, and any other job related math skill that may fall within the Skill Sets listed in Section 3. A thorough review of the types of mathematics required for the test is beyond the scope of this study guide. Consult an appropriate math text (see Section 6, References) if there is unfamiliarity with any of these specific math skills. Appendix A provides general strategies for approaching math problems, math anxiety, and resources for remedial study.

**Arithmetic**

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

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

Be prepared to apply these basic skills to work-related problems. The following example problem requires application of knowledge and application of basic arithmetic and the ability to convert units.

**Example:**

Determine the volume of a concrete slab that measure 150 feet long, 200 feet wide, and 3 inches thick. Express your answer in cubic yards.

First convert inches to feet:

\[
\frac{3 \text{ inches}}{12 \text{ inches}} = 0.25 \text{ feet}
\]

Next, using the formula for volume given in Table 4-2, determine the volume of the concrete slab in cubic feet:

Vol = LWd
Vol = 150 feet x 200 feet x 0.25 Feet
Vol = 7,500 cubic feet
Finally, calculate the volume of concrete in cubic yards:

7,500 cubic feet x 1 cubic yard
   27 cubic feet
= 277.78 cubic yards

**Geometry**

Candidates should be able to calculate circumference, find the area of a rectangle, circle, and the volume of a rectangular solid or a right cylinder. This problem requires application of knowledge and application of basic geometry, arithmetic, and the ability to convert units.

Example:

What is the area of a manhole that measures 40 inches in diameter? Express your answer in square feet.

First convert inches into feet.

\[
40 \text{ inches} \times \frac{1 \text{ foot}}{12 \text{ inches}} = 3.33 \text{ feet}
\]

Then calculate the area of the manhole using the formula for the area of a circle given in Table 4-2.

\[
A = 0.785D^2
\]

\[
A = 0.785 \times 3.33 \text{ feet} \times 3.33 \text{ feet}
\]

\[
= 1,256 \text{ ft}^2
\]

Area of manhole

\[
= 8.71 \text{ square feet}
\]
# Mechanical Technology Grade 1-4
## Conversion Factors & Formulas

### Section 4: Test Preparation

<table>
<thead>
<tr>
<th>Category</th>
<th>Conversion Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cubic foot</td>
<td>1,728 cubic inches</td>
</tr>
<tr>
<td>1 cubic foot</td>
<td>7.48 gallons</td>
</tr>
<tr>
<td>1 cubic foot of water</td>
<td>62.43 pounds</td>
</tr>
<tr>
<td>1 gallon of water</td>
<td>8.34 pounds</td>
</tr>
<tr>
<td>1 cubic foot/second</td>
<td>448.8 gallons/minute</td>
</tr>
<tr>
<td>1 MGD</td>
<td>694 gallons/minute</td>
</tr>
<tr>
<td>1 horsepower</td>
<td>33,000 foot pounds/minute</td>
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<td>1 psi</td>
<td>2.31 feet of water</td>
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<td>1 horsepower</td>
<td>746 watts</td>
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<tr>
<td>1 horsepower</td>
<td>42.45 Btu/minute</td>
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<td>1 MGD</td>
<td>1.55 cubic feet/second</td>
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<td>1 Btu</td>
<td>778 foot-pounds</td>
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<td>1 watt</td>
<td>3.412 Btu/hour</td>
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<tr>
<td>1 thermal unit</td>
<td>100,000 Btu</td>
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Steel: 0.00000633/°F
Brass: 0.00001/°F

### Formulas

- **Circumference** of a circle = \( \pi \times \text{diameter} \)
- **Area of a circle** = \( \frac{\pi \times \text{diameter}^2}{4} \)
- **Area of a rectangle** = \( \text{base} \times \text{height} \)
- **Volume of a rectangular solid** = \( \text{length} \times \text{width} \times \text{height} \)
- **Volume of a triangular solid** = \( \frac{\text{base} \times \text{height}}{2} \)
- **Volume of a cylinder** = \( \frac{\pi \times \text{radius}^2 \times \text{height}}{4} \)
- **Flowing quantity** = \( \text{Area} \times \text{Velocity} \)
- **Efficiency** = \( \frac{\text{work output}}{\text{work input}} \)
- **Energy** = \( \text{power} \times \text{time} \)

### Thermal Expansion

\[ \text{Thermal expansion} = \text{coeff. of thermal expansion} \times \text{length} \times \Delta T \]

### Coefficients of thermal expansion

- **Hydrostatic force** = \( \text{column area} \times \text{column height} \times \text{fluid density} \)

### Motor Horsepower

\[ \text{Motor horsepower} = \frac{\text{flow} \times \text{head} \times \text{specific gravity}}{3960 \times \text{efficiency pump} \times \text{efficiency motor}} \]

### Brake Horsepower

\[ \text{Brake horsepower} = \frac{\text{flow} \times \text{head} \times \text{specific gravity}}{3960 \times \text{efficiency}} \]

\[ 3 \text{phase } A = \frac{746 \times \text{horsepower}}{1.732 \times V \times \text{efficiency} \times \text{power factor}} \]

\[ \text{Brake horsepower} = \frac{\text{water horsepower}}{\text{efficiency}} \]

\[ \text{Water horsepower} = \frac{\text{flow} \times \text{total head} \times \text{specific gravity}}{3960} \]

\[ V = \frac{d}{t} \]
This section provides a practice certification test to help certificate candidates become familiar with the test format and subject matter. The actual certification test is given on a computer at a secure testing site. The computer-based test (CBT) requires test takers to be able to use a computer mouse and some very basic keyboard functions. Candidates who have never taken a computerized test are strongly encouraged to try the online CBT demo to become familiar with the computerized test format before going to a test site. A CBT tutorial is also available to candidates just before they start their test. For more information about CBT and to try the CBT demo go to www.cwea.org/cbt.

The number of test questions on the actual certification test may range from about 90 to 130 questions (this practice test has over 50 questions). The time limit for the test is 3 hours. The computerized certification test can be paused for restroom breaks, but the 3-hour clock will not stop. A formula table very similar to Table 4-1 (Section 4) will be available as a window on the computer screen during the test. The format of the test questions on the computerized certification test is very similar to the multiple-choice questions given in this practice test. There are no fill-in or essay type questions given on the test. Most questions on the certification test are worth 1 point, however some can be worth up to 5 or more points depending on the level of difficulty or calculations required. No point values are given for questions on this practice test so the weighting will not precisely reflect that of the actual certification test. If answered correctly, candidates will earn the number of points given for a question. If a question is not answered correctly, then no points are awarded (there is no penalty for “guessing”). At the test site, calculators are limited to a list of approved calculators. A screen calculator, similar to the basic Windows computer calculator, is also available during the test and can be toggled between basic and scientific modes. For the list of allowable calculators see the Calculator Policy at www.cwea.org/cbt, or contact CWEA at 510-382-7800, or tcp@cwea.org.

The practice test includes a key at the end of the test. Some questions that require calculations include solutions that are given after the key. These are indicated on the key with “see solutions” to the right of the correct answer. Candidates are encouraged to find the solutions to all of the questions requiring calculations themselves.
Practice Test

Select the best answer for each item below.

1. Why should plans and specifications for wastewater installations be carefully reviewed?
   A. To identify potential safety hazards
   B. To ensure consistency of symbols in the P&ID
   C. To check for proper color-coding of power conductors
   D. To check for proper color-coding of power conductors

2. As a maintenance supervisor, you must assign someone to be primarily responsible for safety supervision. Which of the following would you consider most appropriate?
   A. Pick a permanent safety supervisor for planning continuity and better follow-up on reported hazards.
   B. Rotate the responsibility monthly to ensure everybody has an equal chance to learn the job.
   C. Assign the job to yourself because no one else has the authority to enforce safety regulations throughout the entire plant.
   D. Ask for a volunteer since they will be more conscientious and capable than an appointed person.

3. A working centrifugal pump suddenly stopped flowing sewage. Which of the following is the most probable cause?
   A. Excessive speed of pump
   B. Air leaking into pump suction
   C. Worn bearings
   D. Inadequate air level

4. Periodic inspection and testing of mechanical equipment by the staff at a plant is done mainly to:
   A. estimate the time before breakdown.
   B. discover minor equipment faults before they develop into major breakdowns.
   C. encourage the crew to better understand how the equipment works.
   D. help the crew better understand individual responsibilities.
5. The rated capacity of a pump is usually given in terms of:
   A. electrical consumption and gallons per minute pumped.
   B. electronic consumption and velocity of flow.
   C. horsepower and velocity flow.
   D. gallons per minute pumped and pressure head.

6. Which of the following best describes cavitation within a centrifugal pump?
   A. The pump becoming over-pressurized
   B. The pump going air bound
   C. The pumping of entrapped air
   D. The formation and collapse of vapor bubbles in the pump

7. What causes false brinelling of an anti-friction bearing?
   A. External impact vibration
   B. Excessive speed
   C. Excessive heat
   D. Excessive load

8. Which of the following is not susceptible to corrosion?
   A. Stainless steel
   B. Aluminum
   C. PVC
   D. Copper

9. Which of the following is an advantage to using a mechanical seal versus mechanical packing in a pump?
   A. Ease of installation
   B. Initial cost
   C. No leakage
   D. Vibration dampening qualities
10. Closing the discharge valve on an electric motor driven centrifugal pump during pumping will cause the motor's amperage draw to:
   A. decrease.
   B. increase.
   C. remain unchanged.
   D. trip the circuit protection device.

11. Priming is most frequently required in a:
   A. centrifugal pump.
   B. rotary pump.
   C. reciprocating pump.
   D. gear pump.

12. Vertical propeller pumps are classified as:
   A. positive displacement pumps.
   B. axial-flow or mixed-flow pumps.
   C. turbine pumps.
   D. rotary lobe pumps.

13. Cathodic protection uses which type of corrosion to an advantage to protect a metal?
   A. Galvanic
   B. Interfilm
   C. Microbiological
   D. Dissolution

14. When an application calls for fast on-off operation, low pressure drop, good sealing, and flow in both directions, which of the following valves is the best choice?
   A. A gate valve
   B. A ball valve
   C. A needle valve
   D. A globe valve
15. An intercooler is generally found on a/an:
   A. water pump.
   B. steam pump.
   C. air compressor.
   D. air receiver.

16. The function of an unloader on an electric motor-driven air compressor is to:
   A. drain the condensate from the cylinder head.
   B. prevent excess pressure in the receiver.
   C. reduce the speed of the motor when the maximum pressure is reached.
   D. release the pressure in cylinders in order to reduce the starting load.

17. A globe valve is categorized as what type of valve?
   A. cracking
   B. adjustable
   C. linear
   D. rotary

18. A plug valve is categorized as what type of valve?
   A. adjustable
   B. rotary
   C. linear
   D. cracking

19. Fill in the blank with the correct answer. Flowing Fluid in a piping system has ______ and velocity
   A. force
   B. energy
   C. resistance
   D. mass
20. Fill in the blank with the correct answer. Advantage of pneumatic valve actuators is that it may be ________ indefinitely without overheating.
   A. controlled
   B. stalled
   C. used
   D. actuated

21. What would cause blower air system low pressure?
   A. plugged diffusers at air header
   B. Closed Suction Valve
   C. diffusers off at air header
   D. bad drive motor coupling

22. What would cause blower oil system low pressure?
   A. check valve sticks open
   B. incorrect oil type
   C. defective bearings
   D. restricted ventilation

23. For blowers operated under normal service, when should oil for gears and bearings be changed and the filters cleaned?
   A. Every 2800 hours
   B. Every 1400 hours
   C. Every 3200 hours
   D. Per manufacturer recommendations

24. What is a Venturi meter used to measure?
   A. Flow of sewage
   B. Pressure of sewage
   C. Temperature of sewage
   D. Depth of sewage
25. A Parshall flume is used to measure:
   A. liquid flows in an open channel.
   B. air flows in a heating system.
   C. water flow in a piping system.
   D. exhaust emissions.

26. A tank is 8 feet high and 8 feet in diameter. What is the water depth in feet if the tank is filled with 1,109 gallons of treated water?
   A. 1.35 feet
   B. 2.7 feet
   C. 2.95 feet
   D. 3.5 feet

27. If water is flowing 18 inches deep through a 2-foot wide channel at a velocity of 1.5 ft./sec., what is the flow of rate in GPM?
   A. 270
   B. 2,020
   C. 2,423
   D. 24,235

28. Which of the following formulas correctly shows the relationship between absolute pressure and gauge pressure?
   A. absolute pressure added to atmospheric pressure = gauge pressure
   B. absolute pressure added to gauge pressure = atmospheric pressure
   C. absolute pressure = gauge pressure added to atmospheric pressure
   D. absolute pressure = gauge pressure subtracted from atmospheric pressure

29. The ratio of the weight of a substance to the weight of an equal volume of water is called the:
   A. specific volume of the substance.
   B. specific gravity of the substance.
   C. velocity of the substance.
   D. fractional weight of the substance.
30. Which of the following procedures should be taken to calculate the velocity of a fluid in an open channel?
   A. Divide the speed of the fluid by time
   B. Divide gallons per minute by time
   C. Divide the distance traveled by time
   D. Divide the liquid depth by time

31. How much more water will a 6" diameter pipe carry than a 3" diameter pipe under the same conditions?
   A. 2 times
   B. 4 times
   C. 3 times
   D. 6 times

32. Water is flowing through a 24-inch diameter pipe at 2.5 feet per second. What is the flow rate in gallons per minute?
   A. 3,526 gpm
   B. 4,490 gpm
   C. 5,260 gpm
   D. 7,854 gpm

33. If a digester is 75 feet tall and 150 feet in diameter, what is the volume, in million gallons (MG)?
   A. 0.26 MG
   B. 6.61 MG
   C. 9.91 MG
   D. 13.25 MG

34. Which of the following is the RPM of a four-pole synchronous motor in the United States?
   A. 3,600
   B. 1,800
   C. 1,200
   D. 900
35. A circuit has 120 volts applied across a resistance of 6 ohms. What is the current?
   A. 20 amps
   B. 50 watts
   C. 75 watts
   D. 720 amps

36. A 480-volt system has a resistance of 20 ohms. What is the power consumed, in watts?
   A. 20 watts
   B. 24 watts
   C. 9,600 watts
   D. 11,520 watts

37. Which of the following methods is used to protect workers against cave-ins in trenches 5 feet deep or greater?
   A. Locking in and tagging out method
   B. Laddering method
   C. Shoring method
   D. Confined spacing method

38. In order to properly ground portable electric hand tools, it is usually necessary to use a:
   A. three prong plug.
   B. fuse.
   C. circuit breaker.
   D. solenoid.

39. In which of the following locations should the Safety Data Sheets be located?
   A. At the facility library
   B. In the break room
   C. At the work area
   D. In the manager’s office
40. Accidents are **less** likely to occur if:
   A. employee morale is kept high.
   B. safety policies are frequently changed.
   C. safety policies are informal.
   D. employee input is solicited for safety programs.

41. If the contents of a container are described as "toxic", it means they are:
   A. poisonous.
   B. explosive.
   C. dangerous.
   D. volatile.

42. The greatest hazard associated with a liquid polymer spill is:
   A. fire.
   B. toxicity.
   C. an explosion.
   D. slipping.

43. If a person has had contact with chlorine gas and his/her eyes have been exposed to the gas, one should:
   A. apply a weak solution of boric acid to neutralize the chlorine.
   B. keep the eyes closed and cover both eyes even if only one has been exposed.
   C. flush the eyes with a weak solution of baking soda to neutralize the chlorine.
   D. flush the eyes with generous amounts of water for at least 10 minutes.

44. Which item must be replaced when connecting a new chlorine cylinder?
   A. The fiber washer
   B. The air and water regulator
   C. The needle valve seat
   D. The pressure regulator
45. Which of the following describes the proper method for lifting a heavy object?
   A. Stand far away from the load with knees bent and the back at a 45 degree angle, lift by straightening the knees and slowly straightening the back.
   B. Stand close to the load with feet solidly placed and far apart, knees bent, then lift by straightening the legs keeping the body at a 30-degree angle.
   C. Stand far enough away from the load so that with knees bent the back is at a 45 degree angle, then lift by straightening the back.
   D. Stand close to the load, with feet solidly placed and slightly apart and knees bent; then lift by straightening the legs, keeping the back as nearly vertical as possible.

46. Magnetic flow meters are classified as what type of meter?
   A. Displacement
   B. Head area
   C. Flow velocity
   D. Differential flow

47. A thread chaser is likely to be used to:
   A. flare tubing.
   B. adjust die stocks.
   C. repair damaged threads.
   D. remove broken belts.

48. 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 ft.
   B. 1,145 ft.
   C. 1,165 ft.
   D. 1,185 ft.
49. 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, in square yards.
   A. 84 yd\(^2\)
   B. 180 yd\(^2\)
   C. 540 yd\(^2\)
   D. 1,620 yd\(^2\)

50. Which screw thread is most commonly used for most applications?
   A. #4 class fit
   B. #1 class fit
   C. #3 class fit
   D. #2 class fit

51. Which of the following describes using staff members to accomplish common objectives?
   A. controlling
   B. delegating
   C. planning
   D. managing

52. Performance appraisal forms should:
   A. not contain a rating scale.
   B. be limited to three performance factors.
   C. not be open to discussion.
   D. make the appraisal process consistent.

53. How should a supervisor address rumors of downsizing that is circulating among staff members?
   A. Find out who is spreading the gossip and inform him/her what she knows
   B. Ask a manager for permission to find out who is spreading the rumor
   C. Call a meeting to verify the accuracy of the information
   D. Ignore the whole thing because the truth will come out soon
54. Due to unusual circumstances, your crew is assigned another job in addition to regular assignments. Management has informed you that no additional help is available and that no overtime is permitted. What is the best course of action for you to take as a supervisor in such a situation?
   A. Inform your crew to work faster in order to complete the additional assigned work.
   B. Assist your crew in completing the additional assigned work.
   C. Proceed with the regular assignments and complete as much of the additional assigned work as possible.
   D. Inform management that your crew cannot complete the additional assigned work.

55. Which is most true about disagreements in the workplace?
   A. It is always detrimental to the work unit
   B. It is potentially useful
   C. It is never educational
   D. It is never appropriate

56. The quality in a supervisor that is most likely to make him or her popular with his or her subordinates is:
   A. efficiency in controlling operations.
   B. loyalty to agency norms and goals.
   C. fairness in dealing with personnel.
   D. attention to the health and safety of employees.

57. Maintenance systems, whether computer generated or manual records, should include (choose best match):
   A. equipment, scheduled maintenance and safety records.
   B. equipment, scheduled maintenance, work orders and cost records.
   C. tools, SOPs, and safety records.
   D. location of equipment, supplier and parts records.
58. A well-completed work order would have (mark least necessary answer):
   A. Written observations that may require further maintenance with parts or a change in
      the maintenance schedule.
   B. name of suppliers of parts.
   C. the initial or name of the person who completed the job.
   D. the time and date of job completion.

59. Which of the following is used to prevent overloading on mechanical equipment?
   A. A fuse
   B. A bushing
   C. A shear pin
   D. A circuit breaker

60. The symptom that would cause wear on the top surface of a V-belt is:
   A. belt slip.
   B. worn sheaves.
   C. rubbing against the guard.
   D. misalignment.

END OF PRACTICE TEST
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.

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Selected Problem Solutions

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

Solution:

\[ E=IR \text{ or Voltage} = \text{Current} \times \text{Resistance} \]
120 volts = Current \times 6 ohms
120 volts = Current (amps)
6 ohms
20 amps = Current

49. 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 = 1,145 feet
50. 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 ft²
Area = 1,620 ft² x 1 yd²
  9 ft²
Area = 180 yd²
Section 6

Study Materials

The following section includes the titles and information of primary and secondary references for the Technologist. Because these references contain the majority of the information needed for the CWEA certification test, it is recommended that these references be obtained for personal use. They may also be obtained at a university library or possibly an employer’s library.

The Internet is also a valuable resource. However, when searching for material the source should be considered and your search information should be as targeted as possible to obtain the resource requested. If possible, you should target colleges, government agencies, public works agencies and similar trustworthy sources for your requests.

Study Materials Referenced in Section 3

- Affinity laws
  http://www.engineeringtoolbox.com/affinity-laws-d_408.html

- AutoCAD symbols

  Thomas B. Davis, Carl A. Nelson, Audel

- Maintenance Manager’s Standard Manual, 2nd Edition
  Thomas A. Westerkamp, Building News
  888-264-2665 www.bnibooks.com

  Thomas B. Davis, Carl A. Nelson, Audel

- Operation of Municipal Wastewater Treatment Plants Manual of Practice No. 11
  Water Environment Association

- Operation of Wastewater Treatment Plants, 7th Edition
  Office of Water Programs, California State University Sacramento
  6000 J Street, Sacramento, CA 95819-6025, 916-278-6142 www.owp.csus.edu

- Valve & Actuator Technology
  Wayne Ulanski, McGraw-Hill
- **Wastewater Operator Field Guide**  
  John M. Stubbart, William C. Lauer, Timothy J. McCandless, Paul Olson, American Water Works Association  
  6666 W. Quincy Ave. Denver, CO 80235, 800-926-7337 [www.awwa.org](http://www.awwa.org)  

- **Water, Wastewater, and Stormwater Infrastructure Management**  
  Neil S. Grigg, CRC Press  
  800-272-7737 Fax:800-374-3401 [www.crcpress.com](http://www.crcpress.com)  
  Additional Study Materials

**Additional Study Materials**

- **2012 WATCHBook: Work Area Traffic Control Handbook**  
  888-264-2665 [www.bnibooks.com](http://www.bnibooks.com)  

- **California Manual on Uniform Traffic Control Devices, (POCKET GUIDE)**  
  U.S. Department of Transportation, Federal Highway Administration  

- **Condensed Hydraulic Data (POCKET GUIDE)**  
  Cornell Pump Company  
  P.O Box 6334, Portland, OR 97228-6334, 503-653-0330 [www.cornellpump.com](http://www.cornellpump.com)  

- **Environmental Laws and Regulations, Navigating the Green Maze**  
  Joseph j. Bernosky, P.E., , American Water Works Association  
  6666 W. Quincy Ave. Denver, CO 80235, 800-926-7337 [www.awwa.org](http://www.awwa.org)  

  American Water Works Association  
  6666 W. Quincy Ave. Denver, CO 80235, 800-926-7337 [www.awwa.org](http://www.awwa.org)  

- **Pocket Ref**  
  Thomas J. Glover, Sequoia Pub; 4th Edition  

- **Pocket Guide to Flanges, Fittings, and Piping Data**  

- **USA North’s California Excavation Manual (POCKET GUIDE)**  
  Underground Service Alert, USA North  
  [http://usanorth.org/calaw.pdf](http://usanorth.org/calaw.pdf)
Appendix A
You and Wastewater Math

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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 geometry, (area and volume problems). For specific kinds of math skills and problems you may encounter on the Collection System Maintenance certification test, please review Sections 3, 4, and 5 of this study guide.

Section 1: 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:

- CWEA local section study sessions
- Technical Certification Training Classes and Annual Conferences
- CWEA Northern 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 want 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 Office of Waste Programs, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819.

Section 2: 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. Make sure you use only a calculator that you can take into the test site (see www.cwea.org/cbt for a list of approved calculators).

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,

\[ 2 \times 3 = (2)(3) = 6 \]

**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”.

\[ mgd = \frac{\text{million gallons}}{\text{day}} \]
\[ cfs = \frac{\text{cubic feet}}{\text{second}} \]
\[ ppm = \frac{\text{parts}}{\text{million}} \]
\[ gpm = \frac{\text{gallons}}{\text{minute}} \]
\[ pso = \frac{\text{pounds}}{\text{square inch}} \]
\[ mg/L = \frac{\text{miligrams}}{\text{Liter}} \]
\[ \text{gpd/square foot} = \frac{\text{gallons/day}}{\text{square foot}} \]
\[ 10\% = \frac{10}{100} \]
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.

\[
\text{mgd} = \frac{3.5 \text{ million gallons}}{0.5 \text{ day}} = 7 \text{ mgd}
\]

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:

\[
\frac{7.48 \text{ gal}}{1 \text{ cu ft}} \quad \text{or} \quad \frac{1 \text{ cu ft}}{7.48 \text{ gal}}
\]

to convert cubic feet units into gallons or vice versa

\[
\frac{10 \text{ cu ft}}{1} \cdot \frac{7.48 \text{ gal}}{1 \text{ cu ft}} = \frac{(10 \text{ cu ft})(7.58 \text{ gal})}{1 \text{ cu ft}} = 75.8
\]

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.

\[
\frac{10 \text{ gal}}{1} \cdot \frac{1 \text{ cu ft}}{7.48 \text{ gal}} = \frac{(10 \text{ gal})(1 \text{ cu ft})}{7.48 \text{ gal}} = 1.34 \text{ cu ft}
\]
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

\[
D_t = \frac{\text{volume}}{\text{flow}}
\]

\[
D_t = \frac{675,460 \text{ gal}}{1,000,000 \text{ gal/day}} = 0.675 \text{ days}
\]

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

\[
D_t = \frac{426 \text{ ft}^3}{1,000 \text{ cfs}} = \frac{426 \text{ ft}^3}{1,000 \text{ ft}^3/\text{sec}} = 0.426 \text{ sec}
\]

**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

\[
\frac{(0.11)(V_1)}{0.11} = \frac{(0.0075)(100)}{0.11}
\]

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
The word is given below.

Notice how the units cancel out leaving the answer in hours.

\[
\text{Time} = \frac{43,000 \, \text{ft}^3}{2.7 \, \text{ft}^3/\text{sec} \cdot \frac{1 \, \text{min}}{60 \, \text{sec}} \cdot \frac{1 \, \text{hr}}{60 \, \text{min}}} = 4.42 \, \text{hr}
\]

**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 ft³.

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

Use the factor to convert cubic feet into gallons.

\[
\text{volume} = \frac{120,000 \, \text{cu ft}}{1} \cdot \frac{7.48 \, \text{gal}}{1 \, \text{cu ft}} = 897,600 \, \text{gal}
\]

**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:

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

b. 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
The solution is presented in two parts.

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

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(702) = 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 ft\(^2\))(47 ft) = 180,785.5 ft. \( ^3 \)

However, you want the volume in gal so use the factor \( \frac{7.48 \text{ gal}}{1 \text{ cu. ft}} \) to convert.

Volume in gallons = \( \frac{(180,785.5 \text{ ft}^3) \left( \frac{7.48 \text{ gal}}{1 \text{ ft}^3} \right)}{1} = 1,352,275.54 \text{ gal} \)

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 hour or factors \( \frac{60 \text{ min}}{1 \text{ hour}} \) or \( \frac{1 \text{ hour}}{60 \text{ min}} \) to convert. You want the hour unit to cancel out, so you will use the first factor. The time becomes:

Rate of flow in gal per minute = \( \frac{1,352,275.54 \text{ gal}}{360 \text{ min}} = 3,756.32 \text{ gal per min} \)

**Section 3: 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.
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**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. Be sure to use only an approved calculator for the test site (a list is available at www.cwea.org/cbt). 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.

**Write Out Problems.** You will be given a dry erase sheet to use at the test site. Practice math problems using scratch paper. Use this 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.
Section 4: 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. Take the practice test in this study guide 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 in your wallet 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. You are not allowed to use notes on the exam, so be sure to put the list away so that your honesty is not questioned. When you start your test, quickly write these formulas or facts on your dry erase sheet. 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 test site—before, during, and maybe even after. Different people have different ways of dealing with their anxiety during tests (and remember, they are likely to be taking a completely different test than you). 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


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 ft³ 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

Technical Terms

40 CFR 121-124: The federal storm water regulations for the permitting of municipalities and industries. Regulations define storm water terms, permitting, inspecting, and sampling requirements.

40 CFR 136: The regulations for sampling preservation and analyses of water, wastewater, and solid waste.

40 CFR 403: The federal regulations defining the elements of a pretreatment program, prohibited discharges, and the approval process for establishing a pretreatment program.

Acid: A compound which liberates hydrogen ions and has a pH below 7.

Alkalinity: The measurement of a sample's capacity to neutralize acid.

Approval Authority: The agency determining whether a pretreatment program contains the necessary elements to meet the intent of the Act.

Atomic Weight: The sum of the number of protons and the number of neutrons in the nucleus of an atom. Atomic weights of elements are found on periodic tables.

Base: A compound which liberates hydroxide ions and has a pH above 7.

Biochemical Oxygen Demand (BOD): The quantity of oxygen utilized in the biochemical oxidation of organic matter under standard laboratory procedures for five days at 20° Centigrade, usually expressed as a concentration (e.g., mg/L). BOD measurements are used to indicate the organic "strength" of wastewater.

Biological Treatment: A waste treatment process by which bacteria and other microorganisms break down complex organic or inorganic (e.g., ammonia) materials into simple, nontoxic, more stable compounds.

Categorical Industrial User (CIU): An industrial user (see IU definition below) that is conducting processes subject to a categorical standard promulgated by the U.S. EPA.

Centrifugal Pumps: Pumps using centrifugal force to convey liquid. Discharge will vary according to inlet and discharge pressure.

Chain-of-Custody: A legal record (which may be a series of records) of each person who had possession of an environmental sample, from the person releasing the sample, to the person who collected the sample, to the person who analyzed the sample in the laboratory, to the person who witnessed the disposal of the sample.

Chemical Oxygen Demand (COD): The amount of oxygen (expressed in mg/L) consumed from the oxidation of pollutants during a specific test. As such, COD is a measure of the oxygen-consuming capacity of the pollutants present in wastewater. The results of the COD test are not necessarily related to the BOD, because the chemical oxidant responsible for utilizing the oxygen may react with substances which bacteria do not stabilize.
Appendix B: Glossary

Cipolletti Weir: A trapezoidal sharp-crested weir for measurement of liquid discharge in open channels.

Clean Water Act (CWA): Public law (PL 92-500) enacted in 1972, which 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 set forth the authority for the U.S. EPA to establish pretreatment standards for existing and new sources discharging industrial wastewater to publicly owned treatment works (POTWs).

Composite Sample: A collection of individual samples obtained at regular intervals, based either on flow or time. The individual samples are combined proportionally.

Concentration Based Discharge Limits: Allowable concentration of a pollutant in wastewater discharges, usually expressed as a concentration (i.e., mg/L) in the discharge.

Confined Space: A space which has limited openings for entry and exit, has unfavorable natural ventilation which could contain or produce dangerous air contaminants (or create an atmosphere of oxygen deprivation), and which is not intended for continuous employee occupation. A permit may be required under OSHA to enter a confined space.

Control Authority: The agency responsible for implementing a pretreatment program.

Conventional Pollutants: Those pollutants which are usually found in domestic, commercial or industrial wastes (such as suspended solids or biochemical oxygen demand) that POTWs are designed to treat.

Density: The relationship between weight and volume, e.g., grams per cubic centimeter or pounds per gallon.

Detention Times: The residence time of wastewater undergoing treatment in a treatment unit such as a clarifier or tank. Minimum detention times are required for settling, chemical treatment, and biological treatment.

Doppler Flow Meter: A device that measures the velocity of a liquid by measuring the change in frequency between a wave source and the meter.

Electroplating: The process of applying a thin metal coating to the surface of a substrate by electrodeposition of dissolved metal in a plating solution.

Flow Equalization: Temporary storage of wastewater flow to provide more uniform flow or waste characteristics for treatment or discharge.

Flume: A specially shaped open channel flow section with an area and/or slope that is different from that of the channel.

Grab Sample: A sample which is taken from a wastestream without regard to the flow in the wastestream, and over a period of time not to exceed 15 minutes.

Holding Time: The maximum time allowed between when a sample is taken and when it must be analyzed in the laboratory, in accordance with standard preservation, storage, and analytical procedures.

Dissolved Sulfide (H2S): Produced by the biological reduction of sulfate and organic matter under anaerobic (oxygen-free) conditions. Dissolved sulfide can combine with hydrogen to form hydrogen sulfide gas. H2S gas is potentially hazardous to sewer maintenance workers.
**Industrial User (IU):** Any non-domestic source which introduces pollutants into a POTW.

**Industrial Wastewater:** Any non-domestic wastewater (excluding storm water).

**Magnetic Flowmeter:** A flowmeter that creates a magnetic field across a pipe flowing full, in which the liquid acts as a conductor to measure the velocity and flow in the pipe.

**Mass Based Limits:** Discharge limits based on allowable dry weight of pollutant, usually expressed in pounds per day (lbs/day).

**Mass Emission Rate:** The rate of discharge of the dry weight of a pollutant in wastewater or air, expressed in lbs/day or kilograms per day (kg/day).

**Material Safety Data Sheets (MSDS):** Sheets providing information about manufactured chemicals, as required by the Hazard Communication Rule.

**Molarity:** Moles per liter; a measure of concentration.

**Mole:** An Avogadro's number of something.

**Molecular Weight:** The sum of the atomic weights of all atoms making up a molecule.

**National Pollutant Discharge Elimination System (NPDES):** The federal permitting program designed to control all discharges of pollutants from point sources into U.S. waterways, as required under the CWA.

**National Prohibited Discharge Standards:** Prohibitions, applicable to all nondomestic dischargers, regarding the introduction of pollutants into POTW as set forth in 40 CFR 403.5.

**Neutralization:** Addition of an acid or alkali (base) to a liquid to cause the pH of the liquid to move toward a neutral pH of 7.0.

**Normality:** A measure of the concentration of a solution.

**Oxidation-Reduction:** Reactions involving the transfer of electrons, with oxidation being the loss of electrons and reduction being the gain of electrons. ORP, or oxidation-reduction potential, is a qualitative measure of the state of oxidation in metal waste treatment systems. ORP is used to control the chemical addition to optimize the oxidation of compounds such as cyanide or reduction of metals such as hexavalent chromium.

**Parshall Flume:** An open channel flow measuring device with a constricted throat that produces a head or water depth that is related to discharge.

**Pass-Through:** The passage of untreated pollutants through a POTW which could violate applicable water quality standards or NPDES effluent limitations.

**pH:** The negative logarithm of the hydrogen ion (H+) concentration; the measure of the relative acidity or alkalinity of a solution on a scale from 0 (acidic) to 14 (basic).

**Pollutants of Concern (POC):** Compounds in wastewater that pose a potential threat to the POTW or its ability to comply with environmental standards.
**Positive Displacement Pumps**: Pumps that use pistons, diaphragm action, etc., to convey liquid. The discharge rate of these pumps does not vary with inlet or outlet pressure.

**Pretreatment Standard**: Any regulation promulgated by the EPA in accordance with Sections 307(b) and (c) of the Clean Water Act, applying to a specific category of industrial users and providing limitations on the introduction of pollutants into POTWs. This term includes BMPS, the prohibited discharge standards under 40 CFR 403.5, and local limits [per 40 CFR 403.3 (j)].

**Precipitation**: Part of a treatment process that takes dissolved pollutants out of solution to form a precipitate that can be removed by filtration or settling.

**Printed Circuit Board**: A circuit for electronic apparatus made by depositing conductive material, usually copper, on an insulating surface.

**Process-Inhibition**: The concentration of a pollutant that will reduce the effectiveness or efficiency of a biological treatment process in the POTW.

**Publicly Owned Treatment Works (POTW)**: A treatment works which is owned by a state, municipality, city, town, special sewer district, or other publicly owned and financed entity, as opposed to a privately owned (industrial) treatment facility. This definition includes any devices and systems used in the storage, treatment, recycling and reclamation of municipal sewage or industrial wastes of liquid nature. It also includes sewers, pipes and other conveyances only if they convey wastewater to a POTW treatment plant. The term can also mean the municipality (public entity) which has jurisdiction over the indirect discharges to and the discharges from such a treatment works.

**Settling**: The treatment process by which settleable or floatable solids are removed from wastewater by gravity separation in a tank or other vessel.

**Sludge Quality Standard**: Allowable concentration or mass of a pollutant in POTW sludge, or biosolids, used for land application, found in 40 CFR 503.

**Specific Gravity**: (1) The weight of a particle, substance, or chemical solution in relation to the weight of an equal volume of water. Water has a specific gravity of 1.000 at 4°C (39°F). (2) The weight of a particular gas in relation to an equal volume of air at the same temperature and pressure. Air has a specific gravity of 1.0. Chlorine, as a gas, has a specific gravity of 2.5.

**Total Suspended Solids (TSS)**: Residue (expressed as mg/L) that is removed from a wastewater sample by a standard laboratory filtration procedure.

**Turbine Meter**: A positive displacement meter with an internal turbine turned by the water flow. Flow is proportional to the turbine rotation speed.

**V-notch Weir**: A triangular sharp-crested weir for measurement of liquid discharge in open channels.

**Volatile Solvents**: A solvent that is capable of being evaporated or changed to a vapor at relatively low temperatures.

**Weir**: A dam built across an open channel over which liquid flows, usually through some type of opening or notch.
**Wet Well:** A compartment or tank in which wastewater is collected. The suction pipe of a pump may be connected to the wet well or a submersible pump may be located in the wet well.

**Worker Right-to-Know Laws:** Legislation that requires employers to inform employees of the possible health effects resulting from contact with hazardous substances. At locations where this legislation is in force, employers must provide employees with information regarding any hazardous substances that they might be exposed to under normal working conditions or reasonably foreseeable emergency conditions resulting from workplace conditions. OSHA's Hazard Communication Standard (HCS) (29 CFR Part 1910.1200) is the federal regulation. There are also state statutes that are called Right-to-Know Laws.

**Management and Supervision Terms**

**Ability:** The quality of being able to perform; a natural or acquired skill or talent.

**Accident:** Unplanned or uncontrolled event in which action or reaction of an object, material, or person results in personal injury.

**Accountability:** Non-assigned liability for the manner in which an organizational obligation held by a member is discharged, either personally or by subordinates.

**Active listening:** Conscious process of securing information through full attention, intent listening, and alert observation.

**Affirmative Action:** In-company program designed to remedy current and future employment inequities. Americans with Disabilities Act (ADA): Prohibits employment discrimination based on a person’s mental or physical disability.

**Appraisal interview:** Meeting held between a supervisor and an employee to review performance rating and, using the evaluation as a basis, to discuss overall quality of work performed, and methods of improvement, if necessary.

**Arbitration:** Labor dispute or employee grievance settlement by an impartial umpire selected through mutual agreement by organization and worker’s union.

**Attrition:** Reduction in a work force due to natural events and causes, (e.g., retirement, death, resignation), as opposed to planned reductions (e.g., discharges, layoffs, early retirement).

**Authority:** The power needed to do a specific job, or to carry out one’s responsibilities, usually handed down from immediate bosses or superior.

**Body language:** Nonverbal body movements, facial expressions and/or gestures that project or reveal underlying attitudes and sentiments.

**Budget:** Plan, or forecast, especially of allowable expenses in operation of a department.

**Budgetary control:** Planning and reporting system incorporating standards for operating conditions and results, as well as costs and expenses, within a single document.

**Certification Exam:** An examination administered by a state or professional association that candidates take to indicate a level of professional competence.
**Chain-of-Command:** Formal channels in an organization that distributes authority from top down.

**Code of Federal Regulations (CFR):** A publication of the United States Government that contains all of the proposed and finalized federal regulations, including environmental.

**Collective bargaining:** Process of give-and-take engaged in by management and collective employees representatives to reach formal, written agreement about wages, hours, and working conditions.

**Communication process:** Giving and receiving information and understanding, such as between a supervisor and an employee, leading to a desired action or attitude.

**Computerized Maintenance Management System (CMMS):** A computerized system to assist with the effective and efficient management of maintenance activities through application of computerized elements including: work orders, routine standard jobs, bills of materials, application parts, and lists of numerous other features.

**Competition:** Relatively healthy struggle among individuals or organizational groups to excel in striving to meet mutually beneficial goals.

**Conflict:** Disruptive clash of interests, objectives, or personalities, between individuals or groups within an organization.

**Control:** To exercise authoritative influence over; the authority or ability to manage and/or direct. Cost-benefit analysis: Technique for weighing pros and cons of alternative actions, in which both intangible benefits as well as costs are assigned dollar values.

**Cost variance report:** Listing of allowable expenses compared with actual expenses incurred.

**Decision-making:** Part of the problem-solving process that entails evaluation of alternative solutions and a choice of an effective action.

**Delegation:** The act in which authority is given to another person in the organization to accomplish a specific job.

**Differential treatment:** The act of treating a minority or protected group member differently from other applicants or employees.

**Discipline:** Imposition by management—in such a manner as to encourage more constructive behavior—of a penalty on an employee for infraction of a rule, regulation, or standard.

**Discrimination:** Managerial action or decision based on favoring or disfavoring one person or group member over another on the basis of race, color, ethnic or national origin, sex, age, handicap, Vietnam era war service, or union membership.

**Division of work:** Principle that performance is more efficient when a large job is broken down into smaller, specialized tasks.
**Due process:** Employee’s legal entitlement to a fair hearing, usually before an impartial party and with appropriate representation, before discipline can be meted out.

**Employee turnover:** Measure of how many people come to work for an organization and do not remain employed by that organization, for whatever reason.

**Ergonomics:** Study of how workers react to their physical environment; used in design of more comfortable and productive workstations.

**Equal Employment Opportunity (EEO):** System of organizational justice, stipulated by law, that applies to all aspects of employment; intended to provide equal opportunity for all members of the labor force.

**Feedback:** Process of relaying measurement of actual performance back to an individual or unit, so that action can be taken to correct, or narrow, the variance.

**Gantt Chart:** Chart that enables a planner to schedule tasks in the most productive sequence, and that also provides a visual means for observing and controlling progress.

**Geographical Information System (GIS):** An integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, images, and other resource data that are geographically referenced.

**Grievance:** Job-related complaint stemming from an injury or injustice, real or imaginary, suffered by an employee, for which relief or redress from management is sought.

**Grievance procedure:** Formalized, systematic channel for employees to follow in bringing complaints to the attention of management.

**Hazard:** Potentially dangerous object, material, condition, or practice present in the workplace, to which employees must be alert and from which they must be protected.

**Hostile Work Environment:** Conditions such as harassment, offensive speech, or unwelcomed conduct, that create an abusive, antagonistic, or inhospitable work place.

**Information Management System (IMS):** System comprised of data processing devices, programs, and people that collects, analyzes, exchanges, and delivers information to an organization in such a manner as to aid managers in making decisions.

**Information:** Dates, past or present facts, observations, or conclusions, collected in numbers and words that have been selected, arranged, and analyzed (processed) to make them useful for a specific human (managerial) activity.

**Injury Illness Prevention Plan:** Plan required by California Senate Bill (SB) 198 to establish, implement, and maintain an effective program helping assure employee safety while on the job. It includes eight elements: management assignments and responsibilities, safety communications system with the employees, system assuring employee compliance with safe working practices, scheduled inspections and compliance system, accident investigation, health and safety training and instruction, and record-keeping and documentation.
**Injury Illness Prevention Plan**: Plan required by California Senate Bill (SB) 198 to establish, implement, and maintain an effective program helping assure employee safety while on the job.

**It includes eight elements**: management assignments and responsibilities, safety communications system with the employees, system assuring employee compliance with safe working practices, scheduled inspections and compliance system, accident investigation, health and safety training and instruction, and record-keeping and documentation.

**Job breakdown analysis**: Segmentation of a job into key elements, or steps, which require an employee to perform, induce, or supervise an action that advances work toward completion.

**Job evaluation**: Systematic technique for determining job worth, compared with other jobs in an organization.

**Just cause**: Reason for a disciplinary action that is accurate, appropriate, well founded, deserved and meets the test of prior notification of unacceptable behavior and its penalty.

**Knowledge**: Information that can be learned from reading, listening to an expert, or keenly observing a situation; often a prerequisite to skill development.

**Management**: Process of obtaining, deploying, and utilizing a variety of essential resources in support of an organization’s objectives.

**Management by objectives (MBO)**: Planning and control technique where supervisors and their immediate superiors agree on goals to be attained and/or standards to be maintained.

**Management development**: Systematic program for improving the knowledge, attitudes, and skills of supervisors and managers.

**Management principles**: Set of guidelines established for carrying out the management process.

**Management process**: General sequence of five unique functions—planning, organizing, staffing, directing or activating, and controlling—provided by managers for any organization.

**Manager**: An individual who plans, organizes, directs, and controls work of others in an organization.

**Material Safety Data Sheets (MSDS)**: Sheets providing information about manufactured chemicals, as required by the Hazard Communication Rule (HCR).

**Mentor**: Knowledgeable, often influential, individual who takes an interest in, and advises, another person concerning that person’s career.

**Morale**: Measure of the extent of voluntary cooperation—as well as the intensity of desire—to meet common work goals, as demonstrated by an individual or work group.

**Motivation**: Process that impels someone to behave in a certain manner in order to satisfy highly individual needs.

**Networking**: Informal process of getting to know, and create confidence among others who—through mutual exchange—help advance one’s career.
**Non-managerial employees**: Workers who receive direction from managers, who perform specific, designated tasks, and who are responsible only for their own performance.

**Organizing**: Deciding who does what work and delegating authority to the appropriate person.

**Organization**: Structure derived from systematically grouping tasks to be performed, and from prescribing formal relationships that strengthen the ability of people to work together more effectively.

**Performance appraisal**: Formal and systematic evaluation of how well a person performs work and fills an appropriate role in the organization.

**Penalty**: Punishment or forfeiture imposed as discipline by management on an employee.

**Personality**: An individual’s unique way of behaving and of interpreting events and the actions of others.

**PERT Chart**: Graphic technique for planning a project in which a large number of tasks must be coordinated, by showing the relationship between tasks and critical bottlenecks that may delay progress towards completion.

**Policies**: Broad guidelines, philosophy, or principles which management establishes and follows in support of organizational goals.

**Procedures**: Methods, prescribed by management, for the proper and consistent forms, sequences, and channels to be followed by individuals and units of an organization.

**Productivity**: Measure of efficiency that compares operational output value with cost of resources used.

**Progressive Discipline**: Providing increasingly harsh penalties for substandard performance or broken rules, as the condition continues or the infraction is repeated.

**Quid pro quo**: An equal exchange or substitution; e.g., as applied to sexual harassment, when a supervisor threatens to fire or not promote an employee if they do not provide sexual favors in return.

**Regulations**: Special rules, orders, and controls set forth by management, restricting the conduct of units and or individuals within an organization.

**Reprimand**: Severe expression of disapproval or censure by management of an employee, usually written as well as oral, and retained in an employee’s personal file.

**Responsibilities**: Those duties one is held accountable for.

**Responsibility**: Duty or obligation to perform a prescribed task or service or attain an objective.

**Retributive**: Punishment inflicted as vengeance.

**Reverse discrimination**: Notion that implementation of affirmative action deprives qualified members of non-protected groups of their rightful opportunities.

**Satisfaction**: State that exists when motivating needs—such as interesting and challenging work, full use of one's capabilities, or recognition for achievement—are met.
**Schedules**: Detailed assignments dictating how facilities, equipment, and/or individuals are used, according to times and dates, in accomplishment of organizational objectives.

**Sexual Harassment**: Unwanted sexual advances, requests for sexual favors, or other visual, verbal, or physical conduct of a sexual nature, which is conditioned upon an employment benefit, unreasonably interferes with an individual’s work performance, or creates an offensive work environment.

**Skill**: The capacity to perform a job related action by blending relevant knowledge and physical or perceptual ability.

**Specification**: Collection of standardized dimensions and characteristics pertaining to a product, process, or service.

**Stereotype**: Characterization of an individual on the basis of a standardized, oversimplified view of characteristics believed to be held in common by a group to which the individual is assumed to belong.

**Supervisor**: Manager who is in charge of, and coordinates, activities of a group of employees engaged in related activities within a department, section, or unit of an organization.

**Suspension**: Temporary removal by management of an employee privilege (such as the right to report to work and receive pay for it) until proper actions have been determined and imposed.

**Time budget**: Charting technique for planning the systematic distribution of a supervisor’s time.

**Theory X**: Negative approach to human relations in which a supervisor presumes most people don’t like to work and thus need to be pushed or threatened.

**Theory Y**: Positive approach to human relations whereby a supervisor presumes that, given meaningful work, most people will try hard to achieve, especially when there is an opportunity to improve their self-regard.

**Tolerance**: Permissible deviation, or variance, from a standard.

**Type A individual**: Person characterized by high standards of achievement and an urgency to attain them, who is especially susceptible to stress.

**Unfair labor practices**: Practices engaged in by management or labor unions that are judged by federal labor law to be improper, especially when they interfere with the right to organize or when they discriminate against labor union activities.

**Unity of Command**: Principle that each individual should report to only one boss.

**Unity of Direction**: Principle that there should be a single set of goals and objectives that unites the activities of everyone in an organization.

**Variance**: Gap, or deviation, between actual performance, condition, or result and a standard of expected performance, condition, or result.

**Warning**: A reprimand so worded as to give formal notice to an employee that repetition of a particular form of unacceptable behavior will draw a penalty.

**Worker’s compensation**: Financial reparations or awards granted by an employer to an employee who has suffered an on-the-job injury or illness that is judged to have permanently restricted the employee’s earning capacity.
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### Appendix C

**Common Acronyms and Abbreviations**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>AA</td>
<td>atomic absorption</td>
</tr>
<tr>
<td>AC</td>
<td>alternating current</td>
</tr>
<tr>
<td>AC</td>
<td>acre</td>
</tr>
<tr>
<td>AF</td>
<td>acre-foot (feet)</td>
</tr>
<tr>
<td>AFY</td>
<td>acre-foot per year</td>
</tr>
<tr>
<td>AMSA</td>
<td>Association of Metropolitan Sewerage Agencies</td>
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<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
</tr>
<tr>
<td>APHA</td>
<td>American Public Health Association</td>
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<tr>
<td>AS</td>
<td>activated sludge</td>
</tr>
<tr>
<td>ASCE</td>
<td>American Society of Civil Engineers</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
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<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
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<tr>
<td>AWT</td>
<td>advanced wastewater treatment</td>
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<tr>
<td>AWWA</td>
<td>American Water Works Association</td>
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<tr>
<td>BECP</td>
<td>Business Emergency and Contingency Plan</td>
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<tr>
<td>BMP</td>
<td>Best Management Practice</td>
</tr>
<tr>
<td>BMR</td>
<td>Baseline Monitoring Report</td>
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<tr>
<td>BNR</td>
<td>biological nutrient removal</td>
</tr>
<tr>
<td>BOD5</td>
<td>biochemical oxygen demand after 5 days</td>
</tr>
<tr>
<td>BTU</td>
<td>British thermal unit</td>
</tr>
<tr>
<td>C</td>
<td>Celsius</td>
</tr>
<tr>
<td>Cal-OSHA</td>
<td>California Occupational Safety and Health Act</td>
</tr>
<tr>
<td>Cal-EPA</td>
<td>California Environmental Protection Administration</td>
</tr>
<tr>
<td>CBOD</td>
<td>carbonaceous biochemical oxygen demand</td>
</tr>
<tr>
<td>CCE</td>
<td>carbon chloroform extract</td>
</tr>
<tr>
<td>CCR</td>
<td>California Code of Regulations</td>
</tr>
<tr>
<td>cf</td>
<td>cubic feet (foot)</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>cfs</td>
<td>cubic feet per second</td>
</tr>
</tbody>
</table>
Appendix C: Common Acronyms and Abbreviations

CH4  Methane
CIU  Categorical Industrial User
CM  common mode
CMOM  Capacity Management, Operations, and Maintenance
COD  chemical oxygen demand
CPU  central processing unit
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  (V/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
ERP  Enforcement Response Plan or Emergency Response Plan
F  Fahrenheit
F/M  food to microorganism ratio
ft  feet (foot)
ft²  square foot
ft³  cubic feet
FTU  formazin turbidity unit
GAC  granular activated carbon
gal  gallon
GFI  ground fault interrupter
GPD  gallons per day
GPM  gallons per minute
GTAW  gas tungsten arc welding
Appendix C: Common Acronyms and Abbreviations

H2S  hydrogen sulfide
HCP&ERP  Hazard Communications Program and Emergency Response Plan
Hp  horsepower
HPLC  high-performance liquid chromatography
Hz  Hertz
IC  ion chromatograph
ICE  Institute for Credentialing Excellence (formerly NOCA)
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 1,000
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
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>mL</td>
<td>milliliter</td>
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<tr>
<td>MLSS</td>
<td>mixed liquor suspended solids</td>
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<tr>
<td>MLVSS</td>
<td>mixed liquor volatile suspended solids</td>
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<tr>
<td>MMI</td>
<td>Man Machine Interface</td>
</tr>
<tr>
<td>MOP</td>
<td>Manual of Practice</td>
</tr>
<tr>
<td>MPN</td>
<td>most probable number</td>
</tr>
<tr>
<td>MR&amp;R</td>
<td>Monitoring and Reporting Requirements</td>
</tr>
<tr>
<td>MS</td>
<td>mass spectrometer</td>
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<tr>
<td>MSDS</td>
<td>Material Safety Data Sheets</td>
</tr>
<tr>
<td>MTBF</td>
<td>mean time between failures</td>
</tr>
<tr>
<td>MTTR</td>
<td>mean time to repair</td>
</tr>
<tr>
<td>N</td>
<td>normal</td>
</tr>
<tr>
<td>NEC</td>
<td>National Electrical Code</td>
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<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
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<tr>
<td>NEPA</td>
<td>National Environmental Policy Act</td>
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<tr>
<td>NM</td>
<td>Normal Mode</td>
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<tr>
<td>NOD</td>
<td>nitrogenous oxygen demand</td>
</tr>
<tr>
<td>NPDES</td>
<td>National Pollutant Discharge Elimination System</td>
</tr>
<tr>
<td>NPSH</td>
<td>net positive suction head</td>
</tr>
<tr>
<td>NTU</td>
<td>nephelometric turbidity unit(s)</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>operation and maintenance</td>
</tr>
<tr>
<td>OCT</td>
<td>Operator Certification Test (State of California)</td>
</tr>
<tr>
<td>OES</td>
<td>Office of Emergency Services</td>
</tr>
<tr>
<td>OMR</td>
<td>operations, maintenance, and replacement</td>
</tr>
<tr>
<td>OOC</td>
<td>Office of Operator Certification (SWRCB)</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Administration/Act</td>
</tr>
<tr>
<td>OTE</td>
<td>oxygen transfer efficiency</td>
</tr>
<tr>
<td>P</td>
<td>Pico, a metric prefix meaning one millionth of a millionth, or one trillionth (10⁻¹²)</td>
</tr>
<tr>
<td>PC</td>
<td>personal computer</td>
</tr>
<tr>
<td>PCB</td>
<td>polychlorinated biphenyls</td>
</tr>
<tr>
<td>pH</td>
<td>potential of hydrogen</td>
</tr>
<tr>
<td>P&amp;ID</td>
<td>piping and instrumentation diagram</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>PID</td>
<td>proportional gain, integral action time and derivative action time</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>POTW</td>
<td>Publicly Owned Treatment Works</td>
</tr>
<tr>
<td>PPB</td>
<td>parts per billion</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
</tr>
<tr>
<td>PPM</td>
<td>parts per million</td>
</tr>
<tr>
<td>prct</td>
<td>percent</td>
</tr>
<tr>
<td>psi</td>
<td>pound per square inch</td>
</tr>
<tr>
<td>PSIA</td>
<td>pounds per square inch absolute</td>
</tr>
<tr>
<td>PSID</td>
<td>pounds per square inch differential</td>
</tr>
<tr>
<td>PSIG</td>
<td>pounds per square inch gage</td>
</tr>
<tr>
<td>PVC</td>
<td>polyvinyl chloride (pipe)</td>
</tr>
<tr>
<td>QA/QC</td>
<td>quality assurance/quality control</td>
</tr>
<tr>
<td>RAS</td>
<td>return activated sludge</td>
</tr>
<tr>
<td>RBC</td>
<td>rotating biological contactor</td>
</tr>
<tr>
<td>RCP</td>
<td>reinforced concrete pipe</td>
</tr>
<tr>
<td>RFI</td>
<td>Radio Frequency Interference</td>
</tr>
<tr>
<td>RMS</td>
<td>root mean square</td>
</tr>
<tr>
<td>RTD</td>
<td>resistance temperature device</td>
</tr>
<tr>
<td>RWQCB</td>
<td>Regional Water Quality Control Board (State of California)</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory Control and Data Acquisition</td>
</tr>
<tr>
<td>SCR</td>
<td>semiconductor (or silicon) controlled rectifier</td>
</tr>
<tr>
<td>SD</td>
<td>standard deviation</td>
</tr>
<tr>
<td>SDI</td>
<td>sludge volume index</td>
</tr>
<tr>
<td>sec</td>
<td>second</td>
</tr>
<tr>
<td>SI</td>
<td>System Internationale D'Unites (metric units)</td>
</tr>
<tr>
<td>SMR</td>
<td>Self-Monitoring Report</td>
</tr>
<tr>
<td>SS</td>
<td>suspended solids</td>
</tr>
<tr>
<td>SSO</td>
<td>sanitary sewer overflow</td>
</tr>
<tr>
<td>SVI</td>
<td>sludge volume index</td>
</tr>
<tr>
<td>SVR</td>
<td>sludge volume ratio</td>
</tr>
<tr>
<td>SWRCB</td>
<td>(California) State Water Resources Control Board</td>
</tr>
<tr>
<td>TAC</td>
<td>Technical Advisory Committee</td>
</tr>
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</table>
Appendix C: Common Acronyms and Abbreviations

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
m  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
WDO/WDR  Waste Discharge Order/Waste Discharge Requirement
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