Need-to-Know Criteria

Maintenance Technologists School Class III
February 2011

Suggested Reference Materials

All of the below listed reference manuals are available through the NC AWWA-WEA Book Store
Go to: http://www.ncsafewater.org/

- Either of one (1) of these three (3) California State University (CSUS), Sacramento (SAC) Foundation, Office of Water Programs
  - Operation of Wastewater Treatment Plants, Volume II (WW SAC)
  - Industrial Waste Treatment, Volume II (Ind W SAC)
  - Water Treatment Plant Operation, Volume II (W SAC)

  These manuals are also available through the NC AWWA-WEA Bookstore.

- Pumps and Pumping (PP) / Arasmith Consulting
- Electrical Fundamentals for Water and Wastewater (EFWW) / Arasmith Consulting
- Industrial Maintenance, 3rd Edition, by Denis Green & Jonathon F. Gosse (Ind. Maint.)
- Need to Reference / Code of Federal Regulations(CFR), Title 29, Part 1910 Occupational Safety and Health Standards Available at: www.osha.gov; click on Standards

Students will Need-to-Know the Criteria for Maintenance Technologists Class 1, 2 & 3

Materials, Tools and Lubrication

1. Required Advanced Material Selection – Adhesives, Anti-seize compounds, Coatings/Paints, Epoxy, Fastening Devices, Gaskets, Locking Compounds, Metals, O-rings, Plastics, Sealants, Shims, Solvents
   (Volume 2, 5th Edition) Reference / W SAC / Chapter 20
   (2nd Edition)Reference / Ind. Maint. / Chapter 2

2. Required Advanced Knowledge of Materials – Application Procedures, Corrosion Control, Material Compatibility, Material Safety Data Sheets
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 20, 22, 23

   (Volume 2, 5th Edition) Reference / W SAC/Chapter 18, 19, 20 Reference / Ind. Maint. / Chapter 3

4. Required Advanced Knowledge of Ancillary Crafts – Welding/Cutting Equipment
5. Required Advanced Use of Precision Tools – Alignment, Caliper, Dial Indicator, Laser, Micrometer
6. Required Advanced Knowledge of Tools – Accuracy, Non Sparking, Precision, Sharpening, Tool Storage
7. Required Advanced Use of Lubricants – Grease, Oil, Water

Pumps

1. Management of Pump Repair
2. Management of Pump Preventive Maintenance
3. Pump Troubleshooting
4. Determining Pump Condition with Pump Hydraulics
5. Air binding: Removal of Air
6. Cavitation: Avoidance
7. Operating against a Closed Valve: Closed/Partially Opened
   a. How does pump respond?
8. Pump Curves: Reading and Uses
   a. System Head Curve
   b. System Static Head
   c. Effects of Pump Diameter change on Pump Curve
9. Pump Efficiency; Read and Calculate
10. Pump Hydraulics/Head: Horsepower, NPSH, TDH, Static Head Capacity
11. Reverse Rotation/Non Reverse Rotation: Differences and Uses
   a. Non-Reversing Ratchet: How it Works
12. Water Hammer: Surge Control and ARV’s
   a. Well Vents
   b. Control Valves
13. Control Systems: Types and Uses
   a. Level Control Types
14. Knowledge of pump components
15. Impellers: Types, Installation and Removal
Rotating Components

1. Bearing Types and Applications

(4th Edition) Reference / Audel / Chapter 17, 18, 19
(9th Edition) Reference / PP / Lesson 3
Reference / Ind. Maint. / Chapter 9

2. (Mostly applications as Types appear to have been covered some in I and II – Match the load and type of force with proper bearing

Ball, Needle, Radial, Roller, Spherical, Tapered, Thrust, Babbitt, Sleeve, linear

3. Self Aligning non friction

4. Bearing materials

a. Babbitt
b. PTFE
c. Nylon
d. Bronze Impregnated
e. Ceramic – Rolling element

5. Bearing identification and nomenclature

a. Numbering
b. Conrad style vs. Max Style

6. Bearing protection
   a. Housings
   b. Seals
   c. Shields
   d. Storage

7. Shafts
   (4th Edition) Reference / Audel / Chapter 24

8. Specifications for use
   a. Metal
   b. Clearance / Tolerance
   c. Journals
   d. Roundness

9. Rotating Assemblies – Fans, Blowers, Pumps
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 19
   a. Single stage vs. Multiple stage
   b. Alignment, and Vibration standards
   c. Key Factors
      i. Heat
      ii. RPM
      iii. Material Moved
      iv. Temperature

Motors and Drives

1. Motors – Characteristics and uses
   a. Key Terms
      i. Impedance, Induction, Capacitance
   (2nd Edition)Reference / EFWW / Lesson 3, Glossary
   b. Single Phase
   (2nd Edition)Reference / EFWW / Lesson 4
   (2nd Edition)Reference / EFWW / Lesson 37
   c. Capacitor Start / Capacitor Run
   d. Split Phase
   e. Permanent Split Capacitor
   f. Capacitor Start / Induction Run

2. Start Capacitors/Run Capacitors

3. Centrifugal Start Switches

4. Polyphase AC (3 Phase)

5. 3 Phase Induction Motor

6. Wye configuration

7. Delta configuration

8. Wye/Delta configuration

9. Part Winding start

10. Wound Rotor

11. DC Motors
   a. Electrical Properties
b. Permanent Magnet
c. Fields
d. Armature

12. Convert Hp to KVA and KVA to Hp

(2nd Edition) Reference / EFWW / Lesson 4

13. Mechanical Drives

Reference / Ind. Maint. / Chapter 9

14. Belt Types and Applications

a. V-Belts
b. Link Belt
c. Timing Belt
d. Flat Belt
e. Slip and Creep

15. Alignment & Tension

a. Straight Edge v. String alignment v Laser
b. Calculating proper tension

(4th Edition) Reference / Audel / Chapter 26
Reference / Ind. Maint. / Chapter 9

c. Ft lbs of force deflection per span (ctr to ctr of shaft)

16. Chain Sprockets and application

(4th Edition) Reference / Audel / Chapter 28
Reference / Ind. Maint. / Chapter 9

a. Single Hub
b. Double Hub
c. Inspection of Sprocket condition
d. Identification of sprockets (nomenclature)

17. Gear Types

(4th Edition) Reference / Audel / Chapter 29
Reference / Ind. Maint. / Chapter 9

a. External vs. Internal
b. Spur, Helical, Bevel, Worm, Mitre

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**Pipes and Valves**

1. Utilizing the proper operations, lubrication and maintenance procedures to maintain the following valves

(Volume 2, 5th Edition) Reference / W SAC / Chapter 15, Lesson 7

a. Gate
b. Plug
c. Butterfly
d. Globe
e. Check-Ball-Flapper
f. Pinch
g. Sluice
h. Shear
i. Diaphragm
j. Pressure Relief

2. Maintain the pipes, fitting and connections associated with plant piping systems

a. Pipes
   i. Ductile Iron, Cast Iron
ii. Clay
iii. Iron pipe
iv. PVC – Schedule 40 and 80
v. Steel
vi. Copper
vii. Concrete
viii. Stainless Steel

b. Fittings
   i. Elbows
   ii. Tees
   iii. Wyes
   iv. Reducers
   v. Sleeves
   vi. Adapters
   vii. Unions

c. Connections
   i. Flanges
   ii. Mechanical Joint
   iii. Bell & Spigot
   iv. Uni-flange
   v. PVC Cement
   vi. Solder
   vii. Threaded
   viii. Welded

3. Utilizing the proper procedures and techniques to inspect and maintain tanks and reservoirs
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, Lesson 5
   a. Steel
   b. Concrete
   c. Elevated
   d. Above Ground
   e. Below Ground
   f. Cathode Protection

4. Utilizing the proper procedures and techniques to inspect and maintain backflow preventers
   a. Air Gap
   b. Pressure Vacuum Breaker
   c. Double Check Valve Assembly
   d. Reduced Pressure Principle Assembly

5. Inspect, adjust or replace valve packing when applicable
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, Lesson 4

6. Lubricate valve gearing and rising stems
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, Lesson 4

7. Lap or replace valve body seats as required
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, Lesson 4

8. Adjust the gland on a plug valve
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, Lesson 4

9. Adjust clearances on sluice gates
   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, Lesson 4

10. Select proper valve for a specific application

11. Select the correct piping material for a specific application
12. Inspect, replace (cut if applicable) gaskets for various valves and piping systems

13. Select the appropriate sealant for threaded pipe connections

14. Utilizing the proper tooling chase existing or cut new threads for piping systems

15. Utilizing the proper maintenance procedures to glue PVC pipe and fittings using the correct cleaner, primer and glue

16. Utilizing the proper maintenance procedures to remove/install pipe hangers and restraints on piping systems

17. Utilizing the proper maintenance procedures and techniques to remove obstructions preventing flow through piping and valves

18. Utilizing the proper maintenance procedures to test and set lift and reseat pressure on a pressure relief valve

19. Utilize the proper procedures to inspect and maintain the different types of tanks and reservoirs

20. Utilize the proper procedures to inspect and maintain a cathode protection system

21. Utilize the proper procedures to recognize, inspect, maintain and test the different types of backflow preventers

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**Safety Practices**

1. Advanced Overview of Industrial Safety Standards
   a. Commercial Drivers License (CDL)
   b. Equipment Operator Certification
   c. Safety Practices

2. Follow Advanced Safety Procedures
   a. Chemical Handling
   b. Confined Space Entry
   c. Cross Connection Control
   d. Electrical Hazards
   e. Explosion proof lighting
   f. Extension cords
   g. Fire Safety
   h. Laboratory Safety
   i. Lock-out / Tag-out
   j. Traffic Control / Work zone safety
k. Required trenching & shoring  

3. Advanced Knowledge of Safety Procedures

a. Amperage  

b. Arc Flash

(c. Certification requirements)

d. Combustible gas devices

e. Emergency Response Plans

f. Fall/retrieval equipment

g. Fuel Tanks / Cans

h. Grounding

i. Job safety analysis

j. Lighting protection

k. Material Safety Data Sheets

l. Personal Protective Equipment

m. Rescue procedures

n. Resistance

o. Right to Know Law

p. Ventilation

q. Voltage

r. Wattage

s. Wire Sizing

t. Working over water
Pressure Vessels and Blowers

Advanced knowledge of compressors, blowers, boilers and associated devices.

1. Required Advance knowledge of Boilers
   a. Definition / MAWP (Maximum Allowable Working Pressure)
   b. Definition / BHP (Boiler Horse Power)
   c. Safety Valve Fitting
   d. Low Pressure Boiler / MAWP up to 15 psi
   e. High Pressure Boiler / MAWP 15 psi & over 6 BHP
   f. Firebox / Round Top, Flat Sides
   g. Safety Valves
   h. Definitions / Boiler Fittings & Accessories
   i. Feed water Valves
   j. Water Column
   k. Condensate Return Tanks
   l. Low Water Cutoff & Testing
   m. Feed water Regulators
   n. Bottom Blow down Valves
   o. Feed water Pumps
   p. Boiler Startup & Shutdown Procedures
   q. Boiler Water Treatment, Internal, External
   r. Types of Fans
   s. Steam Traps

2. Required Advance knowledge of Compressors / Blowers
   a. Compressor Maintenance
   b. Chiller Water Systems
   c. Pneumatic Systems
   d. Definition – Air Compressor
   e. Definition – Pneumatic Systems
   f. Compressor Types / Piston (Reciprocating, Single & Multi Stage), Vane, Centrifugal, Screw
   g. Relief Valve
   h. Inter & After Cooler
   i. Compressed Air Dryers
   j. Oil & Moister Separator
   k. Compressor Unloader
   l. The Control of Hazardous Energy (lockout/tag out)

Electrical Devices and Concepts

Advanced knowledge of electrical theory, electrical apparatus types, devices and operation
1. Required Advance Knowledge of Electrical Devices
   a. Ammeter
      (2nd Edition) Reference / EFWW / Lesson 7
   b. Conduit - National Electrical Code
      (2nd Edition) Reference / EFWW / Lesson 4
   c. Ground Fault Circuit Interrupters (GFCI)
      (2nd Edition) Reference / EFWW / Lesson 5
   d. Internal Motor Heating Coils
      (2nd Edition) Reference / EFWW / Lesson 8
   e. Leak Detection (Insulation)
      (2nd Edition) Reference / EFWW / Lesson 7, 8
   f. Magnetic Starters
      (2nd Edition) Reference / EFWW / Lesson 4
   g. Motor Control
      (2nd Edition) Reference / EFWW / Lesson 4
   h. Phase Protection Monitoring
      (2nd Edition) Reference / EFWW / Lesson 5
   i. Vibration Monitoring
      (2nd Edition) Reference / EFWW / Lesson 9
   j. Voltmeter
      (2nd Edition) Reference / EFWW / Lesson 7
   k. Watt Hour Meter
      (2nd Edition) Reference / EFWW / Lesson 4
   l. Megger
      (2nd Edition) Reference / EFWW / Lesson 7

2. Identify Electrical Devices
   a. Soft Start (reduced voltage starter)
   b. Variable Frequency Drives
      (2nd Edition) Reference / EFWW / Lesson 4

3. Maintain Electrical Devices
   a. Capacitors
      (2nd Edition) Reference / EFWW / Lesson 3
   b. Circuit Breakers
      (2nd Edition) Reference / EFWW / Lesson 4
   c. Fuses
      (2nd Edition) Reference / EFWW / Lesson 4
   d. Heaters/Overload Protection
      (2nd Edition) Reference / EFWW / Lesson 5
   e. Knife Switches
      (2nd Edition) Reference / EFWW / Lesson 4
   f. Relays
      (2nd Edition) Reference / EFWW / Lesson 5
   g. Switch Gears
      (2nd Edition) Reference / EFWW / Lesson 4
   h. Transformers
      (2nd Edition) Reference / EFWW / Lesson 4
   i. Wound Rotors
      (2nd Edition) Reference / EFWW / Lesson 4
   j. Characterize electric motor operation and condition
      (2nd Edition) Reference / EFWW / Lesson 8

4. Required Advanced Knowledge of Electrical Concepts
   a. Amperage
      (2nd Edition) Reference / EFWW / Lesson 1
   b. Grounding
      (2nd Edition) Reference / EFWW / Lesson 4
   c. Load Demand
      (2nd Edition) Reference / EFWW / Lesson 3
   d. Resistance, Voltage
      (2nd Edition) Reference / EFWW / Lesson 2
   e. Wattage
      (2nd Edition) Reference / EFWW / Lesson 3
   f. Wire Sizing
      (4th Edition) Reference / Audel / Chapter 36
   g. Electrical Line Diagrams
      (2nd Edition) Reference / EFWW / Lesson 6
   h. Electrical Math
      (2nd Edition) Reference / EFWW / Lesson 2, 4
   i. Ladder Logic Diagrams
      (2nd Edition) Reference / EFWW / Lesson 6

5. Required Advanced Knowledge of Regulations / Standards
   a. National Fire Protection
   b. National Electrical Code

Instrumentation

The focus of Class 3 is CALIBRATION AND MAINTENANCE OF INSTRUMENTS
1. The level of instruction and testing is that of **ADVANCED MAINTENANCE SKILLS** with emphasis on
   a. **INSPECTION** of Instrumentation and Control Systems
   b. **MANAGEMENT** of the duties required to maintain Instrumentation and Control Systems
   c. **PREDICTIVE MAINTENANCE** aspects of Instrumentation (to include **ANALYSIS** of results)

   The NTK topics for Class 3 below are in addition to the topics identified from Class 1 and Class 2 Instrumentation NTK. Reference sources follow each topic where applicable.

2. Understand maintenance procedures (including proper care, cleaning and operational verification) of the following Instruments
   a. Air velocity Transmitter
   b. Chart Recorder
   c. Chlorine concentration Analyzer
   d. Chlorine gas Detector
   e. Conductivity Analyzer
   f. Dissolved Oxygen Analyzer
   g. Oxidation Reduction Potential Analyzer
   h. Particle Count Analyzer
   i. pH Analyzer
   j. Streaming Current Analyzer
   k. Temperature Transmitter
   l. Flow Totalizer

3. Be able to identify the following Terms associated with Calibration of Instrumentation
   a. Calibration
   b. Accuracy
   c. Precision (or Repeatability)
   d. Sensitivity
   e. Linearity
   f. Span (or Range)
   g. Standard (or Reference)
4. Understand general Calibration procedures for the following categories of instrumentation
   a. Pressure transducers
   b. Temperature transducers
   c. Flow meters
   d. Level meters
   e. pH and ORP analyzers
   f. Chemical Concentration Analyzers
   g. Gas Monitors (detectors)
   h. Paced Metering Pumps

5. Identify Troubleshooting techniques for Instrumentation and Control Systems

Need-to-Know the Math Criteria for Maintenance Technologists Class 1, 2 & 3

Formula / Conversion Table Below

Math

Advanced Knowledge of Math
1. Required Advance knowledge of Shop Geometry
   a. Use of a Protractor
      i. Angles (Measure or Make)
      ii. Adding and subtracting angles
   b. Circles
      i. Circumferences
      ii. Radius
      iii. Diameter
      iv. Chord
      v. Arc
c. Triangles
   i. Right
   ii. Acute
   iii. Obtuse
d. Regular Polygons
   i. 3 – Triangle
   ii. 4 – Square
   iii. 5 – Pentagon
   iv. 6 – Hexagon
   v. 7 – Heptagon
   vi. 8 – Octagon
   vii. 9 – Nonagon
   viii. 10 – Decagon
e. Dividing a Line
f. Erecting a Perpendicular Line
g. Areas of Geometric Shapes
   h. Triangle \( A = \frac{bh}{2} \)
   i. Rectangle \( A = ab \)
   j. Square \( a = b^2 \)
   k. Parallelogram \( A = ah \)
l. Circle: \( \pi r^2 \)

2. \( 1 \text{ Hp} = 33,000 \text{ ft.-l.b.s./min.} \)

   a. WHp – Water Horsepower / \( \text{WHp} = \frac{\text{TDH} \times Q \times d}{33,000 \text{ ft.-l.b.s./min./Hp}} \)
   b. BHp – Brake Horsepower /
      \( \text{BHp} = \frac{\text{WHp}}{0.70} \) (70% Efficiency)
   c. EHp – Electrical Horsepower /
      \( \text{BHp} = \frac{\text{BHp}}{0.90} \) (90% Efficiency)

3. \( 1 \text{ Hp} = 746 \text{ Watts} \)
4. \( 1 \text{ Kw} = 1000 \text{ Watts} \)
5. Watts Law \( P = V \times A \)
6. 1 ft. of Water = 0.433 psi
7. Station Efficiency = Water Hp \( \frac{\text{Water Hp}}{\text{Brake Hp}} \)
8. Pump Efficiency = Water Hp \( \frac{\text{Water Hp}}{\text{Brake Hp}} \)
9. Feet of Head = \( \frac{\text{psi}}{0.422 \text{ ft./psi}} \)
10. Feet of Water = \( \frac{\text{inches of Hg} \times 13.55}{12“ / \text{ft.}} \)
11. The Specific Gravity of Mercury is 13.55
12. Velocity Head \( V^2/2g \)
   a. \( V = \) Velocity in feet per second
   b. \( g = \) the acceleration due to gravity – 32.2 ft./sec. \(^2\)
13. Determine water depth w/pipe 0.433 psi./ft.  

14. Flow & Velocity  
   \[ Q = VA \quad V = \frac{Q}{A} \]  
   a. \( V \) = Velocity cfs (cubic feet second)  
   b. \( Q \) = Flow ft./sec. (feet per second)  
   c. \( A \) = Cross Sectional Area  
   d. 1 cfs = 448 GPM  

15. TDH Calculations  
   a. Suction Conditions \( \text{TDH} = \frac{\text{Discharge psi} - \text{Suction psi}}{0.433 \text{ psi/ft}} \)  
   b. Suction Lift w/ Vacuum Gauge \( \text{TDH} = \frac{\text{Discharge psi}}{0.433 \text{ psi/ft}} + \text{Suction Vacuum inches of Hg} \times 1.13 \text{ in/ft} \)  
   c. Suction Lift \( \text{TDH} = \frac{\text{Discharge psi}}{0.433 \text{ psi/ft}} + \text{Suction Lift in feet} \)  

16. \( E = IR \quad I = \frac{E}{R} \quad R = \frac{E}{I} \)  
   a. Power = Current x Voltage so \( P = I \times V \) or \( I = \frac{P}{V} \) or \( V = \frac{P}{I} \)  

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**Drawings**  

1. Operation and Maintenance Manuals  
   a. Types of Drawings in Manual  
   b. How they are used  
      i. Reactive maintenance  
      ii. Preventive Maintenance  
      iii. Predictive maintenance  

2. Standard operation procedures  
   a. Who should write  
   b. How organized  
   c. How much detail needs to be included  
   d. What is the benefit  

3. Electrical and Instrumentation Drawings  
   a. Programmable Logic Controllers  
      i. Definition  
      ii. Uses  
   b. Ladder Logic  
      i. Definition  
      ii. Examples  
      iii. How to interpret  

4. Geographic Information System (GIS)  
   a. Uses  
   b. Examples  
   c. How to interpret  

5. Schematics  
   a. Types
b. Examples

c. How to interpret

6. Graphing
   a. SCADA Trending
      i. Uses
      ii. How to interpret
   b. Vibration analysis
      i. Predictive maintenance

7. Construction Drawings
   a. As-built Drawings/Blueprints
      i. Definition
      ii. Purpose
      iii. How to ensure accuracy
      iv. Examples of typical shortcomings

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**Maintenance Management**

1. Required Advance Administrative / Maintenance Management
   a. Corrective Maintenance
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   b. Employee Training
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   c. Planning Scheduling (prioritizing)
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   d. Predictive Maintenance
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   e. Preventive Maintenance
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 15
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, 19
      (Volume 2, 3rd Edition) Reference / Ind W SAC/ Chapter 8
   f. Record Keeping
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
      (Volume 2, 3rd Edition) Reference / Ind W SAC/ Chapter 8
   g. Work Order
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   h. Writing Reports
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23

2. Required Advance Knowledge of Administrative / Maintenance Management
   a. Computer Maintenance Management Systems
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   b. Reporting Requirements
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   c. Spreadsheet Software
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   d. Word Processing Software
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23

3. Required Advance Knowledge of Ancillary Crafts
   a. Computers
      (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 19

   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   a. Fences
   b. Lighting and Locks
   c. Chemical Delivery
   d. Surveillance

   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   a. Data Security
   b. Vehicle Security

   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   a. Computer Access
   b. System Access

   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   a. Perform / Update

   (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   a. Communication System
   b. Homeland Security
   c. Security Awareness

9. Required Advance Regulations and Standards
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 22, 23
      (Volume 2, 3rd Edition) Reference / Ind W SAC/ Chapter 7
      Reference / Osha.gov / 1910.147
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 20, 22
      (Volume 2, 3rd Edition) Reference / Ind W SAC/ Chapter 7
      Reference / Osha.gov / 1910.147
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 22
      (Volume 2, 3rd Edition) Reference / Ind W SAC/ Chapter 7
      Reference / Osha.gov / 1910.147
      (Volume 2, 5th Edition) Reference / W SAC/ Chapter 22, 23
      (Volume 2, 3rd Edition) Reference / Ind W SAC/ Chapter 7
      Reference / Osha.gov / 1910.147

10. Required Advanced Knowledge of Regulations and Standards
   a. CHEMTREC (Volume 2, 6th Edition) Reference / WW SAC/ Chapter 20
       (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18, 20, 22, 23
       (Volume 2, 3rd Edition) Reference / Ind W SAC/ Chapter 8
       Reference / Osha.gov / 1910.147
       (Volume 2, 5th Edition) Reference / W SAC/ Chapter 18
   c. Department of Transportation (Volume 2, 5th Edition) Reference / W SAC/ Chapter 23
   e. National Incident Management System
### Formula / Conversion Table

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps = $\frac{\text{Volts}}{\text{Ohms}}$</td>
<td>Current (Amps) equals the Volts divided by the Ohms.</td>
</tr>
<tr>
<td>Area of Circle = $(0.785) (\text{Diameter}^2)$ or $(\pi) (\text{Radius}^2)$</td>
<td>The area of a circle is calculated using the diameter or radius.</td>
</tr>
<tr>
<td>Area of Cone (lateral area) = $(\pi) (\text{Radius}) \sqrt{\text{Radius}^2 + \text{Height}^2}$</td>
<td>The lateral area of a cone is calculated using the radius and height.</td>
</tr>
<tr>
<td>Area of Cone (total surface area) = $(\pi) (\text{Radius}) (\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})$</td>
<td>The total surface area of a cone includes the lateral area and the base.</td>
</tr>
<tr>
<td>Area of Cylinder (total outside surface area) = $[\text{Surface Area of End #1}] + [\text{Surface Area of End #2}] + [(\pi) (\text{Diameter}) (\text{Height or Depth})]$</td>
<td>The total surface area of a cylinder includes the area of the two circular ends and the lateral surface.</td>
</tr>
<tr>
<td>Area of Rectangle = $(\text{Length}) (\text{Width})$</td>
<td>The area of a rectangle is calculated by multiplying its length by its width.</td>
</tr>
<tr>
<td>Area of a Right Triangle = $\frac{(\text{Base})(\text{Height})}{2}$</td>
<td>The area of a right triangle is half the product of its base and height.</td>
</tr>
<tr>
<td>Average (arithmetic mean) = $\frac{\text{Sum of All Terms}}{\text{Number of Terms}}$</td>
<td>The average is calculated by summing all terms and dividing by the number of terms.</td>
</tr>
<tr>
<td>Circumference of Circle = $(\pi) (\text{Diameter})$</td>
<td>The circumference of a circle is calculated using its diameter.</td>
</tr>
<tr>
<td>Degrees Celsius = $(\text{Degrees Fahrenheit} - 32) \left(\frac{5}{9}\right)$ or $\frac{(\text{F} - 32)}{1.8}$</td>
<td>The conversion from Fahrenheit to Celsius is performed using these formulas.</td>
</tr>
<tr>
<td>Degrees Fahrenheit = $[\text{Degrees Celsius} \left(\frac{9}{5}\right) + 32]$ or $[\text{Degrees Celsius} (1.8) + 32]$</td>
<td>The conversion from Celsius to Fahrenheit is performed using these formulas.</td>
</tr>
<tr>
<td>Electromotive Force (E.M.F), volts = $(\text{Current, amps}) (\text{Resistance, ohms})$ or $E = IR$</td>
<td>The electromotive force is calculated by multiplying current by resistance.</td>
</tr>
<tr>
<td>Filter Backwash Rate, GPM/sq ft = $\frac{\text{Flow, gpm}}{\text{Filter Area, sq ft}}$</td>
<td>The filter backwash rate is calculated by dividing the flow rate by the filter area.</td>
</tr>
<tr>
<td>Flow Rate, cfs = $(\text{Area, sq ft}) (\text{Velocity, ft/sec})$ or $Q = AV$ where: $Q$ = flow rate, $A$ = area, $V$ = velocity</td>
<td>The flow rate in cubic feet per second is calculated by multiplying the area by the velocity.</td>
</tr>
<tr>
<td>Force, pounds = $(\text{Pressure, psi}) (\text{Area, sq in})$</td>
<td>The force is calculated by multiplying the pressure by the area.</td>
</tr>
<tr>
<td>Horsepower, Brake (bhp) = $\frac{\left(\text{Flow, gpm}\right) (\text{Head, ft})}{(3,960) (\text{Decimal Pump Efficiency})}$</td>
<td>The brake horsepower is calculated by dividing the product of flow and head by the constant.</td>
</tr>
</tbody>
</table>
Horsepower, Motor (mhp) = \frac{(Flow, gpm)(Head, ft)}{(3,960)(Decimal Pump Efficiency)(Decimal Motor Efficiency)}

Horsepower, Water (whp) = \frac{(Flow, gpm)(Head, ft)}{3,960}

Leakage, gpd = \frac{Volume, gallons}{Time, days}

Reduction in Flow, % = \frac{(Original Flow - Reduced Flow) (100\%)}{Original Flow}

Slope, % = \frac{Drop or Rise}{Distance} \times 100

Specific Gravity = \frac{Specific Weight of Substance, lbs/gal}{Specific Weight of Water, lbs/gal}

Velocity, ft/sec = \frac{Flow Rate, cu ft / sec or Distance, ft}{Area, sq ft or Time, sec}

Volume of Cone = \frac{1}{3} (0.785) (Diameter^2) (Height)

Volume of Cylinder = 0.785 (Diameter^2) (Height)

Volume of Rectangular Tank = (Length) (Width) (Height)

Watts (DC circuit) = (Volts) (Amps)

Watts (AC circuit) = (Volts) (Amps) (Power Factor)

Wire-to-Water Efficiency, % = \frac{\text{Water Horsepower, HP}}{\text{Power Input, HP or Motor HP}} \times 100

Wire-to-Water Efficiency, % = \frac{(Flow, gpm) (Total Dynamic Head, ft) (0.746 \text{ kw/hp})(100)}{(3,960) (Electrical Demand, kilowatts)}

Conversion Factors:

1 acre = 43,560 square feet
1 acre foot = 326,000 gallons
1 cubic foot = 7.48 gallons
1 cubic foot = 62.4 pounds
1 cubic foot per second = 0.646 MGD
1 foot = 0.305 meters
1 foot of water = 0.433 psi
1 gallon = 3.79 liters
1 gallon = 8.34 pounds
1 grain per gallon = 17.1 mg/L
1 horsepower = 0.746 kW or 746 watts or 33,000 ft. lbs./min.
1 million gallons per day = 694 gallons per minute
1 million gallons per day = 1.55 cubic feet per second
1 mile = 5,280 feet
1 pound = 0.454 kilograms
1 pound per square inch = 2.31 feet of water
1 ton = 2,000 pounds
1% = 10,000 mg/L
Π or π = 3.14

Abbreviations:

cfs         cubic feet per second
ga          feet
gr          grams
gpd         gallons per day
gpg         grains per gallon
gpm         gallons per minute
inc         inches
kw          kilowatt
lbs         pounds
mg/L        milligrams per liter
mgd         million gallons per day
ml          milliliter
psi         pounds per square inch
Q            flow