Need-to-Know Criteria

For

Maintenance Technologists

School Class 2

Revised MAY 2010

Suggested Reference Materials for Class 2

• Either of one (1) of these three California State University (CSUS), Sacramento (SAC) Foundation, Office of Water Programs
  o Operation of Wastewater Treatment Plants, Volume II (WW SAC)
  o Industrial Waste Treatment, Volume II (Ind W SAC)
  o Water Treatment Plant Operation, Volume II (W SAC)
• Arasmith Consulting
  o Pumps and Pumping (PP)
  o Electrical Fundamentals for Water and Wastewater (EFWW)
• Code of Federal Regulations(CFR), Title 29, Part 1910 Occupational Safety and Health Standards - Available at: www.osha.gov; (click on “Regulations” and choose “Part 1910” from the list)

Students will Need-to-Know the Criteria for both Maintenance Technologists Class 1 & Class 2
### Materials, Tools and Lubrication

1. **Required material selection to include:**
   - a. Adhesives – types and uses.
   - b. Anti-seize compounds – Purpose and selection.
   - d. Epoxy – types, purpose, uses, and surface preparation.
   - e. Fastening devices – Bolts, nuts, washer types and styles, and screws.
   - g. Locking compounds – Importance of compounds and proper selection.
   - h. Metals – Carbon steel, stainless steel, brass, bronze, copper, aluminum, zinc, and composite materials.
   - i. O-rings – Sizing, selection, and material compatibility.
   - j. Plastics – Selection of materials and compatibility.
   - k. Sealants – Types and uses.
   - l. Shims – Styles and uses.
   - m. Solvents – Types and uses.

2. **Required knowledge of materials:**
   - a. Application procedures – proper assembly techniques and importance of being thorough.
   - b. Corrosion control – using coatings and paints to minimize corrosion.
   - c. Material compatibility – Use of compatibility charts for making sure that systems are adequately designed so dissimilar properties are minimized.
   - d. Material Safety Data Sheets
   - e. Storage procedures – Safe and proper storage of tools, materials, chemicals, and lubricants.

3. **Required use of tools:**
   - a. Calibration equipment – understand and identify types of equipment.
   - b. Electrical instruments – Use of and understanding electrical instruments.
   - c. Hand Tools – Identify and understand basic use pliers, wrenches, hammers, screwdrivers, chisels, probing tools etc.
   - d. Hoists/Cranes
   - e. Ladders
   - f. Machining Equipment – Identify lathes, milling machines, and drill presses and be familiar with the uses of them.
   - g. Power Tools – Identify and safely use electrical, air, and battery powered tools.
   - h. Pressure/Hot Water Washers – Safely use and identify the types of steam and pressure washers.
   - i. Rigging – Gathering data, estimating weights, and properly and safely moving loads.
   - j. Scaffolds
   - k. Sand Blasters – Be aware of sandblasting waste and associated disposal procedures.
   - l. Solvent Tanks – Identification, proper use, and safety latches.
   - m. Welding/Cutting Equipment – Use of hot work permits.

4. **Required use of precision tools:**
   - a. Alignment – Tools associated with alignment of shafts, belts, sheaves, sprockets, and chains.
b. Calipers – Checking alignment and related components using calipers.
c. Dial Indicator – Use of dial indicators to check for and correct misalignment.
d. Laser – Using the laser alignment methods to check for and correct misalignment.
e. Micrometer – Using micrometers to check for and correct misalignment.
f. Feeler Gauge – Use of feeler gauges to check for and correct all types of misalignment.

5. Required knowledge of tools:
   a. Accuracy.
   b. Non sparking – Proper use of and applications.
   c. Precision – Proper care, storage, and usage of precision tools.
   d. Sharpening – Importance of using properly sharpened tools.
   e. Tool Storage – Importance of properly storing and storage solutions. Tool cleanliness and associated safety.

6. Required use of lubricants:
   a. Grease – Proper use of and selection and identifying the problems of under and over greasing. The different bases and compounds, techniques, and manufacturer recommendations.
   b. Oil – Lubrication schedules, proper levels, viscosities, effects of temperature, synthetics, fire points, pour points, and flash points.
   c. Water – The uses of water as a lubricant and for cooling.

7. Required knowledge of lubrication:
   a. Food Grade Lubricants – Applications and proper selection.
   b. Grades of lubricants – Viscosities and single weights versus multi-weight oils. Grease selection will also be covered.
   c. Load – Pairing of loads and pressures with lubricants.
   d. Lubrication systems – Recognizing the styles of systems and dealing with problems and issues associated with them.
   e. Manufacturer Requirements – Understanding lubricant and equipment recommendations and making the best choices.
   f. Petroleum based lubricants – The ups and downs of using the petroleum products.
   g. Product Compatibility – Using lubricant charts to determine compatibility among products.
   h. Sampling – Advantages and disadvantages of analysis.
   i. Scheduling – Setting up PM schedules using lubricant and equipment manufacturer specifications.
   j. Synthetic based lubricants – Advantages and disadvantages of using synthetics.
   k. Temperature – Effects temperatures have on lubricants. Knowing the importance of the pour, flash, and fire points.
   l. Purpose – Reduction of heat and friction in mechanical systems.
   m. Additives- To know the proper application and when and when not to use them.
   n. Analysis – To determine when analysis should be done and when it is simply cheaper to change lubricants and service equipment.
   o. Application Method – How to determine proper viscosities of lubricants and techniques, tips, and tricks to applying them.
   q. Disposal Systems – Proper maintenance of oil disposal systems and the importance of them.
   r. Environment – Importance of keeping all lubricants contained and the ill effects of spills.
   s. Failure Analysis – How to properly analyze failure of lubricants.
   t. Filter Systems – Install and maintenance and importance of filter systems.

8. Required Predictive Maintenance:
   a. Amperage – Understanding amps, what they are, what they mean, and the importance and how to safely take readings.
   b. Flow Monitoring – Measuring flow and how to apply it to related equipment.
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<td>c.</td>
<td>Hour Readings – Importance of hourly readings, which ones you really need, and keeping and applying them to trend problems and events.</td>
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<td>Oil Analysis – Timing, analyzing, and trending problems with proper analysis.</td>
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<td>e.</td>
<td>Pressure Recording – Trending, documentation, and effects of pressure on equipment.</td>
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<td>Temperature Monitoring – Trending, documentation, and effects of temperature on equipment.</td>
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<td>g.</td>
<td>Vibration Analysis – What a vibration analysis is, how it is taken, what they mean, details of an analysis, and deciding which equipment to test.</td>
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**Pumps**

1. Required Knowledge of Pump Operations
   a. Understanding Air Binding – removal of air from pump volute.
   b. Pump Cavitation – definition and avoidance.
   c. Operation against a closed valve – shutdown head.
      effects of partially closed discharge valve.
   d. Pump Curve – three basic types, examples of use.
   e. Pump Efficiency – calculation of efficiency.
   f. Pump Hydraulics – pump curves, NPSH, TDH.
   g. Reverse Rotation – direction of rotation.
      non-reversing ratchet.
   h. Water Hammer/Surge – cause and reduction of.
   i. Flush/Seal Water - uses, types, cross connection.
2. Required Knowledge of Pump Components
   a. Impellers – types, removal and installation.
   b. Lantern Ring – removal.
   c. Mechanical Seals – selection and replacement of mechanical sleeves.
   d. Packing – selection and replacement of packing.
   e. Shaft Sleeves – removal and installation.
   f. Stuffing Box – inspection
   g. Slinger Rings – function.
   h. Suction/Discharge Valves – suction and discharge piping.
   i. Volute – volute case removal and installation.

**Rotating Components**

1. Required Knowledge of Bearings and Bushings
   a. Types of bearings and bushings
   b. Inspection of bearings and bushings
   c. Lubrication methods and schedules
   d. Cleaning procedures
   e. Disassembly, repair and assembly of bearings
   f. Installation of bearings and bushings
   g. Bearing fit
2. Required Knowledge of Shafts
   a. Coupling Techniques
   b. Types of couplings
   c. When to use a specific type of coupling
   d. Disassembly and inspection of couplings
   e. Coupling lubrication
   f. Interference fit vs. clearance fit
3. Maintain Bearings
a. Ball  
b. Needle  
c. Radial  
d. Roller  
e. Spherical  
f. Tapered  
g. Thrust

4. Maintain Bushings  
a. Babbitt  
b. Sleeve

**Motors and Drives**  
1. Required intermediate knowledge of Motors

a. Brake Horsepower  
b. Enclosures  
c. Hollow Shaft  
d. Motor Brushes  
e. Motor efficiency  
f. Motor Windings  
g. Mounting  
h. Rotation  
i. Service Factor

2. Maintain Drive Equipment

a. Actuators  
b. Belts  
c. Brakes  
d. Chains  
e. Clutches  
f. Drive Coupling  
g. Drive Shafts  
h. Gearbox  
i. Gears  
j. Universal Joints  
k. Variable Speed Belt Drive

**Pipes and Valves**  
1. Utilizing the proper operations, lubrication and maintenance procedures to maintain the following valves:  
a. Gate  
b. Plug  
c. Butterfly  
d. Globe  
e. Check-Ball-Flapper  
f. Pinch  
g. Sluice
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. Inspect, adjust or replace valve packing when applicable.
4. Inspect, replace (cut if applicable) gaskets for various valves and piping systems.
5. Utilizing the proper maintenance procedures select the appropriate sealant for threaded pipe connections.
6. Utilizing the proper maintenance procedures and tooling chase existing or cut new threads for piping systems.
7. Utilizing the proper maintenance procedures to glue PVC pipe and fittings using the correct cleaner, primer and glue.
8. Utilizing the proper maintenance procedures to remove/install pipe hangers and restraints on piping systems.
9. Utilizing the proper maintenance procedures and techniques to remove obstructions preventing flow through piping and valves.
10. Utilizing the proper maintenance procedures to test and set lift and reseat pressure on a pressure relief valve.

**Safety Practices**

1. Required to follow intermediate safety procedures
   a. Chemical Handling
   b. Confined Space Entry
   c. Cross Connection Control
   d. Electrical Hazards
   e. Fire Safety
1. Required Knowledge of Safety
   a. Amperage
   b. Emergency Response Plans
   c. Fuel Tanks / Cans
   d. Grounding
   e. Material Safety Data Sheets
   f. Personal Protective Equipment
   g. Resistance
   h. Voltage
   i. Wattage
   j. Right to Know Law
   k. Wire Sizing

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<td>6. Frequency (60 hertz) (1 cycle = 1/60 Hz = .0167 milliseconds)</td>
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<td>2. What should you consider when selecting wire size?</td>
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<td>3. How can you determine the proper voltage and allowable current in amps for a piece of equipment?</td>
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<td>4. Should you be qualified and authorized before repairing or troubleshooting electrical circuits or equipment?</td>
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<td>5. What should you consider before measuring voltage?</td>
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<td>6. How can you determine if there is voltage in a circuit?</td>
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7. What should you check before applying an Ohm meter or megger to electrical equipment or circuits?
8. What should you turn off before using a megger?
9. What precautions should be taken before attempting to change fuses?
10. What could be the cause of amp readings different from the nameplate rating?
11. How do you test for voltage with a voltmeter when the voltage is unknown?
12. What are two types of safety devices found in main electrical panels or control units?
13. Why are fuses used to protect?
14. Why must a fuse never be bypassed or jumped?
15. How does a circuit breaker work?
16. Should you energize electrical equipment with an unfused disconnect that may startup?
17. What should be done when a fuse or circuit breaker "blows" or trips?
18. Motor and supervisory control systems are composed of what types of auxiliary electrical equipment?
19. What are three basic factors that contribute to the reliable operation of electrical systems found in pump stations?
20. What can be measured with a multimeter?
21. What three measurements are commonly made with a VOM?
22. When measuring resistance with a VOM, what is the state of the power supply?
23. What is a clamp on amp meter primarily used to measure?
24. When measuring amperage of a motor, what is the state of the motor?
25. What is the intended purpose of internal motor heating coils?
26. What is the primary function of a GFCI device?
27. There are four common conditions that can cause severe damage to three phase motors. What are they and how can they be prevented?
28. What is the standard unit of measurement for resistance?
29. What reference should you use for proper wire sizing for electrical circuits, motors and services?
30. What is a watt hour meter and how is it used?

### Instrumentation

The questions below are in addition to the questions from Class 1 Instrumentation NTK. The reference material is in parenthesis for each question.

1. Describe maintenance procedures (including proper care, cleaning, calibration, and operational verification) of the following level measuring devices?
   - Bubblers (Bubblers)
   - Ultrasonic (Ultrasonic)
   - Electrode (Electrode)
   - Float (Float)
   - Other level measuring instruments (Other level measuring instruments)
   - Explain the proper application of the level measuring devices above (Explain the proper application of the level measuring devices above).

2. Describe maintenance procedures (including proper care, cleaning, calibration, and operational verification) of the following “Open Channel” flow measuring devices?
   - V-notch weir (V-notch weir)
   - Palmer-Bowles flume (Palmer-Bowles flume)
   - Parshall flume (Parshall flume)
   - Other open-channel flow meters (Other open-channel flow meters)
   - Explain the proper application of the open channel flow measuring devices above (Explain the proper application of the open channel flow measuring devices above).

3. Describe maintenance procedures (including proper care, cleaning, calibration, and operational verification) of the following “Closed Pipe” flow measuring devices?
   - Ultrasonic (including Time of Flight & Doppler) (Ultrasonic (including Time of Flight & Doppler))
   - Magnetic (Magnetic)
   - Pressure differential (venturi & orifice plate) (Pressure differential (venturi & orifice plate))
   - Propeller (Propeller)
4. Other closed pipe flow meters
f. Explain the proper application of the closed pipe flow measuring devices above.

5. How can you use drawdown methods to calibrate or confirm the proper operation of both level and flow measuring devices?

What other troubleshooting techniques would you use to check for proper operation of Level/Flow measuring devices above?

Math

Need-to-Know the Criteria for Maintenance Technologists Class 1
And Formula / Conversion Table Below

DRAWINGS
1. Electrical and Instrumentation Drawings
   a. Electrical Line diagrams
   b. Process and Instrumentation Diagrams
2. Graphing
   a. Interpret charts
3. Construction Drawings:
   a. Plan View
   b. Section View
   c. Determining where section is cut
   d. Typical Details
   e. Scales
      i. How to determine correct scale.
   f. Dimension Lines
   g. Leaders
   h. Discipline sheets
   i. Contours
   j. Patterns
   k. As-built Drawings/Blueprints

Maintenance Management

1. Required to know intermediate Administration / Maintenance Management
   a. Corrective Maintenance
   b. Employee Training
   c. Predictive Maintenance
   d. Preventive Maintenance
   e. Record Keeping
   f. Work Orders
   g. Writing Reports
   h. Computer Maintenance Management Systems
      i. Reporting Requirements
      j. Spreadsheet Software
      k. Word Processing Software
2. Be able to Maintain intermediate System Security
   a. Fences
   b. Lighting and Locks
   c. Chemical Delivery
   d. Surveillance
3. Protect intermediate System Security
   a. Data Security
   b. Vehicle Security
4. Restrict intermediate System Security
   a. Computer Access
   b. System Access

5. Required intermediate knowledge of system security
   a. Communication System
   b. Homeland Security
   c. Security Awareness

6. Required intermediate knowledge of regulations and standards
   a. Comply with requirements
   b. Implement Requirements
   c. Record Requirements
   d. Report Requirement
   e. CHEMTREC
   f. Department of Homeland Security
   g. Department of Transportation
   h. Environmental Protection Agency 40 CFR
   i. National Incident Management System
   j. National Sanitation Foundation
   k. Occupation Safety & Health Administration
   l. Office of Hazardous Materials Safety
   m. State / Provincial Regulations

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**Formula / Conversion Table**

Amps = \[ \frac{\text{Volts}}{\text{Ohms}} \]

Area of Circle = \((0.785) \text{ (Diameter}^2\) \) or \((\pi) \text{ (Radius}^2\) \)

Area of Cone (lateral area) = \((\pi) \text{ (Radius)} \sqrt{\text{Radius}^2 + \text{Height}^2}\)

Area of Cone (total surface area) = \((\pi) \text{ (Radius)} (\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2})\)

Area of Cylinder (total outside surface area) = [Surface Area of End #1] + [Surface Area of End #2] + \([\text{\((\pi) \text{ (Diameter) (Height or Depth)}\)\]}\]

Area of Rectangle = (Length) (Width)

Area of a Right Triangle = \(\frac{(\text{Base})(\text{Height})}{2}\)

Average (arithmetic mean) = \(\frac{\text{Sum of All Terms}}{\text{Number of Terms}}\)

Circumference of Circle = \((\pi) \text{ (Diameter)}\)

Degrees Celsius = (Degrees Fahrenheit - 32) \(\left(\frac{5}{9}\right)\) or \(\left(\frac{\text{F} - 32}{1.8}\right)\)

Degrees Fahrenheit = \(((\text{Degrees Celsius}) \left(\frac{9}{5}\right) + 32\) or \(((\text{Degrees Celsius}) \left(1.8\right) + 32\)

Electromotive Force (E.M.F), volts = (Current, amps) (Resistance, ohms) or \(E = IR\)
Filter Backwash Rate, gpm/sq ft = \( \frac{\text{Flow, gpm}}{\text{Filter Area, sq ft}} \)

Flow Rate, cfs = (Area, sq ft) (Velocity, ft/sec) or Q = AV where: Q = flow rate, A = area, V = velocity

Force, pounds = (Pressure, psi) (Area, sq in)

Horsepower, Brake (bhp) = \( \frac{(\text{Flow, gpm}) (\text{Head, ft})}{(3,960) (\text{Decimal Pump Efficiency})} \)

Horsepower, Motor (mhp) = \( \frac{(\text{Flow, gpm}) (\text{Head, ft})}{(3,960) (\text{Decimal Pump Efficiency}) (\text{Decimal Motor Efficiency})} \)

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

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

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

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

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

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

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

Volume of Cylinder = \( 0.785 \cdot (\text{Diameter}^2) \cdot (\text{Height}) \)

Volume of Rectangular Tank = \( \text{Length} \cdot \text{Width} \cdot (\text{Height}) \)

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, % = \( \frac{(\text{Flow, gpm}) (\text{Total Dynamic Head, ft}) (0.746 \text{ kw/hp})(100)}{(3,960) (\text{Electrical Demand, kilowatts})} \)
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 pi = 3.14

Abbreviations:
cfs cubic feet per second
ft feet
g grams
gpd gallons per day
gpg grains per gallon
gpm gallons per minute
in inches
kW kilowatt
lbs pounds
mg/L milligrams per liter
MGD million gallons per day
mL milliliter
psi pounds per square inch
Q flow