ABC
Association of
Boards of Certification

2805 SW Snyder Blvd., Suite 535 Ankeny, Iowa 50023
P: (515) 232-3623 F: (515) 965-6827
www.abccert.org

ABC

Association of Boards of Certification

Water Distribution Need-to-Know Criteria

A Need-to-Know Guide when preparing for the ABC Water Distribution Certification Examination.

Acknowledgement

The Association would like to thank the members of the 2010-2011 Water Distribution Validation and Examination Committee for their effort in conducting the job analysis and developing the ABC *Need-to-Know Criteria* for Water Distribution Operators. Committee members included:

- Ray Olson, Colorado (Chair)
- Tom Arnbrister, Washington
- Audrey Burchanan, Nova Scotia
- Brian Kellsey, Alberta
- Martin Nutt, Arkansas
- Kathy Weinsaft, Wyoming
- Mike Wentink, Nebraska
- Chuck Van Der Kolk, Michigan

Introduction

As part of the development of its certification exams, the Association of Boards of Certification (ABC) conducted a job analysis of water distribution operators in 2010. As part of this process, ABC conducted a national survey of distribution operators. This *Need-to-Know Criteria* was developed from the results of ABC's 2010 distribution operator job analysis.

How the *Need-to-Know Criteria* Was Developed

Review of Task Survey

The results of the 2010 task analysis survey were provided to the ABC Distribution V&E Committee. In the task analysis survey, operators rated job tasks and capabilities for frequency of performance and seriousness of inadequate or incorrect performance. These two rating scales were used because they provide useful information (i.e., how critical each task is and how frequently each task is performed) pertaining to certification. Of the 617 individuals in the water distribution industry who completed the survey, 122 were class I operators, 151 were class II operators, 124 were class III operators, and 135 were class IV operators.

Analysis of Ratings

The composite criticality ratings and percentage of operators reporting that they performed the tasks were presented to the Distribution V&E Committee in January 2011 to begin development of the new *Need-to-Know Criteria*. V&E committee members were given the opportunity to retain tasks which did not meet decision criteria (a criticality value of at least 10.5 and a percent performing value of at least 50%) if a significant rationale could be provided for their importance on the examination. The V&E committee members were also given the opportunity to remove any tasks which met criteria on the survey but were deemed untestable or inappropriate for the water distribution certification examination. Final examination blueprint weights were calculated by summing the criticality values of all remaining tasks, and dividing the criticality value of each task by the grand total criticality value. Weights of individual tasks were summed for each core competency area to determine the proportion of the water distribution certification examination devoted to each core competency.

Core Competencies

The essential tasks and capabilities that were identified through this process are called the core competencies. The following pages list the core competencies for distribution operators. The core competencies are clustered into the following job duties:

- System Information/Components
- Monitor, Evaluate, and Adjust Disinfection
- Laboratory Analysis
- Install Equipment
- Operate Equipment
- Perform Maintenance
- Perform Security, Safety, and Administrative Procedures

The level of knowledge (i.e., comprehension, application, analysis) required for each task is also identified in the following pages.

- **Comprehension** is the most basic level of understanding and remembering. Items written at the comprehension level require examinees to recognize, remember, or identify important ideas.
- Items written at the **application** level require examinees to interpret, calculate, predict, use or apply information and solve problems.
- Items written at the **analysis** level require examinees to compare, contrast, diagnose, examine, analyze, and relate important concepts.

The level of knowledge is a hierarchy from basic comprehension to analysis. The level of knowledge tested is cumulative. Therefore, tasks identified as application may include questions written at both the application and comprehension levels. Tasks identified as analysis may include questions written at the comprehension, application, and analysis levels.

About the Association of Boards of Certification

Established in 1972, the Association of Boards of Certification (ABC) is a non-profit member-driven organization dedicated to protecting public health and the environment by advancing the quality and integrity of environmental certification programs. ABC membership includes almost 100 certifying authorities, representing more than 40 states, nine Canadian provinces as well as several international programs. Existing solely for its members, ABC is the voice for the profession and serves as the conduit for information in an ever-changing industry.

Over 70 certification programs currently test approximately 35,000 operators and laboratory analysts annually through ABC's industry-leading Certification & Testing Services. Over 400,000 water and wastewater operators, laboratory analysts, and backflow prevention assembly testers have taken an ABC exam since the testing program began in 1982.

ABC Vision
Promote integrity in environmental certification throughout the world.

ABC Mission
ABC is dedicated to advancing the quality and integrity of environmental certification programs.

ABC Objectives
- Promote certification as a means of protecting public health, the infrastructure, and the environment.
- Promote uniformity of standards and best practices in certification.
- Serve as the technical resource for certification entities.
- Facilitate the transfer of certification between certifying authorities.
- Serve the needs of our members.

ABC Distribution Certification Exams

The ABC distribution certification exams evaluate an operator's knowledge of tasks related to the operation of distribution systems. The ABC Distribution V&E Committee determined the content of each exam based on the results of the national task analysis survey. To successfully take an ABC exam, an operator must demonstrate knowledge of the core competencies in this document.

Four levels of certification exams are offered by ABC, with class I being the lowest level and class IV the highest level. The specifications for the exams are based on a weighting of the job analysis results so that they reflect the criticality of tasks performed on the job. The specifications list the percentage of questions on the exam that fall under each job duty. For example, 18% of the questions on the ABC class I distribution exam relate to the job duty "Operate Equipment." For a list of tasks and capabilities associated with each job duty, please refer to the list of core competencies on the following pages.

ABC Water Distribution Exam Specifications

Blueprint Area	Class I	Class II	Class III	Class IV
System Information/Components	9%	9%	9%	9%
Monitor, Evaluate, and Adjust Disinfection	11%	11%	10%	10%
Laboratory Analysis	21%	21%	21%	20%
Install Equipment	5%	5%	5%	5%
Operate Equipment	18%	18%	18%	18%
Perform Maintenance	20%	20%	20%	21%
Perform Security, Safety, and Administrative Procedures	16%	16%	17%	17%

System Information/Components	Class I	Class II	Class III	Class IV
Assess system demand	Application	Application	Analysis	Analysis
Install joint restraints	Application	Application	Application	Analysis
Install shoring	Application	Application	Application	Analysis
Install thrust blocks	Application	Application	Application	Analysis
Layout system	N/A	N/A	Application	Application
Map system	Comprehension	Comprehension	Comprehension	Comprehension
Perform pressure readings	Application	Application	Application	Analysis
Preparedness contingency/contingency plan	Application	Application	Application	Analysis
Read blueprints, readings, and maps	Application	Application	Application	Analysis
Select materials	Application	Application	Analysis	Analysis
Select type of pipes	Comprehension	Application	Application	Analysis

System Information/Components Continued	Class I	Class II	Class III	Class IV
Size mains	Comprehensive	Comprehensive	Application	Analysis
Write plans	Application	Application	Application	Analysis

Required Capabilities

Knowledge of:

- Approved backflow methods and devices
- Biological science
- Blueprint readings
- Building codes
- Corrosion control process (including cathodic protection)
- Fire flow requirements
- Function of recordkeeping system
- General hydraulic principles
- Hydrology
- Local codes and ordinances
- Measuring instruments
- Mechanical drafting
- Operation and maintenance practices
- Pipe fittings and joining methods
- Piping material, type and size
- Potential causes of disasters in facility
- Potential impact of disasters in facility
- Regulations
- Standards
- Watershed management

Ability to:

- Adjust equipment
- Assess likelihood of disaster occurring
- Generate a written safety program
- Generate capital plans
- Generate long- and short-term plans
- Interpret data
- Organize information
- Perform distribution math
- Perform impact assessments
- Perform physical measurements
- Record information
- Write policies and procedures
- Review reports

Monitor, Evaluate, and Adjust Disinfection	Class I	Class II	Class III	Class IV
Monitor Disinfection				
Calcium hypochlorite disinfection	Application	Application	Application	Application
Chlorine gas disinfection	Application	Application	Application	Analysis
Sodium hypochlorite disinfection	Application	Application	Application	Application
Evaluate Disinfection				
Calcium hypochlorite disinfection	Analysis	Analysis	Analysis	Analysis
Chlorine gas disinfection	Analysis	Analysis	Analysis	Analysis
Sodium hypochlorite disinfection	Analysis	Analysis	Analysis	Analysis

Monitor, Evaluate, and Adjust Disinfection Continued	Class I	Class II	Class III	Class IV
Adjust Disinfection				
Calcium hypochlorite disinfection	Analysis	Analysis	Analysis	Analysis
Chlorine gas disinfection	Analysis	Analysis	Analysis	Analysis
Sodium hypochlorite disinfection	Analysis	Analysis	Analysis	Analysis
Inspect Source Water				
Identify and evaluate potential sources of source water contamination	Analysis	Analysis	Analysis	Analysis
Wells	Application	Application	Application	Application

Required Capabilities

Knowledge of:

- Biological science
- Disinfection concepts
- Disinfection design parameters
- Disinfection process
- General chemistry
- Laboratory equipment
- Measuring instruments
- Physical science
- Proper chemical handling and storing
- Regulations
- Reporting requirements
- Safe Drinking Water Act (SDWA)
- Safety procedures
- Sampling requirements
- Testing instruments
- Watershed management
- 40 CFR 141 Subpart C: Monitoring and Analytical Requirements (turbidity, coliforms, organic contaminants, organic contaminants)
- 40 CFR 141 Subpart D: Reporting and Recordkeeping Requirements
- 40 CFR 141 Subpart F: Maximum Contaminant Level Goals and Maximum Residual Disinfectant Level Goals
- 40 CFR 141 Subpart G: National Primary Drinking Water Regulations: Maximum Contaminant Levels and Maximum Residual Disinfectant Levels
- 40 CFR 141 Subpart H: Filtration and Disinfection

Ability to:

- Adjust equipment
- Adjust flow patterns
- Adjust system units
- Calibrate equipment
- Calibrate instruments
- Interpret data
- Perform distribution math
- Recognize normal and abnormal analytical results

Required Capabilities Continued

Knowledge of:

- 40 CFR 141 Subpart L: Disinfectant Residuals, Disinfection Byproducts, and Disinfection Byproduct Precursors
- 40 CFR 141 Subpart P:Enhanced Filtration and Disinfection Systems Serving 10,000 or More People
- 40 CFR 141 Subpart T: Enhanced Filtration and Disinfection Systems Serving Fewer Than 10,000 People
- 40 CFR 141 Subpart U: Initial Distribution System Evaluations
- 40 CFR 141 Subpart V: Stage 2 Disinfection Byproducts Requirements

Laboratory Analysis	Class I	Class II	Class III	Class IV
Collect and Preserve Samples				
Chlorine demand	Application	Application	Analysis	Analysis
Chlorine residual	Application	Application	Analysis	Analysis
Coliforms	Analysis	Analysis	Analysis	Analysis
Lead/copper	Application	Application	analysis	Analysis
Nitrate	Application	Application	Analysis	Analysis
Nitrite	Application	Application	Analysis	Analysis
pH	Application	Application	Analysis	Analysis
Radionuclides	Application	Application	Analysis	Analysis
Synthetic organic chemicals (SOC)	Application	Application	Analysis	Analysis
Temperature	Application	Application	Analysis	Analysis
Volatile organic chemicals (VOC)	Application	Application	Analysis	Analysis
Perform Laboratory Analysis				
Chlorine demand	Analysis	Analysis	Analysis	Analysis
Chlorine residual	Analysis	Analysis	Analysis	Analysis
pH	Application	Application	Analysis	Analysis
Temperature	Application	Application	Analysis	Analysis

Laboratory Analysis Continued	Class I	Class II	Class III	Class IV
Interpret Laboratory Analysis				
Chlorine demand	Analysis	Analysis	Analysis	Analysis
Chlorine residual	Analysis	Analysis	Analysis	Analysis
Coliforms	Application	Application	Analysis	Analysis
Hardness	Application	Application	Analysis	Analysis
Iron	Application	Application	Analysis	Analysis
Lead/copper	Analysis	Analysis	Analysis	Analysis
Nitrates	Application	Application	Analysis	Analysis
Nitrites	Application	Application	Analysis	Analysis
pH	Application	Application	Application	Analysis
Radionuclides	Application	Application	Analysis	Analysis
Synthetic organic chemicals (SOC)	Application	Application	Analysis	Analysis
Temperature	Application	Application	Application	Analysis
Turbidity	Application	Application	Application	Analysis
Volatile organic chemicals (VOC)	Application	Application	Analysis	Analysis

Required Capabilities

Knowledge of:

- Biological science
- Disinfection concepts
- Disinfection design parameters
- Disinfection process
- General chemistry
- Laboratory equipment
- Monitoring requirements
- Normal characteristics of water
- Physical science
- Proper chemical handling and storing
- Proper sampling procedures
- Quality control/quality assurance practices
- Record keeping policies
- Regulations
- Reporting requirements
- Safe Drinking Water Act (SDWA)
- Safety procedures
- Sampling requirements
- Testing instruments
- 40 CFR 141 Subpart B: Maximum Contaminant Levels (arsenic, nitrate, turbidity)

Ability to:

- Calibrate equipment
- Calibrate instruments
- Determine what information needs to be recorded
- Diagnose/troubleshoot equipment
- Follow written procedures
- Interpret data
- Interpret Material Safety Data Sheets
- Organize information
- Recognize normal and abnormal analytical results
- Record information
- Review reports
- Transcribe data
- Translate technical language into common terminology

Required Capabilities Continued

Knowledge of:

- 40 CFR 141 Subpart C: Monitoring and Analytical Requirements (turbidity, coliforms, organic contaminants, organic contaminants)
- 40 CFR 141 Subpart D: Reporting and Recordkeeping Requirements
- 40 CFR 141 Subpart E: Special Regulations, Including Monitoring Regulations and Prohibition on Lead Use
- 40 CFR 141 Subpart F: Maximum Contaminant Level Goals and Maximum Residual Disinfectant Level Goals
- 40 CFR 141 Subpart G: National Primary Drinking Water Regulations: Maximum Contaminant Levels and Maximum Residual Disinfectant Levels
- 40 CFR 141 Subpart H: Filtration and Disinfection
- 40 CFR 141 Subpart I: Control of Lead and Copper
- 40 CFR 141 Subpart L: Disinfectant Residuals, Disinfection Byproducts, and Disinfection Byproduct Precursors
- 40 CFR 141 Subpart S: Ground Water Rule
- 40 CFR 141 Subpart V: Stage 2 Disinfection Byproducts Requirements

Install Equipment	Class I	Class II	Class III	Class IV
Backflow prevention devices	Comprehension	Application	Analysis	Analysis
Hydrants	Application	Application	Application	Application
Meters	Application	Application	Application	Application
Piping	Application	Application	Application	Application
Service connections	Application	Application	Application	Application
Taps	Application	Application	Application	Analysis
Valves	Application	Application	Application	Analysis
Water mains	Application	Application	Application	Analysis

Required Capabilities

Knowledge of:

- Approved backflow methods and devices
- Blueprint readings
- Building codes
- Corrosion control process (including cathodic protection)
- Dechlorination process
- Different types of cross-connections
- Different types of joints, restraints and thrust blocks
- Function of tools
- Personal protective equipment
- Pipe fittings and joining methods
- Piping material, type and size
- Pneumatics
- Proper lifting techniques
- Protective coatings and paints
- Safety procedures

Ability to:

- Demonstrate safe work habits
- Diagnose/troubleshoot equipment
- Identify potential safety hazards
- Inspect pumps
- Operate safety equipment
- Perform distribution math
- Recognize unsafe work conditions
- Select safety equipment
- Use hand tools
- Use power tools

Operate Equipment	Class I	Class II	Class III	Class IV
Blowers and compressors	Comprehension	Comprehension	Comprehension	Comprehension
Chemical feeders	Application	Application	Application	Analysis
Chlorinators	Analysis	Analysis	Analysis	Analysis
Computers	Comprehension	Application	Application	Application
Drives	Comprehension	Application	Application	Analysis
Electrical motors	Application	Application	Analysis	Analysis
Electronic testing equipment	Comprehension	Comprehension	Application	Analysis
Engines	Comprehension	Application	Application	Application
Generators	Application	Application	Application	Application
Hand tools	Application	Application	Application	Application
Heavy equipment	Comprehension	Comprehension	Application	Analysis
Hydrants	Application	Application	Application	Analysis
Hydraulic equipment	Comprehension	Comprehension	Application	Application
Instrumentation	Application	Application	Application	Analysis
Leak correlators/detectors	Application	Application	Application	Analysis
Pipe locators	Application	Application	Application	Analysis
Power tools	Application	Application	Application	Application
Pumps	Application	Application	Application	Analysis
Samplers	Comprehension	Application	Application	Analysis

Operate Equipment Continued	Class I	Class II	Class III	Class IV
SCADA	Comprehension	Application	Application	Analysis
Tapping equipment	Comprehension	Application	Application	Analysis
Telemetry system	Application	Application	Analysis	Analysis
Valve locators	Application	Application	Application	Analysis
Valves	Application	Application	Analysis	Analysis

Required Capabilities

Knowledge of:

- Facility operation and maintenance
- Function of tools
- General electrical principles
- General hydraulic principles
- General mechanical principles
- Internal combustion engines
- Lubricant and fluid characteristics
- Operation and maintenance practices
- Pipe fittings and joining methods
- Piping material, type and size
- Pneumatics
- Quality control/quality assurance practices
- Start-up and shut down procedures
- Testing instruments

Ability to:

- Adjust equipment
- Adjust flow patterns
- Adjust system units
- Calibrate equipment
- Calibrate instruments
- Demonstrate safe work habits
- Operate safety equipment
- Perform distribution math
- Perform physical measurements
- Recognize unsafe work conditions
- Select safety equipment
- Use hand tools
- Use power tools

Perform Maintenance	Class I	Class II	Class III	Class IV
Blowers and compressors	N/A	N/A	N/A	Application
Chemical feeders	Application	Application	Application	Analysis
Chlorinators	Application	Application	Analysis	Analysis
Corrosion control	Application	Application	Analysis	Analysis
Cross-connection control	Application	Application	Analysis	Analysis
Drives	N/A	N/A	N/A	Analysis
Electric motors	Application	Application	Application	Application
Electrical grounding	Application	Application	Application	Application
Engines	Comprehension	Application	Application	Analysis
Evaluate operation of equipment	Application	Application	Analysis	Analysis
Facility inspection	Application	Application	Analysis	Analysis
Generators	Application	Application	Application	Application
Hydrants	Application	Application	Analysis	Analysis

Perform Maintenance Continued	Class I	Class II	Class III	Class IV
Hydraulic equipment	N/A	N/A	Application	Analysis
Hypochlorinators	Application	Analysis	Analysis	Analysis
Instrumentation	Application	Application	Application	Analysis
Leak detection	Application	Application	Analysis	Analysis
Lock-out/tag-out	Application	Application	Application	Application
Meters	Application	Application	Application	Analysis
Pressure sensors	Application	Application	Analysis	Analysis
Pumps	Application	Application	Analysis	Analysis
Service connection	Application	Application	Application	Analysis
Service pipes	Application	Application	Application	Application
Valves	Application	Application	Application	Analysis
Water mains	Application	Application	Analysis	Analysis
Water storage facility	Application	Application	Analysis	Analysis

Required Capabilities

Knowledge of:

- Approved backflow methods and devices
- Blueprint readings
- Building codes
- Corrosion control process (including cathodic protection)
- Different types of cross-connections
- Different types of joints, restraints and thrust blocks
- Facility operation and maintenance
- Facility security
- Function of tools
- General electrical principles
- General hydraulic principles
- General mechanical principles
- Internal combustion engines
- Laboratory equipment
- Local codes and ordinances
- Lubricant and fluid characteristics
- Measuring instruments
- Operation and maintenance practices
- Personal protective equipment
- Pipe fittings and joining methods
- Piping material, type and size
- Pneumatics
- Potential causes of disasters in facility
- Potential impact of disasters in facility

Ability to:

- Adjust equipment
- Adjust flow patterns
- Adjust system units
- Assess likelihood of disaster occurring
- Assign work to proper trade
- Calibrate equipment
- Calibrate instruments
- Demonstrate safe work habits
- Diagnose/troubleshoot equipment
- Diagnose/troubleshoot system units
- Differentiate between preventative/corrective maintenance
- Discriminate between normal/abnormal conditions
- Evaluate facility performance
- Evaluate operation of equipment
- Evaluate system units
- Identify potential safety hazards
- Inspect pumps
- Interpret data
- Interpret Material Safety Data Sheets
- Maintain inventory control system
- Maintain system in normal operating condition
- Monitor electrical equipment
- Monitor mechanical equipment
- Obtain unbiased data
- Operate safety equipment
- Organize information

Required Capabilities Continued

Knowledge of:

- Proper chemical handling and storing
- Proper lifting techniques
- Protective coatings and paints
- Quality control/quality assurance practices
- Record keeping policies
- Safety procedures
- Sanitary survey processes
- Start-up and shut down procedures
- Testing instruments
- Well-head protection

Ability to:

- Perform distribution math
- Perform general maintenance
- Perform general repairs
- Perform physical measurements
- Recognize normal and abnormal analytical results
- Recognize unsafe work conditions
- Record information
- Review reports
- Select safety equipment
- Translate technical language into common terminology
- Use hand tools
- Use power tools

Perform Security, Safety, and Administrative Procedures	Class I	Class II	Class III	Class IV
Manage System				
Administer safety/compliance program	Comprehension	Application	Application	Analysis
Conduct cross-connection surveys	Application	Application	Analysis	Analysis
Develop budget	N/A	N/A	Analysis	Analysis
Develop operation and maintenance plan	Application	Application	Analysis	Analysis
Develop/maintain sample site plan	Application	Application	Analysis	Analysis
Participate in sanitary surveys	Application	Application	Application	Application
Regulatory reporting	Analysis	Analysis	Analysis	Analysis
Promote Public Relations				
Promote customer service program	N/A	Application	Analysis	Analysis
Respond to complaints	Application	Application	Application	Analysis

Perform Security, Safety, and Administrative Procedures Continued	Class I	Class II	Class III	Class IV
Safety Program				
Chemical safety	Application	Application	Application	Analysis
Confined space entry	Application	Application	Application	Application
Excavation, shoring and trenching	Application	Application	Application	Application
General safety	Application	Application	Application	Application
Personal protective equipment	Application	Application	Application	Application
Public protection	Application	Application	Application	Application
Recordkeeping				
Compliance	Application	Application	Application	Application
Corrective actions to system deficiencies	Application	Application	Application	Application
Equipment repair/replacement	Application	Application	Analysis	Analysis
Laboratory	Application	Application	Analysis	Analysis
Maintenance	Application	Application	Application	Application
System operation	Application	Application	Analysis	Analysis

Required Capabilities

Knowledge of:

- Biological science
- Blueprint readings
- Building codes
- Data acquisition techniques
- Disciplinary procedures
- Emergency plans
- Employment laws
- Facility security
- Function of recordkeeping system
- General chemistry
- General electrical principles
- General hydraulic principles
- General mechanical principles
- Human resource practices
- Hydrology
- Local codes and ordinances
- Memorandums of understanding and agreements
- Monitoring requirements
- Potential causes of disasters in facility

Ability to:

- Assess likelihood of disaster occurring
- Assign work to proper trade
- Communicate in writing
- Communicate verbally
- Conduct meetings
- Conduct training programs
- Coordinate emergency response with other water organizations relative to the distribution system
- Determine what information needs to be recorded
- Develop a staffing plan
- Develop a work unit
- Evaluate facility performance
- Evaluate promotional materials
- Evaluate proposals
- Follow written procedures
- Generate a written safety program
- Generate capital plans
- Generate long- and short-term plans

Required Capabilities Continued

Knowledge of:

- Potential impact of disasters in facility
- Principles of finance
- Principles of general communication
- Principles of management
- Principles of measurement
- Principles of public relations
- Principles of supervision
- Public notification requirements
- Public participation requirements
- Quality control/quality assurance practices
- Record keeping policies
- Regulations
- Reporting requirements
- Risk management
- Safe Drinking Water Act (SDWA)
- Sanitary spring design
- Sanitary survey processes
- Standards
- Water reuse
- Watershed management
- 40 CFR 141 Subpart A: General (definitions, coverage, variances and exemptions, siting requirements, and effective dates)
- 40 CFR 141 Subpart D: Reporting and Recordkeeping Requirements
- 40 CFR 141 Subpart O: Consumer Confidence Reports
- 40 CFR 141 Subpart Q: Public Notification of Drinking Water Violations

Ability to:

- Identify potential safety hazards
- Interpret data
- Negotiate contracts
- Obtain unbiased data
- Organize information
- Perform distribution math
- Perform impact assessments
- Prepare proposals
- Recognize normal and abnormal analytical results
- Recognize unsafe work conditions
- Record information
- Review reports
- Select safety equipment
- Transcribe data
- Translate technical language into common terminology
- Write policies and procedures

References

The following are approved as reference sources for the ABC distribution examinations. Operators should use the latest edition of these reference sources to prepare for the exam.

American Water Works Association (AWWA)

- *Water Transmission and Distribution*
- *Water Distribution Operator Training Handbook*
- *Basic Science Concepts and Applications*
- *Water System Security, A Field Guide*
- *Water Quality*

To order, contact:
American Water Works Association
6666 West Quincy Ave
Denver, CO 80235
Web site: www.awwa.org
Phone: (800) 926-7337
Fax: (303) 347-0804
E-mail: custsvc@awwa.org

Association of State Drinking Water Administrators (ASDWA) and National Rural Water Association (NRWA)

- *Security Vulnerability Self Assessment Guide for Small Drinking Water Systems*

To order, contact:
ASDWA
1025 Connecticut Ave NW Ste 903
Washington DC 20036
Available online in PDF format
Web site: www.asdwa.org
Phone: (202) 293-7655
Fax: (202) 293-7656
E-mail: info@asdwa.org

California State University, Sacramento (CSUS) Foundation, Office of Water Programs

- *Water Distribution System Operation and Maintenance*
- *Small Water System Operation and Maintenance*
- *Utility Management*
- *Manage for Success*

To order, contact:
Office of Water Programs
California State University, Sacramento
6000 J Street
Sacramento, CA 95819-6025
Web site: www.owp.csus.edu
Phone: (916) 278-6142
Fax: (916) 278-5959
E-mail: wateroffice@owp.csus.edu

ABC & C_2EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams

Alkalinity, as mg $CaCO_3$/L $= \dfrac{(\text{Titrant Volume, mL})\,(\text{Acid Normality})\,(50{,}000)}{\text{Sample Volume, mL}}$

$\text{Amps} = \dfrac{\text{Volts}}{\text{Ohms}}$

*Area of Circle $= (.785)\,(\text{Diameter}^2)$

$= (\pi)\,(\text{Radius}^2)$

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 exterior surface area) = [Surface Area of End #1] + [Surface Area of End #2] + [(π) (Diameter) (Height or Depth)]

*Area of Rectangle = (Length) (Width)

*Area of a Right Triangle $= \dfrac{(\text{Base})\,(\text{Height})}{2}$

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

Average (geometric mean) $= [(X_1)\,(X_2)\,(X_3)\,(X_4)\,(X_n)]^{1/n}$ *The* n*th root of the product of* n *numbers*

Chemical Dry Feeder Calibration, lbs/day $= \dfrac{(\text{Dry Chemical Collected, grams})\,(60\text{ min/hr})\,(24\text{ hr/day})}{(454\text{ grams/lb})\,(\text{Time, min})}$

Chemical Feed Pump Setting, % Stroke $= \dfrac{\text{Desired Flow}}{\text{Maximum Flow}} \times 100\%$

Chemical Feed Pump Setting, mL/min $= \dfrac{(\text{Flow, MGD})\,(\text{Dose, mg/L})\,(3.785\text{ L/gal})\,(1{,}000{,}000\text{ gal/MG})}{(\text{Liquid, mg/mL})\,(24\text{ hr/day})\,(60\text{ min/hr})}$

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

$= 2\,(\pi)\,(\text{Radius})$

Composite Sample Single Portion $= \dfrac{(\text{Instantaneous Flow})\,(\text{Total Sample Volume})}{(\text{Number of Portions})\,(\text{Average Flow})}$

CT Calculation = (Disinfectant Residual Concentration, mg/L) (Time, min)

Degrees Celsius = (Degrees Fahrenheit - 32) ($^5/_9$)

$= \dfrac{(°\text{F} - 32)}{1.8}$

*Pie Wheel format for this equation is available at the end of this document.

Degrees Fahrenheit = (Degrees Celsius) ($^{9}/_{5}$) + 32

= (Degrees Celsius) (1.8) + 32

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}} \qquad \textit{Units must be compatible}$$

*Electromotive Force (EMF), volts = (Current, amps) (Resistance, ohms) *or* E = IR

$$\text{*Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

$$\text{Feed Rate, gal/min (Fluoride Saturator)} = \frac{(\text{Plant capacity, gpm})\ (\text{Dosage, mg/L})}{18{,}000\ \text{mg/L}}$$

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{(\text{Dosage, mg/L})\ (\text{Capacity, MGD})\ (8.34\ \text{lbs/gal})}{(\text{Available Fluoride Ion, \% expressed as a decimal})\ (\text{Purity, \% expressed as a decimal})}$$

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(\text{Backwash Rate, gpm/ft}^2)\ (12\ \text{in/ft})}{7.48\ \text{gal/ft}^3}$$

$$\text{Filter Drop Test Velocity, ft/min} = \frac{\text{Water Drop, ft}}{\text{Time of Drop, min}}$$

$$\text{Filter Flow Rate or Backwash Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter Area, ft}^2}$$

$$\text{Filter Yield, lbs/hr/ft}^2 = \frac{(\text{Solids Loading, lbs/day})\ (\text{Recovery, \% expressed as a decimal})}{(\text{Filter Operation, hr/day})\ (\text{Area, ft}^2)}$$

*Flow Rate, cfs = (Area, ft^2) (Velocity, ft/sec) *or* Q = AV *Units must be compatible*

*Force, lbs = (Pressure, psi) (Area, in^2)

$$\text{Gallons/Capita/Day} = \frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$$

$$\text{Hardness, as mg } CaCO_3\text{/L} = \frac{(\text{Titrant Volume, mL})\ (1{,}000)}{\text{Sample Volume, mL}} \qquad \textit{Only when the titration factor is 1.00 of EDTA}$$

$$\text{Horsepower, Brake (bhp)} = \frac{(\text{Flow, gpm})\ (\text{Head, ft})}{(3{,}960)\ (\text{Pump Efficiency, \% expressed as a decimal})}$$

$$\text{Horsepower, Motor (mhp)} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3{,}960)(\text{Pump Efficiency, \% expressed as a decimal})(\text{Motor Efficiency, \% expressed as a decimal})}$$

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

$$\text{Hydraulic Loading Rate, gpd/ft}^2 = \frac{\text{Total Flow Applied, gpd}}{\text{Area, ft}^2}$$

$$\text{Hypochlorite Strength, \%} = \frac{\text{Chlorine Required, lbs}}{(\text{Hypochlorite Solution Needed, gal})\,(8.34\ \text{lbs/gal})} \times 100\%$$

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

*Mass, lbs = (Volume, MG) (Concentration, mg/L)(8.34 lbs/gal)

*Mass Flux, lbs/day = (Flow, MGD) (Concentration, mg/L) (8.34 lbs/gal)

Milliequivalent = (mL) (Normality)

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

$$\text{Normality} = \frac{\text{Number of Equivalent Weights of Solute}}{\text{Liters of Solution}}$$

$$\text{Number of Equivalent Weights} = \frac{\text{Total Weight}}{\text{Equivalent Weight}}$$

$$\text{Number of Moles} = \frac{\text{Total Weight}}{\text{Molecular Weight}}$$

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

$$\text{Removal, \%} = \left(\frac{\text{In} - \text{Out}}{\text{In}}\right) \times 100\%$$

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

$$\text{Solids, mg/L} = \frac{(\text{Dry Solids, grams})\,(1{,}000{,}000)}{\text{Sample Volume, mL}}$$

$$\text{Solids Concentration, mg/L} = \frac{\text{Weight, mg}}{\text{Volume, L}}$$

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

$$\text{Surface Loading Rate or Surface Overflow Rate, gpd/ft}^2 = \frac{\text{Flow, gpd}}{\text{Area, ft}^2}$$

Three Normal Equation = $(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$ *Where $V_1 + V_2 = V_3$*

Two Normal Equation = $N_1 \times V_1 = N_2 \times V_2$ *Where N = normality, V = volume or flow*

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, ft}^3/\text{sec}}{\text{Area, ft}^2}$$

$$= \frac{\text{Distance, ft}}{\text{Time, sec}}$$

*Volume of Cone = (1/3) (.785) (Diameter^2) (Height)

= (1/3) [(π) (Radius^2) (Height)]

*Pie Wheel format for this equation is available at the end of this document.

*Volume of Cylinder = (.785) (Diameter^2) (Height)

= (π) (Radius^2) (Height)

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

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

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

$$\text{Weir Overflow Rate, gpd/ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

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

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

Abbreviations:

cfs	cubic feet per second
DO	dissolved oxygen
ft	feet
g	grams
gpd	gallons per day
gpg	grains per gallon
gpm	gallons per minute
hp	horsepower
hr	hour
in	inches
kW	kilowatt
lbs	pounds
mg/L	milligrams per liter
MGD	million gallons per day
mL	milliliter
min	minute
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
Q	flow
SS	settleable solids
TTHM	total trihalomethanes
TOC	total organic carbon
TSS	total suspended solids
VS	volatile solids

Conversion Factors:

1 acre = 43,560 square feet
1 acre foot = 326,000 gallons
1 cubic foot = 7.48 gallons
= 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
= 8.34 pounds
1 grain per gallon = 17.1 mg/L
1 horsepower = 0.746 kW
= 746 watts
= 33,000 ft lbs/min
1 mile = 5,280 feet
1 million gallons per day = 694 gallons per minute
= 1.55 cubic feet per second (cfs)
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 = 3.14159

Alkalinity Relationships: All Alkalinity expressed as mg/L as $CaCO_3$

Result of Titration	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Concentration
P = 0	0	0	T
P < ½T	0	2P	T – 2P
P = ½T	0	2P	0
P > ½T	2P – T	2(T – P)	0
P = T	T	0	0

Key: P – phenolphthalein alkalinity T – total alkalinity

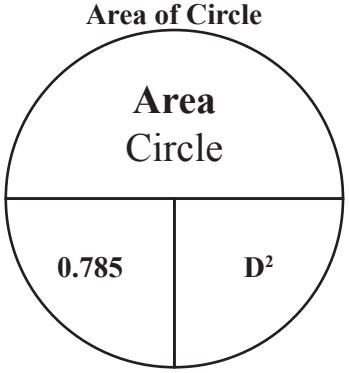
*Pie Wheel format for this equation is available at the end of this document.

***Pie Wheels:**

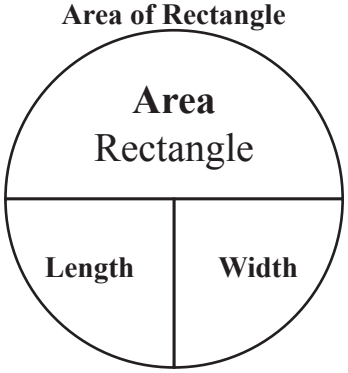
- To find the quantity above the horizontal line: multiply the pie wedges below the line together.
- To solve for one of the pie wedges below the horizontal line: cover that pie wedge, then divide the remaining pie wedge(s) into the quantity above the horizontal line.

Given units must match the units shown in the pie wheel.

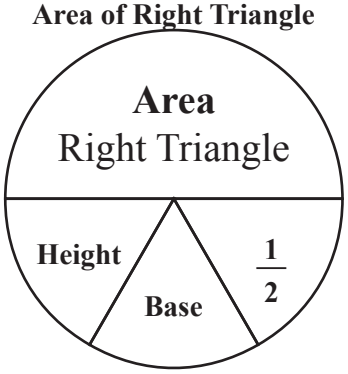
Area of Circle



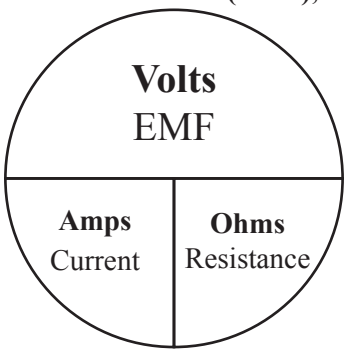
Area of Rectangle



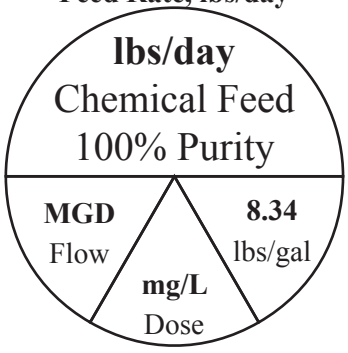
Area of Right Triangle



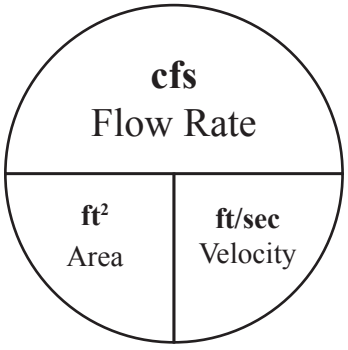
Electromotive Force (EMF), volts



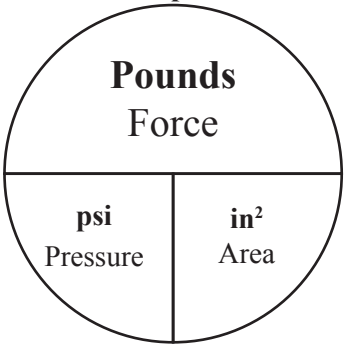
Feed Rate, lbs/day



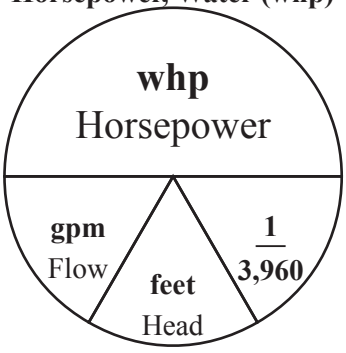
Flow Rate, cfs



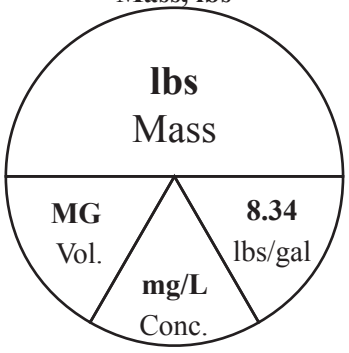
Force, pounds



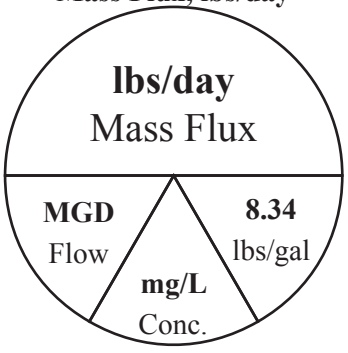
Horsepower, Water (whp)



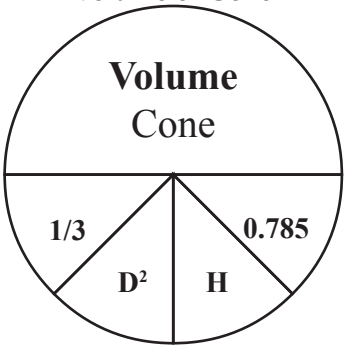
Mass, lbs



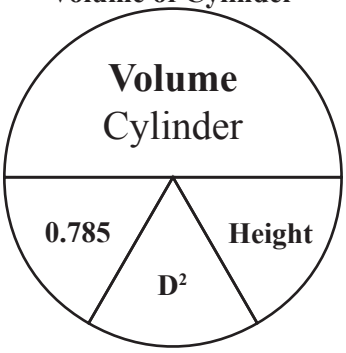
Mass Flux, lbs/day



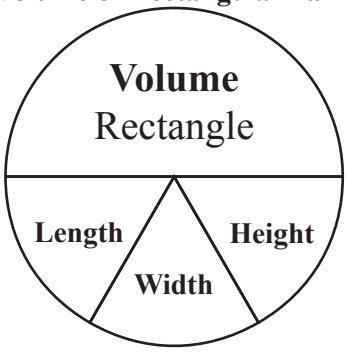
Volume of Cone



Volume of Cylinder



Volume of Rectangular Tank



ARKANSAS WATER DISTRIBUTION LICENSE -- MATHEMATICS STUDY GUIDE

The key to studying for the math portion of the license exam begins with the formula sheet. The formula sheet should serve as a guide to the type of questions that will be encountered on the exams. By using the formula sheet and the California text practice questions, a better understanding of the required math should be made more apparent.

The following is a list of math categories that relate to the formula sheet. Examples of some problems have been noted for study. The examples shown **do not** depict the only application that each formula may be used. These examples can be utilized to see how some formulas are executed. All formulas and examples may not be included. You may also find other examples of problems on your own.

In the "EXAMPLE" Column of the table below, **"A"** denotes sample problems located in the Arithmetic Appendix and **"Ch"** denotes chapter of the treatment books. The numbers are the chapter and/or section of that part of the treatment books.

FORMULA TOPIC	CSUS BOOK	EXAMPLE
Area of Circle	Distribution O&M	A.23 Circle
Area of Cylinder	Distribution O&M	A.24 Cylinder
Area of Rectangle	Distribution O&M	A.21 Rectangle
Area of Triangle	Distribution O&M	A.22 Triangle
Average (arithmetic mean)	Distribution O&M	Ch 5.21
Average (Quarterly), ug/L	Distribution O&M	Ch 5.21 example # 1
Average (Running Quarterly Annual), ug/L	Distribution O&M	Ch 5.21 example # 3
Chemical Feed Pump Setting, % Stroke	Treatment I	A.131 example # 5
Chemical Feed Pump Setting, mL/min	Small System O&M	A.153
Circumference of Circle	Distribution O&M	A.23 Circle
Degrees Celsius	Distribution O&M	A.43
Degrees Fahrenheit	Distribution O&M	A.43
Detention Time	Distribution O&M	A.30 example # 3
Discharge Rate	Distribution O&M	A.86 example c
Efficiency	Distribution O&M	A.86
Electromotive Force (E.M.F), volts	Treatment II	Ch 18.114
Feed Rate, (Dosage), lbs	Distribution O&M	A.131
Feed Rate (Dosage), lbs/day	Distribution O&M	A.131 example # 2
Flow Rate, cfs	Distribution O&M	A.71
Force, pounds	Distribution O&M	A.6
Gallons/Capita/Day	Small System O&M	Ch 8.02
Horsepower, Brake (bhp)	Distribution O&M	A.83
Horsepower Brake	Distribution O&M	A.86
Horsepower, Motor (mhp)	Distribution O&M	A.84
Horsepower, Water (whp)	Distribution O&M	A.86
Hypochlorite Strength, %	Distribution O&M	A.134.3
Motor Efficiency, %	Distribution O&M	A.86
Motor Power Input	Distribution O&M	A.83
Pump Capacity, gpm	Distribution O&M	A.86 1 Capacity
Pump Efficiency %	Distribution O&M	A.86 2 Efficiency
Velocity, ft/sec	Small System O&M	A.7
Volume of Cone	Distribution O&M	A.33 Cone
Volume of Cylinder	Distribution O&M	A.32 Cylinder
Volume of Rectangular Unit	Distribution O&M	A.30 Rectangle
Watts (DC circuit)	Treatment II	Ch 18.115
Wire to Water Efficiency, %	Distribution O&M	A.86