Drinking Water Operator Certification Training

Module 11:
Administration of Water Treatment Plants

This course includes content developed by the Pennsylvania Department of Environmental Protection (Pa. DEP) in cooperation with the following contractors, subcontractors, or grantees:
The Pennsylvania State Association of Township Supervisors (PSATS)
Gannett Fleming, Inc.
Dering Consulting Group
Penn State Harrisburg Environmental Training Center

Topical Outline

Unit 1 – Regulatory Monitoring and Reporting

I. Monitoring of Water Treatment Plant Operations
   A. Water Treatment Plant Federal and State Regulatory Requirements
   B. Permits
   C. Role of Management in Monitoring

II. Reporting
   A. Federal and State Regulations
   B. Supplemental Reporting (Local Community Education)
   C. Backup Information and Files
   D. Submission and Retention of Data

Unit 2 – Developing Standard Operating Procedures (SOP)

I. Definition of a Standard Operating Procedure
   A. Intent of Standard Operating Procedures During Normal Operations
   B. Sample SOP

II. Understandable
   A. Use of a Checklist
   B. Common Terminology

III. Updated Frequently
   A. Process Change
   B. Operational Change
   C. History of Problems

IV. Accessible
   A. Common Library or Central Storage
   B. Staff Awareness of SOPs

V. Emergency Response Plans
   A. Emergency Response Plan (Non Terrorist Related)
   B. Usage During Emergency Conditions
   C. Identify Hazards and Access Vulnerability

Unit 3 – Budget

I. Incurred Costs

II. Projected Budget
   A. Short-Term
   B. Mid-Term
   C. Long-Term

III. Procurement
   A. Development of a Budget
   B. Emergency
   C. Bid Requirements
   D. State "Piggyback"

Unit 4 – Personnel

I. Hiring and Managing Staff
   A. Criminal History Check
   B. Union Contracts
   C. OSHA

II. Utilization of Staff
   A. Full Time
   B. Part Time
   C. Temporary Staff and Special Projects

III. Staff Improvement
   A. Setting Goals
   B. Training Requirements
   C. Disciplinary Action

IV. Safety

Unit 5 – Water Production

I. Production at WTP
  A. Production
  B. Daily and Seasonal Variable Usage
  C. Emergency Production Requirements

II. Waste Generated and Disposal

Unit 6 – Chemical Inventory

I. Variations on Operational Requirements
  A. Seasonal
  B. Other Variations

II. Safety
  A. Material Safety Data Sheet
  B. Chemical Compatibility
  C. Risk Management Plan

III. Sources/Vendors
  A. Sources
  B. Feed System

Unit 7 – Electrical Power

I. Plant Distribution System
  A. High Voltage
  B. Medium Voltage
  C. Low Voltage

II. Emergency Back Up System
  A. Secondary Utility Feeder
  B. Emergency On-Site Generator
  C. Portable or Trailer Units
  D. Uninterruptible Power Supply—Computer Application
  E. Evaluation of Key Equipment Electrical Requirements
  F. Electrical Budget Management

Unit 8 - Fuel

I. Sources
   A. Local Suppliers
   B. Emergency Supply

II. Fuel Consumption
   A. Normal Usage
   B. Emergency or High Output Operation Usage

Unit 9 – SCADA and Instrumentation

I. Supervisory Control and Data Acquisition (SCADA)
   A. Usage
   B. SCASA vs LAN
   C. Master Terminal Unit
   D. Remote Terminal Unit or Programmable Logic Controller

II. Normal Operation
   A. Flow
   B. Process Parameters
   C. Remote Locations Monitoring
   D. Monitoring of System from Remote Locations

III. Emergency Operations
   A. Cross Connection Control
   B. Water Main Break
   C. Fire Support

IV. When Should a SCADA Be Considered?
   A. Less Staffing
   B. Possible Process Optimization

Unit 1 – Regulatory Monitoring and Reporting

Learning Objectives

- Describe how water treatment plants comply with their minimum federal and state monitoring requirements.
- List the three ways in which management ensures that the staff complies with monitoring requirements.
- Discuss reporting requirements when complying with federal and state regulations.

Water Treatment Plant (WTP) Federal and State Regulatory Requirements

Minimum Requirements

Sampling schedules must be developed for each facility. Sampling requirements will vary based on both **water source** and **parameters** (contaminants). Different parameters will require different sampling schedules.

Table 1-1 Abbreviated List of Monitoring and Sampling Minimum Requirements [1]

Table	Description
A	Initial Monitoring Requirements for Maximum Contaminant Levels (MCLs) at Surface Water Systems
B	Check Sampling for Primary Contaminants
C	Repeat Monitoring Requirement for MCLs at Surface Water Systems
D	Reduce Monitoring for MCLs Following Completion of Repeat Monitoring
E	Number of Monthly Coliform Samples required Based on Population
F	Lead and Copper Requirements-Initial Monitoring
G	Tier 1, 2, and 3 Lead and Copper Sites
H	Responsibilities to Notify DEP Directly
I	Public Notification Requirements

Refer to Appendix 1 (page A-2) in this workbook.

NOTES

Sample Types

- **Raw** – A sample taken from the source of the feed water. Examples: stream, well, ground water, reservoir.
- **Plant** – A sample taken from a specific location within the WTP site.
- **Entry Point** – A sample taken from the location where WTP discharges into the distribution system.
- **Distribution** – Samples taken at key locations in the water distribution system after leaving the plant.
- **Maximum Residence** – A sample taken from a location within the distribution system where water can reasonably be expected to have the greatest distribution age.
- **Check** – A sample taken to verify results of a previous sample.
- **Special** – A sample taken to address a specific and individual issue. For example: responding to a Taste and Odor (T&O) complaint from a customer.

Sample Methods – Defined by the Department of Environmental Protection (DEP)

- **Grab** – A grab sample is an individual sample of at least 100 milliliters, collected at randomly selected times over a period not to exceed 15 minutes.
- **Continuous** – A continuous sample is generally based on constant analysis as flow is diverted from the main process flow stream. The analytical result may be either shown on an instantaneous readout display or recorded with a constant feed graphing recorder.
- **Composite** – A composite sample consists of at least 8 individual samples, each of which contains at least 100 milliliters. These samples are obtained at periodic intervals during the operating hours of a facility, over a 24-hour period. The composite must be flow-proportional.

What is an example of the use of a grab sample to cross calibrate a continuous sample?

Supplemental Sampling and Monitoring Requirements

- Any EPA violation should initiate supplemental analysis or process review.
- Public notification of violations by the system operator is required. EPA provides information in Public Notification Notebook [816-R-00-010/ June 2000].
- Process optimization/benchmark - *Refer to Appendix 2 (page A-11) in this workbook.*

Which of the problems in Appendix 2 have you come across? How were they resolved?

Permits

Water Allocation Permit (WAP) (withdraw) - *Refer to Appendix 3 (page A-14) in this workbook.*

The **WAP** is used as a master plan for a given water service area. In addition, the WAP:

- can continue for an extended period.
- shall specify the allowable withdraw rates and monitoring conditions on the transmittal letter.
- typically contains an introduction and historical information.
- should define past, present and future water uses and supply.
- shall document no conflict with other agencies.
- is seldom updated; nevertheless, a current copy should be kept on file.

National Pollutant Discharge Elimination System (NPDES) Discharge Permit - *Refer to Appendix 4 (page A-21) in this workbook.*

An **NPDES** permit:

- normally lasts for 5 years.
- specifies discharge criteria for water returned to stream.
- usually has three distinct parts.
  - ✓ Part A identifies the system and lists monitoring criteria. It is the most recognized portion of the permit.
  - ✓ Part B identifies standard conditions (generally standard throughout water systems).
  - ✓ Part C identifies "Other Requirements" and "Special Conditions."

Water Supply Permit (WSP) - *Refer to Appendix 5 (page A-41) in this workbook.*

- A WSP is issued during construction of new facilities.
- A water system may have several WSPs if additions to previous facilities have occurred.
- A WSP is normally specific to a well-defined task.
- Obtaining a WSP permit – *Refer to Appendix 6 (page A-46) in this workbook.*
- Water Resources Planning Act of 2002 (legislation still pending as of 3/03).
  - ✓ New legislation that took 20 years to develop.
  - ✓ Requires registration of water users that exceed 10,000 gpd as a 30-day average.
  - ✓ Requires development of a State Water Plan within five years (2007).
  - ✓ Possible grant availability if water loss exceeds 20%.

Role of Management in Monitoring

Establish Policies

Policies established by management must have several features. They must communicate, provide a quality product to customers, inform customers when necessary, minimize operating and long-term expenses, protect staff, and conform to federal and state regulations.

Communicate the Policies

- Written policies help to prevent misunderstanding and serve as long-term documentation. They should be:
  - ✓ updated and/or reviewed after any major change in system.
  - ✓ reviewed if any corrections of a problem require new techniques to be implemented.
  - ✓ current with state and federal regulations.
- Oral Policies can:
  - ✓ simplify instructions.
  - ✓ reinforce or supplement written policies.
  - ✓ reinforce instruction.
  - ✓ address minor issues and encourage informal feedback.

Observe and Modify

Discuss a simple operating procedure at a WTP and develop a policy statement to address an issue.

Provide Training and/or Educational Resources

- EPA website – www.epa.gov/safewater
- DEP website – www.dep.state.pa.us

Federal and State Regulations

Annual Water Quality Consumer Confidence Report (CCR) – Federal and State Required

- CCR was first required in October 1999.
- Guidance for water suppliers, EPA 816-R-99-002/March 1999, is available in hard copy from EPA or as a downloadable document from the EPA website.
- EPA has created a series of radio and print ads for use in developing CCRs.
- EPA has developed CCR Writer (v 1.5) software as a tool for water suppliers to create their CCRs.

Sanitary Surveys - *Refer to Appendix 7 (page A-47) in this workbook.*

- The purpose of sanitary surveys is to:
  - ✓ reduce risk of waterborne disease.
  - ✓ provide an opportunity to educate system operators.
  - ✓ identify systems needing technical or capacity development.
  - ✓ identify candidates for enforcement action.

- Eight basic components of a sanitary survey are:
  - ✓ water source.
  - ✓ treatment.
  - ✓ finished water storage.
  - ✓ distribution system.
  - ✓ pumps, pump facilities, and controls.
  - ✓ monitoring, reporting and data verification.
  - ✓ water system management and operations.
  - ✓ operator compliance with State requirements.

Operation and Maintenance Plan – *Refer to Appendix 8 (page A-55) in this workbook.*

Supplemental Reporting (Local Community Education)

- A little good public relations can go a long way in avoiding future problems.
- The public should not hear about their water system only when rates are going to be increased or when problems develop.
- Annual open house events might be considered.
- Water conservation tips to reduce water bills are appreciated, even during times when drought conditions are not occurring.

Backup Information and Files

- Store all back up data in a separate location. If utilizing a computer backup, be aware of the stability of the storage media and the possibility of future accessibility.
- The more important the data/file, the more frequently it should be backed up.
  - ✓ Highly critical files may need to be backed up daily or at least weekly.
  - ✓ Less critical files should be backed up on a monthly basis.
  - ✓ Full system backup should be performed once a quarter to semi-annually.
- Backup sequence must be easy to complete.

Submission and Retention of Data

Content

- The content of some reports, such as the NPDES permit, are defined.

Which reports do you remember must be available for public review?

Monthly Operating Reports

- Each report has a defined submission deadline date. As an example, the monthly NPDES Permit Discharge Monitoring Report (DMR) must be submitted to EPA and DEP by the 28th of the next month.
- All reports are currently required to be submitted in hard copy.
- EPA is implementing a program (as of November 1, 2002) to phase in electronic submission of NPDES data called Permit Application Software System (PASS). Additional information can be found at www.epa.gov/npdes/pass.

Record Retention Time Categories

- 2 years
  - ✓ Monthly operational reports
  - ✓ Work orders are typically kept for only 2-3 years
- 3 years
  - ✓ Performance monitoring (§ 109.301), PA Code
- 5 years
  - ✓ Bacteriological analysis
  - ✓ Updates Risk Management Plan (RMP) (Discussed in depth in the Safety module)
  - ✓ Variance or exemption records
- 12 years
  - ✓ Chemical analysis
  - ✓ Sanitary survey information
  - ✓ Use of acrylamide or epichlorohydrin
- Life of facility
  - ✓ Maps, distribution plans, permit (design criteria) information, Emergency Response Plan (ERP), Open and Maintenance Plan (O& M), Cross Connection plan.

Unit 1 Exercise

1. List three **Sample Types**. ____________________

   ____

2. List three **Sample Methods**. ____________________

   ____

3. (**T** or **F)** A **Water Allocation Permit** is a master plan for any given water service area. __________

4. List two occurrences that require a **Water Supply Permit**. ____________________

   ____

5. For how many years are **Monthly Operating Reports** kept? ____________________

6. For how many years are **Risk Management Plans** kept? ____________________

[1] Condensed from *Summary of Key Requirements for Community Water Systems*, DEP, document # 383-0810-101, November 26, 2001.

Unit 2 – Developing Standard Operating Procedures

Learning Objectives

- State why Standard Operating Procedures (SOP) are important.
- Develop an SOP.
- State when it is necessary to modify an SOP.

Intent of Standard Operating Procedures (SOP) During Normal Operations

An **SOP:**

- Is a listing of all actions governing a defined event.
- Provides a consistent method to insure that a defined event is always handled similarly. Written SOPs prevent the exclusion of any steps which can occur when a task is not performed frequently.
- Is useful in transferring information from senior staff to entry-level individuals. As an employee's experience increases, however, less reliance on the SOP may occur.
- May be supplemented by instructions in the form of videotapes or hands-on training.
- May serve as legal documentation.
- Should periodically be implemented by staff while being observed to ensure that staff follows the SOP precisely.

Sample SOP

Exchanging 150 pound Chlorine Cylinder (revised January 2003)
Steps may vary depending upon chlorine system manufacturer and plant layout

1. Verify that chlorine cylinder is empty by comparing scale weight with registered weight on end of cylinder.
2. Notify main office that a cylinder is necessary and request second staff member to assist.
3. After second staff arrives, shut valve on 150-pound cylinder.
4. Turn off automatic switchover device. Verify that no chlorine feed is occurring from control panel and indicator tube.
5. Turn on ventilation system and allow room to vent for 5 minutes. Safety light will come on after pre-programmed timer elapses.
6. One member of the team dons the Self Contained Breathing Apparatus (SCBA) as a precautionary measure.
7. Enter room and start actual exchange process.
    a. Detailed instructions could be posted there but manufacturer's information and illustrations should be posted on north side of chlorine feed room.
8. After cylinder is exchanged, place protective cap on empty cylinder. Move cylinder to empty storage area and mark cylinder as empty.
9. Remove SCBA and return to storage rack. Determine if SCBA bottle needs refilling and handle accordingly.
10. Return chlorine feed system to operation.
11. Notify main office that chlorine cylinder exchange is complete.
12. Check for chlorine residual at sampling point.

List three reasons it is important to create and follow SOPs.

A Standard Operating Procedure must be understandable to even entry-level employees. The use of a checklist, common terminology, and proper phrases will contribute to that end.

Use of a Checklist

- Ensures items are not overlooked.
- Provides a brief summary of all items to be considered.
- Establishes a formal order of actions to complete.
- Becomes part of a permanent file and provides documentation of the specific steps completed. Checklists often require entry of the time of an action that is taken. Readouts from a pump (PSI or RPM) may also be entered into the checklist. Monthly operating reports may include copies of checklists.

Table 2-1 Sample checklist list showing chlorine residual testing

Date	Time	Well house (mg/L)	City Hall (mg/L)	Adjustments made	Initial
6/16/04	11:30	3.4	0.8	none	thj
6/17/04	11:00	2.4	0/0	increase feed pump	rtm

Common Terminology

- Use only proper terms to describe water systems and water system components verbally and within the body of the SOP to ensure clarity of communication. Slang terms are misleading and confusing, especially to inexperienced employees.
- Use of a "Webster-type" dictionary may not be sufficiently detailed. Several reference documents provide a dictionary type list of the appropriate common terms.
  - ✓ For example the EPA reference document “Terms of Environment” is available at the EPA website www.epa.gov/OCEPAterms/.
- The proper placement and identification of signage can reduce confusion. Signage need not be fancy but it must be legible, consistent with information in the SOP, and use proper terminology.

- Information released to the public should always use proper terms to improve understanding and correct interpretation of the data.
  - ✓ EPA reference documents containing acceptable definitions and phrases:
    - "2002 Edition of the Drinking Water Standards and Health Advisories; EPA 822-R-02-038/Summer 2002."
    - EPA website www.epa.gov and http://www.epa.gov/teachers/curriculumwater.htm.
    - DEP website www.dep.state.pa.us/dep/deputate/waterops/.
    - American Water Works Association website www.awwa.org/.

Process Change

- If a new process is constructed at a facility, an SOP will be needed. For example, when an automatic system to control chlorine feed is installed, the SOP should include at least the following:
  - ✓ Actual control settings to be followed (For example, "Set point is to maintain a chlorine residual at the distribution pump sampling tap of 0.75 mg/L.").
  - ✓ Procedures determining the frequency with which the control system should be cross calibrated against the desired outcome. For example, "…chlorine residual will be checked with grab sample once per week."
  - ✓ How to adjust the control system. For example, "If a residual varies plus/minus more than 15% of the desired setting, the chlorine feeder must be adjusted."
  - ✓ How to revert to manual control in the event of system control failure. For example, "In the event of unacceptable control, turn the Hand-Off-Auto switch to Hand and check chlorine feed within 45 minutes."
- The modification of an existing system could also require SOP changes.

Operational Change (Regulation Driven)

New regulations or changes in existing regulations may require that a SOP be modified.

- The Lead and Copper (LC) rule – *Refer to Appendix 1, Table F (page A-7) in this workbook.*
- Expansion of the number of customers may require SOP modification.
  - ✓ "Number of monthly coliform samples required based upon population" – *Refer to Appendix 1, Table E (page A-6) in this workbook.*

History of Problems

A history of problems is a key indicator that either the current SOP does not address the issue or it addresses it incorrectly.

Common Library or Central Storage

All SOPs must be located in an easily accessible common library or central storage location. Additional copies may be located elsewhere. For example, a copy of a chlorine cylinder exchanging procedure may be located near, but not in, the chlorine room. A reference system must be provided if any additional copies are located outside the central library. This ensures that when an SOP is updated, the older version is retrieved and eliminated.

Staff Awareness of SOPs

The staff must be made aware that an SOP is available for a specific task. They should be willing to use the SOP and to report any discrepancy they discover to management. Since senior staff typically develops the SOP, care should be taken to ensure it will be understood and followed by all employees.

☑ **Class Activity – Developing an SOP**

Emergency Response Plan (Non Terrorist Related)

An **Emergency Response Plan** (ERP) is an emergency condition SOP or group of SOPs - *Refer to Appendices 10, Instructions (page A-76) and 11, ERP Template (page A-80) in this workbook.*

Instructions for ERP Plan Template

- Section 1 encourages development of an organization table. It should include what hours each "in charge" person is available for contact. It may have both an on duty and off duty organization table.
- Section 2 identifies specific emergencies and the corresponding contacts. This table should list any emergency no matter how limited its possibility. If an emergency occurs which is not listed, the operator should be alerted to the need for an additional ERP.
- Section 3 describes the systems and locations. It should be verified after any upgrade and at least on an annual basis. It will include description of the surrounding area, water storage and system demand.
- Section 4 is used in conjunction with the organization table.
- Section 5 identifies the available equipment. This list will change as new equipment is obtained or old is decommissioned.
- Section 6 contains the actual measures to be followed for each emergency. All items listed in Section 2 are to be detailed in this section. An operator should develop a process to handle each potential emergency before it occurs rather than try to adapt during the actual event. A partial list of minimum events is provided. However, each system has unique aspects that must be addressed. "**When in doubt, plan it out.**"
- The use of posted photographs of actual emergency shutoff settings and dialed directions can be helpful.
- After each emergency, the actual actions taken must be compared to what was listed. This is a prime time to update the list.

Ideally, any employee within the water system should be able to follow the listed actions items in an ERP and respond to the emergency. To this end the operator should avoid long descriptions as part of the actual corrective action. More detailed information may be developed and referenced but, if confusing, it should not be included with the actual corrective action.

Usage During Emergency Conditions (EC)

- Recognition of EC
  - ✓ Emergency conditions should alert staff that conditions at the facility are not normal and that the ERP should be implemented.
  - ✓ The ERP will direct staff, regardless of level, to implement a proper response. If a lower level staff member implements the ERP, EC protocol requires that upper level management must be informed. Depending upon the severity of the incident and the outcome, management may be notified immediately.

Table 2-2 Examples of Emergency Conditions

Distribution system failure (force main break, booster station failure)
Flooding of main treatment plant
Pump Failure
Disinfection Failure
Power Outage
Depletion of Well Water Source
Water Contamination
Prolonged Water Outage

- Recovery from EC
  - ✓ At the end of the EC, staff should be directed to return to normal SOP.
  - ✓ This is the prime time to determine if any actions items were not adequately covered in ERP. Documenting as much information as possible during EC will contribute to the success of a review.
  - ✓ A written report should be prepared and submitted, depending upon the specific EC, to DEP or to the public.

- A feedback system should be developed to document lessons learned during EC. In the example of a flood, the following information should be gathered after conditions are returned to normal.
  - ✓ Time of notification of impending flood.
  - ✓ Actual time flood water entered plant.
  - ✓ Measurement of highest water level, in relation to physical structures at plant.
  - ✓ Location where water entered first.
  - ✓ Equipment or structures damaged by flood.
  - ✓ Reports of maximum flood stage in stream.
  - ✓ Corrective action taken by staff.
  - ✓ Other agencies contacted or action taken.
  - ✓ Length of time water was affected and to what degree.
  - ✓ Operators should record all complaints by date, time, location, and any follow up action.
  - ✓ Description of repairs and/or replacements required to restore units.
  - ✓ Contractor, repair, service, or equipment vendor involved in any EC.
  - ✓ Cost of repairs.
  - ✓ Actions taken to prevent future problems.
  - ✓ Public notice given.

Identify Hazards and Access Vulnerability

- As one attempts to access the hazards or vulnerability of plant conditions, an acknowledgment that Murphy's Law is likely to prevail is a wise perspective. Nothing is foolproof. Look at the equipment and question yourself.
  - ✓ Hazards can negatively impact personal safety of both the public and the staff.
  - ✓ Vulnerability can result from environmental problems or accident potential.
    - ▪ Example of environmental problem—low water level in supply stream.
    - ▪ Example of accident potential—existence of poor equipment creating a system that is vulnerable to high incidence of failures.

Unit 3 – Budget

Learning Objectives

- List three typical expense categories seen in water plant budgets.
- Describe three cost trends that can be discerned from careful comparisons of monthly budgets.
- Explain the difference between short-term and long-term budgets.

Categories

Chemical Expense

Chemical usage may exhibit seasonal variations causing the monthly budget to fluctuate. Can you think of some examples?

- The costs of certain chemicals increase as a result of tightened security. Chemicals such as oxidizers, which may be used in the fabrication of terrorist devices, are being tracked more closely, creating an increase in costs from supplier.
- Since usage and costs vary among chemicals, it is prudent to list each one as a separate line item in your budget. If not, they should at least be listed individually on support documentation. This will provide greater insight into changes in individual chemical costs and help to better manage those costs.
- Benchmark actual usage against typical values to determine if your system's values are significantly different than "normal." For example, you can compare actual usage against design values for your facility. The Basis of Design for a system should be available from the design engineer. It lists anticipated dosages that can be equated to cost.
- If costs are increasing at a rate greater than the inflation rate, the operator may need to determine cost/pound or gallon. The reason for the increase may be due to ineffective operation or change of process conditions.

Power Expense

Normal electric usage may also fluctuate from month to month. Careful attention to usage fluctuations is important in controlling costs. Comparing current costs against previous year's costs requires careful analysis. Numerous factors may exist. For example:

- High dosage rates of chemicals require more mixing costs and residual processing costs.
- Increased water consumption, typical during summer, creates an increase in power usage.
- A booster station with electric heat or aeration in a tower to prevent freezing increases power usage during extreme temperatures.

When power usage starts to increase for unknown reasons, management must begin to look for potential causes. Are leaks occurring in system? Are pumps overdue for rebuild? Is electric heat set higher than necessary? Are pumps operated simultaneously, creating a "peak demand" charge?

Equipment Expense

Acquisition and cost of equipment maintenance are part of a budget.

Miscellaneous or Unidentified Expenses

- It is acceptable to put small items into one miscellaneous category as long as that category remains one of the smaller breakdown items in the budget. Too many expenses in a miscellaneous category reduce the ability to determine which expense is increasing.
- Organize expenses into budget categories. Group expenses with similar characteristics such as chlorine, soda ash, and polymer into a chemical category.
- Compare budget values with previous actual expenses. Having several years of past data can be helpful.
- Identify any categories that are increasing at a greater rate than inflation or another evident cause.
- Be able to justify why any category significantly increased or decreased.

Short-Term (Annual)

Examples of annual expenses include chemicals, electric, fuel oil, and preventive maintenance tasks performed by the staff. These are items that are used or occur within a year's budgetary time frame. An annual budget should balance. A plant will not operate successfully with more expenses than income.

Mid-Term (5 Years)

Mid-term budgetary items include those that should be budgeted in advance. A mid-term item is typically a large expense requiring an extended planning period. Items placed into a 5-year plan are not necessarily acquired at the end of that term. The plan must include an end of term review to assure acquisition is still necessary.

Long-Term (10+ Years)

Long-term budgeting is used for major purchases or system upgrades and may require either a Capital Improvement Program (CIP) or funding through the issuance of a bond or taking of a loan.

- Over time the accurate estimating of an equipment expense becomes more difficult. The updating of older equipment may increase efficiency and yield savings. To determine the feasibility of an equipment update, estimate the cost savings vs. the expense of the new device and determine the payback period in months or years.
  - ✓ Examples: construction of new tank or a process modification.

Development of a Budget

The PA Department of Environmental Protection has available at its website a number of water system self-assessment guides with budgeting worksheets. Each is specific to a type of water treatment system. They can be found at:

- http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/wsm_tao/guide_assoc.pdf.
- http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/wsm_tao/guide_investor.pdf.
- http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/wsm_tao/guide_mhp.pdf.
- http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/wsm_tao/guide_authority.pdf.

Emergency

A fund must be available for emergency events. In the case of possible endangerment to customers, additional flexibility in acquiring replacement equipment is often possible at the municipal level. Private water systems do not fall under the same restrictions as public systems. Therefore, if in doubt about what is permissible for a municipality, the solicitor should be contacted.

Bid Requirements

Public systems:

- If the item costs between $4,000 and $10,000, three quotes are required. If the cost is in excess of $10,000, normal bidding procedures are required.
  - ✓ A minimum advertisement time of one week is specified. However, 30 days is the common minimum time.
  - ✓ Clarification of municipal bidding – *Refer to Appendix 12 (page A-86) in this workbook for reference purposes only.*

State “Piggyback”

Act 57 of May 15, 1998, permits local public procurement units to participate in those contracts for supplies, services, or construction entered into by the Department of General Services (DGS). A "local public procurement unit" is defined as “any political subdivision, public authority…including a council of governments or an area government…”

Please direct any correspondence to:

Department of General Services Cooperative Purchasing
Attention: Susan Plecker
415 North Office Building
Harrisburg PA 17125
Telephone: 717-787-1105 (voice)
Fax: 717-783-6241
E-Mail: splecker@state.pa.us

☑ Class Activity

Table 3-1 Sample Budget

1. WATER COLLECTION TREATMENT, PUMPING	1999	2000	% Chg	2001	% Chg	2002	% Chg
Labor	246,000	267,025	8.5	286,251	7.2	292,650	- 2.2
Chemicals	65,120	67,968	4.4	82,485	21.4	91,256	10.6
Water analysis	9,000	11,680	29.8	9,199	-21.2	9,500	3.3
Fuel oil	11,500	12,315	7.1	15,157	23.1	16,200	6.9
Supplies and expenses	75,000	81,683	8.9	109,075	33.5	145,123	33.0
Water purchased	3,300	3,268	-1.0	3,438	5.2	3,500	1.8
Electric	127,900	135,000	5.6	140,000	3.7	143,564	2.5
Sub-total	$537,820	$578,939	7.6	$645,605	11.5	$701,793	8.7
2. WATER DISTRIBUTION							
Labor	44,000	45,667	3.8	44,834	-1.8	46,000	2.6
Supplies and expenses	21,000	22,225	5.8	20,177	-9.2	21,950	8.8
Misc. services	23,000	24,220	5.3	22,145	-8.6	26,789	21.0
Electric	12,500	13,400	7.2	15,123	12.9	17,892	18.3
Sub-total	100,500	105,512	5.0	102,279	-3.1	112,631	10.1
Total	$638,320	$684,451	7.2	$747,884	9.3	$814,424	8.9

NOTES:

Increase in chemical cost during 2001 was a result of taste and odor problems. Appears to be long term problem.

Change in water analysis cost resulted from diagnostic testing to determine taste and odor issue.

Unit 4 – Personnel

Learning Objectives

- Describe when and why operators are required to submit a copy of their criminal history record.

Criminal History Check

A criminal history check on certain employees, performed by the Pennsylvania State Police, is required by PA Act 11 2002. It must accompany all applications for **certification** and **re-certification**. Existing certified operators are required to submit a copy of their criminal history record with the renewal application, pursuant to a schedule for renewal established by the board.

The criminal background check can be dated no earlier than 90 days prior to the operator signing the renewal application and can be requested by mail for a fee at the Pennsylvania State Police at Public Information Office 1800 Elmerton Avenue, Harrisburg, PA 17110, 717-783-5556, http://www.psp.state.pa.us/psp/site/default.asp. Allow at least 4 weeks for processing.

- The Pennsylvania State Police use an electronic system: the Pennsylvania State Police's Public Access to Criminal History (PATCH) system. PATCH is scheduled to become accessible to the public in the early part of 2003.
- Criminal check request form, SP4-164 Form – *Refer to Appendix 14 (page A-88) in this workbook*.
  - ✓ DO NOT select the block to review your entire criminal history. This block would retrieve arrests as well as convictions. Only you are entitled to view your arrests. Selecting this block could also create delays in receiving the report.
  - ✓ In the area that states "Reason for Request," select "Other" and specify water/wastewater operator certification requirement.
  - ✓ A certified check or money order is required; personal checks or cash will not be accepted. The 2003 fee is $10.00.

Union Contracts

- The water system operating entity must recognize union contracts.
- Union workers are not permitted to create conditions that could lead to endangerment of public health or safety.
- Management must post each job description for the facility.

Occupational Safety and Health Administration (OSHA)

Occupational Safety and Health Act (OSHA) of 1970

- The mission of the Occupational Safety and Health Administration (OSHA) is to save lives, prevent injuries, and protect the health of America's workers. OSHA guidelines are not fully approved in Pennsylvania for public workers.
  - ✓ OSHA encourages states to develop and operate their own job safety and health programs.
  - ✓ OSHA approves and monitors state plans.
  - ✓ There are currently 23 States and jurisdictions operating complete OSHA approved state plans.
  - ✓ The Occupational Safety and Health State Plan Association (OSHSPA) is the organization of officials from the 25 states that administer OSHA approved state plans.

Full Time

Emergency and Overtime Operations

- Unless union defined, full time staff members do not usually require special working conditions that might limit manpower allocations. The full time staff is typically more knowledgeable of water system operations and protocols than part time or temporary staff. Full time staff should be strongly encouraged to become certified operators. New Water and Wastewater Operator Certification Law (PA Act 11 2002) requires certification for any individual who makes process control decisions.

- When overtime events occur on a frequent basis, additional staff of either full time or part time individuals should be considered.

Part Time

- Part-time staff is often more knowledgeable than outside contractors but may require more supervision than a full time employee.

- Part time employment provides an excellent opportunity to evaluate an individual for full time placement.

- A good prospect for part time employment may be a staff member who is preparing to or has already retired.

Temporary Staff and Special Projects

- Temporary staff is generally only utilized for very specific tasks or projects and, therefore, is required for only a defined period.
  - ✓ Temps normally require specific instructions from management to perform projects.
  - ✓ Temps will also require instruction about any unique operating aspects of the specific water system.

Setting Goals

SMART Goals

- Is it Specific?
- Is it Measurable?
- Is it Ambitious?
- Is it Reachable?
- Is it Time-bound?

Training Requirements

- New Water and Wastewater Operator Certification Law (Act 11, 2002) requires continuing education. Detailed information can be found at the DEP website:
  - ✓ http://www.dep.state.pa.us/waterops_apps/etpmain/certification/certificationNew.asp
- Specific guidelines for the new Act 11 are available in the document below:
  - ✓ http://www.dep.state.pa.us/eps/docs/cab200149b1126000/fldr20027081209004/doc20036kb4301002/150-0200-002.pdf

Disciplinary Action

The following four guidelines provide a basic structure for disciplinary action.

- Advance warning
- Quick
- Uniform
- Consistent

Safety cannot be compromised in an effort to accomplish a task. Reluctance of an employee to perform a task due to safety or health issues must be taken seriously and properly resolved.

Unit 5 – Water Production

Learning Objectives

- Define water plant flow balance.
- Describe volume conveyed and volume billed.
- Discuss seasonal water usage.
- Calculate water fire demand in gallons per minute.

Production

Production Based Per Day

The operation of a Water Treatment Plant typically places treatment units into service for a period of at least several hours up to all day. At times, all units may be in service and throughput at or near maximum level. At other times, one or more units may be shut down to lower demand need or simply to repair units and then throughput of a treatment process may be considerably less.

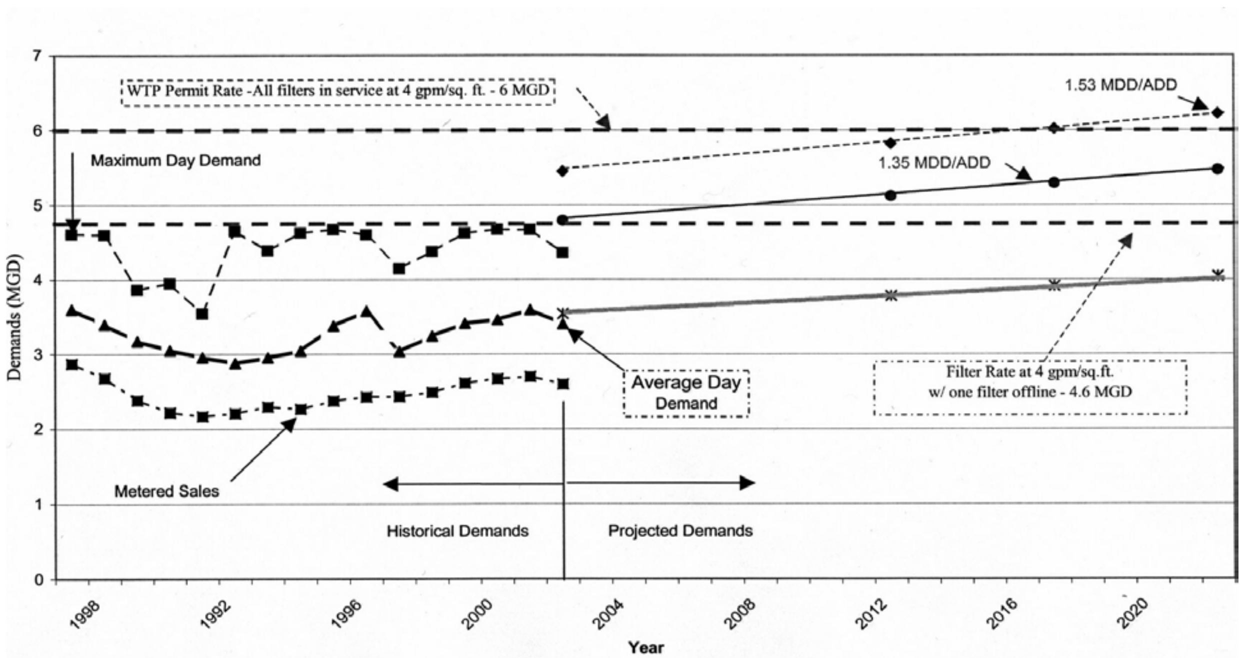


Figure 5-1 Demand Projections and WTP Capacity

Water Plant Flow Balance

- The amount of gallons pumped or transferred through each treatment phase should be tracked.
  - ✓ Use of calibrated process flow meters is the preferred method of tracking flows. If such instrumentation is not available, other techniques such as pump run times or tank levels are alternative methods that can be employed.
- Waste byproducts will be generated and will need to be diverted from main flow stream.
- Waste byproduct generation compared to volume into distribution system should be monitored. Residual solid generation is monitored by two parameters: the volume of flow wasted and the mass of solids removed. Waste byproduct generation should be tracked by volume and mass either with a flow meter or with a basin/tank that is filled. As an example, when the concentration of suspended solids increases, the volume of the conveying fluid decreases. If a waste stream concentration of waste byproducts of 3,000 mg/L can be increased to 6,0000 mg/L, the volume of associated water is cut in half.

Volume Conveyed Compared to Volume Billed

- While there is some loss expected, there is no well-defined guideline. Twenty percent is the figure that is sometimes used and is referenced in the Water Resources Act of November 2002.

- Revenue may not be realized:
  - ✓ The Demand Productions and WTP capacity chart on the previous page shows a line for "metered sales." Additional volumes to track include un-metered but billed sales and non-billed volume (lost revenue that must be re-cooped by increase in cost per gallon of billed sales).
  - ✓ Billing based upon a standard assumed usage per household or fixture is outmoded and inefficient. It does not encourage water conservation by the household and can lead to erroneous conclusions about water loss. Individual household metering provides a more effective, efficient, and accurate tracking of both use and loss.

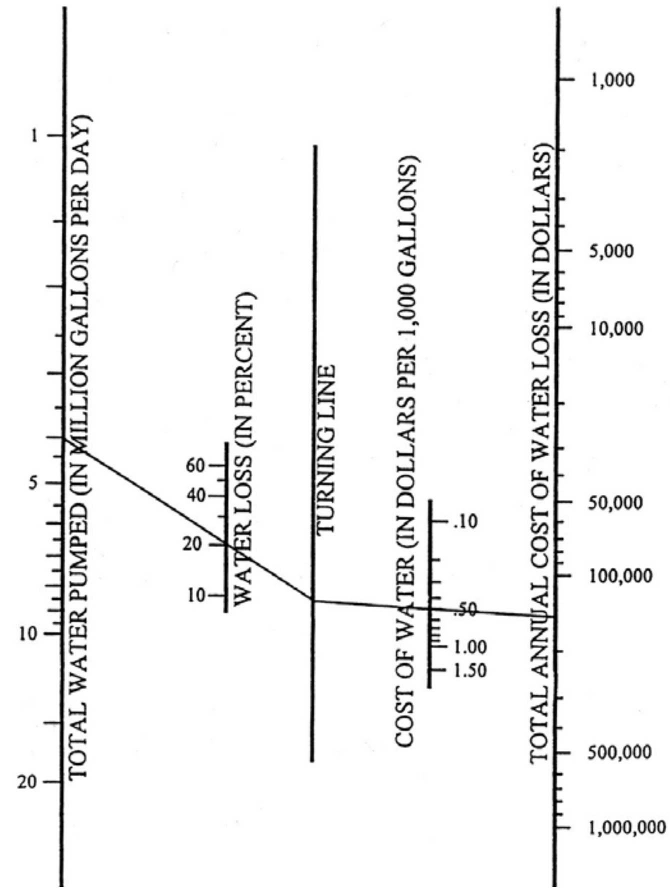
- Revenue loss may occur due to loss in water transmission from defined problem areas such as leaks in the distribution main.

- Revenue loss can also occur due to inaccurate water meters. The operator must evaluate the cost of meter replacement vs. projected additional revenue.

Table 5-1 Water Leak Reference Table

LEAK THIS SIZE	LOSS PER DAY* (GALLONS)	LOSS PER YEAR* (MILLION GALLONS)
1/16"	980 (1,310)	0.35 (0.48)
1/8"	3,975 (5,300)	1.5 (1.9)
1/4"	15,900 (21,200)	5.8 (7.7)
3/8"	35,900 (47,800)	13.1 (17.5)
1/2"	63,800 (85,000)	22.3 (31.0)
5/8"	99,600 (132,800)	36.4 (48.5)
3/4"	143,400 (191,200)	52.3 (69.8)
1"	255,000 (340,000)	93.1 (124.1)

* BASED UPON 60 (80) PSI



Total water pumped = 4 MGD
Water loss = 20%
Cost of water = $.50/1,000 gallon
Total annual cost of water loss =?

Figure 5-2 The Hidden Cost of Water Loss

Daily and Seasonal Variable Usage

It is common for water usage to vary throughout the day. This phenomenon is referred to as a diurnal variation.

- Typically minimal consumption occurs at night. It is then that the storage tanks are usually being refilled. It is critical to monitor the refilling of storage vessels when unattended to prevent overfilling.

Winter usage is less than summer usage. Can you think of any reasons for this?

____

____

In un-metered areas winter usage may **increase** in cold weather. What could cause this?

____

____

Emergency Production Requirements

Fire Support

- The National Board of Fire Underwriters Recommendations:
  - ✓ For one and two family dwellings, production shall be 1,000 gpm.
  - ✓ For downtown business districts or communities with less than 200,000 people, the production formula is:
    - $Q = 1020\sqrt{p}\,(1 - 0.01\sqrt{p})$ for British units when **Q** = discharge in gal/min and **p** = population in thousands
- The Insurance Services Office Guide recommendations from the International Fire Service Training Association (IFST) 1993: **F** = required flow rate (gpm) and **C** = coefficient of construction type

Table 5-2 IFST Recommendations

C value	Construction	Max. flow rate(gpm)
1.5	Wood frame	8,000
1.0	Ordinary	8,000
0.8	Noncombustible	6,000
0.6	Fire resistant	6,000

$$\mathbf{F = 18 \times C \times \sqrt{A}}$$

Calculate water fire demand where A = total floor area, ft^2, for a 2-story building of "ordinary" construction of 6000 square feet.

For a town greater than 2,500 people, the National Board of Fire Underwriters (NBFU) recommends providing a minimum of 10 hours duration of water. Otherwise size for at least 4 hours. We will assume this town has greater than 2,500 people. Calculate total gallons required based on the above gpm answer.

Shared System – Intercommunity Support

For example, if one community is taking a basin off line and will be unable to keep up with water consumption, another community may be able to assist by either interconnection of transmission lines or by trucking water to the affected community.

Solids Generated as a Result of Water Treatment

Typical Methods to Handle Solids Generated as a Result of Water Treatment

- Discharge solids to sanitary sewer system, if acceptable by wastewater treatment plant.
- Discharge partial backwash filtrate by decanting the clear liquid and concentrating the solids. The clear liquid may need further treatment prior to discharge into a receiving stream, as stipulated in NPDES permit.
- Process solids on site and transport to application area or disposal site.
- Discharge to storage lagoon for processing at a later time. Typically storage capacity allows for ten or more years before the lagoon is filled. At that time, the actual cleaning of the sludge will occur.
- Any flocculation or coagulation type chemicals used will require collection, removal, and processing of the flocculation or coagulation agents plus their associated pollutants later in the water plant.

Form 20 R, "Application for Residual Waste General Permit" – *Refer to Appendix 15 (page A-89) in this workbook for reference only.*

Unit 6 – Chemical Inventory

Learning Objectives

- Define a Chemical Abstract Number.
- State the chlorine condition that requires a chemical Risk Management Plan.

Seasonal

Seasonal variations in temperature occur and will require the careful monitoring of chemical inventory. Some chemicals may not allow for prolonged storage, especially when affected by temperature.

- Taste and odor (T&O) complaints may increase in the summer. T&O is controlled by the use of Powered Activated Carbon (PAC). Monthly dosage of PAC in winter is at 2 mg/L but the dosage can increase in summer up to 10 mg/L.

☑ **Class Activity – Dosage Variation**

Calculate the monthly supply for winter operation if dosage is at 2 mg/L to a water production flow of 2.5 mgd (million gallons per day). The conversion factor from metric to pounds = 8.34.

Calculate the monthly supply for summer dosage at 10 mg/L with water production increased to 2.7 mgd.

- PAC characteristics:
  - ✓ Average density is 33 – 35 pounds/cubic foot depending upon grade and type. Lowest density is typically 25 pounds per cubic foot.
  - ✓ Depending upon the manufacturer, PAC is shipped in 55 lb vinyl bags or sacks, 220 lb fiber drums, 500 lb fiber drums, or 1,000 to 1,100 lb "super sacks."
  - ✓ Bulk purchase can be as large as a 20,000 pound trailer.
- Costs of PAC
  - ✓ Multi-month shipment may be available and that cost is typically lower on a per pound basis.

Other Variations

- Chemical availability may be affected by the loss of production by a supplier, a manufacturer unable to supply for a period of time, or a manufacturer eliminating a chemical from production.

- On site causes of chemical unavailability include unexpected problems at WTP that create a non-typical demand upon inventory, a loss of WTP inventory due to product contamination, a spill or leak, or automatic control system problems.

- Management can control chemical budget items by considering the cost savings of larger shipments, possible sale events from supplier, and comparing vendors periodically to verify minimum cost per pound.

- Active inventory management will assist you in staying below Threshold Planning Levels 40 CFR 68 (Code of Federal Regulations). We will explore this further in a moment.

Material Safety Data Sheet (MSDS)

MSDS copies need to be located in a central area. An extra copy is needed at site of usage, particularly if that is a remote site such as a booster station.

- The MSDS sheet information format is defined under Federal program. Extensive information is available at http://www.access.gpo.gov/nara/cfr/waisidx_01/29cfr1910a_01.html.
- General information in the MSDS is uniform for all chemicals and from each manufacturer, as defined by the federal directive.
- MSDS provides general guidelines and compatibility issues (such as fire suppression).
- Additional information about MSDS is provided in the Safety module.

Chemical Compatibility

Chemicals may not be compatible with other substances. More detailed information on chemical compatibility can be found in chart form at http://www.bifrost.unl.edu.ehs/chemicalino.compchrt.html (source from Municipally Environmental Laboratory, EPA). Some common examples are:

- Addition of phosphorus to water creates a reaction.
- Mixing of anti-freeze with sodium hypochlorite powder (HTH) can create fire.
- PAC will absorb oxygen from a moist area.
- The addition of chlorine solution (bleach) to ammonia will create a toxic off gas.
- Some chemicals will affect pumps.
    - ✓ Chlorinated water has a severe corrosive effect on carbon steel and some stainless steel.
    - ✓ Chlorinated water has no corrosive affect on PVC, kynar, or viton.
    - ✓ Fluorosilicic acid (or hydrofluosilicic acid), which is used for fluoride addition, is not compatible with carbon steel or most stainless steel but has a high compatibility with monel, Hastelloty C, or kynar.

Risk Management Plan (RMP)

When Congress passed the Clean Air Act Amendments of 1990, it required EPA to publish regulations and guidance for chemical accident prevention at facilities using extremely hazardous substances. The Risk Management Program Rule (RMP Rule) was written to implement Section 112(r) of these amendments. The rule, which built upon existing industry codes and standards, requires companies of all sizes that use certain flammable and toxic substances to develop a Risk Management Program.[2]

- Detailed information can be found in *Guidance for Auditing Risk Management Plans/Program Under Clean Air Act 112 (r”),* available from EPA.
- RMP Audit information is available at http://www.epa.gov/swercepp/factsheets/auditfactsheet.pdf and at http://www.epa.gov/ceppo/pubs/audit_gd.pdf.
- The RMP must be updated every 5 years (minimum elapsed time).
- A change in process requires update at that point in time (sooner than the 5 year minimum).
- A change in accident history also requires an update of RMP sooner than the 5 year minimum.

Chemical Abstract Service Registry Number Data Standard (CAS) is a number assigned to each chemical. It reduces confusion that can occur when a name is used for a chemical, since any individual chemical may be referred to by many different trade names. As an example, hydrogen sulfide is assigned a CAS 7783-06-4 but some common synonyms are: dihydrogen monosulfide, dihydrogen sulfide, hydrogen sulfuric acid, hydrogen sulphide, hydrosulfuric acid, stink damp, sulfureted hydrogen, or sulfur hydride. Further detail can be found at http://www.epa.gov/irmpoli8/casstandard/.[3]

Table of Threshold Planning Levels for Mandatory RMP

- Clean Air Act 112 (r) (5) table excerpt:
  - ✓ Chlorine [CAS7782-50-5] = 2,500 pounds
  - ✓ Chlorine dioxide [CAS 10049.04-4] = 1,000 pounds
  - ✓ Bromine [CAS7726-95-6] = 10,000 pounds
  - ✓ Sulfur dioxide [CAS 7446-09-5] (anhydrous) = 5,000 pounds
  - ✓ Hydrogen fluoride (annhydraous) [CAS 7664-39-3] = 1,000 pounds

Class Activity – Determine if RMP Is Required

Chlorine usage at the WTP site is 11 pounds per day. Annual shipment is received at one time. Is an RMP required?

The water system consists of a well and intake from surface water. Several miles separate the two locations. Water from the well is conveyed to the WTP before being processed and pumped into the distribution system. Chlorine usage at the well is 4 pounds per day for 365 days per year. The WTP uses 5 pounds per day for 365 days per year. All shipments are in one ton containers. Is an RMP required?

Sources

We need a primary and alternative supplier for every item and should know normal delivery times of each to be able to address supplier shortages and take advantage of competitive pricing.

Feed System

Some feed systems are limited to using one specific chemical form or type of shipment container. For example:

- A liquid feed system may not be able to use a dry chemical. Consequently, you may need to consider installing a liquefier or dissolver as an intermediate step.
- Some **pure chlorine** gas systems cannot handle **pure liquid** chlorine.
- Some feed pumps cannot handle a suction lift, limiting selection of pumps if the container is equipped with only top unloading ports.
- If you attempt to suction lift volatile chemicals, the vapor pressure of the fluid will result in loss of the liquid state. Vaporization will occur and the fluid will not be pulled into the pump device.
- An automatic feed system can reduce chemical usage by allowing flow paced equipment to maintain a constant dosage rate based upon volume of flow past a defined measuring/monitoring point or by allowing feed variability, depending upon a feedback signal from an in-line analyzer.

[1] Title 29 – Labor, Chapter XVII – Occupational Safety and Health Administration, Department of Labor, Part 1910 – Occupational Safety and Health Standards.

[2] US EPA, Chemical Emergency Preparedness and Prevention, RMP Program Overview.

[3] Chemical Abstract Service Registry Number Data Standard, US Environmental Protection Agency, 1- 19839:1.

Unit 7 – Electrical Power

Learning Objectives

- Describe the level of electrical expertise required to work with High, Medium, and Low Voltage equipment, respectively.
- Define Gen-Set.

High Voltage

High Voltage lines are defined as Multi kilo-volt lines (from 115,000-volt grid and above). WSP staff are not authorized nor qualified to work on high voltage equipment feeders. Isolation distances depend upon voltage.

- OSHA guide section 1910.333 lists the following criteria:
  - ✓ 50,000 volts and below = 10 feet isolation distance.
  - ✓ 50,000 volts and above = 10 feet plus 4 inches for every additional 10,000 volts isolation distance.
  - ✓ Ladders must remain outside isolation area.

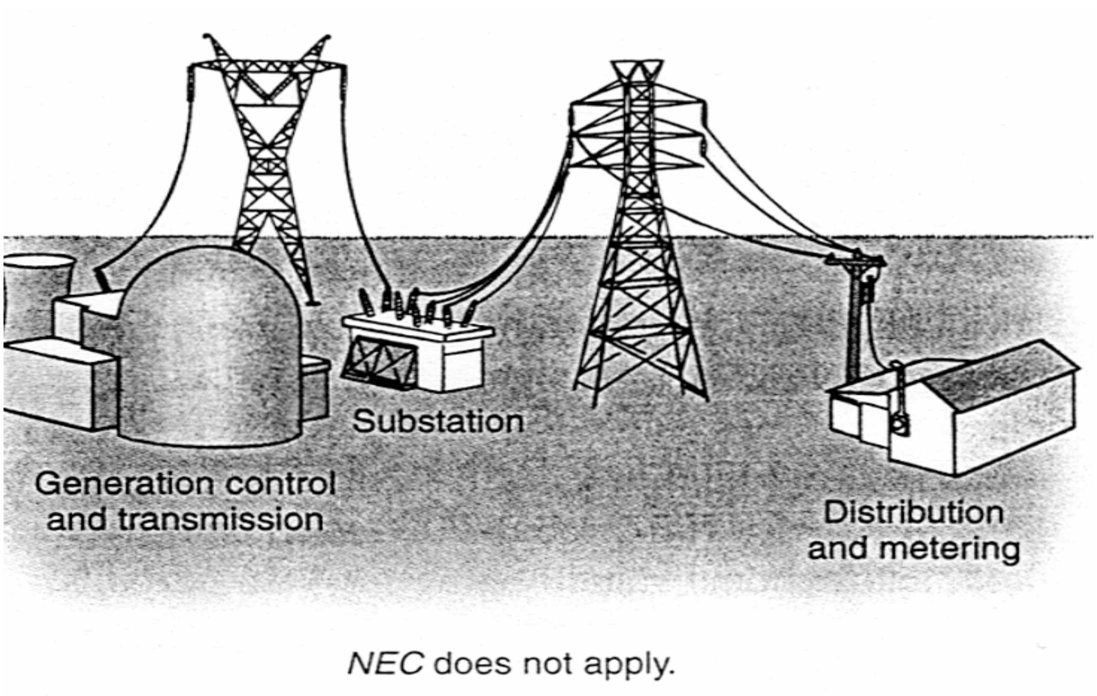


Figure 7-1 Example of high voltage station [1]

This level of equipment is well beyond the ability of operators and most "domestic/residential" or even commercial electricians. It requires highly specialized techniques and equipment. Attempting to work on this equipment almost guarantees injury or death.

Medium Voltage

Medium voltage ranges from 480 to 69,000 volt line. A sub station drops voltage from a high voltage grid. A sub station or transformer can drop the voltage down to 480.

- Voltage within Main Control Centers (MCC) may include 480 volt, 240 volt, and 120 volt AC current inside, as well as DC voltage control circuits.
- A registered electrician may be able to work on some but not all equipment in the medium voltage environment.
- Isolation distances between MCC and other apparatus for 600volts or less are found in National Electrical Code (NEC) 110.26 since MCC may include up to 480 volt current.
  - ✓ Typical feeder section in a WTP must have 4 feet in front of panel in facing a second panel, provided there is no access from the side or back.

This level of equipment is well beyond the ability of operators and most "domestic," "residential," or commercial electricians. Specialized techniques and equipment are required. Attempting to work on this equipment almost guarantees injury or death.

Low Voltage

Low voltage ranges up to 480 volt three wire circuits but can include some 600 volt three wire circuits. A registered electrician is able to work on this equipment.

- Isolation distances between MCC and other apparatus for 600 volts or less are found in National Electrical Code (NEC) 110.26.
  - ✓ Typical MCC in WTP with 3 feet in front of panel, provided there is no access from side or back.
  - ✓ Grounding must be maintained with a ground fault interrupter (GFI).

A registered electrician is able to work on this equipment.

Class Activity – Isolation Distances

Table 7-1 Sample Isolation Distances [2]

	Minimum Clear Distance		
Nominal voltage to ground	**Condition 1***	**Condition 2***	**Condition 3***
601-2,500	0.9 m (3 ft)	1.2 m (4 ft)	1.5 m (5 ft)
2,501-9,000	1.2 m (4 ft)	1.5 m (5 ft)	1.8 m (6 ft)
9,001-25,000	1.5 m (5 ft)	1.8 m (6 ft)	2.8 m (9 ft)
25,001-75 kv	1.8 m (6 ft)	2.5 m (8 ft)	3.0 m (10 ft)
Above 75 kv	2.5 m (8 ft)	3.0 m (10 ft)	3.7 m (12 ft)

* **Condition 1** – Exposed live parts on one side and no live or grounded parts on other side of the working space or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials.

* **Condition 2** – Exposed live parts on one side and grounded parts on other side. Concrete, brick, or tile walls shall be considered as grounded surfaces.

* **Condition 3** – Exposed live parts on both sides of workspace with the operator between.

If a plant addition includes possible installation of new equipment in a space in a motor control center room, with service of 12,000 volt, what would be the isolation distance under the best conditions (Condition 1)?

Secondary Utility Feeder

The dependability of water supply from a WTP is critical. The public assumes that water quality and quantity will be sufficient at all times.

- A second source for providing water pressure must be able to maintain the water supply even in an emergency situation.
  - ✓ An emergency electrical power source (i.e. standby generator) can supply power to other equipment and is normally sized to provide standby service. If the main electrical feeder to area has poor service history, the generator might be sized for prime service.
    - The generator may have manual transfer switchgear due to higher voltages. Some systems have automatic transfer capability.
  - ✓ Emergency diesel engine driven pumps provide limited service since they power no other equipment or lights.
  - ✓ Multiple staff members, capable of switching to the secondary utility feeder, will decrease the potential for prolonged loss of service.

Emergency On-Site Generator

There must be a disconnect switch to isolate the generator from the rest of the power grid. This is necessary to prevent injury to utility workers correcting a problem in the main feeder as the generator is energized.

- A typical WTP has a diesel Gen-Set (a term used to mean an engine driven electrical generator).

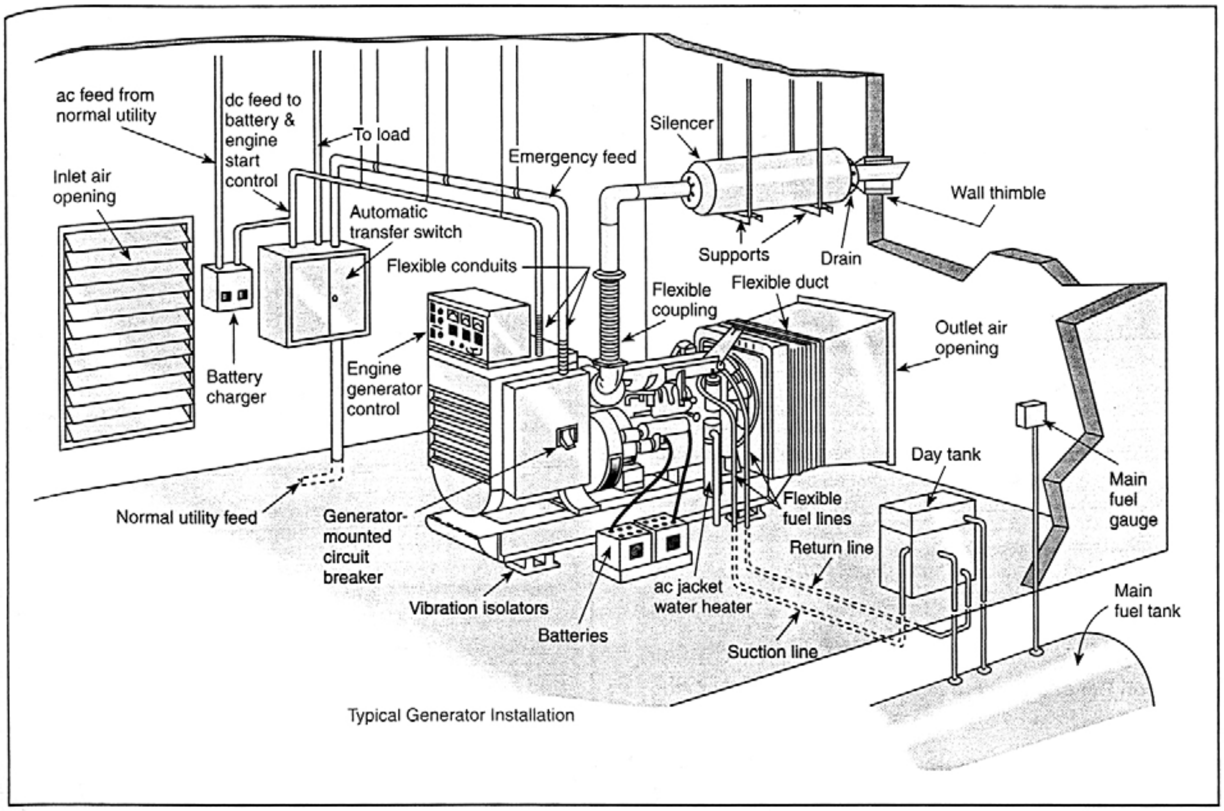


Exhibit 700.1 A typical generator installation supplying standby power in ratings from 55 kW to 930 kW, 60 Hz. (Redrawn from Caterpillar)

Figure 7-2 Typical Gen-Set [3]

- Preventive maintenance is more critical to gasoline fired engines. They are, therefore, less favored than diesel engines.

- Propane fired gen-sets are usable for small installations. There is less of a problem of "gumming" than in a fuel system such as gasoline.

Preventative maintenance on the emergency power source is critical since there may be no other backup available.

Portable or Trailer Units

In order to employ portable or trailer units safely, the WTP must have a main electrical feeder disconnect switch to ensure that there is no back feed to the grid from the emergency generator.

- A throw switch.
- An emergency electrical pigtail connection cord with interlock to prevent connection while on main electrical service.

Uninterruptible Power Supply (UPS)—Computer Application

A UPS can also serve as a Transit Voltage Surge Suppressor (TVSS) for a computer. Additional computerized controls would be required to maintain history of information (data) stored on computer because the UPS has a finite and limited amount of power storage.

- Know the rating of UPS to allow for adequate time to save/shutdown computer.
- Test the alarm circuit that alerts staff to UPS being on line.

Evaluation of Key Equipment Electrical Requirements

- List all key equipment at the main facility and at any remote booster stations.
- Determine if equipment can be isolated or if the entire facility must be powered during an emergency.
- Determine how equipment will come on line after a power switch.

Electrical Budget Management

We first need to know how the peaking factor, such as 1 minute divided by the average power consumed during the month, is calculated at the facility. For example, peaking factor may be calculated on 5 second, 1 minute, or 15 minute maximum electrical pull from utility.

- To conserve connected load when rotating equipment, shut off one pump before turning on the next unit. This will reduce the peaking factor that is applied to the electrical bill.

Monitor power usage. A sudden increase in power usage may indicate other problems or problematic events.

- Equipment inefficiencies can lead to additional electrical use.
- When chemical addition is increased, processing costs rise as a result of more equipment being in service.
- Thermographic analysis (infra-red scan) is used to detect locations in MCCs where poor electrical connections may exist. It is common for connections to develop unacceptable electrical transfer as a result of the contacts heating up and cooling down when equipment cycles. Over a period of time, the expansion and contraction will generate less actual contact surface area. As less area is available, the resistance increases. As more power is used in heating, the cost to run that equipment increases. If undetected or uncorrected, an electrical fire can develop.
- Seasonal demands will create some variability in usage. These changes are usually traced to an increase in water production, discussed in an earlier unit.
- Comparing the increased efficiency vs cost and then evaluating a payback time period will determine whether to replace used equipment.

Class Activity – Cost Justification of New Equipment

An old pump, estimated to be only 50% efficient, consumes 5,500 kW/hr/month with a power cost of $ 0.11/kW/hr. Calculate the annual cost of this pump.

A new pump will cost $9,500. It is approximately 78% efficient and will consume 3,500 kW/hr/month with a power cost of $0.11 kW/hr. Calculate the annual cost of this pump.

Calculate how long before the new pump will be paid for by the annual cost savings?

[1] National Electrical Code 2002 Handbook: Exhibit 700.1 p 989.

[2] "Minimum Depth of Clear Working Space at Electrical Equipment," Summarized from National Electrical Code Table 110.34 (A) (NEC).

[3] Caterpillar Corporation, Standard Operator Manual.

Unit 8 – Fuel

Learning Objectives

- Identify three fuel types and their typical uses.
- List four criteria an operator should understand and describe about each fuel consuming unit in the water system.

Local Suppliers

Identification of both regular and alternative suppliers for all fuel types at the water system is an important first step toward controlling fuel supplies, costs, and quality. Can you think of some reasons why?

- We need to understand and identify each fuel consuming unit in the Water System by the following criteria in order to plan for efficient purchase and usage.
  - ✓ Normal and maximum usage.
  - ✓ Normal reorder point and how is it determined.
  - ✓ Fuel storage capacity at site.
  - ✓ Normal and emergency fueling procedures.
- Fuel types and typical uses.
  - ✓ Gasoline is used for light duty portable generators, portable pumps, vehicles, and power equipment but has limited usage for stationary units.
  - ✓ Diesel fuel is used in heavy duty trailer and permanent generators, emergency water pumps, and vehicles. The fuel specification information must be obtained from each unit that uses diesel. Some units can run on "blended fuels" to address winter operation.
  - ✓ LPG (Propane) is used for light to moderate duty generators and heaters.

Emergency Supply

In an emergency situation, a tanker containing liquid fuel may need to be escorted to the facility. We should plan ahead to meet the tanker at an easily identifiable local landmark. Local fire or police maybe required to escort the tanker to the WTP in emergency conditions.

- Drum transfers (liquid) are useful for small fuel transfer. All containers must be properly marked and used for only one type of fuel. Hand crank pumps are mounted on top of 55 gallon diesel drums or a similar setup in the truck bed.
  - ✓ An ATV or snowmobile trailer sled may provide emergency transport.
- Propane refueling requires a local supplier.

Normal Usage

Approximate Fuel Consumption

We are somewhat dependent upon the engine manufacturer to supply base information on fuel consumption. We can then calculate a close approximation of fuel consumption with the following major factors known:

- Engine size and power output.

- Altitude – As altitude increases, efficiency decreases. Turbocharged units will offset this effect.

- Type of engine – Diesel engines may have a much higher flow rate to engine than what is used for combustion.

- Propane Issues
  - ✓ Operator must be aware of vaporization rate. Cold storage of propane will reduce available fuel evaporation rate. Horizontal vs vertical oriented cylinders may have different vaporization rates.
  - ✓ We may not be able to use "domestic" 17/20 lb propane cylinders for source since the supply may not be enough to power the engine.

All fuel usage estimates must be checked against real data such as records of fuel tank levels during known periods when the generator is in service and connected to normal load. Comparing "apples to apples" is important when analyzing usage.

Emergency or High Output Operation Usage

Typical emergency or high output values are found in manufacturers' brochures. These values assume maximum output. To prepare for emergency condition usage demand, we must maintain an adequate level in the fuel tank to operate throughout the crisis.

- Allowing a diesel engine to run out of fuel will require "bleeding" of the fuel system that may take several minutes to an hour. Be aware of the appropriate procedure to "bleed" a system prior to an emergency arising.

- Propane usage must be carefully monitored since refill procedures require a supplier. Sight gauges are available on larger size tanks to determine fuel level.

Class Activity – Fuel Consumption of Staggered vs. Non-Staggered Startup of the Emergency Generator

This example is NOT intended to replace the services of a qualified generator supply company but rather to illustrate proper diesel Gen-Set sizing for maximize fuel efficiency and the prevention of "wet stacking."

Wet stacking is defined as a set of conditions which may include fuel residue collecting on the valve stem of the deisel engine or unburnt fuel in the exhaust system which can lead to engine problems or "blow-by" of fuel past the rings that may allow accumlation of fuel in the crankcase. Improper lubrication may then result in bearing failure.

Load Estimation Procedure

- To estimate connected load, inventory the plant and list all equipment.
- To convert hp into kW, multiply hp by 0.75.
- Diesel fuel consumption is estimated at 0.07 gal/hr per kW at maximum load.
- At lower loading, i.e. 50% of maximum load, use 0.04 gal/hr per kW of Gen-Set.

Calculation Examples

A WTP requires 500 hp of motors and 25 kW of lighting and similar loads at maximum operation. During normal operation total use = 145 hp of motors and 25 kW lighting.

Calculate Normal Load.

Calculate Maximum Load.

Option A: Non-Staggered Start Up

Assume the entire connected load is energized at the same time. The in-rush current in motors creates about a 60% surge factor for a few seconds.

Calculate what kW load the generator would need to handle.

Calculate a rough estimate on fuel consumption.

This size diesel generator would allow all equipment to operate immediately. However, after a few minutes when the condition is stabilized, several of the motors may be shutting down. Normal load operation 135 kW/ 475 kW = 28%. This could result in Gen-Set operating at less than 30% which will lead to poor diesel fuel consumption and possibly "wet stacking."

Option B: Staggered Start Up

Assume that delay timers or Programmable Logic Controllers (PLC) are installed throughout the facility. The delay system is set up so that major groups of equipment are energized about 10 seconds apart. The first connected electric bank allows all lights and similar equipment to be energized.

Table 8-1 Staggered Start Up [1]

Time (sec.)	Load not connected yet, kW	Load to be connected, kW	Load being connected w/ 60% in rush factor	Load on generator after inrush satisfied
0	375 kW (motor) + 25 kW (lights) = 400 kW	120 kW (motor) + 25 kW (lights) = 145 kW	(120 kW + 60%) + 25 kW = 217 kW	145 kW
10	400 kW - 145 kW = 255 kW	100 kW	100 kW + 60% = 160 kW	145 kW + 100kw = 245 kW
20	255 kW - 100 kW = 155 kW	90 kW	90 kW + 60% = 144 kW	245 kW + 90 kW = 335 kW
30	155 kW- 90 kW = 65 kW	65 kW	65 kW + 60% = 125 kW	335 kW + 65 kW = 400 kW

Additional Considerations

At smaller Gen-Set operations, use of propane becomes an option. Such sized propane/natural gas fired gen-set do not have a "'wet stacking" concern. A small booster station of approximately two single phase 5 hp pumps may have a connected load of about a 35 kW starting load and 7 kw running load. The amount of propane consumed is dependent upon the load. At 100% the fuel consumption is approximately 45 cubic feet per hour, at 75% load the consumption is 36.7 cubic feet per hour, and a 50% load decreases to 30 cubic feet per hour.

[1] Paul J. Farrell of Onan Cummins Power Systems, Inc. (1549 Bobali Drive, Harrisburg, PA 17104).

Unit 9 – SCADA and INSTRUMENTATION

Learning Objectives

- Define Systems Control and Data Acquisition (SCADA).

Supervisory Control and Data Acquisition (SCADA) is a computer system for gathering and analyzing real time data. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining, and transportation. A SCADA system gathers information, such as where a leak on a pipeline has occurred and transfers the information back to a central site, alerting the home station that the leak has occurred. It carries out necessary analysis and control, such as determining if the leak is critical, and displays the information in a logical and organized fashion. SCADA systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or incredibly complex, such as a system that monitors all the activity of a municipal water system.

Usage

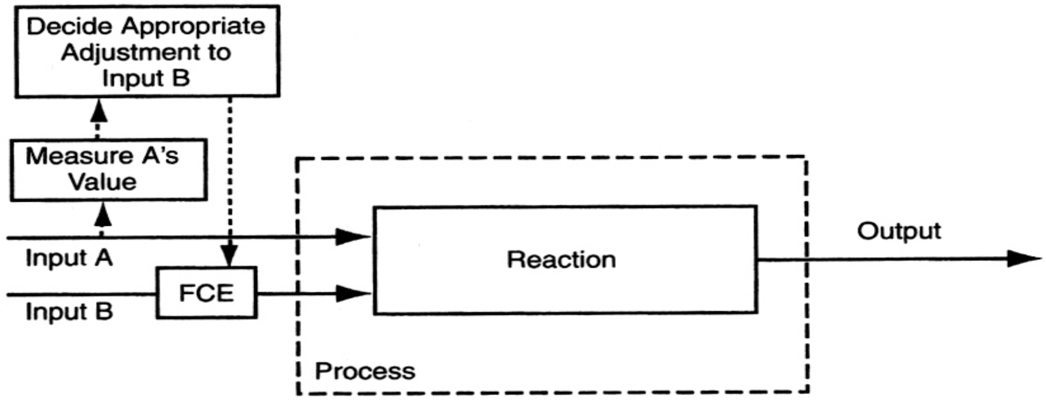
Instrumentation can exist without SCADA but SCADA can **only** exist with instruments upon which it depends to obtain field measurements. This allows for process control decisions, based on a previously programmed logic, to be initiated.

Typically the type of signal generated is beyond the knowledge level of the operator. Instrumentation can be either analog or digital (with more being digital). Analog signals are generated continuously and the readout may be shown as a position on a chart.

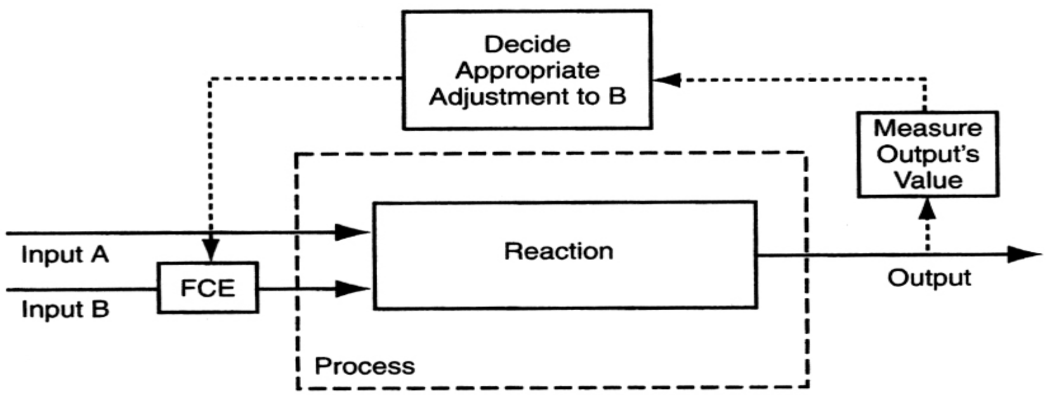
Feed Forward vs Feedback Control Logic

- Feed forward control logic is proactive. Actions are initiated based on pre-programmed logic that does not require or monitor actual input. It does not require knowledge of an existing problem to initiate an action.

- Feedback control relies on a measurement taken. Based on the difference between the desired setting and the actual reading, an action is initiated. An advantage of feedback control is that the action initiated is based on actual measured affects.



(A) Feedforward Control Loop



(B) Feedback Control Loop

Final Control Element (FCE) is the actual device used to adjust the process

Figure 9-1 Generic Control Loops [1]

Would a critical parameter be more efficiently controlled by the feedback method? Why or why not?

SCADA vs LAN

A Local Area Network (LAN) may be part of a SCADA system. As the complexity or remoteness of field devices increase, the likelihood of employing a SCADA may increase. Another benefit of a SCADA may be the reduction of the need for operator input in mundane tasks.

Master Terminal Unit (MTU)

The MTU refers to the main location to which all data is transmitted. Based upon the difference between input signals and desired output, an action will be implemented.

Remote Terminal Unit (RTU) or Programmable Logic Controller (PLC)

- The RTU may be as simple as a pH probe or tank level indicator located in a tank. The RTU does not cause an operation to be initiated but only serves as a method to compare actual against desired settings.

- A Programmable Logic Controller (PLC) has a bit higher level of field sophistication. It can allow a person, through a password protected system, to create changes to field measurement devices that generate control signals to local equipment. Generally PLCs are limited to local equipment (less than about 100-200 feet from sensors). In contrast, many miles of distance may separate SCADA components.

Flow

- Flow may denote either liquid or air. Flow can be monitored or controlled by the operation of either pumps of constant speed or variable output.

- Flow rate may also be controlled through usage of a throttling type valve. This method allows for use of a constant speed pump that is cheaper than a variable speed pump. Output is controlled by applying artificial head against the system to control the rate of flow.

Process Parameters

Depending on the results of monitored parameters, process adjustments may be made either automatically or manually. Some examples are:

- turbidity.

- chlorine residual or ozone.

- color.

- chemical feed systems.

Remote Locations Monitoring

A **remote location** is defined as some point not within the immediate location of the controller.

- A feed pump station may be located several hundred meters from the main control building.

- A booster station may have pumps and/or chlorine residual analyzers located several miles from the main WTP site.

- A water reservoir may have level measurement information telemetered to a SCADA. Staff may be able to connect to the SCADA and monitor the reservoir depth. Additionally the SCADA may have trigger levels that implement a call out sequence to key telephone numbers.

Monitoring of System from Remote Locations (Laptop/Modem)

As the SCADA evolves, systems may allow access though Wide Area Network (WAN) or Internet connections providing the staff with the ability to evaluate the state of the system while offsite. As satellite and wireless communication develop, more communities are generating an ability to link the laptop computer through a wireless network into the SCADA system. Such a level of sophistication is generally more typical for larger WTP systems.

Cross Connection Control

Water flow indicators may be used to determine if flow through a key location is in the normal flow direction. If water backflow is detected, an isolation process may be initiated to prevent cross connections.

Water Main Break

SCADA may be used to remotely close key valves after a water main break is reported.

Fire Support

A SCADA would normally put into action extra pumps to increase water production for fire support.

In what other ways could a SCADA be important to fire support?

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Less Staffing

The ability of a SCADA to continuously monitor key locations results in less staff attention. Although the amount of staff required decreases, the level of education and knowledge by the staff increases.

Possible Process Optimization

SCADA creates the opportunity for processes to be optimized. For example, two downstream probes in a sedimentation basin may monitor the amount and effect of coagulate added to a flow stream.

[1] American Water Works Association, *Instrumentation and Control Manual of Water Supply Practices*, p. 162.