SCADA System Maintenance. Really?

Illinois Section American Water Works Association

The authoritative resource in the State dedicated to Safe DRINKING water

T-CON

TECHNOLOGY CONFERENCE

STRAND

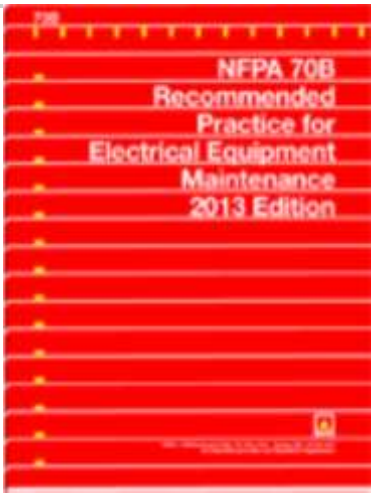
Introduction

- History
- Guidelines for Effective Maintenance
- SCADA System Basics
- Maintenance of Field Devices
- Maintenance of PLCs
- Maintenance of Computers
- SCADA System Life Cycle Replacement
- Maintenance Tools/Software
- Q&A

STRAND

History

- NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
  - Developed originally in 1968
  - Current Edition: 2013
  - Purpose: "…..to reduce hazards to life and property that can result from failure or malfunction of industrial-type electrical systems and equipment." (NFPA 70B, 1.2)



History

- Causes of electrical equipment failure
  - Excessive heat
    - Lack of ventilation/cooling
    - Build-up of dirt, dust, contaminants
    - High equipment loads
    - Frequent cycling
  - Deterioration of materials
    - Corrosive or damp environment
    - Temperature swings
    - Excessive heat and/or loading
  - Infrequent use

Guidelines for Effective Maintenance

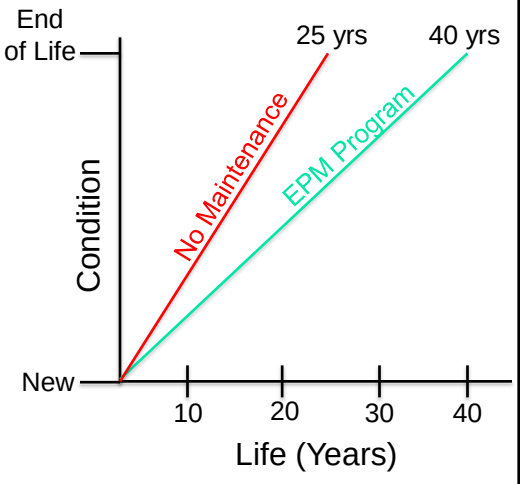
- Develop an Electrical Preventive Maintenance (EPM) program
- Essential elements
  - Identify qualified personnel
  - Determine maintenance requirements, priorities, and budget
  - Develop scheduled inspection, testing, and service of equipment
  - Identify and perform corrective work
  - Document results of inspection, testing, and work performed
- Goals of an effective EPM program
  - Maximize personnel safety
  - Minimize equipment loss
  - Maximize production economics

Guidelines for Effective Maintenance

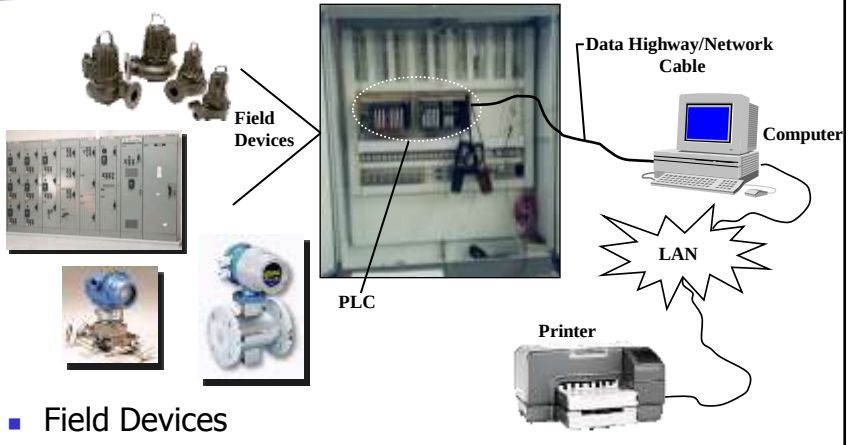
- Maintain adequate spare parts inventory
  - Critical components
    - Continuously operating equipment
    - Equipment without redundancy
  - Obsolete, unsupported, or proprietary equipment
    - Parts no longer available
    - Hardware incompatible with current software
  - Long lead time equipment
  - Volatile pricing

Guidelines for Effective Maintenance

- Direct Benefits
  - Early problem detection = lower repair costs
  - Accidents and/or insurance claims minimized
  - Downtime and interruption of service reduced
- Indirect Benefits
  - Safer work place = higher morale and productivity
  - Increased efficiency (personnel and equipment)
  - Increase equipment lifetime
  - Reduced risk



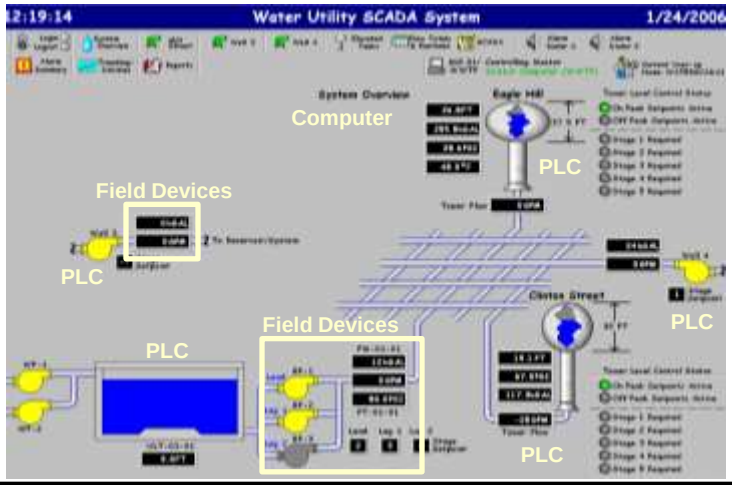
SCADA System Basics - Components



- Field Devices
- PLC (Programmable Logic Controller)
- Computers and Related Equipment

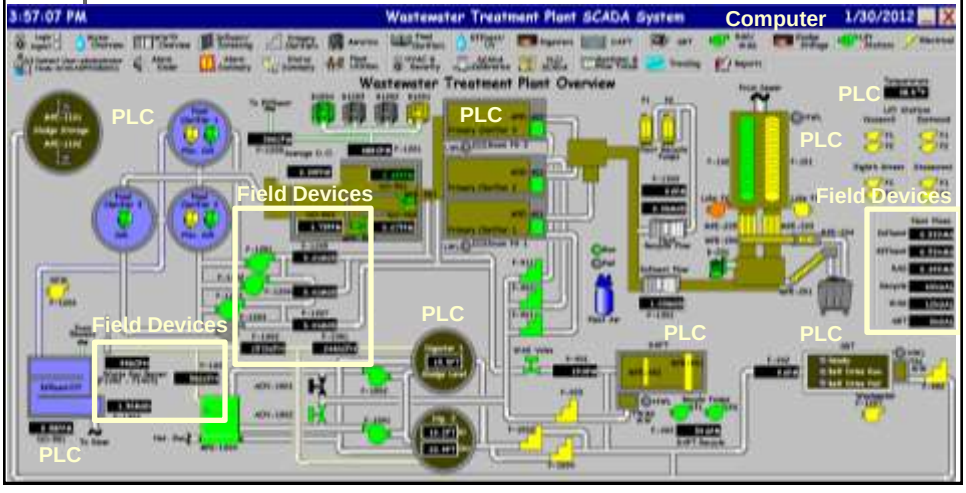
SCADA System Basics - Architecture

- Single Master with Remotes via Radio (Water System)
  - Distributed PLCs with PLC-based control



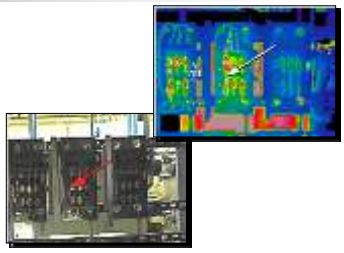
SCADA System Basics - Architecture

- Single Master with Remotes via Fiber (WWTP)
  - Distributed PLCs with PLC-based control



Maintenance of Electrical Field Devices

- Motor Control Centers
  - Suction/Cloth Cleaning
    - Annually
    - Increases longevity/life of sensitive electronics by reducing heat
  - Thermal scanning
    - Annually
    - "Hot spots" show potential locations for fire/ignition to occur
    - Excessive heat breaks down conductor insulation, reducing life
    - Bolted bus and wire connections should be scanned
  - Circuit breaker inspection and exercise
    - Every 1-3 years, depending on type and use
    - Physical breaker operation
    - Trip overloads if breaker-style allows
    - Check for excessive heating, discoloration, cracking
    - Thermal scan can identify unbalanced loads



Maintenance of Electrical Field Devices

- Motor Control Centers - Failure Scenario
  - Premature failure of Motor Control Center (i.e. WWTP or Well)
    - Dirt accumulation and lack of ventilation caused increased heat build-up and premature failure of main circuit breaker
    - Outage occurs on Sunday afternoon
      - Overtime labor to respond to alarm
      - Operation of standby generator (diesel fuel) during outage
      - Expedited manufacture, shipping, delivery, and installation costs
  - EPM would have identified "hot spot" and lack of ventilation
    - Planned outage could be performed during normal working hours
    - Equipment life extended
    - Lower repair cost

Maintenance of Electrical Field Devices

- Motor starters

  - Annually
    - Suction/Cloth Cleaning
    - Verify/test overload tripping
    - Check for loose connections and signs of overheating
- VFDs, Reduced Voltage Starters
  - Annually
    - Suction/Cloth Cleaning
    - Check for loose connections and signs of overheating
    - Check current and voltage output
    - Verify control/reference signals
    - Follow manufacturer's recommendations

Maintenance of Electrical Field Devices

- Motor Starters - Failure Scenario
  - Variable Frequency Drive Failure
    - One of the VFD cooling fans fails
    - Increased heat inside VFD cabinet
    - VFD replacement required before end of life
    - Unit out of service, could be as long as several months (reduced capacity)
  - EPM would have found inoperable cooling fan
    - Equipment life extended

Maintenance of Electrical Field Devices

- Pressure transducers
  - Annually, depending on manufacturer
- Flowmeters
  - Propeller
    - Annually
  - Magnetic
    - 3-5 years. Typically has to be returned to the manufacturer
- Level transducers
  - Submersible
    - Annually
  - Ultrasonic
    - Annually
- Analytical instruments
  - Chlorine residual
    - Monthly, quarterly, and annually
  - Fluoride residual
    - Monthly, quarterly, and annually
- Scales
  - Annually
- Chemical leak detection
  - Monthly

Maintenance of Electrical Field Devices

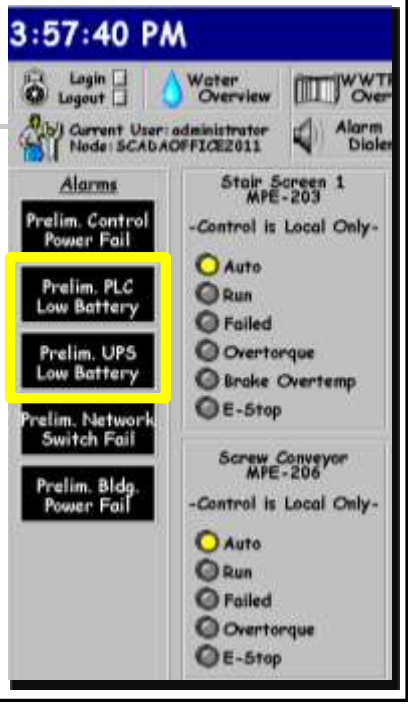
- Instrumentation - Failure Scenario
  - Well pump flowmeter calibration drifts
    - Flow pacing of chemical feed could be excessive or inadequate
    - High flow readings may give false indication of water loss
  - WWTP influent flowmeter calibration drifts
    - Flow pacing of chemical feed could be excessive or inadequate
    - Flow paced operation of equipment may be affected
      - Samplers, RAS Pumps, etc
    - Undesirable conditions may occur in treatment process
      - Too few samples, low sludge blanket, etc
  - EPM would have maintained proper calibration
    - Production/treatment errors minimized

Maintenance of PLCs

- Check normal operation
  - Monthly
  - Verify I/O for each card regularly (annually)
  - Check wiring for excessive heat and loose connections (annually)
- Memory Modules/EEPROMs
  - Annually, more often as needed
  - Download to device after all program changes
  - Periodic simulation to reload program from memory device
  - Maintain spare for critical locations

Maintenance of PLCs

- PLC Batteries
  - Replacement every 5-7 years
  - Disposal & Storage
    - Follow manufacturer's instructions
    - Lithium batteries contain toxic materials!
  - Integrate monitoring into SCADA system where possible
- UPS Batteries
  - Replacement every 3 years, sooner if needed
  - Perform UPS self-test monthly
  - Integrate monitoring into SCADA system where possible



Maintenance of PLCs

- PLCs – Failure Scenario (memory module)
  - Utility switching creates high voltage condition
  - PLC Fault Occurs
  - Memory module has "old" PLC program
  - Plant controls adversely affected
  - Service call required from SCADA system supplier

Maintenance of PLCs

- PLCs – Failure Scenario (UPS battery)
  - Natural utility power fluctuation
  - UPS on-line intermittently
  - Battery at end of life, doesn't function properly
  - PLC sees loss of power, reloads program from memory module
  - Setpoints "magically" change
    - Last time program was saved to memory module

Maintenance of Computers - Physical

- Location of Computer
  - Not on floor
  - Adequate airflow – don't cover!
  - Physical orientation
    - Vertical towers installed vertically, same with horizontal desktops, to keep hard drive mounted flat
    - Installing improperly can cause failure in as little as 2 years, due to improper stress on hard drive bearing
  - Not subject to dust/dirt, which create excessive heat
    - Heat is computer's greatest enemy
    - Just 0.005 mm of dust (barely enough to see) can raise internal temperature of components by 5%!
  - Verify compliance/requirements of manufacturer's warranty

Maintenance of Computers - Physical

- Cleaning
  - Internal components, fans, openings
    - Bi-annually, more if adverse environment
    - Use suction cleaning to extent possible
    - Can of air for inaccessible locations
    - Verify compliance/requirements of manufacturer's warranty (some are voided when case is opened)
    - Verify power is off and proper grounding
  - Monitor
    - Every two years
    - Clean dirt/dust off ventilation/openings
  - Keyboard
    - Use suction cleaning to extent possible, then can of air
    - Purchase "in-use" cover for dirty/dusty locations

Maintenance of Computers - Operational


- REBOOT, REBOOT, REBOOT
  - SCADA Computers typically in operation 24/7
  - "Flushes" computer's Random Access Memory (RAM)
    - Memory used "as-needed" by operating programs
    - Inefficiencies of Windows operating system does not release all memory in use
    - Can cause computer to operate very slowly over time
    - Can cause files to become corrupt and loss of data
    - Perform reboot **MINIMUM** of twice/month, preferably weekly
  - Alleviates most operational problems

Maintenance of Computers - Security

- SCADA System Security
  - Follow recommendations of Vulnerability Assessment (VA) and Anti-Terrorism guidelines
  - SCADA Computers **NOT** recommended to be connected to Internet
  - Run anti-virus software manually
    - Can interfere with SCADA programs
    - Update anti-virus definitions, minimum monthly
  - Firewall should be configured if computer has remote access via dial-up or internet
    - Will need to be configured to run with SCADA software

Maintenance of Computers - Security

- Usernames and Passwords should be setup for Operating System and SCADA HMI software
  - Independent usernames
  - Auto-logoff after period of inactivity
- Passwords should be "strong" passwords
  - Mixed upper and lower case, numbers, symbols
  - Minimum of 8 characters
  - Fewer than 8 characters can be cracked in a matter of days
  - Example: Wtr$caDa23
- Change passwords regularly
  - Minimum of 3 times per year

Maintenance of Computers – Data Management

- Historical and Reporting Data
  - Store on hard disk as long as operationally useful
  - Excessive data can cause computer to slow down and lock-up
- Data Back-up and Archiving
  - Back-up data as frequent as necessary
    - For what time period can you accept a loss of data?
    - Is there redundant data storage?
  - Minimum recommendation for back-up is monthly
  - Archive data periodically for off-site storage
    - Catastrophic loss (i.e. fire, lightning strike, etc)
    - Use two different mediums (i.e. compact disc, hard drive, cloud)
  - Use built-in back-up utilities if available within software packages (i.e. reporting software)

Maintenance of Computers – Software

- Licensing and Support Contracts – Windows software
  - Microsoft life-cycle varies, 3-10 years
    - 5 years of mainstream support
    - 5+ years of expended support
    - Updates, patches, downloads available to licensed users throughout life cycle
    - May or may not be beneficial to end-user
    - May be required to be compatible with new software
- Licensing and Support Contracts – HMI software
  - Quarterly software updates
  - Annual support contracts
    - Annual support cost ~15-20% of initial software purchase
    - Equates to re-purchase of software ~5-6 years
    - Includes Technical support from software manufacturer
    - May or may not be beneficial to end-user
    - Valuable if computer/operating system is replaced frequently

Maintenance of Computers – Operating System

- Regular Computer Maintenance Recommended
  - Remove unused programs/software
    - Annually
    - May be removed if pre-installed with computer
  - Free-up wasted space using Windows Disk Clean-up tool
    - Quarterly
    - Removes temporary files, compressed files, old files, and empties recycle bin
  - Run Windows Disk Defragmenter regularly
    - Quarterly
    - Optimizes storage of files within Windows, allows computer to run more efficiently

SCADA System Life Cycle Replacement

- Computer replacement recommended every 3-5 years
  - Manufacturer's warranty can be 3-5 years
    - Parts may be unavailable after 3 years
    - Software may not be supported after 5 years
    - Catastrophic failure more likely after 3 years, increased after 5 years

  - Computer replacement warrants hardware and software replacement
    - New OS not compatible with old versions of HMI or reports
    - New/existing hardware not compatible with earlier software
    - Earlier versions of software may no longer be supported
    - New software = more efficient, new/enhanced features

SCADA System Life Cycle Replacement

- PLCs, VFDs, and Instrumentation, 10-15 year expected lifetime
  - Parts may be unavailable after 10 years
  - Hardware may no longer be supported after 10 years
  - Catastrophic failure more likely after 10 years, increased after 15 years
  - Wiring and I/O can typically be reused
  - Earlier replacement means increased chance of re-using existing programming

- Electrical wiring replacement recommended after 30 years
  - Insulation degrades and becomes brittle
    - Increased chance of fire, shorting, ground faults, and damage to equipment
  - Equipment vibration can cause loose connections, creating hot-spots

Maintenance Tools/Software

- 100s of maintenance software packages available
  - Simple ⇒ Complex
  - Low Cost ⇒ High Cost
  - Automatic/SCADA Integrated ⇒ Manual

Summary

- Electrical systems/equipment require maintenance!
- Key to maximizing safety, maximizing economics, and reducing down-time is an effective EPM
- Standards/guidelines are available as a resource
- Utilize SCADA and maintenance software as a tool

Reference Materials

- NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- NEMA Standards Publication AB 4-2009
- Eaton Electrical Corporation, Publication No. MZ01220001E
- Microsoft (www.microsoft.com), Computer Setup and Maintenance
- PC World (www.pcworld.com), Hardware Tips: Complete PC Preventive Maintenance Guide



Questions

- Any questions?

March 2008