Hampton Roads Sanitation District
Strategic Automation Configuration Guide

Automation Standards

January 26, 2021

Introduction

Software, hardware, and network standards must be defined before any distributed control system (DCS) design effort can be undertaken. Such standards benefit the DCS development team by providing a consistent design and an organized implementation plan. This, in turn, benefits the final user in the form of an efficient DCS operation and maintenance environment. This document details the DCS automation standards for the Hampton Roads Sanitation District, and future projects.

This Automation Standards document is intended to be a living document, and as such, will be continuously updated. Changes will occur more frequently as new plants are added, and new types of control are defined.

This volume is ordered into sections which provide a broad-brush approach to standards, guidelines, and best practices. For each plant or pump station, a second volume will be developed, having additional tabbed sections containing standards that are unique to that specific plant or pump station.

Due to the necessity to restrict access to sensitive information about HRSD's network infrastructure, control details, database, etc., the original Automation Manual has been split into two sections. The first of which is intended to provide a detailed overview of the OVATION system and recommended practices, that would be of use to an Architect Engineer in understanding the OVATION system. The second manual mirrors the first in section numbers, etc. This manual contains details of the control systems' networking set up, program details, and protocols used. This second manual will be used for internal purposes only by HRSD to configure the system.

GUIDE
SPECIFICATION
SECTION 40 94 23
DISTRIBUTED CONTROL SUBSYSTEM (DCS)

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): X3.5, Flow Charts Symbols and Usage.
2. Instrumentation, Systems, and Automation Society (ISA):
   a. S5.2, Binary Logic Diagrams for Process Operations.
   b. S5.4, Instrument Loop Diagrams.
   c. S5.5, Graphic Symbols for Process Displays.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (10,000 Volts Maximum).

1.2 SUMMARY

A. This section covers requirements for Distributed Control Subsystem (DCS) and is in addition to requirements in Section 40 90 10, Process Instrumentation and
Control Systems (PICS). Key technical definitions and requirements for DCS are given in Section 40 90 10, Process Instrumentation and Control Systems (PICS).

B. DCS functions include data acquisition, process control, historical data storage, text and graphical data display, alarming, data analysis, and report generation. Requirements listed, identify minimum acceptable system performance. Provide hardware and software features required to allow configuring of a fully operational system, with convenient operator interface and efficient equipment use.

****

****

C. DCS Overview: The complete Distributed Control System shall be the latest version of the Ovation System, manufactured and supplied by Emerson Process Management (EMR). The system shall include the following components and features as shown on the DCS System

Block Diagram:

1. All DCS communications modules and cables shall be redundant.
2. All DCS power supplies shall be redundant.
3. Interface gateway to Allen-Bradley PLC SLC.
4. All DCS hardware shall be powered from "true on-line double conversion" type UPS units provided by the DCS supplier. All UPS units shall be monitored by the DCS for faults and low battery conditions. UPS units shall be located in communication cabinets in control room locations and in separate enclosures for RIO units.
5. All I/O modules shall be provided with field termination units with factory interconnect cable.
6. All DCS equipment shall be powered through shielded isolation transformers. Transformers and associated circuit breaker panels shall be sized and provided by DCS supplier.

D. Configuring of Applications Software shall be provided by EMR.

1.3 DEFINITIONS

A. Abbreviations:

1. As specified in Section 40 90 10, Process Instrumentation and Control Systems (PICS).
2. CPU: Central Processing Unit.
3. EMR: Emerson Process Management (DCS Supplier).
4. EWS: Engineering Workstation.
5. PMCS: Process Monitoring and Control Software.
6. LAN: Local Area Network.
7. DCU: Digital Control Unit.
8. PLC: Programmable Logic Controller.
9. RTU: Remote Terminal Unit.
10. ACC: Area Control Center.
11. CAD: Computer Aided Design.

B. Terms:

1. Circular Files: Files in which each latest record written to file replaces oldest record in file.
2. Log a Message: Print a message on an alarm/status printer.
3. OIS: Includes computer with standard operator station software, operator's keyboard, and CRT monitor.

C. Types of Variables:

1. Calculated Analog Points (CA): Analog variables computed from DCU inputs, manual inputs, calculated discrete points, and other calculated analog points.
2. Calculated Discrete Points (CD): Discrete variables computed from DCU inputs, manual inputs, calculated analog points, and other calculated discrete points.
3. Manual Inputs (MI): Variables whose values are manually entered, e.g., laboratory data.
4. Process Variables (PV): Analog variables from DCU analog inputs and calculated analog points.
5. Report Variables: Variables computed by report generator.

1.4 SUBMITTALS

A. Action Submittals:

1. DCS block diagram and overview description.
2. Bill of Materials:
   a. Breakdown to level of individual plug in modules.
   b. Information: Name of part, manufacturer, model number, options included, and quantity. Organize by ACC, and within ACC organize by enclosure and component (for example, DCU, EWS, OIS).
3. Room Layout Drawings: For each ACC, show to scale enclosure, furniture, DCS equipment, and service area requirements.
4. Power Connection Diagram: For DCS equipment, show interconnection from power sources through uninterruptible power supplies and power distribution panels to DCS equipment.
5. Grounding Diagram: For DCS equipment, show grounding philosophy and implementation.
6. Interconnecting Wiring and Cabling Diagrams: For DCS equipment, identify terminal receptacles, cable ID tags, actual cable lengths, and maximum distance limitations between cabinets or components.
7. Component Submittal: For each DCS component:
   a. General data and description.
   b. Engineering Specifications and data sheets.
   c. Scaled drawings and mounting arrangements.
   d. Equipment weights.
   e. Power and grounding requirements.
   f. External electrical interconnection and interface definitions.
8. Shop Drawings for Specifically Assembled DCS Equipment:
   a. A complete connection diagram.
   b. Data sheets on each major item, annotated as necessary to describe specific items furnished.
   c. Scaled Layout and Fabrication Drawings:
      1) Cable access areas and cable routing.
      2) Power termination and ground lug location.
      3) Data cable termination points.
      4) Field signal termination points.
      5) Anchor bolt size and location.
   d. Installation and mounting detail drawings.
   e. Equipment weights.

9. Input/Output (I/O) Point List for All I/O Points: Information in the list shall include all items shown on the I/O lists in these documents and the following information where applicable:
    a. Point names and descriptions.
    b. Point addresses, tag numbers, functions, ranges, and engineering units.
    c. Wire and cable assignments.
    d. DCU card layout, module and block number.
    e. Field wiring termination assignments.
10. Power Consumption and Heat Dissipation Summary for DCS Equipment: Voltages, current, phase(s), and maximum heat dissipations in Btu/hr.

B. Software Shop Drawings:

1. System Software Documentation: Complete reference information for system users. Detailed descriptions including features, limitations, and use of System Software.
    a. Operating System and Utilities:
        1) Base Documentation: For day-to-day users of tasks, including editing files and using command procedures.
        2) General User Documentation:
            a) Using files, directories, command language, and text editors.
            b) Alphabetic list of errors, warning and informational messages including explanation and response required.
        3) System Manager Documentation:
            a) Setting up systems.
            b) Maintaining system and files.
            c) Optimizing performance.
            d) Networking features.
        4) Programming Documentation:
            a) Linking, loading, running, and debugging tasks.
            b) Screen management.
            c) Librarian and file management.
            d) Device support and device drivers.
    a. Programming Language. Syntax, execution, use and reference capabilities.
    b. Online and Offline Diagnostics: How they are used, and various execution options available.
    c. Communications with DCS and PLC equipment. Describe configuration, operation, limitations, and diagnostics for LANs, data highway, serial links, and other communication

paths. Provide sufficient documentation to allow third parties to troubleshoot communications problems with devices connected to DCS.

2. PMCS Documentation: Detailed technical reference manuals and user level manuals.
    a. Types of Manuals:
        1) System Manager Documentation:
            a) Initial system setup.
            b) Data base and file structures.
            c) Communication with field devices.
            d) Maintaining system and files.
            e) Troubleshooting system problems.
            f) Optimizing performance.
        2) System Engineer Documentation:
            a) Configuring applications software.
            b) Documenting applications software.
        3) Operator Documentation: Using the PMCS with configured applications software.
    b. PMCS Functions Covered:
        1) Process data base.
        2) Communication with field devices.
        3) Calculated analog points and calculated discrete points.
        4) Input processing.
        5) Message logging.
        6) DCS diagnostic alarms.
        7) Alarm handling.
        8) Control processor.
        9) Restart program.
        10) Man-machine interface-general functions.
        11) Graphics display generator.
        12) Types of displays.
        13) Alarm/status log history.
        14) Historical data collection.
        15) Data retrieval.
        16) Trending.
        17) Report generator.

C. Informational Submittals:

1. Testing related Submittals.
2. O&M Manuals-Hardware:
    a. Updated version of hardware Shop Drawings.
    b. Component Manufacturers' O&M Manuals: Instructions for installation, operation, maintenance, troubleshooting,

and calibration.

c. Bill of materials for parts. Separate list of installed parts from lists for spare parts and expendables provided.

d. List of additional spare parts recommended.

3. Reproducible Hardware Drawings:

a. DCS block diagram.

b. Power and grounding interconnection diagrams.

c. Interconnection wiring and cabling diagrams.

4. O&M Manuals-Software Documentation:

a. Updated version of software Shop Drawings described under Article Submittals.

b. For system software that is not a product of the DCS manufacturer, include manufacturer's original disks and manuals with hardware shipments.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Control Room: NEMA 1.

B. Other Locations: As noted.

1.06 SEQUENCING AND SCHEDULING

A. Refer to Section 40 90 10, Process Instrumentation and Control Systems (PICS).

1.7 MAINTENANCE

A. Maintenance Service Agreement: Services provided following system acceptance.

1. Service Agreement:
   a. Duration: 2 years.
   b. Demand Maintenance: As requested by Owner.
   c. Manufacturer's recommended preventive maintenance, checking system error counters, and installing required engineering changes.
   d. Remote Monitoring and Diagnostic Service: Direct telephone line link between DCS and DCS manufacturer's maintenance center. Service supports connection of DCS to remote equipment at DCS manufacturer's service center, which can be used to diagnose hardware and software problems with all DCS equipment.
2. Telephone Support Service:
   a. Duration: 2 years.
   b. Available during normal business week.
   c. Provided by persons thoroughly familiar with DCS supplied.
3. Software Update Service:
   a. Duration: 4 years.
   b. Coverage: Standard software, including both system software and PMCS.
   c. Include new software versions, documentation updates, newsletters, user notes, software performance reports, interim software updates, revisions, releases, and fixes, etc.

1.8 EXTRA MATERIALS

A. Spare Parts:

1. When computing percentages for spare parts, round up fractions to nearest whole number.
   a. Modules and Power Supplies: For all DCS equipment except printers, and personal computer portion of engineering workstations and OISs:
      1) 2 of each size and type of power supply used.
      2) 1 of each type of electronic circuit board or electronic module used, except for process I/O modules.
      3) 2 of each type of process I/O module required to handle the points shown in I/O lists in Supplements at end of

this section.

b. Engineering Workstation: One.

c. Fuses: 20 percent, but no less than 10 of each type and current rating used.

PART 2 PRODUCTS

2.1 SYSTEM PERFORMANCE

A. Availability: 99.999 percent minimum.

B. Capacity:

1. Provide DCS with sufficient capacity to handle specified equipment and functions required by Contract Documents and equipment listed under paragraph Future Components, and still have specified spare capacity. Except for software configuring, implementing listed future components shall not require addition of DCS hardware or software to the DCS equipment supplied under this contract, other than the listed future components.
2. For example, provide I/O racks, power supplies, processor capacity and inter-rack cables in each DCU supplied under this contract, for DCU future I/O.
3. *Refer to following items as an indication of complexity of applications software that DCS will be required to support:*
   a. Drawings: Process and Instrumentation Diagrams.
   b. Section 40 90 10, Process Instrumentation and Control Systems (PICS): Supplements, Functional Descriptions, DCS Special Functions.
   c. Input/Outputs List in Supplements at end of this section.
4. Capacity refers to required physical size, storage capacity, and processing throughput of DCS hardware and software. DCS changes required to implement listed future components shall be limited to "configuring" data base tables and system parameters to allow system to recognize the additional equipment.

C. Response Times:

1. Basis for Response Times:
   a. All DCUs and OISs are in operation.
   b. Each EWS and OIS has been configured with 5,000 tags.
   c. Spare slots in DCUs have been used to implement I/O points in table under paragraph DCU Spare Plug-In Slots, under Article Spare Parts.
   d. Process graphic displays have 20 active points minimum, and points distributed between DCUs.

2. OIS Response Time: Number of seconds from when an operator requests a new OIS display until that display is fully presented on screen with active data displayed. For each type of display, table lists maximum allowable times in seconds for:
   a. Average: Average time to call up display.
   b. Worst: Worst case call up time.
   c. Refresh: Rate at which data on display is updated.

Display Type	Average	Worst	Refresh
Group Display	1.0	2.0	1.0
Process displays	2.0	2.0	1.0
Alarm summary	1.0	1.0	1.0
Historical trends, four process variables minimum			
30 minutes	1.0	1.0	--
1 hour	2.0	2.0	--
8 hours	2.0	2.0	--
1 day (24 hours)	3.0	3.0	--
1 week (7 days)	5.0	5.0	--
30 days	10.0	10.0	

3. Viewing Input Changes:
   a. Given following conditions:
      1) Operator is viewing a process graphic display.
      2) A displayed point's field input to a DCU changes its value.
   b. Time From Field Input Change Until New Value Appears on Process Graphic Display: 2 seconds, maximum.
4. End-to-End Response Time for DCUs:
   a. Given following conditions:
      1) Operator is viewing a process graphic display.
      2) Operator gives command through OIS to change status of DCU discrete output point from ON to OFF.
      3) At DCU discrete output point is wired back into a

discrete input point.

4) Discrete input is displayed on process graphic display being viewed.

b. Time from operator command to change discrete output until new value of discrete input appears on graphic display: 3 seconds, maximum.

5. End-to-End Response Time for PLCs:
   a. Conditions: Same as for end-to-end timing for DCUs.
   b. Time From Operator Command to Change Discrete Output Until New Value of Discrete Input Appears on Graphic Display:
      15 seconds, maximum.

D. DCU Input Scan Rate:

1. Analog Inputs: 2 seconds, maximum.
2. Discrete Inputs: 1 second, maximum.

E. Redundancy and Reliability:

1. No single failure of any DCS equipment, including data highway or power supplies, shall cause loss of any functions except as noted for failure of the following items.
   a. DCU with Redundant Processors: No loss of function.
   b. Any OIS: Loss of function limited to use of that OIS.
   c. Any Engineering Workstation: Loss of function limited to use of that engineering workstation.
   d. Any Process I/O Card: Limited to loss of functions dependent on signals from/to that card.
2. Provide means to manually switch functions of failed OISs to another unit.

2.2 SYSTEM SOFTWARE

A. Operating System: General purpose, multiuser, multiprocessing operating system:

1. Multiprocessing support for simultaneous execution of process monitoring, and control software tasks, and system support tasks.
2. Batch processing operating under control of command files.
3. Priority task scheduler with provisions for job initiation on time of day, elapsed time, hardware interrupt, process event, request from another task, or operator request.

4. Schedule I/O operations on a priority basis with all I/O carried out concurrently with program execution.
5. Device independent input/output system using online reassignable logical unit numbers for peripheral devices and file names for disk and tape files.
6. Ability to delete, replace, or add process control task or system support while online.
7. Multilevel password protection scheme to control access to different system support tasks and disk-based data structures.
8. Systems Generation: Allow configuring of an operating system to meet specific requirements of hardware and software configuration.
9. All software on system should have the appropriate number of licenses for the hardware the system was shipped with.
10. Licensing for the Historical points on the Historian (Drop 160) should be 50% greater than when the system is shipped for future expansion purposes.

B. Programming Languages: Provide compilers each programming language used by DCS.

C. Utilities:

1. File Management: General-purpose file system supporting dynamic creation, extension, and deletion of disk files from source programs, object programs, and data files.
2. Network Communications: General-purpose network communications software to support local area network connection between DCS central processing units and with personal computers. Allows for exchange of disk files between computer systems.
3. Debugging Aids: Online and offline debugging aids for high and low level language environments.
4. Disk Backup and Reload: Operator-initiated utility for maintaining backup copy using the latest technology.

D. Diagnostics:

1. Online Diagnostics: Complete system of diagnostic software to monitor, isolate, identify, tabulate, and alarm system hardware malfunctions and software failures.

E. Additional Software Tools: For each OWS provide current versions of manufacturer’s standard software tools.

F. Transportable Applications: While applications software is being developed and tested offsite, each OIS, EWS, and DCU may be temporarily substituted for a similar unit. For example, applications software for EWSs, DCUs, and OISs for one ACC may be developed and tested using equipment for a different ACC. Allow applications software for one unit to be transported to other units of same type. Provide software, software licenses, and hardware needed to support this type of transporting and substitution, whether or not these software, software licenses or hardware will actually be used in final configuration.

G. Capacity to Handle Software Upgrades: Provide DCS hardware able to adequately run major software upgrades introduced by DCS manufacturer the life of DCS product line.

2.3 PROCESS MONITORING AND CONTROL SOFTWARE (PMCS)

A. Types of PMCS Software:

1. Control: Executes on DCUs.
2. Monitoring and Supervisory Control of DCUs: Executes on OISs and EWS.
3. Configuring of Applications Software: Executes on EWS and OIS. Includes utilities and configuring aids in either online or offline modes.
4. Communications: Executes on DCUs, OISs, and EWS.

B. Types of Displays:

1. Index Displays: Alphanumeric display with major and minor indexes that identify access to all subsequent displays.
2. Overview Displays: Alphanumeric displays that show a summary of the group and process graphic displays. Includes the display names and descriptions./
3. Group Displays:
    a. Detailed information on a number of analog control loops, analog indications, discrete sequencing functions, and discrete status indicators, in any configurable combination.
    b. Groups of analog controller and indicator displays. "Faceplate" type displays having all the operator interface features normally provided by conventional electronic analog controllers and indicators. These features include display of ranges, units, pacing constants, AUTO/MANUAL status, tag numbers, service descriptions, bar graph representation and numeric values of process variables, outputs, and set

points.

c. Discrete sequence step indications, time value indications, AUTO/MANUAL mode indications, tag numbers, and service descriptions.
d. Discrete status indications including ON/OFF status of discrete inputs and outputs, AUTO/MANUAL status of discrete outputs, software selector switch position indications, tag numbers, service descriptions, Boolean, integer, real, and string parameter values.
e. Detail Displays: Configuration parameters associated with an individual loop or process 1/0 point, such as, controller tuning constants, timer values, scaling constants, alarm settings, etc.

4. Trend Displays: Provide functions described under paragraph Trending.
5. Alarm Summary Display: Shows all existing alarms and unacknowledged alarms. Refer to paragraph Alarm Handling.
   a. Display format similar to messages logged on alarm/status printer.
   b. Retains last 1,000 alarms, minimum.
   c. Include time of day at which alarm was detected.
   d. Alarms grouped by priority, highest priority first.
   e. Within priority groupings, alarms listed in reverse chronological order.
   f. Unacknowledged alarm messages shall be displayed in reverse video.
   g. Single-key acknowledgement of all alarms shown on a currently displayed page of alarm summary display.
6. Process Graphic Displays: Configurable.
   a. Display Objects:
      1) Process Flow streams: Labeled and color coded.
      2) Process Structures: Basins, tanks, wet wells, channels, etc.
      3) Major Equipment Items: Pumps, blowers, drives, compressors, etc.
      4) Major Control Devices: Gates, valves, etc.
      5) Instruments.
      6) Targets to allow quick access associated process graphic displays.
7. Diagnostic Displays:
   a. DCS Diagnostic Display: Graphic display showing operational status of DCS, including data highway and OIS.

C. Historical Data Collection Files:

1. Periodically save designated variables for trending, report generation, and historical records. Allow any process variable to be selected for saving in data collection files.
2. Data Entry for Manual Inputs:
   a. Direct entry into historical files of data values for manual input variables.
   b. Data entered through menus based on configurable groups of related manual inputs.
3. Disk Files:
   a. High Resolution Data:
      1) Sample Interval: Adjustable from 1 secondto 15 minutes.
      2) Period Covered: Multiple day, adjustable.
      3) Content: Time of day, date, and values of designated process variable. Value saved may be either instantaneous value or average over sample interval.
   b. Hourly Data:
      1) Sample Interval: 1 hour.
      2) Period Covered: Multiple day, adjustable.
      3) Content: Time of day, date, average, maximum, minimum, and totalized hourly values of designated process variables.
   c. Daily Data:
      1) Sample Interval: 1 day.
      2) Period Covered: Multiple day, adjustable.
      3) Content:
         a) For Designated Process Variable:
            (1) Daily minimum and maximum values.
            (2) Time occurrence of daily minimum and maximum values.
            (3) Average daily value.
            (4) Daily total (for flow and other rate type variables).
         b) End of day values for designated run time counters and cycle counters.
         c) Daily values for designated report variables and manual inputs.
      1) In case DCS is down at midnight, allow manual initiation of this file update at a later time.
3. Historical Archive File: Maintains permanent record of data saved in daily data disk file. On command, copy 1 month of data from daily

   data disk file to historical archive tape file. Provide operator selectable commands for both manual initiation and automatic timed initiation of this archival operation. Copy operation does not alter disk files. Disk data continues to be available for data retrieval functions.

D. Trending:

1. General Features:
    a. Trending is a special case of previously specified Data Retrieval function.
    b. Simultaneous trending of different sets of variables on different trend output devices.
    c. OIS Trend Resolution: Pixel level.
    d. Variables Per Trend: User selectable, one to four minimum, all displayed in same trend window.
2. Trend Types:
    a. Real-Time: Continuous plotting of variables as a function of time.
        1) Plottable Variables: Any process variable, report variables, discrete variable, and manual input defined in process data base.
        2) Minimum Plot Sample Interval: Same as scan rate.
    b. Historical: Plotting any variables from Historical Data Collection files as a function of time.
3. Retrieval Parameters: Specific variables, data types, retrieval period, sample interval, process variable scales, and output device. Refer to paragraph Data Retrieval.
4. Process Variable Scales:
    a. Independent selection for each variable of low scale and high scale values in engineering units of process variable axis. For example, if scales for variables A and B are 0.00 to 1.00 and 100 to 200 respectively, and if A=0.50 and B=l 50, both A and B would plot
    at exactly the same point (the mid-point of process variable axis).
    b. Display individual, engineering units' scales for each variable being trended.
    c. Readout Cursor: Adjustable by user over range of time scale. Values are displayed in engineering units of each trended variable intersected by readout cursor.
    d. Point Descriptions: Tag number and description are shown for each trended variable.
4. Trend Groups: Aid requesting of frequently used trends. Each Trend Group contains all data retrieval parameters needed to specify trend display for up to four variables.
    a. Provide a minimum of 10 trend groups.
    b. Allow operator to create custom trend groups as desired.

E. Utility Programs: Software that helps in the configuring of applications, including but not limited to database format translations (to and from dBase, EXCEL), checking and verification of control configuration, configured blocks, and display configuration.

H. PMCS Manufacturer: EMR.

2.4 DCS COMMUNICATIONS

A. General: High speed masterless communication system linking all DCS stations as shown on DCS block diagrams in the Drawings. DCS stations are defined as DCUs, OISs, EWSs, printers, and gateway modules.

B. DCU Data Highway Performance:

1. Communication Speed: 100 Mbps, minimum.
2. Operating Length: 5,000 feet, minimum.
3. Stations Supported per Highway: 100, minimum.

C. Redundancy and Reliability:

1. Communications system fully redundant; no single failure of communications component results in loss of communications to any DCS station.
2. Redundant Components: Including, but not limited to, communications controllers, modems, power supplies, data highway cables, and cable connectors.
3. Redundant data highway cable lengths: Different cable lengths (paths) for each highway cable shall not affect operation.
4. Automatic detection of communications system component failure.
5. Automatic switchover from failed communications system component to backup component without any interruptions to normal operations. Alarm switchover and identify failed component in alarm message.
6. Communication system not affected by connection, disconnection, and failure of DCS stations.

D Peer-to-Peer Communications: Direct communication over data highway between DCUs. Allows DCUs to exchange data base values. Communication not dependent on OISs or EWSs. Allow at least 10 percent of any DCS database values to be exchanged with other DCUs on a regular basis without degrading system performance.

C. Applications Software Transfers: For stations connected to communications system:

1. Download control logic from EWSs to DCUs.

2. Upload control logic from database server.
3. Download monitoring and display configurations from EWSs to OISs and other EWSs.
4. Upload monitoring and display configurations from database server.

D. DCS/PLC Communications:

1. Periodically read all discrete and analog inputs and outputs for each PLC.
2. On demand, read from and write to internal PLC registers including individual timers, counters, timer/counter preset values, control loop set points, high/low limits, computed variables, control loop tuning constants, status indicators, and sequence START/STOP commands.
3. DCS Capacity to Read and Write PLC Data: DCS able to read all PLC inputs and write all PLC outputs at least once every 15 seconds.

2.5 HARDWARE-GENERAL

A. DCS Block Diagram: Refer to control system functional block diagram in Drawings. Interconnecting lines shown on block diagram imply information flow and not necessarily wiring.

B. DCS Manufacturer: Emerson Process Management (EPM); Ovation System, latest version.

C. Control Room Layout: Refer to Drawings.

D. Equipment Mounting: Unless otherwise noted, mount all DCS components in NEMA rated cabinets.

E. Color: Manufacturer's standard.

F. Cables Required:

1. For interconnection between all DCS components, except where leased telephone lines are shown.
2. Fiber Optics Cables: As shown on Drawings, for interconnection between DCS components.
3. Data Highway and Local Area Network:
   a. Media: Fiber optics, coaxial, meeting DCS manufacturer's specifications.
4. Cables Under 50 Feet in Length: Prefabricated with connectors and factory tested with DCS.
5. Furnish and install communications cables.

G. Special signal conditioning/repeating equipment as required for proper operation of DCS.

H. Isolation Transformers: Provide for all DCS equipment to protect DCS from damage by electrical transients induced in cables by lighting discharges or electrical equipment.

I. . Power to DCS Equipment:

1. From isolation transformers and uninterruptible power supply (UPS) units provided under this section.
2. Supplied from dual feed circuits.
3. Provide circuit breaker panelboard at each DCU and RIO location.

J. Power Failure Detection and AUTO Restart:

1. Prevents errors due to power failure or short-term power fluctuations that occur when UPS is not operating.
2. Power Failure: Voltage variations more than plus or minus 10 percent of normal for a duration of 0.5 second or longer. Causes DCS equipment to automatically shut down as required to prevent introducing errors on disk.
3. Short-Term Power Fluctuations: Voltage variations more than plus or minus 10 percent of normal for durations of 0.5 second to 1 millisecond. DCS shuts down as above or is buffered to prevent fluctuations from causing errors.
4. DCS executes restart program and return to normal operation when power is restored. Battery backed-up real-time clock used by DCS during automatic restart to set time and date.

J. I/O Lists:

1. DCU Input/Output List: Covers I/O points directly connected to DCS process I/O modules.

****

I. **

a. POINT TAG (OLD): Existing point tag in the old PLC based control system.
b. POINT TAG (NEW): New point tag to be used in the DCS software. This tagging system must follow the new HRSD standards. If new tag is not given, create tag in accordance with standards.
c. POINT DESCRIPTION: Point name to be used in the DCS software.
d. DCU/RIO: DCU or RIO number where point is to be terminated.
e. UP: Unit Process that the point is associated with.

f. DI: Discrete input signal, 24V dc.

g. DO: Discrete output signal, 24V dc.

h. AI: Analog input signal, 24V dc, 4 to 20 mA dc current signal.

i. AO: Analog output signal, 24V dc, 4 to 20 mA dc current signal. May be powered: from DCS or from field power supply.

j. TC: Thermocouple input signal, type K unless otherwise indicated.

k. SET (Contact Closed): Condition when the input device is closed or energized.

l. RESET (Contact Opened): Condition when the input device is not closed or energized.

m. SENSOR RANGE (Signal Range): Analog sensor and/or signal range.

n. AI POWER (DCS/FIELD): For analog inputs only, indicates loop power from either the DCS cabinet (DCU or RIO) or from a field power supply. FIELD also applies to typical 4 wire devices such as magnetic flow meters which do not need a powered 4 to 20 mA dc loop. If not indicated default is FIELD.

o. TERMINAL NO.: First terminal number in interface cabinet, field panel or other interface point. This will generally be the positive terminal.

p. TERMINAL NO.: Second terminal number in interface cabinet, field panel or other interface point. This will generally be the negative or common terminal if

q. TERMINAL NO. SHIELD: Terminal number for cable shield when needed with shielded cables.

r. REFERENCE DRAWING: Number or designation of the existing equipment drawing where interface terminals are shown.

s. P&ID: Process and Instrumentation Drawing where the equipment and signals are shown.

t. TOT: Total number of required active I/O points for each DCU or RIO unit. This includes DI, DO, AI, AO and TC signals.

u. COMMENTS: Any additional pertinent or clarifying information that may be included for reference or general information.

L. DCS Component: Provide all components required for a complete operational DCS system.

M. DCU and RIO Enclosures:

1. Number of standard cabinets as required for each DCU or RIO.
2. HRSD prefers back-to-back style cabinets with modules in front and corresponding termination units in back. If this cannot be

accommodated due to limited floor space, then side by side cabinets will be acceptable.

3. Doors: Hinged doors for front and back access.
4. DCU/RIO Enclosure (Front half cabinet):
   a. DCU modules mounted in front.
   b. No field cables brought into cabinet.
   c. Sufficient rack space to accommodate specified future input/outputs, and associated power supplies, processors, communications and interface modules.
5. DCU/RIO Interface Cabinet (Rear half or side cabinet):
   a. All field terminations in cabinet.
   b. Houses all interface relays, timers, distribution breakers, fuses and miscellaneous items.
   c. Cabinet divided by 11-gauge, minimum, mounting panel allowing equipment to be mounted both sides of panel.
   d. Sufficient space in cabinets for terminations of specified spare I/O points and associated interface relays, timers, distribution breakers, fuses and miscellaneous items.
6. Typical Wiring Schematic: See Drawings.
7. DCU Spare Plug-In Slots: For each DCU/RIO, provide sufficient spare space in wired module cages plus sufficient terminals, power supplies, interfacing relays, and cabling to permit future addition of process I/O modules to bring total I/O point counts to those shown in following table. Numbers in parenthesis are remote I/O. Figures in table include required spares.
8. HRSD prefers Top Hat Enclosures on top of DCU/RIO's so conduits can penetrate it instead of DCU/RIO's. Inside of Top Hat enclosures two 4 inch knockouts can be made one for analog wiring and one for digital wiring. These knockouts should be centered in between the terminal connections.

2.6 HARDWARE-DCS COMPONENT LIST

A. Distributed Control Unit: Provide sufficient control processors, but no fewer than the number listed, for each DCU such that each control processor shall have 50 percent spare capacity when control functions have been configured.

B. Process Input/Output Modules:

1. I/O List: Provide sufficient I/O modules to handle the points shown in the I/O lists in Supplements at end of this section.
2. Spares: Refer to Article Spare Parts for additional requirements.
3. Remote I/O Modules: Mount all remote I/O modules within a given

ACC in a cabinet that is separate from the DCU cabinet for that ACC.

C. Operator Interface Station: Manufacturer's standard with one or two monitors as shown.

D. Engineering Workstation: Manufacturer's standard.

E. Historical Data Processor: Provide one of the following options for historical data collection, archival, and retrieval:

1. Historical functions implemented by OISs. To provide redundancy, multiple OISs simultaneously handle these functions.
2. Historical functions implemented through dedicated historical processors. For redundancy, provide a minimum of two such processors.

F. Gateway Modules for Interface with Non-DCS Equipment:

****

XIII. ************************************

1. PLCs: Allen-Bradley, Modicon, GE.
2. Where possible, use Modbus over Ethernet protocol.
3. Except with Allen Bradley PLC. Use native protocol.

7. HARDWARE-FURNITURE

****

XIV. ************************************

A. Control Room Console:

1. Provide 3-position console.
2. Integrated multiple bay enclosures suitable for sit down operation. House OISs, EWSs, printers, communications processors, data highway communications equipment, and power supplies.
3. Units made of high impact, durable plastic top. Desktops capable of supporting 400 pounds, minimum, on extended surfaces. Bushed holes for power and signal cables to devices located on desktop. Edges of desktops beveled or rounded. Forms feed slots in desktops for printer paper. Cupboards below printers with shelves to hold feed paper.
4. Operator Station Layouts: Provide layouts for each operator station as shown on drawings and listed below. Bays are listed from left to right as **operator views console.**

a. Types of Bays: Following abbreviations are used to identify required bays:
1) OIS or EWS.
2) Printer: Console printer surface.
3) Work: Console work surface.
4) Wedge: Console wedge section.

5. Colors: As selected by Owner.
6. Manufacturer and Product: Evans; Series 200, or equal.

B. Chairs:
1. Quantity: 8.
2. Type: Mid-back desk chair with five-arm base, T-arms, back height adjustment, back angle adjustment, seat angle adjustment, arm height adjustment, pneumatic height adjustment, and electrostatic discharge (ESD) option.
3. Castors:
    a. ESD soft, dual-wheel for use on hard floors.
    b. ESD hard-composition, dual-wheel for use on carpet.
4. Finish: Approved by chair manufacturer for use with ESD option. Custom color selected by Owner.
5. Manufacturer: Steelcase Inc. Criterion series 453-5500.

2.8 HARDWARE COMPONENT SPECIFICATIONS

A. Distributed Control Unit (DCU):

1. Independent units completely fabricated, with components installed and wired at factory.
2. Implement control logic (applications software) configured through the EWS.
3. Capable of continuing to execute control logic to maintain control over process even if all other stations are down and data highways are nonfunctional.
4. Primary Components:
    a. Control processors (redundant).
    b. I/O modules.
    c. Redundant data highway communications processors.
    d. Power supplies.
5. Control Processors:
    a. Execute control logic compiled by EWS.
    b. Communicate with I/O modules, data highway, other control processors and PLCs.
6. Redundant Control Processors:

a. Required for all units.
b. Both control processors receive and process information simultaneously. Faults detected by processors themselves without the need for data highway to be available. When fault is detected, non-defective processor assumes control without affecting normal operation.
c. Allow online configuration of control processors without interruption to process control functions.

7. Power Supplies:
   a. No interruption of operation due to single failure of any power supply.
   b. Capable of providing 24V dc power from DCU to field instruments.
8. Transportable Applications: Applications software developed offline on EWS can be downloaded to control processors. Control processors can

   emulate one another and applications software developed and debugged on one control processor can be saved, and later downloaded to a different control processor without additional modification.

B. Process Input/Output Modules:

1. Common Requirements:
   a. Surge Withstand Capability: ANSI/IEEE C37.90A.
   b. Discrete Output Fuses: Points individually fused either on I/O module or in field termination unit.
   c. Each I/O module shall be replaceable without disturbing the field

      I/O wiring connected to it.
   d. Provide a separate field termination unit and factory interconnect cable for each I/O module.
1. Analog Inputs (Isolated 4 to 20 mA dc):
   a. Type: Isolated 4 to 20 mA dc signals conforming to ISA S50.l.
   b. Input Range: 4 to 20 mA dc, minimum.
   c. Accuracy: Plus, or minus 0.1 percent of span.
   d. Resolution: 12 bits, minimum.
   e. Transmitter Power: 24V dc at 20 mA.
   f. Isolation: 300V minimum between points.
   g. Common Mode Rejection: 90 dB, minimum.
   h. Normal Mode Rejection: 33 dB, minimum, for frequencies of 60-Hz and above.
   i. Analog-to-Digital Converter: No more than eight inputs per converter.

3. Analog Outputs (Isolated 4 to 20 mA dc):
   a. Type: Isolated 4 to 20 mA dc signals conforming to ISA S50.l.
   b. Accuracy: Plus or minus 0.1 percent of span.
   c. Resolution: 12 bits, minimum.
   d. Isolation: 300V minimum between points.
4. Discrete Inputs (Contact Sense 24V dc):
   a. Type: 24V dc supplied by DCU impressed on external contacts to sense their OPEN/CLOSE status.
   b. Isolation: 300V minimum between points.
   c. Maximum Current for Turn On: 3 mA.
   d. LED ON/OFF status indicators for each point.
5. Discrete Outputs (Voltage Output 24V dc):
   a. Type: DCU supplies 24V dc to operate relays in external control panels.
   b. Isolation: 300V minimum between all output points.
   c. Maximum Load Current: 2 amps.
   d. LED ON/OFF status indicator for each point.

C. Uninterruptible Power Supplies (UPS): Manufacturer's standard continuous on-line type sized for a minimum of 30 minutes operation at full load conditions.

D. Isolation Transformers: Manufacturer's standard.

E. Circuit Breaker Panels: Manufacturer's standard.

2.9 SOURCE QUALITY CONTROL

A. Factory Demonstration Tests:

1. Scope: For all DCS equipment. See Section 40 90 10, Process Instrumentation and Control Systems (PICS).
2. Location: DCS manufacturer's factory.
3. Loop Specific Functions: See Section 40 90 10, Process Instrumentation and Control Systems (PICS).
4. Non-Loop Specific Functions:
   a. Input/output point generation and point processing.
   b. Control strategy generation.
   c. Message logging and alarm handling.
   d. Process control display generation and configuration.
   e. OIS displays and user entries.
   f. Power up, startup, and system restart.
   g. Printing/plotting functions.
   h. Failure mode and backup procedures including power failure, auto restart, and disk backup, and reload.
   i. Data base configuration and use.
   j. Historical data collection and retrieval.

k. Creation of a typical report and production of specified reports.

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

A. Operational Readiness Test: Refer to Section 40 90 10, Process Instrumentation and Control Systems (PICS).

B. Performance Acceptance Test: Include the same types of testing that are specified for factory demonstration test.

3.2 MANUFACTURER'S SERVICES

A. General: Provide experienced personnel and management in field (Staging Site, and Plant Site) to coordinate and complete: installation, termination, adjustment, testing, training, and startup assistance.

B. Startup and Testing Team: Provide onsite, a team of at least two persons experienced in DCS systems engineering, hardware maintenance, and software configuring during the total period required to:

1. Check the installation, termination, and adjustment of all subsystems and their components.
2. Perform and complete onsite tests.
3. Provide startup assistance.

3.1 SUPPLEMENTS

A. Supplements listed below follow "End of Section," are a part of this Specification.

1. DCS Equipment Schedule.
2. DCS Input/Output List, included with Contract Drawings.

END OF SECTION

Hampton Roads Sanitation District Strategic Automation Configuration Guide

Software and HMI Standards

January 8, 2015

Cleaning wastewater every day for a better Bay.

1 Introduction

Software, Hardware and Network standards must be defined before any Distributed Control System (DCS) design effort can be undertaken. Such standards benefit the DCS development team by providing a consistent design and an organized implementation plan. This, in turn, benefits the final user in the form of an efficient DCS operation and maintenance environment. This document details the DCS automation standards for the Hampton Roads Sanitation District projects.

This Automation Standards document is intended to be a living document, and as such, will be continuously updated. Changes will occur more frequently as new plants are added, and new types of control are defined.

This Volume is ordered into sections which provide a broad brush approach to standards, guidelines and best practices. For each plant or pump station, a second Volume will be developed, having additional tabbed sections containing standards that are unique to that specific plant or pump station.

2 Database

The Input/Output (I/O) database is the most important information required for a DCS project. Not only does it assist in the definition of control strategies and custom graphics, but it also provides point details that almost every standard software package on the DCS system uses. A successful DCS project starts with an I/O database that is 100% complete and accurate in both functional definition and record field content.

The following three sections define the core database record fields. The first section defines fields that are common to all data types. The remaining two sections define fields based upon whether the data type is analog or digital. Some of these fields are included for informational purposes only. Also, many of these fields will not necessarily appear in all of the published project I/O listings.

Emerson's Database Initial Definition Tool (DBID) is an offline pc-based utility that can be used to enter this essential database information for the DCS. Once the information is entered, the utility produces a file that can be imported into the actual Ovation DCS equipment.

References

- Appendix I – Database Field Entry
- Appendix II - Word and Phrase Abbreviations
- Ovation Record Types Reference Manual – REF_1140
- Ovation I/O Reference Manual - REF_1150

1. Common Fields

- Point Name is a unique identifier that is assigned to each field input and output. This identifier is coded with information pertaining to the plant, unit process, ISA and loop information associated with the I/O point.

- English Description is a functional definition of the Point Name, and appears in various system displays and listings. These rules are followed when assigning this field:

    - English Description is limited to 30 characters.

    - To benefit all users, English Description terminology, abbreviations and acronyms are consistent. Abbreviations are assigned so that their interpretations are as intuitive as possible, within the 30 character limit. Note that abbreviations are usually, but not necessarily unique, and that the context of the full description may provide the interpretation of what an abbreviation or acronym represents.

    - English Description specifically defines which device is being referenced. For example, “PUMP 1” is not an acceptable specific description, whereas ‘TANK 1 GRIT PUMP 1” is an acceptable specific description.

- I/O Type defines the four distinct data types used in the database:

    - Analog Input (AI) is a continuous process or status input reading over a measured range.

    - Analog Output (AO) is a continuous control output signal, typically used to control a VFD or modulating valve.

    - Digital Input (DI) is a two-state reading of a device state, process state or device position.

    - Digital Output (DO) is a two-state control output signal, typically used to energize an interposing relay that starts a motor or drives a valve.

- Xmtr defines the communication method used between the DCS and the field device. The following communication methods are defined:

    - 4-20 mA - Specifies an Analog Input or Analog Output with a milliamp signal level that is directly proportional to a measured range or control range.

    - 2W - Specifies the use of a serial communication link (e.g. a PLC or valve communications link). Any I/O Type can use this communication method.

    - 24VDC - Specifies a digital signal that switches a 24 volt DC potential when reading a state or energizing a relay.

    - 120VDC - Specifies a digital signal that switches a 120 volt AC potential when reading a state or energizing a relay.

    - TC – Specifies an Analog Input with a millivolt signal level that is a function of sensed temperature.

- History defines which points should be archived. Analog points also require a historical deadband, which defines the incremental change required before a new analog value is archived. The default deadband value for an analog I/O point or calculated value is 1%., whereas critical points would be assigned a 0.5% value, and other points are not configured to be archived at all.

- P&ID references where the device can be found in the project specification P&ID or Electrical Plan drawing.

- DCU is a term used to describe a redundant control processor and it's supporting hardware.

- Alarm Priority (AP) is intended to inform the Operator of the urgency of an alarm. HRSD assigns alarm priority level definitions.

- Point Alias is an auxiliary database field that has been designated to hold the Old Point Tag, as designated in the project database.

- Characteristics are assigned to allow the User to assign console destinations for alarm points, and also as a sorting mechanism used with the Ovation Point Review utility.

- Security is assigned as a 32 bit field that defines which Users have access to the various control and tuning functions associated with each point.

2. Analog Fields

- AI Power specifies whether a 4-20 mA signal is powered locally at the DCU (DCS) or from a field power source (FIELD). Note that shields for all analog signal cabling will be grounded at the DCS.

- Top Bar (TB) is the maximum scale value of the point represented in engineering units. This attribute determines the scaling used for bar graphs and trend lines.

- Bottom Bar (BB) is the minimum scale value of the point represented in engineering units. This attribute determines the scaling used for bar graphs and trend lines.

- Range combines the TB and BB fields into a single field, for clarity.

- Engineering Units (EU) is the unit of measure that point value represents. Examples of Engineering Units would be PPM, MGD, GPM, PSI, etc. This description is limited to six characters.

- Decimal Places (FM) defines the number of decimal places that will be shown in the Point Information screen and by default on Graphics (unless otherwise defined within the graphic code).

- High Sensor (HS) is the maximum electrical range of the instrument providing the point value. For example, if an instrument operates within a 4-20 mA range, HS would be 20 mA. Likewise, if the instrument operates within a 1-5 VDC range, HS would be 5 VDC. Only enter the numerical value in the field; 5 in the last example. Note that for 4-20 mA signals, the high sensor alarm setting will be set at 20.4 mA.

- Low Sensor (LS) is the minimum electrical range of the instrument providing the point value. For example, if an instrument operates within a 4 to 20 mA range, LS would be 4 mA. Likewise, if the instrument operates within a 1 to 5 VDC range, LS would be 1 VDC. Only enter the numerical value in the field; 1 in the last example. Note that for 4-20 mA signals, the low sensor alarm setting will be set at 3.6 mA.

- High Alarm (HL) is the value at which an alarm is generated on increasing signal.

- Low Alarm (LL) is the value at which an alarm is generated on decreasing signal.

- Deadband (DB) minimizes the occurrence of nuisance alarming when a signal oscillates near a High Limit or Low Limit setting. Once a point has exceeded either threshold, the alarm will remain active until the signal passes back through the threshold by the amount specified in Deadband.

- Deadband Algorithm represents the units of the Deadband (DB) value indicated above (standard, percentage range, ratio, etc.)

- Top Output Scale (TW) represents the maximum value of an Analog Output in Engineering Units.

- Bottom Output Scale (BW) represents the minimum value of an Analog Output in Engineering Units.

3. Digital Fields

- Reset Description (RS) describes the state of a device or command when a Digital Input or Digital Output contact is opened.

- Set Description (ST) describes the state of a device or command when a Digital Input or Digital Output contact is closed.

- Alarm State (AR) specifies which logic state should be alarmed for a digital point, contact closed (AR = 1) or contact opened (AR = 0).

- Alarm is an alternative method used to display the Alarm State on a database listing and is positioned to indicate whether the Reset Description or the Set Description is the alarm state of the signal.

3 DCS Control Philosophy

The Ovation DCS offers a wide variety of hardware configurations and software tools, allowing the user maximum flexibility in the implementation of control applications. Like any software-based program, Ovation control applications follow stringent guidelines that dictate the programming structure and control logic flow. Implementation of such guidelines is critical to the efficient development of the control logic, successful installation of the DCS and ease of software maintenance for years to come.

The following sections summarize the DCS control application program structure, typical of the logic flow required for HRSD process control applications.

References

- Appendix IX – Level 1 Control Templates
- Appendix X – DCU Software Mapping
- Appendix XI – Sample Control Strategy
- Ovation Algorithms Reference Manual – REF_1100

Process Control Programming Structure

HRSD process control applications require two distinct layers of automation. Each layer requires a specific set of I/O signals and provides a limited level of automation. These levels can be summarized as follows.

Level 1 Control

This is the lowest level of automation, and provides manual start/stop/open/close control and monitoring of devices such as valves, pumps, breakers, etc. From a software standpoint, this layer of control is designed in a modular logic format since most devices require the same basic control functions. Provisions are also made to accept commands from higher levels of automation.

Devices that require continuous control signals such as modulating valves and variable speed drives are also considered as Level 1 control. The control for these devices is typically unique in nature and, therefore, is omitted below to simplify the discussion of control layering. Modulating control is specifically addressed later in this document.

Level 2 Control

This level of automation provides automatic control of multiple devices within a single process. Examples of logic functions included at this level are:

- Equipment sequencing
    - Lead/lag priority assignment
- Automatic equipment alternation of parallel devices

Much of this softwareis designed in a modular format.

Level 1 Control Automation

Level 1 control automation provides manual control/monitoring of devices such as valves, pumps, breakers, etc. This is the software equivalent of the type of hardwired controls that normally appear at a control panel or MCC. Features that appear at this level of software include:

- Operator interface
- Equipment protection interlocks
- Process interlocks

- Commands from other automation levels
- Device fail alarms

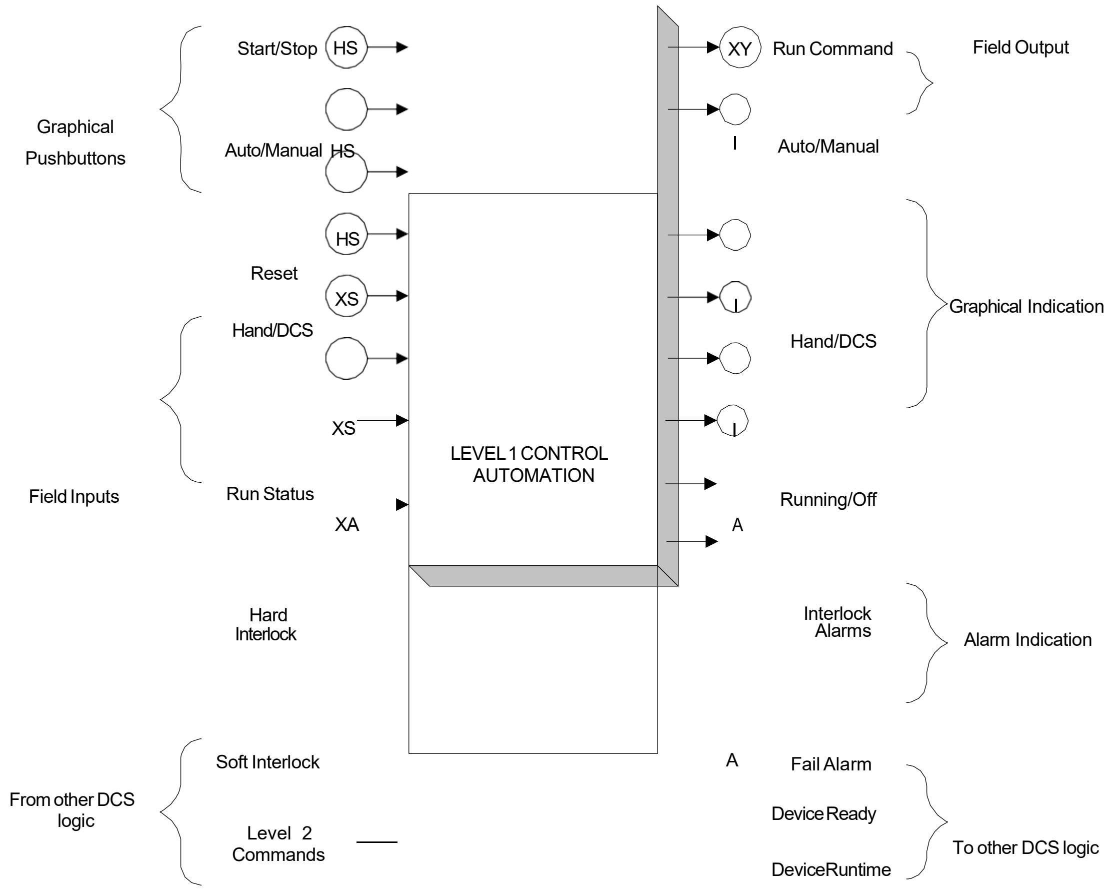


Figure 3.1.1 – Level 1 Control Automation Software Module

Figure 3.1.1 depicts a software module that controls an individual device such as a motor or breaker. This example generates one maintained control output based upon various Operator, I/O and DCS input signals. The module is designed to accommodate the worst case logic requirements of all field devices that utilize one maintained control output. For any device that does not match the requirements of the worst case device, all non-applicable input/output signals are disabled or ignored at the software module.

Other modules are developed for each type of control output requirement, e.g., one momentary output, two maintained outputs, two momentary outputs, etc. All modules have the same general characteristics:

- Operator Inputs – Graphical Pushbuttons
    - Start/Stop or Open/Close pushbuttons are provided to allow manual control from the DCS.
    - Auto/Manual pushbuttons are provided for any device that also has Level 2 control automation.
    - Reset pushbuttons are provided to allow the Operator to reset failure alarms.
- Field/DCS Inputs – Status and Interlock
    - Hand/DCS status is used to determine when the device is available for DCS control. Manual control pushbuttons are defeated when a device is in Hand control.

- Device status provides the control feedback that is necessary to determine that the device is properly responding to the control output. A failure alarm is generated when the device does not respond properly to the DCS commands.
- Hard (field) and soft (DCS) interlocks are used in permissive/interlock logic, providing equipment/safety protection.
- Level 2 automation normally provides start/stop commands to Level 1 automation for control such as device sequencing, lead/lag operations and automatic device alternation.

- Operator Display – Status and Alarms
    - Operator control interface to Level 1 automation is normally depicted as a Manual/Auto (M/A) control station. The M/A station displays all status and alarm information, enabling the Operator to control, monitor and troubleshoot device operation from one graphic display.
- Field/DCS Outputs – Command Outputs and Device Ready Status
    - Command outputs drive the I/O that provides the DCS with the means to control the device.
    - In order to make control decisions without duplicating Level 1 logic, Level 2

automation requires a Device Ready status from the associated Level 1 automation. Device Ready status is a single signal that indicates that a device is in DCS control, is in DCS Auto, and has all interlocks cleared.

Level 2 Control Automation – Process Control

This portion of Level 2 control automation provides automatic control of multiple devices. This type of automation typically replaces repetitive or scheduled Operator functions that involve multiple pieces of equipment. Features that appear at this level of software include:

- Operator interface
- Process interlocks
- Process startup, shutdown and normal control
- Command/status from other automation levels
- Process fail alarm

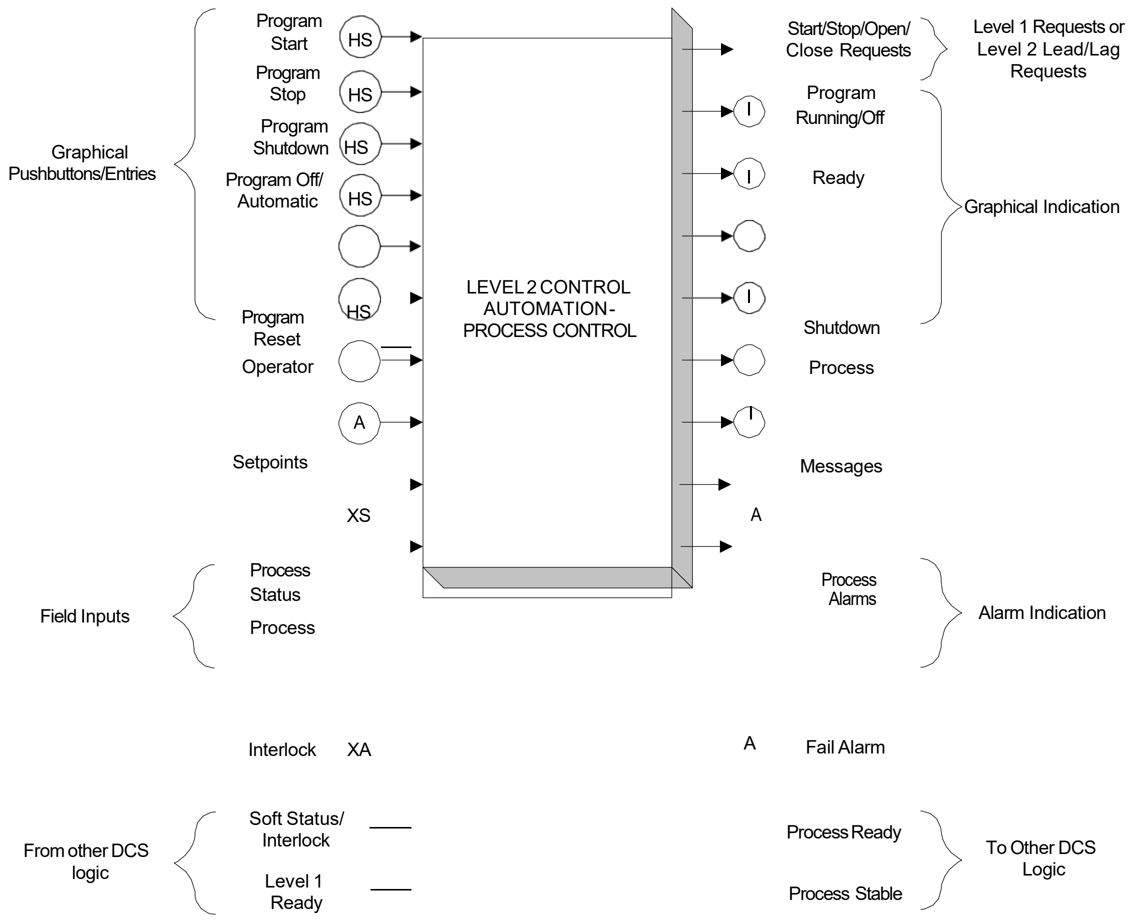

Graphical Pushbuttons/Entries
Program Start
HS
Program Stop
HS
Program Shutdown
HS
Program Off/ Automatic
HS
HS
Program Reset
Operator
A
Setpoints
XS
LEVEL 2 CONTROL AUTOMATION - PROCESS CONTROL
Field Inputs
Process Status
Process
Interlock
XA
From other DCS logic
Soft Status/ Interlock
Level 1 Ready
Start/Stop/Open/ Close Requests
Level 1 Requests or Level 2 Lead/Lag Requests
Program Running/Off
I
Ready
I
I
Graphical Indication
Shutdown
Process
Messages
A
Process Alarms
Alarm Indication
A
Fail Alarm
Process Ready
Process Stable
To Other DCS Logic

Figure 3.1.2 – Level 2 Control Automation Software Process Control Module

Figure 3.1.2 depicts a software module that controls multiple devices in response to process conditions and a predetermined program. This example generates multiple start/stop/open/close requests to other software modules. The interface to the Operator and to other software modules may be standardized, however the control program is customized based upon the process control requirements.

Other modules are developed for each specific process requirement. All modules have the same general characteristics:

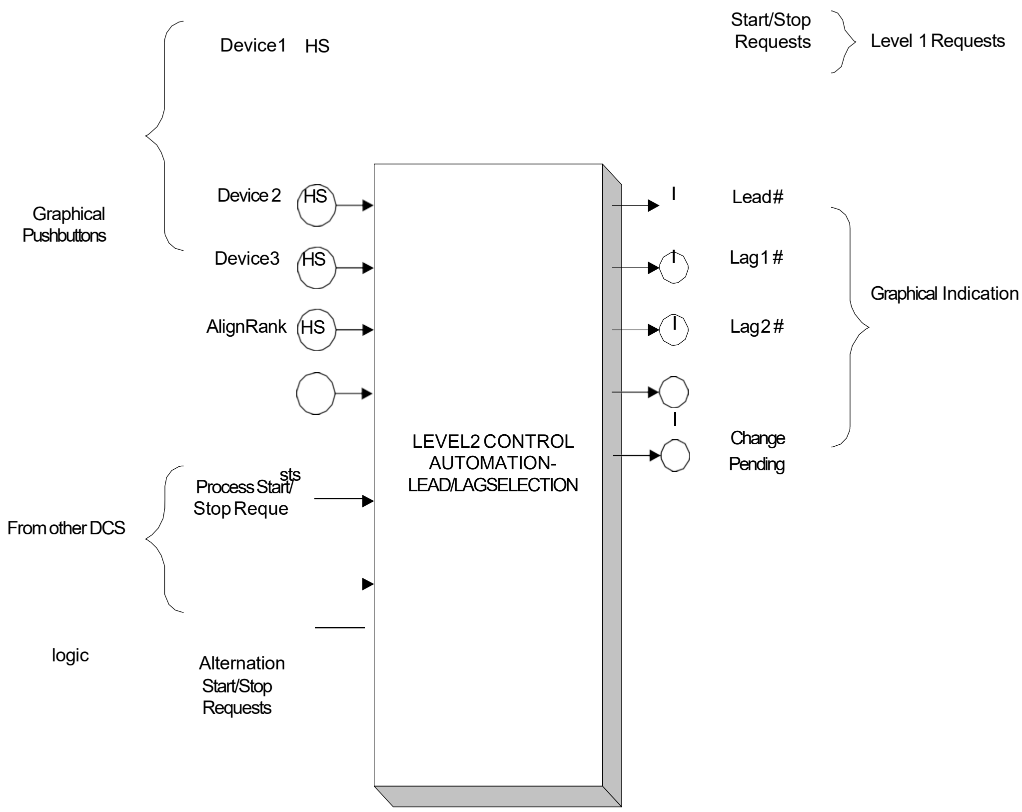
- Operator Inputs – Graphical Pushbuttons/Entries
  - Program Start and Stop pushbuttons are provided for Operator initiation of the process. A Program Off pushbutton is provided to reset a sequence to its first step, when applicable. Process setpoints and timer settings are also typically required. A Program Reset is also provided as a means to reset any sequence FAIL event before reinitiating the sequence. A Program Shutdown pushbutton may also be required, which provides an immediate shutdown of the associated equipment.
- Field/DCS Inputs – Status and Interlock
  - Process status provides the control feedback that is necessary to determine that the process is properly responding to the control requests. A fail alarm is generated when the process does not respond properly.
  - Hard (field) and soft (DCS) interlocks are used in startup/shutdown permissive logic, providing process protection. Equipment/safety protection is provided at the Level 1 control automation.
  - Level 1 control automation provides Device Ready status information to Level 2 automation. This allows the Level 2 automation to determine which devices are available to control the process.
- Operator Display – Status and Alarms
  - Operator control interface to Level 2 automation is normally depicted on an entire graphical display or a single control window, depending on the complexity of the process control. The graphic displays all status and alarm information and provides the Operator with informational messages that are unique to the process. This enables the Operator to control, monitor and troubleshoot the process operation from one graphic display. Level 1 M/A stations are also sometimes accessible from this display.
- Field/DCS Outputs – Control Requests and Process Ready Status
  - Control requests drive other software modules such as Level 2 Lead/Lag, Level 2 Alternation or Level 1.

Level 2 Control Automation – Lead/Lag Selection

This portion of Level 2 control automation accommodates the manual start/stop prioritization of multiple devices. Features that appear at this level of software include:

- Operator interface

- Manual start/stop prioritization



- Commands from/to other automation levels

Figure 3.1.3 – Level 2 Control Automation Software Lead/Lag Selection Module

Figure 3.1.3 depicts a software module that determines the specific selection of the next Level 1 device to start/stop. This example generates a control request for each device based upon various Operator and DCS input signals. The final selection is based on a predetermined order that is set manually. The module is designed to accommodate the worst case logic requirements of all processes that utilize a Lead/Lag type of selection. For any process that does not match the requirements of the worst case process, all non-applicable input/output signals are disabled or ignored at the software module.

Other modules may be developed for various types of control output requirement, e.g., Active/Standby, Lead1/Lead2/Lag, etc. All modules have the same general characteristics:

- Operator Inputs – Graphical Pushbuttons
    - Device pushbuttons are provided to allow manual order selection from the DCS. The Operator determines this by pressing the Device pushbuttons in the desired order.
    - The Align Rank pushbutton enables the Operator to execute an automatic re-alignment of the devices to match a new device order. Here, the highest priority devices are automatically started, and lower priority devices are stopped until the device statuses match the selected order.
- DCS Inputs – Status and Commands
    - This control module processes all requests from the Level 2 Process Control Module, and from the Level 2 Automatic Alternation Module when applicable.
- Operator Display – Status
    - Selection orders are displayed so that the Operator is aware of which device will be selected next.
    - The Operator may select a new device order if all devices are in the DCS Manual mode. Once an assignment is made for each device, a Pending Change message informs the Operator that the desired devices may again be placed in DCS Auto, then the Align Rank pushbutton will rotate the devices to match the new order.
- DCS Outputs – Control Requests
    - Control requests drive the associated Level 1 control automation.

Level 2 Control Automation – Automatic Alternation

This portion of Level 2 control automation requests the alternation of parallel devices based on one of several specified criteria:

- Runtime comparison to a manually set cycle timer
    - On start of alternating devices
- On device with least accumulated runtime, when device start is requested.

Features that appear at this level of software include:

- Operator interface
- Device current runtime comparison

- Commands to other automation levels

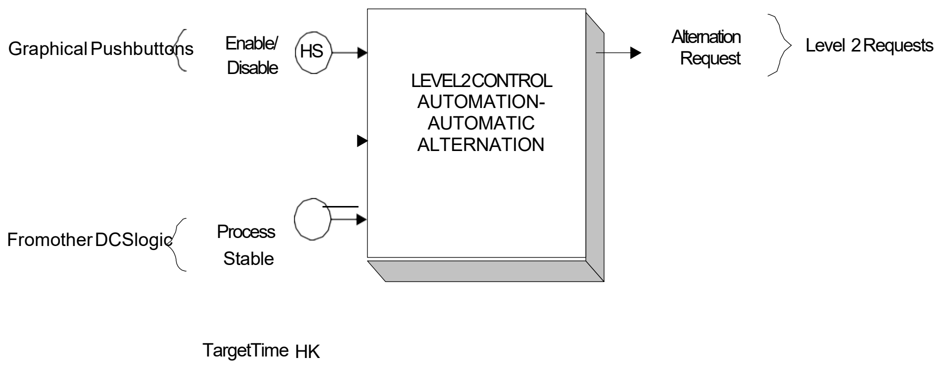


Figure 3.1.4 – Level 2 Control Automation Software Automatic Alternation Module

Figure 3.1.4 depicts a software module that determines when Level 1 devices need to be alternated. This example generates a control request to a Level 2 Lead/Lag Selection module based upon various DCS input signals. The output command is triggered based on equipment current runtime comparison to a manually set cycle timer. The module is designed to accommodate the worst case logic requirements of all processes that require automatic alternation. For any process that does not match the requirements of the worst case process, all non-applicable input/output signals are disabled or ignored at the software module. This module has the following general characteristics:

- Operator Inputs – Graphical Pushbuttons
  - Enable/Disable selections activate/deactivate the automatic control.
- DCS Inputs – Status and Commands
  - In this example, the device's current runtime is compared to a target (elapsed) time setpoint to determine when the equipment should alternate. Device current runtimes are calculated at Level 1.
  - When applicable, Level 2 automation only permits equipment alternation when the process is stable.
- DCS Outputs – Control Requests
  - Control requests drive the associated Level 2 Lead/Lag Selection Module.

Control Automation

Figure 3.1.5 summarizes the general handshaking requirements between Level 1 and Level 2 controls:

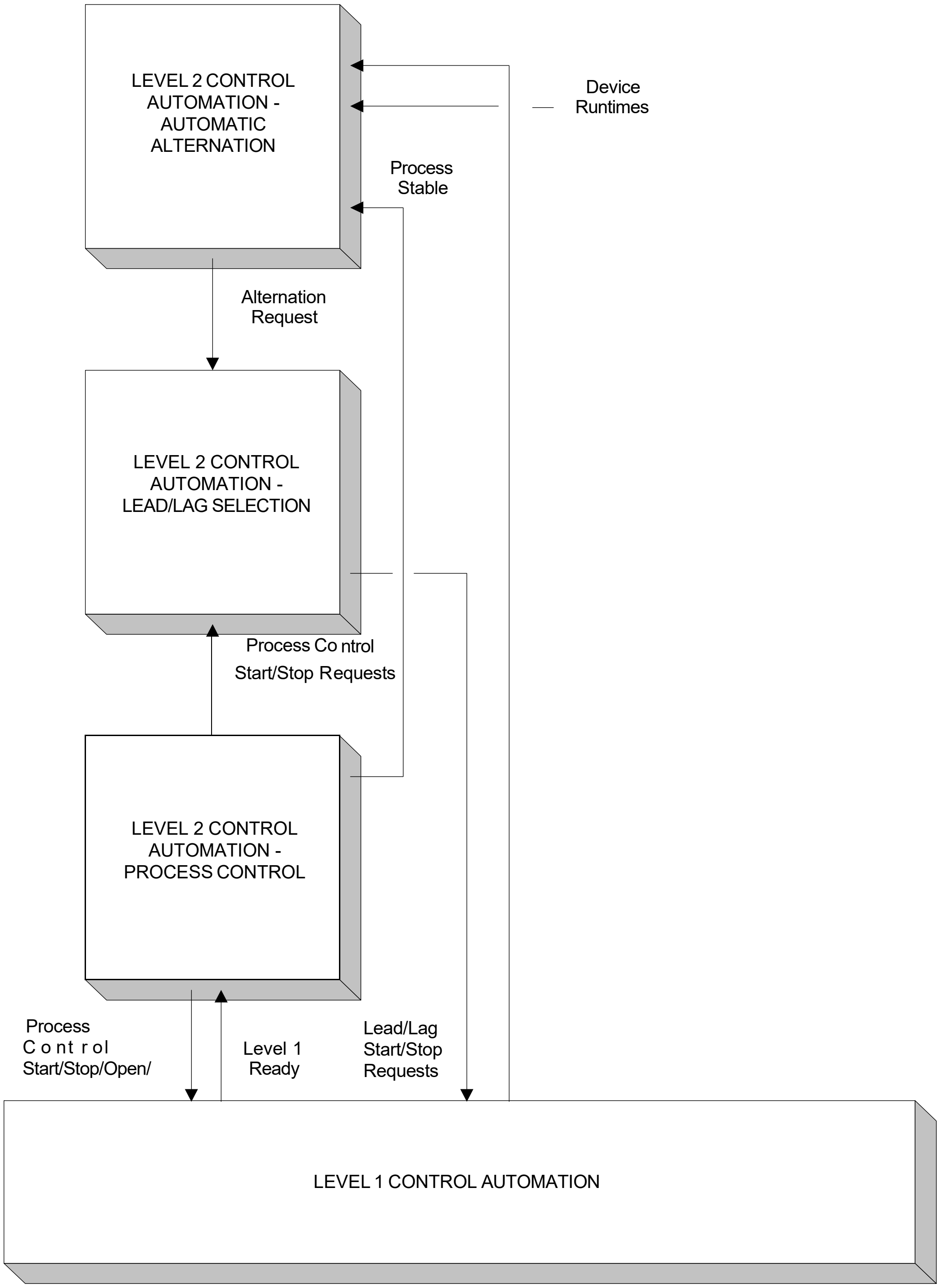


Figure 3.1.5 – Level 1/2 Control Automation Command/Status Flow

Failure and AvailabilityModes

The following alarms and failure modes will be provided for the indication of abnormal conditions of the equipment controlled by the DCS. This logic is provided to alert the operator of abnormal conditions that affect the DCS controls, and to provide the automatic controls with the information required to adapt to the same abnormal conditions. Note that upper case terms are used to represent control pushbuttons and indications that are integrated onto the Operator/Engineer displays.

General Failure and Availability Modes

- DATA LINK FAILURE - The DCS and PLC application programs combine to create a simple pulse train, or watchdog signal, for each DCS/PLC data link. If the pulse train ceases alternating between logic 0 and logic 1 states, then a DATA LINK FAILURE alarm is set. After a communication between the DCS and the PLC is reestablished, this alarm will be cleared automatically and after a predefined time delay all the DCS control functions will be restored.

- READY - The DCS continuously monitors the status and alarm condition of each controlled device. A device is defined as READY under the following conditions:

    - The local HAND/DCS switch is in DCS position, and

    - The device INTERLOCK flag is reset (if applicable), and

    - The device PERMISSIVE flag is reset (if applicable), and

    - DATA LINK FAILURE flag is reset (if applicable), and

    - None of the DCS originated alarms described below and specified for each type of the controlled device are active, e.g., drive FAIL TO START, drive FAIL TO STOP, valve FAIL TO OPEN, valve FAIL TO CLOSE, etc.

- AVAILABLE - This flag is used by Level 2 software to determine the equipment availability. A device is defined as AVAILABLE for strategy under the following conditions:

    - device READY flag is set, and

    - The device is selected to DCS AUTO mode

Drive Failure Modes

- INTERLOCK - This signal combines a complete list of DCS signals, which are defined as interlock criteria for a running drive that is controlled by the DCS, e.g., drive OVERLOAD, pump DISCHARGE PRESSURE HIGH, etc. The number and types of alarms included in drive INTERLOCK is specific for each type of controlled device and is defined at the database level or derived from other DCS logic. All signals, which are included in a drive INTERLOCK are displayed at the M/A station. Under occurrence the DCS commands the drive to STOP, prevents it from starting and sets the drive FAILED alarm.

- PERMISSIVE - This signal combines a complete list of DCS signals, which are defined as start-up permissive criteria for a drive that is controlled by the DCS. The number and types of alarms included in drive PERMISSIVE is specific for each type of controlled device and is defined at the database level or derived from other DCS logic. All signals, which are included in a drive PERMISSIVE are displayed at the M/A station. Under occurrence the DCS commands the drive to STOP and prevents it from starting.

- FAIL TO START - When a stopped electrical drive is commanded to start by the DCS in either MANUAL or AUTO mode and a running feedback is not received within a preset time, the Operator will receive a FAIL TO START alarm for the drive. This alarm is latched at the DCS and can be either manually reset by the Operator at the respective M/A station or is automatically reset when the drive HAND/AUTO switch is turned to HAND position. If the drive is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- FAILED - If a running electrical drive (e.g., pump, blower, etc.) stops while commanded to run by the DCS in either MANUAL or AUTO mode or if the drive INTERLOCK signal is set for such a drive, the Operator will receive a FAILED alarm for the drive. This alarm is latched at the DCS and can be either manually reset by the Operator at the respective M/A station or is automatically reset when the drive HAND/AUTO switch is turned to HAND position. If the drive is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- FAIL TO STOP - When a running electrical drive is commanded to stop by the DCS in either MANUAL or AUTO mode and a stop feedback (removed running feedback) is not received within a preset time, the Operator will receive a FAIL TO STOP alarm for the drive. This alarm is latched at the DCS and can be either manually reset by the Operator at the respective M/A station or is automatically reset when the drive HAND/AUTO switch is turned to HAND position. If the drive is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- SPEED DEVIATION - This alarm will be activated at the DCS for a variable speed pump if, for a preset amount of time the actual pump speed differs from the required pump speed by more than a preset value.

Valve Failure Modes

- INTERLOCK - This signal combines a complete list of DCS signals, which should interlock a controlled valve, i.e., valve JAMMED, valve HIGH TORQUE, etc. The number and types of alarms included in valve INTERLOCK is specific for each type of controlled device and is defined at the database level, or derived from other DCS logic. All signals, which are included in a valve INTERLOCK are displayed at the M/A station.

- FAIL TO OPEN - When a valve is commanded to open by the DCS in either MANUAL or AUTO mode and an open feedback is not received within a preset time, the Operator will receive a FAIL TO OPEN alarm for the valve. This alarm is latched at the DCS and can be either manually RESET by the Operator at the respective M/A station or is automatically reset when the valve HAND/AUTO switch is turned to HAND position. If the valve is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- FAIL TO CLOSE - When a valve commanded to close by the DCS in either MANUAL or AUTO mode and a close feedback is not received within a preset time, the Operator will receive a FAIL TO CLOSE alarm for this valve. This alarm is latched at the DCS and can be either manually RESET by the Operator at the respective M/A station or is automatically reset when the valve HAND/AUTO switch is turned to HAND position. If the valve is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- SWITCH FAILURE - If at any time both OPEN and CLOSE limit switch signals are received by the DCS at the same time, the SWITCH FAILURE alarm will be set. This alarm is latched at the

DCS and can be only manually RESET by the Operator at the respective M/A station. If the valve is controlled through a data link, this alarm will be disabled during DATA LINK FAILURE.

- POSITION DEVIATION - This alarm will be activated at the DCS for a modulating valve if, for a preset amount of time the actual valve position differs from the required valve position for more than an preset value.

(a) 4 Custom Graphics and HMI Configuration

Custom graphics are the most important interface tool provided with the DCS. These graphics, combined with the Ovation Human/Machine Interface (HMI) software packages, provide the monitoring and control access required for the Plant Operations and Maintenance (O&M) staff to perform their daily tasks. Development of an efficient, user-friendly HMI environment enhances the performance of the user and the resulting Plant operation.

Like any user interface, graphics design and HMI configuration must consider “human factors”. These factors include:

- Consistency
- Navigation
- Presentation (e.g., colors, blinking, shapes)
- Control accessibility
- Uniformity between different applications

The purpose of this Section is to define the approach used for the design and development of DCS control and monitoring graphics, and how they are integrated into the HMI environment. Specific concepts, examples and programming notes are included in various Sections of this document to assist the software development and maintenance efforts.

References

- Appendix III – Graphic Hierarchy
- Appendix IV – Graphic Navigation
- Appendix V – Graphic Display Elements
- Appendix VI – Process Colors
- Appendix VII – Graphic Macro List
- Appendix VIII – Sample Graphic Types
- Operator Station User Guide – OW331-20
- Operator Station Configuration Guide – OW331-21
- Graphics Builder Use Guide for Ovation 3.3 – OW331-90
- **ISA 101 standards.**

4.1. Graphics Hierarchy

4.1.1 General

- **Graphics should follow ISA 101 standards.**

A graphics hierarchy defines the "road map" for the organization and navigation of the DCS graphics. An effective graphic hierarchy provides the user with a consistent and an intuitive interface to the DCS monitoring and control functions.

The following general design concepts must first be established:

- Graphic Types – Most graphic types should mimic the appearance of project mechanical, architectural, electrical and instrumentation drawings. Standard formats are established for each type based upon desired levels of monitoring and control functionality, giving the user an immediate "feel" for the content and control accessibility of each graphic. In addition, each graphic type should appear somewhat similar to the other types. These standardized appearances also aid in identifying the hierarchical location of each graphic, resulting in more intuitive navigation actions by the user.

- Functional Areas – Functional Areas are established based upon plant-specific areas, unit processes and auxiliaries. Related piping, structures and equipment are grouped together on a graphic or set of graphics, to the extent allowed by the density limitations of the graphic type being used. Note that pan and zoom features are available as part of the standard viewing system, and their use should be considered when evaluating Functional Areas and graphic density. However, because of the number of user actions required to pan and zoom, its use should not be relied upon for normal user activities.

- Navigation – Paging symbols and Pop-Up windows are used to guide the user through the hierarchical map. Standard symbol locations and consistent graphic types result in more intuitive paging actions by the user. Paging symbols are also sometimes assigned for process lines that are continued between graphics.

- Pop-Up Windows - Pop-Up Windows provide a powerful alternative to using full-size graphics for paging, monitoring and control functions, significantly reducing the required number of user mouse actions.

4.2 Graphic Types

4.2.1 Plant Overview Graphics

Plant Overview graphics provide the highest level of display for the user's DCS operation. These graphics summarize the equipment layout and process status for multiple Functional Areas on a single graphic.

Three types of Plant Overview graphics are designed:

4.2.2 Display Menu – This provides a one-page summary of all custom mainscreen graphics provided with the system. This graphic is normally shown in a format that shows the hierarchical arrangement of the graphics.

4.2.3 Plant Overview - This provides a simplified P&ID diagram of the entire plant process and includes dynamic information for major plant process variables and equipment statuses.

4.2.4 Multi-Process Overview – This provides a simplified P&ID diagram of several related plant unit processes on a single graphic and includes dynamic information for major process variables and equipment statuses.

5 Unit Process Overview Graphics

Four types of Unit Process Overview graphics are designed:

5.1 P&ID graphics provide status update and high level control of multiple related devices within a Plant Functional Area. These graphics inherently can become very dense; therefore process and equipment representations are kept simple, may not always provide a true representation of equipment orientation, and look similar to the process and instrumentation drawings (P&ID) found in the project plans. Functional process layout is shown, along with related process variables, statuses, alarms and controls.

5.2 Electrical Single Line graphics are specific to electrical equipment arrangements and are similar to the one-line drawings found in the project plans. Functional electrical layout is shown, along with related process variables, statuses, alarms and controls.

- DCS System Status graphics represent the DCS network architecture and provide a constant update of the control system hardware status.

- Tabular graphics provide a summary of miscellaneous dynamic information that does not have an efficient graphical representation or would otherwise clutter another graphic. Information is presented in functionally grouped tables.

6 Unit Process Graphics

Two types of Unit Process graphics are designed:

- P&ID graphics provide individual control of devices related to a specific area or process. Process and equipment representations utilize a two-dimensional style of symbols. Functional process layout is shown, along with related process variables, statuses, alarms and controls.

- Electrical Single Line graphics are specific to electrical equipment arrangements and are similar to the one-line drawings found in the project plans. Functional electrical layout is shown, along with related process variables, statuses, alarms and controls.

7 Graphic Functional Areas

Graphic Functional Areas are established based upon plant-specific areas, unit processes and auxiliaries. Definition of these areas establishes the graphic display hierarchy. The following guidelines are used in the assignment of Functional Areas:

- Related process flow and plant areas are grouped.

- Processes should be separated from common plant auxiliary systems such as plant air and water. This causes less confusion and congestion on potentially dense graphics.

- Related graphics should be combined when sufficient space exists, thus minimizing the total number areas and simplifying navigation.

- Control for any specific device should appear in the fewest possible areas to minimize confusion.

- A specific range of graphic numbers is assigned to each area.

8 Graphic Navigation

With the proper design of Graphic Types and Functional Areas, most Graphic Navigation should inherently exist. The following guidelines are used in the assignment of Graphic Navigation:

- Navigation symbols should appear in consistent locations from graphic to graphic. When navigation symbols are grouped, their order (left/right/top/bottom) should reflect the process flow, which should also reflect the graphic hierarchy.

- Each graphic should contain a mechanism (drop-down menus or "shortcut keys") that enables immediate access to other graphics.

- Process lines may include paging symbols when the lines connect to other graphics.

- Extraneous paging symbols should be avoided since there is no location consistency from graphic to graphic. This tends to confuse the user and also uses valuable graphic space. Instead, the hierarchical design should already provide an intuitive means for the user to quickly display any graphic.

- Paging between different graphic types tends to be confusing and should be avoided.

9 Pop-Up Windows

Pop-Up Windows should be used extensively to facilitate user monitoring and control actions, and to reduce the number of user paging actions. Size should be considered when designing these windows, since it may be undesirable for the window to cover a substantial portion of the main graphic, however some applications require that no limit be defined. Predefined symbols locate the "poke field" areas that call up the windows from the mainscreen graphics. The following are uses for Pop-Up windows:

- Manual/Auto Control Stations - Analog/digital control stations are the most common application for Pop-Up Windows. Standard station sizes are defined, as well as the maximum number of stations per window. Equipment symbols are used to designate the associated poke field areas.

- Strategy Windows - Start/Stop strategy, Lead/Lag selection, value entry, sequence initiation and sequence step displays are typical functions applied to Strategy Windows. The possible combinations of these functions should be predefined, which would in turn define the number of user actions required to initiate a typical control. Due to the wide variation of possible control combinations, these windows typically have no predefined sizes. Text or equipment symbols are used to designate the associated poke field areas.

- Paging Menu - These "drop-down" windows allow the user to quickly navigate between graphics.

10. Base Workstation Features

10.1 General

When designing custom graphics, consideration must be given to the user interaction with the base workstation features. Custom graphic elements and related workstation functions should have a similar appearance and "feel". Note that it is not in the scope of this Section to define the specific workstation parameters, but only to summarize the relation of the graphic interface to standard workstation functions.

The following base workstation features must be considered when implementing the custom graphic design:

- Alarm List
- Trend Package
- Custom Graphic Menus
- Custom Keypad
- Keyboard Paging Arrows
- Diagram Display
- Navigation and Control
- Security Levels
- Operating System Commands

10.2 Workstation/Custom Graphic Interaction

- Alarm List.
    - Alarms should follow ISA 18 recommendations. The Alarm List provides a centralized interface for the user to manage all process and control system alarms. Custom graphics can provide a similar interface:

- Dynamic Display Elements - Any graphic display element can be designed to change color and/or blink based upon its associated alarm statuses. Implementing these dynamics on the custom graphics provides the user with the same information presented on the Alarm List, with the benefit of specifying only the subset of alarms that is associated with the graphic being displayed. Any combination of color and blink dynamics can be used on the custom graphics.

- Alarm List Invocation - The Alarm List appears in a window that is independent from the custom graphic viewing system, with the call-up icon being located on the workstation desktop. Custom graphics can be designed to call up the Alarm List from an icon coded within the graphic.

- Bell Silence and Alarm Acknowledge Control - These controls are standard functions on the Alarm List window and can be replicated on the custom graphics. Subject to alarm filtering parameters, the Operator may Silence or Acknowledge any DCS alarm from any workstation.

11 Trend Package

The Trend Package provides trending capability for 600 groups of points, each group having a maximum of 8 points apiece. Trend Groups appear in windows that are independent from the custom graphic viewing system. Custom graphics can be designed to call any specific trend group window without having to use the standard trend group menu function.

12. Diagram Display

The workstation's Operating System includes a program that displays any custom graphic by entering/selecting the assigned graphic number. This function is intended as a development/troubleshooting aid only and should not be made available to most users.

13 Navigation and Control

The workstation provides various means to navigate the cursor and activate control functions. Most users will use the mouse/trackball for as many functions as the interface is designed to accommodate, therefore the majority of custom graphic designs encourage the use of the mouse/trackball to select and activate the controls.

14 Security Levels

The workstation provides security controls through the use of the Ovation user login identification. Ovation Control and Engineering Function accessibility is enabled/disabled through the Ovation workstation security tools. Custom graphics may be viewed at any security level; however, control, engineering and maintenance functions are normally restricted.

15 Operating System Commands

Custom graphics have the capability of executing any Operating System command that is accessible by the user's security level. Typically, users of custom graphics have little need for such a feature to be included (except for convenience), since most programs available to the user are already accessible by other methods via the workstation's Operating System menus.

16. Base Graphic Standards

16.1 General

All graphics should follow ISA 101 standards.

Base graphic standards provide the foundation from which all custom graphic designs evolve. Like any project, these standards must be developed before any programming begins, and its associated documentation must be updated as the project progresses. Strict enforcement of such standards provides a consistent design, as well as a product that is cost-effective to develop and maintain. The following general categories of information must be defined:

- Graphic Window Parameters
- Graphic Layout Guidelines
- Plant-Specific Information
- Graphic Element Appearance

16.2 Graphic Window Parameters

Primary consideration must be given to the graphic dimensions, it's call-up location and the background color of the graphic window. The following parameters are configurable for each graphic:

- Design Size - Graphics are normally designed with a single, standard dimension that does not cover the entire desktop. This provides consistency and allows quick access to desktop icons for base workstations functions such as the Alarm List and the Trend Package.
- Fixed/Default Size and Location - These parameters determine whether each graphic is called up in a fixed size and location, or whether it should simply assume the previously displayed graphic's size and location. As with any desktop arrangement, users typically find it annoying for the system to resize and rearrange their windows, therefore fixed parameters are normally discouraged here.
- Resize/Zoom - These parameters are typically enabled to allow the user to fit more windows on the screen, and to enable the user to obtain a clearer view of the area of interest on the graphic. Note, however, that graphics should not be designed to require the user to zoom/pan the graphic window.
- Background Color - A single, dark background color should be chosen for all graphics, thus reducing eye strain for the user. The design should also allow for sections of a graphic to have another background color, thus furnishing a means to highlight a group of related devices.
- Grid - When possible, custom graphics should be designed on a fixed grid map. This simplifies graphic development and maintenance, and results in a better design.

17 Graphic Layout Guidelines

All custom graphics, no matter which type is chosen, are normally designed with some common display elements. These elements are typically placed in one of five areas, with the same information appearing in the identical location from graphic to graphic:

- Header Area (top)

- Footer Area (bottom)
- Left Margin
- Right Margin
- Corners

The following types of information are typically assigned to these areas. Care must be taken to minimize the amount of graphic space assigned to these areas, considering that the body of the graphic may need to consume all available space.

- Graphic Number - This information is helpful for development and troubleshooting, as well as for general reference needs in the project documentation.
- Graphic Title - In normal discussion, graphics are referenced by description instead of by number, therefore a concise title is appropriate for each.
- Navigation - These areas are ideal locations for the implementation of hierarchical graphics paging pop-up windows and shortcut keys.
- Time/Date - This information is sometimes useful for reference on graphic screen dumps, showing process variable values at a specific time and date.
- Process Variable Information - These areas are ideal locations for the display of major process information, such as Plant Influent Flow or Unit Megawatts.
- Plant/DCS Specific Information - Other important information such as plant location or DCS status can be placed here.
- Access to Base Workstation Features - Normally, graphics are sized in such a manner that desktop icons are readily accessible. In cases where graphics are designed to cover the majority of the desktop, access to base workstation features may be required in these areas.
- People are conditioned to read information in fixed directions. For example, in the United States, the typical user tends to read from left to right, and from top to bottom. Graphic designers must consider this natural user response when arranging screen content, and processes should tend to flow in these directions. Note that in this same example, the expected flow also favors a clockwise direction over a counter-clockwise direction.

18 Plant-Specific Information

As installations vary from company to company, and industry to industry, there are limitless possibilities of plant-specific information that may be required to be included on the custom graphics. The minimum required information is outlined below. Normally this information can be found in the project plans and specifications.

- Process Colors - Many installations color code the physical plant piping to facilitate the tracing of pipes. The custom graphics should follow a similar color scheme.

19 Base Graphic Elements

All custom graphic content consists of one or more base graphic elements that have stand-alone functionality, and act as building blocks for more complex graphic elements. Base static and dynamic features must be pre-defined and passed into the design of complex graphic elements.

19.1 Base Graphic Element Appearance

Ergonomic guidelines must be followed when choosing colors, blink attributes and fonts:

- Bright colors should be avoided, as well as large blank areas of light coloring on a dark background.
- When choosing a color, always consider the background color on which the associated element will appear and check for an acceptable degree of contrast.
- The overall graphic design should reduce the possibility of having too many different colors on a single graphic. Too many colors make the graphic look "busy" since the user's mind will subconsciously attempt to interpret each color.
- The exclusive use of color to convey specific information should be avoided since the user may suffer from some degree of color-blindness.
- Large blinking elements should be avoided, as well as elements that always blink.
- Font sizes and styles should be consistent between like functions.
- The number of different font sizes and styles should be minimized.
- Because of the density requirements of a typical set of custom graphics, it is difficult to avoid using small font sizes. Graphic designers should preview all font choices on a CRT that has the minimum size and resolution that will be used on the installed system.
- Center text on both the X and Y axis when the background is a colored bar. When using blank spaces to center text, and an odd number of spaces are available, put the extra space on the right side of the text (e.g. --center---, not ---center--).
- Capital letters should be used for most text to make the graphics more readable.

19.2 Base Graphic Element Functions

Pre-defining the base function of each type of graphic element results in consistent custom graphics and simplifies their development and maintenance. Base functional definitions should include size, color, and dynamic behavior.

- Text - Text is the most used graphic element, and default system text sizes should be used. Graphics designers must take into consideration that the size of most other graphic elements will be affected by the text sizes that are chosen.
- Lines - Lines are commonly used for piping, table construction and as pointing mechanisms. Line types and widths are chosen from system default menus. The use of different line types should be limited, since only a few different types are easily distinguishable on the typical graphic display.

- Polygons - Polygons are commonly used for piping and structural graphic representations. One advantage that polygons have over lines is that they have the option of including an outline color.

- Rectangles - Regular rectangles are used as needed. OL rectangles are normally used as background elements for 3-D representations.

- Shapes - A shape library provides pre-defined symbols for use throughout the graphics. Often, however, macros are instead used for this purpose because of their flexibility in including other graphic elements and complex dynamics.

- Filled Areas - Fills are used to paint areas within a specific boundary. Often, however, polygons are favored because the fill boundary rules are sometimes difficult to implement, and because fills tend to consume more of the workstation's processor resources.

- Process Points - Process points display analog values in a wide variety of formats. Quality indications are often included to display when a value may be invalid or not updating.

- Bargraphs - Bargraph indicators are used in a manner similar to that provided by hardened control panels. Bargraphs are useful in providing a more physical representation of an analog value. This is normally applied to a display such as tank level , or where related values are displayed side by side, as in the case of an M/A station.

- Poke Fields - Poke fields provide the user with the ability to interact with the graphics and process controllers. Typical applications include navigation and control. Unique symbols are used to indicate where poke fields are available.

- Entry Fields - Entry fields provide the user with the means to input data into the control system Typical applications include tuning adjustments and equipment start/stop prioritization.

19.3 Macros

- In order to simplify programming, graphic elements can be combined into library elements called macros. Macros feature a fill-in-the-blanks approach to programming simple or complex display elements.

Appendix I – Database Field Entry

General

This Appendix describes various database entry guidelines. The enclosed listings provide the User with the pre-defined options that are available for each entry. Refer to Section 2 of this document for general database information and references.

I/O Point Names

This Appendix describes the point naming scheme for I/O points. I/O point names are limited to 16 characters in length, and some non-alphanumeric characters are not allowed. When assessing I/O point naming lengths, internal point naming standards must also be considered.

Plant and Pump Station Naming Standards

I/O points must have a unique name on a single DCS network. Identical point names on different networks are not recommended since it can cause confusion when data is drawn from multiple networks. The first three characters will describe the Plant or Pump Station with which the point is associated.

Unit Process Standards

To facilitate data sorting and identification, the fourth and fifth characters of the point name will represent a Plant Unit Process. For consistency, Unit Process designations will match between different Plants, and pre-defined HRSD designators (two-digit numbers) will be used.

Function Designator

The third designator in the point naming scheme will consist of a four character representation that most closely describes the point function, generally following ISA standards.

Loop Designator

The fourth designator in the point naming scheme will consist of a four digit loop identifier, and typically represent a single device or group of related devices. Loop assignments are defined in the project database.

Loop Suffix Designator

For devices that have the same Plant/UP/ISA/Loop designators, a provision is made to differentiate point names through the addition of an alphabetic (A-Z) loop suffix.

Typical Point Name

Using the aforementioned schemes, a typical point name will appear as in the following example:

ABP12FITX2013

This point name represents a flow indicating transmitter at the Army Base Treatment Plant, Unit Process 12, and identified by loop number 2013.

All DCU and RIO cabinet alarms shall be included in unit process 99 and be tagged as follows:

UPS summary alarm	ABP99YAAXxxyy
UPS low battery	ABP99YABXxxyy
UPS on battery	ABP99ONBTxxyy
UPS on bypass	ABP99ONBYxxyy
UPS ON STATUS	ABP99ONSTxxyy
Cabinet door closed	ABP99CLSSxxyy

Where xx = Drop and yy = RIO. Examples: ABP99YAEX0100 is Drop 1 UPS is bypassed, ABP99YABX2221 is RIO 21 UPS low battery, which is controlled by drop 22.

<u>Internal Point Names</u>

Internal point names are added to the DCS as required to implement the control logic. These can be Analog, Digital or Packed points, and will follow a pattern similar to that used for I/O points, with the following exceptions:

<u>Internal Function Standards</u>

The third designator in the point naming scheme will consist of a four digit pseudo-ISA representation that most closely describes the internal point function.

<u>Fourteenth Character</u>

In order to quickly identify internal points, the fourteenth character will be a dash "- ".

<u>Internal Point Suffix</u>

A two-character suffix is added to the last two positions, thus allowing multiple internal points to be assigned to a single control function.

<u>Typical Internal Point Name</u>

Using the aforementioned schemes, typical internal point names will appear as in the following examples:

ABP01B00X1036-00

ABP01FCLS1036-00

The first point name would represent internally generated packed status bits, while the second represents a FAIL TO CLOSE alarm for the same unit process 1 device at the Army Base Treatment Plant, identified by loop number 1036.

Alarm Priority and Color Standards – Follow ISA18

Any point designated as an alarm must be assigned a priority and a color for display on the DCS Alarm List. The Ovation system provides for up to 8 alarm priorities, 1-8 (most critical to least critical). Note that the color assignment made here will also be used on the custom graphic displays, as applicable.

Alarm Destination Standards

At the HMI, the User can select Normal or Priority Mode for alarm list display. Typically, the Normal Mode is configured to show all alarms. Priority Mode is typically configured to display User-specific or Location-specific alarms. Alarm destination is used to assign each point to these alarm configurations. Note that 26 categories of alarm destination are available, and one is reserved for DCS-related alarms.

Point Characteristics Standards

At the HMI, the User is provided with a utility to sort thru the system database points for various status information. Point Characteristics provides the sorting mechanism. Eight characters are assigned to each point to categorize the possible sort combinations. Note that the first Point Characteristic is always the alarm destination designator.

HRSD Functional Tag Standards and Conventions

Tag	Function	Initiating Device
AAHH	Analyzer Alarm High High	Gas Monitoring System
AAHX	Analyzer Warning High	Gas Monitoring System
AALX	Analyzer Alarm Low	Gas Monitoring System
AITX	Analysis Indicator Transmitter	Analysis Transmitter or System
CLSC	Valve/Slide Gate Close Command	DCS
CLSP	Valve/Slide Gate Close Permissive	DCS
CLSS	Valve/Slide Gate Close Status	Field Device
EAHX	Voltage Alarm High	Generator System
EALL	Voltage Alarm Low Low	Generator System
EALX	Voltage Alarm Low	Generator System
EITX	Voltage Indicator	Generator System
FALX	Flow Alarm Low	DCS
FITQ	Flow Indicator Transmitter Totalizer	Flow Transmitter (pulse)
FITX	Flow Indicator Transmitter	Flow Transmitter
FSLX	Flow Switch Low	Flow Switch
HSAS	Hand Switch in Auto Status	HOA Selector Switch
HSHS	Hand Switch Hand Status	HOA Selector Switch
HSOS	Hand Switch Off Status	HOA Selector Switch
IITX	Current Indicator	Generator System
JHXX	Power Demand High	Power Transmitter
JITX	Power Indicator	Generator System
HBCX	Heartbeat Output	DCS
KQIX	Run Time Indicator	Field Equipment
HBIX	Heartbeat Input	PLC
LAHH	Level Alarm High High	Field Equipment
LAHX	Level Alarm High	Field Equipment
LALL	Level Alarm Low Low	Field Equipment
LALX	Level Alarm Low	Field Equipment
LITX	Level Indicator Transmitter	Level Transmitter
LSHH	Level Switch High High	Level Switch or System
LSHX	Level Switch High	Level Switch or System
LSLL	Level Switch Low Low	Level Switch or System
LSLX	Level Switch Low Limit	Level Switch or System
LSXX	Switch	Field Equipment

NAHH	Torque Alarm High High	Torque Monitoring System
NAHX	Torque Alarm High	Torque Monitoring System

HRSD Functional Tag Standards and Conventions

Tag	Function	Initiating Device
NIXX	Torque Indication Torque	Torque Monitoring System
NSHH	Switch Fail Not Running	Torque Monitoring System
OFST	Status (OFF) Running	MCC, AFD, Control Panel
ONST	Status (ON) Running	MCC, AFD, Control Panel
ONSF	Forward Running Reverse	MCC, AFD, Control Panel
ONSR		MCC, AFD, Control Panel
OPNC	Open Command	DCS
OPNP	Open Permissive	DCS
OPNS	Open Status	DCS
PAHH	Pressure Alarm High High	Control Panel
PAHX	Pressure Alarm High	Control Panel
PALL	Pressure Alarm Low Low	Control Panel
PALX	Pressure Alarm Low	Control Panel
PDAH	Differential Pressure Alarm High	DCS
PDAL	Differential Pressure Alarm Low	DCS
PDHH	Differential Pressure Alarm/Switch High High	DCS/Differential Pressure Switch
PDLL	Differential Pressure Alarm/Switch Low Low	DCS/Differential Pressure Switch
PDSH	Differential Pressure Switch High	Differential Pressure Switch
PDSL	Differential Pressure Switch Low	Differential Pressure Switch

PDIT	Pressure Differential Indicating Transmitter PITX PSXX PSHH PSHX PSLL	Differential Pressure Transmitter

PSL Pressure Limit Switch

X Pressure Switch High High Pressure Switch High Pressure

Switch Low Low

Pres
sure Pressure Switch Low

Indicating Transmitter

T

Pre r a n s m i t t e r S

ssu re w i t c h S

Pres w i t c h S

sure w i t c h S

Pres w i t c h

sure Switch

Pres

sure

Pres

sure

Pres
sure

QITX	Power Factor Indicator Transmitter	Electrical Systems
RUNC	RUN Command FORWARD	DCS
RUNF	Run Command	DCS
RUNP	Run Permissive	DCS
RUNR	Run REVERSE Command	DCS
SAHX	Overspeed Alarm	Generator System
SIXX	Speed Indication Pump	VFD panel
SCXX	SPEED Command Speed	DCS
SSLX	Switch Low	Zero Speed Switch

HRSD Functional Tag Standards and Conventions

Tag	Function	Initiating Device
TAHH	Temperature Alarm High High	Generator System
TAHX	Temperature Alarm High	Generator System
TCTX	Temperature Sensor	Thermocouple Temp
TITX	Temp Indicator Transmitter	Device Field
VAHX	Vibration Alarm High	Equipment
VITX	Vibration Transmitter Weight	Vibration Transmitter or System
WITX	Indicating Transmitter Event	Weight Transmitter
YAAX	Alarm No 1	MCC AFD, Control Panel
YABX	Event Alarm No 2	, AFD, Control Panel
YACX	Event Fail Alarm Common	MCC, AFD, Control Panel
YADX	Event Alarm No 3	MCC, AFD, Control Panel
		MCC,
YAXX	Emergency Stop Position	Field Equipment
ZCXX	Command Position	DCS
ZIXX	Indication	Position Transmitter

NOTE: Any required point type tags that are cannot be expressed using this list must be approved for use by HRSD and Emerson.

Appendix II - Word and Phrase Abbreviations

General

This Appendix describes the Plant equipment abbreviation standards. The following lists set forth the abbreviation convention for all Plant structures, equipment and devices that appear in the DCS and its related documentation. For general use, two lists are included, one sorted by word/phrase, and the other sorted by abbreviation. A third list is provided for the point Set/Reset fields.

Abbreviations are required for every aspect of a DCS project, from database definition to Alarm Lists, Trend Groups and custom graphics. Abbreviation standards are vital; however, they are difficult to enforce on large projects with many people, and with many software packages having different text length limitations. Other complications are that multiple words may require the same abbreviation, and that not all possible words can always be pre-defined in an abbreviations list.

The following guidelines shall be used when adding new abbreviations:

- For multiple words, use a common acronym, or create an acronym using the first letter of each word.

- For single words, abbreviations should be constructed to provide unique representation without need for context and intuitive interpretation for the user.

- Periods (.) should never be used in abbreviations, and other extraneous punctuation should be avoided.

Appendix III – Graphic Hierarchy

Graphics Standards are being updated to comply with ISA 101

General

This Appendix describes the Plant graphic hierarchy. The graphic hierarchy list presented on the following pages does not necessarily represent a final design, as requirements change during project approval and development. Graphic numbering is spaced for future expansion, and to provide numbering consistency between Plants. These numbers are pre-assigned and may change. Note that the graphics hierarchy and paging menus are designed such that the Operator need not be concerned with recognizing or memorizing graphic numbers.

Graphics Hierarchy

HRSD Graphics Hierarchy

Menu Name		
GraphicNo.	**GraphicTitle**	**Graphic Style**
Main Window		
	Overview	ISA 101 Level 1
Top Level Process - appears on all menus		
2000	PlantOverview	ISA 101 Level 2
2010	Plant Overview Table	ISA 101 Level 2
2020	Liquid ProcessOverview	ISA 101 Level 2
2030	BiosolidsProcessOverview	ISA 101 Level 2
2040	Program Status Overview	Tabular
PRELIMINARY		
2100	Preliminary Treatment Overview	ISA 101 Level 2
2110	InfluentScreeningSystem	2D
2120	Plant Influent Pumping System	2D
2130	Grit RemovalSystem	2D
2150	Bio Solids / Septage receiving/Handling	2D
PRIMARY		
2200	PrimaryTreatmentOverview	ISA 101 Level 2
2210	Primary Clarification1/2/3	2D
2220	Primary Clarification4/5/6	2D
2230	Primary ScumSystem	2D
2250	Intermediate Pumping	2D

Menu Name	Graphic No. Main Window	Graphic Title	Graphic Style
SECONDARY			
	2300	Secondary Treatment Overview	ISA 101 Level 2
	2310	Aeration Basins 1/2	2D
	2320	Aeration Basins 3/4	2D
	2330	Nitrate and Anoxic Recycle Pumps	2D
	2340	Aeration Blowers	2D
	2350	Secondary Clarifiers	2D
	2360	RAS and WAS	2D
	2370	Foam Removal/ Scum Pumping	2D
CONTACT TK/EFFL			
	2500	Contact Tank/Effluent Overview	ISA 101 Level 2
ODOR CONTROL			
	2700	Odor Control Overview	ISA 101 Level 2
	2710	Odor Control Station	2D

CHEMICAL

2860

2800

2870

Chemical Systems Overview Hypochlorite System Bisulfite System Caustic

2810

System

2820

Primary Treatment Polymer System Secondary Treatment Polymer System Methanol I

2830

Storage and Pumping

2840

Ferric Chloride system

2850

I S A 1
0
1
L
e
v
e
l
2
2
D
2D
2D
2D
2D
2D
2D

Menu Name	GraphicNo. Main Window	Graphic Title	Graphic Style
Thickening			
	2900	Thickening Overview	ISA 101 Level 2
	2910	Thickener 1	2D
	2920	Thickeners 2	2D
	2970	ThickeningPolymer System	
DEWATERING			
	3000	DewateringOverview	ISA 101 Level 2
	3010	Primary Biosolids Storage and Pumping	2D
	3020	Waste Activated Biosolids Storage and Pumping	2D
	3030	NorfolkWater Solids	2D
	3040	Centrifuges Dewatering	2D
	3070	Polymer System	2D
INCINERATION			
	3100	Incineration Overview	ISA 101 Level 2D
	3110	BiosolidsConveying/FBS	2D
	3120	Incinerator1	2D
	3140	Incinerator2	2D
	3160	Ash Handling System	2D
NITRIFICATION			
	3195	Nitrification Enhancement Overview	ISA 101 Level 2

AUXILIARY

3200	Auxiliary System Overview	ISA 101 Level 2

SAFETY/SECURITY

3300	Safety/Security	Tabular
3310	Overview Gas	Tabular

Menu Name	Monitoring	
GraphicNo. Main Window	**Graphic Title**	**Graphic Style**

ELE TRICAL

3400	Electrical SystemOverview	One-line
3410	Emergency Generation Overview	One-line
3420	Generator1	2D
3430	Generator2	2D
3440	Generator3	2D
3450	Generator AuxiliarySystems	2D

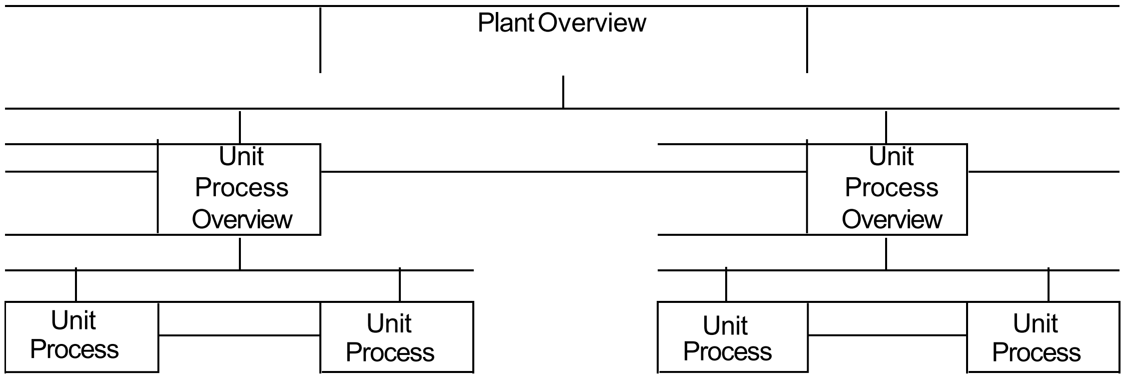
DCS

1800	DCS Status Overview	One-line

Appendix IV - Graphic Navigation

General

The general navigational structure between Plant Overview graphics, Unit Process Overview graphics and Unit Process graphics can be diagrammed as follows:



Other navigational guidelines are as follows:

- Up/Down/Left/Right paging is supplied on the graphic window's menu bar. Up/Down paging "rolls over" to stay within a single Unit Process graphic set, whereas the Left/Right paging links to other Unit Process graphic sets.
- Drop-down menu based paging is included on each graphic to allow "two-click" access to any other graphic.
- Flow lines are provided with poke field paging that connects to other graphics.
- The Top Level Paging Menu (Diagram 1000) provides a site map to the system's mainscreen graphics and is depicted in manner similar to a GUI file folder structure.

Appendix V – Graphic Display Elements

General

This Appendix describes the details of the graphic static and dynamic elements, in table format. This is followed by several examples of how these elements are combined to form standard graphic layouts.

Graphic Windows Parameters

Parameter	Comment
Design Size	1100w X 770h
Fixed/Default Size and Location	Default size and position for all main screens and pop-up windows
Resize/Zoom	Resize and zoom enabled, but not considered as normal an operator function when laying out the graphic design
Background Color	Gray40 for all main screens, gray70 for pop-up windows
Base Font	Standard ovation vector-based font
Grid	Minimum allowable size

Table V.1 - Graphic Windows Parameters

Graphic Layout Guidelines

Header Area	Comment
Title Bar	Graphic title and graphic number
Top Left Corner	Plant name, time/date
Top Right Corner	Shortcut bar with Display Menu access and Help file (.pdf) access
Custom Buttons	Pop-up graphic menu access. Menu groupings are based on graphic hierarchy.

Table V.2 - Graphic Layout Guidelines

Base Graphic Element Functions - Static Text

Function	Size	FG Color	BG Color	Comment
Engineering Units - Process Points	2	White	Same as graphic	
Engineering Units - M/A Station	1	Same as process bargraph	Same as graphic	
General Main Screen Text	1 or 2	White	Same as graphic	
Header Title Bar - Graphic Number	1	Darkgreen	Gray60	
Header Title Bar - Graphic Title	5	Darkgreen	Gray60	
Header Title Bar - Plant Name	5	Darkgreen	Gray60	
M/A Station - General Labels	2	White	Same as graphic	
M/A Station or Strategy - Control PB Labels	2	Black	Gray70	
M/A Station or Strategy - Title Line 1&2	2	Darkgreen	Gray60	
Strategy Window - Text	2	White	Same as graphic	
Table Headings and Labels	2	White	Same as graphic	

Table V.3 - Base Graphic Element Functions - Static Text

Base Graphic Element Functions - Dynamic Text

Function	Size	Text	FG Color	BG Color	Comment
Process Point	2	Dynamic Value	Green	Same as graphic	Alarm colors match the colors defined for the alarm list. Quality alarm is FG red, except for Timed Out which is FG magenta.
Main Screen or Control Window - Alarm Text or M/A Interlock	2	Derived from English Description	Gray shade varies based on BG color, normally 10 shades lighter.	Same as graphic	Alarm colors match the colors defined for the alarm list.
Main Screen - Running/ Stopped Status	2	R S	White Black	Red Green	Device shapes also turn yellow upon FAIL.
Main Screen - Open/ In Travel/ Close	2	O I C	White Black Black	Red White Green	Device shapes also turn yellow upon FAIL.
Main Screen - Open/ Close	2	O C	Black White	Green Red	Device shapes also turn yellow upon FAIL.
Main Screen - Not Ready/ Running/ Ready Sequence Status	2	N R D	Black White Black	Magenta Red Green	None None None
Main Screen - Hand/DCS Mode	2	H D	White White	Red Blue	None None
M/A Station - Manual/ Auto	2	MANUAL AUTO	White White	Red Blue	None None

Function	Size	Text	FG Color	BG Color	Comment
M/A Station - Device Status	3	STOPPED RUNNING FAIL TO START FAIL TO STOP FAIL	White Black Black Black Black	Red Green Yellow Yellow Yellow	None None See 2nd note. See 2nd note. See 2nd note.
M/A Station - Hand/DCS	2	HAND DCS	White White	Red Blue	None None
M/A Station Manual Reject	2	MREJ	White	Red	None
M/A Station Track	2	TRACK	White	Blue	None
M/A Station - Valve Status	2	OPENED IN TRAVEL CLOSED FAIL TO OPEN FAIL TO CLOSE SWITCH FAIL	White Black Black Black Black Black	Red White Green Yellow Yellow Yellow	None None None See 2nd note. See 2nd note. See 2nd note.
M/A Station - Breaker Status	2	OPENED CLOSED FAIL TO OPEN FAIL TO CLOSE SWITCH FAIL	Black White Black Black Black	Green Red Yellow Yellow Yellow	None None See 2nd note. See 2nd note. See 2nd note.
Strategy Control Window - Device Availability	2	Device Name (available) Device Name (not available)	White Gray50	Same as window Same as window	None None

Function	Size	Text	FG Color	BG Color	Comment
General Dynamic Message	2	Message specific	Black	White	None
Strategy Control Window- Status	2	NOTREADY RUNNING READY FAIL	Black White Black Black	Magenta Red Green Yellow	None None None None
Sequence Step Window - Sequence Ready/ Not Ready/ Failed/ Selected/ Active/ Done	2	READY N READY FAILED SELECTED ACTIVE DONE	Black Black Black Black White Black	Green Magenta Yellow Green Red White	None None None None None None

Table V.4 - Base Graphic Element Functions - Dynamic Text

Notes:

- Functions that are identical between Windows and Main Screens have identical dynamics.
- For unacknowledged alarms, the display element is reverse-video. When in alarm and acknowledged, the reverse video changes to normal, with the appropriate alarm color. No blinking is used for alarms.
- Device symbols include color dynamics that match those described for the associated dynamic text.
- Bargraphs are included on main screens where dynamic levels are displayed, and on M/A Stations. Bargraph colors match the associated process color (Appendix VI) on main screens, and match the process point colors on M/A Stations (PV - Darkgreen, SP/Bias - White, Output – Dodgerblue4, Feedback - Blue).

Base Graphic Element Functions - Lines

Function	Size	Type	FG Color	BG Color	Comment
General Use	1	Solid	White	None	None
Tables	1	Solid	White	None	None.

Table V.5 - Base Graphic Element Functions - Lines

Notes:

- Process lines follow the color standard set forth in Appendix VI. Where polygons are used as process lines, they also have a black outline.

Appendix VI - Process Colors

General

This Appendix details the standard process flow descriptions, abbreviations and associated graphic colors. Note that the Base Color specified herein is a description of the approximate color being used. In actual practice, the graphics are coded with the Custom Color Name listed. Through the operating system's "rgb.txt" color palette definition, each Custom Color Name can be modified as needed to finalize the actual RGB properties of the color to be used. These properties can be adjusted at any time, providing a simple method of fine-tuning the graphic colors for the final working environment.

The custom colors that are added to the library have the following RGB values. Cut and paste this information into the system rgb.txt file if it needs to be recreated:

```
58  95 205          air1
255 255   0         gas1
255 165   0         hazard1
  0 245 255         sewage1
139  69  19         solids1
0   139 139         water1
```

Appendix VII – Graphic Macro List

General

Macro details are provided in their respective Graphic Builder source codes. The enclosed list provides a summary of the HRSD custom macros. Usage examples are provided in the form of final system main screen and Graphic Builder source codes.

Appendix VIII – Sample Graphic Types

Graphics Standards are being updated to comply with ISA 101

Appendix IX – Level 1 Control

Templates

General

Control template details are provided in their respective Control Builder ACAD drawings. The following list provides a summary of the HRSD control templates. Implementation examples are provided as part of the DCS Automation Standards – Proprietary Volume.

Control Template Types:

- MOTOR/DEVICEWITH SINGLE MOMENTARY OUTPUT
- MOTOR/DEVICE WITH SINGLE MAINTAINED START COMMAND
- MOTOR/DEVICEWITH TWO MAINTAINED START COMMANDS (TWO SPEED MOTORS REVERSABLEMOTOR)
- M/A STATION – ANALOG
- M/A STATION – PULSE
- VALVE WITH SINGLEOPEN COMMAND
- VALVE/GATEWITH TWO MAINTAINEDOUTPUTS
- VALVE/GATEWITH TWO MAINTAINED OUTPUTS AND MANUAL STOP
- VALVEWITH TWO MOMENTARY OUTPUTS

Appendix X – DCU Software Mapping

General

DCU software, like many significant project activities, requires planning and coordination between multiple developers. This Appendix provides an example of DCU software mapping, which defines where each major section of control software resides.

Each Ovation DCU (controller or drop) provides the User with 999 "sheets" of control logic capacity. Once programmed and loaded into the controller, each sheet can be viewed dynamically on the DCS workstation. Each sheet is therefore subject to ergonomic guidelines and programming efficiency guidelines.

Ergonomic and programming efficiency guidelines include:

- Analog control should generally flow in a top-to-bottom/left-to-right logic flow.
- Digital control should generally flow in a left-to-right/top-to-bottom logic flow.
- Sheet I/O connectors should be kept on the edges of the sheet, except where significant programming efficiencies would result.
- Similar controls should look similar from sheet to sheet. Sheets should be copied whenever possible.
- Control loops (strategies) should be grouped. Within a group, control types should flow as follows:
    - Common logic
    - Sequential logic
    - Analog (PID) logic
    - Digital (motors, valves, etc.) logic

The enclosed listing is an example of the grouping of control loop software. A similar map shall be developed for the HRSD projects in order to provide an optimal software development environment and an ergonomic final product.

Appendix XI – Common Control Functions

(b) 1 Common Control Functions

The following sections describe some of the common control functions provided in the DCS. These functions include the baselogic required to manually controlany device, as well as other miscellaneous controls and calculations used in process control applications. The descriptions in this chapter are derived from the HRSD Automation Standards document. Refer to that document for more detailed descriptions, as well as sample control logic drawings.

1. Continuous Control

- This type of control provides the Operator with the capability of positioning a device throughout its full controllable range. Typical applications include modulating valve controls and VFD speed controls.

- The device can be placed in either MANUAL or AUTO mode of operation. The current selection is displayed at the respective M/A station and can be changed by pressing the respective M/A station's pushbuttons at any time, subject to the following exceptions:

    - The device is rejected to MANUAL mode when quality of the Process Variable (PV) signal is set to BAD (e.g., due to I/O card failure or input signal out of range).

    - The device is rejected to MANUAL if the LOCAL/DCS switch is not in DCS position.

    - For devices controlled via serial link, the device mode is rejected to MANUAL mode when the DATA LINK FAILURE alarm is active.

    - Specific MANUAL REJECT conditions are defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). Upon a MANUAL REJECT condition, the DCS issues an alarm (if applicable), and the device mode is rejected to MANUAL.

- Specific TRACKING conditions are also defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). Upon a TRACKING condition, the DCS issues an alarm (if applicable), and the Operator is not able to manually adjust the associated DCS output signal. Note that devices are able to TRACK in both the AUTO and MANUAL modes.

    - In case of speed control applications when the device is not running the speed is tracked to zero.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in MANUAL mode, then subject to TRACKING conditions, the position can be directly adjusted from the DCS at the discretion of the Operator.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in AUTO mode, then subject to TRACKING conditions, the position will typically be controlled by a PID controller which adjusts the output based on an error signal calculated as a difference between an Operator-entered setpoint and the PV value.

- The following tracking rules are provided in order to ensure bumpless transitions between the following modes:

    - While switching from AUTO to MANUAL mode, the output will be set to the last value calculated in AUTO mode, until changed by the Operator.

APPENDIX XI - COMMON CONTROL FUNCTIONS

    - While MANUAL mode is selected, the PID algorithm's output will equal the manually entered output value, allowing for a bumpless transition from MANUAL to AUTO mode.

    - While the device LOCAL/DCS switch is not in DCS position, the DCS will track the applicable device feedback signal (typically valve position or drive speed percentage) and set algorithm's output equal to that signal.

  - For devices controlled via serial link, upon recovering from a DATA LINK FAILURE, the DCS will track the applicable device feedback signal and set algorithm's output equal to that signal.

- Application-specific tracking conditions may also apply based on the type of automatic control that is provided. A common example of this type of device tracking occurs when a higher level sequential control attempts to position a device based upon the requirements of the sequence. Refer to strategy sections labeled "DCS Automatic Control" for any applicable details.

- The device DEVIATION alarm will be activated at the DCS if, after a preset amount of time (initial value 30 seconds, Engineer adjustable) if the device feedback signal differs from the demand for more than a preset amount (initial value 5 percent, Engineer adjustable).

- When required, the M/A station output value will be characterized in order to adjust the DCS output to a specific device response curve, thus providing a linear control system response to the process.

2. Open/Stop/Close Control

- This type of control provides the Operator with the capability of basic OPEN and CLOSE functions for devices such as valves, gates or breakers. STOP functionality is included only when the associated I/O is available, allowing the Operator to select intermediate valve/gate positions.

- The device can be placed in either MANUAL or AUTO mode of operation via the graphical switch at the workstation. AUTO mode of operation enables the device to work in conjunction with a higher-level sequential control, when applicable. Note that for devices controlled via serial link, the device mode is not rejected to MANUAL when the DATA LINK FAILURE alarm is active.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in MANUAL mode, then subject to OPEN PERMISSIVES, CLOSE PERMISSIVES and TRIPS, the device can be opened and closed from the workstation at the discretion of the Operator.

- Specific OPEN PERMISSIVE and CLOSE PERMISSIVE signals are defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). If the PERMISSIVE is not met, then the device may not be opened or closed further.

- If the device is commanded to open by the DCS and an OPENED feedback is not received within a preset time (Engineer adjustable), the Operator will receive a FAIL TO OPEN alarm for the device. This alarm is latched at the DCS and must be RESET before the device can be opened from the DCS.

- If the device is commanded to close by the DCS and a CLOSED feedback is not received within a preset time (Engineer adjustable), the Operator will receive a FAIL TO CLOSE alarm for this device. This alarm is latched at the DCS and must be RESET before the device can be closed from the DCS.

- If at any time both OPEN and CLOSE limit switch signals are received by the DCS at the same time, the SWITCH FAILURE alarm will be set. This alarm is latched at the DCS, and this condition must be cleared before the alarm can be RESET by the Operator at the respective M/A station.

- When the RESET pushbutton is selected to clear an alarm, the device will be switched from AUTO to MANUAL mode of operation.

- For devices controlled via serial link, upon recovering from a DATA LINK FAILURE, the current device position will be tracked and the DCS command will be set accordingly to maintain the device position. Also, the device FAIL TO OPEN, FAIL TO CLOSE and SWITCH FAILURE alarms will be disabled during a DATA LINK FAILURE.

- For devices with no OPENED and/or CLOSED status feedback, the corresponding FAIL TO OPEN, FAIL TO CLOSE and SWITCH FAILURE alarms are disabled where the DCS cannot verify the device position.

3. Start/Stop Control

- This type of control provides the Operator with the capability of basic START and STOP functions for a two state device.

- The device can be placed in either MANUAL or AUTO mode of operation via the graphical switch at the workstation. AUTO mode of operation enables the device to work in conjunction with a higher level sequential control, when applicable. Note that for devices controlled via serial link, the device mode is not rejected to MANUAL when the DATA LINK FAILURE alarm is active.

- If the respective LOCAL/DCS switch is in DCS position and the AUTO/MANUAL graphical switch at the workstation is in MANUAL mode, then subject to PERMISSIVE and TRIP conditions, the device can be started and stopped from the workstation at the discretion of the Operator.

- Specific PERMISSIVE and TRIP conditions are defined for each device (see the lists presented in each strategy section labeled "DCS Manual Control"). PERMISSIVE conditions are defined as startup criteria for the device, whereas TRIP conditions are defined as running criteria for the device. In addition, either signal may incorporate an Engineer adjustable delay, as required. If the PERMISSIVE condition is not met, the DCS issues an alarm (if applicable) and prevents the device from running. However, the PERMISSIVE condition has no effect on a running device. Upon a TRIP condition, the DCS issues an alarm (if applicable), commands the device to STOP.

- If a stopped device is commanded to start by the DCS and a running feedback is not received within a preset time (initial value 5 seconds, Engineer adjustable), the Operator will receive a FAIL TO START alarm for the device. This alarm is latched at the DCS and must be RESET before the device control functions will be enabled at the DCS.

- If a running device stops while commanded to run by the DCS, the Operator will receive a FAIL TO RUN alarm for the device. This alarm is latched at the DCS and must be RESET before the device control functions will be enabled at the DCS.

- When the RESET pushbutton is selected to clear an alarm, the device will be switched from AUTO to MANUAL mode of operation.

- If a running device is commanded to stop by the DCS, and a stop feedback (removed running feedback) is not received within a preset time (Engineer adjustable), the Operator will receive a FAIL TO STOP alarm for the device. This alarm is latched at the DCS and must be RESET before the device control functions will be enabled at the DCS.

- For devices with no RUNNING status feedback, the appropriate FAIL TO RUN, FAIL TO STOP and FAIL TO START alarms are disabled since the DCS cannot verify the device status.

- After the device is stopped, the DCS imposes a RESTART DELAY to prevent the restart of that device for a preset time period (Engineer adjustable).

- The DCS provides a runtime algorithm for the device which calculates the following values:

- Total runtime - This indicates the device total accumulated runtime and cannot be RESET by the Operator.

- Current on time - This indicates the accumulated run time since the device was started for the last time. This value remains unchanged after the device is stopped and is reset when the device starts again. This calculation is for internal use, and therefore does not appear on the custom graphics.

- Maintenance runtime - This indicates the accumulated run time since the last manual RESET by the Operator.

- For devices controlled via serial link, upon recovering from a DATA LINK FAILURE, the current device status will be tracked and the DCS command will be set accordingly to maintain the device status. Also, the device FAIL TO START, FAIL TO STOP and FAIL TO RUN alarms will be disabled during a DATA LINK FAILURE.

4. Flow Totalizer

The flow totalizer logic accumulates a flow reading over a time period, thus providing the Operator with a volume calculation for that time period.

DCS flow totalizer logic calculates three different outputs:

- Totalflow - Theflow valueaccumulatedovertimeperiodsincethe lastmanualRESET initialized by the Engineer.

- Current 24 hr. flow - The flowvalue accumulated since last automatic RESET, which occurs at the last shift change of the day.

- Previous 24 hr. flow - The frozen flowvalue accumulated duringprevious day, which is saved when the Current 24 hour flow total is reset.

The algorithm stops accumulating flow when:

- The quality of the flow signal is set to BAD (i.e., due to I/O card failure or input signal is out of range), or

- The flow signal carries only insignificant noise, i.e., the value of the signal is lower than 5% of the signal's range (Engineer adjustable).