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7. Abstract

THIS DOCUMENT DESCRIBES THE HARDWARE COMPUTER SYSTEM, FOR THE MINI DATA ACQUISITION AND CONTROL SYSTEM (DACS) THAT WAS FABRICATED BY LOS ALAMOS NATIONAL LABORATORY (LANL), TO SUPPORT THE TESTING OF THE SPARE MIXER PUMP FOR SY-101.

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**SYSTEM DESIGN DESCRIPTION
for
"Mini-DACS"
DATA ACQUISITION AND CONTROL SYSTEM**

September 1994

Prepared by:

Leonard T. Trujillo
Los Alamos National Laboratory

and

Samuel O. Smith
EG&G Energy Measurements

Prepared for:

Westinghouse Hanford Company
P.O. Box 1970
Richland, W.A. 99352

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1.0 FUNCTION AND DESIGN REQUIREMENTS

1.1 INTRODUCTION

The 241-SY-101 high level waste tank, within the Hanford Reservation, has experienced periodic gas releases of hydrogen, nitrous oxide, ammonia, and methane. Because the gas represents a potential danger, as some releases are above the lower flammability limit (LFL), a mixer pump mitigation scheme has been developed to mitigate these gases.

In order to provide a safe reliable method to control the mixer pump, collect and archive data associated with the mitigation process, and ensure operational integrity of the entire process, a Data Acquisition and Control System (Mini-DACS) was delivered jointly between Los Alamos National Laboratory, Westinghouse, and EG&G Energy Measurements. Previous to the installation of the mixer pump into 241-SY-101, several "cold tests" were run on the pump at the Westinghouse MASF facility to determine the pump's overall efficiency, operational readiness, and potential reliability. The pump control and associated instrumentation for these "cold tests" were accomplished by fabricating a smaller, scaled-down, version of the future Mini-DACS system. The smaller system was intended to be a temporary solution specifically designed to provide test engineers with data necessary to certify the readiness of the pump through acceptance test procedures (ATP). Now, a more permanent solution "Mini-DACS" is being implemented:

The mixer pump has been installed into 241-SY-101 for roughly one year and is considered to be successful at the mitigation process. The concept of using this technology to solve gas build-up has been proven and therefore will be used on other tanks with similar characteristics. In addition, a standby replacement pump must be certified to replace the existing pump in 241-SY-101 on the event of it's failure.

1.2 BASIS FOR REQUIREMENTS

The requirements for the MINI-DACS as based on the Letter of Instruction (LOI), Westinghouse document 9453516--Mit94-1889, requesting fabrication of a Mini-Data Acquisition and Control System to control the operation of the back-up mixer pump as well as providing process control to instrument, monitor and generally support off-line testing and verification of various proposed, and existing, tank mitigation methods.

Because of open-ended design requirements (proposed and future designs for mitigation) this system will provide the flexibility to be reconfigured to adapt to a changing environment.

1.3 FUNCTIONAL REQUIREMENTS

The Mini-DACS system is required to support the performance testing of mixer pumps and associated hardware at the MASF. Eventually, the pumps, and other mitigation processes, could be inserted at the 241-SY-101 site. In order to provide a smooth, semi-bumpless, exchange of the existing pump, the applications software and hardware must mimic the process control functionality of the full DACS-1 system at the 101 site.

The Mini-DACS control functions include pump manual control, operation monitoring, test system operating condition indication, and selected displays to advise operating personnel of the current operating status of the systems. For detailed Mini-DACS functional requirements, see WHC-SD-WM-CSRS-022.

1.4 HARDWARE REQUIREMENTS

The Mini-DACS computers and PLC hardware is required to emulate the existing control portion of the 241-SY-101 DACS-1 system as close as reasonably possible.

The computer operator stations will be sturdy, of steel construction, and suitable for the MASF environment. The stations will provide a comfortable environment for the operators (room for two operators) and contain a working surface for miscellaneous paper duties. The operators console will be portable via rolling casters to various locations throughout the MASF. For safety, the console will have the capability to lock against movement.

The Mini-DACS will include a 40" X 60" Nema type enclosure that is also portable via rolling casters. The enclosure will house a Modicon 984E Programmable Logic Controller (PLC) and I/O modules as described in the bill of material, Appendix A. Again, this portion of the Mini-DACS will emulate that of DACS-1 in functionality.

A data logger, for alarm and event logging, and a screen image copier, for runtime and historical trend analysis, is required.

1.5 SOFTWARE REQUIREMENTS

Genesis process control software, from Iconics Inc., is required. Control strategy for two computers and Remote Supervisory Station software for the remaining computer is required. Support software is also required; memory manager, PLC programming software, and DOS 6.0. All software is required to be of the same version as the DACS-1 system.

1.6 ACRONYMS

AFD Adjustable Frequency Drive
AOP Alarm Operational Procedure
ARP Alarm Response Procedure
ASCII American Standard for Computer Information
BASIC Beginner's All-Purpose Symbolic Instruction Code
BCD Binary Coded Decimal
BNC Bayonet connector type N, size C
DACS Data Acquisition and Control System
hp horsepower
LAN Local Area Network
PC Personal Computer
PLC Programmable Logic Controller
RSS Remote Supervisory Station
RTD Resistance Thermal Device
SA Safety Assessment
VFD Variable Frequency Drive
VSD Variable Speed Drive
Note: VSD and VFD are synonymous (see AFD also).
WAN Wide Area Network

2.0 DESIGN DESCRIPTION

2.1 INTRODUCTION

A Mini-DACS to monitor and control mitigation experiments at Hanford is being provided by LANL. The Mini-DACS located at the MASF will control both current, and future, pumps, probes and other conceptual mitigation designs. In addition, Mini-DACS will provide process visibility to operators and collect for archive associated test data for dissemination to analysts. The majority of the data are recorded at a low frequency of no less than once per second. This system uses commercially available process control software and hardware as the basis for overall operation. However additional software specifically necessary to operate individual tests will require custom routines within the commercial software.

2.2 SYSTEM BLOCK DIAGRAM

The Mini-DACS system is configured as shown in Figure 2.1.

Figure 2.1 Mini-DACS Configuration

Mini-DACS is centered on a Personal Computer (PC) platform with computers (3 ea.) from Programmable Logic Controller network for communications to the I/O field. A dot matrix printer is supplied for alarm and event logging or other uses defined by the test in progress. Each computer has access to the printer via a Black Box printer multiplexer. An Image copier is also multiplexed from each computer to provide a "screen dump" of real-time trending, historical trending, or instant data status as displayed on the computer screens.

A Modicon 984E Programmable controller is supplied with I/O hardware as listed in the bill of material, Appendix A.

2.3 SITE SUPPORT

The site support required by the MASF is five ea. 20 Amp circuits and four ea. telephone lines. And, of course, Instrumentation technician support for wiring I/O and operations personnel for system operators.

3.0 SUBSYSTEMS DESCRIPTIONS

The Mini-DACS is comprised of three subsystems; computers and support peripherals, PLC and I/O, and control system software. The software described in this section is that which is the applications software, not the specific user developed software required to operate the process.

Figure 3.1 shows an overall block diagram of the Mini-DACS. It is divided into three major subsystems:

1. PLC system for instrumentation
2. Genesis control system
3. Auxiliary systems and components

Figure 3.1 DACS Block Diagram

Each major subsystem is further divided into its own subsystems and will be described on that basis. LANL also provides site support, which is described below.

3.1 COMPUTERS AND SUPPORT PERIPHERALS

There are three ea. computers from Texas Micro Systems Inc. delivered with the Mini-DACS. They are model 4210 and contain:

- 2 ea. 3 1/2" Floppy drives
- 1 ea. 245 Meg Hard Drive
- 1 ea. 1 Meg Video Card
- 1 ea. Keyboard
- 1 ea. 19" Monitor

The Image copier is from Geneval Corp (Austin, Texas) and is a model CHC-443MV, Video Printer. All support equipment, multiplexers, paper, etc. is listed in Appendix A.

The matrix printer is a model IBM 2390 PLUS with the printer multiplexer from Black Box model SW809.

Trackballs are supplied for all three computers by Kensington, model EXPERT MOUSE. Stations 5 and 6 are serial port trackballs, while station 8 is a buss trackball. This is configured to accommodate the usage of 2 serial ports for motor control on this station.

3.1.1 Computer Console Environment

The computers and peripherals are mounted in a series of standard workstation consoles from Crenlo, Inc. The workstations are designed to provide work space and operations space for two operators. Two workstations are joined by a 30 degree angle and each has provisions for two monitors or other support equipment. The two work stations are then joined by a complimentary set which when combined form a four console environment. The split between workstations was designed to provide for ease of movement around the MASF as well as simplifying shipping.

The Mini-Dacs is designed to provide telephone service within easy reach of operators at either workstation location. Three voice line connections are available. Another line is semi-dedicated for data transmission.

There are three consoles, each with a Texas Microsystems model 8014 industrial-type PC. The consoles are numbered 5, 7, and 8 in a clockwise order. The layout is given

in drawing H-9-5015 (LANL 68Y-155870 #2). The functionality of the Genesis Stations 5, 7, and 8 are described in Section 3.3. In addition to the computer consoles are two printers.

3.2 PROGRAMMABLE LOGIC CONTROLLER AND I/O

The PLC supplied with Mini_DACS is a Modicon 984E-785 with an S908-110 I/O processor. The major difference between this system and DACS-1 is that the communications cable from the I/O field to the PLC is non-redundant. The I/O processor uses an E908-016 Executive Cartridge for up to 1024 In and 1024 out channels for each of 16 drops.

Figure 3.2 shows a breakdown of the PLC system. The PLC system consists of the following:

1. Controllers
2. I/O drops
3. Auxiliary systems

Figure 3.2 PLC Hierarchical Diagram

3.2.1 I/O Housing Hardware

The I/O modules are mounted in racks which are attached to a large phenolic slate. The slate is then attached to a Nema enclosure that is portable via large caster wheels. To prevent tipping of the Nema enclosure, out-riggers have been designed to provide a

larger apparent footprint than the standard Nema base. Power is received from Westinghouse via a twist-lock connector, and provides 2 ea. 20 Amp circuits.

There are currently more than 20 channels of I/O that are described in the System Requirements Specification WHC-SD-WM-CSRS-022 Table 1 and HMT-2 (Spare Grout Pump) Preliminary Instrument list (S.A. Brisbin, August 1994).

This document will use the term "I/O drop," or just "drop" to indicate a communication tap, to be consistent with the current documentation (H-2 drawings, the Mini-Mini-DACS software, and the I/O channel list).

3.2.1.1 DROP 1

The I/O field is made up of Modicon-AEG 800 series I/O. Typical I/O modules being used on the Mini-DACS are: model B875-101 analog input, model B824-16 24-Vdc output, and model B883-200 thermocouple. The I/O configuration is flexible. The I/O is connected to the 984A via coaxial cables to the 984A PLC. As a first cut at the I/O configuration, 64 analog inputs and 64 discrete are wired for use. Additional reconfiguration is expected and the flexibility is within the design to accomplish those tasks. In addition, several spare and different types of I/O modules have been purchased in anticipation of expected usage and are listed in the bill of material inventory, Appendix A.

3.2.1.2 DROP 2 (Note: For information only)

Modicon modules in a single I/O drop (drop 2), for the spare mixer pump instrumentation. It consists of two Modicon racks. In the first rack are 3 model B875-101 modules set for 4-20 mA inputs. In the second rack is a model B827-024 digital input (24-V switch) module and a B865-002 BCD input module. There are no outputs (controls) in this I/O drop. The following pump signals are monitored:

1. Intake and discharge pressure
2. Intake and discharge flow
3. Intake and discharge temperature
4. Motor oil temperature
5. Motor oil moisture limit
6. Rotational motor position
7. Rotational motor limits

3.2.2 Auxiliary Systems for the PLC

The PLC has a proprietary communications network called ModBus Plus. All the computers contain the Modicon ModBus Plus interface card, SA-85. Each I/O drop has a model P810 rack power supply and a model J890 remote I/O interface module. The J890 is used to control the internal working of the rack(s) in the particular drop, and to communicate with the 984A PLCs. Each drop is connected to the 984A controller via coaxial cables configured according to H-2-140169. The J890 modules communicate module status and data to the 984Es. The J890s also receive setup information from the 984As for the modules in their rack(s).

Where there is more than one Modicon rack in a particular drop, one rack acts as the primary rack while the others are secondary. The primary rack contains the P810 and J890 modules. Communications to the secondary racks are provided via a model W801 multiconductor cable. Power is supplied to the secondary racks via a model W808 cable connecting the two racks.

Where external power is required (i.e., to control relays), power supplies are used. Normally these are 24-V high-current (several Amps) instrument-grade power supplies, physically located beneath the appropriate Modicon model B824-016 module, to provide relay power for the pump in run signals.

3.2.3 Modicon Console (Station 7)

The first computer rack in the trailer houses the console for the Modicon 984A controllers. The computer is a Texas Microsystems model 8014. The monitor is a Texas Microsystems model 1006R-G. The connection from the console computer to the Modicon controller is via Modbus Plus. The computer is connected to the system printer through port LPT1. A track ball is used for cursor manipulation and is connected to port COM2.

Installed on Station 7 is Modsoft application software. Modsoft, Modicon's programming and utility software, provides the following functionality: offline program development, online program maintenance, and I/O module status monitoring. The Modsoft protocol uses these utilities for reading/writing registers or discrete inputs/outputs and for broadcasting data.

Another Modicon software application used in Mini-DACS is Modbus Plus. This software provides a rapid data communication network permitting connectivity between computers, man-machine interfaces, and other Modicon devices. Modbus Plus communications are a reliable method to handle remote data transfers and programming operations. Modbus is used as the direct connection to Station 5.

3.2.4 Modicon-Genesis Interface

Interface to the Genesis system is via Modbus-Plus protocol (see Modicon 984 User's manual). Station 5 is used to pass data to and from the Modicon PLC. Information is retrieved and sent to the PLC with Modbus Plus driver that executes in parallel with the other Genesis runtime functions.

3.3 GENESIS (DATA ACQUISITION AND CONTROL)

3.3.1 General

Genesis is an industrial process control system produced by Iconics in Foxborough, MA. The software is built on a real-time operating system, AMX, providing a multitasking and preemptive scheduling of events. This networked computer system, using this multi-tasking software shell, is designed to collect data from operator input, the PLC, and the variable frequency drives, display the data in real time to test engineers, and log the data for archival and future analysis. Functions embedded in the system for controlling and positioning the pump allow the Genesis system to use the data collected from the PLC and variable frequency drives to warn test engineers of critical conditions.

The nucleus of the Mini-DACS is the system of three PCs running Genesis. The PCs are called stations and are numbered 5, 7, and 8. Figure 3.3 shows a block diagram of the connection between the computers, and Section 3.3.2 explains the primary function of each PC.

3.3.2 Genesis Stations

Station 5 is the Genesis data collection runtime station.

Station 8 is the pump control runtime station.

Station 7 is a local console for the data collection station.

The main functions of the MASFTEST strategy on Station 5 are instrument monitoring, data logging, alarm generation, and PLC control. Essential to these functions are communications with the Modicon PLC, with the Station 8 MOTOR strategy and with other stations on the network. In addition to the main functions, the strategy also provides the ability to generate hard-copy reports of the data. Given

Figure 3.3 Genesis Computer Block Diagram

below is a overview of these TEST strategy functions and the communication paths needed to accomplish them. The Genesis TEST strategy on Station 5 communicates with the Modicon PLC via an RS-232 serial communications link. It communicates via the ArcNet with the Station 8 MOTOR strategy, the RSS stations for operator displays, and with Station 9, the data-archiving computer.

Data monitoring is one of the primary functions of the TEST strategy. Pump instrumentation data and system status information are presented on a number of operator display screens. The operator displays fall into four basic categories plus a MAINMENU screen. The MAINMENU screen shows the organization of all of the other screens in the system. Three of the screen categories are used for monitoring and are discussed below. The fourth screen category is used for report generation and will be mentioned in the CSDD.

The TEST strategy is responsible for logging data to the Station 5 hard drive. The data are used for monitoring and to evaluate the results of the pump tests.

The runtime MOTOR strategy on Station 8 contains logic for controlling and positioning the pump. This logic uses operator input, the current status of the pump and directional motors, and the current feedback signal levels of critical variables to determine what the directional motor should do. This task will command the directional motor's frequency drive to move the pump to the operator's desired position when all conditions are correct.

The mixing pump motor is controlled through its variable frequency drive by the logic associated with pump operation in the MOTOR strategy. The logic uses the current values of critical variables to decide if commands from the operators to start or stop the pump motors should be honored. If allowable, commands are sent to change the pump's operating status.

There is logic embedded in the MOTOR strategy to abort the directional or pump motor operation. This task will immediately shut down operation of either motor if any of the abort criteria becomes active. Station 8 will display alarm conditions in the alarm summary and warn the operator with an audible alarm when a signal goes into alarm state.

3.3.2.1 Station 5

Station 5, the primary data acquisition computer, is connected to the Modicon 984 PLC through Modbus Plus. The strategy functions Station 5 performs are as follows:

1. Send and retrieve field values from the Modicon 984 I/O drops
2. Write those engineering values to disk as Genesis history files
3. Participate in the watchdog timer with the 984 ladder logic
4. Provide a printed test report as a key macro
5. Look for abort conditions in the strategy
6. Send aborts to the 984 for inclusion in the abort limit ladder logic.

3.3.2.2 Station 7

The primary role for Station 7 is as an RSS. This local RSS station is linked to Station 5 and can receive and send values to the TEST strategy allowing the operator to display and change values in the strategy. These RSS terminals are allowed access to the runtime station strategy through graphic displays developed for the strategy.

3.3.2.3 Station 8

This personal computer is dedicated to running the Genesis Runtime MOTOR strategy. The Gen-Net network node name Station 8 is used to reference this computer. The main task Station 8 performs during communication with the AF5000+ variable frequency drives are monitoring data from the drives and sending commands to them. This is performed with the Eaton AF5000+/Genesis communications driver.

3.3.3 Genesis Network (ArcNet)

3.3.3.1 General

The Genesis system peer-to-peer network communications between control computers is handled via Arcnet protocol and Standard Micro Computer SM-130E network cards. This allows data to be shared between terminals. The Genesis network also supports host communications to multiple supervisory stations, allowing several consoles to access common data. The physical network protocol used by Genesis is ArcNet hardware implemented in a star configuration. The ArcNet and other network connections are coupled to an active hub with coaxial cable as shown in Figure 3.3.

3.3.3.2 Physical Connection

Each of the Genesis stations is connected via an ArcNet link in a "star" configuration. Each station has an SMD model PC-130 ArcNet card. A BNC connector on the card is attached to a length of RG-62 cable. Each of the cables is connected to a BNC connector on one ArcNet hub module located in trailer equipment rack 8. The hub module is either a CCSI model MODHUB-16, or SMD model HUB-03-120 (both are interchangeable).

3.3.3.3 Software Communication

Information must be exchanged between system components to integrate all of the data and control signals into a workable whole. Communication routines are employed to read signals and data from the PLC and AF5000 devices and to send control commands to the pump equipment. The display terminals share data over ArcNet, a real-time data network. This network permits multiple users to share information and allows strategies to share critical signals and control commands.

Communication between the TEST and MOTOR strategies is accomplished via ArcNet using what Genesis refers to as a "node block." The node block is located in the MOTOR strategy. This node block allows the MOTOR strategy access to TEST strategy blocks for reading and writing. Data relating to the variable-speed drives for pump motor control and directional motor control are sent from the MOTOR strategy to the TEST strategy. The TEST strategy relays the abort status from the PLC to the MOTOR strategy so that it can initiate an independent pump shutdown.

Pump tests are initiated from the MOTOR strategy. By using the TEST strategy as a middleman, critical data and other information for the control of the tests are shared by the MOTOR strategy and the PLC. These are such things as test-enable signals and timer durations so the PLC can time the length of a test independently and use abort limit values that vary based upon the pump speed used for a particular test.

Data from the positional encoder are needed in the MOTOR strategy. Since these data originate in the PLC, the TEST strategy becomes the middleman for this as well. The TEST strategy communicates with the Modicon PLC via Modbus Plus. A complete list of the tags transferred between the TEST and MOTOR strategies can be found in the CSDD. Figure 3.3 shows the connection between the Modicon PLC and Genesis.

Data are logged first locally on Station 5 by the TEST strategy. After a successful transfer to a non-volatile media, the data are then deleted from Station 5.

3.3.4 Passwords and Security

There are two types of security implemented on the Mini-DACS: passwords and Genesis security keys. The passwords are kept by the cognizant programmers and the MASF operators.

3.3.4.1 Passwords

Genesis contains three levels of password entry into the Mini-DACS system (and a non-access level). These levels are listed below, along with the privileges afforded by each level. In addition to the operational passwords, is a separate password to protect the configuration.

Level	Scope of permitted operation
View only (0 access)	<ul style="list-style-type: none">● No changes● No submenus● No exit to DOS
Operator 1	<ul style="list-style-type: none">● Data entries in user displays can be modified● No submenus displayed● No exit to DOS
Technician 2	<ul style="list-style-type: none">● Algorithm submenus displayed and values on first page can be changed● Mode of operation can be switched between auto and manual
Engineer 3	<ul style="list-style-type: none">● All values can be changed during the runtime session

The four levels listed above apply to operation of the Genesis software. There is another password for the programmer that allows configuration to take place. Software changes are done offline using special configuration software. No one may change the software without the configuration software, password, and the configuration security key (see below). There may be more than one password for each level, to keep track of who has logged on.

3.3.4.2 Security Keys

The Genesis software is protected from copying and pirating by use of security devices called "keys" or "dongles." In addition to copy protection, is *use* protection. There are three levels of user protection, all hierarchical. The highest level is called the configuration level, next is the run-time level, and the lowest is the RSS level. Station 5 and Station 8 have configuration keys and Station 7 has an RSS key. All keys are attached to port LPT1 before the printer cable is attached. Figures 2.5 and 2.6b show the configuration.

3.4 AUXILIARY SYSTEMS

Auxiliary systems include printers, printer switches, the video copier system, and PC external speakers.

3.4.1 Printers

There are two printers in use in the console area. Figure 3.4 show block diagram of the printer configuration.

3.4.2 Genesis Printer and Security Keys

Stations 5, 7, and 8 share a single IBM Proprinter. The computers share the printer using a Bufo Enterprises model KC 6012 Auto Data switch, similar to the Black Box switch, described above (except this is set up for three ports vs up to eight ports for the Black Box switch). This switch is located inside the console rack for Station 3. Standard Centronics parallel cables connect from ports LPT1 of each computer to the smart switch. A standard Centronics cable connects the smart switch to the printer. For more information on the hardware security devices see Section 3.3.4.2.

3.4.3 Video Copier

The computers share a single Shinko model CHC-443MV2 color video screen copier. The copier has its own multiplexers, model SPA-9-4, tied to the video output of each computer. A push button at each station causes the copier to print the image on the selected screen. Figure 3.5 shows a block diagram of the connection with one line representing signals for red, green, blue, horizontal and vertical sync, and a signal called CNI (R, G, B, H, V, and C), all carried on RG-59/U coaxial cables.

Video signals from the backs of the computers are split out from the 15-pin DA connector to separate coaxial lines for each of the signals (a multiheaded "snake").

Each signal is connected to BNC connectors on the SPA-9-4 units. A separate multiheaded connector attaches from the SPA-9-4 unit to the video monitor, with a 15-pin gender adapter to mate with the monitor connector. Drawing LANL 5Y169636D-1 shows the details.

Figure 3.4 X24E Printer Connection

Separate RG-59/U coaxial cables with BNC connectors for each signal (R, G, B, V, H, and C) connect the SPA-9-4 units together in a chain, with the Shinko copier at the end of the chain.

3.4.4 External Speakers

To increase the volume of the alarms from the Genesis stations, external amplified speakers are connected to the internal PC speakers. For all stations, the connection is made by splicing a 3-mini stereo connector to each PC speaker, then wiring amplified speakers to that connector. The speakers are mounted under the console platforms for the keyboards.

For Stations 7 and 8, a Radio Shack 40-1267 amplified stereo speaker is mounted below the respective keyboards. It is powered by a 9-V plug-in power supply (Radio

Shack 273-1651B).

Radio Shack 40-167 and 40-1267 amplified speakers are mounted below the respective keyboards. It is powered by a 9-V plug-in power supply (Radio Shack 273-1651B). Different types of speakers were used to provide different tones for each of Stations 5 and 8.

Figure 3.5 Shinko Screen Copier Block Diagram

3.5 AF5000 VARIABLE SPEED DRIVE (Note: For information only)

3.5.1 General

The mixer pump and the rotation motor are both controlled by Eaton model AF/IS-5000+ variable (adjustable frequency) speed drives. The mixer pump motor is controlled by a 200 HP unit and the rotational motor is controlled by a 5 hp unit. Both units use a 480 Vac pulse width modulated (PWM) controller. This is a state-of-the-art electronic microprocessor-controlled speed controller manufactured by Eaton, Inc.

The AF-5000+ AFD is designed to provide adjustable speed control for three phase motors. These microprocessor-based pulse-width-modulated (PWM) drives have features allowing custom programming of the drive's performance. The mixer pump and rotation motors are both controlled by AF-5000+ AFDs.

3.5.2 Mini-DACS to AF-5000+ Interface

The communications link between the AF-5000+ Adjustable Frequency Drive (AFD) units and the Mini-DACS is an RS-232 serial connection between Station 8 and the two motor drives. Because RS-232 is an end-to-end protocol and does not allow "taps" or daisy-chaining, two comm ports are used between Station 8 and the drive units. Figures 3.3 and 3.6 show the connection. In addition to the Station 8 serial link, the AFDs are interfaced with two remote keypads, called Soft Touch Operator Panels (S.T.O.P.). These keypad displays provide drive status and diagnostic information. For more details regarding how these function, consult VI files # 22570 and 22571 regarding the Eaton AF-5000+. The complete data path for the AF-5000+ AFDs is from the drives to Station 8 using a serial link, then to Station 5 and on to the PLC utilizing ArcNet and Modbus Plus as described in Section 3.3.

Figure 3.6 Station 8 to AF5000 Interface

3.5.3 Controls

As mentioned in previous sections, transducers located on the mixer pump that monitor the pump parameters such as flow, pressure, temperature, and strain, interface to the Mini-DACS through the Modicon I/O. The Mini-DACS monitors, displays, and records the outputs of these transducers to indicate the status of the mixer pump and Tank 101-SY during operation. The Mini-DACS assists the test operator in controlling the mixer pump and the mitigation test parameters to within predetermined upper and lower safe operating limits. The Mini-DACS compares the incoming data with the stored alarm and abort limits in the software and automatically alerts the operator when limits are exceeded. The Mini-DACS automatically shuts off current to the pump when abort limits are exceeded. This is the only "real" control function of the Mini-DACS.

4.0 SYSTEM LIMITATIONS, CASUALTY EVENTS AND RESPONSES

4.1 SYSTEM LIMITATIONS

The pump rotational motor and the main drive motor are electrically interlocked to prevent both from running at the same time. A so-called "sweep" with the jets rotating through the tank is not currently possible.

4.1.1 Control Software Limitations

The control software is designed to shut off an operating pump in a very short time based on any one of dozens of parameters being out of a preset range. Once a parameter is detected out of range, an abort occurs, and the pump is shut off.

4.1.2 Consequences of Abort Conditions

Limits for determining an abort are entered on the Genesis hot-test software display called Critical Parameters. The strategy linked to the display stores the limits into registers in the Modicon PLC. Ladder Logic in the PLC continuously looks for conditions calling for an abort by using the limit parameters. If an abort is calculated, a contact is closed in a binary module controlled by the PLC, interrupting power to the pump. In addition, notification of the abort is sent back to Genesis, and the strategy sends stop pulses to the pump and direction AFDs.

4.1.3 Pump Over-Speed Protection

Every AF5000+ motor drive has a parameter field MAXSPD, the maximum speed in the recorded speed unit that can be programmed through the SPDSET command. If an

operator tries to command the drive to run at a value greater than the MAXSPD value, the speed set point becomes the value stored in MAXSPD. The MAXSPD value is stored in nonvolatile RAM so that the last programmed value is present upon power cycling.

Genesis also protects the set-point entry field from being programmed with values out of range. Range extents are entered in AIN blocks in the configurator. These are changed by an operator entering the run-time system at the engineer password level or by a programmer knowing the password for altering the strategy. If an operator tries to over- or under-limit a set point, Genesis restricts the entered value to the appropriate point.

The AF5000+ variable speed motor drives can be controlled by a manual panel or by the Mini-DACS. During pump testing the control will be from the Mini-DACS over an RS-232 communications link (see Figures 3.3 and 3.6). The manual control panels will be disabled to avoid interference with the Mini-DACS. Protection against and inadvertent overspeed command is enabled by setting a MAXSPD in nonvolatile memory in the motor drive. This can be done over the communications link. A command to the speed controller to exceed this speed will be disregarded and the speed set to the value of MAXSPD.

4.1.4 Genesis vs Modicon Speed

The PLC is much faster than Genesis running on the PC. For real-time response (under 50 ms) ladder logic must be used. Genesis minimum response time is approx. 1 s or greater. For higher level functions that do not require "instant" response, Genesis may be used.

4.2 Applications Software

All of the computers are configured with MS-DOS v6.0 in compliance with Westinghouse site standards and license agreements. In addition each computer will also have a memory manager from Helix Inc, NetRoom v3.0. NetRoom was purchased with a four "seat" license and is dedicated to Mini-DACS. Expert Mouse driver software is also loaded to support the trackball.

The applications software for process control is by Iconics Inc. and called Genesis, v3.72. Stations 5 and 8 contain full Genesis configuration software with GEN-NET-ARC network software, v3.64. Station 7 is configured as a Remote Supervisory Station (RSS) running RSS-Remote-A software, v3.72. This station will be used as a slave to Station 5 during the control process.

Station 7 will also be loaded with Modicon Modsoft, v1.2, purchased in a single "seat" license to configure and program the PLC. This software is also dedicated to the Mini-DACS.

5.0 OPERATIONS

5.1 INTRODUCTION

The three trailer operations are as follow:

1. Pump operation
2. Data logging
3. Configuration changes.

Each will be discussed in general. Maintenance and repair are discussed in Section 6. Records of these operations are kept in the test engineer's log and the EG&G technician's log. The Westinghouse test engineer's log is the only official log (defined by an SOP). The test engineer's log is transcribed semi-weekly and is available, along with the archived data. It contains information on pump running, repairs, alarms acknowledged, and more.

5.2 PUMP OPERATION

The operating mode in the MASFPUMP software is completely manual.

5.2.1 Manual Operation

On Station 8, upon pressing the "manual operation" button, the directional drive display is drawn. Operating parameters that can be entered on this display include:

1. Maximum drive speed (rpm)
2. Drive speed set-point (rpm)
3. Acceleration (rpm/s)
4. Deceleration (rpm/s)
5. High-position limit (deg)
6. High-gap limit (deg)
7. Low-gap limit (deg)

Command fields on the directional drive display include a dynamic data entry field for the desired nozzle angle set point and a state field to enable movement of the directional motor. There is also a button to stop the direction drive by sending a stop

pulse to the device block. This could be connected in the strategy to the PLC to kill power to the directional motor. Process point fields include:

1. Measured nozzle position
2. Drive ready indicator
3. In-deadband indicator
4. At-speed indicator
5. Low-position
6. Limit-exceeded indicator
7. Drive fault indicator
8. High-position
9. Limit-exceeded indicator
10. Drive stopped indicator
11. Start inhibit indicator
12. Forward indicator
13. Motor voltage (V)
14. Reverse indicator line voltage (V)
15. Reverse enabled indicator

Trying to drive the nozzle position beyond a limit results in a start inhibit until the set point is adjusted to within the position limits.

It is possible to maneuver to the manual pump screen from the direction screen with a press of a button. The pump motor screen has the following operating parameters (some data entry and some process points):

- Maximum drive speed (rpm)
- Measured acceleration (rpm/min)
- Set point acceleration (rpm/min)
- Measured deceleration (rpm/min)
- Set point deceleration (rpm/min)

Command fields on the manual pump screen include a pump speed set point data entry field, start and stop buttons, and a state field to enable starting and stopping. The buttons are only enabled for 6 s. If not pressed within that time, they are again disabled. Once the drive is started, entering a new speed set point causes the pump to ramp to that speed. There is another stop button at the bottom of the screen that issues a stop to the pump drive. However, it could be connected to the PLC to interrupt power to the pump. Process point fields on the manual pump display include:

- Measured speed (rpm)
- Forward indicator
- Drive-ready indicator
- Reverse indicator
- At-speed indicator
- Reverse enabled indicator
- Drive fault indicator
- Motor current (amp)
- Drive stopped indicator
- Motor voltage (V)
- Forward indicator
- Line voltage (V)
- Reverse indicator
- Motor oil temperature 1 (deg F)
- Reverse enabled indicator
- Motor oil temperature 2 (deg F)

5.2.2 Alarms and Aborts

Normal pump operation is kept under control of the Modicon Ladder logic and the Genesis strategy software. All parameters are continually monitored by the software. Each parameter is compared against 2 limits; an alarm limit and an abort limit. If any one of the parameters is above the alarm limit, an alarm sounds and the event is logged electronically. If any parameter is above the abort limit, the same type of alarm will sound, the event will be logged, and if the pump was running it will be immediately stopped.

The alarm and abort limits are defined in the Test Plan WHC-SD-WM-TP-220 and Computer System Requirements Specification WHC-SD-WM-CSRS-022..

5.2.3 ARPs and AOPs (Note: For information only)

Are there written Alarm Response Procedures and Alarm Operational Procedures to follow in cases of certain alarms and aborts? These documents are located in ... TBD. A possible resource is the Mini-DACS Acceptance Test Procedure WHC-SD-WM-ATP-088.

5.3 DATA LOGGING

Station 5 is responsible for the data logging operation, also called, "archiving." This function is completely automatic. No operator action is required (except to start the process, and reboot if a lock-up occurs).

5.4 CONFIGURATION CHANGES (Note: For information only)

Changes to the software to accommodate more equipment, to fix bugs, to add more data logging, all fall under a configuration management plan (WHC-SD-WM-CMP-001). A change control board takes requests for software and hardware changes, reviews them and approves or disapproves the requests. All necessary documentation, ECNs, procedures, etc. are tracked through the board.

When a change to the software is approved, a cognizant programmer tests the change in a simulator, then implements it in the Mini-DACS. The change is tested and verified. Appropriate documentation is updated.

When a change to the hardware is approved, a cognizant engineer writes an ECN, and requests personnel to make the change. The change is implemented, tested and verified. Appropriate documentation is updated.

6.0 MAINTENANCE

Several procedures have been defined for performing Mini-DACS preventative maintenance. There are two types of maintenance based on who would perform the procedure: computer maintenance and regular system maintenance. In addition are periodic checks to the recording system, and calibrations.

6.1 COMPUTER MAINTENANCE

Computer maintenance consists of several procedures to be performed by qualified personnel or under supervision of the cognizant programmer. The list includes:

1. Texas Microsystems PC filter cleaning
2. Texas Microsystems PC floppy disk cleaning
3. Other PC maintenance (virus checks, disk compression)
4. Modicon PLC communication checks
5. Startup and shutdown

6.1.1 PC Filter Cleaning

This procedure should be performed monthly. To perform this procedure, the PC chassis must be slid out from the console racks, and they must be powered down. The procedure is given in the technical manual.

6.1.2 PC Disk Cleaning

This procedure should be performed monthly or if a particular floppy drive is heavily used. To perform this procedure, the power must be turned on to the PCs. This procedure is given in the technical manual.

6.1.3 Other PC Maintenance

Other PC maintenance covers incidental items such as cleaning the video screens, replacing printer ribbons and toner, and replacing paper. These do not require formal procedures, but refer to the manufacturer's directions.

Software maintenance includes: erasing unused temporary files, performing virus checks, and defragmenting the hard disk drives. The cognizant engineer/programmer for the Mini-DACS should have methods to perform these tasks (i.e., Norton Utilities, PC Tools), and following the direction of those methods, perform them on a regular basis.

6.1.4 Modicon PLC Communication Checks (Note: For information only)

This procedure should be performed on a regular basis. This procedure is used to check the status of the PLC and can detect problems, early before they are serious. The procedure is given in the technical manual.

6.2 CALIBRATION PROCEDURES

The following Mini-DACS equipment requires calibration:

1. Modicon B875
2. Modicon B883

6.2.1 Modicon B875 Calibration

The Modicon manual for the model B875-101 analog input module provides a procedure for calibration of the internal 10-V reference. Modicon recommends annual recalibration of the reference. This procedure should be part of a larger procedure for a loop calibration (i.e., CBRS).

6.2.2 Modicon B883 Calibration

Modicon has provided a separate procedure for calibrating the model B883-200 thermocouple modules. Modicon recommends a 3-year cycle for recalibration. This procedure is extensive and should be done by a standards lab. This procedure should be incorporated into a larger (i.e., CBRS) procedure.

7.0 REFERENCES

1. Westinghouse Hanford Company, "101-SY Backup Pump Performance Demonstration Test," 4A-93-00063/W.
2. T.R. Benegas, "Spare Mixer Pump Test Functional Design Criteria," Westinghouse Hanford Company report WHC-SD-WM-FDC-TBD, June 1993.
3. "Draft Quality Assurance Project Plan for the Data Acquisition and Control (DACS Project)."
4. "Test Plan for Run-In Acceptance Testing of 241-SY-101 Mitigation Mixer Pump-2," WHC-SD-WM-TP-220.
5. S. A. Brisbin, "Spreadsheet Input/Output Channel List," Westinghouse, WHC-SD-WM-HMT2-TBD.
6. "Los Alamos National Laboratory (LANL) Letter-of-Instruction for the Mini-DACS Acquisition (DACS) at the Maintenance and Storage Facility (MASF), for the Hydrogen Mitigation Program," MIT94-1889, 9453516, G.F. Vargo.
7. "Software Specification for the Mini-DACS Acquisition (DACS) at the Maintenance and Storage Facility (MASF), WHC-SD-WM-CSRS-022, G.F. Vargo.
8. "Mini-DACS Conceptual Design Description," LANL, L.T. Trujillo, March 1994.
9. "Engineering Task Plan for the Mini-DACS Acquisition (DACS) at the Maintenance and Storage Facility (MASF)," WHC-SD-WM-WP-279.

APPENDIX A - HARDWARE VENDOR INFORMATION**List of Materials**

Texas Micro Systems Computers--Requirements are 3 ea.	
ITEM DESCRIPTION	NUMBER REQUIRED (EA.)
4210 System Chassis	3
D486 DXC/33/W 16 Megs Ram	3
HD 245-IDE 245 Meg Hard Drive	3
FDE-1.44 3 1/2" Floppy Drive	6
SVGA 1 Meg Video Card	3
KB1A-E 101-Key Keyboard	3
1009R 19" Monitor	3
SR1 20" Rack Slide	3
SR4 18-20" Rack Slide	3
ICONICS Inc. -- GENESIS Control Software	
ITEM DESCRIPTION	NUMBER REQUIRED (EA.)
GEN-6-C With ModBus Plus Device Driver	2
GEN-NET-ARC	2
RSS-REMOTE-A	1
STANDARD MICRO COMPUTERS	
ITEM DESCRIPTION	NUMBER REQUIRED (EA.)

SMC-130E ARCNET NETWORK CARDS	3
MODICON Inc.	
ITEM DESCRIPTION	NUMBER REQUIRED (EA.)
PC-E984-785 PLC	1
AS-S908-110 I/O Processor	1
AS-E908-016 Executive Cartridge	1
AS-H19-209 Primary Housing	1
AS-B875-111 Analog Input Module	10
AS-B824-016 24VDC Output Module	2
AS-B825-016 24VDC Input module	2
AS-B883-200 Thermocouple module	3
AS-B885-002 ASCII Basic Input Module	1
AS-P810-000 Power Supply	3
AS-J890-001 Remote I/O Interface	2
H827-103 Primary Housing	2
H827-100 Secondary Housing	1
AS-W801-002 I/O Signal Cable	1
AS-W808-002 Pwr Cable W/O P.S.	1
AS-804-002 Pwr Cable W P. S.	1
MA-0185-100	3
MA-0331-000 Splitter	1
Modsoft -Single User	1
AM-SA85-000 Modbus Interface	3
97-9841-100 Modbus Plus Cable	1

MBK-T185 Terminating Connector Kit	1
MBK-T085 "DAISY" Connectors	6
AS-MBPL-001 Connector Crimp Tool	1
AS-8534-000 Low Density Connector	4
AS-8535-000 Analog Connector	10
ELECTRICON RESOURCES INC.	
ITEM DESCRIPTION	NUMBER REQUIRED (EA.)
NEMA Enclosure for I/O	1
Enclosure Backplate—Phenolic	1
Cooling Fan Kit	1
Model A-PA10AXFN—10" Fan	
Exhaust Kit for 10" Fan	1
Model A-EXGR4	
ARROW ELECTRONICS	
ITEM DESCRIPTION	NUMBER REQUIRED (EA.)
Terminal Block—2 Through Connects	125
Model 280-524	
End Stops/Seperators 280-343	30
End Stops 209-101	10
Carrier Rail 210-162	4
Operating Tool	2
Number Labels 1-50, 209-566	1

Number Labels 51-100, 209 -507	1
Number Labels 100-150, 209-508	1
OPERATOR WORKSTATIONS	
CRENLO, INC	NUMBER REQUIRED (EA).
Slope Frame W/Writing Top	4
Model XFRS-312119-WT-EN3BE	
30 Deg Wedge Unit Slope Frame	2
Model XWFR-312130-A-ENBE	
Left Hand Plain Inside Removable Panel	1
Model XSPI-3121A-LH-EN-3BE	
Right Hand Plain Inside Removable Panel	1
Model XSPI-3121A-RH-EN-3BE	
Left Hand Louvered Rear Doors	4
Model XDS-4919-LV-LH-EN-3BE	
CFM Fan Assembly	4
Model FT-291-3 291	
Casters 3" Above Slope Frames	16
Model HW-450-LK	
Perforated Top Panels	4
XPN-1919-PA-EN-3BE	
Split Writing Top Vintage Oak	1
XOPT-945219-00-258	
IMAGE COPIER	

GENEVAL CORP.	NUMBER REQUIRED (EA).
Shinko CHC-443MV Video Printer	1
Model 260-443MV	
One Channel Multiplexer—Mitsubishi Int'l-SPA-9-4	3
Model 260-650	
Remote Switch—Mitsubishi Int'l-SP1-10-1	3
Model 206-655	
3 Color Ribbon—Mitsubishi Int'l-060-97-0149	12
Model 260-400	
3 Color Paper—Mitsubishi Int'l-060-97-0095-069	12
Model 260-410	
DOT MATRIX PRINTER	
Mc Bride & Associates	NUMBER REQUIRED (EA).
IBM Printer Model 2390 Plus	1
PRINTER MULTIPLEXER	
BLACK BOX INC.	
Printer Multiplexer—8 Channel SW-809	1

APPENDIX B - MANUFACTURES MANUALS AND OTHER DOCUMENTATION MATERIALS

MANUAL DESCRIPTION	QUANTITY PROVIDED
Advanced Diagnostics Certification--TM Computers	3
Black Box Multiplexer Print--From Each Station	1
Texas Micro--User's Manual--CPU Model D486	3
Texas Micro--Operator's Manual--4210 Mainframe	3
Texas Micro--Maintenance Manual--4210 Mainframe	3
Texas Micro--VGA/16 Adapter--User's Manual/Util Software	3
Intecolor--Operator's Manual--Model 998000-020	3
Shinko Electric--User's Guide--Model SPA-9-1, Multiplexer	3
Shinko Electric--User's Guide--Model SPA-10-1, Copy Switch	3
Shinko Electric--User's Guide--Model CHC-443MV-- Copier	1
Kensington--User Manual--Expert Mouse	3
Black Box Corp--User Manual--SW809, Auto Switch	1
SMC--Configuration Guide-SM-130E, ArcNet Interface	3
Diagsoft--Diagnostics Software--QA Plus	3
Modicon--System Planning Guide-PC-E984	3
Modicon--Function Control Function Library-Users Guide	3

MANUAL DESCRIPTION	QUANTITY PROVIDED
Modicon-High/Low Density Installation Instructions	3
Modicon-Analog Input Installation Instructions-B875-111	10
Modicon-User's Guide-IBM Host Based Devices-SA-85	3
Modicon-Installation Guide-ModBus Plus Network	3
Modicon-ASCII BASIC Installation Instructions-B885-002	1
Modicon-Thermocouple Module Installation Inst.-B883-200	3
Modicon-Remote I/O Interface Installation Inst.-J-890/101	2
Modicon-Module Housing Installation Inst.-H819/H827	3
Modicon-Remote I/O power Supplies Installation-P810-001	3
Modicon-ModSoft Programmable Controller System Manual	1
Modicon-ModSoft Programmer User Manual	1
Iconics-Genesis Users Guide-GEN-NET	2
Iconics-Genesis Users Guide-ModBus Plus	1
Iconics-Genesis Users Guide-Remote Supervisory Station	1
Iconics-Genesis Users Guide-Tutorial	2
Iconics-Genesis Users Guide Vol. I&II-Configurator	2

APPENDIX C - GENESIS SOFTWARE LICENSE

Genesis software is controlled via a hardware key attached to the parallel port of the Mini-Mini-DACS computers. The following list represents the software, as delivered, and control key serial numbers.

- GEN-6-C, full system software. Key serial number—SN1940, Lot 934L52125.
- GEN-6-C, full system software. Key serial number—SN1941, Lot 933I52125
- GEN-NET/A, ArcNet software. Serial number—GN-3429.
- GEN-NET/A, ArcNet software. Serial number—GN-3430.
- RSS/A, Remote Supervisory software. Key serial number—RSS-SN877, Lot 9339L52132. Network serial number—GN—3431.
- DD-ModPlus Driver—SN-303.
- Tutorial Software, 2 ea.

APPENDIX D - DRAWING LIST

DRAWING TITLE	DESCRIPTION	DRAWING NUMBER	SHEET No.
MINI-DACS	SYSTEMS CONFIGURATION	68Y-155870	1
MINI-DACS (CONSOLE MECHANICAL)	ASSEMBLY 100	68Y-155870	2
MINI-DACS	DETAIL 101	68Y-155870	3
MINI-DACS (NEMA CABINET)	ASSEMBLY 200	68Y-155870	4
MINI-DACS	DETAILS 201 & 202	68Y-155870	5
MINI-DACS [cons1_blkDIA]	CONSOLE REAR VIEW BLOCK DIAGRAM	68Y-155870	201
MINI-DACS [phen_brdDIA]	NEMA I/O PANEL BLOCK DIAGRAM	68Y-155870	202
MINI-DACS [CPU_c_SLOTS]	CPU CARD SLOTS BLOCK DIAGRAM	68Y-155870	203
MINI-DACS [wire1_DIA]	WIRING DIAGRAM FOR DROP 1, RACKS 1&2	68Y-155870	240
MINI-DACS [wire2_DIA]	WIRING DIAGRAM FOR DROP 2, RACK 1	68Y-155870	241
MINI-DACS [print_DIA]	PRINTER & PHONE ONE LINES WIRING DIAGRAM	68Y-155870	242
MINI-DACS [ULTIPX_line]	MULTIPLEXER ONE LINE WIRING DIAGRAM	68Y-155870	243
MINI-DACS [driveCBL_DIA]	DRIVE CABLE ASSEMBLY WIRING DIAGRAM	68Y-155870	244
MINI-DACS [Mbus_cbl_ASY]	MODBUS CABLE ASSEMBLY	68Y-155870	245
MINI-DACS [PwrF_cbl_dwg]	POWER FEED CABLE DRAWING	68Y-155870	246

APPENDIX-D (cont.) LANL Drawings Listed With WHC-H-9-XXXX Numbers.

H-9-5015 SH 1 MINI-DACS ASSEMBLY SYSTEMS CONFIGURATION

H-9-5015 SH 2 MINI-DACS ASSEMBLY ASSEMBLY 100

H-9-5015 SH 3 MINI-DACS ASSEMBLY DETAIL 101

H-9-5015 SH 4 MINI-DACS ASSEMBLY ASSEMBLY 200

H-9-5015 SH 5 MINI-DACS ASSEMBLY DETAILS 201 & 202

H-9-5016 SH 1 MINI-DACS CONNECTION DIAGRAM FOR DROP 1, RACKS 1 & 2

H-9-5016 SH 2 MINI-DACS CONNECTION DIAGRAM FOR DROP 2, RACK 1

H-9-5016 SH 3 MINI-DACS CONNECTION DIAGRAM PRINTER & PHONE 1-LINES

H-9-5016 SH 4 MINI-DACS CONNECTION DIAGRAM MULTIPLEXER ONE LINE

H-9-5017 SH 1 MINI-DACS BLOCK DIAGRAM CONSOLE REAR VIEW

H-9-5017 SH 2 MINI-DACS BLOCK DIAGRAM NEMA I/O PANEL

H-9-5017 SH 3 MINI-DACS BLOCK DIAGRAM CPU CARD SLOTS

H-9-5018 SH 1 MINI-DACS CABLE ASSEMBLY DRIVE CABLE

H-9-5018 SH 2 MINI-DACS CABLE ASSEMBLY MODBUS

H-9-5018 SH 3 MINI-DACS CABLE ASSEMBLY POWER FEED

APPENDIX E - SYSTEM VALIDATION AND VERIFICATION

GENERAL

Validation and Verification (V&V) for both hardware and software on the Mini-DACS system is on a subsystem level. QA procedures for the DACS are discussed in "Draft Quality Assurance Project Plan for the Data Acquisition and Control (DACS) Project" and have been reviewed by cognizant WHC QA personnel. The first subsystem is the hardware I/O clusters, including the actual I/O modules and the PLC. The second subsystem is composed of the automated sequences for all experiments under the PC/Genesis configuration. Although the basic format adheres to LANL Group J-8 software quality control procedures, there is some deviation to compensate for the unique methods involved in the programming of this process control system. For example, there is very little "standard" text-generated, high-level language programming involved on the Mini-DACS system. Instead, the Modicon system uses Ladder Logic programming techniques. Ladder Logic is a language that can best be described as the building of a schematical representation of the intended signal flow, on screen, that is in turn compiled into a functional interface between field signals and the PLC. Genesis, on the other hand, uses a series of configurable control function blocks that interconnect and that when combined, produce the required results. This means the programming is difficult to document. There are no provisions for a comment line next to each Ladder Logic diagram or function block. Documentation is provided in the form of a textual description of the logic involved, including functionality, in standard engineering documentation protocol.

Validation is at the I/O cluster level. Each module on the I/O cluster is installed and wired in accordance with EG&G workmanship standards: QC Division Electronic/Electrical Workmanship Standards, Manual 43, Vol. 1. Once the I/O is wired, a checklist outlining initial power-up procedures is executed. Also, initial register mapping is programmed into the PLC so that on-screen calibration may begin. At this point, communication is confirmed at the PLC with the I/O in place. A calibration procedure is then executed to ensure that each module is in line with factory specifications. For example, if an analog input module is used, a precision voltage source is applied (the voltage source is traceable to EG&G standard lab). Three readings are then taken; each at a different predetermined value, to check for linearity and accuracy. On the PLC end, the values are checked for total bit count, as well as proper I/O mapping. This procedure is repeated every four days to determine the existence of any drift. The modules are certified by serial number if the unit is within specifications. It is anticipated that all spare units are validated in the same fashion.

All other hardware (such as PC computers) validation is determined by pre-burn-in before the items are fielded. This measure is designed to protect against infant failures of equipment. All equipment is fully exercised in the most real-world conditions available.

Software verification is established by simulation. The overall software concept is to form modules that provide the total required functions. Each required sequence, evasive action, or shutdown algorithm is written in a single module and linked to the overall system. They are placed in either the PLC or the Genesis systems depending on the requirements; fast logic is handled in the PLC, and the not-so-fast logic is in the Genesis software. In either case, the I/O required for a particular sequence is wired to an I/O field simulator. The simulator inputs voltages that correspond to full-scale engineering units. The sequences are tested for the proper occurrence based on the alarm, value, or permissive input of the I/O field. A checklist with detailed information about the software module is followed during the simulation process. In addition, before the software modules are tested, the programmer's software modules undergo scrutiny through peer review with a backup programmer(s). Once the software is tested using the checklist, confirmation is achieved through dynamic operation by different control operators. This process introduces a different operating perspective for the software and detects any "bugs" open to those differences.

Once the system has been checked out and certified, change control procedures become the major governing factor in V&V.

The acceptance test performed by WHC is an end-to-end test with all I/O components in operating mode, except that the system is connected to a motor simulator rather than the motor. The test is run by taking off one sequence at a time.

OPERATOR TRAINING

Initial certification for operation of the Mini-DACS system included the training sessions on both a Modicon overview of the hardware and software and operator training on the Genesis process control software. The custom course outline was configured to allow maximum on-line training in the most realistic environment available by simulation. The Genesis control software allows manual inputs to be entered from a remote supervisory station, thus certain events and alarms may be simulated. WHC training instructors observed as the simulations were run. Consult WHC training for details.

APPENDIX F - Mini-DACS USER GUIDE

1.0 LOGON

A Station 5 (Master Station)

- 1) Change directory by typing; **CD MASFTTEST**
- 2) Type; **RUNTIME MASFTTEST** (This will startup station 5 as the Master station.)
- 3) Pull up the Password - Security menu by entering; **ALT-P**
- 4) Type in appropriate password to get to security level 3.

B Station 8 (Pump control Station)

- 1) Change directory by typing; **CD MASFPUMP**
- 2) Type; **RUNTIME MASFPUMP** (This will startup station 8 as the pump control station.)
- 3) Pull up the Password - Security Menu by entering; **ALT-P**
- 4) Type in appropriate password to get to security level 3.

C Station 7 (RSS Station)

- 1) Choose option 1> GENESIS (if at C prompt push **CTRL-ALT-DEL** to reboot the computer and bring up the option of 1> GENESIS or 2> MODSOFT)
- 2) Change directory by typing; **CD MASFTTEST**
- 3) Type; **RSS MASFTTEST** (This will startup station 7 as the Remote Sensory Station (RSS))
- 4) Pull up the Password - Security Menu by entering; **ALT-P**
- 5) Type in appropriate password to get to security level 3.

2.0 ALARM RESPONSE

Respond to every alarm

- 1) **F4** - accesses the Alarm/Event Summary screen
 - a) alarms received on Master station (5) should be responded to on the Master station.
 - b) alarms received on Pump Control station (8) should be responded to on the Pump Control station.
- 2) with mouse highlight alarm (colored red, green if alarm condition has cleared) then push **F4** to acknowledge alarm.
 - a) Alarm that has not been acknowledged, and has not cleared will be colored red on the Alarm/Event Summary screen.
 - b) Alarm that has been acknowledged, but has not cleared will be colored yellow.
 - c) Alarm that has not been acknowledged, but has cleared will be colored green.
 - d) Alarm that has been acknowledged, and has cleared will clear off the Alarm/Event Summary screen.
 - e) The most recent alarm will also appear in the bottom right hand corner of the screen.
- 3) **ALT-G** - will acknowledge all alarms.
- 4) can "silence" alarm with any keystroke. (This is not recommended per Conduct Of Operations)
- 5) remember to log all alarms (don't clear alarms off screen before logging them).
- 6) Spurious alarms can be silenced by calling up the desired tag name (by entering **F2** and typing the tag name into the tag box on the subscreen, or highlighting the desired tag with the mouse and pressing **ENTER**) and then highlighting the Priority box in the Tag Details subscreen and entering a **0** and pressing **ENTER**. (This is not recommended per Conduct of Operations unless proper approval is given)

All alarm priorities are set to default value of 1 which will annunciate alarm and print out alarm on the Alarm/Event Summary screen. When an alarm priority is set to 0 it will no longer annunciate or printout to the Alarm/Event Summary screen.

3.0 SCREEN MOBILITY

- A Return to previous screen by entering **F6**

- B Select any screen display by entering **F1** and then typing the name of the desired screen.
- C Call up Alarm/Event Summary screen by entering **F4**

4.0 HISTORY FILES AND TRENDING

- A History files on the Master station (5) can be called up and graphically displayed and manipulated by;
 - 1) enter **ALT-H** to pull up History file menu
 - 2) Ensure that the "GRAPHIC" selection has a **Y** for yes.
 - 3) Pick file to be displayed by highlighting desired file name with mouse and entering **S-F6**
 - 4) Choose to replay file by entering **S-F5**
 - 5) Choose to display plot by entering **S-F5**
 - 6) The tags in the selected file to be displayed can be chosen by using the **PAGE DOWN** and **PAGE UP** keys.
 - 7) The blue time line on the plots can be moved through the times on the history file by using the arrow keys.
 - 8) The y-axis ranges can be changed for each tag by highlighting the desired range value box (same color as the tag name) with the mouse and typing in the new desired value and pressing **ENTER**.
- E Current values can be plotted on Trend screens, by bringing up the Trend Menu using **F7** then choosing the desired tag names to be plotted.

5.0 LOGOFF

All Stations

- 1) Must be logged on at security level 3.
- 2) enter **ALT-E**
- 3) answer **Y** and press **ENTER**

6.0 KEY COMMANDS

SHIFT-?	Help System
F1	Display Directory (for choosing screens)
F2	Tag Details (for calling up desired tags)
F4	Alarm/Event Summary screen and acknowledge individual alarms
F6	Return to previous screen
F7	Trend Menu
ALT-E	Exit Genesis
ALT-G	Acknowledge all alarms
ALT-H	History Replay
ALT-P	Password-Security Menu