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SHMS-E PLC COMPUTER SOFTWARE DESIGN DESCRIPTION

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Standard Hydrogen Monitoring System (SHMS) programmable logic controller (PLC) computer software system design description.

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SHMS-E PLC COMPUTER SOFTWARE

DESIGN DESCRIPTION

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SHMS-E PLC COMPUTER SOFTWARE DESIGN DESCRIPTION

1.0 INTRODUCTION

1.1 Background

The Standard Hydrogen Monitoring System (SHMS) is designed to monitor the volume percent hydrogen concentration during potential gas releases from the Hanford underground waste storage tanks. A flexible gas continuous monitoring system was needed that could be expanded to measure gas compositions at both high and low sensitivities. For these reasons, a modified version of the SHMS (entitled SHMS-E) has been developed. The SHMS-E analytical (often referred to as SHMS-E+) measures gas concentrations in selectable ranges of approximately: Hydrogen (3-100,000 ppm); Nitrous Oxide (10-4,000 ppm); Ammonia (10-10,000 ppm) and Methane (10-4,000 ppm). The SHMS-E basic will monitor Hydrogen using electro-chemical cells, but will not have the Microsensor Technology Inc. (MTI) dual-column gas chromatograph, BrüelKjær (B&K) photo-acoustic spectrometer, and associated computers installed though they may be installed with minimal hardware changes in the future if needed.

1.2 Purpose

The purpose of this SHMS-E PLC software design document is to provide:

- The SHMS-E PLC computer software requirements specification, which documents the essential requirements of the PLC software and its external interfaces.
- The SHMS-E PLC computer software design description.
- The user documentation for using and maintaining the PLC software and any dedicated hardware.
- The requirements for computer software design verification and validation.

1.3 Scope

This document describes the design of the Standard-E Hydrogen Monitoring System, (SHMS-E) programmable logic controller (PLC) software components. The original design was implemented in 1992 and the monitor enclosures were sited on the SY-101 waste tank in support of the Hydrogen Mitigation Project. The PLC computer software design description used in the design of the first system are provided in WHC-SD-WM-CSDD-004, *Standard Hydrogen Monitoring System System Computer Software Design Description* (Lopez 1992).

2.0 REQUIREMENTS

2.1 Overview

The alarm annunciator and control system is based upon eleven system inputs to a PLC. Each input triggers multiple outputs. The programmable logic controller (YYC-001) is responsible for processing the inputs and triggering the appropriate outputs for local or remote annunciation and control. Refer to Table 1.0 for the system inputs, alarm annunciators and controls generated from those alarms. Refer to drawing H-14-100836, *Standard-E Hydrogen Monitoring System One-Line & Elementary Diagrams*, for the following discussion.

2.2 Functions

The inputs to the PLC are designed to activate the annunciators on loss of power (fail safe condition), with the exception of the high hydrogen contacts. Loss of power to the hydrogen indicating transmitters and the data recorder will not produce a "false positive", i.e. a high hydrogen alarm will not be generated. Loss of power to the PLC will activate the remote annunciators and the local beacons. On loss of incoming power to the entire system, the remote alarm contacts (which are also designed for fail-safe operation) will open, generating a remote alarm.

The high hydrogen (red) beacon, the trouble (amber) beacon, the remote alarms, and the audible wavering horn automatically reset on loss of the alarm condition. Conversely, the enclosure door alarm indicator lamps retain their alarm state after the loss of the alarm condition, until manually reset.

The enclosure door alarm indicator lamps are turned on directly by a PLC output. Conversely, on a high hydrogen alarm condition that is triggered from either of the two $\%H_2$ electrochemical monitor system inputs, the PLC de-energizes a high hydrogen relay (CR-055) to provide an open contact to a remote annunciator interface (a terminal block) and turn on the high hydrogen beacon. Likewise, on any of the other alarm conditions, the PLC de-energizes a trouble relay (CR-063) to turn on the trouble beacon and provide an open contact to a remote annunciator interface (a terminal block). The enclosure alarm annunciator horn (YAH-050) is activated with each alarm.

The HORN ACKNOWLEDGE push button (PB-050) allows the operator to disable the horn during an alarm condition without disabling the ability for another system input to activate the horn.

The hydrogen monitor calibration push button and push button lamp (P.B./PAL-054) is used to flag calibration of the electrochemical cell systems. Contacts are provided to de-energize the cabinet trouble relay (CR-063) and provide a discrete signal to the host computer (PC-070) when calibration is in process.

TABLE 1.0

System Inputs	Input to PLC	Alarm Generated	Annunciators/Outputs
Electro Chemical High Range % H_2 Monitor System	Data Recorder NC Contact or H2 indicating transmitter (NASH-054) OPEN above set point	High Hydrogen	Red Strobe Light Beacon (NAH-055) Audible Wavering Horn (YAH-050) Enclosure Door Lamp (NAH-054) Grab Sample Valves (SOV-050/51) Grab Sample Lamp (PBL-059) Reset Sampler Lamp (PBL-058) Remote High Hydrogen Alarm
Electro Chemical Low Range % H_2 Monitor System	Data Recorder NC Contact or H2 indicating transmitter (NASH-055) OPEN above set point	High Hydrogen	Red Strobe Light Beacon (NAH-055) Audible Wavering Horn (YAH-050) Enclosure Door Lamp (NAH-054) Grab Sample Valves (SOV-050/51) Grab Sample Lamp (PBL-059) Reset Sampler Lamp (PBL-058) Remote High Hydrogen Alarm
Sample Flow Measurement System	DC input Limit Alarm NO Contact (FSL-057) OPEN below set point	Low Sample Flow	Amber Strobe Light Beacon (XA-063) Audible Wavering Horn (YAH-050) Enclosure Door Lamp (FAL-057) Remote Trouble Alarm
Sample Gas Line Temperature Monitoring System	Temperature Controller NO Contact (TSL-050) OPEN below set point	Gas Temp Low	Amber Strobe Light Beacon (XA-063) Audible Wavering Horn (YAH-050) Enclosure Door Lamp (TAL-050) Remote Trouble Alarm
Calibration Gas Line Temperature Monitoring System	Temperature Controller NO Contact (TSL-056) OPEN below set point	Gas Temp Low	Amber Strobe Light Beacon (XA-063) Audible Wavering Horn (YAH-050) Enclosure Door Lamp (TAL-050) Remote Trouble Alarm

TABLE 1.0 (cont.)

System Inputs	Input to PLC	Alarm Generated	Annunciators/Outputs
Enclosure Temperature Monitoring System	Temperature Controller NO Contact (TSHL-062) OPEN above and below set points	Cabinet Temp (Enclosure)	Amber Strobe Light Beacon (XA-063) Audible Wavering Horn (YAH-050) Enclosure Door Lamp (TAHL-062) Remote Trouble Alarm
Grab Sample System	Grab Sample push button NC Contact (P.B.-059)	Not Applicable	Grab Sample Valves (SOV-050/51) Grab Sample Lamp (PAL-059) Reset Sampler Lamps (PAL-058 and YAL-058)
Grab Sample System	Reset Sampler push button NC Contact (P.B.-058)	Not Applicable	Enables the following controls and annunciators: Grab Sample Valves (SOV-050/51) Grab Sample Lamp (PAL-059) Reset Sampler Lamps (PAL-058 and YAL-058)
Alarm System	Alarm Test push button NC Contact (P.B.-052)	All Annunciators Except Hydrogen Monitor Calibration	Red Strobe Light Beacon (NAH-055) Amber Strobe Light Beacon (XA-063) Audible Wavering Horn (YAH-050) Enclosure Door Lamps (FAL-057,NAH-054,TAL-050,TAHL-062, YAL-058) Internal Panel Lamps (PAL-058, PAL-059) Remote High Hydrogen Alarm Remote Cabinet (Enclosure) Trouble Alarm
Alarm System	Alarm Reset push button NC Contact (P.B.-051)	Not Applicable	Resets All Annunciators Except Reset Sampler if the alarm condition has previously cleared. (Does not affect Reset Sampler and Grab Sampler)
Horn Acknowledge	Horn Acknowledge push button NC Contact (P.B.-050)	Not Applicable	Resets/Silences the horn but does not lock it out for subsequent alarms.
* Condensate Return Peristaltic Pump Drip Pan Moisture Monitoring System	Moisture Controller NO Failsafe Contact OPEN with sensed moisture and loss of controller power	Drip Pan Moisture	Amber Strobe Light Beacon (XA-063) Audible Wavering Horn (YAH-050) Remote Trouble Alarm

* Moisture Alarm added per logic software version 1.01.

The ALARM RESET push button (P.B.-051) clears all local alarm annunciator lamps, if the alarm condition has returned to normal. For example, if a low sample gas temperature condition is met. The horn sounds, the trouble (amber) beacon is activated, the low gas temperature enclosure door alarm lamp is turned on and a remote trouble annunciator signal is provided. An operator would be sent to investigate the problem. The operator would acknowledge the horn and proceed with troubleshooting. If an instant later, a low flow condition is met. The horn turns on again, and now the low sample flow enclosure door alarm lamp is turned on. After acknowledging the horn and correcting both problems, the trouble beacon and the remote trouble annunciator automatically reset. The operator then pushes the ALARM RESET push button, to reset low gas temperature and low sample flow enclosure door alarm lamps.

The beacons, horn, enclosure door alarm lamps (except Hydrogen Monitor Calibration Lamp) and remote annunciation can all be tested at the same time with the ALARM TEST (P.B.-052) push button provided on the enclosure door. Consequently, the programmable logic controller outputs are also verified with this test.

3.0 PLC DESCRIPTION

Ladder logic for the Standard Hydrogen Monitoring System-E (SHMS-E) has been developed utilizing SHMS-E elementary diagrams and operational design information. This document describes ladder logic version 1.0 (standard SHMS-E) and version 1.01 (SHMS-E with condensate return peristaltic pump).

Programming the programmable logic controller (PLC) is accomplished by running Modsoft®, a MS-DOS based software package provided by Modicon, Inc. The ladder logic is downloaded to the PLC via an RS-232 link, referred to by Modicon as Modbus®. This RS-232 connection will also provide the communication path when the SHMS is connected to a laptop PC in the field (or during testing).

3.1 Programmable Logic Controller

Programmable Logic Controllers (PLC) offer many advantages over other control devices. These advantages typically are:

- Improved reliability
- Easier maintainability
- Smaller space required
- Programmable as system requirements change
- Less expensive than equivalent hard-wired systems
- More flexible (can perform more functions)
- Reusable

The programmable controller used for the alarm annunciation system requires only 247.5 cm^2 (97.5 in^2) of mounting area including wiring access and provides 24 I/Os, which includes 15 inputs and 9 outputs. Conversely, approximately 20+ electro-mechanical relays would have been required to implement the relay logic necessary to fulfill the Hydrogen Monitoring System Requirements. The nominal dimensions of a single electro-mechanical relay including wiring access are 7.6 cm(H) x 12.7 cm(W) x 7.6 cm(D) (3 in x 5 in x 3 in). Physically locating 20 relays would require approximately 1935 cm^2 (300 in^2) and an extensive amount of wiring. The Basic Unit, requires 115 VAC input, and allows connection to 115/230 VAC output circuitry. The internal logic needed to program the PLC and the hard wiring setup is documented on engineering drawings H-14-100836, *Standard-E Hydrogen Monitoring System One Line, Elementary Diagrams*, and H-14-100843, *Standard-E Hydrogen Monitoring System P.L.C. Ladder Diagram.* Included in this document are:

- Reference symbol table (Appendix A)
- PLC system configuration (Appendix B)
- Ladder logic network diagrams (Appendix C)

4.0 LADDER LOGIC NETWORK DESCRIPTIONS

The following sections describe the individual networks that collectively make up the ladder logic of the SHMS PLC system. Refer to Appendix C for the appropriate ladder logic network diagram.

The alarm test button, represented by the normally open (N.O.) and the normally closed (N.C.) input contacts 10008 (ALTESTI), is common to seven of the ten networks. Since it functions similarly throughout the system, it is discussed separately after the discussions of the individual networks.

4.1 Network 1 - Hydrogen and Trouble Beacons

This network controls the high hydrogen alarm beacon and remote alarm, and the local cabinet trouble beacon and remote cabinet trouble alarm. In addition, the beacons and remote alarms are tested in this network.

4.1.1 High Hydrogen Beacon

On power-up and under normal operating conditions (instruments powered up and operating properly), power is applied to the N.O. input contact 10001 (HIGHH2I). Therefore, power is passed by contact HIGHH2I and output coil 1 (H2BEACO) is energized. This provides power to the high hydrogen relay, which, due to the fail-safe design, causes the high hydrogen beacon and remote alarm to remain off. When an alarm condition exists (high hydrogen or instrument failure), power is no longer applied to HIGHH2I, which interrupts power and de-energizes the high hydrogen beacon out (H2BEACO). This turns on the high hydrogen beacon and remote alarm. They will remain on as long as the alarm condition exists. Likewise, the beacon and remote alarm will go off as soon as the alarm condition clears.

4.1.2 Cabinet Trouble Beacon

On power-up and under normal operating conditions, power is applied to the N.O. input contacts 10003 (LSAMPFLOWI), 10004 (HLCABTEMPI), 10005 (LCALTEMPI), 10006 (LSAMPTEMPI), and 10011[1] (MOISTI). Therefore, power is passed by all of these contacts and output coil 2 (TROUBBEACO) is energized. This provides power to the cabinet trouble relay, which, due to the fail-safe design, causes the trouble beacon and remote cabinet trouble alarm to remain off.

When an alarm condition exists (either low sample flow, high/low cabinet temperature, low calibration gas temperature, low gas sample temperature, moisture in the drip pan[1], or an instrument failure), power is no longer applied to the respective input contact, which interrupts power and de-energizes the local cabinet trouble beacon out (TROUBBEACO). This turns on the trouble beacon and remote cabinet trouble alarm. They will remain on as long as the alarm condition exists. Likewise, the beacon and remote alarm will go off as soon as the alarm condition clears.

4.2 Network 2 - High Hydrogen

This network controls the high hydrogen amber enclosure door alarm light and tests the amber enclosure door alarm light.

On power-up and under normal operating conditions, power is applied to the N.C. input contact 10001 (HIGHH2I) and the N.O. input contact 10010 (ALRSTI). Therefore, power is not passed by contact HIGHH2I, but is passed by contact ALRSTI. Since the intermediate output coil 104 (HIGHH2X) is not yet energized, contact 104 (HIGHH2X) does not pass power. Therefore, output coil 3 (HIGHH2O) is not energized.

When an alarm condition exists (high hydrogen or instrument failure), power is no longer applied to HIGHH2I, which now passes power and energizes coil HIGHH2X. On the next scan, power is passed by contact HIGHH2X which latches coil HIGHH2X. This energizes coil high hydrogen out (HIGHH2O). The high hydrogen amber enclosure door alarm light will remain on as long as the alarm condition exists. However, even when the alarm condition clears, HIGHH2X and HIGHH2O remain energized until the ALARM RESET push button (P.B.-051) is pressed. When the ALARM RESET is pressed, power is interrupted to ALRSTI, coils HIGHH2X and HIGHH2O are de-energized, and the alarm light is cleared.

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[1]Added in ladder-logic version 1.01.

4.3 Network 3 - Low Sample Flow

This network controls the low gas sample flow amber enclosure door alarm light and tests the amber enclosure door alarm light.

On power-up and under normal operating conditions, power is applied to the N.C. input contact 10003 (LSAMPFLOWI) and the N.O. input contact 10010 (ALRSTI). Therefore, power is not passed by contact LSAMPFLOWI, but is passed by contact ALRSTI. Since the intermediate output coil 105 (LSAMPFLOWX) is not yet energized, contact 105 (LSAMPFLOWX) does not pass power. Output coil 4 (LSAMPFLOWO) is not energized.

When an alarm condition exists (low gas sample flow or instrument failure), power is no longer applied to LSAMPFLOWI, which now passes power and energizes coil LSAMPFLOWX. On the next scan, power is passed by contact LSAMPFLOWX which latches coil LSAMPFLOWX. This energizes coil SAMPLE FLOW LOW OUT (LSAMPFLOWO). The low gas sample flow amber enclosure door alarm light will remain on as long as the alarm condition exists. However, even when the alarm condition clears, LSAMPFLOWX and LSAMPFLOWO remain energized until the ALARM RESET push button (P.B.-051) is pressed. When the ALARM RESET is pressed, power is interrupted to ALRSTI, coils LSAMPFLOWX and LSAMPFLOWO are de-energized, and the alarm light is cleared.

4.4 Network 4 - High/Low Cabinet Temperature

This network controls the high/low cabinet temperature amber enclosure door alarm light and tests the amber enclosure door alarm light.

On power-up and under normal operating conditions, power is applied to the N.C. input contact 10004 (HLCABTEMPI) and the N.O. input contact 10010 (ALRSTI). Therefore, power is not passed by contact HLCABTEMPI, but is passed by contact ALRSTI. Since the intermediate output coil 106 (HLCABTEMPX) is not yet energized, contact 106 (HLCABTEMPX) does not pass power. Therefore, output coil 5 (HLCABTEMPO) is not energized.

When an alarm condition exists (high/low cabinet temperature or instrument failure), power is no longer applied to HLCABTEMPI, which now passes power and energizes coil HLCABTEMPX. On the next scan, power is passed by contact HLCABTEMPX which latches coil HLCABTEMPX. This energizes coil HIGH/LOW CABINET TEMPERATURE OUT (HLCABTEMPO). The high/low cabinet temperature amber enclosure door alarm light will remain on as long as the alarm condition exists. However, even when the alarm condition clears, HLCABTEMPX and HLCABTEMPO remain energized until the ALARM RESET push button (P.B.-051) is pressed. When the ALARM RESET is pressed, power is interrupted to ALRSTI, coils HLCABTEMPX and HLCABTEMPO are de-energized, and the alarm light is cleared.

4.5 Network 5 - Low Gas Temperature

This network controls the low calibration gas temperature and low sample gas temperature amber enclosure door alarm light and tests the amber enclosure door alarm light.

On power-up and under normal operating conditions, power is applied to the N.C. input contacts 10005 (LCALTEMPI) and 10006 (LSAMPTEMPI), and the N.O. input contact 10010 (ALRSTI). Therefore, power is not passed by contacts LCALTEMPI and LSAMPTEMPI, but is passed by contact ALRSTI. Since the intermediate output coil 107 (LGASTEMPX) is not energized, contact 107 (LGASTEMPX) does not pass power. Therefore, output coil 6 (LGASTEMPO) is not energized.

When an alarm condition exists (low calibration gas temperature, low sample gas temperature or instrument failure), power is not applied to the respective contact LCALTEMPI or LSAMPTEMPI, which now passes power and energizes coil LGASTEMPX. On the next scan, power is passed by the respective contact LCALTEMPI or LSAMPTEMPI, which latches coil LGASTEMPX. This energizes coil gas temperature low out (LGASTEMPO). The low gas temperature amber enclosure door alarm light will remain on as long as the alarm condition exists. However, even when the alarm condition clears, LGASTEMPX and LGASTEMPO remain energized until the ALARM RESET push button (P.B.-051) is pressed. When the ALARM RESET is pressed, power is interrupted to ALRSTI, coils LGASTEMPX and LGASTEMPO are de-energized, and the alarm light is cleared.

4.6 Networks 6 and 7 - Grab Sample

These two networks control the grab sample process and test the two amber reset sampler lights located on the instrument panel and enclosure door.

On power-up and under normal operating conditions, power is applied to the N.C. input contacts 10001 (HIGHH2I) and 10002 (GRABSAMPI). Therefore, power is not passed by contacts HIGHH2I or GRABSAMPI. Initially, the output coil to the 300 second timer, 101 (TIMEDONE), is de-energized. Therefore, N.C. contact 101 (TIMEDONE) is passing power. Since output coil 9 (GRABSAMPO) is initially de-energized, N.O. contact 9 (GRABSAMPO) is not passing power at this time.

When either a high hydrogen alarm condition occurs or the grab sample push button (P.B.-059) is pressed, power is interrupted to the respective input contact HIGHH2I or GRABSAMPI, which now passes power. Since output coil 7 (SAMPRSTO) is initially de-energized, N.C. contact 7 (SAMPRSTO) passes power, energizing output coil 9 (GRABSAMPO). This energizes the grab sample solenoid valves, initiating the taking of the grab sample, and turning on the green grab sample light. On the next scan, the three N.O. contacts GRABSAMPO pass power. This (a) latches the output coil GRABSAMPO, (b) begins the 300 second timer, and energizes the intermediate output coil 103 (SAMPRSTX).

On the following scan, contact 103 (SAMPRSTX) passes power, energizing output coil 7 (SAMPRSTO), and turning on the amber instrument panel and enclosure door reset sampler lights.

In the absence of any actions or high hydrogen alarm, the grab sample solenoid valves, green light and amber lights remain energized until output register 40001 (GRABTIME) reaches 300 seconds. When 300 seconds is reached, the top output from the timer passes power and energizes output coil 300 SECOND TIMER COMPLETE (TIMEDONE). On the next scan, N.C. contact 101 (TIMEDONE) no longer passes power. Since N.C. contact RESET SAMPLER OUT (SAMPRSTO) is not passing power (coil SAMPRSTO is still energized), output coil GRAB SAMPLE OUT (GRABSAMPO) is de-energized, turning off the green light and de-energizing the grab sample solenoid valves. Contact TIMEDONE at the bottom input to the timer is no longer passing power, which resets the holding register GRABTIME to zero. The output coil to the timer TIMEDONE is de-energized, which subsequently restores the N.C. contacts TIMEDONE to their initial states (passing power).

After the grab sample is taken, the N.C. contact 9 (GRABSAMPO) will allow power to pass and intermediate output coil 102 (RESETSAMP) is energized. This allows N.O. contact 102 (RESETSAMP) to keep coil SAMPRSTX energized. Pressing the grab sample reset push button (P.B.-058) interrupts power to N.O. input contact 10007 (SAMPRSTI). Power is not passed by SAMPRSTI and coil RESETSAMP is de-energized. Contact RESETSAMP (resets sampler after timer complete) no longer passes power, and output coil SAMPRSTX is de-energized. On the next scan, N.O. contact SAMPRSTX does not pass power and output coil SAMPRSTO is de-energized. This turns off the amber instrument panel and enclosure door reset sampler lights and all is restored to the initial conditions.

If the taking of the grab sample is initiated by a high hydrogen alarm condition, and if the condition persists, then N.O. input contact 10001 (HIGHH2I) does not pass power. This prevents the output coil 101 (TIMEDONE) from being energized before the full 300 seconds passes, even if the grab sample reset push button, N.C. input contact SAMPRSTI, is pressed. However, if the high hydrogen alarm condition clears itself, or if the grab sample is initiated by pressing the grab sample push button (assuming no high hydrogen alarms occur), then pressing the grab sample reset push button before the 300 seconds has passed will energize coil TIMEDONE, resetting all grab sample valves and lights.

Note: If a high hydrogen alarm condition exists after a sample has been taken, but before the grab sample reset push button has been pushed, a new grab sample will be taken immediately after the reset push button is pressed.

4.7 Networks 8, 9 and 10 - Cabinet Horn Latches and Cabinet Horn Output

These three networks control the alarm horn and also test the horn.

On power-up and under normal operating conditions, power is applied to the negative transitional input contacts HIGHH2I, LSAMPFLOWI, HLCABTEMPI, LCALTEMPI, LSAMPTEMPI, and MOISTI[1]. Therefore, power is not passed by any of these contacts. Power is pass by the N.O. input contacts 10009 (HORNACKI) and 10010 (ALRSTI). Since the intermediate output coils 201 (HIGHH2H), 202 (LSAMPFLOWH), 203 (HLCABTEMPH), 204 (LGASTEMPH), and 205[1] (MOISTH) are not yet energized, the respective contacts do not pass power. Therefore, output coil 12 (ALHORNO) is not energized, and no horn sounds.

When an alarm condition exists (high hydrogen, low gas sample flow, high/low cabinet temperature, low calibration gas temperature, low sample gas temperature, moisture in drip pan[1], or instrument failure), power is interrupted to the respective negative transitional contact. The contact passes power for one scan and energizes the respective intermediate coil. This energizes coil cabinet alarm horn out (ALHORNO), sounding the horn. On the next scan, power is passed by the contact corresponding to the intermediate coil, which latches the intermediate coil. The horn will remain on as long as the alarm condition exists, or until either the horn is acknowledged or reset. If the alarm clears itself, the corresponding N.C. contact will not pass power. The intermediate coil de-energizes which then causes coil ALHORNO to de-energize (the horn quits sounding automatically). If the alarm condition persists, pressing either the horn acknowledge push button (P.B.-050) or alarm reset push button (P.B.-051) interrupts power to the corresponding N.O. contact HORNACKI or ALRSTI. This also results in ALHORNO to de-energize.

4.8 Alarm Test - Networks 1, 2, 3, 4, 5, 7, and 10

The following table summarizes actions resulting from alarm test. On power-up and under normal operating conditions, power is applied to the N.O. input contact 10008 (ALTESTI) in network 1, and to the N.C. input contacts ALTESTI in networks 2, 3, 4, 5, 7 and 10. When the alarm test push button (P.B.-052) is pressed, power is interrupted as long as the button is held in, interrupting power to ALTESTI. In network 1, N.O. ALTESTI does not pass power and the output coils in network 1 are de-energized. In the other networks, N.O. ALTESTI passes power and several output coils in these other networks are energized.

[1]Added in ladder-logic version 1.01.

Network	Output Coil	Tag Name	Result of Alarm Test Button Action	
			Button Pressed	Button Released
1	1	H2BEACO	High hydrogen beacon and remote alarm turn on	Beacon and remote alarm turn off, unless a real alarm condition exists
1	2	TROUBBEACO	Local cabinet trouble beacon and remote cabinet trouble alarm turn on	
2	3	HIGHH2O	High hydrogen amber light turns on	Amber light turns off, unless either a real alarm condition exists or the alarm reset had not yet been pressed following a previous alarm
3	4	LSAMPFLOWO	Low sample flow amber light turns on	
4	5	HLCABTEMPO	High/low cabinet temperature amber light turns on	
5	6	LGASTEMPO	Gas temperature amber light turns on	
7	7	SAMPRSTO		
10	12	ALHORNO	Horn sounds	Horn quits sounding, unless either a real alarm condition exists or the horn acknowledge button or alarm reset had not yet been pressed following a previous alarm

5.0 VERIFICATION AND VALIDATION

Upon successful installation of the SHMS-E system logic into the programmable logic controller, a label will be affixed on the PLC with the following information displayed:

(1) Drawing number/Revision date of the drawing of the logic installed
(2) Revision number/date for the software
(3) Date installed
(4) Initial of Verifier/Validator

There are two options available for verification and validation of the PLC setup.

5.1 Acceptance Testing

The first method for verification and validation is by comparing the Standard Hydrogen Monitoring System performance against the SHMS-E requirements. This method is perform at the time of the SHMS-E system installation. The *Standard-E Hydrogen Monitoring System Shop Acceptance Test Procedure*, WHC-SD-WM-ATP-191, and the *Standard-E Hydrogen Monitoring System Field Acceptance Test Procedure*, ATP-040-001 are performed to verify that the SHMS-E requirements have been met.

5.2 Independent Review

The second option is to compare the PLC ladder logic printout with the defined ladder logic diagram documented in engineering drawing H-14-100843, *Standard-E Hydrogen Monitoring System P.L.C. Ladder Diagram*. This comparison should be performed on the official release copies for each revision. A designated reviewer may initial the label upon satisfactory inspection of the software installation.

6.0 CONFIGURATION CONTROL

Each PLC software file shall contain a revision number. The revision date will be the date/time stamp on the software.

6.1 Configuration Status Accounting

Remote Automation Instrumentation Laboratory (RAIL) shall prepare a status accounting file before software release. The status accounting file shall contain a functional description of the contents of the file and the revision history. The revision history shall include a description of the initial release and all subsequent changes to the file. The description shall include the following:

- ♦♦ Revision number/revision date
- ♦♦ Nature and Rationale for the change
- ♦♦ Identity of author making the change:

Instructions on how to build the software product from the files shall include identification of support software. Support software includes compilers, assemblers, editors, operating systems, and other utility software.

6.2 Discrepancy Reporting & Corrective Actions

Any person who identifies any problems or discrepancy at any time shall report it to the cognizant design engineer. The cognizant design engineer shall include a written description of the problem or discrepancy in the design file under "Problems". The cognizant design engineer shall provide a copy of this written description to the cognizant manager responsible for characterization and monitoring systems. The corrective action is recorded in an action-tracking database by the cognizant manager. The cognizant manager and cognizant design engineer are responsible for assuring correction of the problem or discrepancy.

6.3 Media Control

The form of media used to store approved release software shall be 12 cm. CD ROM disks. The software media shall be stored in at least two locations. One set of the software media shall be stored in a locked fire-resistant file cabinet drawer labeled "software records" in the file named "SHMS-E software". This file cabinet will be located at a location specified by the manager of Remote Automation Instrumentation Laboratory. Each approved release software shall bear the name "SHMS-E", the version number, a disk number (sequential integer starting at 1), and the initials of the Design Engineer, with date.

7.0 SAFETY, RELIABILITY, & QUALITY ASSURANCE

7.1 Safety Classification and Signature Designation

The monitoring instruments and systems used for the Hanford Waste Tank Standard-E Hydrogen Monitoring System are classified as a non-safety related General Service system in accordance with the requirements of HNF-PRO-516, "*Safety Classification of Structures, Systems, and Components*". Failure of the SHMS does not adversely effect the environment or the health and safety of the personnel operating the enclosure. General design and quality assurance requirements for Non-Safety items shall be followed.

Although the SHMS function does not require it to be safety class or safety significant, its connection to the tank vapor space may necessitate designation of protective equipment as Defense-in-Depth Safety Equipment List components.

At a minimum, documentation must satisfy an SQ Documentation Approval Designation Level with Environmental Assurance (E) as deemed appropriate. A ESQ is a designator for documentation that impacts occupational safety [including "as low as reasonably achievable" (ALARA) principles], environmental monitoring, and requires quality assurance verification of conformance to requirements. These have been determined in accordance with HNF-PRO-233, "*Approval of Environmental, Safety, and Quality Affecting Documents*" and HNF-PRO-317, "*Engineering Document Approval and Release Requirements*".

7.2 Quality Assurance and Quality Control

All work is conducted in accordance with the relevant quality requirements of FDH-MD-002, "Quality Assurance Manual", and the engineering support documents: HNF-PRO-227, "*Engineering Document Identification Requirements*", HNF-PRO-239, "*Design Analysis Report Requirements*", HNF-PRO-241, "*Engineering Specification Requirements*", HNF-PRO-242, "*Engineering Drawing Requirements*", HNF-PRO-243, "*Interface Control Requirements*", HNF-PRO-244, "*Engineering Data Transmittal Requirements*", HNF-PRO-317, "*Engineering Document Approval and Release Requirements*",HNF-PRO-439, "*Supporting Document Requirements*" (Design Control, Design Verification, Change Control, Interface Control, Instruction, Procedures, and Drawings). Equipment that is deployed in Hanford's waste tank applications must be in compliance with National Environmental Protection Act requirements and have appropriate documentation to address safety and regulatory issues associated with the deployment activity.

8.0 REFERENCES

A) Payne, M. A.,1994, "*In-Tank Instrument Safety Classification*", (Internal Memo, 9307342B R1, to R. E. Gerton, October 14, 1993), Westinghouse Hanford Company, Richland, Washington.

B.) FDH-MD-002, "*Quality Assurance Manual*", Fluor Daniel Hanford Company, Richland, Washington.

C.) HNF-PRO-227, "*Engineering Document Identification Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

D.) HNF-PRO-233, "*Approval of Environmental, Safety, and Quality Affecting Documents*", Fluor Daniel Hanford Company, Richland, Washington.

E.) HNF-PRO-239, "*Design Analysis Report Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

F.) HNF-PRO-241, "*Engineering Specification Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

G.) HNF-PRO-242, "*Engineering Drawing Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

H.) HNF-PRO-243, "*Interface Control Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

I.) HNF-PRO-244, "*Engineering Data Transmittal Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

J.) HNF-PRO-317, "*Engineering Document Approval and Release Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

K.) HNF-PRO-439, "*Supporting Document Requirements*", Fluor Daniel Hanford Company, Richland, Washington.

L.) HNF-PRO-516, "*Safety Classification of Structures, Systems, and Components*", Fluor Daniel Hanford Company, Richland, Washington.

9.0 BIBLIOGRAPHY

9.1 U.S. GOVERNMENT

DOE, 1989, DOE Order 6430.1A, *General Design Criteria*, U.S. Department of Energy, Washington, D.C.

9.2 FLUOR DANIEL HANFORD COMPANY

SD-WM-SAR-016 Safety Analysis Report Double Shell Tank Farms 241-AN, AW, AP & SY (OSR-T-152-00001)

OSD-T-151-00007 Unclassified Operating Specifications for 241-AN, AP, AW, AY, AZ, and SY Tank Farms

9.3 CODES AND STANDARDS

American National Standards Institute (ANSI)

ANSI/IEEE Std 100, *Standard Dictionary of Electrical and Electronics Terms*, 1988.

ANSI/UL 508, *Standard for Industrial Control Equipment*, 1988.

Institute of Electrical and Electronics Engineers (IEEE)

IEEE Standard 1016-1987.

National Electrical Manufacturers Association, (NEMA)

NEMA ICS-1, *General Standards for Industrial Control Systems*, 1988.

National Fire Protection Association (NFPA)

NFPA 70, *National Electrical Code*, 1990.

Underwriter's Laboratory

UL 698 - Standard for Industrial Control Equipment for Use in Hazardous Locations

LIST OF APPENDICES

APPENDIX - A Reference Symbol Table

MODSOFT® REFERENCE SYMBOL TABLE

Discrete Output Coils

00001	H2BEACO	HIGH HYDROGEN BEACON OUT
00002	TROUBBEACO	LOCAL CABINET TROUBLE BEACON OUT
00003	HIGHH2O	HIGH HYDROGEN OUT
00004	LSAMPFLOWO	SAMPLE FLOW LOW OUT
00005	HLCABTEMPO	HIGH/LOW CABINET TEMPERATURE OUT
00006	LGASTEMPO	GAS TEMPERATURE LOW OUT
00007	SAMPRSTO	RESET SAMPLER OUT
00009	GRABSAMPO	GRAB SAMPLE OUT
00012	ALHORNO	CABINET ALARM HORN OUT

Discrete Internal Coils

00101	TIMEDONE	300 SECOND TIMER COMPLETE
00102	RESETSAMP	RESETS SAMPLER AFTER TIMER COMPLETE
00103	SAMPRSTX	INTERMEDIATE COIL FOR RESET SAMPLER OUT
00104	HIGHH2X	INTERMEDIATE COIL FOR HIGH HYDROGEN OUT
00105	LSAMPFLOWX	INTERMEDIATE COIL FOR SAMPLE FLOW LOW OUT
00106	HLCABTEMPX	INTERMEDIATE COIL FOR HIGH/LOW CABINET TEMP. OUT
00107	LGASTEMPX	INTERMEDIATE COIL FOR GAS TEMPERATURE LOW OUT
00201	HIGHH2H	INTERMEDIATE COIL FOR HIGH HYDROGEN HORN
00202	LSAMPFLOWH	INTERMEDIATE COIL FOR LOW SAMPLE FLOW HORN
00203	HLCABTEMPH	INTERMEDIATE COIL FOR HIGH/LOW CABINET TEMP. HORN
00204	LGASTEMPH	INTERMEDIATE COIL FOR LOW GAS TEMPERATURE HORN
00205[1]	MOISTH	INTERMEDIATE COIL FOR DRIP PAN MOISTURE HORN

Discrete Input Registers

10001	HIGHH2I	HIGH HYDROGEN IN
10002	GRABSAMPI	GRAB SAMPLE IN
10003	LSAMPFLOWI	LOW SAMPLE FLOW IN
10004	HLCABTEMPI	HIGH/LOW CABINET TEMPERATURE IN
10005	LCALTEMPI	LOW CALIBRATION TEMPERATURE IN
10006	LSAMPTEMPI	LOW SAMPLE TEMPERATURE IN
10007	SAMPRSTI	RESET SAMPLER IN
10008	ALTESTI	ALARM TEST IN
10009	HORNACKI	HORN ACKNOWLEDGE IN
10010	ALRSTI	ALARM RESET IN
10011[1]	MOISTI	DRIP PAN MOISTURE IN

Output Registers

40001	GRABTIME	GRAB SAMPLE TIMER ACCUMULATION REGISTER
40400[1]	VERSION	PLC LADDER LOGIC VERSION NUMBER

[1]Note: These coils and registers added in ladder logic version 1.01; all others in version 1.00

APPENDIX - B PLC System Configuration

CONFIGURATION OVERVIEW

PLC :

PLC Type	MICRO-S
Model	311/01
System Memory	2.0K
Micro Child ID	None

Ranges :

0xxxx	00001	- 01024
1xxxx	10001	- 10256
3xxxx	30001	- 30032
4xxxx	40001	- 40400
4xxxx <-> SFC	None	

0xxxx <-> SFC	None

Size of Full Logic Area	01138
No. of I/O Map Words	00017

I/O :

Number of Segments	2
Number of Children	0
I/O Locations	1

Specials :

Battery Coil	00081
Timer Register	40011
Time of Day Clock	
Config Extension Size	0

MICRO PORTS

MODE	RS232-1	RS232-2	RS485
Single	MODBUS	MODBUS	ASCII

MODBUS Parameters

Port	Mode	Data Bits	Parity	Stop Bits	Baud	Address	Delay
RS232-1	RTU	8	EVEN	1	9600	1	10 ms
RS232-2	RTU	8	EVEN	1	9600	1	10 ms

MICRO I/O MAP

Single I/O

PLC	:	MICRO 311/01	Holdup Time	:	N/A
Used Inputs	:	016 of 512 Points	Used Outputs	:	016 of 512 Points
Next Input	:	10001	Next Output	:	00001

Location	Type	Reference Numbers Input	Output	Data Type	Description
DISC I/O :	MIC131	10001-10016	0000 -00016	BIN	16@115V I/O 8TR/4RY
INT/CTR IN :	NotAvl	-	-		
TMR/CTR IN :	NotAvl	-	-		
ANALOG I/O :	NotAvl	-	-		
DATA TRANS:	NotAvl	-	-		

APPENDIX - C Ladder Logic Network Diagrams

SHMS Ladder Logic Network List

Network List - Segment 1

Network #1	HYDROGEN AND TROUBLE BEACONS
Network #2	HIGH HYDROGEN
Network #3	LOW SAMPLE FLOW
Network #4	HIGH/LOW CABINET TEMPERATURE
Network #5	LOW GAS TEMPERATURE
Network #6	GRAB SAMPLE (1 OF 2)
Network #7	GRAB SAMPLE (2 OF 2)
Network #8	CABINET HORN LATCHES (1 OF 2)
Network #9	CABINET HORN LATCHES (2 OF 2)
Network #10	CABINET HORN OUTPUT

Note: Represents networks for ladder logic version 1.00, except where noted on individual networks.

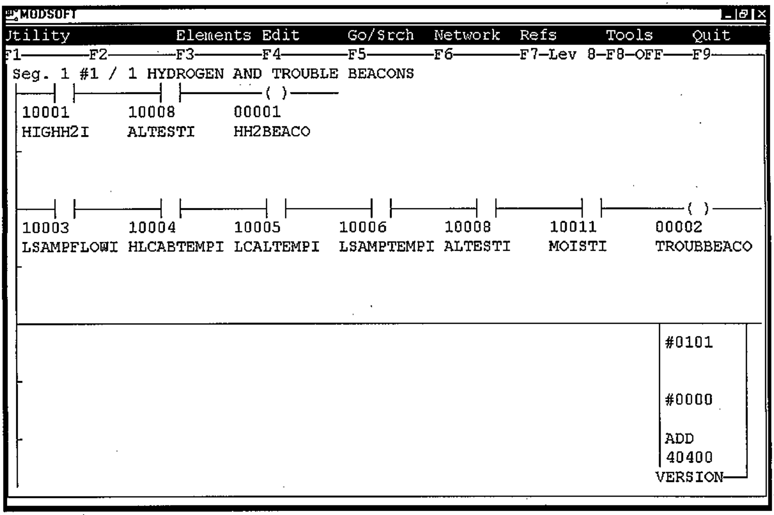

Figure 1. Network #1 - Hydrogen and Trouble Beacons

Added in ladder logic version 1.01:

(1) Contact 10011, MOISTI
(2) "ADD" function block containg register 40400, VERSION

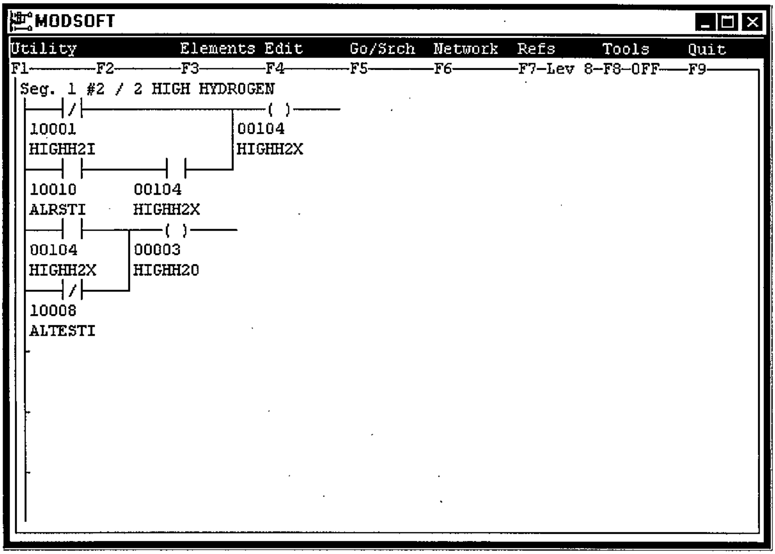

Figure 2. Network #2 - High Hydrogen

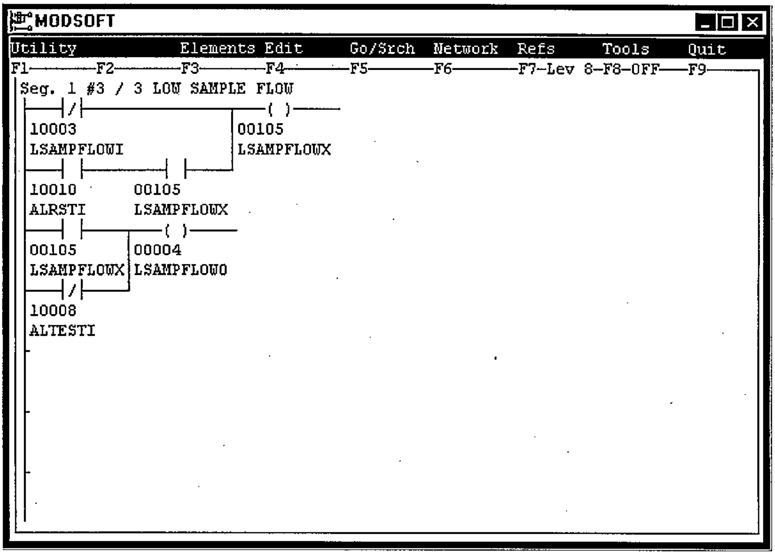

Figure 3. Network #3 - Low Sample Flow

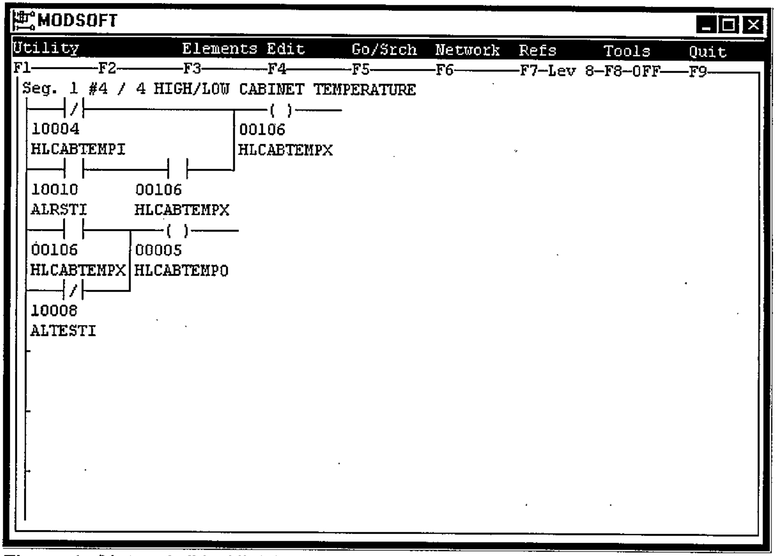

Figure 4. Network #4 - High/Low Cabinet Temperature

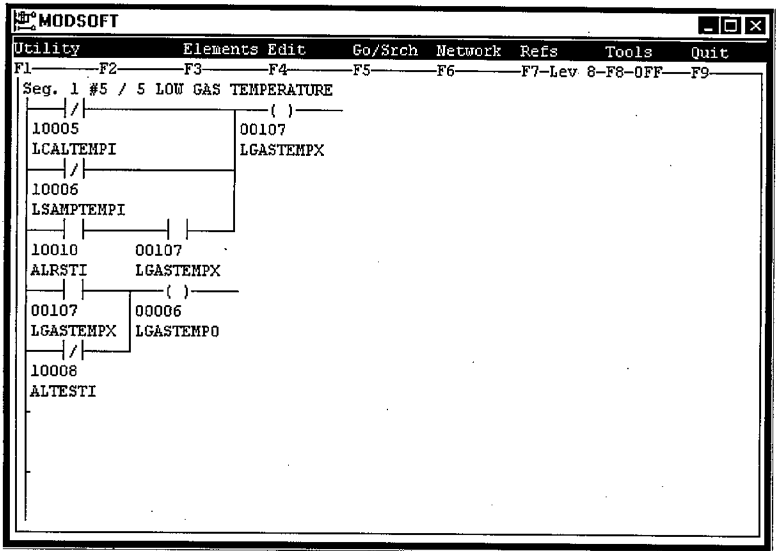

Figure 5. Network #5 - Low Gas Temperature

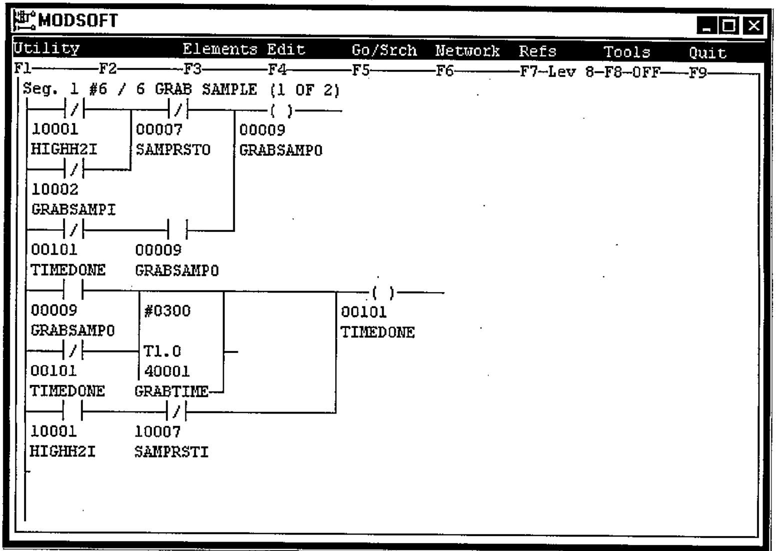

Figure 6. Network #6 - Grab Sample (1 of 2)

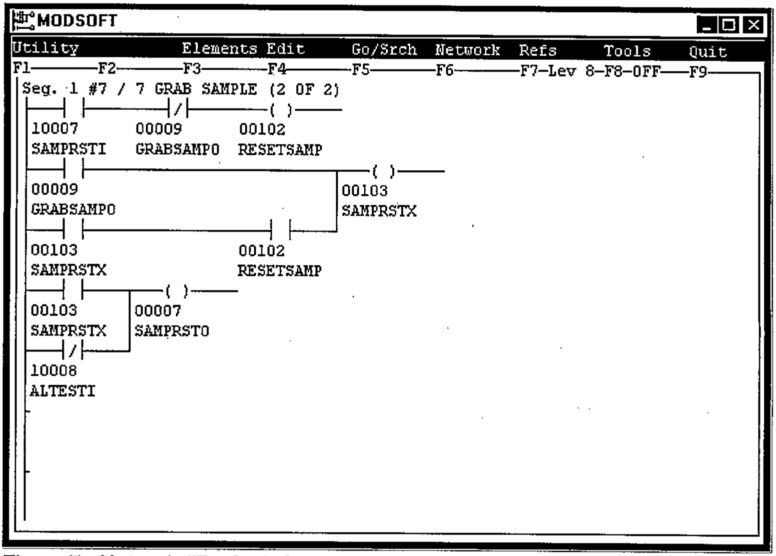

Figure 7. Network #7 - Grab Sample (2 of 2)

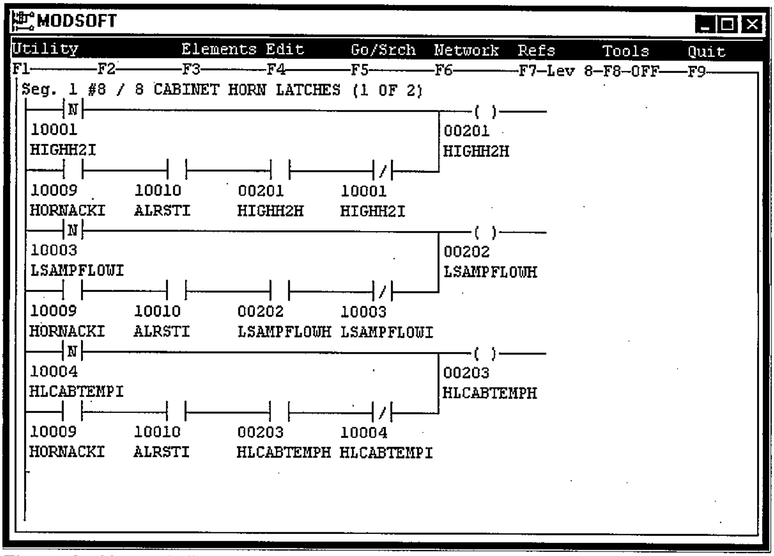

Figure 8. Network #8 - Cabinet Horn Latches (1 of 2)

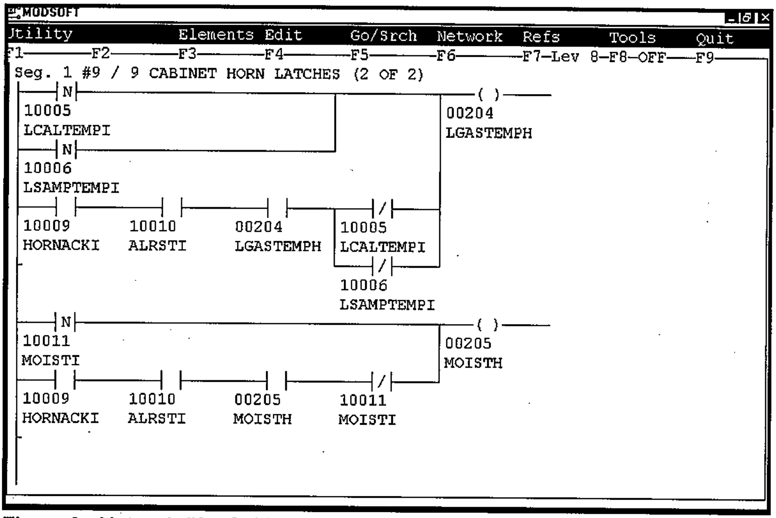

Figure 9. Network #9 - Cabinet Horn Latches (2 of 2)

Added in ladder logic version 1.01:

(1) The bottom segments that include contact 10011, MOISTI, coil 00205, MOISTH, and contact 00205, MOISTH

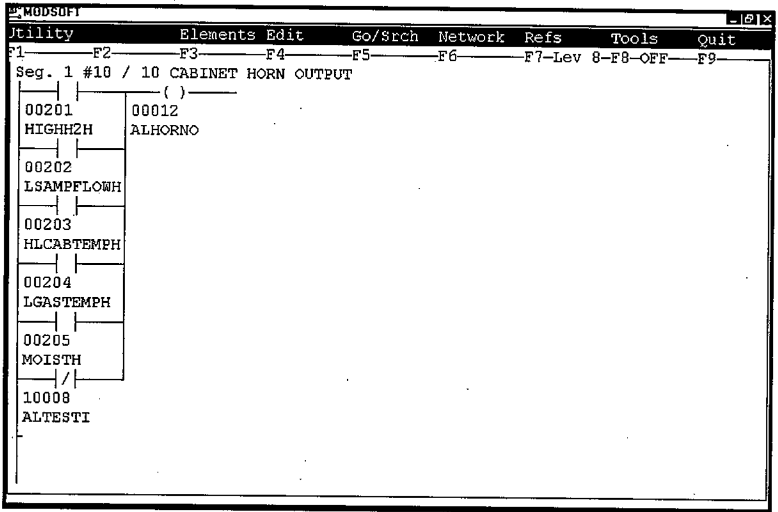

Figure 10. Network #10 - Cabinet Horn Output

Added in ladder logic version 1.01:

(1) Contact 00205, MOISTH

APPENDIX - D Downloading Ladder Logic to the PLC

1. Contact the RAIL software custodian to obtain a properly configured laptop computer containing the required Modsoft ladder logic software.

2. Connect the communications cable between the laptop computer COM port and the PLC comm 1 port.

3. After starting the computer, double-click on the "MODSOFT" icon on the "Desktop" to start the ladder logic program.

4. Press <ENTER>.

5. Use the right/left arrow keys to the "Transfer" menu item.

6. Use the up/down arrow keys to the "File to PLC" item. Press <ENTER>.

7. Press <ENTER> to select "SHMS".

8. If prompted to Stop Controller, type in "Y", then press <ENTER>.

9. When prompted to Start Controller, verify "N", then press <ENTER>.

10. Use the right/left arrow keys to the "Online" menu item.

11. Use the up/down arrow keys to the "Select Program" item. Press <ENTER>.

12. Press <ENTER> to select "SHMS".

13. Press the "F2" key to select "PlcOps".

14. Press the "F8" key to select "Save to".

15. On the "Flash RAM Loading Options" box, type in "Y" then press <ENTER> for both questions. A red system message box should appear stating that "EEPROM was successfully programmed".

16. Press the <ESC> key.

17. Press the "F1" key to select "Start".

18. When prompted to Start Controller, type in "Y", then press <ENTER>.

19. Press <ESC> three time (until prompted to leave Online), then type in "Y", then press <ENTER>.

20. Press <ESC> until prompted to leave Modsoft, then type in "Y", then press <ENTER>.

21. Disconnect the communications interconnect cable between the laptop and the PLC.

DISTRIBUTION SHEET

To	From	Page 1 of 1
DISTRIBUTION	B.L. Philipp SESC	Date 5/27/98
Project Title/Work Order SHMS-E PLC Computer Software Design Description		EDT No. 606766
		ECN No. n/a

Name	MSIN	Text With All Attach.	Text Only	Attach. / Appendix Only	EDT/ECN Only
T.C. Schneider	L6-37	X			
D.D. Tate	L6-37	X			
J.R. Bunch	L6-37	X			
M.F. Erhart	R1-56	X			
R.L. Schlosser	R1-56				X
R.W. Reed	T4-07				X
L.S. Krogsrud	T4-07				X
M.C. Tipps	T4-07				X
B.L. Philipp (3)	L6-37	X			
Central Files	B1-07	x			