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SUBJECT: HRT-CP INSTRUMENTATION DESIGN MANUAL

TO: W. E. Unger

FROM: R. K. Adams

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II

OAK RIDGE NATIONAL LABORATORY

TO: W. E. Unger

DATE: August 17, 1956

From: R. K. Adams

Subject: HRT-CP Instrumentation Design Manual

The accompanying design manual should serve to summarize the instrumentation design of the HRT Core Processing Plant.

Should a major process modification be installed, this manual will be revised to provide information helpful in effectively acquainting the operating personnel with the instrumentation.

R. K. Adams
Application Section
Instrument Department

RKA/psw

III

TABLE OF CONTENTS

	<u>PAGE NO.</u>
INTRODUCTION	1
1.000 Primary Elements	1-4
1.100 Pressure Elements	1-2
1.110 PE-1	1
1.120 PdE-S-1	2
1.130 PE-C-1, PE-C-2	2
1.200 Level Elements	3-4
1.210 LE-T-2-2	3
1.220 LE-T-2-1	3
1.230 LE-Cell-1	4
1.300 Temperature Elements	4
1.400 Flow Elements	5
1.410 FE-C-1, FE-C-2	5
1.500 Noise Pickups, XE-P-1F, XE-P-1R, XE-S-1	5
2.000 Control Systems	5-6
2.100 PdC-S-1	5-6
2.200 TC-T-1	6
2.300 HIC-H-3	6
3.000 Electrical and Instrument Connections	6-7
3.100 Thermocouple Wall Piercings	6
3.200 Electrical Wiring	7
4.000 Transducers	7-8
4.100 Foxboro Dynalogs	7
4.200 Swartwout Converters	8

IV

TABLE OF CONTENTS (continued)

	<u>PAGE NO.</u>
5.000 Transducer Rack	8-9
5.100 Freeze Plug Thermocouple Scanner	8-9
5.200 Vapor Flow Counters	9
5.300 Radiation Instruments	9
6.000 Operating Panelboards	9-10
7.000 High Pressure Instruments	10
8.000 Low Pressure Instruments	10
9.000 Cell Instruments	10
10.000 Valve Actuators and Panel Pushbuttons	11
11.000 Freeze Plug and Solenoid Valve Actuation and Indication	11
12.000 Safety and Alarm Circuits	11-15
12.100 Underflow Sampler	12
12.200 Overflow Sampler	12
12.300 Full Supply System	12
12.400 Carrier Inlet Lines	13
12.500 Valve HCV-937	13
12.600 Chemical Plant Supply and Return Line	13-14
12.700 Let Down Valve HCV-T-1-2	14
12.800 Heater H-3	14-15
12.900 Heater H-11	15
13.000 Interlocks for Service Operation	15
SEE TABLE I	16-17
14.000 Safety Interlocks and Valve Actuator Patch Panels	18-19
INDEX	20-21

CF-56-8-117

HRT CHEMICAL PROCESSING PLANT INSTRUMENTATION
DESIGN MANUAL

INTRODUCTION

It is the intent of this instrumentation design manual to describe the installation and design of the HRT-Core Processing Plant in detail so that operation and maintenance of the plant may be made more effective. Process instruments will be described fully, but auxiliary instrumentation such as pressure gauges, rotameters, etc. will not be mentioned. Where detailed questions arise as to electrical circuitry or instrument connections, the drawings and specification sheets should be consulted.

1.000 Primary Elements

1.100 Pressure Elements

The primary pressure elements are located in a lead shielded enclosure attached to the Cell C east wall near the top of the cell. Connections between the instruments and the process are made by stainless steel tubing.

1.110 PE-1

Process pressure in the hydroclone circulation loop is measured by a 0-2500 psi Baldwin-Lima-Hamilton type SR-4 strain gauge element. This element consists of a flattened tube to which strain sensitive gauges are cemented. The bonding of the gauges to the metal tube is affected by temperature and by radiation. For these reasons, the Baldwin cell is located in the lead shielded enclosure remote from the high temperature process area.

1.000 Primary Elements (continued)

1.120 PdE-S-1

The differential pressure drop across the hydroclone separator is measured by a 0-50 psi inductance type differential pressure transmitter fabricated by the Foxboro Company. This differential pressure transmitter is similar to others used in industrial instrument measurements and consists of a metal diaphragm which moves an iron core surrounded by two electrical coils. The change in inductance of these coils is the electrical output of the differential pressure cell.

A control system for maintaining the differential pressure across the hydroclone separator is described in Paragraph 2.100.

1.130 PE-C-1, PE-C-2

The pressure in the vapor lines between the carriers and the recombiner-condensers is measured by two 0-50 psia Baldwin-Lima-Hamilton strain gauge elements. These pressure elements consist of a bellows which deflects a metal beam to which are cemented the strain sensitive gauges. As is the case with the high pressure Baldwin cells, the gauge bonding in these instruments is sensitive to high temperature and radiation.

1.000 Primary Elements (continued)

1.200 Level Elements

1.210 LE-T-2-2

The D₂O receiver liquid level is measured by a 0-200 lb. Baldwin-Lima-Hamilton load cell. This element consists of a column which supports the load being measured and to which are fastened the strain sensitive gauges. The tare weight of the tank is electrically compensated for in the measuring instrumentation, to be mentioned in Paragraph 3.000. The load cell is enclosed in its own lead shielded enclosure directly above Tank T-2.

1.220 LE-T-2-1

An auxiliary level measurement of the D₂O receiver liquid level is provided by a thermal level probe. This probe consists of a heater surrounded by thermocouple junctions embedded in a stainless steel housing. The thermocouple junctions are spaced in equal increments along the length of the probe.

In normal operation, the thermocouples in the portion of the probe which is immersed in the liquid will produce an electrical output which is small. The output from the thermocouples in the portion of the probe which is not immersed in the liquid will be greater. This is due to the differences in heat transfer of the probe-to-liquid and probe-to-vapor surfaces. The bottom thermocouple junction, which is always immersed in the liquid is used to compensate the instrument for changes in liquid temperature.

1.000 Primary Elements (continued)

1.230 LE-Cell-1, LE-C-1, LE-C-2

Liquid level measurements of the Cell C sump and Carriers C-1 and C-2 is also a thermal level probe having a single point on-off signal. The thermocouple junctions in this type of thermal level probe are not spaced to give a continuous level measurement along the probe but are arranged to indicate absence or presence of liquid at a specified point.

1.300 Temperature Elements

Temperature elements are thermocouples made of chromel-alumel wires which are sheathed in 1/8" OD Type 304 stainless steel tubing; the wires are insulated from the sheath by fiberglass.

The thermocouple junctions have been made by welding the wires and tubing into a closure of the end. Most of the thermocouple applications are simply the 1/8" OD tubing thermocouple junction welded to the process piping at the desired point. For some of the temperature measurements, thermocouple wells have been provided such as in the recombiner-condenser and condensate outlet. Each thermocouple application is duplicated and a spare thermocouple may be connected to the measuring or controlling instrument at the junction box in the transducer rack.

The temperature control system for the underflow receiver system is described in Paragraph 2.200.

1.000 Primary Elements (continued)

1.400 Flow Elements

1.410 FE-C-1, FE-C-2

Vapor flow in the lines from the carriers to the recombiner-condensers is measured by turbine type flow elements fabricated by the Potter Aeronautical Company. These elements consist of a rotating turbine in which is mounted a permanent magnet. Each time this magnet rotates past a fixed coil on the outside of the element, an electrical pulse is produced. The number of pulses per minute is proportional to the flow rate.

1.500 Noise Pickups, XE-P-1F, XE-P-1R, XE-S-1

Microphones to detect the sounds of the front and rear bearings of the circulating pump P-1 and the hydroclone separator are provided. The microphones are housed in water-tight containers. The output from any one microphone may be selected for listening at the panelboard.

2.000 Control Systems

2.100 PdC-S-1

Control of the hydroclone differential pressure to the value determined by the operator at the control panel is accomplished automatically by a pneumatic controller PdC-S-1.

Acting on the signal from the differential pressure cell, PdE-S-1 and the transducer PdY-S-1, the controller output pressure causes the pneumatic cylinder operator, PdCV-S-1 to regulate the speed of the variable frequency generator. This, in turn,

2.000 Control Systems (continued)

varies the output of the circulating pump P-1 by the frequency-speed-head relationship of the canned rotor pump.

2.200 TC-T-1

Control of the temperature of the underflow receiver and its contents to the temperature determined by the operator at the control panel is accomplished automatically by a pneumatic controller TC-T-1. Acting on the signal from the thermocouple, TE-T-1, and the transducer TY-T-1, the controller output pressure causes the pneumatically operated powerstat to adjust the voltage supplying the H-11 heaters, thereby varying the temperature of the air in the H-11 - T-1 loop.

2.300 HIC-H-3

Control of the heat input to the high pressure system and the resultant high pressure system temperature is determined by manual control at the control panel. A pneumatic pressure from HIC-H-3, adjusts the pneumatically operated powerstat supplying heater H-3.

3.000 Electrical and Instrument Connections

3.100 Thermocouple Wall Piercings

1/8" stainless steel sheathed thermocouple lines from the process terminate in tubing fittings at sealed junction boxes inside Cell C near the roof plugs. On the west wall of Cell D, wiring from these junction boxes passes through conduit boxes filled with a sealing compound. The length of conduit between the sealing boxes and the junction boxes inside Cell C is pressurized to insure against leakage of Cell C atmosphere into the operating area.

3.000 Electrical and Instrument Connections (continued)

3.200 Electrical Wiring

Cell C electrical leads pass through sealed junction boxes inside Cell C, and sealing conduit boxes in Cell D. These conduits are also pressurized between the two boxes to insure against leakage of Cell C atmosphere into the operating area.

4.000 Transducers

All primary elements have an electrical output. Panel instrumentation, interlock switches and control valves are pneumatically actuated. Transducers are required to convert the primary element electrical signals to the standard 3-15 psi pneumatic signal range.

4.100 Foxboro Dynalogs

The Foxboro Company Dynalog indicator with 3-15 psi pneumatic output is used as a transducer for the following primary measurements:

- 1) High pressure loop static pressure.
- 2) Hydroclone differential pressure.
- 3) Carrier C-1 vapor pressure.
- 4) Carrier C-2 vapor pressure.
- 5) D₂O level from the Baldwin load cell.
- 6) Overflow sampler chamber pressure.
- 7) Underflow sampler chamber pressure.

These transducers are essentially Wheatstone bridge type detectors which operate on an alternating current signal of 1000 cps frequency. The 3-15 psi pneumatic output is obtained through the use of levers and linkages from a pneumatic relay to the scale pointer.

4.000 Transducers (continued)

4.200 Swartwout Converters

Swartwout Company emf-to-pneumatic transmitters are used to convert the electrical signals from the D₂O tank thermal level probe and the controlling thermocouple in the underflow receiver to the standard 3-15 psi. signal. These instruments have a chopper type D.C. amplifier and an electrical to pneumatic pressure relay.

5.000 Transducer Rack

The transducer rack in Cell D houses the primary element transducers and includes mounting facilities for the remote valve actuating solenoid valves and electrical control relays. Also mounted in this transducer rack are the freeze plug automatic thermocouple scanner, the Potter Aeronautical Company counters, pneumatically operated variable voltage regulators, and the radiation monitoring instruments.

5.100 Freeze Plug Thermocouple Scanner

The freeze plug automatic thermocouple scanner is used to scan continuously the freeze plug thermocouples in the processing plant and to indicate the condition of the freeze plug by means of the panel lights at the freeze plug graphic symbol on the panelboard.

The thermocouple scanner actuation of the panel indicator lights is explained in Paragraph 11.000.

Each thermocouple is scanned for a period of one minute every 12 minutes. The panel of the scanner provides controls for selecting a specific freeze plug thermocouple for interrogation

5.000 Transducer Rack (continued)

at any time, and also provides a switch for testing any panel freeze plug indicator light.

5.200 Vapor Flow Counters

The Potter Aeronautical Company counters are simply an electronic pulse amplifier which amplifies the pulse received from the Potter turbine type flowmeters so as to actuate a mechanical counter on the transducer rack and on the operating panelboard.

5.300 Radiation Instruments

The radiation measuring instruments include amplifiers, for amplifying the signals from the ion chambers monitoring the radiation in various points in the plant. These instruments indicate the radiation level on a meter and actuate a relay for the alarm if a given point in the process has a radiation level higher than the setpoint on the monitoring instrument panel.

6.000 Operating Panelboards

The operating panelboard consists of one eight-foot section of graphic process representation which contains process variable recorders, indicators and valve and freeze-plug actuating switches which are associated with individual process components and connecting lines.

At either side of the graphic panel is a two-foot section of panel in which instruments related to the entire process and instruments used to furnish auxiliary information are mounted. The multipoint temperature recorders and indicators are mounted in these panels as are the pump start-stop switches, the annunciators, and the noise pickup selector switch and speakers. In the lower portions

6.000 Operating Panelboards (continued)

of each side or wing panel is a central control circuit patch and jumper panel which displays the control and interlock circuitry to be made at a central location.

Such items as valve actuators and panel pushbuttons, freeze-plug and solenoid valve actuators, and safety interlock and valve actuator patch panels will be discussed in more detail in Paragraphs 9.000, 10.000, and 13.000.

7.000 High Pressure Instruments

Instrumentation in the high pressure portion of the core processing plant consists of the high static pressure measurement (0-2500 psi), the hydroclone differential pressure measurement (0-50 psi) and miscellaneous loop and underflow receiver temperature measuring points (0-350° C.) and the high pressure sampler pressure measurement (0-300" H₂O).

8.000 Low Pressure Instruments

Low pressure instruments in the core processing facility consists of the carrier vapor pressure cells, D₂O vapor flow elements, D₂O tank weigh cell and thermal level probe, miscellaneous temperature measuring points (0-150° C.) and the low pressure sampler pressure measurement (0-300" H₂O).

9.000 Cell Instruments

Miscellaneous variables pertaining to the Core Processing Plant Cell C are: the Cell C sump level instrument, the cell pressure instrument, the noise pickups, and the cell radiation monitoring instruments.

10.000 Valve Actuators and Panel Pushbuttons

At either side of the valve symbols on the graphic panel are an indicator light and an indicator light pushbutton. The amber light with the white bar engraved in it is used only as an indicator light to show when the valve is closed. The blue indicator light pushbutton with the arrow engraved in it is used as an indicator light to show when the valve is opened and as a pushbutton knob to actuate the valve. Depressing the blue button and turning it clockwise will actuate the valve.

11.000 Freeze Plug and Solenoid Valve Actuation and Indication

The blue indicator light pushbutton at freeze plug symbol on the graphic panel is intended to show the condition of the freeze plug. Either of two conditions will actuate the indicator light but both of these conditions must be satisfied in order for the light to be off.

Either the solenoid valve being energized or the freeze plug temperature point being too warm will cause the light to go on. The solenoid valve must be de-energized and the freeze plug temperature point must prove the freeze plug to be cold before the light will go off. The pushbutton knob actuates the solenoid valve when depressed and locked in its clockwise position. Actuation of the solenoid valve stops the flow of freon to the freeze plug.

12.000 Safety and Alarm Circuits

Instrument Drawing Q-1671-46 shows the arrangement of the safety and interlock circuits in the core processing plant. This drawing is reproduced on metal plates and is attached to the transducer rack on panel 14.

12.000 Safety and Alarm Circuits (continued)

The following explanation of the instrument interlocks is based on the memo, W. L. Carter to R. K. Adams, dated February 20, 1956, ORNL Central Files No. 56-2-9. A number of revisions in this memo have been necessitated by process changes. The following information is the latest obtainable.

12.100 Underflow Sampler

To protect the operating personnel from the excessive pressure in the underflow sampler solution chamber, switch PX-SA-2 is interlocked with switches HX-T-1-1 and HX-T-1-3 and HX-P-1-1. The action closes valves HCV-T-1-2, HCV-T-1-4 and HCV-P-1-2 when the pressure in the isolation chamber $\geq$ 10 psig. PX-T-1-1 also interlocks HX-T-1-1 and HX-T-1-3 as noted under Paragraph 12.700.

12.200 Overflow Sampler

To protect the operating personnel, from the hazards due to excessive pressure in the overflow sampler isolation chamber, switch PX-SA-1 is interlocked with switch HX-H-5-1. The action closes valve HCV-H-5-2 when the pressure in the isolation chamber $\geq$ 10 psig.

12.300 Fuel Supply System

In order to avoid a back-up of activity into the fuel supply tank T-11, pressure switches PX-C-1 and PX-C-2, which are in the low pressure system are interlocked with switches HX-T-11-1 and HX-T-11-3. The action closes valves HCV-T-11-2 and HCV-T-11-4 with a signal from either or both of these pressure switches when the pressure in the low pressure system is $\geq$ 5 psig.

12.000 Safety and Alarm Circuits (continued)

12.400 Carrier Inlet Lines

Lines 1111 and 1112 are the process solution inlet lines to Carrier C-2 and C-1 respectively, whereas, line 1116 is a jumper line between lines 1112 and 162 to permit returning an underflow receiver charge to the reactor dump tanks. To preclude inadvertent routing of an underflow receiver charge to an undesired vessel or vessels, switches HX-C-2-1, HX-C-1-1 and HX-162-1 are interlocked so that only one of these valves HCV-C-2-2, HCV-C-1-2 and HCV-162-2 can be opened at a time.

12.500 Valve HCV-937

This valve is in line 162 and is inside the reactor cell; line 162 connects the fuel dump tanks with the chemical plant fuel supply system and low pressure system. To prevent pressure and activity build-up in these areas in the case of an emergency dump of the reactor core, a pressure signal from the reactor low pressure system actuates PX-350B which closes valve HCV-937 at pressure ≥ 5 psig. The same pressure signal actuates PX-350C which interlocks switches HX-T-11-1 and HX-T-11-3 to close valves HCV-T-11-2 and HCV-T-11-4.

12.600 Chemical Plant Supply and Return Lines

In case of a catastrophic condition - such as a ruptured vessel or line - in the chemical plant high pressure equipment, the supply lines from the reactor must be closed to avoid emptying the reactor contents into Cell C. Under these conditions, pressure in the chemical plant equipment will begin to drop, therefore, switch PX-1 is interlocked with switches

12.000 Safety and Alarm Circuits (continued)

HX-1B and HX-1A. The action closes valves HCV-141 and HCV-142 at pressures ≤ 1600 psia. An automatic start-up interlock is provided to assist in putting the chemical plant on stream. At this time the high pressure system pressure will be 1250 psia. Without the start-up interlock, the 1600 psia interlock will not permit valves HCV-141 and 142 to be opened at 1200 psia. Once the high pressure system has reached 1650 psi, returning through 1600 psia will automatically close valves HCV-141 and HCV-142.

A second interlock has been provided for these valves to satisfy the following requirement: HCV-141 and HCV-142 cannot be opened without the concurrence of both the operator in the reactor and the operator in the chemical plant area. Also, their interlock is such that either of these operators can independently close these valves. HCV-141 and HCV-142 and HX-1A and HX-1B accomplish this.

12.700 Let Down Valves HCV-T-1-2

To guard against dumping the underflow receiver to the low pressure system before pressure has been reduced, switch PX-T-1-1 is interlocked with switch HX-T-1-1. The action prevents valve HCV-T-1-2 being opened if the high pressure system pressure is ≥ 50 psig.

12.800 Heater H-3

In the event that heater H-3 should be overheated, switch TIX-H-3 will shut down the heater at a temperature previously set by the operator (0 to 800° C.). The heater will auto-

12.000 Safety and Alarm Circuits (continued)

matically come on as the temperature falls below the set point. The temperature set point is adjustable at TIX-3 in the transducer rack.

12.900 Heater H-11

In the event heater H-11 should become overheated, temperature switches TIX-H-11-1 and TIX-H-11-2 will shut off the heaters as the temperature rises over the previously adjusted set point (0-1200^o C.). These heaters also will automatically come on as the temperature falls below the point set by the operator at TIX-H-11-1 and TIX-H-11-2 in the transducer rack.

13.000 Interlocks for Service Operations

TABLE I SHOWS THE SYSTEM OF INTERLOCKS FOR SERVICE OPERATIONS.

16

TABLE I

SYSTEM OF INTERLOCKS OF SERVICE OPERATIONS

<u>Line</u>	<u>Sleeve No.</u>	<u>Service</u>	<u>Valve No.</u>	<u>Action</u>
1401	CS-20-1	LPS & SC	RCV-T-12-6	Valve closes on radiation signal from either RIX-1454 (cold water drain line 1454) or RIX-T-12 (condensate to T-12); set point to be determined in field.
1402		LPS & SC	RCV-T-12-5	
1408		HPS	RCV-T-12-10	
1413		HPS	RCV-T-12-11	
1473		H ₂ O & LPS	RCV-T-12-8	
1474		H ₂ O & LPS	RCV-T-12-7	
607	CS-2-1	HPS	RCV-Cell-2-4	Valve closes by means of PX-Cell-2 when Cell C pressure reaches 12 psia
1403		H ₂ O & SC	RCV-T-12-2	Valve closes on radiation signal from either RIX-1454 or RIX-T-12; set point to be determined in field.
1404		H ₂ O & SC	RCV-T-12-1	
1411		SC	RCV-T-12-9	
1428		H ₂ O & SC	RCV-T-12-4	
1430		H ₂ O & SC	RCV-T-12-3	
1454		SC	RCV-1454	
1458	CE-20-5	H ₂ O	RCV-1458-2	Valve closes on radiation signal by means of RCV-1458-1 from RIX-1458; (water from space cooler); set point to be determined in field.
1630	CS-20-2	Freon 11	LCV-T-13-10	Valve closes by means of LX-T-13 on low F-11 level in T-13.
1633			LCV-T-13-8	
1635			LCV-T-13-7	
1637			LCV-T-13-6	
1639			LCV-T-13-5	
1642			LCV-T-13-3	
1644			LCV-T-13-1	
1652			LCV-T-13-4	
1654			LCV-T-13-11	
1657			LCV-T-13-9	
1632	CS-2-2	Freon 11	LCV-T-13-2	Valve closes on low F-11 level in T-13.

TABLE I (Continued)

Line	Sleeve No.	Service	Valve No.	Action
1501	CE-20-1	Inst. Air	PCV-Cell-2-6	Valve closes all valve air lines by means of PX-Cell-2
1502				when Cell C pressure is ≥ 12 psia.
1507				
1512				
1514				
1518				
1521				
1525				
1526				
1529				
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1534				
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1544				
1547				
1548				
1551				
1552				
1576				
1600	CE-20-5	Hot Air	PCV-Cell-2-3	Valve closes by means of PX-Cell-2 when Cell C pres. ≥ 12 psia
1601	CE-20-5	Hot Air	PCV-Cell-2-2	Valve closes by means of PX-Cell-2 when Cell C pres. ≥ 12 psia

Freon Circulating Pumps P-13 and P-14: To preclude stoppage of freon ll circulation to the freeze plugs in the event of a pump failure, switch PX-1640 is interlocked with pumps P-13 and P-14 so that P-14 which normally is idle, will be started when the system pressure drops below 65 psig. The same signal also stops P-13 which has been operating. Reset of this switch is accomplished by a pushbutton near the pumps.

Cell Vacuum Pump: A sudden release of activity in the cell could create a biological hazard in the outside atmosphere if the cell vacuum pump (Item 89a) were allowed to continue operation because this pump discharges to the stack. Therefore, the cell radiation monitor will shutdown the pump motor by means of RIX-Cell-1 as well as close valve PCV-949 in the suction line. This radiation signal will override the normal pressure signal which causes the pump to maintain cell pressure between 7.0 and 8.0 psia.

14.000 Safety Interlock and Valve Actuator Patch Panels

These patch panels have been provided to allow temporary lock out and/or change of the electrical control and interlock circuitry. The construction of the patch panel is such as to allow several functions to be accomplished:

- 1) Lock out of an interlock contact.
- 2) Jumpering of an interlock contact.
- 3) Interconnection of interlocks so that one pressure switch or radiation switch may actuate a number of solenoid valves or process block valves.

When the patch cord is fully inserted the plug and jack combination on the patch panel is designed to disconnect the patch cord from all circuits in the direction of the tail of the arrow engraved beside the patch point. The arrow head indicates the circuits to which the patch cord is always connected be it fully inserted or not. A detent mechanism engages the patch cord plug to hold it in the fully inserted position.

If it is desired to allow the patch cord to remain connected to all of the circuitry associated with the patch point, it may be withdrawn until the dente is disengaged. With the patch cord plug in this position, it is connected to both sides of the interlock circuit at that point. If it is desirable to disable or lock out any contact, a patch plug with the yellow tip may be inserted until the detent is engaged thereby interrupting the continuity of the circuit.

14.000 Safety Interlock and Valve Actuator Patch Panel (continued)

With all interlock and patch cords in full view of the operator at the panelboard, it should be simple to determine the status of the safety interlock, and valve actuation circuitry. It is anticipated that the patch and jumper panels will virtually eliminate serious operational difficulty caused by forgotten remotely jumpered or altered circuits.

I N D E X

<u>INSTRUMENT</u>	<u>SECTION</u>	<u>PAGE NO.</u>
FE-C-1	1.410	5
FE-C-2	1.410	5
HCV-C-1-2	12.400	13
HCV-C-2-2	12.400	13
HCV-H-5-2	12.200	12
HCV-P-1-2	12.100	12
HCV-T-1-2	12.100, 12.700	12, 14
HCV-T-1-4	12.100	12
HCV-T-11-2	12.300, 12.500	12, 13
HCV-T-11-4	12.300, 12.500	12, 13
HCV-141	12.600	13-14
HCV-142	12.600	13-14
HCV-162-2	12.400	13
HCV-937	12.500	13
HIC-H-3	2.300	6
HX-1A	12.600	13-14
HX-1B	12.600	13-14
HX-C-1-1	12.400	13
HX-C-1-2	12.400	13
HX-C-2-1	12.400	13
HX-C-2-2	12.400	13
HX-H-5-1	12.200	12
HX-P-1-1	12.100	12
HX-T-1-1	12.100, 12.700	12, 14
HX-T-1-3	12.100	12
HX-T-11-1	12.300, 12.500	13
HX-T-11-3	12.300, 12.500	13
HX-162-1	12.400	13
LE-C-1	1.230	4
LE-C-2	1.230	4
LE-T-2-1	1.220	3
LE-T-2-2	1.210	3
LE-Cell-1	1.230	4
PE-1	1.110	1
PE-C-1	1.130	2
PE-C-2	1.130	2
PdC-S-1	2.100	5-6
PdCV-S-1	2.100	5-6
PdE-S-1	1.120, 2.100	2, 5-6
PdY-S-1	2.100	5-6
PX-1	12.600	13-14
PX-C-1	12.300	12
PX-C-2	12.300	12
PX-SA-1	12.200	12
PX-SA-2	12.100	12
PX-T-1-1	12.100, 12.700	12, 14
PX-350B	12.500	13
PX-350C	12.500	13

I N D E X (continued)

<u>INSTRUMENT</u>	<u>SECTION</u>	<u>PAGE NO.</u>
TC-T-1	2.200	6
TE-T-1	2.200	6
TI-X-3	12.800	14-15
TI-X-H-3	12.800	14-15
TI-X-H-11-1	12.900	15
TI-X-H-11-2	12.900	15
TY-T-1	2.200	6
XE-P-1F	1.500	5
XE-P-1R	1.500	5
XE-S-1	1.500	5

I-IV AND
1-21