ENERGY NORTHWEST

INTEROFFICE MEMORANDUM

DATE: December 26, 2002

TO: Distribution: RMMoise

FROM: Procedure and Manual Control, Administrative Services, (901A)

SUBJECT: **System Training Manual**
Distribution Package 2002-743

REFERENCE:

The following Procedure(s) have been revised/approved and is to be inserted in your controlled copy of the Manual and the superseded revision is to be removed and destroyed:

Procedure	Rev	Title/Comments
Volume 1, Chapter 1	7	DC Power Distribution System
Volume 1, Chapter 4	7	Isophase Bus Duct and Cooling System
Volume 2, Chapter 3	9	Feed Water System *Replace the Text Only, No Change to Drawings*
Volume 2, Chapter 10	9	Plant Service Water
Volume 3, Chapter 8	8	Potable Water

To verify receipt and inclusion of these procedures, please sign, date and **return this receipt** within FIFTEEN (15) WORKING DAYS of the date of this IOM. Or you may FAX to me at (509) 377-2479.

Energy Northwest
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Richland, WA 99352

ATTN: Procedure Control (MD 901A)

Date ______ Signature of Manual Holder ______ Controlled Copy Number ______

Attachments
Please ensure that you are accessing the Manual Control Catalog Located under the General Information on ENNET to determine revision status

A001

System Training Manuals
Distribution List 2002-743

Copy	Name	Title	Maildrop
1	BROWN AM / CNTRL RM	SYSTEM-2	927O
3	BROWN AM / OSC	SYSTEM-2	927O
4	BOND SA / NUC TRNG LIB	SYSTEM-2	1027
6	LIBRARY / PEC	SYSTEM-2	PEC
7	BIRD SL / LIBRARY	SYSTEM-2	PE24
9	BLDG 9 LIBRARY	SYSTEM-2	909
10	NRC / RESIDENT INSPECTOR	SYSTEM-2	988C
11	MILLER M / EOF LIB	SYSTEM-2	1050
12	THOMASON SC / TSC	SYSTEM-2	964C
13	FRANCISCO BD / JIC	SYSTEM-2	1035
15	COWLEY RR / DOH	SYSTEM-2	OTHER
16	CUSHING J / NRC	SYSTEM-2	OTHER
18	BENTRUP PE / BPA	SYSTEM-2	1399
20	SUMSION IF	SYSTEM-2	917E
21	WALLI LA / LICENSING	SYSTEM-2	PE20
24	ORBETA CV	SYSTEM-2	1022
25	LOMAX JEANNETTE	SYSTEM-2	OTHER
26	ORBETA CV / RM 248	SYSTEM-2	1022
27	ORBETA CV / SIMULATOR	SYSTEM-2	1022
28	SAWYER WH	SYSTEM-2	PE30
29	ORBETA CV / RM 225	SYSTEM-2	1022
30	OUTAGE MGR / DABNEY JW	SYSTEM-2	909
31	WESTERGARD / FIN TEAM	SYSTEM-2	927S
32	SLY CD	SYSTEM-2	PE20

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COLUMBIA GENERATING STATION

SYSTEM DESCRIPTION

Volume 1, Chapter 1

DC POWER DISTRIBUTION SYSTEM

Reviewed by:	Robert R McQuoid Engineering	12-6-02 Date
Reviewed by:	J Bruce Operations	12/11/02 Date
Approved by:	[signature] Operations Training Manager	12/11/02 Date

MINOR REVISION RECORD

Minor Rev Number	Description of Revision	Affected Pages	Entered By	Effective Date	Manager Approval

TOPIC: DC POWER DISTRIBUTION SYSTEM

I. PURPOSE

The DC Power Distribution System is designed and constructed so as to reliably deliver power at the required voltages to all DC station loads. LO-5255 Purpose

II. DESIGN BASES

A. Compliance to Criteria

1. In accordance with General Design Criterion 17, IEEE Standard 308-1974 and NRC Regulatory Guide 1.6, Revision 0, redundancy and independence of DC power sources and distribution equipment is provided by the separate (Division 1 and 2) battery systems. This redundancy extends from the batteries and battery chargers through distribution panels, cabling, switchgear, and protective devices. The system provides designed redundancy to all loads except the 250 VDC loads, the main guard house 405 VDC loads, 125 VDC HPCS loads, and the 125 VDC balance of plant loads.

2. The Class 1E batteries are designed to have sufficient capacity to supply all their respective DC loads for a minimum of two (2) hours following a loss of power to their chargers coincident with a design basis accident. Testing has shown that our batteries were actually good for considerably longer than the two hours required following the loss of power to their associated chargers.

3. The HPCS DC power system is a separate and independent safety-related (Class 1E) system comprising Division 3. The Division 3 DC loads serve a separate safety function not provided by Division 1 and 2 directly. However, the ADS system supplied via Division 1 and 2 can compensate for the loss of the entire Division 3 system.

4. There are no electrical connections between the DC buses for Division 1, 2, and 3, and there is no automatic or manual transfer of load between divisions. The elimination of ties between DC systems prevents a single failure from affecting more than one division.

III. GENERAL DESCRIPTION

LO-9019 Volts & ID

A. The DC Power Distribution System adds reliability to the plant control and emergency systems due to its capacity to perform its design function for several hours following a complete loss of plant AC.

B. The Class 1E DC power systems consist of:

1. Three electrically independent and separate 125 VDC distribution systems (S1-1, S1-2, and S1-HPCS)

2. Two electrically independent and separate ±24 VDC distribution systems (DP-S0-A and DP-S0-B)

3. One 250 VDC distribution system (S2-1).

   Most of the loads supplied by the Class 1E DC power systems are separate and redundant for increased plant reliability and safety. There are no redundant electrical loads at the 250 VDC level, therefore there is only one 250 VDC system.

C. The Non-Class 1E DC power systems consist of:

1. Two 125 VDC systems in the Tower MakeUp water pumphouse (Division A; S1-3 and B; S1-4)

2. One 125 VDC balance of plant system in the Radwaste Building (S1-7)

3. One 405 VDC battery dedicated to inverter E-IN-4 located in the main guardhouse (S1-6)

Loads on the Non-Class 1E 125 VDC power systems consists of switchgear control power, small DC valve motive power and instrumentation.

D. Each DC distribution system has a battery and a battery charger that are normally connected to the bus such that these two sources of power are operating in parallel. The charger is normally supplying system electrical loads with the battery on a float charge. The Security 405 VDC battery is unique because its only load is inverter E-IN-4.

E. The DC Distribution system provides power for emergency lighting for the Control Room, Remote Shutdown room and stairwell in between, in the event there is a loss of all AC lighting systems.

F. Float and Equalizing charges.

The purpose of a "float" charge is to keep the battery at normal operating voltage. The "equalizing" charge, often defined as a controlled overcharge, is an extended period of charge (several hours to many days) to aid in removing all the sulfate on the plates built up during a discharge. The equalize charge also ensures that the individual cells within the battery are fully charged, equal to one another, and that the electrolyte is stirred up by the gassing of the cells.

IV. COMPONENT DESCRIPTION

A. Batteries (Figure 13)

1. Each battery has the necessary amp-hour discharge capacity to sustain system loads for a minimum of two hours. For the Class 1E batteries, this capacity is specifically for a loss of power to the charger coincident with a design basis accident. The batteries have capacity to carry designed load at 60°F without decreasing battery voltage below 1.81 volts/cell (1.75 volts/cell for 24 VDC) with loss of output from the battery chargers during the specified period. Battery capacity is sufficient to provide starting currents while operating at full load.

2. The DC Power Distribution system consists of lead-calcium type batteries. The battery cells are constructed to retard corrosion, withstand overcharging, and maintain structural integrity during a seismic event. Negative plates will have a life equal to, or greater than, the positive plates, and each battery will have a minimum rated life expectancy of twenty years. Each battery will be enclosed in a sealed container fitted with spray proof vent plugs, and each container is of sufficient size to prevent undue compression of the plates in the container.

3. Insulation between plates is of a microporous rubber. Each terminal post is designed to handle the current capacity of each unit. Nominal specific gravity is 1.215 at 77°F.

4. Each container is designed for sufficient capacity to collect sediment to preclude cleaning during its design lifetime.

5. All battery systems are mounted on two step steel battery racks designed to meet the seismic condition of the specific battery system. Each battery cell has high and low electrolyte level marks.

6. The 250 VDC and 125 VDC Power Distribution systems have a blown fuse indicator and alarm on the fuse that separates the battery and the main power distribution panel. The indicator is located within the associated battery fuse box in the battery room and alarms in the main control room.

B. Battery Chargers

1. The battery chargers for the 250 VDC and 125 VDC system operate ungrounded. The 24 VDC system has two (2) 24 VDC batteries in series with the center point grounded for a ± 24 VDC system.

2. The chargers are the static type with self-regulating silicon rectifier elements. They are constant voltage, fully automatic with solid

state control circuits. The chargers are designed to maintain 2.25 volts/cell float charge and 2.40 volts/cell equalizing charge while maintaining DC system load. Separate controls are provided for float and equalizing modes. However, the equalizing potentiometer can be adjusted down to float voltage or the float potentiometer can be adjusted up to equalize voltage if needed.

3. An AC input voltage is applied to the full-wave bridge circuit of the charger through its power transformer. The bridge has two (2) silicon power rectifiers and two (2) thyristors. The thyristors provide rectification and serve as phase controlled elements. The output voltage of the bridge is fed through a filter circuit to the DC output terminals. The output current is limited to 115 to 125% of rated output current by a current limiting circuit.

4. The chargers are designed to have sufficient capacity to recharge the connected batteries from their design minimum values to their fully charged values within 24 hours while supplying normal connected loading.

5. Battery charger alarm contacts are designed to open on an alarm condition. Each charger is equipped with a loss of AC relay (74) on the AC input and an undervoltage relay (27) on the DC output which activates an annunciator in the main control room. In addition, each charger has 2 DC overvoltage relays (59) to provide activation of an annunciator in the main control room and at a higher voltage; a shunt trip of the output breaker (see Figure 10).

6. The charger cabinet is a metal-clad enclosure, floor mounted, self-supporting, dead-front, and hinged. The cabinets are designed for convection cooling.

C. DC Motor Control Centers (125 VDC, 250 VDC)

1. The DC motor control centers are a group of combination starters and other control and protective devices. Each unit is designed to meet seismic and quality requirements. A common horizontal power bus runs throughout the top of each cabinet with separate vertical bus to which each starter and other apparatus are connected.

2. Each control center is a series of critical sections joined together to form a free standing and completely enclosed dead front unit capable of future expansion in either direction. The motor control centers are constructed with terminal blocks located in each compartment controlling an outgoing circuit. Incoming power cables and outgoing motor and branch circuits enter and/or exit from the top of each motor control center. Adequately sized vertical and horizontal wiring troughs are provided. The horizontal wiring trough is located at the top of the cabinet.

3. All combination starters are no smaller than NEMA 1. These starter units are the combination type, with fusible switches and magnetic contactors. Each starter unit has provisions for connecting the vertical bus by means of self-aligning silver plated stab-on connectors. Each starter unit is designed to accurately guide the stab-on connectors from the withdrawn position to the connected position.

4. Reduced voltage starters are used to start system loads (motors) and bring them up to rated speed gradually. A resistor is present in the starting circuit to reduce current to the motor during starting. In a point acceleration, the contacts from a timing relay close and the resistance is reduced to allow motors to come to full speed. In a multi-point acceleration, timing relays reduce resistance in steps before rated conditions are obtained. Timing of the points of accelerations are controlled by pneumatic time relays.

5. Each 125 VDC and 250 VDC motor starter is equipped with an undervoltage relay (27) on the motor side of the disconnect switch monitoring power to the motor. This relay disconnects power to the control circuit and opens the motor contactor when power to the motor is lost. This feature also allows safe entry into the motor starter by de-energizing the starter control circuits when the disconnect is opened.

6. Magnetic contactors are capable of picking up at 60% and dropping out at 20% of nominal coil voltage and are equipped with thermal overload elements. The magnetic contactors will stand 110% of rated voltage continuously. Each contactor has two normally open, and two normally closed sets of auxiliary contacts in addition to starter seal-in contacts. Fused disconnect switches used in combination starters are two pole, single throw, manually operated with quick-make, quick-break mechanisms. Fuses are current limiting rated interrupting capability of 100,000 amps RMS symmetrical fault at rated voltage. Fusible switches have external operating handles with interlock requiring handle to be in OFF position before door can be opened and a defeater arrangement,

bypassing the interlock, for access for line-circuit. Switch can be locked into either CLOSED or OPEN position with provision for three padlocks.

D. DC Distribution Panels

1. The DC Distribution panels are dead-front, surface mounted, enclosed cabinets with fusible switches. Each panel contains lugs, mains and ground buses per contract drawings. Each panel is equipped with a ground lug welded to the panel. Individual fusible switches can be removed, replaced, or installed on the panel without disturbing adjacent switches or without disturbing the main bus or branch circuit connections.

2. Fusible switches are the heavy duty, quick-make, quick-break type. Panels are rated for 5,000 amps RMS interrupting capacity. Breakers for the 250 VDC are rated 10,000 amps RMS symmetrical interrupting capacity.

3. The DC distribution panels at the TMU Pumphouse have provisions for a locally mounted ground detection relay, lights, and test pushbuttons.

E. Battery and Charger Data

1. Division 1 and 2 125 VDC (Figure 1, 14 and 14a)

   a. Each **Division 1 and 2 battery (B1-1, B1-2)** has 58 cells with a capacity of 1190 amp-hours and is capable of supplying power for at least two hours to their respective safe shutdown loads without the use of the associated battery charger.

   b. Each **Division 1 and 2 charger (C1-1A, C1-1B, C1-2A, C1-2B)** is sized to carry normal and postaccident steady dc loads, while simultaneously recharging the battery from its discharged state (1.81-V per cell) to its fully charged state (charging current has stabilized) within 24 hr. The battery chargers receive 480-V ac input power from their respective Divisions 1 and 2 480-V MC-7A and 8A. For each division, one charger will be on line while the other will normally be available for service if the on-line charger fails or has to be removed from service. The chargers are rated 200 amps dc output. The old 125 V dc charger E-C1-1, (formally Division 1) is disconnected and spared in place for use as temporary power.

   c. Normal **Division 1 and 2 DC load** is less than 128 amps.

2. Division 3 125 VDC System, HPCS (Figure 2 and 13)

   a. **The HPCS 125 VDC battery (B1-HPCS)** has 58 cells with a capacity of 100 amp-hours and is capable of operating required essential loads for a LOCA condition or any other emergency shutdown for at least two hours without any aid from the charger.

   b. **The HPCS 125 VDC charger (C1-HPCS)** is supplied by power panel MC-4A. It is rated at 50 amps DC and is capable of carrying the largest combined demand of the various direct current system loads while simultaneously recharging the battery from 1.81 volts/cell to full charge within 24 hours.

3. ± 24 VDC (Div. 1 and 2) Systems (Figure 3 and 17)

   a. **Each 24 VDC division** has two 12-cell 24 volt banks **(B0-1A & 1B, B0-2A & 2B)** connected in series with common point grounded. In the event of a loss or interruption of charger 24 VDC (plus or minus) output, the batteries will maintain power to their respective DC systems. The capacity of each battery is 150 amp-hours at an 8 hour rate.

   b. **Each 24 VDC charger (C0-1A & 1B, C0-2A & 2B)** is capable of carrying the largest combined demand of the various steady state DC loads while simultaneously restoring the battery from 1.75 volts/cell to its rated voltage in 24 hours. The 24 VDC charger is rated at 25 amps and is powered by PP-7A and PP-8A for Division 1 (CO-1A, CO-1B) and Division 2 (CO-2A, CO-2B) respectively.

   c. **Total 24 VDC loads** are 15 amp (Div. 1) and 17 amps (Div. 2).

4. 250 VDC Division 1 System (Figure 4, 15)

   a. **The 250 VDC battery (B2-1)** is capable of supplying all DC power required to safely shutdown the plant and/or to limit the consequences of a design basis accident for at least two hours. The battery consists of two 116 cell batteries in parallel and has a discharge capacity of 2380 amp-hours at an 8 hour rate to 1.81 volts/cell.

b. The **250 VDC charger (C2-1)** is capable of carrying the largest combined demand of the various steady state loads while simultaneously restoring the battery from its discharged state (1.81 volts/cell) to its fully charged state in 24 hours. 250 VDC Charger C2-1 is rated at 400 amps and is powered from MC-7A.

5. Main Plant 125 VDC (Non-Class 1E) System (Figure 5 and 16)

   a. **Main Plant Battery (B1-7)** has 58 cells with a capacity of 1190 amp-hours at an 8-hour discharge rate down to 1.81 volts/cell.

   b. **Main Plant Battery Charger (C1-7)** is similar to the Division 1 and 2 125 VDC battery chargers C1-1 and C1-2. It is powered from MC-6B.

6. TMU Pumphouse 125 VDC System (Figure 6)

   a. **TMU Pumphouse batteries (B1-3 and B1-4)** are rated for 100 amp-hours on an 8-hour discharge rate.

   b. **TMU Pumphouse chargers (C1-3 and C1-4)** are rated at 25 amperes and are powered from SM-72 through MC-7R and SM-82 through MC-8R respectively.

7. Security 405 VDC System (Figure 7)

   The **Security Battery (B1-6)** consists of 180 cells at 2.25 volts/cell with a 1-hour capacity of 620 amps to a minimum of 1.75 volts/cell. There is no separate battery charger for the Security DC System. Battery B1-6 is charged by inverter IN-4 internal charger-rectifier.

F. Emergency DC Lighting Systems

1. **125 VDC emergency lighting** (incandescent) is provided in the Main Control Room, in the access route from the Main Control Room to the Remote Shutdown (RSD) Room (Stair A-7), in the RSD Room and in the Main Guardhouse. The lighting is powered from Division 1 and 2 125 VDC. 125 VDC emergency lighting is normally on in all areas except for the Main Control Room. A loss of DIV 1 or DIV 2 normal AC lighting results in energizing the Main Control Room 125 VDC emergency lighting of the same division (see Figure 12). When DIV 1 or DIV 2 normal AC lighting is restored, the associated division 125 VDC emergency lighting is de-energized. LO-5258 CR Emerg lighting

2. **Battery powered emergency lighting (incandescent) is provided for: 1) areas and access routes to those areas that contain controls that are vital for the safe shutdown of the reactor and 2) areas that need lighting for plant personnel to safely exit the plant. Safe shutdown related emergency lighting has an 8 hour capacity and is seismically restrained in seismic areas. Plant egress related emergency lighting has a 1.5 hour capacity.**

LO-5259 Battery pack purposes

a. Areas with Safe Shutdown emergency lighting include:

1) In the Control Room

2) Stair A-7 from the Control Room to the RSD Room

3) In the RSD Room

4) At the Alternate RSD Panel in SM-7 SWGR Room

5) At the FRTS SWGR in SM-8 SWGR Room

6) Access route to #2 DG, DG Corridor (el. 441')

7) Reactor Building 522' South and East passage areas

8) Reactor Building 548' South passage area

9) Reactor Building 572' South passage area

10) Reactor Building SW Stairwell (A-6)

11) Radwaste Building 525' near Chillers and Division 2 HVAC

b. Areas with plant egress emergency lighting include:

1) #2 RPS room

2) ECCS equipment rooms (el. 420' and 441')

3) RCC pump area (el. 548')

4) Non-vital 4160 VAC SWGR area (TB el. 471)

5) DG Bldg

6) Standby Service Water pumphouse 1 and 2

7) Circulating Water Pumphouse

8) Technical Support Center (TSC)

G. Ground Detection System (Figure 8, 8A, 8B and 18)

1. DC distribution system busses S2-1, S1-1, S1-2 and S1-7 have provisions for remotely mounted (Bd. C) ground detection relays, meters, test switches and reset pushbuttons. Each ground meter indication on Board C is a milliampere meter, but indicates in "ohms". Normally when no ground exists there is no current flow through the ground detection meter because there is not a complete path for current to flow from one side of the battery through ground to the other side of the battery.

2. A 10 KΩ test ground can be placed on either the Negative or Positive side of a DC Bus by use of the Ground Detector Test Switch located inside the back of Board C. The Test switch positions are POS, OFF, and NEG with a spring return to OFF from either of the two other positions. Below each test switch is a reset pushbutton used to reset the ground alarm for the respective DC system.

3. When a Neg ground is introduced to the system with the test switch, current flows from the negative terminal of the battery to the 10 KΩ resistor R2, through the test switch, the Ground meter and alarm relay (left to right flow) to the positive terminal of the battery. This results in a reading of negative 10 KΩ on the ground meter and a ground alarm.

   LO-5261 Explain function

   When the test switch is released to OFF, the ground meter indication returns to mid scale (infinity), and the reset pushbutton must be depressed to allow the ground alarm to be reset.

4. Similarly, when a POS ground is introduced to the system with the test switch, current flows from the positive terminal of the battery to the 10 KΩ resistor R1, through the test switch, the Ground meter and alarm relay (left to right flow) to the negative terminal of the battery. This results in a reading of positive 10 KΩ on the Ground meter and a ground alarm.

5. If a ground is severe enough (@ 15 KΩ) a ground alarm will annunciate for the respective bus. Reset the ground alarm by depressing the ground reset pushbutton for the respective bus in the back of Board C.

6. Three DC distribution busses have provisions for a locally mounted ground detection relay, lights, and test pushbuttons (S1-3, S1-4 and S1/HPCS). These ground relays protect the system against double ground faults. Detection of the ground fault is provided by the 64 relay, ground fault detector, and the two lights. The lights are normally lit and connected in such a manner that

when any ground develops, the light connected to the grounded polarity goes off. The 64 relay coil is connected at the center point of the two lights (voltage dividing circuit) and ground.

Normally, the voltage divider receives full bus voltage and the 64 relay coil is de-energized. When a ground fault develops, the coil of the 64 relay receives adequate voltage to energize the relay coil. In order to "reset" the ground once it has been cleared, the operator must depress the associated ground alarm reset pushbutton. Test pushbuttons are also provided to check operation of the ground detection system

V. CONTROL THEORY AND INTERLOCKS

A. Control Room Controls

1. **Ground Detector Test Switch*** — Figure 18
   3-position switch; POS-OFF-NEG (Spring return to OFF)

   POS - Places a 10 KΩ test ground on the positive DC Bus which results in a +10 KΩ ground indication on the associated ground meter and activates the associated DC Bus ground annunciator.

   OFF - Normal position of the Test Switch; all test grounds removed from the Ground detector circuit. Ground meter indication should return to center (infinity) as long as an actual ground does not exist.

   NEG - Places a 10 KΩ test ground on the negative DC Bus which results in a -10 KΩ ground indication on the associated ground meter and activates the associated DC Bus ground annunciator.

2. **Reset Pushbutton***

   RELEASED - The ground detector alarm circuit is enabled.

   DEPRESSED - The associated DC bus ground alarm is reset.

   * These controls are located within Board C (in back) and there is a test switch and reset pushbutton for S2-1, S1-1, S1-2 and S1-7 DC Busses.

3. **S1-3 and S1-4 has local Test Switches, Reset Pushbuttons and Ground Indication lights**

4. **24 VDC Division 1 Monitor Selector (Bd C)** 2-position switch; 1A - 1B

   1A - Selects C0-1A and B0-1A amp indication on C0-1A/1B and B0-1A/1B ammeters next to switch.

   1B - Selects C0-1B and B0-1B amp indication on C0-1A/1B and B0-1A/1B ammeters next to switch.

5. **24 VDC Division 2 Monitor Selector (Bd C)** 2-position switch; 2A - 2B

   2A - Selects C0-2A and B0-2A amp indication on C0-2A/1B and B0-2A/1B ammeters next to switch.

   2B - Selects C0-2B and B0-2B amp indication on C0-2A/1B and B0-2A/1B ammeters next to switch.

B. Local Controls

1. **Battery Charger Controls:** Figures 15 – 17
(C2-1, C1-7, C0-1A, C0-1B, C0-2A, C0-2B)

Each battery charger has similar controls; a 0 – 120 hr Timer, FLOAT and EQUALIZER adjusting screw and toggle switch.

0 – 120 hr Timer	When moved from the 0 hr. position, it sets charger output to EQUALIZER voltage until the timer automatically returns to 0 hr. then returns to FLOAT voltage. This Timer NOT normally used.	
FLOAT adjust	Used to set float voltage (normally; 261 ±1 VDC for 250 VDC 130.5 ±1 VDC for 125 VDC and 27 ±.2 VDC for 24 VDC systems.)	
EQUALIZER adjust	Used to set equalizer voltage (normally 279 ±1 VDC for 250 VDC 139.2 ±1 VDC for 125 VDC and 27.9 ±.2 VDC for 24 VDC systems.)	LO-15128 LO-15129 LO-15131
Toggle switch	Selects either FLOAT or EQUALIZER voltage	Float/ Equalizer switches

2. **Battery Charger Controls and Alarms lights:** Figure 14 & 14a
(C1-1A, C1-1B, C1-2A, C1-2B)

Each battery charger has identical controls; a FLOAT and EQUALIZER pushbutton and associated FLOAT and EQUALIZER potentiometer.

FLOAT adjust	Used to set float voltage (normally 130.5 ±1 VDC)	
EQUALIZER adjust	Used to set equalizer voltage (normally 139.2 ±1 VDC)	LO-15128 LO-15129 LO-15131
FLOAT pushbutton	Selects FLOAT voltage	Float/ Equalizer controls
EQUALIZER pushbutton	Selects EQUALIZER voltage	

"FAN FAILURE" red lamp	ON when either of the two fans speed drops below centrifugal switch setpoint
"FLOAT" green lamp	ON when charger is in float mode
"CHARGER FAILURE" red lamp	ON when one of the following is ON: 1) DC output undervoltage 2) one phase of AC power failure
"EQUALIZE" yellow lamp	ON when charger is in equalize mode
"CHARGER FUSE BLOWN" red lamp	ON when one of fuses 331, 332 or 332 (AC input to SCRs) have blown
"DC OUTPUT OVERVOLTAGE" red lamp	ON when output is above 141.0 +/- 0.5 volts
"DC OUTPUT UNDERVOLTAGE" red lamp	ON when output is below 127.0 +/- 0.5 volts
"AC POWER FAILURE" red lamp	ON on loss of AC input voltage
"COMMON ALARM" red lamp	ON when one of the following is ON: 1) charger failure 2) DC output overvoltage 3) DC output undervoltage 4) Fan failure 5) Charger fuse blown 6) AC power failure

3. **Battery Charger Controls - C1-HPCS**

This battery charger is different than the other DC chargers in that it does not have a toggle switch to select FLOAT or EQUALIZER voltages. EQUALIZER voltage is manually selected (without automatic timing) by turning the 0 – 24 hr Timer to the HOLD position.

0 – 24 hr Timer	When moved from the 0 hr. position, it sets charger output to EQUALIZER voltage until the timer automatically returns to 0 hr. then returns to FLOAT voltage. When moved to the HOLD position, this sets charger output to EQUALIZER voltage until the timer is manually turned to the 0 hr. position.	LO-15130 Float/ Equalizer Timer
FLOAT adjust	Used to set float voltage (normally 130.5 ±1 VDC)	
EQUALIZER adjust	Used to set equalizer voltage (normally 139.2 ±1 VDC)	

VI. INSTRUMENTATION AND ALARMS

A. Instrumentation

1. Board C

Function	Range
Bus S1-1	
125 VDC Battery Charger C1-1 Amps DC	0 - 300
125 VDC Battery B1-1 Amps DC	200 - 0 - 1000
125 VDC Dist. Panel S1-1 Volts	0 - 150 volts
125 VDC Bus S1-1 Ground	-0 KΩ - ∝ - +0 KΩ
Bus S2-1	
250 VDC Battery Charger C2-1 Amps DC	0 - 500
250 VDC Battery B2-1 Amps DC	600 - 0 - 1200
250 VDC Dist. Panel S2-1 Volts	0 - 300 volts
250V DC Bus S2-1 Ground	-0 KΩ - ∝ - +0 KΩ
24 VDC DIV 1	
* CO-1A (1B) AMPS DC	0 - 50
* BO-1A (1B) AMPS DC	10 to 0 to 40
SO-A VOLTS	0 - 30 volts

Bus S1-2

125 VDC Battery Charger C1-2 Amps DC	0 - 300
125 VDC Battery B1-2 Amps	200 - 0 -1000
125 VDC Dist. Panel S1-2 Volts	0 - 150 volts
125 VDC DC Bus S1-2 Ground	-0 KΩ - ∝ - +0 KΩ

Bus S1-7

Charger C1-7 Amps DC	0 - 300
Battery B1-7 Amps DC	200 - 0 –1000
Bus S1-7 Volts DC	0 - 150 volts
125V DC Bus S1-7 Ground	-0 KΩ - ∝ - +0 KΩ

24 VDC DIV 2

* CO-2A (2B) AMPS DC	0 - 50
* BO-2A (2B) AMPS DC	10 to 0 to 40
SO-B VOLTS	0 - 30 volts

* A two-position Selector Switch for each Division is used to select between 1A and 1B, and between 2A and 2B.

2. Local

Function	Location	Range
250 VDC Battery Charger C2-1 Amps	C2-1	0 - 500
250 VDC S2-1 Dist. Panel Amps	S2-1	600 - 0 – 1200
250 VDC Battery Charger C2-1 VDC	C2-1	0 - 300
125 VDC Battery Charger C1-1A(B) Input Amps	C1-1A(B)	0 - 100
125 VDC Battery Charger C1-1A(B) Output Amps	C1-1A(B)	0 - 300
125 VDC Battery Charger C1-1A(B) Input Volts	C1-1A(B)	0 - 600
125 VDC Battery Charger C1-1A(B) Output Volts	C1-1A(B)	0 - 150
125 VDC Main Dist. Panel S1-1 Amps	S1-1	200 - 0 – 1200
125 VDC Battery Charger C1-2A(B) Input Amps	C1-2A(B)	0 - 100
125 VDC Battery Charger C1-2A(B) Output Amps	C1-2A(B)	0 - 300
125 VDC Battery Charger C1-2A(B) Input Volts	C1-2A(B)	0 - 600
125 VDC Battery Charger C1-2A(B) Output Volts	C1-2A(B)	0 - 150
125 VDC Main Dist. Panel S1-2 Amps	S1-2	200 - 0 – 1200

Function	Location	Range
125 Batt. Chg. C1/HPCS DC Amps	HPCS-C1	0 - 75
125 Batt. Chg. C1/HPCS DC volts	HPCS-C1	0 - 200
125 VDC Battery Charger C1-3 Amps	C1-3	0 - 300
125 VDC Dist. Panel S1-3 Amps	S1-3	0 - 1200
125 VDC Battery Charger C1-3 Volts	C1-3	0 - 150
125 VDC Dist. Panel S1-3 Volts	S1-3	0 - 150
125 VDC Battery Charger C1-4 Volts	C1-4	0 - 150
125 VDC Dist. Panel S1-4 Volts	S1-4	0 - 150
125 VDC Battery Charger C1-4 Amps	C1-4	0 - 300
125 VDC Dist. Panel S1-4 Amps	S1-4	0 – 1200
24 VDC Battery Charger C0-1A Amps	C0-1A	0 - 50
24 VDC Battery Charger C0-1B Amps	C0-1B	0 - 50
24 VDC Batt. Chg. C0-1A DC volts	C0-1A	0 - 30
24 VDC Batt. Chg. C0-1B DC volts	C0-1B	0 - 30
24 VDC Power Panel DP-S0-A Volts	DP-SO-A	0 – 75
24 VDC Power Panel DP-S0-A Volts	DP-SO-A	0 – 75
24 VDC Battery Charger C0-2A Amps	C0-2A	0 - 50
24 VDC Battery Charger C0-2B Amps	C0-2B	0 - 50
24 VDC Batt. Chg. C0-2A DC volts	C0-2A	0 - 30
24 VDC Batt. Chg. C0-2B DC volts	C0-2B	0 - 30
24 VDC Power Panel DP-S0-B Volts	DP-SO-B	0 – 75
24 VDC Power Panel DP-S0-B Volts	DP-SO-B	0 - 75
TG-EOP-1, Main Turb. EOP	MC-S2-1B	0-1000

B. Alarms

NOTE: See Associated Annunciator Procedures for the current setpoints.

Drop #	Annunciator Title
1. P601	
A1-4.1	125 VDC BATTERY HPCS BI BUS UNDERVOLTAGE
A1-4.2	125 VDC BATTERY HPCS BI BUS TROUBLE
A1-4.3	HPCS 125 VDC BATT CHARGER C1-HPCS TROUBLE
2. P603	
A7-1.1	ANNUNCIATOR 125 VDC LOSS
3. Board B	
B1-10.7	ANNUNCIATORS 125 VDC LOSS
4. Board C	
C1-1.3	BUS 7 CONTROL POWER UNDERVOLTAGE
C1-3.7	24 VDC CHARGER C0-1A TROUBLE
C1-4.7	24 VDC CHARGER C0-1B TROUBLE
C1-5.7	24 VDC BATTERY FUSE BLOWN
C1-7.4	250 VDC CHARGER C2-1 TROUBLE
C1-8.2	125 VDC BATTERY B1-1 GROUND
C1-8.4	250 VDC BATTERY B2-1 GROUND
C1-8.7	ANNUNCIATORS 125 VDC LOSS
C1-9.2	125 VDC CHARGER C1-1A/1B TROUBLE
C1-9.4	250 VDC LOSS BATTERY B2-1 FAILURE
C1-10.2	125 VDC LOSS BATTERY B1-1 FAILURE
C1-10.3	125 VDC DIVISION 1 OUT OF SERVICE
C1-10.4	250 VDC DIVISION 1 OUT OF SERVICE
C1-10.7	24 VDC DIVISION 1 OUT OF SERVICE

C5-1.3	BUS 8 CONTROL POWER UNDERVOLTAGE
C5-5.7	125 VDC CHARGER C1-7 TROUBLE
C5-6.7	125 VDC BATTERY B1-7 GROUND
C5-7.4	24 VDC BATTERY BLOWN FUSE
C5-7.7	125 VDC LOSS BATTERY B1-7 FAILURE
C5-8.2	125 VDC BATTERY B1-2 GROUND
C5-8.4	24 VDC CHARGER C0-2A TROUBLE
C5-9.2	125 VDC CHARGER C1-2A/2B TROUBLE
C5-9.4	24 VDC CHARGER C0-2B TROUBLE
C5-9.7	ANNUNCIATORS 125 VDC LOSS
C5-10.2	125 VDC LOSS BATTERY B1-2 FAILURE
C5-10.3	125 VDC DIVISION 2 OUT OF SERVICE
C5-10.4	24 VDC DIVISION 2 OUT OF SERVICE

5. **P672**

A9-3.1	ANNUNCIATOR 125 VDC LOSS

6. **Board M**

M-7.5	TOWER MAKEUP DC CHARGER "A" TROUBLE
M-7.6	TOWER MAKEUP DC CHARGER "B" TROUBLE

VII. SYSTEM OPERATIONAL SUMMARY

A. Normal Operation

Each charger in the DC Power Distribution system receives AC input voltage from its respective AC power source. The chargers convert the AC input to a DC output voltage and current. This DC output from the chargers supplies power to the DC Motor Control Centers and DC Power Distribution Panels and supplies float and equalizing voltage to its respective battery.

The battery chargers supply a DC voltage of sufficient potential to maintain a 2.25 volts/cell float charge on the batteries. The equalizing charge (when performed) is 2.40 volts/cell and is continued until a specific gravity of 1.215/cell at 77°F on the pilot or low cell is observed. During normal operations, the batteries will supply power to the system should any heavy, transient load be rejected by the battery charger operating in an otherwise normal mode.

B. Abnormal Operation

1. Battery Chargers

With the battery chargers in a system removed from operation by tripping or maintenance, the associated batteries would assume the loads automatically and supply power until battery capacity was depleted (2 hour minimum by design).

2. Batteries

If the batteries are removed from service, the system would not be affected as the battery chargers normally handle the power loading. However, with the batteries not operable, the load rejected by a battery charger during a heavy transient condition will not cause the charger to trip, only over voltage will. Since the charger has a current limiting circuit, the charger would not be capable of supplying more power. The equipment causing the transient conditions would not be able to start (pump and valve motors) or operate at lower power levels (light, relays, instruments if within operational level tolerances).

3. DC Distribution System

With either the chargers or the batteries supplying power, the DC Distribution system will distribute the load to the DC Motor Control Centers and DC Power Distribution Panels. If a feed to any DC Distribution System component is interrupted, all power to that component is lost until the cause of the interruption is corrected. There are no transfer or tie points to an auxiliary DC power source. It should be noted, however, that design for the 125 VDC and 24 VDC systems allow for redundancy. The 250 VDC system does not have redundancy, as this system does not have any redundant, essential components.

C. Emergency Operation

1. Battery Chargers

During loss of normal power, the battery chargers do not supply power to the connected DC load system. Emergency AC input power is supplied to chargers C2-1, C1-1, C1-2, C0-1A, C0-1B, C0-2B automatically from the emergency diesel generator. Chargers C1-3 and C1-4 are on bus supplied by SM-72 and SM-82. However, feeders to these chargers via MCCs 7R and 8R open during AC power loss and must be reclosed manually.

The 24 VDC and 125 VDC systems provide for redundancy of essential components. Therefore, should a system fail, its redundant system will provide power to its engineered safeguard system during LOCA. The 250 VDC system does not have any essential components, and therefore, no redundant 250 VDC system.

2. Batteries

Upon loss of AC input voltage to the battery chargers, the charger associated battery system will assume the connected load until the chargers are fed by power from the backup source (diesel generator). Upon resumption of normal service by the chargers, the batteries will start to recharge to pre-power loss levels. Recharge time will vary depending on how long the load was assumed by the batteries.

3. Loss of DC buses

<u>Loss of S2-1</u>

LO-7657 250 VDC failure effects

a. IN1 Continues to operate but lose "Normal DC". AC source (MC-7A) should automatically carry the load.

b. RCIC Will NOT start. However, if RCIC is running when S2-1 is lost, RCIC will remain on line with flow control still available. Manual trip using the trip pushbutton is also possible. Power and indication is lost to: RCIC-V-1, 13, 19, 22, 59, 45, 69 and RCIC-P-2 & 4. Indication is lost due to a "27 UV" relay on each component's 250 VDC supply that de-energizes 125 VDC control power upon loss of 250 VDC.

c. RHR Continues to operate but lose power to RHR-V-8 and 23.

d RFW Continues to operate but lose power to both RFP Emergency Oil Pumps.

e. Main Turbine Continues to operate but lose power to Emergency Oil Pump and Air Side Seal Oil Backup pump.

f. RWCU Continues to operate, but lose pwr to RWCU-V-4.

Overall effect on plant from 100% power:

Plant continues to operate but with loss of RCIC initiation and Emergency Oil pumps capability.

<u>**Loss of S1-1**</u>

a.	IN3	Continues to operate but lose "Normal DC". AC source (MC-7A) should automatically carry the load.	LO-7652 S1-1 failure effects
b.	RCIC	Cannot be started and will trip if running. Indication and control is lost to over 2/3 of the RCIC controls on P601. RCIC trips following loss of 125 VDC due to mech. overspeed because of the bias set on the EGR controller causing the Gov valve to fully open. RCIC could be operated by locally resetting the trip and opening and positioning the Throttle valve manually to control speed/flow.	
c.	RHR	RHR-P-2A cannot be started but would remain running if previously started. Lose initiation logic control power, control/indication to RHR pump "A" and RHR-V-40. Lose position indication for V-73A & 74A.	
d.	LPCS	LPCS-P-1 cannot be started but would remain running if previously started. Lose control/indication to LPCS pump.	
e.	ADS & SRVs	Prevents operation of ADS SRVs from Div 1 logic and prevents opening SRVs manually from P601 or automatically in "relief" mode.	
f.	DG1	Can't start DG1. Can't emergency trip from Control room. If previously started, DG1 would continue running, but at full load (due to mech. gov. setting) and supplying voltage but unable to control it.	
g.	ATWS/ARI	Prevents operation of Div 1 valves. Lose indication/control.	
h.	SM7	Lose indication/control of all breakers on SM-7 except 75/72.	
i.	RPS	If a full scram signal occurred; Backup Scram solenoid CRD-SPV-110A (ND) would not energize and amber Backup scram lights for Div 1 would remain de-energized.	
j.	RRC	RRC pumps continue to run normally. No effect on ability to change power with flow. Lose indication/control of CB-RPT-3A and 4B.	

Loss of S1-1 (cont'd)

k. FWLC — No effect on RPV level, however Narrow Range "C" RPV level indicator fails downscale. Also, a Channel "C" Level 8 trip would be received following restoration of power (which could be reset).

l. CR Annunciators — Lose all annunciators on OG panel except that you receive the "ANNUNCIATOR 125 VDC Loss" alarms on P672-A9 3-1.

m. CAC — Lose indication/control of Div 1 CAC.

Overall effect on plant from 100% power:

Plant operation continues but operation of Div 1 equipment is severely limited.

Additional plant responses:

Lose indication/control of:

RCC-P-1A

RCC-V-6 (however, valve auto-closes following power restoration!)

SW-P-1A

CRD-P-1A

RWCU-V-4 (motor is 250 VDC but uses 125 VDC control power)

Remote S/D panel controls for RCIC

Alternate Remote S/D panel controls SRVs, RHR and SW loop A

<u>Loss of S1-2</u>

LO-7653

S1-2 failure effects

a. IN2 — Continues to operate but lose "Normal DC". AC source (MC-8A) should automatically carry the load.

b. RCIC — Minimal effect; lose control/indication of RCIC-V-113 (Vac bkr isol), V-25 (Stm drain) and V-4 (Cond pmp disch).

c. RHR — RHR-P-2B and 2C cannot be started but would remain running if previously started. Lose initiation logic control power, control/indication to RHR "B and C" pumps. Lose position indication for V-73B & 74B.

d. ADS & SRVs — Prevents operation of ADS SRVs from Div 2 logic.

e. DG2 — Can't start DG2. Can't emergency trip from Control room. If previously started, DG2 would continue running, but at full load (due to mech. gov. setting) and supplying voltage but unable to control it.

f. ATWS/ARI — Prevents operation of Div 2 valves. Lose indication/control.

g. SM8 — Lose indication/control of all breakers on SM-8 except 85/82.

h. RPS — The Inbd Scram Disch Volume drain (V-11) would close (due to CRD-SPV-186 de-energizing). If a full scram signal occurred; Backup Scram solenoid CRD-SPV-110B (ND) would not energize and amber Backup scram lights for Div 2 would remain de-energized.

i. RRC — RRC pumps continue to run normally. No effect on ability to change power with flow. Lose indication/control of CB-RPT-3B and 4A..

Loss of S1-2 (cont'd)

j. FWLC	No effect on RPV level, however Narrow Range "B" RPV level indicator fails downscale. Also, a Channel "B" Level 8 trip would be received following restoration of power (which could be reset).
k. CR Annunciators	Lose all annunciators on P601, 602 and 603 except that you receive the ANNUNCIATOR 125 VDC Loss" alarm on P603-A7 1-1.
l. CAC	Lose indication/control of Div 2 CAC.

Overall effect on plant from 100% power:

Plant operation continues but operation of Div 2 equipment is severely limited.

Additional plant responses:

Lose indication/control of:

- RCC-P-1B & 1C
- SW-P-1B
- CRD-P-1B
- Remote S/D panel controls for SRVs, RHR and SW loop B

<u>Loss of S1-7</u>

LO-7654
LO-6843

S1-7 failure effects

a. IN5 — Continues to operate but lose DC source. AC source (MC-8A) should automatically carry the load.

b. RFW — Both RFPs trip due to loss of control power to trip circuits. Emergency DC oil pumps lose control power (MC-S2-1B).

c. Main Turbine — Lose power to Lockout relays for DEH Low Level and Anti-motor. Lose ability to auto or manually trip turbine from the control room. Emergency DC oil pump loses control power (MC-S2-1B). MS Bypass Valves reset solenoid fails open such that when/if the turbine is tripped the BPVs will go fully open then slowly close as DEH hydraulic drops to about 1000 psig. Hydraulic pressure will stabilize around 300 - 400 psig with both DEH pumps running.

d. SM1,2,3 Control Power — Lose all circuit breaker control and indication. Including buses fed by these switchgear.

e. SH5,6 Control Power — Lose all circuit breaker control and indication.

f. 500KV Control Power — Lose all circuit breaker control and indication. Unable to use Unit trips.

g. CR Annunciators — Lose all annunciators on <u>Bd A, B and C</u> except that you receive the two "ANNUNCIATOR 125 VDC Loss" alarms on P800-C5 10-7 and P820-B1 10-7.

Overall effect on plant from 100% power:

Plant scrams on RPV low level due to loss of FW flow and the Turbine Generator windmills at 1800 RPM connected to the grid. Neither the Turbine or the 500KV bkrs can be tripped from the Control Room.

When/if the Turbine Generator is tripped, the BPVs fully open as noted above. When/if the 500KV bkrs are tripped, the electric plant will NOT auto transfer to TR-S (loss of BOP electrical buses). In addition, the Aux Boiler loses control power.

<u>**Loss of 125 VDC S1/HPCS**</u>

a. Loss of ability to start and control DG3

b. Loss of control power for SM-4 switchgear.

c. Loss of power to HPCS logic in Control Room panel P625

d. Loss of valve position indication on P601 for HPCS-V-10&11

e. Loss of control and motive power for backup pumps DLO-P-10 and DO-P-6.

Overall effect on plant from 100% power:

Plant operation continues but operation of PRM equipment is limited.

<u>**Loss of 24 VDC S0-A or S0-B**</u>

Loss of S0-A:

LO-7655
S0-A failure effects

SRM A and C fail downscale

IRM A , C, E and G fail downscale

The following PRMs on P604 fail:

- RadWaste Effluent Monitor
- RHR SW HX-1A outlet
- OG Post Treatment Div 1

BISIs Div 1 fail

FDR-V-187 and 188 Radwaste Effluent to River - Close

Loss of S0-B:

LO-7656
S0-B failure effects

SRM B and D fail downscale

IRM B , D, F and H fail downscale

The following PRMs on P604 fail:

- RHR SW HX-1B outlet
- OG Post Treatment Div 2
- CW Blowdown
- RCC Radiation

BISIs Div 2 fail

CBD-LCV-1 Circ Water Blowdown - Closes

RCC-V-101 RCC Expansion Tank Vent - Closes

Overall effect on plant from 100% power:

Plant operation continues but operation of PRM equipment is limited.

VIII. SYSTEM INTERRELATIONSHIPS

The DC Distribution system supplies power to many various plant systems. The system interrelationship is a function of the distribution and is identified in the Power Supplies section.

IX. POWER SUPPLIES

A. 250 VDC Main Distribution Panel S2-1 supplies: LO-5263

1. Vital Bus Uninterruptible Power Source Static Inverter IN-1 250 VDC

2. 250 VDC Motor Control Center MC-S2-1A (Rx 471') Loads

   RWCU-V-4, NS[4] Isol. Valve
   RHR-V-8, S/D Cooling OTBD. Suction Isol. Valve
   RHR-V-23, Reactor Hd. Spray Iso. Valve
   RCIC-V-1, Turb. Trip and Throttle Valve
   RCIC-V-13, Pump Discharge Valve
   RCIC-V-19, Min. Flow Bypass Valve
   RCIC-V-22, Test Return to CST's
   RCIC-V-59, Test Return to CST's
   RCIC-V-64, Steamline Isol. Valve
   RCIC-V-45, Steamline to Turb. Valve
   RCIC-P-2, RCIC Vacuum Pump
   RCIC-P-4, RCIC Condensate Pump
   RCIC-V-69, Vacuum Pump Disch. Valve

3. 250 VDC Motor Control Center MC-S2-1B (TB 441')

   TG-EOP-1, Main Turb. Emergency Oil Pump
   TG-ASOBP-1, Air Side Oil Backup Pump
   RFT-EOP-1A, RFP Turbine Emerg Oil Pump
   RFT-EOP-1B, RFP Turbine Emerg Oil Pump

B. 125 VDC Main Distribution Panel S1-1, (Division 1) supplies:

LO-5262 125 VDC load relationship

1. Critical Instrument Power Inverter IN-3
2. MC-S1-1D, 125 VDC Motor Control Center (RPS A Room)
   CAC-V-2, H_2 Rec. 1 Drywell Inlet Iso. Valve
   CAC-V-6, H_2 Rec. 1 Drywell Outlet Iso. Valve
   CAC-V-4, H_2 Rec. 1 Supp. Pool Inlet Iso. Valve
   CAC-V-8, H_2 Rec. 1 Supp. Pool Outlet Iso. Valve
   RCC-V-6, Reactor Building Cooling Line Valve
   RCIC-V-31, Pump Suct. Valve
   RCIC-V-10, Pump Suction Valve
   DO-P-3A1, Diesel F.O. Backup Pump
   DO-P-3A2, Diesel F.O. Backup Pump
   DLO-P-2A1, Diesel Eng. L.O. Circ. Pump
   DLO-P-2A2, Diesel Eng. L.O. Circ. Pump
   RCIC-V-46, Turbine Cool. Wtr Supply Valve
   RCIC-V-110, Turbine Exhaust to Supply Pool Vac. Bkr.
   RCIC-V-8, Steam Line Iso. Valve
   RCIC-V-68, Turbine Exh. Valve to Supp. Pool
   RHR-V-40, Disch. to RW Iso. Valve
   MS-V-19, Main Steam Outboard drain
3. DP-S1-1A, I&C NSSS Board (Main Control Room)
   RCIC, RHR, RFW, and P601
   P827 Bd W
   P612, FDR and RCIC
   P672 and Ann. P672
   ADS and SRV A/C Solenoids
   RCIC, RHR-A, LPCS and P629
   RPS, RPT and P609
   ATWS/ARI DIV 1 Logic/Solenoid Valve Power
   Control Room Emergency Lights
4. DP-S1-1D, Div 1 Critical SWGR and RSD Panel (RSD Room)
   RSD Rm and Stair A-7 Lighting
   RSD MCC Bkr Control for RCIC and RHR valves
   WMA-FU-54A Heat Det. Water Spray
   REA-FU-2A Heat Det. Water Spray
   125 VDC Bkr Test Cab
   RWHV-A and RBHV-A Panels
   H_2 Recombiner Panel CAC-HR-1A
   P601, RCIC and P001 RSD
   SH-12 RPT-4B Control and Indication

5. DP-S1-1E, Diesel Generator 1 Distr. Pnl (DG-1)
   DG Switchgear DG1-7
   Eng. Contr. Panel DG/RP1
   Exciter Panel DG/REP1
   DG 1 and 2 Bkr Test Cab.
   DG Building HVAC Panels DGHV-1 and DGHV-4
6. DP-S1-1F (SM-7 SWGR Room)
   SL-73 SWGR Control Power
   SL-71 SWGR Control Power
   SM-7 SWGR Control Power and UV Control
   SH-9 SWGR RPT-3A BKR Control Power
   SH-12 SWGR RPT-4B BKR Control Power
   MC-S2-1A Control Power (RWCU-V-4 and RCIC-V-59)
   Alternate RSD Panel (RHR-V-8)

C. <u>125 VDC Main Distribution Panel S1-2 (Division 2) supplies</u>:

1. Critical Instrument Power Inverter IN-2
2. MC-S1-2D, 125 VDC Motor Control Center (RPS B Room)
   CAC-V-11, H_2 Rec. 2 Drywell Inlet Iso. Valve
   DO-P-3B1, Diesel Engine F.O. Backup Pump
   CAC-V-15, H_2 Rec. 2 Drywell Outlet Iso. Valve
   DO-P-3B2, Diesel Engine F.O. Backup Pump
   CAC-V-13, H_2 Rec. 2 Supp. Pool Inlet Iso. Valve
   DLO-P-2B1, Diesel Engine L.O. Circ. Pump
   CAC-V-17, H_2 Rec. 2 Supp. Pool Outlet Iso. Valve
   DLO-P-2B2, Diesel Engine L.O. Circ. Pump
   RCIC-V-113, Turbine Exhaust to Supp. Pool Vacuum Bkr
3. DP-S1-2A, I&C NSSS Board (Main Control Room)
   P601, P602 and P603 Annunciators and P602
   RHR-V-73B and 74B, RCIC-V-4 and 25, and P601
   RHR DIV 2 and P618
   ADS and SRV B solenoids and P631
   RPS B (BU SCRAM Vlv, Trip), SDV Vlvs Time Delay Ckt.
   TIP and P607
   Rx Lvl Inst, RFW LC Rx Hi Lvl, P613
   P811 Board J
   Control Room Emergency Lights
   ATWS/ARI DIV 2 Logic/Sol Vlv Pwr

4. DP-S1-2D, Div 2 Critical SWGR and RSD Panel (RSD Room)

   RSD Room and Stair A-7 Emergency Lighting
   SM-8 SWGR Control, Indication & UV Protection Relays
   SL-81 SWGR Control and Indication
   SL-83 SWGR Control and Indication
   SH-10 SWGR RPT-3B Bkr Control and Indication
   SH-11 SWGR RPT-4A Bkr Control and Indication
   RSD Panel, RHR-P-2B and SW-P-1B RSD Control Power
   DG2-8 Backup Control Power (FRTS Panel)
   WMA-FU-54B Heat Detector water spray
   REA-FU-2B Heat Detector water spray
   RBHV-B Panel
   H_2 Recombiner Panel CAC-HR-1B
   Reactor Bldg 125 VDC Bkr Test Cab.
   8-DG2 Backup Control Power (FRTS Panel)

5. DP-S1-2E, Diesel Generator 2 Distr. Pnl (DG-2)

   DG Switchgear DG2-8 Control Power
   Eng. Contr. Panel DG/RP2
   Exciter Panel DG/REP2
   DG Building HVAC Panels DGHV-2 and DGHV-4-2
   Eng. Contr. Panel (Alt Pwr Source) DG/RP2

D. <u>125 VDC Distribution Panel S1-7 supplies</u>:

1. IN-5A, TDAS/PRIME UPS Static Inverter

2. DP-S1-1B, I&C B.O.P. Bd. (Main Control Room)

   Bd. B MD-V-75 thru 87, MSL Hi Rad Trip and Ann. P820
   Bd. C Generator Relay and Ann. P800
   Bd. S Ann. and P851
   Bd. A Ann., P840
   P626 and P821 Bd. W Ann.
   Bd. F Protective Relay and P842
   500 KV Primary Set Protective Relay Rack

3. DP-S1-1C (TB 441)

SL-11 SWGR Control Power and Ground Fault
SL-31 SWGR Control Power and Ground Fault
SH-5 SWGR Control Power
SM-1 SWGR Control Power
SM-3 SWGR Control Power
SM-75 SWGR Control Power
SH-13 SWGR LF2A Bkr Control Power
Tie Bkr 21-11 Control Power
Tie Bkr 31-21 Control Power
RFW-DT-1A Unit Contr. Pnl
RRC A Panel P001A
HVAC Control Panel TSC-1

4. DP-S1-1C-1 Panel (TB 441')

Makeup Demin. Panel Annunciator Power
IR-16 (HD Valves)
MC-S2-1B Control Power
Main Gen. Voltage Reg. Field Bkr
Auto Start Control for M-1, 2 and 3 Fans (1st section)

5. DP-S1-1C-2 Panel (TB 501')

IR-3 and BS valves
SL-53 SWGR Control Pwr and Ground Fault
Turbine Bldg HVAC Panels TGHV-1 & 2

6. DP-S1-1C-3 BPA Interface Communication Panel (RW 525')

OSC Bd "O" OSC-1
Oscillograph Initiative Relay
230 KV MWTT RR-8
500 KV Bkr Aux Relays
500 KV MWTT and Sync Rack RR-17

7. DP-S1-2B, I&C B.O.P. Bd. (Control Room)

Bd. "C" 500 KV Bkr Control and MN Gen Sec Prot Relay
Bd. "C" Ann.
Bd. "S" Ann. and P851
Bd. "B" MSL Hi Rad Trip, Anti Motoring-DEH Lo Lvl, and Main Turbine Trip Circuit
Bd. "F" Gen Overall Protective Relay
TR-B Protective Relays
Bd. "J", CAC and FPC Annunciators
ARC-B, Aux. Rel. Cab. Voltage Reg Alarms
500 KV Secondary Relay Rack
Sec. Control Console (SAS)

8. DP-S1-2C (TB 441')
   SH-6 SWGR Control Power
   SM-2 SWGR Control Power
   SM-85 SWGR Control Power
   SL-21 SWGR Control Power and Ground Fault
   SL-63 SWGR Control Power and Ground Fault
   EXC-1 and Main Generator Voltage Regulator
   ARC-B DC Fail Alarm
   Gen. Aux. Pnl. Annunciators
   125 VDC Bkr Test Cab. Bd 12C
   SCW M/U Solenoid valve SW1-CB2
   Unit Contr. Pnl RFW-DT-1B
   RFPT-1B Trip and Reset ckt. relays
   RRC B Panel P001B
   SH-14 SWGR Bkr LF 2B
9. DP-S1-2C-1 (TB 441')
   IR-16 (HD Non-Return Valves)
   TR-B Control Power and Alarm Ckts.
   Aux. Boiler Control Panel
10. DP-S1-2C-2 (TB 501')
   IR-4 and BS valves
   IR-5 and BS valves
   Turbine Bldg HVAC Panels TGHV-1 & 2
   MS BPV SOVs
11. DP-S1-2C-3 (XFMR yard) with the following loads:
   TR-M1 Control Power
   TR-M2 Control Power
   TR-M3 Control Power
   TR-M4 Control Power
   TR-S Control Power
   TR-N1 Control Power
   TR-N2 Control Power
   500 KV Main Trans. Disconnect Switch
   500 KV MOD Switch Control Power (Phase A, B, C)
12. DP-S1-2F (RWCR)
   Radwaste, FPC F/D and Condensate F/D Panel Annunciators
   HVAC Panels: RWHV-B, DGHV-3 and 0GHV-B

E. <u>125 VDC Distribution Panel S1/HPCS supplies</u>:

1. SM-4 Normal Source
2. HPCS Protective Relay Rack IR-H22/P028
3. Engine Control Panel DG/EP3
4. Gen. Aux. Contr. Panel Annunciator Power Supply
5. Diesel Generator Field Flash
6. Control Room Panel P625
7. Control Room Panel P601
8. DLO-P-10, Diesel Soakback Pump
9. Generator Regulator Control Panel DG/RP3

F. <u>+ 24 VDC Power Panel DP-SO-A supplies</u>: LO-5264 24VDC loads

1. SRM Channel A and C and IRM Systems Channel A, C, E & G
2. PRM System Bus A
3. BISI Displays

G. <u>+ 24 VDC Power Panel DP-S0-B supplies</u>:

1. SRM Channel B and D and IRM Systems Channel B, D, F & H
2. PRM System Bus B
3. BISI Displays

H. <u>Battery Chargers Receive Power from</u>:

1. Charger C1-1 - MC-7A
2. Charger C1-2 - MC-8A
3. Charger C1-7 - MC-6B
4. Charger C1-3 - MC-7R
5. Charger C1-4 - MC-8R
6. HPCS Charger - PP-4A
7. Chargers C0-1A, - PP-7A CO-1B
8. Chargers CO-2A, - PP-8A CO-2B
9. Charger C2-1 - MC-7A
10. IN-4 Internal - SL-81 Charger

X. TECHNICAL and LICENSEE CONTROLLED SPECIFICATIONS — LO-5265

A. Technical Specifications — Tech Specs
3.8.4 DC Sources - Operating
3.8.5 DC Sources - Shutdown
3.8.6 Battery Cell Parameters
3.8.7 Distribution Systems - Operating
3.8.8 Distribution Systems - Shutdown

B. Licensee Controlled Specifications
1.8.4 24 VDC Sources
1.8.6 24 VDC Battery Parameters
1.8.7 24 VDC Distribution System

XI. REFERENCES

FSAR Chapter 8.3.2, DC Power Systems

S&P Training Handout DC Power System

E505 DC One Line Diagram

E509 DC Panel Schedules

PMR-85-0670-0, Ground Detection Meters

PMR-84-1536-1, Control Room 125 VDC Emergency Lighting

PPM 2.7.8. 125 VDC Dist. System Div 1, Div 2 and BOP

OTH-88-2, Emergency Lighting

BDC 92-0159-OB, Conversion of several 1.5 hr packs to 8 hr packs

Solidstate Controls Manual (Div 1 & 2 chargers) CVI 02-942-00, 16, 1

SYSTEM LEARNING OBJECTIVES	EO	RO	SRO	STA
5255 State the purpose of the DC Power System.	X	X	X	X
5258 Describe when and how the Control Room DC Emergency lights are energized.		X	X	X
5259 State the purpose of the two types of Battery Pack DC Emergency lamps and their respective capacities.		X	X	X
5261 Describe how the 125 VDC and the 250 VDC ground detectors indicate the severity and the polarity of DC system ground.	X	X	X	X
5262 Given a list of loads that are important to plant safety or vital to plant operation, identify its relation to 125 VDC bus: a. S1-1 b. S1-2 c. S1-7		X	X	X
5263 Given a list of loads that are important to plant safety or vital to plant operation, identify its relation to 250 VDC bus S2-1.		X	X	X
5264 Given a list of loads that are important to plant safety or vital to plant operation, identify its relation to 24 VDC bus S0A(B).		X	X	X
5265 Given a copy of the Technical Specifications, locate the sections that apply to the DC Distribution System.		X	X	X
7652 Predict the effect(s) a failure of 125 VDC bus S1-1 will have on: a. IN3 b. RCIC c. RHR d. LPCS e. ADS f. DG1 g. ATWS/ARI h. SM7 Control Power i. RPS j. RRC k. FWLC l. CR Annunciators m CAC n. SRVs		X	X	X

SYSTEM LEARNING OBJECTIVES	EO	RO	SRO	STA
7653 Predict the effect(s) a failure of 125 VDC bus S1-2 will have on: a. IN2 b. RCIC c. RHR d. ADS e. DG2 f. ATWS/ARI g. SM8 Control Power h. RPS i. RRC j. FWLC k. CR Annunciators l. CAC		X	X	X
7654 Predict the effect(s) a failure of 125 VDC bus S1-7 will have on: a. IN5 b. RFW c. Main Turbine d. SM1,2,3 Control Power e. SH5,6 Control Power f. Generator Breaker Control Power g. CR Annunciators		X	X	X
7655 Predict the effect(s) a failure of 24 VDC bus S0A will have on: a. RPS b. SRM c. IRM d. PRM		X	X	X
7656 Predict the effect(s) a failure of 24 VDC bus S0B will have on: a. RPS b. SRM c. IRM d. PRM		X	X	X
7657 Predict the effect(s) a failure of 250 VDC bus S2-1 will have on: a. IN1 b. RCIC c. RFP d. Main Turbine e. RWCU		X	X	X
6843 Given a Failure of Bus S1-7 identify those automatic actions that may have occurred.	X			
9019 List the WNP-2 battery systems by voltage and system identifier.	X			

SYSTEM LEARNING OBJECTIVES	EO	RO	SRO	STA
15128 Describe the function of the Float/Equalizer Switch CHARGER C2-1	X			
15129 Describe the function of the Float Equalizer Switch CHARGER C1-1/2/7	X			
15130 Describe the function of the Float/Equalizer Timer 125 VDC HPCS BATTERY CHARGER	X			
15131 Describe the function of the Float/Equalizer Switch BATTERY CHARGERS C0-1A, C0-1B, C0-2A, AND C0-2B	X			

SYSTEM TEXT REVISION SUMMARY

REV. 7 AUTHOR; M. Westergren Date: October 2002

1. Revised discussion and local controls of Div 1 & 2 chargers to reflect chargers installed during outage in 2001.
2. Added discussion and definitions for Float and Equalizing charges.
3. Revised Fig. 1 - 5 to illustrate the new Div 1 & 2 chargers and add more detail per P&IDs.

REV. 6 AUTHOR; M. Westergren Date: October 2000

1. Revised "VDC", "volts/cell" and "amp-hour" format to be consistent throughout.
2. Several editorial changes made throughout document based on System Engineer feedback.
3. Revised explanation of DC ground testing and detection.
4. Added description of effect of a loss of each major DC bus.
5. Updated T.S. and LCS list.
6. Revised Fig. 8 and added 8A & 8B to illustrate DC ground detection.
7. Revised Fig. 10 per PTL A162643
8. Added charger local controls to support added EO learning objectives.

REV. 5 AUTHOR; D. Kaopuiki Date: May 1995

1. Deleted learning objectives 5256, 5257 and 5266.
2. Added learning objectives 7652, 7653 and 7654.
3. Modified learning objectives 5261, 5262, 5263 and 5264.

REV. 4 AUTHOR; D. Kaopuiki Date: June 1994

NOTE: All technical revisions are identified with a vertical line located toward the right margin in the text. Format changes are not identified with revision bars.

1. Revised format to include system Learning Objectives at the locations appropriate in the systems text and in a table.
2. Clarified and simplified the General Description.
3. Simplified the Battery and Charger data description.
4. Simplified the Emergency DC Lighting description.
5. Incorporated BDC 92-0159-OB which converted several 1.5 hr battery packs to 8 hr battery packs to meet Appendix R requirements.

REV 3 AUTHOR; D. Dallago Date; October 1992

1. Labeled 125 VDC Main Distribution Panel S1-1 as Division 1 and labeled 125 VDC Main Distribution Panel S1-2 as Division 2 per TUS file comments on learning objectives.

   System Text pages 20 and 21.
2. "Added A/C solenoids" as a load off of DP-S1-1A and added "ADS and SRV B solenoids" as a load off of DP-S-2A per TUS file comments on learning objectives.

   System Text pages 20 and 21.

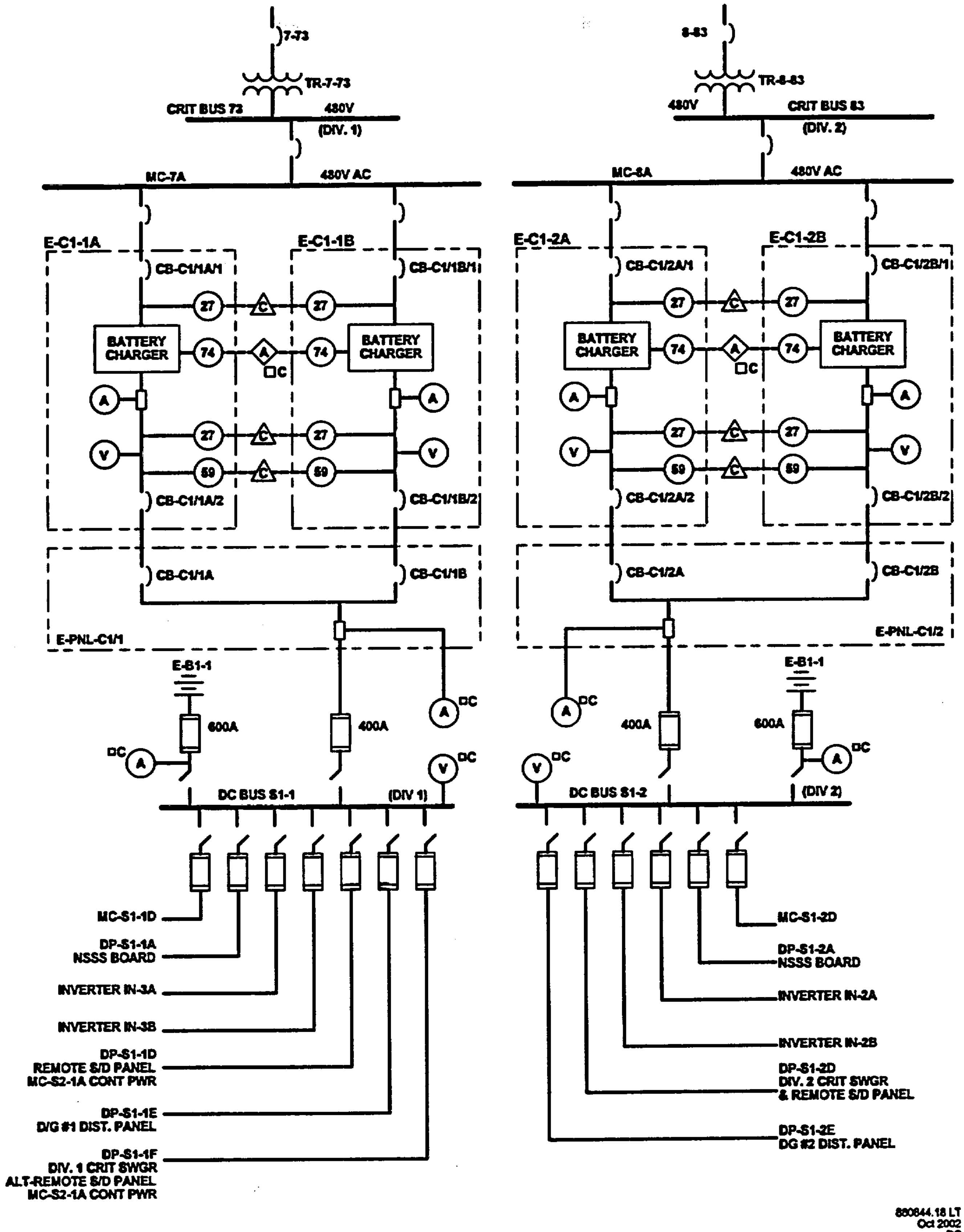
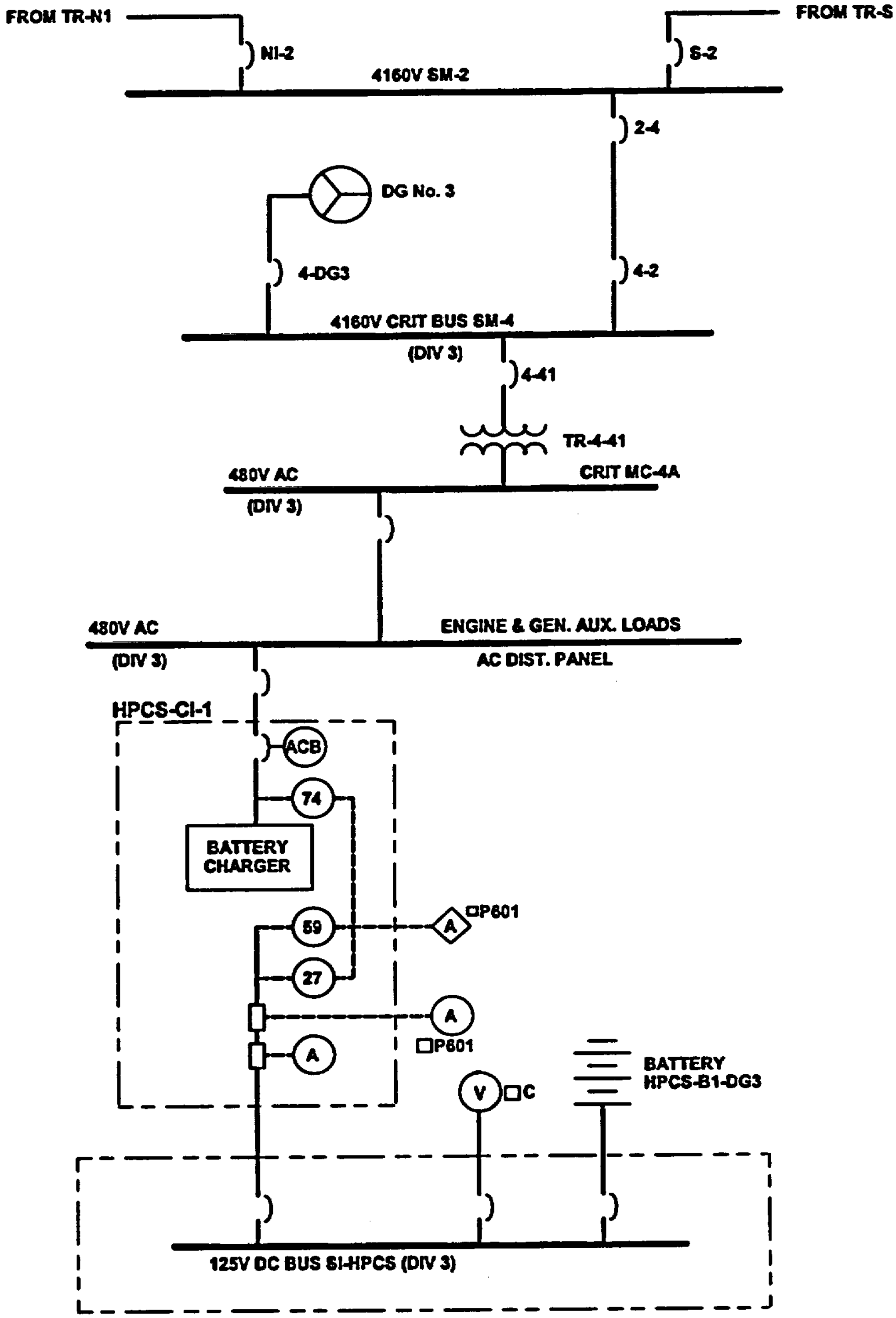


FIGURE 1. 125V DC SYSTEMS



- GEN CONTROLS & FIELD FLASHING
- DIESEL ENGINE CONTROLS
- SWGR CONTROL PWR
- HPCS LOGIC RELAYS
- FUEL & LUBE OIL PUMPS

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Oct 2002
DC

FIGURE 2. HPCS 125 VDC SYSTEM

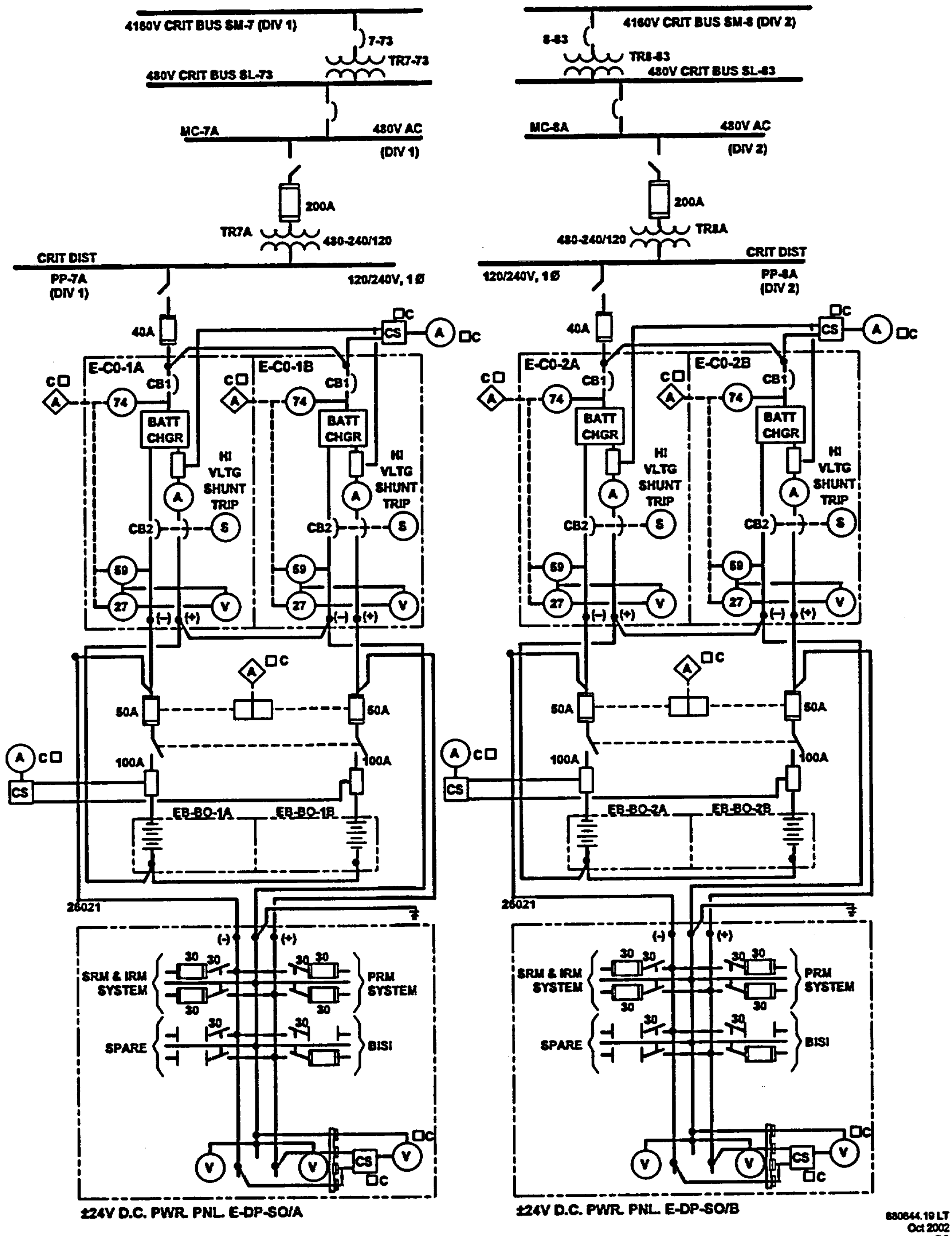


FIGURE 3. ±24 VDC SYSTEMS

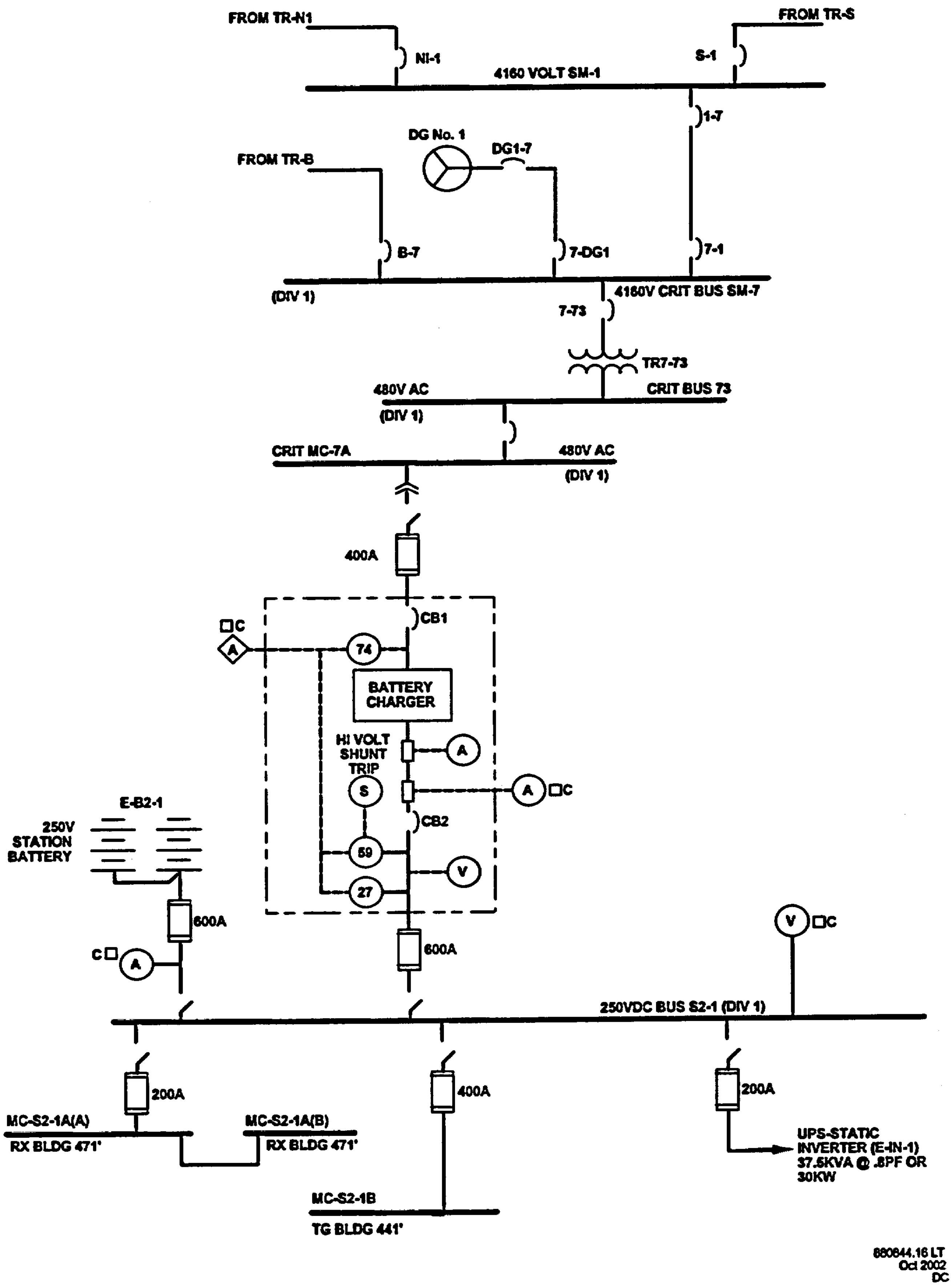
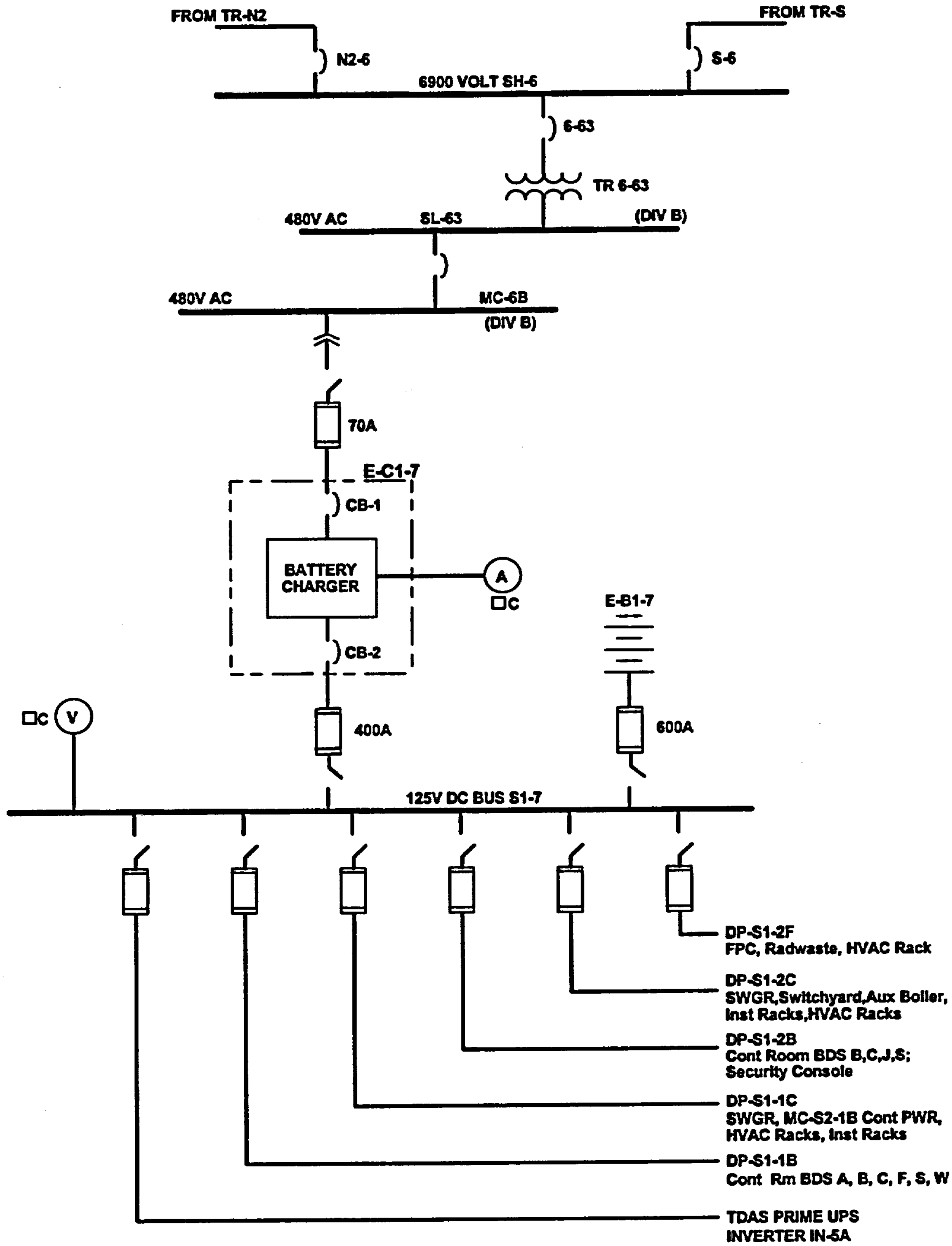


FIGURE 4. 250V DC SYSTEM



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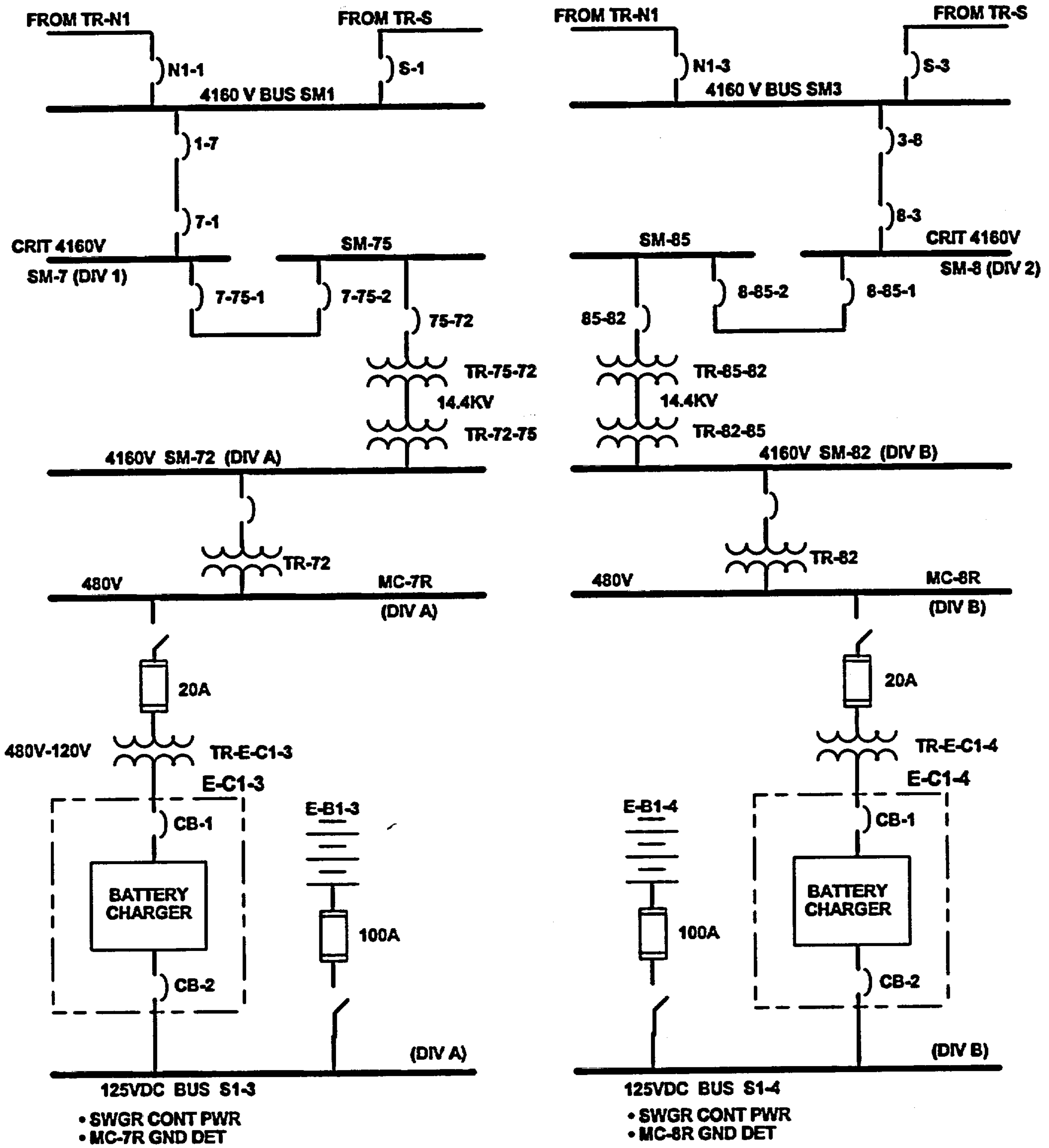
DC

FIGURE 5. NON-CLASS 1E 125 VDC SYSTEM (SI-7)



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DC

FIGURE 6. TMU PUMPHOUSE 125V DC SYSTEM

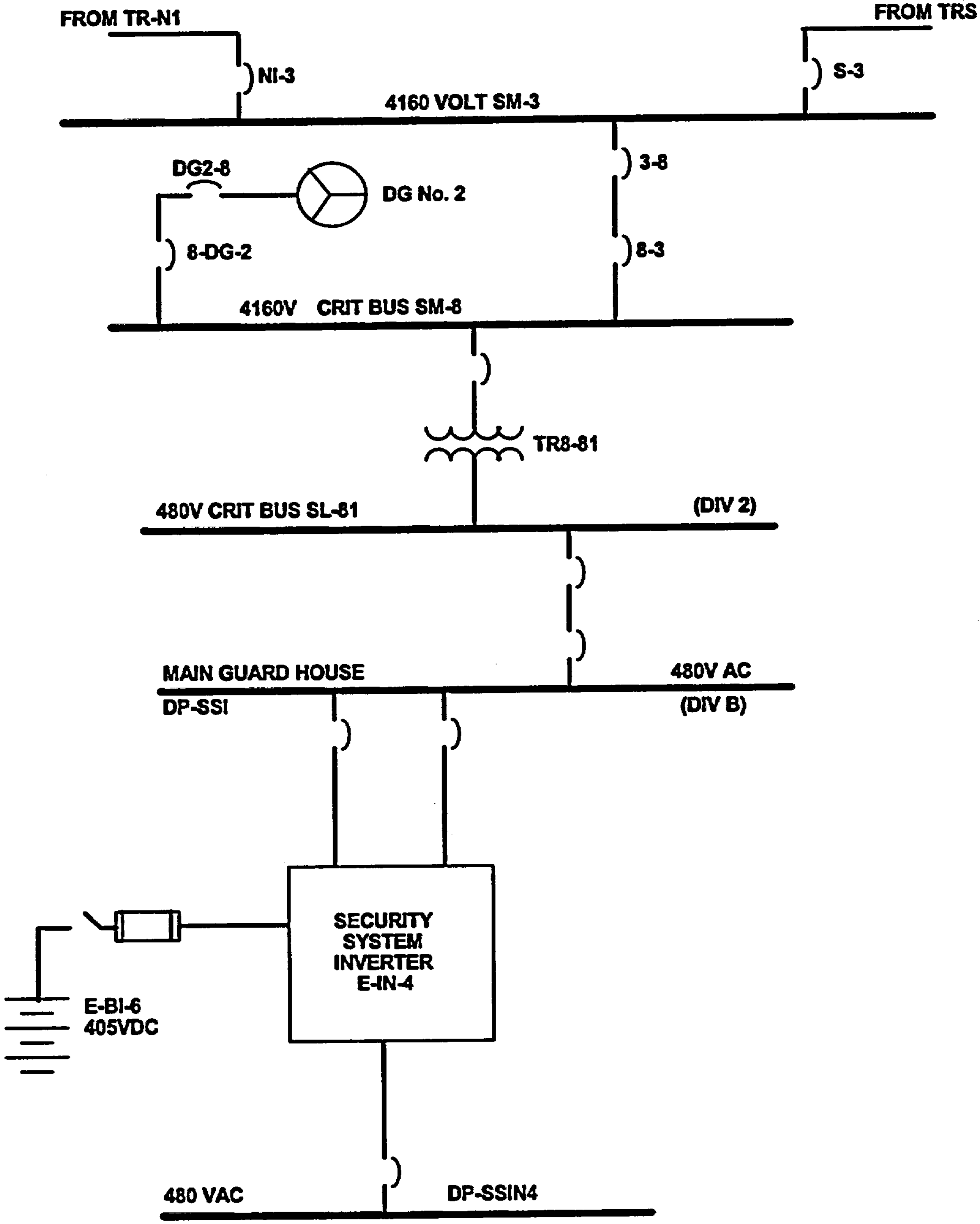

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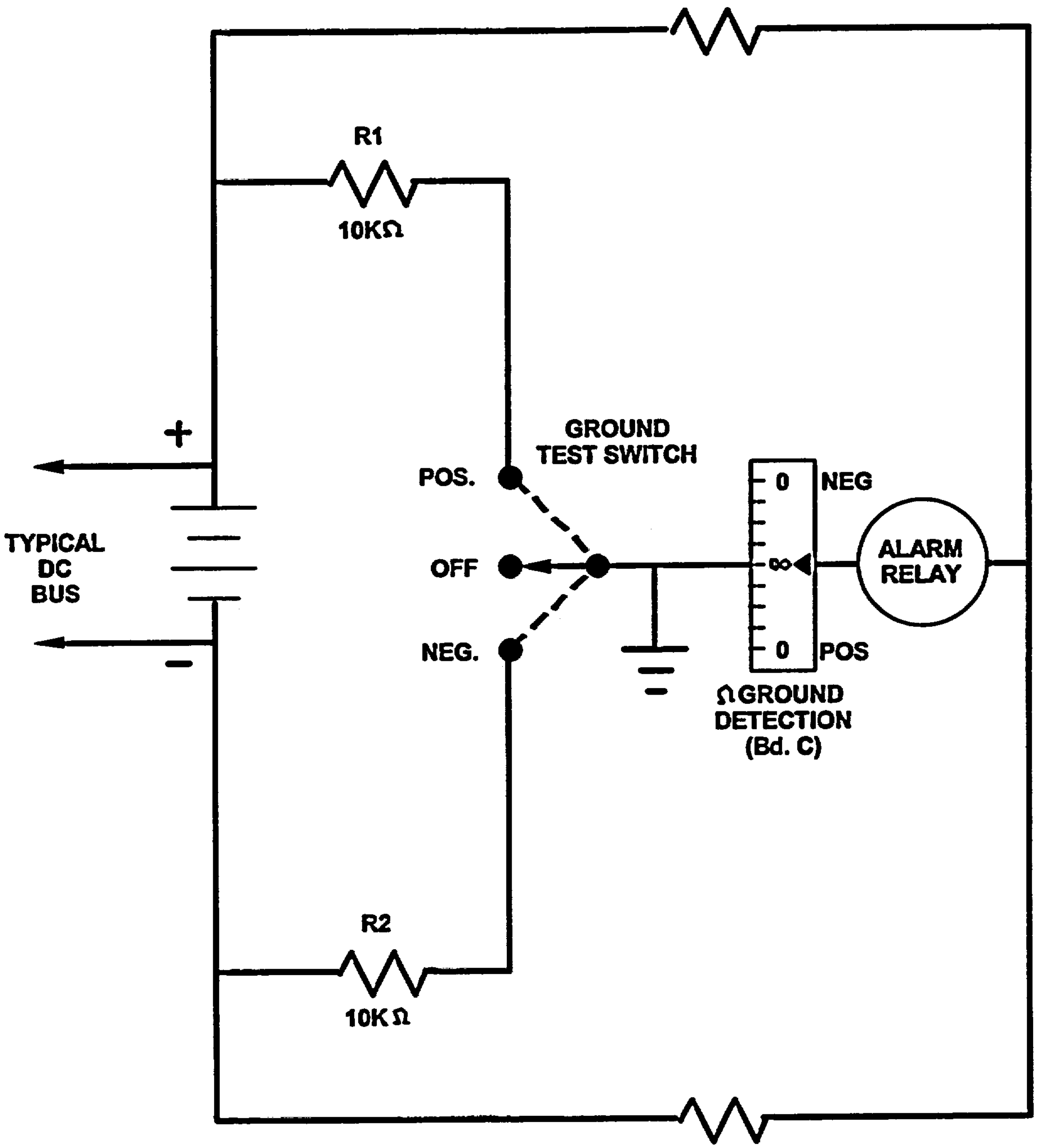
FIGURE 7. SECURITY 405 VDC SYSTEM



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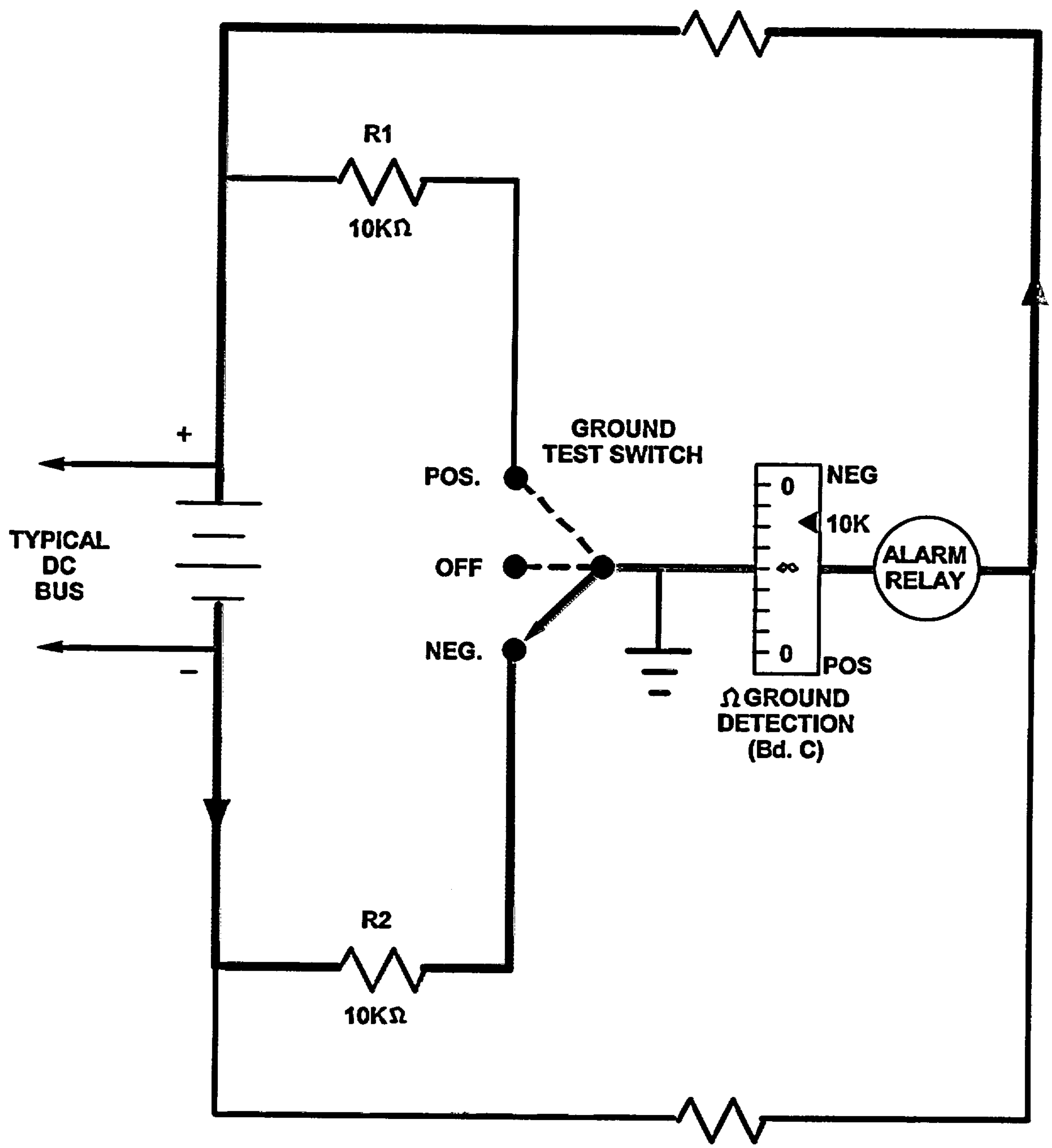
DC

FIGURE 8. DC GROUND DETECTOR S2-1, S1-1, S1-2 AND S1-7



"NEG TEST"

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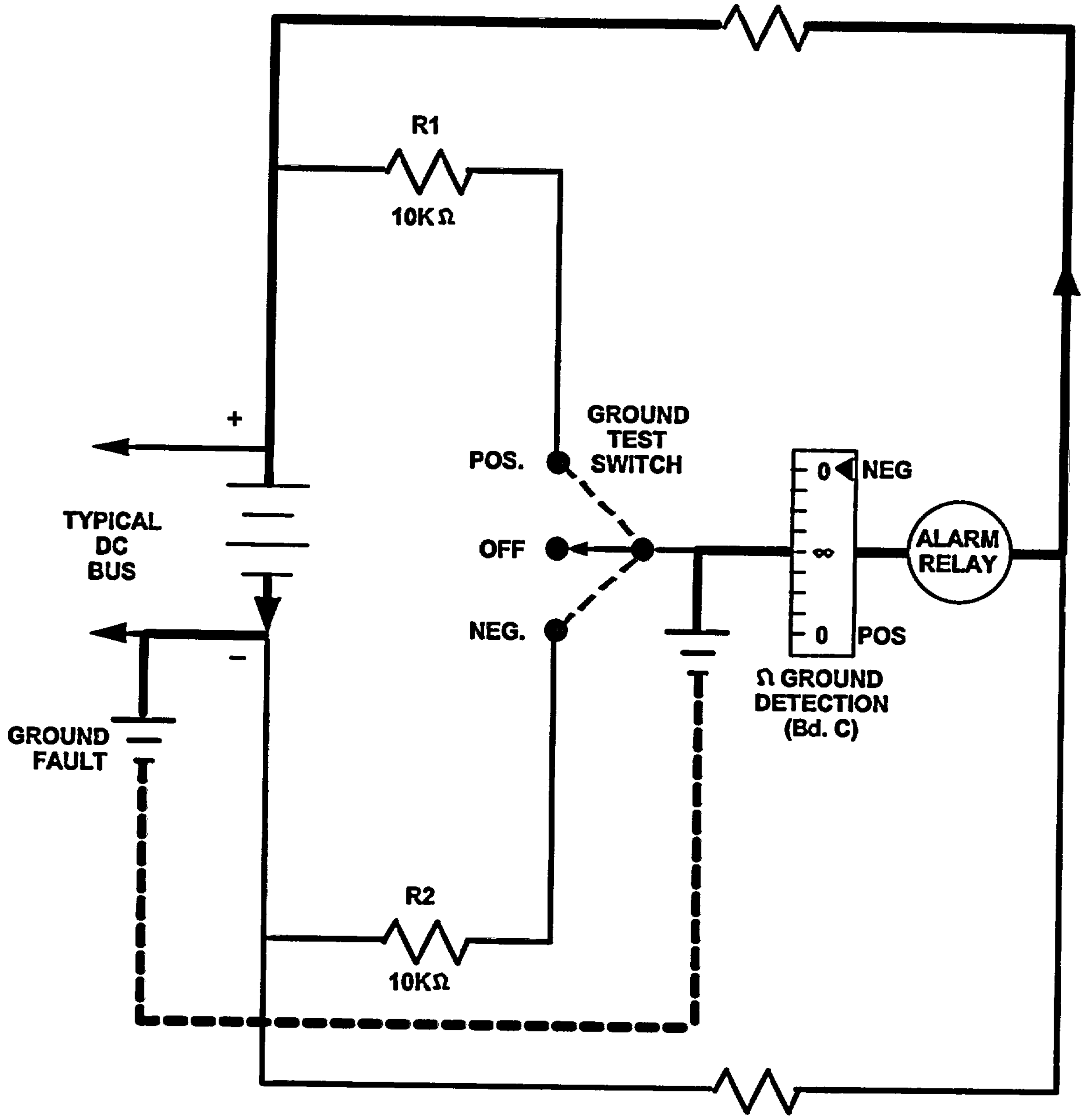
DC

FIGURE 8A. DC GROUND DETECTOR
S2-1, S1-1, S1-2 AND S1-7



"ACTUAL NEG. GROUND"

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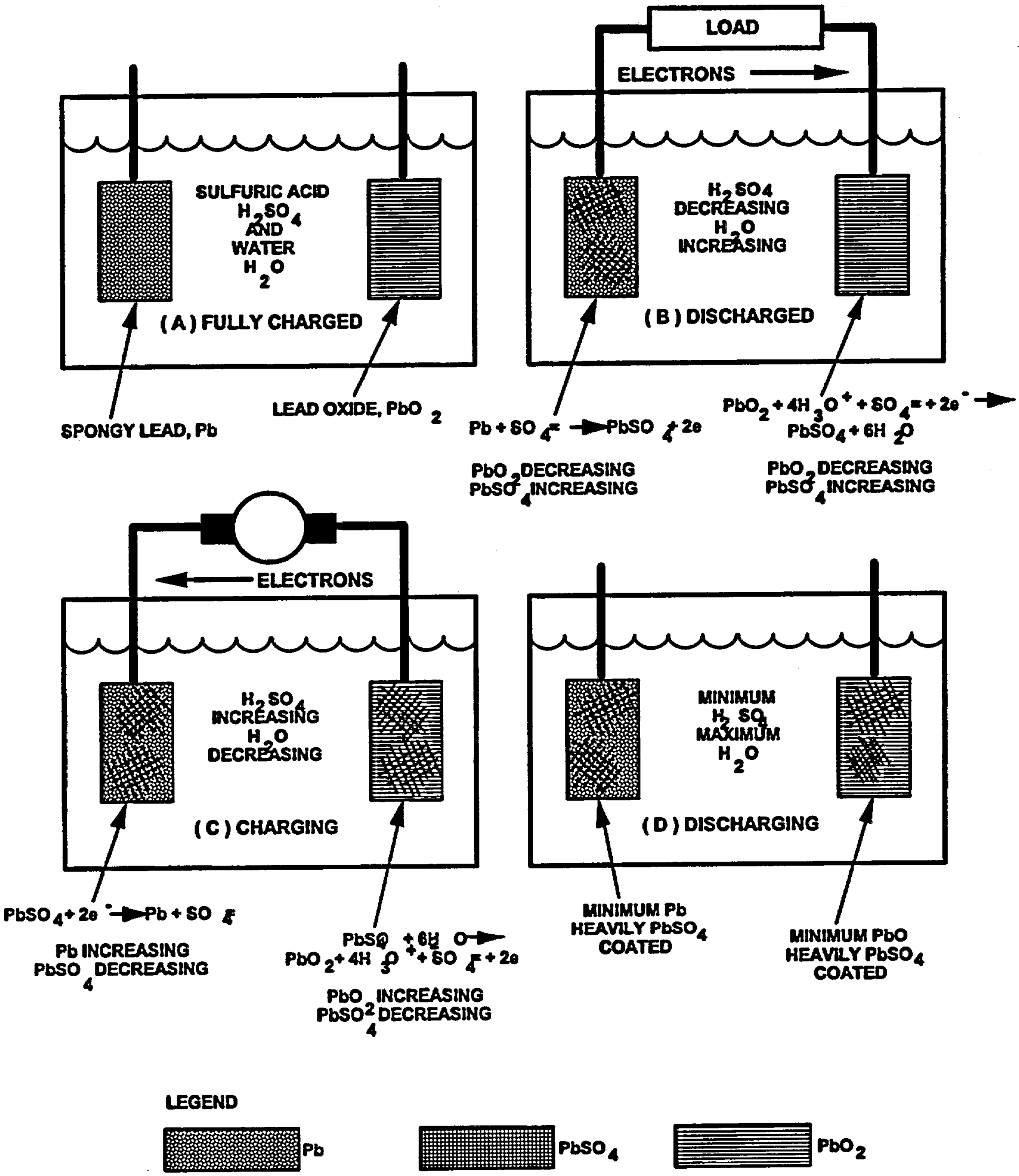
DC

**FIGURE 8B. DC GROUND DETECTOR
S2-1, S1-1, S1-2 AND S1-7**



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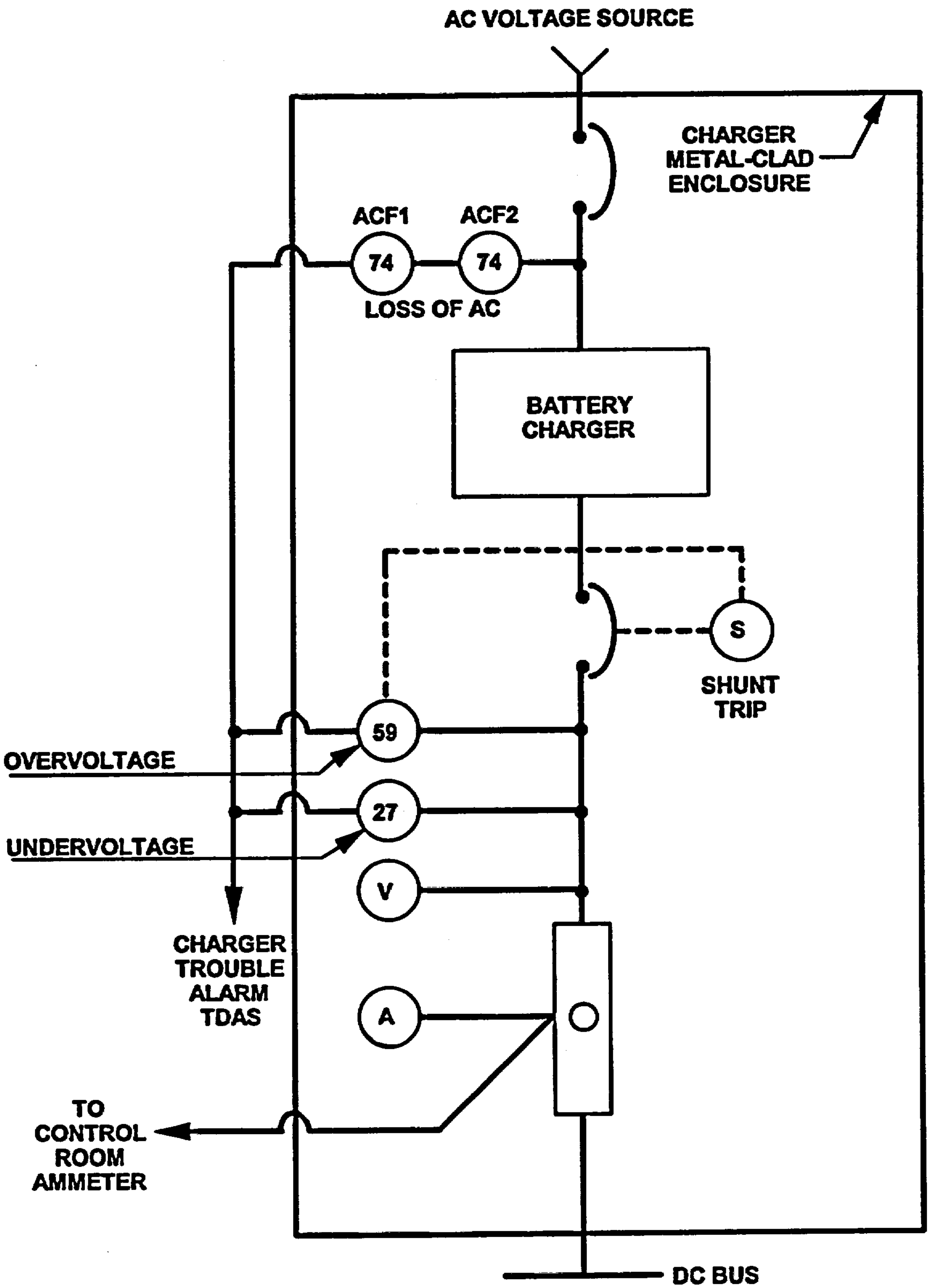
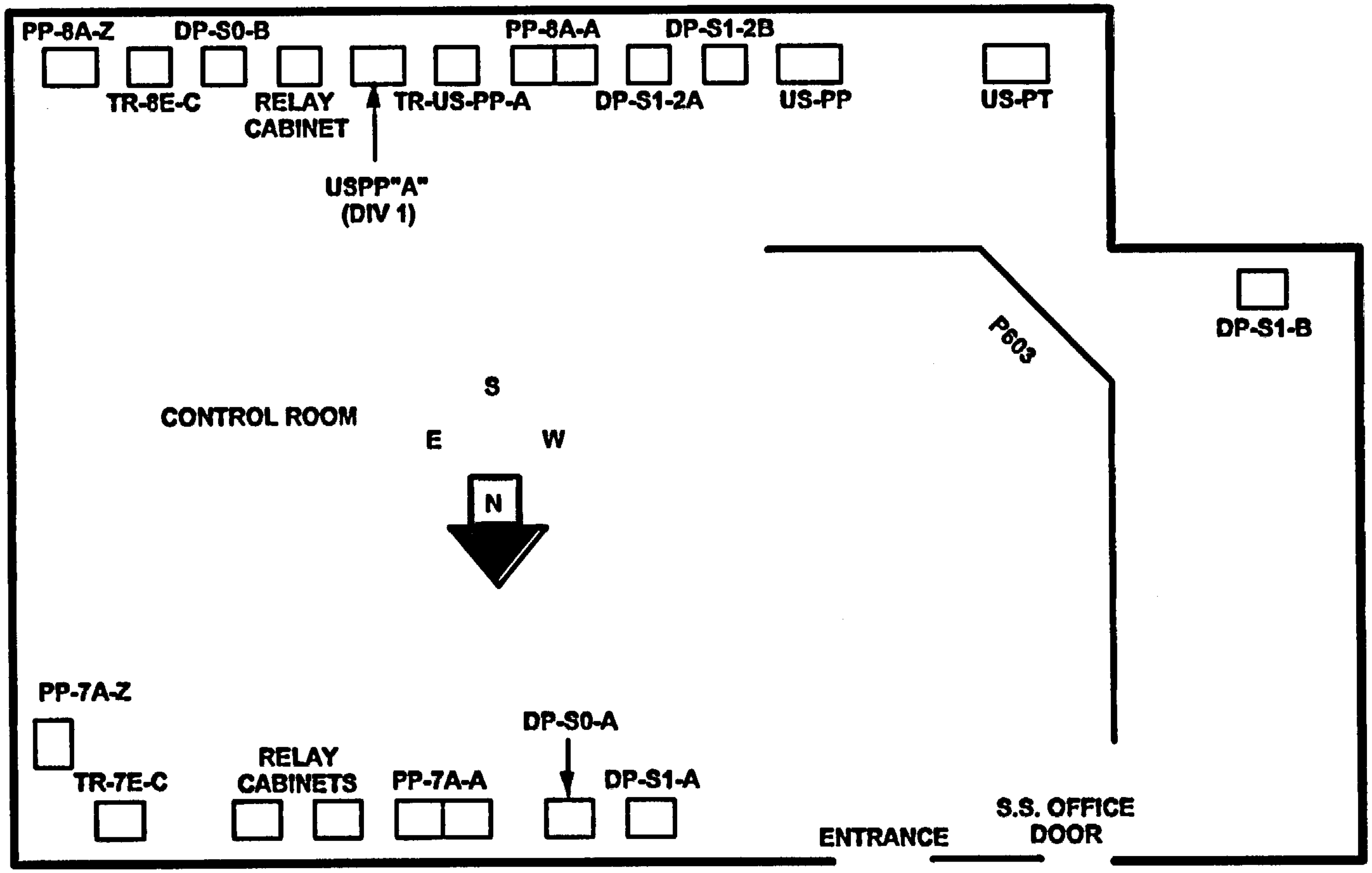
JAN. 1990
DC

FIGURE 9. BASIC CHEMICAL ACTION OF A LEAD-ACID STORAGE BATTERY



822063.02 LT
Oct 2000
DC

FIGURE 10. BATTERY CHARGER TYPICAL INSTRUMENTRATION & CONTROL



DIV 1 BATTERY ROOM	DIV 2 BATTERY ROOM	DIV 1 CHARGER ROOM	DIV 1 CHARGER ROOM	DIV 1 VITAL EQUIP. ROOM	DIV 2 VITAL EQUIP. ROOM	RSD PANEL ROOM
B0-1A	B0-2A	C0-1A	C0-2A	PP-7A	PP-8A	DP-S1-1D
B0-1B	B0-2B	C0-1B	C0-2B	MC-7A	MC-8A	DP-S1-2D
B1-1	B1-2	DP-S1-1	DP-S1-2	IN-1	IN-2	PP-8A-F
B2-1	B1-7	DP-S2-1	DP-S1-7	IN-3	MC-S1-2D	PP-7A-F
		C1-1	C1-2	MC-S1-1D	RPS "B" MG SET	
		C2-1	C1-7	RPS "A" MG SET		

830760.2LT
JULY 2001
DC

FIGURE 11. DC DIST. AND UPS PANEL LOCATIONS

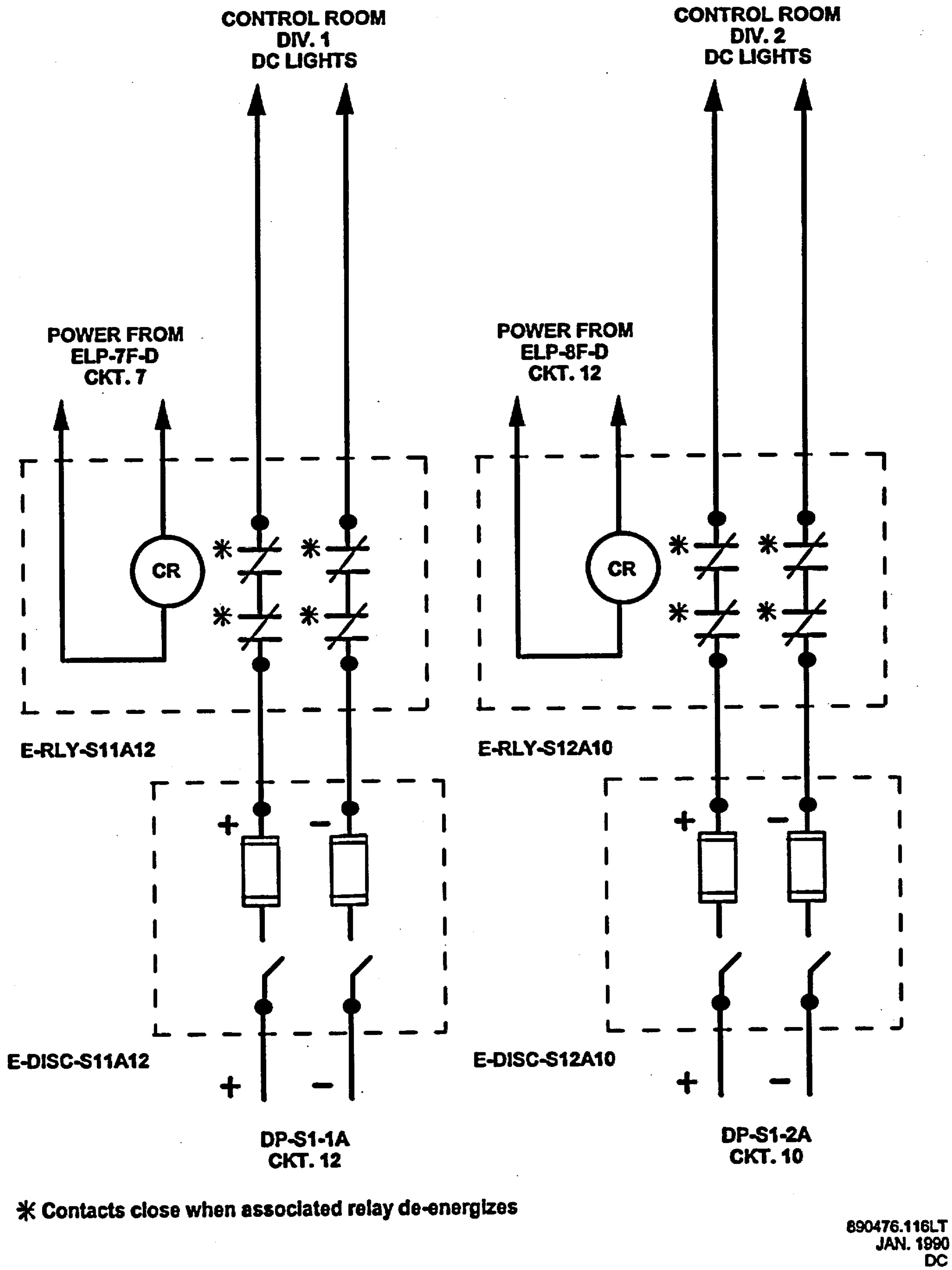
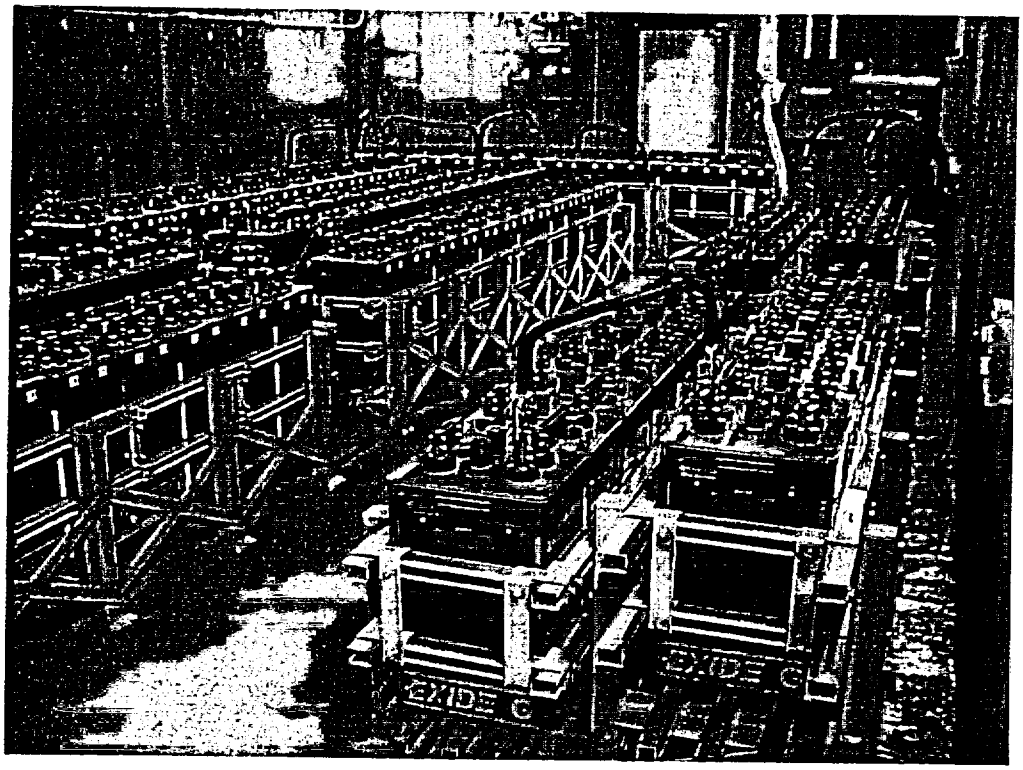
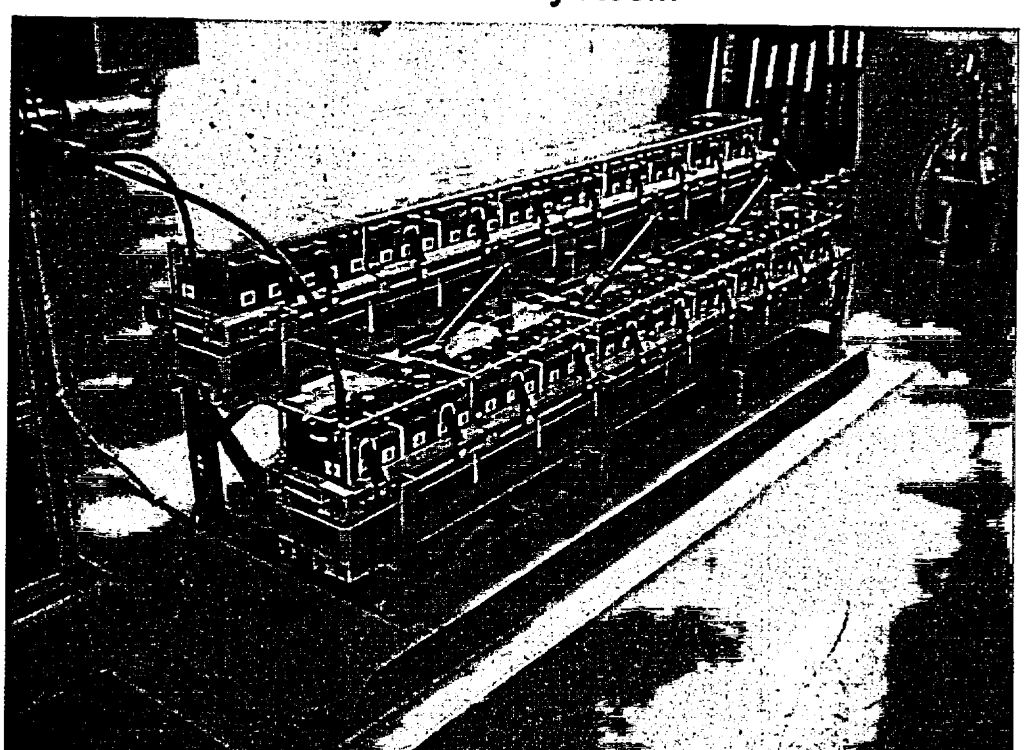


FIGURE 12. CONTROL ROOM EMERGENCY DC LIGHTING



Div 1 Battery Room



HPCS Battery

Oct 2002

Figure 13

DC

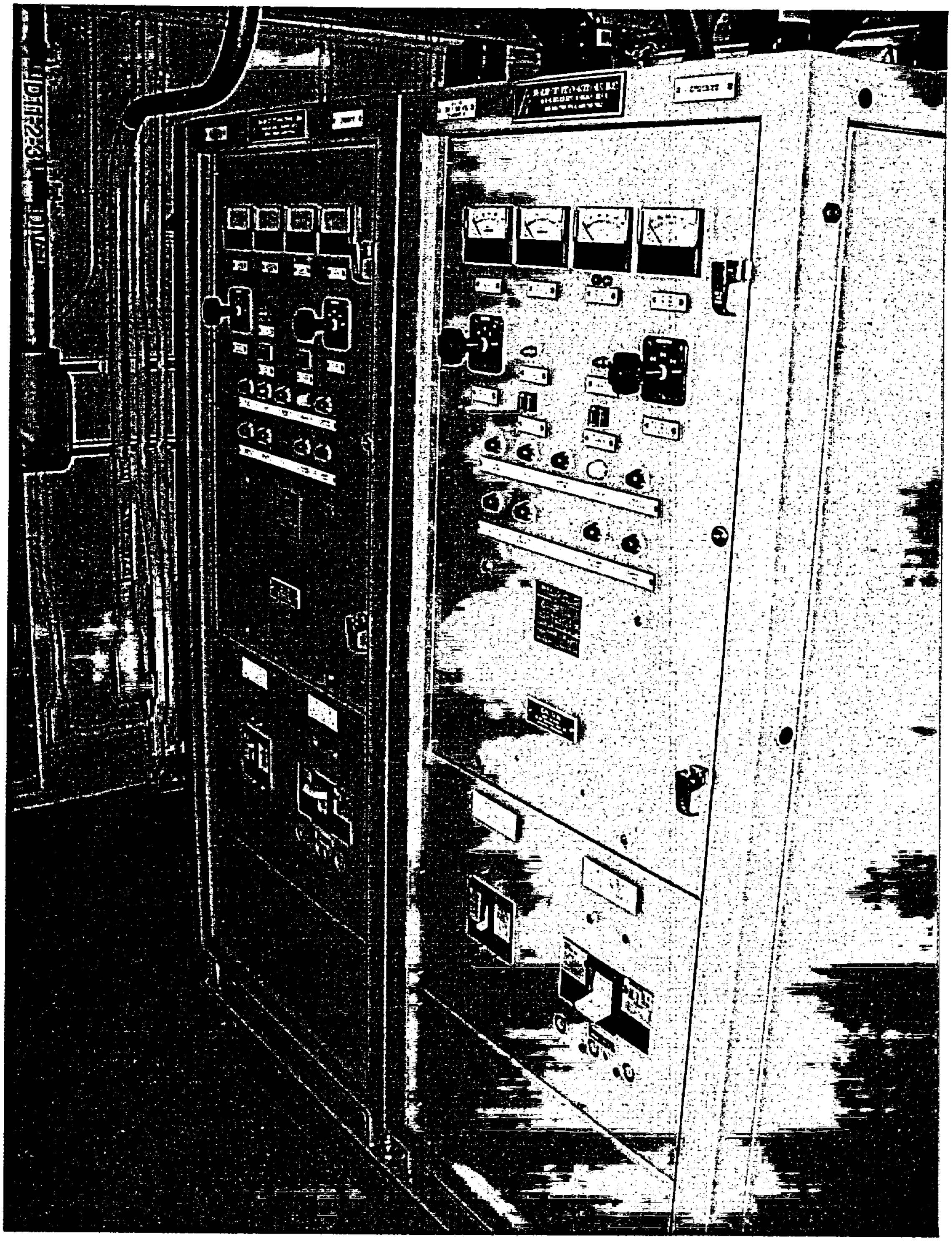


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Figure 14 Chargers C1-1A and C1-1B

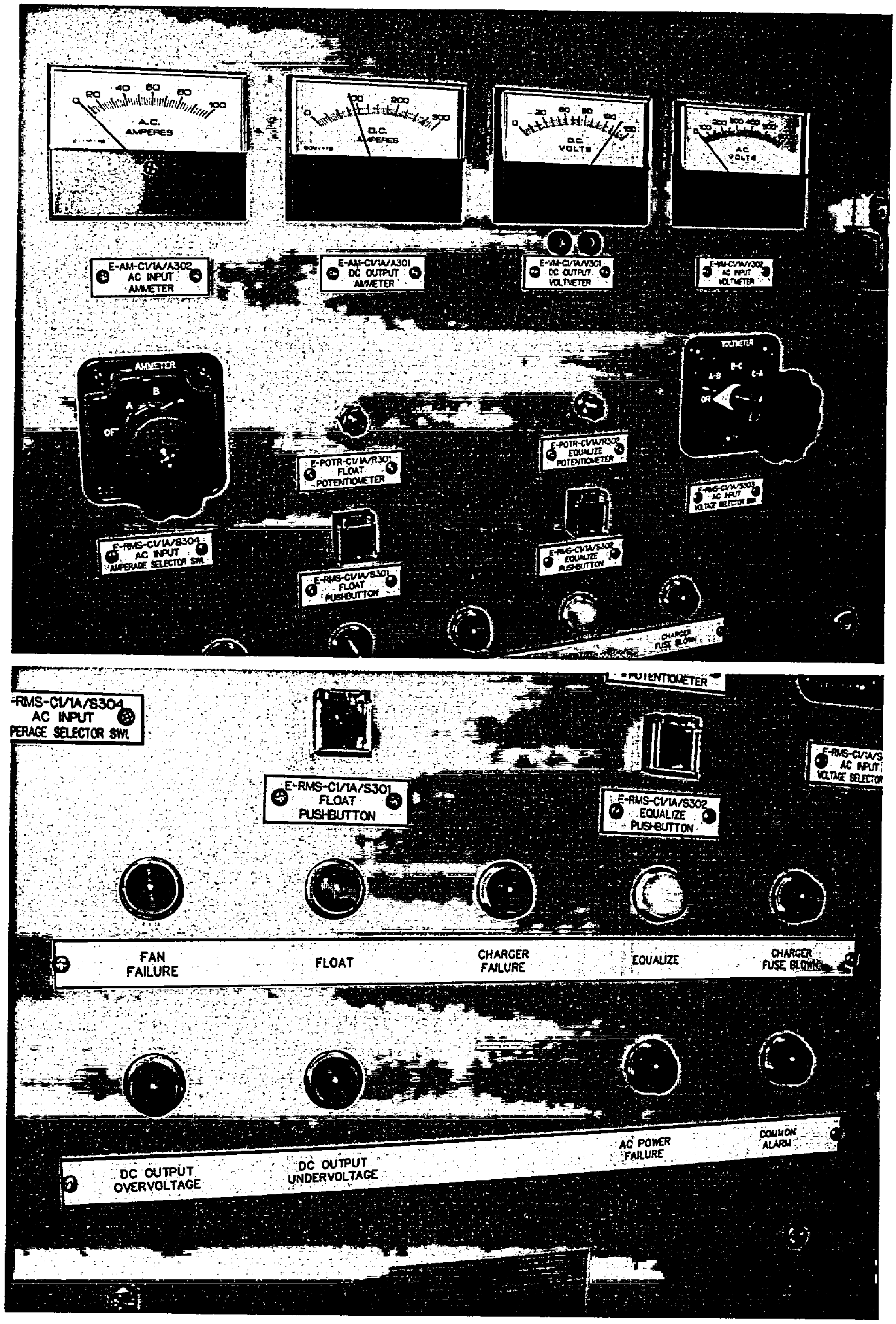
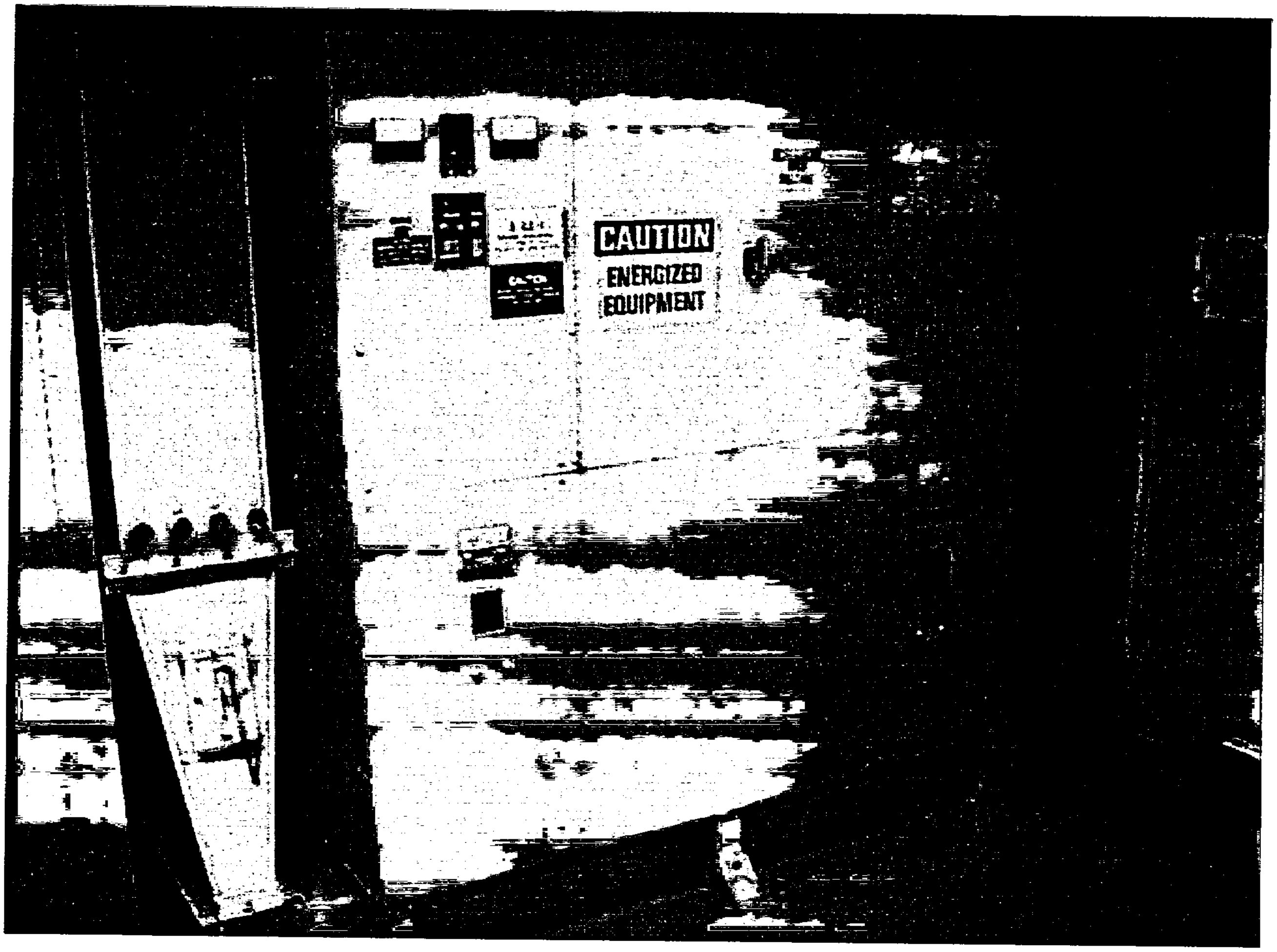


Figure 14a Charger C1-1A



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DC

Figure 15 Charger C2-1

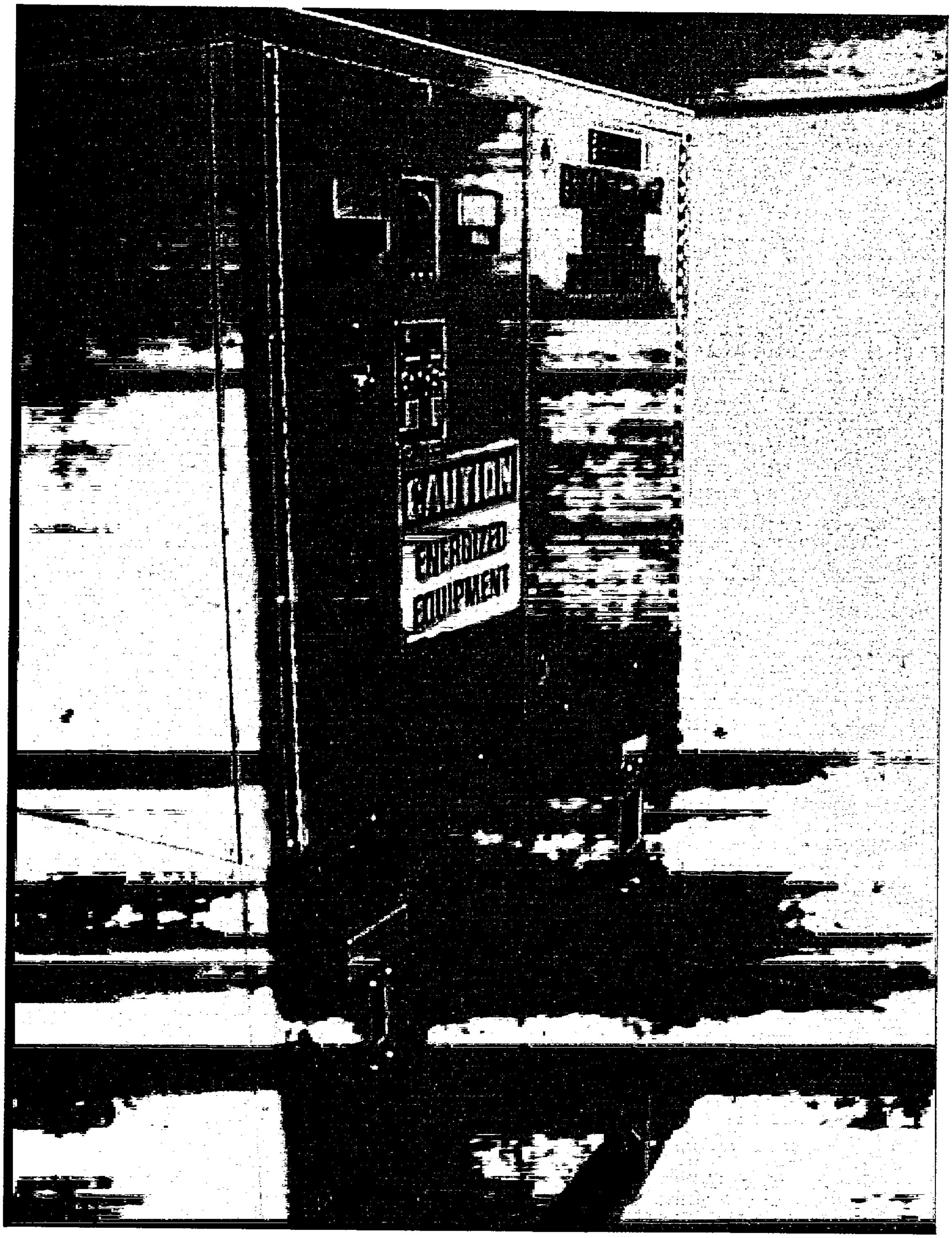

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Figure 16 Charger C1-7

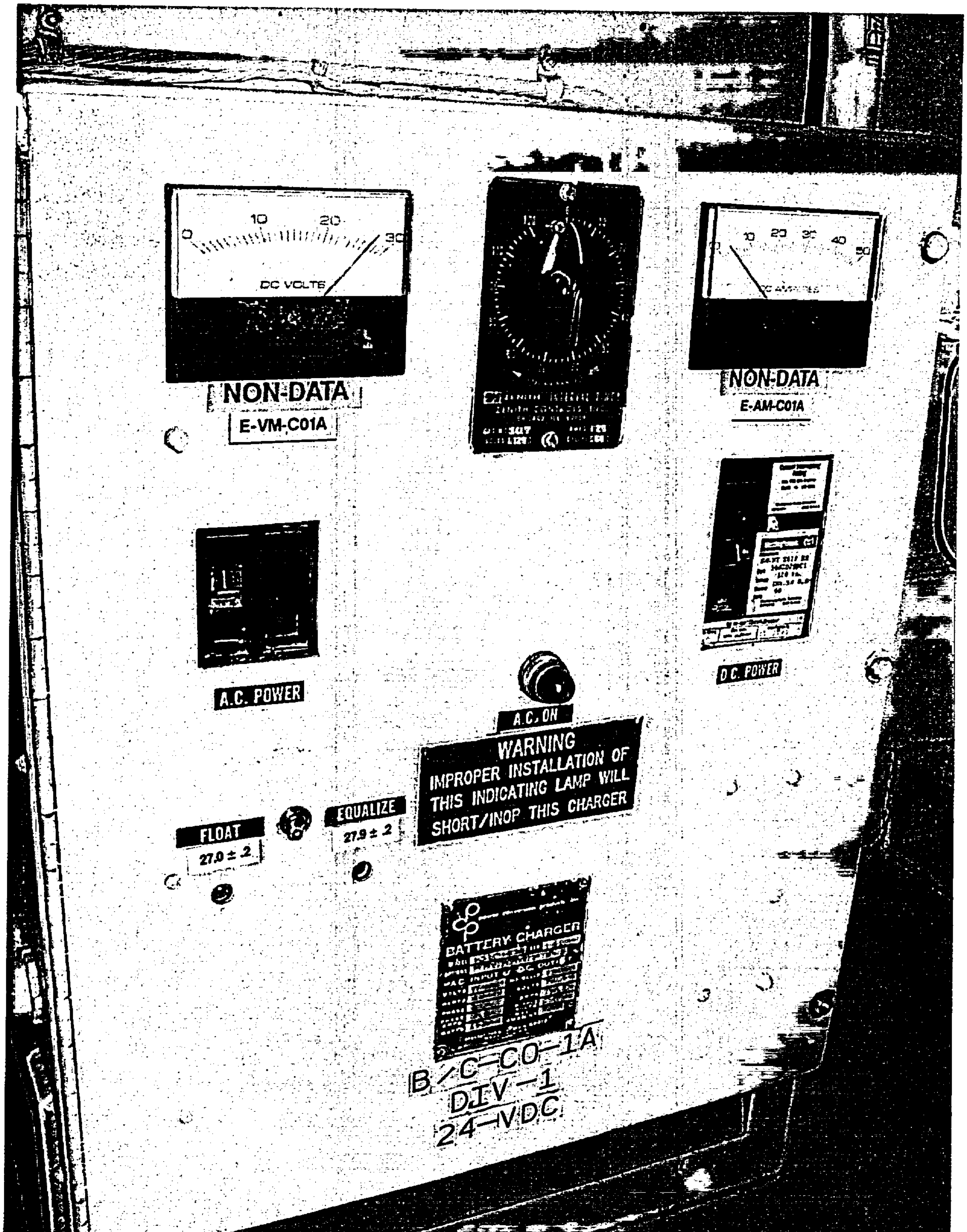

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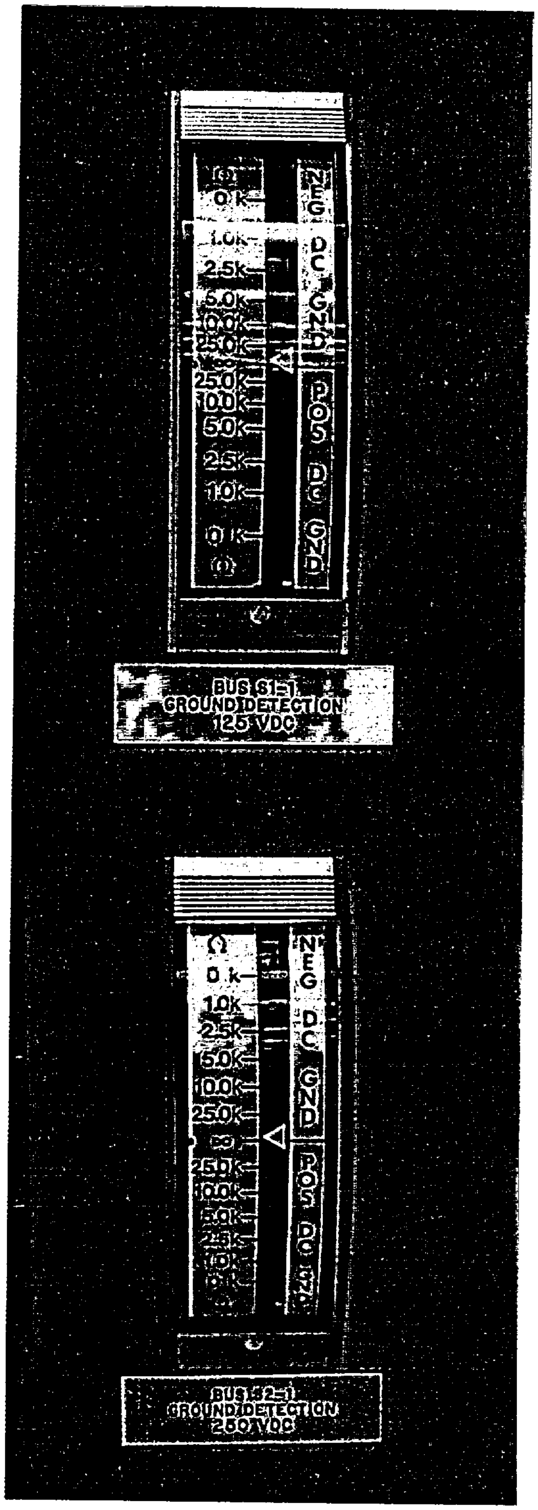
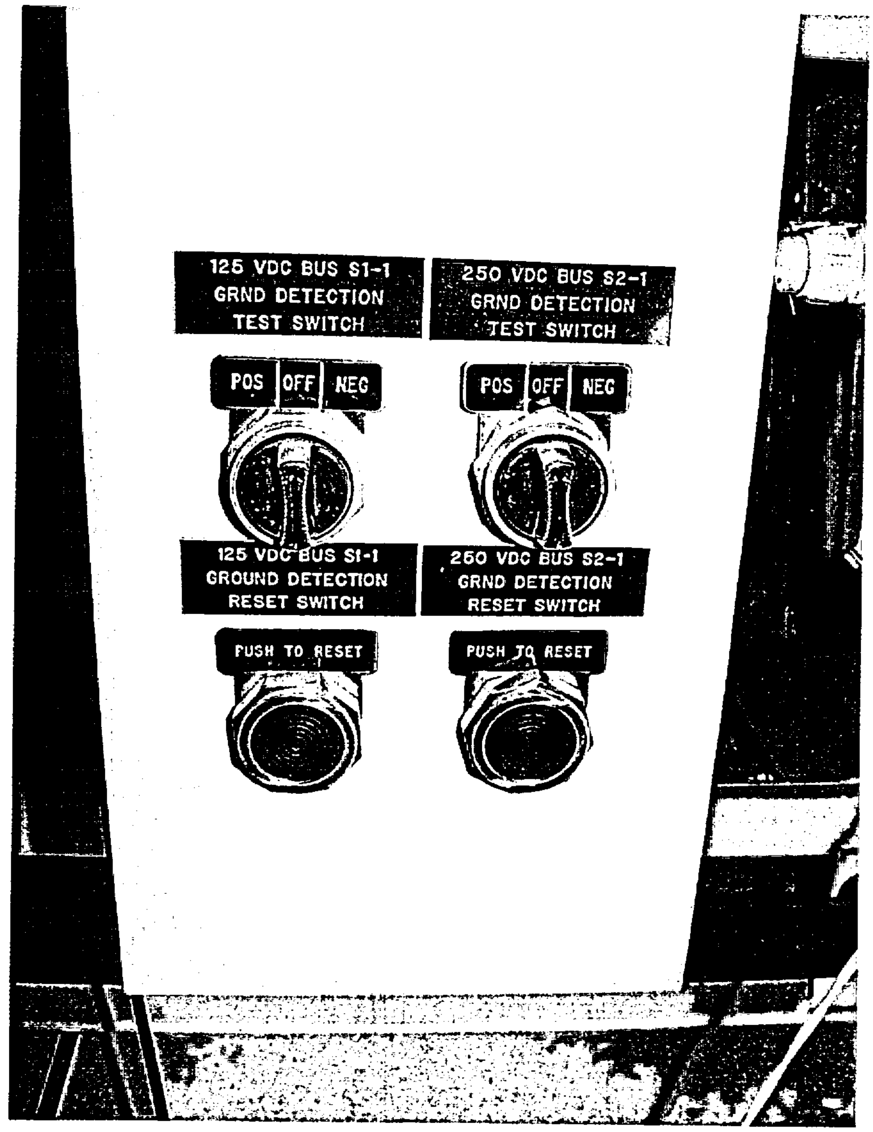
Figure 17 Charger C0-1A





Ground Detector Test Switches (inside Bd C)

Figure 18 Bd C Ground indication

COLUMBIA SYSTEMS
IBD Rev. 7

NOVEMBER, 2002
SD000176
DIC 0023.98

COLUMBIA GENERATING STATION

SYSTEM DESCRIPTION

Volume 1, Chapter 4

ISOPHASE BUS DUCT AND COOLING SYSTEM

Reviewed by:	Stephen Dallas Engineering	11-14-02 Date
Reviewed by:	[signature] Operations	11-27-02 Date
Approved by:	Randy [signature] Operations Training Manager	12/5/02 Date

MINOR REVISION RECORD

Minor Rev Number	Description of Revision	Affected Pages	Entered By	Effective Date	Manager Approval

ISOPHASE BUS DUCT AND COOLING SYSTEM

I. PURPOSE

The purpose of the Isophase Bus Duct and Cooling system is to provide physical protection of the busses, minimize the heating effects of stray flux on surrounding steel, and to provide an enclosure for cooling the main buses to increase their current carrying capacity. LO-5439

II. DESIGN BASES

N/A

III. GENERAL DESCRIPTION (Figure 1)

A. Each phase of the Main Generator output is connected to the Main Transformer, station Normal Transformers and the Generator Surge Protection and Potential Transformers through physically isolated bus duct enclosures. The enclosure connecting the Main Generator to the Main Transformers is composed of two sections; the Main Bus Duct and the Delta Bus Duct. The Main Bus connects the generator to the Delta Bus. The Delta Bus branches connecting the primaries of the Main Transformers in a delta configuration. Disconnects allow TR-M4 to be substituted for any of the other Main Transformers. The sections of bus duct connecting the Main Generator to the Normal Auxiliary Transformers are labeled Auxiliary Bus Ducts. The section of bus duct connecting the Main Generator to the Generator Surge Protection and Potential Transformers has no specific designation.

B. The Bus Duct Cooling System circulates air through the Main Bus Duct, the Delta Bus Duct and the Main Generator Lead Bushings to remove heat generated in the electrical conductors. The system consists of two 100% capacity belt driven fans and heat exchanger sets. Air circulated through the bus ducts by the operating fan transfers the heat from the ducts to the Plant Service Water system through an air to water heat exchanger. The bus duct cooling system is normally operated in a closed loop (recirculation) mode, but can be operated in a once-through mode when Plant Service Water is not available.

C. Hydrogen detectors in the vicinity of the Main Generator Leads monitor for hydrogen leakage from the Main Generator to the bus duct in the event of Main Generator lead bushing seal degradation or failure. High hydrogen conditions in the bus duct may result in a fire or explosion. Bus duct hydrogen concentrations at the lower limit of flammability are alarmed in the control room.

IV. COMPONENT DESCRIPTION

A. Isolated Phase Bus Conductors

The three conductors that carry main generator output to the main transformers are hollow aluminum cylinders 22" in diameter plated with silver at all contact surfaces. Each main conductor connects to the surge protection and potential transformer, and the two station auxiliary transformers via 4" square hollow aluminum conductors. The bus duct conductors are separated from the bus duct enclosure by porcelain insulators located in the interior bottom of the enclosure.

B. Isolated Phase Bus Ducts

1. The main and delta bus ducts are 40" outside diameter sealed aluminum enclosures. Aluminum is used to avoid the hysteresis losses present in steel. The auxiliary bus ducts to the station normal transformer are 22" outside diameter sealed aluminum enclosures. The isolated phase bus ducts and their support beams are fully grounded.

2. At 8,000 amperes and above, stray flux can result in heating of steel members in proximity to the bus, such as building steel, reinforcing bars in concrete, pipe hangers, pipes, cable trays ladders, railings, platforms, and other components. Temperatures achieved due to stray flux are not high enough to affect structural strength or combustibility, but are a serious safety problem.

3. In the continuous-enclosure design isolated phase bus duct, each phase conductor current induces a current opposite in direction and nearly equal in its own phase enclosure, the return path being the other phase enclosures and end plates. This current neutralizes flux from the phase conductor, with the result that external flux is approximately 5% of that which would exist if the enclosures were not present. Therefore, induced heating problems are absent. Additionally, there is a 93% reduction in electromagnetic forces on conductors and insulators.

C. Isolated Phase Bus Duct Cooling

1. The isolated phase bus duct cooling system removes heat from the Main and Delta Bus Ducts. The system consists of two sets of full capacity fans and heat exchangers (Figure 2). The fans, heat exchangers, and dampers are enclosed in one metal cooling unit housing. The cooling fans and dampers are related such that each fan's suction damper is controlled by the other fan's control circuit. The running fan will close the suction damper on the non-running fan. When the running fan is shutdown the non-running fan damper will open. This configuration allows only one cooling fan to be running and prevents bypass air flow from the supply header to the running fan suction through the non-running fan. When both fans are stopped, both fan suction dampers will be open. The system has two supply air and two return air ducts which connect the Main Bus Duct Enclosures to the cooling unit. LO-5444

LO-5440

2. Cooling air flows from the running cooling unit fan to the "A" phase (Aϕ) Main Bus Duct (center) toward the Main Transformers. Air returns from the Main Transformers to the cooling unit via the Bϕ and Cϕ Main Bus Ducts. The air crosses over from the Aϕ to the Bϕ and Cϕ Main Bus Ducts at Main Transformer TR-M4 via the Delta Bus

and at TR-M2 and TR-M3 via deionizer/damper assemblies. The Delta Bus allows TR-M4 to be substituted for any of the other three Main Transformers. The deionizers are screens which prevent ions from traveling phase to phase.

3. Air flow from the Bϕ and Cϕ Main Bus Duct Enclosures returns to a common plenum at the cooling unit. Air flows from the common return air plenum to the running fan's suction via the fan's suction damper (IBD-AD-10A(B)) and associated TSW cooled heat exchanger (IBD-HX-1A(B)).

4. Air flowing to the Main Generator branches to a separate air crossover duct to cool the generator main lead bushing and to purge the space between each generator main lead bushing and bus duct baffle bushing of hydrogen that may have leaked by the generator main lead bushing. This air is exhausted to the turbine building atmosphere under the main generator via screened ports. Makeup air is admitted through normally open manual damper, IBD-AD-11.

5. In the event of a loss of TSW cooling, the fans may be supplied fresh air from the Turbine Building atmosphere through filters and normally closed manual dampers (IBD-AD-13-A and B) for a "once-through" mode of operation. The flow of cooling air to the Main Transformers and Main Generator is as before. However, air returning to the cooling unit from the Main Transformers is exhausted out through the normally open manual damper, IBD-AD-11, discharging the heat to the Turbine Building atmosphere. (Figure 3) LO-5441

6. The internal environment of the auxiliary bus ducts are isolated from the main bus duct environment by seal-off bushings and are not cooled by the bus duct cooling system. The bus extension to the surge protection and potential transformer is pressurized with air from the bus duct cooling system but receives little cooling benefit due to lacking a complete airflow circuit. These sections are cooled by heat transfer to the surrounding environment.

D. Isolated Phase Bus Duct Bushings (Figure 4)

The isolated phase bus duct bushings provide a means to separate the environmental conditions of adjacent bus duct components while maintaining electrical continuity between components. Generally the bushings prevent the transmigration of moisture, air, gas or liquids between components. The Main Generator baffle bushings specifically prevent hydrogen gas or moisture from entering the main bus duct in the event of main lead bushing degradation with the cooling fan operating.

E. Hydrogen (H_2) leak detection

1. H_2 Monitor TG-H2IS-1 is located on the Turbine Building 471' elevation west end, near the Generator Vibration Monitor panel. The monitor receives inputs from four H_2 detectors, three located in vent openings atop each of the three Isophase Bus ducts (A, B, and C), and one located on the Exciter Housing (Doghouse). The monitor LO-5446

provides indication of the amount of H_2 present at each sensor on a 0-100% scale, where 100% corresponds to 4% H_2 by volume (equal to 100% of the Lower Explosive Limit [LEL]). The 0.8% H_2 alarm setpoint corresponds to 20% of scale on the local panel. If H_2 concentration exceeds 50% of scale (2% H_2), the alarm cannot be reset at the local reset button until the concentration drops below 50% of scale. Upon sensing H_2 above 0.8% at any of these locations, an alarm is received in the control room at P800, board C, at C3 10-6.

2. The local control panel has two controls; a "reset" button on the front of the panel for re-setting or acknowledging the alarms locally, and a "meter select" switch inside the panel to select the desired channel (1 through 4) OR have the H_2 meter automatically indicate the highest reading channel.

F. Cooling Unit

1. Each cooling unit fan is designed to supply 100% of the forced air requirements of the main bus duct. The fans are individually rated to deliver 14,600 scfm of air at 6.5 inches of water pressure. Each fan is driven by a 480 VAC, 30 horse power motor through drive belts and pulleys.

2. Each cooling unit heat exchanger is designed to remove some of the heat energy generated by the current flow through the main bus duct. The cooling capacity of each heat exchanger is 1,030,000 BTUs per hour. The remainder of the heat energy generated by the current flow through the main bus duct is dissipated by natural self-cooling. The heat exchangers are the fin and tube type. Air flows around the finned tubes once. Cooling water flows through the tubes at approximately 103 gpm. The cooling water is supplied from plant service water (TSW) with no backup. The cooling coils are designed for 85°F incoming water, 165 psig and a pressure drop of 10 psi.

G. Main Generator Surge Protection and Potential Transformers (Figure 4)

1. Main generator surge protection consists of a station lightning arrestor for each phase. Each arrestor is enclosed in an isolated compartment and connected between the corresponding phase and ground.

2. The main generator potential transformers consist of two step down transformers and fuses per phase. Each transformer/fuse set is enclosed in a compartment and is mounted on a draw out type rack. When these transformer/fuse sets are racked out, they are disconnected from all sources of electricity and fully grounded by use of a sliding contact. The transformer/fuse sets are connected to the respective phase through a resistor when fully racked in.

3. The potential transformers step down the main generator output voltage from 25,000 volts to 125 volts. One potential transformer of each phase supplies the main generator voltage regulator. The second potential transformer of each phase supplies the main generator metering, relaying and synchronization circuits

V. CONTROL THEORY AND INTERLOCKS

A. Control Room Controls

1. Bus Duct Cooling Fan H13-P800 (Board C)

   Three position maintained contact, RUN/STANDBY/OFF

   a. RUN

      1) If other fan is running, no response.

      2) If the other fan is off and the related suction damper is open;

         a) fan starts

         b) associated TSW cooling water valve opens

         c) other fan's suction damper closes

   b. STANDBY — LO-5442

      1) When low air flow across both heat exchangers exists with the other fan stopped or tripped, and the related suction damper is open;

         a) the fan starts

         b) the TSW cooling water valve opens

         c) other fan suction damper closes

   c. OFF

      1) Fan stops, TSW cooling water valve closes and the other fan suction damper opens

B. Local Controls

None

C. Interlocks

1. Cooler Inlet Valves TSW-V-168A(B)

   Open when the related fan starts or main bus duct air temperature is high as sensed by one of six temperature switches located inside the duct. — LO-5446

2. Main Generator - Bus Duct air flow provides a close permissive to the Main Generator Field Breaker. Low flow does not trip the field breaker — LO-5443

VI. INSTRUMENTATION AND ALARMS

A. Control Room

1. Instrumentation (Board C)

a. Main generator output current (0-35 kamps)

b. Main generator output voltage meters and recorder (0-30 kvolts)

c. Main generator output frequency meter and recorder 55-65 Hz)

d. Main generator output watt meter (0-1400 MW)

e. Main generator output VAR meter (-700 to +700 MVAR)

f. Bus duct cooling fan control switches and indicating lights.

2. Alarms (Board C) (See associated annunciator procedures for current setpoints.) LO-5547

a. P800-C4 1.2 GEN BUS DUCT TEMP HIGH

b. P800-C4 2.2 GEN BUS DUCT AIR FLOW LOSS

c. P800-C4 3.2 GEN BUS DUCT CLR FLOW LOSS

d. P800-C3 10.6 H2 LEAKAGE AT IBD/EXCITER

B. Local

1. The Bϕ and Cϕ main bus conductors are equipped with temperature indicators. The indicators are placed at expected highest spot temperature locations. There are six temperature indicators having a range of 0 to 200°C. Three indicators each are located on the Bϕ and Cϕ main bus conductors. The indicators are read locally through viewing windows in the main bus duct enclosure.

VII. SYSTEM OPERATIONAL SUMMARY

A. Normal

1. Surge protection limits the voltage stresses on the Main Generator and the Isolated Phase Bus Ducts to prevent insulation damage resulting in short circuited stator turns and phase-to-ground or phase-to-phase faults. The magnitude of the surge voltage is limited by the station lightning arresters.

2. The Bus Duct Cooling system is normally operated in a "recirculation mode" with one fan and one heat exchanger in service to provide cooling for the conductors inside the bus ducting with the other fan and heat exchanger in "standby". Air flows to the components through the Aϕ and returns to the cooling unit through the Bϕ & Cϕ. LO-5440

B. Abnormal

1. The Bus Duct Cooling system can be operated in a "once-through mode" by opening dampers that align the fan suction to the TB 471' LO-5441

elevation atmosphere and discharging the heated air back to the turbine building atmosphere through the normally open damper at the cooling unit common suction. The flowpath in the ducts remains the same as in the recirculation mode.

2. The standby fan will automatically start on a loss of the running fan that results in the fan controller indicating that the fan is off. The "fan off" condition opens the suction damper on the standby fan and when the low air flow condition is satisfied, the standby fan will start. Mechanical failures of the running fan that do not result in the fan control circuit tripping may result in bus duct low flow and/or high temperature conditions without automatic start of the standby fan. Action to take the running fan control switch to off will enable the standby fan start sequence.

C. Industry Events

1. OE8885 , Hotspot on Isophase Bus, discusses an event at St. Lucie Unit 2 where bolts had become loose at electrical connections due to thermal cycling. The electrical connection degraded producing a point of contact with high resistance. Eventually a thermal runaway condition could have developed and caused additional, significant damage.

2. OER 86009U, Reactor Scram and Electrical Bus Damage, discusses an event where a failure in the Isophase Bus Duct system resulted in a reactor scram and a fire in the vicinity of the Isophase Bus Duct system. Generator hydrogen gas leaking past the generator lead bushings was fueling the fire and it took approximately 2.5 hours to extinguish the fire. The event developed in a rapid manner and no event precursors were identified in the Control Room. The actual cause of the event has not been determined. Columbia Generating Station emphasizes the importance of performing adequate maintenance on the 25 KV distribution system in order to prevent failures in the IBD system.

VIII. SYSTEM INTERRELATIONSHIPS

A. Plant Service Water - Supplies cooling water to the Bus Duct Cooling System Heat Exchangers.

B. Main Generator - Bus Duct air flow provides a close permissive to the Main Generator Field Breaker. Low flow does not trip the field breaker. LO-5443

IX. POWER SUPPLIES

A.	Bus Duct Cooling Fan 1A	MCC-3B Cubicle 8C
B.	Bus Duct Cooling Fan 1B	MCC-2R Cubicle 13C
C.	Bus Duct Cooling Fan 1A Suction Damper Motor & TSW-V-168A	PP-1B-A Circuit #15

D. Bus Duct Cooling Fan 1B Suction Damper Motor & TSW-V-168B — PP-2P-A Circuit #23

E. Potential Transformer Failure Relay — DP-S1-1B Circuit #11

X. <u>TECHNICAL AND LICENSEE CONTROLLED SPECIFICATIONS</u>

A. Technical Specifications

None

B. Licensee Controlled Specifications

None

XI. <u>REFERENCES</u>

A. WNP-2 Systems & Procedures BDC System Lesson (Nov. 1982)

B. PPM 2.5.6; Bus Duct Cooling System

C. PPM 800.C3; Annunciator Panel Alarms

D. PPM 800.C4; Annunciator Panel Alarms

E. Power Plant Electrical Series; Volume 7, Auxiliary Electrical Equipment; Electric Power Research Institute

F. Drawings:

1. M508 Plant Service Water
2. E519, Sheet 11 (Cooling Fan & Valve Controls) EWD 51E003
3. E520, Sheet 6 (Gen. Field Breaker Control) EWD 51E012
4. CVI 02-46-00-0020, Cooling Unit for Isolated Phase Bus

G. Contract 46, Specification 2802-46, Division 16, IBD Design Specifications

TABLE I

ISOLATED PHASE BUS DUCT DATA

Bus Current Ratings

	Continuous Amperes	Momentary Amperes Asymmetrical	Forced Cooled Continuous Amp.	Evaluation Amperes
Main Gen. Bus	30,000	215,000	30,000	30,000
Step-Up Transformer Sub-Bus Delta	17,300	215,000	(self-cooled)	17,300
Both Aux. Transformer Buses	1,200	385,000	-	1,200
Pot. Transformer Tap Bus	1,200	385,000	-	0

Bus Voltage Ratings

Nominal Rated Voltage: 25KV, 3 phase, 60 Hz

Potential Transformers

Manufacturer's Type - GE Type JVS-150
Primary Voltage (volts) – 25,000
Voltage Ratio - 25 KV/125V (200:1) wye-wye
Thermal Rating - 400 VA
Quantity - 6

Surge Protection

Number Arresters - 3 Voltage Rating 25 KV

Service Conditions

Ambient Temperature -	40°C maximum, 10°C minimum indoors
-	46°C maximum, -32.8°C minimum outdoors
Bus Enclosure Temp. Rise	65°C at rated load and 40°C ambient
Bus Enclosure Temp. Rise	40°C at rated load and 40°C ambient

TABLE II

ISOLATED PHASE BUS DUCT DATA

Manufacturer	Krack Corporation
Cooling Coils	
Type	Fin and Tube Type
Area	40.8 square feet
Cooling Capacity	1,030,000 BTU/hr
Water Flow	103 GPM
Entering Water Temperature	85°F
Leaving Water Temperature	105°F
Pressure Drop	5.3 psi
Entering Air Temperature	170 DB °F (76 C)
Leaving Air Temperature	105 DB °F (40 C)
Fan	
Capacity	14,600 @ 6.5" TSP
Speed	2000 RPM
BHP	24
Fan Motor	
Horsepower	30
Speed	1750 RPM
Voltage/Freq./Phase	480/60/3
Type	Squirrel Cage Induction
Manufacturer	Krack Corporation
Coil Shutoff Damper (suction damper)	Motor Driven, parallel acting blades, 90° travel, gasketed blade edges, aluminum end seal
Air Exhaust Damper and Air Intake Damper	Manual, parallel acting Fresh blades, 90° travel, gasketed blade edges, aluminum end seal

SYSTEM LEARNING OBJECTIVES	EO	RO	SRO	STA
5439 State the purpose of the Isophase Bus Duct Cooling System.	X	X	X	X
5440 Describe the air flowpath utilized in the IBD system for the Recirculation mode of operation.	X	X	X	X
5441 Describe the air flowpath utilized in the IBD system for the Once-through mode of operation. Include the conditions that necessitate use of this mode.	X	X	X	X
5442 List the conditions that cause the automatic start of the STANDBY Bus Duct Cooling Fan.	X	X	X	X
5443 Explain the interlock between the BDC system and the main generator field breaker.	X	X	X	X
5444 Explain the interlock between the Bus Duct Cooling Fans and their suction dampers; include the reason for this interlock.	X	X	X	X
5445 State the automatic actions associated with the cooler inlet valves TSW-V-168A (B).	X	X	X	X
5446 State the purpose of the Isophase Bus Duct H2 Monitor.	X	X	X	X
5447 Analyze given key Isophase Bus Duct Cooling system parameter indication and/or responses depicting a system abnormality and determine the course of action to correct or mitigate the problem.	X	X	X	X

SYSTEM TEXT REVISION SUMMARY

REV 7 AUTHOR, M. Avery November 2002

1. Deleted statement about TR-M4 replacing TR-M2 due to impending realignment during R-16. (Pages 3 and 4)
2. Added field breaker interlock to interlock section. (Page 7)
3. Revised references to reflect current Columbia Generating Station procedures. (Page 9)
4. Added reference to contract 46, specification 2808-46, division for IBD design specifications. (Page 10)
5. Updated format.

REV 6 AUTHOR, M. Avery, July 2000

1. Added column for Equipment Operator Learning Objectives.
2. Added information about minimizing effects of stray flux to purpose section and component description for Isolated Phase Bus Ducts.
3. Reordered paragraphs for Isolated Phase Bus Duct Cooling section of Component Descriptions for better flow and clarity. Rephrased as necessary for better clarity.
4. Defined Deionizer
5. Added statement as to purpose of Delta Bus.
6. Indicated that TR-M4 is in service, replacing TR-M2.
7. Corrected EPN for TG-H2IS-1, H2 Monitor.
8. Corrected PT turn ratio to 200/1, secondary voltage to 125V, Primary Voltage to 25KV, and rating to 400VA per system engineer.
9. Added reference to Figure 4 for Main Generator Protection And Potential Transformers.
10. Separated the two conditions considered for the RUN position of Bus Duct Cooling Fan for better clarity.
11. Added additional margin references to learning objective information.
12. Removed redundant phrase from paragraph on surge protection (VII A).
13. Added OE 8885 to Industry Events.
14. Changed WNP-2 to Columbia Generating Station.
15. Added TSW-V-16A and 16B to components on power supply list.

16. Corrected ranges for Main Generator Output Watt Meter and Main Generator Output VAR Meter

REV 5 AUTHOR; R. Guthrie/D. Kaopuiki Date: March 1995

NOTE: All technical revisions are identified with a vertical line located toward the right margin in the text. Format changes are not identified with revision bars.

1. Revised format to include system Learning Objectives at the locations appropriate in the systems text and in a table.
2. Revised title to identify that the text covers the isophase duct components and cooling system and not just the cooling system.

3.	Section I	Reworded section for clarity.
4.	Section IV.B.2 and 3	Removed reference to auxiliary buses being cooled by the bus duct cooling system. Reworded for clarity and added damper EPNs.
5.	Section III	Revised the General Description to be more inclusive of the isophase bus components.
4.	Section IV	Removed reference to capacitors which are no longer installed in system. Created a discussion on the bus duct conductors and added information on how the conductors are suspended in the bus duct. Consolidated the discussion on the bus ducts under one heading. Revised the duct cooling discussion to specifically discuss the interface between the different duct sections and how cooling is accomplished in each section. Clarified the discussion on the branch air flow path to the main generator lead bushings. Consolidated and simplified the discussion on bus duct bushings. Deleted the rating data and extraneous technical data for the main bus, delta bus and auxiliary bus from the component description; this data is found in table 1.
5.	Section V	Clarified fan response for each switch position and consolidated the damper response into the fan control discussion. Deleted discussion on capacitors that no longer exist and deleted the interlock information which is incorporated in the component control information.
6.	Section VII	Moved surge protection information to this section from Component Description. Added information on standby fan response to electrical and mechanical failures of the running fan.
7.	Section XI	Deleted Revisions numbers from drawing.
		Added EWD numbers to E519 and E520
8.	Table I	Removed references to surge protection capacitors.
9.	Figure 1	Revised references to other figures.
10.	Figure 2 & 3	Clarified flowpaths, added EPNs.
11.	Figure 4	Removed capacitors.

12. Revised Learning Objective 5446
13. Added OER 86009U to the System Operational Summary section

REV 4 AUTHOR; D. Dallago Date; March 1993

1. Pages 1 and 6, added sections on Hydrogen leak detection, one for the general description, and one for the component description. Used R-6 training handout.
2. Pages 8 & 9, V. A & B, clarified fan interlocks and fan operation with associated control switches. Used 51E001 through 51E004, E519, Master Instrument Data Sheets for IBD-FS-1A/B.
3. Pages 8 & 9, V. A & B, found in system prints that the flow switches are assigned two different EPNs (IBD-FS-1A/B and BDC-DPS-1/2) and stated to be in two different locations (in the cooling unit and at the fan discharge). Note that the cooling unit is at the fan suction as shown on figures 2 & 3. Discussed this with the system engineer, Tom Sackett, and he told me these discrepancies will not be resolved until sometime after I am scheduled to leave this project. To best deal with this problem in the mean time, I used "educated guesses" and assumed the correct EPN is "IBD-FS-1A/B" and the switches measure differential pressure across the coolers in the return air flow ducts (these are at the fan suctions as shown in CVI 02-0046-20).
4. Page 12, added reference to CVI 02-46-00-0020, Cooling Unit for Isolated Phase Bus.
5. Rearranged material to fit better on pages.
6. Changed all references to "A, B and C phases" to "Aϕ, Bϕ, and Cϕ" for consistency. (Both methods were used previously.)

Additional change since March 1993:

On 7-7-93 M. Westergren corrected a "typo" by moving XII. POWER SUPPLIES from the bottom of pg 11 to the top of pg 12 to clean up the appearance.

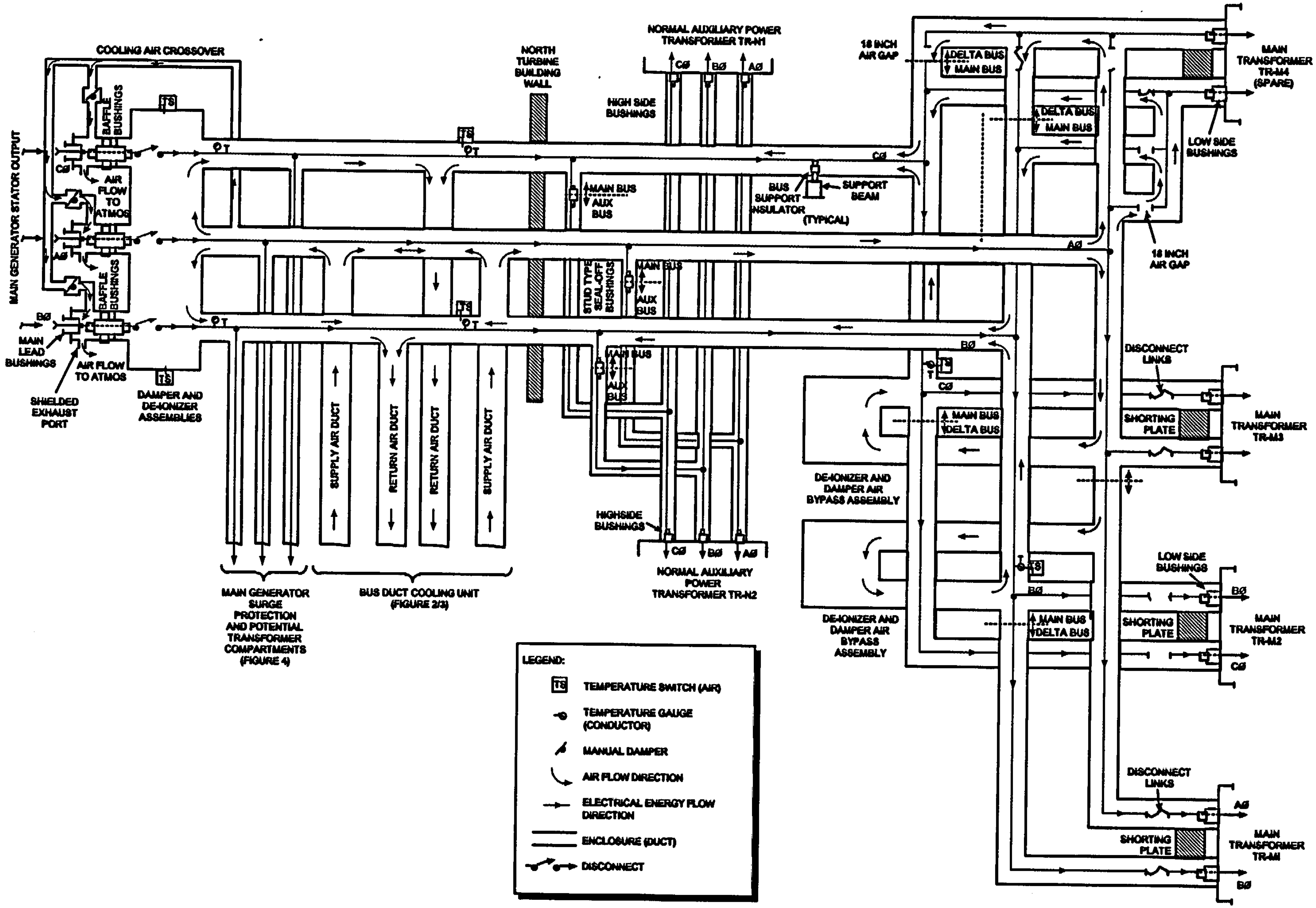


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FIGURE 1. ISOLATED PHASE BUS DUCT FULLY INSTRUMENTED FLOW DIAGRAM

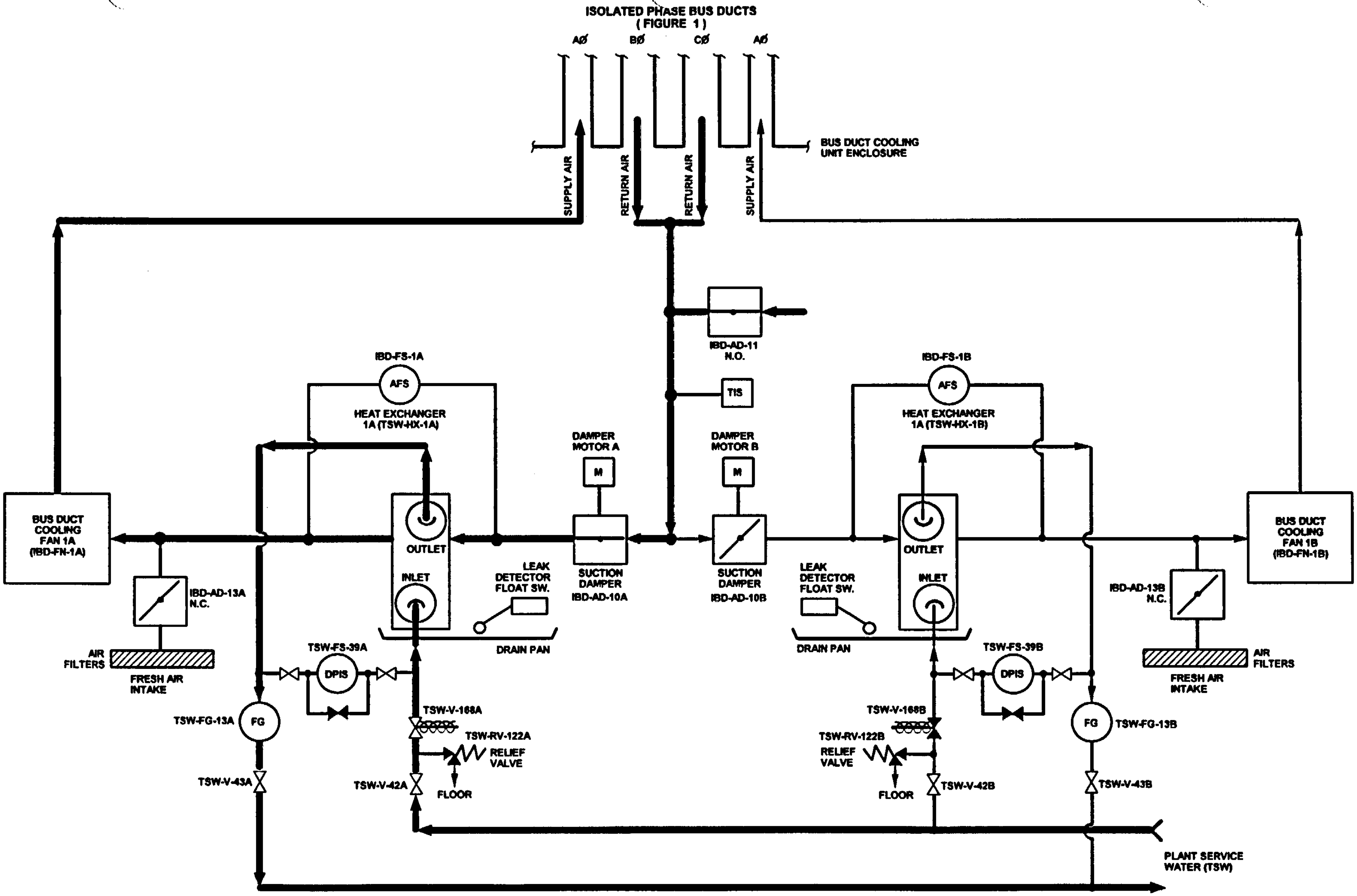

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FIGURE 2. ISOLATED PHASE BUS DUCT COOLING UNIT NORMAL FLOW DIAGRAM

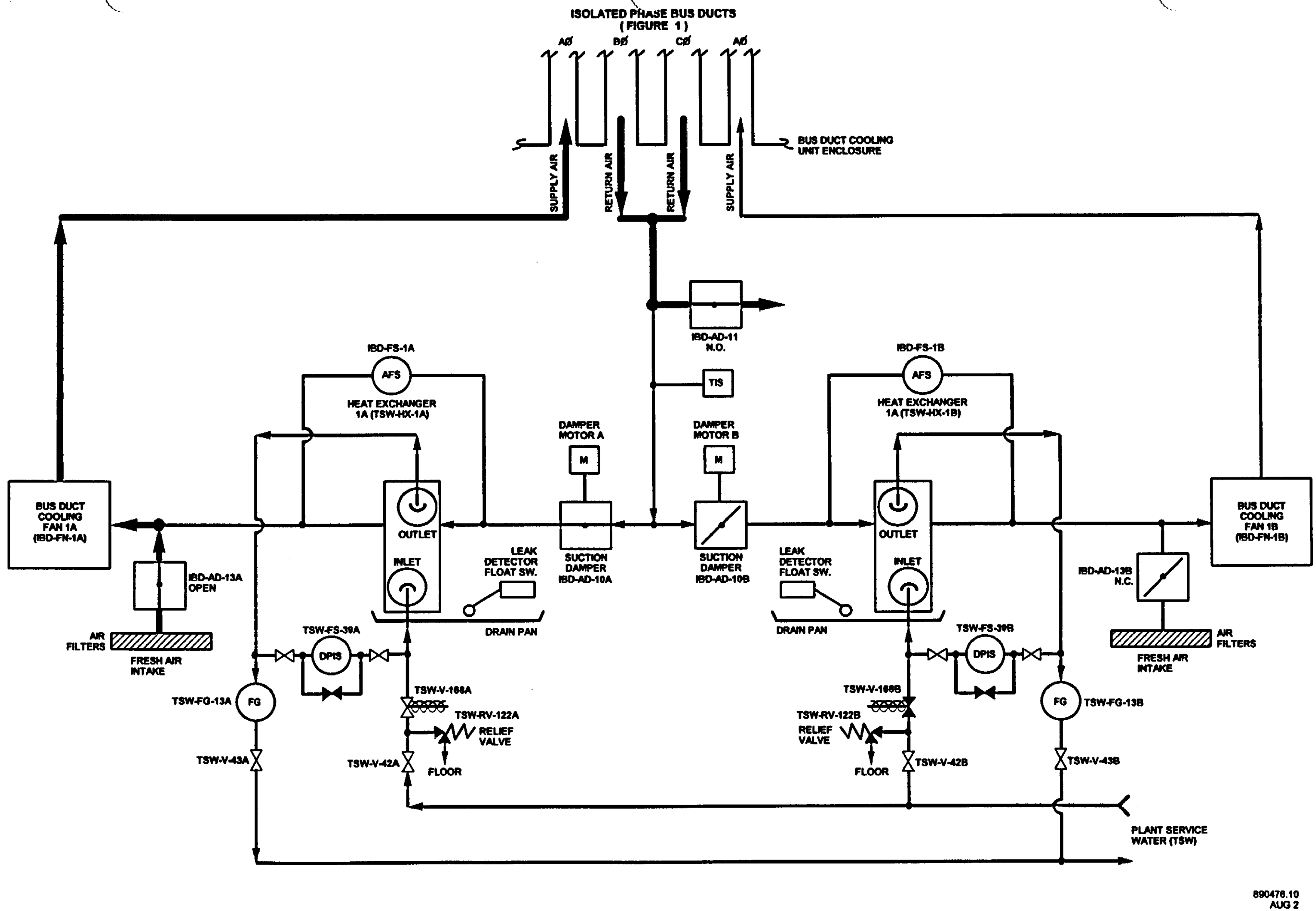

FIGURE 3. ISOLATED PHASE BUS DUCT COOLING UNIT ONCE THROUGH FLOW DIAGRAM

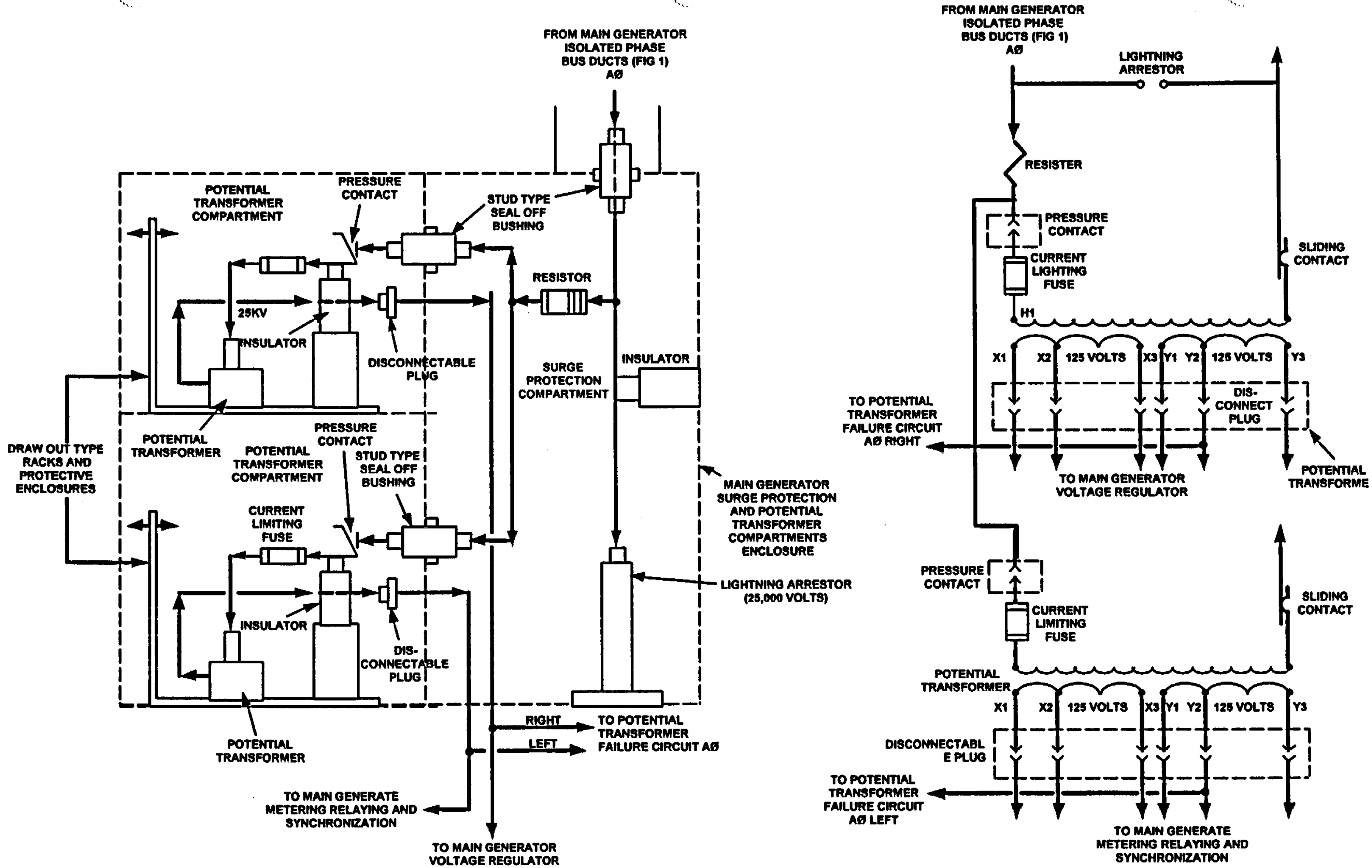

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FIGURE 4. MAIN GENERATOR SURGE PROTECTION AND POTENTIAL TRANSFORMERS (TYPICAL FOR BØ AND CØ)

NOVEMBER, 2002
SD000151
DIC 0023.98

COLUMBIA GENERATING STATION

SYSTEM DESCRIPTION

Volume 2, Chapter 3

FEEDWATER SYSTEM

Reviewed by:	Engineering	11/20/02 Date
Reviewed by:	Operations	11/19/02 Date
Approved by:	Operations Training Manager	11/20/02 Date

MINOR REVISION RECORD

Minor Rev Number	Description of Revision	Affected Pages	Entered By	Effective Date	Manager Approval

FEEDWATER SYSTEM

I. PURPOSE

The primary purpose of the reactor feedwater system is to provide vessel makeup water from the condensate system to the reactor vessel, in the required quantity and at the required temperature and pressure, during all modes of operation. **LO-5746**

II. DESIGN BASES

The feedwater system is designed with sufficient capacity to provide for 115% of the rated required feedwater flow.

III. GENERAL DESCRIPTION

Basic System Flowpath

The feedwater system is an extension of the condensate system. It increases the vessel makeup water pressure, and temperature, to the pressure and temperature necessary to inject into the vessel during normal plant operation (GT 1035 psig).

This system consists of two turbine driven Reactor Feedwater Pumps (RFPs), two High Pressure (HP) Feedwater Heaters , and the associated controls, instrumentation, piping, valves, and equipment to supply the reactor with heated, high quality feedwater. The system extends from the inlet of the RFP's to the six reactor vessel feedwater spargers.

The feedwater leaves the RFPs and flows through two parallel HP feedwater heaters (RFW-HX-6A & 6B), where it is heated by turbine extraction steam. From the HP feedwater heaters the flow passes through two flow measuring elements, two motor operated isolation valves (RFW-V-65A & 65B), and two containment isolation check valves, prior to entering the drywell. Inside the drywell, the two feedwater lines pass through two more check valves, and two manually operated isolation valves, and then split into six feedwater inlet lines to supply the six vessel feedwater spargers. The two reactor feed pumps may be bypassed, and the condensate booster or condensate pumps used, when reactor vessel pressure is not high enough to require their use.

Detailed Feedwater System Flow Path (Figure 1)

Each RFP takes a suction from the common outlet header of the LP condensate feedwater heaters COND-HX-5A & 5B through 24" suction lines.

Each pump suction line is equipped with a manual isolation valve (COND-V-147A & 147B). The pumps discharge through individual 24" discharge lines into a common 30" header. Each pump discharge line is equipped with a check valve, motor operated isolation valve (RFW-V-102A & 102B) and flow instrumentation. Each pump discharge line is equipped with a normally aligned 2" pressure equalizing header that taps off the pump discharge line just downstream of the pump discharge isolation valve and routes feedwater back to a point just upstream of the pump discharge check valve. Each line has a flow restriction orifice and two manual isolation valves. The pressure equalizing header provides a means of equalizing the pressure in an isolated RFP, and keeps an idle pump warm while at the same time preventing an excessive amount of equalizing header flow.

Each RFP has a minimum flow line to enable a minimum amount of flow through the pump when the discharge valve is closed, or during low flow conditions, to prevent the pump from overheating. This line routes feedwater from a point upstream of the pump discharge check valve through an air operated flow control valve (RFW-FCV-2A or 2B) to the main condenser. The minimum flow valves are controlled by the individual pump total flow (discharge + minimum flow) and are interlocked to open for 30 seconds after a scram and interlocked closed after a RFP turbine trip. Additional information concerning this is provided in the CONTROL THEORY AND INTERLOCKS section of this student text.

The RFP's are equipped with a 16" bypass header. This header has a motor operated control valve (COND-V-149) and a check valve. The bypass header routes condensate from the 24" pump suction line to the common 30" RFW discharge header. This bypass header is utilized to supply condensate to the reactor during startup and low power operation when the RFP's are off-line.

Each RFP discharge line has a flow element that is used for RFP flow indication and used by the feedwater level control system to determine total RFP flow.

The discharge flow from the RFP's and/or the RFP bypass header is routed through the high pressure feedwater heaters (RFW-HX-6A & 6B). The high pressure feedwater heaters consist of two 50% capacity parallel heat exchangers. These heat exchangers provide the final stage of feedwater heating. The heat exchangers combine extraction steam and other heater drain condensate on the shell side to heat the feedwater, which is routed through the tube side. Both high pressure feedwater heaters have a motor operated inlet (RFW-V-108A & 108B) and outlet (RFW-V-112A & 112B) isolation valve.

The 6A & 6B feedwater heaters can be partially or completely by-passed through a 20" bypass header. This bypass header is equipped with a motor operated bypass valve (RFW-V-109).

A feedwater recirculation header or long cycle cleanup path is provided from the discharge of the 6A & 6B feedwater heaters to the main condenser. During startup preparations, this flow path allows almost the entire condensate and feedwater system flow to be recirculated to the main condenser for water quality cleanup and vessel inventory control. A 16" recycle line taps off between the outlet of each HP heater and its respective outlet isolation valve (RFW-V-112A & 112B). The recycle lines have motor operated isolation valves (RFW-V-117A and 117B) just as they tap off their respective heater discharge line. The recycle flows combine to form a common 16" line that passes through an isolation valve (RFW-V-14) and recycle flow control valve (RFW-FCV-15) prior to entering the main condenser.
A 16" startup level control line taps off the common 16" recycle header to bypass RFW-V-112A & 112B and their associated 24" headers and it discharges into the common 30" feedwater discharge header.

The 16" startup level control line splits into an 8" line and a 12" line which each contain a startup level control valve. The two feedwater startup level control valves (RFW-FCV-10A & 10B) are utilized to provide makeup control to the reactor vessel during low flow conditions (LT 25%). RFW-FCV-10A & 10B are air operated and controlled by the

Startup Level Controller using a single element control system to regulate reactor vessel level. The two valves operate in series, but overlap, to provide "seamless" control. The two startup level control lines rejoin to form a common line downstream of their startup level control valves. RFW-V-118 isolates the common outlet of the startup level control valves when they are not in use.

The two feedwater heater 6A & 6B discharge lines join to form a 30" feedwater supply header to equalize feedwater pressure and temperature. The main 30" feedwater supply header splits back into two 24" lines (Line A and Line B) prior to leaving the turbine generator building. Each of these feedwater lines has a separate flow element, and flow indication, that is used by the feedwater level control system to determine total feedwater flow.

The feedwater lines (Line A and B) leave the turbine building, travel though the reactor building steam tunnel and penetrate the primary containment to supply the reactor vessel. Each feedwater line is equipped with a motor operated isolation valve (RFW-V-65A or 65B) and a spring closure assist check valve, with position indication, on the steam tunnel side of the drywell wall. The lines are equipped with a regular check valve with position indication, and a manual isolation valve, on the inboard side of the drywell wall. The purpose of the isolation valves and the check valves is to minimize reverse flow and coolant leakage outside containment if a feedwater line should break.

Reactor Water Clean Up (RWCU) system (4") return lines, empty into the feedwater lines inside the steam tunnel between the feedwater isolation valves and the spring closure assist check valves.

Inside the drywell each feedwater line becomes a header that splits into three lines that connect to the reactor vessel to supply six feedwater spargers located inside the reactor vessel.

Detailed Steam Flowpath (Figure 6)

Each Reactor Feedpump Turbine (RFT) is designed to operate on either high pressure (HP) main steam (MS) or low pressure (LP) extraction/bleed steam (BS) from MSR 1B. **LO-5751** High pressure main steam is used to operate the RFT during startup and low power operations when adequate MSR 1B pressure is not available. MS comes from the auxiliary main steam supply down stream of MS-V-146. The MS flow path is through the motor operated isolation valve MS-V-105A/105B, hydraulic stop valve MS-V-172A/172B, RFT HP governor valve and into the lower half of the RFT first stage inlet nozzles. Because of the reduced size of the RFT governor valve HP steam port, a RFT is physically limited to approximately 60% of its total capacity when running only on HP (main) steam.

Low pressure or bleed steam (BS) is used to operate the RFT during high power operations when adequate MSR 1B pressure is available. This method of operation allows full power operation of the RFT, better throttling, and thus finer control of RFT speed. BS comes from the shell side of MSR 1B. The BS flow path is though motor operated isolation valve BS-V-17A/17B, hydraulic stop valve BS-V-60A/60B, RFT LP governor valve and into the upper half of the RFT first stage inlet nozzles.

IV. COMPONENT DESCRIPTION

Reactor Feedwater Pumps (RFP)

The purpose of the RFP's is to maintain RPV level at normal operating pressure and temperature by providing high pressure heated feedwater to the RPV. The RFP's are single stage, horizontal, centrifugal pumps. Each pump has a double suction design with a diffuser type discharge barrel. Condensate enters through the suction nozzle where it is split and directed into each end of the impeller. Feedwater leaves the center of the impeller and passes through the diffuser, which converts the velocity pressure of the liquid leaving the impeller to pressure energy. The feedwater leaving the diffuser enters the pump discharge chamber and exits the pump case through the discharge nozzle. The RFP's are designed to supply 18,520 gpm, at 1273 PSIG with a net positive suction head of 265 feet. Testing during the power ascension test program showed that two feed pumps can provide approximately 134.5% of rated feed flow and one feed pump can provide 70% of rated feed flow. Administration limits have been put in place to limit single pump operation to 65% reactor power.

The pump shaft is equipped with serrated bushing controlled leakage seals at each end. The seals are supplied by a seal water injection system using water from the condensate booster pump discharge header. The mixture of the water that is injected into the seals, and the water at the impeller becomes "hot bleedoff" water and is returned to the condensate booster pump suction header. Some water from the seals runs out of the end of the seals into seal leakby cavities located at each end of the pump.

These leakby cavities drain to a seal water drain tank (MD-TK-2), which in turn drains to the main condenser. Each RFP is located in its own room in the turbine building at T441 elevation. **LO-9161**

Each feedwater pump utilizes two types of oil lubricated bearings. A tri-land journal bearing is located on the impeller shaft outboard of each of the outboard leakby chambers. In addition a single Kingsbury thrust bearing is located on the impeller shaft outside the journal support bearing on the opposite side of the pump from the drive turbine. Both the journal support bearings and the thrust bearing are lubricated by the turbine lubricating oil system.

Reactor Feedwater Pump Drive Turbines (RFPT) (Figures 2, 9)

The reactor feedwater pump drive turbines are 8 stage impulse non-condensing turbines manufactured by Delaval Turbine, Inc. Each turbine has a rated horsepower of 13,200 HP with full power steam flow rate of approximately 118,000 lbm/hr. The turbine casings are split horizontally on the plane of the shaft centerline. Small drain holes are provided in the diaphragms and the turbine case to allow drainage of any condensate that may form. To limit steam leakage from stage to stage each diaphragm is provided with a labyrinth type seal ring. Where the turbine shaft passes through the turbine casing, gland steam enclosures containing labyrinth type seal rings, and guard plates are provided to prevent outboard steam leakage and air in-leakage. Gland steam chambers are located in the shaft gland steam enclosures and are piped to, and work in conjunction with, the sealing steam and gland steam exhaust systems.

The turbine rotor is supported by two tilting shoe, self-aligning, journal bearings, in bearing housings at each end of the turbine casing. In addition, a Kingsbury thrust bearing is located on the governor (outboard) end of the turbine shaft to maintain the axial position of the rotor. The gland steam enclosures, and bearing housings, are physically separated by an air gap and the turbine shaft is visible between the two.

Since the turbine is designed to operate on low or high pressure steam, the turbine steam admittance valve (governor valve) steam chest is supplied by two steam lines (See Figure 6). Low pressure steam is supplied from Moisture Separator Reheater 1B and high pressure steam comes directly from Main Steam. Each steam supply header has a motor operated isolation valve (MS-V-105A/B for high pressure steam and BS-V-17A/B for low pressure steam) and a hydraulically operated stop valve (MS-V-172A/B for high pressure steam and BS-V-60A/B for low pressure steam). Each turbine is equipped with a self contained oil supply and storage system. These oil systems support the RFT bearing lubrication oil, control oil and trip oil needs, and the RFP lubrication oil.

Sealing Steam System (Figure 2, 6 & 7)

The purpose of the Sealing Steam System is to prevent contaminated steam used in the reactor feed pump turbine, hydraulic stop valves, and steam governor (nozzle) valves from entering the turbine building atmosphere. Also to prevent air and non-condensables from being drawn through the RFT seals and then into the main condenser. During normal plant operations Steam Evaporator SS-EV-1A supplies sealing steam to both RFT's. A 3" sealing steam supply header splits into two 3" supply lines, each of which supplies its respective RFT. Each RFT has its own sealing steam pressure control station. The control stations consist of an automatic pressure control valve (SS-PCV-1A/1B) and motor operated isolation valves (SS-V-6A/6B & 7A/7B). Each control valve station has a bypass line equipped with a motor operated bypass valve (SS-V-8A/8B). Both the control valve isolation valves and the bypass valves are remotely operated from the control room. **LO-5749** **LO-9160**

The reactor feedwater turbines have identical sealing steam systems. For simplicity, this discussion will be limited to the system associated with one turbine. The turbine sealing steam, steam condensate drain, and steam gland exhaust systems are interrelated and will be discussed together. The three systems interface each other at the turbine shaft and valve stem glands.

The sealing steam system (See Figure 2) is utilized to pressurize the shaft glands to prevent contaminated steam from escaping to the environment and/or to prevent air and non-condensable gases from entering the turbine case. The drain system allows steam condensate collected at various locations to be drained away. Should condensate be allowed to collect and be drawn into contact with the rotating turbine blading, significant damage would occur. The gland exhaust system is utilized to evacuate the shaft glands by drawing off any steam and/or air that may leak into them along the turbine shaft.

The turbine has six pressure boundary points that utilize part or all of the gland sealing system. These include the turbine inlet and exhaust end shaft glands, the hydraulic HP and LP stop valve stem glands, the HP governor (nozzle) valve stem glands and the LP governor (nozzle) valve lifter bar shaft glands. (See Figure 7)

RFW Turbine Drain System (Figure 2)

The purpose of the RFT drain system is to provide for the removal of condensate from common collection points in the turbine and associated hardware to minimize equipment erosion and damage. Drain ports are located above and below both hydraulic stop valve seats, between the turbine stages, in the governor valve, and in the exhaust steam plenum. **LO-5749**

The drain lines located below both the HP and LP stop valve seats, below the turbine stages, and in the governor valve steam chest, contain orifice plates. The drain from the turbine exhaust plenum has a low point orificed drain and a high point unorificed drain.

These orifice plates are sized to limit the amount of steam and condensate flow to drain. The orificed drain lines collect in a common drain header which directs the condensate to pumped drain tank MD-TK-1. The tank is located in the main condenser hotwell pit on the south side of the A (east) section of the condenser at T433 elevation. This drain system is designed to provide continuous drainage of the turbine during turbine operation. **LO-9159**

The drain ports located above the HP and LP stop valve seats and at the turbine first stage diaphragm are designed to allow remote controlled drainage. These drain lines do not contain restricting orifices. Each drain header contains an air operated drain valve which can be remotely operated from Board A in the main control room. The drain valves automatically open whenever the RFPT first stage steam pressure is less than 10 psig (with valve control switches in AUTO). The HP and LP stop valve above seat drains (MS-V-142A/142B, BS-V-44A/44B), route the condensate directly to the main condenser. The turbine first stage diaphragm drain (BS-V-45A/45B) is routed to the pumped drain tank MD-TK-1. These drains drain condensate prior to turbine operation, and during turbine startup and trip conditions. **LO-9161**

RFW Pump Seals (Figure 3)

The seals on each end of the pump impeller shaft are identical in operation and construction. The pump seals consist of a fixed serrated bushing (labyrinth) arrangement with chambers (ports) for seal water supply (injection) and leak-off (hot bleedoff).

The seal water supply is from the condensate booster pump discharge header. The seal water supply has a duplex strainer in the line prior to the point where it tees to provide seal water to each pump. The strainer differential pressure is monitored by a differential pressure indicator gauge and switch that provides annunciation and an input to the process computer when the differential pressure exceeds 19.5 PSID. Each feedwater pump has two pneumatic temperature control valves (MD-TCV-3A/3B and 4A/4B) which control the seal water injection flow. At each seal, the seal water supply enters the seal water injection chambers and flows inward toward a hot bleed off chamber (to prevent any out leakage of RFP pumped water) and flows outward toward a leakby cavity (to provide shaft cooling). The seal water injection control valves control the amount of relatively cooler seal water that is supplied (injected) into the pump seals as a function of the temperature of the leakby flow through the pump seals into the inboard and outboard seal leakby cavities to maintain 140 - 160°F. **LO-9157**

Lines from the inboard and outboard hot bleedoff chambers join and are routed, via a common header and backpressure control valve to the condensate booster pump suction header. The hot bleedoff back-pressure control valve and its differential pressure controller are designed to maintain the hot bleedoff at approximately 40 psi below feedwater pump suction pressure to reduce the hot bleedoff flow rate and prevent flashing in the seal area. The inboard and outboard hot bleedoff lines each have a temperature gauge to monitor their temperature. Flashing in the hot bleedoff lines will generally occur when the hot bleedoff temperatures exceed 325°F. When flashing occurs, the hot bleedoff flow path is effectively closed off by steam and all the water in the seals flows to the seal leakby cavities at each end of the pump. To prevent flashing, seal water injection must be increased to cool the flashing and/or the hot bleedoff back pressure must be increased to raise the flashpoint by throttling down on the back pressure control valve. **LO-9158**

The seal leakby into the leakby cavities at each end of the pump is routed, via a common header to drain tank MD-TK-2. The tank is located in the main condenser hotwell pit on the south side of the A (east) section of the condenser at T433 elevation. An additional temperature element in each seal leakby cavity drain line inputs to temperature switches to provide input to the process computer and common annunciation for pump hi leak-off flow temperature at GT 200°F.

RFT Oil System (Figure 4)

LO-5749

The purpose of the RFT Oil System is to provide lubrication to the turbine and pump bearings, to provide high pressure control oil for the turbine control and trip systems operation, and to provide lubrication for the turbine turning gear.

Overview

The RFT oil system consists of a reservoir, three electrically driven oil pumps, dual (redundant) oil coolers and filters, the necessary valves and piping to support the system, and local control panels. The oil system is arranged in two subsections such that it can provide two different oil pressures for three different functions, Lubricating Oil at 15-20 psig and Control and Trip Oil at 100-130 psig. The lubricating oil section supplies lubrication to the RFP and RFT bearings and the associated turning gear. The control and trip oil section supplies high pressure control oil to the RFT governor valve controls, and trip oil to the RFT protective trip system which controls the turbine HP stop valve (MS-V-172A/172B) and LP stop valve (BS-V-60A/60B). RFT component and oil systems status is provided in the main control room (H13-P840 Bd A), at local control panels (RFW-DT-1A/1B), and at each turbine and pump. **LO-5750** **LO-9162**

Oil Reservoir (TO-TK-3A/3B)

The RFT oil reservoir contains the oil used in the system and is the mounting location for several RFT oil system components. It is located within the RFT skid below and to the north of the RFT itself. The oil reservoir has an operating capacity of 605 - 715 gallons with level indication and high/low level alarms provided in the main control room (normal operating level is 22 +/- 5". Reservoir accessories include a vapor extractor, dipstick, breather/filter, and an internal deaeration tray with screen for oil returning to the reservoir. The reservoir is fitted with fill, drain, and purifier connections and has access panels. The bottom of the reservoir slopes to a drain connection on the north end. This is where a lube oil conditioner or purifier (RFT-LOC-1A/B) is connected to remove impurities and water from the oil.

Main Oil Pump (RFT-MOP/1A, RFT-MOP/1B)

LO-9162

The main oil pump draws oil from the reservoir and discharges it into the system through a stop/check valve. It is vertically mounted on the oil reservoir with its positive displacement rotary pump located inside the oil reservoir. The pump is driven by a 3500 RPM, 15 HP AC motor through a flexible coupling. The pump and oil system is protected from overpressurization by a relief valve, set at 150 psig, located on the pump discharge pipe. The pump 3" suction line is approximately 6" above the bottom of the reservoir.

Auxiliary Oil Pump (RFT-AOP/1A, RFT-AOP/1B)

The auxiliary oil pump is identical in design, function, and installation to the main oil pump except that it functions only as an auxiliary or backup pump when the main oil pump has been tripped (as indicated by low discharge pressure). Normal system operation can be maintained with either the main or auxiliary oil pump. Like the main oil pump, it has a 150 psig relief valve located on its discharge pipe, and the pump 3" suction line is approximately 6" above the bottom of the reservoir.

Emergency Oil Pump (RFT-P-EOP/1A, RFT-P-EOP/1B)

The emergency oil pump is vertically mounted on the oil reservoir with its positive displacement pump driven by a 3500 RPM, 5 HP, 250 Volt DC electric motor. It is designed to provide low pressure oil, for bearing and turning gear lubrication only, after the RFT has tripped (during coastdown and turning gear operation). It draws oil from the reservoir, and discharges it through a strainer and a stop/check valve directly into the lube oil supply header. The pump and system is protected by a 50 psig pressure relief valve located on the pump discharge line. The pump suction is approximately 6" from the bottom of the reservoir.

Oil Cooler (TO-HX-2A/2B, TO-HX-2C/2D)

Each RFT has two 100% capacity oil coolers (heat exchangers) and a transfer valve to select which cooler is to be in service. The oil cooler serves to cool the oil discharged by the operating oil pump (main and/or auxiliary). An oil filter is installed in each oil cooler line immediately downstream of the oil cooler and selecting an oil cooler also selects its associated filter. The coolers are a two pass design, horizontally mounted, and have removable tube bundles. They are provided with sacrificial anodes for water conditioning. Each cooler is rated at 220,000 BTU/HR to maintain the oil outlet temperature at a nominal 110 - 120°F. A thermometer and a thermocouple in the cooler/filter oil outlet piping provide oil temperature indication and a control signal for the temperature control system. Plant service water (TSW) provides the heat sink for the system and is circulated through the shell side of the oil coolers with an air operated temperature control valve throttling the cooling water outlet as a function of the indicated oil temperature. A thermostatic switch is provided to initiate an alarm should the oil temperature leaving the cooler/filter network reach 140°F. LO-5750

The air-operated transfer valve (TO-V-62A/62B) allows one cooler/filter to be isolated and the other to be placed in service. Crossover and bleed connections allow for the filling of an empty cooler/filter prior to a switchover, so that service will not be interrupted.

Oil Filter (TO-FLT-1A/1B, TO-FLT-1C/1D)

Each RFT has two 100% capacity oil filters, and each filter is located immediately downstream of an oil cooler. The same transfer valve that selects which oil cooler is to be placed in service also selects which oil filter is placed in service. The oil filter removes particles 5 microns and larger from all oil leaving the main or auxiliary oil pumps. Differential pressure gages and transmitters provide local and remote (control room) means of checking the active cooler/filter performance. A differential pressure switch is connected in parallel with the gages to provide remote annunciation (GE 30 psid) when the active filter requires changeover and service. The transfer valve (TO-V-62A/62B), allows one filter/cooler to be isolated and the other filter/cooler to be placed in service. Crossover and bleed connections allow the filling of an empty filter/cooler prior to a switchover, so that a RFT will not occur due to oil pressure fluctuations during transfer.

Turbine Control Oil

The RFT control oil provides oil to the turbine governor valve servo actuator, and governor valve electro-hydraulic operator (EHO), local turbine control panels, the turbine lubrication oil system (separate description), and the turbine trip oil system (separate description).

At each main and auxiliary oil pump discharge line, oil pressure regulating relief valves (RFT-V-1A/1B, 2A/2B) are installed to maintain 100-130 psig oil pressure in the control oil and trip oil systems. The oil supply pumps are designed to provide slightly more flow/pressure then the system requires and the excess is relieved to the turbine oil reservoir. The control oil is routed from each main and auxiliary oil pump discharge line to a common discharge header, through a transfer valve, to one of the two sets of oil coolers/filters, back through the transfer valve, and to a "distribution" header that provides oil to all the related oil subsystems (lubrication, trip, local control panels).

A 10 gallon capacity oil accumulator (RFT-ACC-1A/1B) is connected to the distribution header to act as a surge cushion to dampen out any slight fluctuations in oil pressure the system may see as a result of oil pump starts/stops, etc. The accumulator contains a bladder liner that fills with oil, and the space between the bladder and the accumulator shell is charged with nitrogen to 65 psig.

Connected to the distribution header is a dedicated oil supply line for the RFT governor valve servomotor and EHO control unit. This line contains two 10 gallon capacity oil accumulators (RFT-ACC-2A/3A, 2B/3B) and a duplex filter (RFT-F-3A/3B). The accumulators act as surge cushions to dampen out, and make up for, fluctuations in oil pressure that the system may see as a result of sudden stroking of the governor valve servo during governor valve positioning. The two accumulators contain a bladder liner and are charged with nitrogen to 85-90 psig. Check valves with holes in their discs are installed in each accumulator line to enable the accumulator to provide rapid make-up oil during sudden demand and allow slower refill during recovery. The duplex filter is installed between the accumulator connections and the turbine governor valve servomotor and EHO control unit. The filter contains 3 micron cartridges and is an absolute design, having no bypass around the cartridges. The duplex design allows changing form one filter element to another on-line when an element becomes fouled. A differential pressure indicator is installed on the filter to indicate when a cartridge is fouled, the cartridge should be changed when differential pressure exceeds 20 psid. The 3 micron filter cartridge will not pass water, and one of the first indications that water has gotten into the oil system will be rising filter differential pressure.

Turbine Lubricating Oil

The oil supply line for the turbine, pump, and turning gear, lubricating oil is connected to the distribution header. The turbine lubricating oil provides lubrication and cooling for the turbine and pump journal and thrust bearings, and for the turbine turning gear. The supply line contains a restricting orifice (RFT-RO-5A/5B) to initially reduce the control oil pressure, and a pressure regulating valve (RFT-PRV-2A/2B) to provide fine adjustment of the oil pressure as needed. Oil pressure is adjusted by relieving oil to the turbine oil reservoir. Lube oil pressure is maintained at 15-20 psig, and indication of pressure is provided locally at the pump bearing housings, at the local control panels, and on board A in the main control room (H13-P840 Brd A).

Turbine Trip Oil (Figure 5)

The turbine trip oil portion of the turbine control oil system, provides a means of quickly depressurizing the oil lines leading to the HP stop valve (MS-V-172A/B) and LP stop valve (BS-V-60A/B), such that these valves rapidly close in the event of a turbine trip. The turbine trip system receives high pressure oil from the control oil section through a 3/16" orifice. This small orifice allows the trip oil header to slowly pressurize and open the HP and LP Stop Valves when the turbine is reset. When the turbine is tripped, the trip oil header is dumped to the turbine oil reservoir through one or more flow paths, and the 3/16" orifice prevents the control oil system from recharging the trip oil header portion faster than it is being dumped. The loss of pressure allows a spring loaded slave piston in the HP and LP stop valve actuator assemblies to open which in turn removes pressure from the valve actuator spring loaded main pistons enabling the stop valves to rapidly close (LT 0.5 sec). LO-5750

There are two solenoid trip valves (20TPF and 20TT), two manual hydraulic trip valves (RFT-V-22A/B and RFT-V-23A/B), and one mechanical overspeed trip device in the trip oil system for each RFT.

The primary solenoid trip valve (20TT) energizes to dump the trip oil header to the reservoir, closing the HP and LP stop valves, on any electrically generated RFT trip signal (all RFT trip signals are electrically generated except mechanical overspeed and manual hydraulic). The fail-safe solenoid trip valve (20TPF) is normally energized and is designed to fail open, dumping the trip oil header, on a loss of control power to the turbine trip circuit (125 volt DC, DP-S1-2C).

The RFT can be manually tripped by physically activating either of two manual trip valves. One manual trip valve (RFT-V-22A/B) is located on the local RFT control panel

(TG 441 outside the RFP rooms) and the other (RFT-V-23A/B) is located on the west side of the RFT skid. The turbine can also be manually tripped by depressing an electrical manual trip push-button at the local RFT control panel or placing the Turbine Emerg Trip/Reset to TRIP from Board A in the main control room.

Solenoid valves 20TL, 20TBL1, 20TBL2, and 20R are used to test the mechanical overspeed device without actually overspeeding or tripping the RFT. Refer to Figure 5 and the discussion of the Overspeed Test Switch (located on H13-P840 Brd A in the main control room) in the CONTROL THEORY AND INTERLOCKS section of this student text.

Turbine Local Control Panels

A local control panel (RFT-DT-1A/1B) for each RFT is located outside the turbine/pump rooms at T441, east side. These panels are fed by the control oil distribution header, and contain instrumentation to monitor the turbine, the pump, and the oil system. These panels also provide manual turbine trip capability, and limited turbine startup capability.

Turbine Lube Oil Conditioner

Each RFW turbine has a continuous operation centrifuge oil conditioner (purifier) RFT-LOC-1A/1B, to remove particulate and water from the turbine oil reservoir. The conditioner draws from the turbine oil reservoir low point drain, cleans the oil, and discharges it back into the reservoir a few feet away from the low point drain suction connection. The conditioner contains an electric heater to enable it to heat the oil if necessary to maximize purifying efficiency. Impurities are captured in the centrifuge bowl and water is discharged into an oily waste drain tray located under the conditioner. The oily waste drain contains an excess flow switch and alarm to indicate if the discharge to the drain tray contains an excessive amount of oil/water.

Pump Marine Oil Separator

Each RFW pump has a marine oil separator (RFW-LOC-1A/1B) to separate oil from the excess seal leakby water that vents from the pump inboard and outboard seal leakby drain cavities. The separator consists of a 165 gallon tank that is divided into chambers, and has a discharge pump, high and low level switches to activate the pump, a trace oil filter, and associated piping and valves. Two of the chambers contain polypropylene media to coalesce and concentrate the particles of oil. Oily water enters one end of the separator, flows chamber to chamber, and exits the opposite end. The oil is separated from the water and skimmed off into a separate oily waste barrel. The tank effluent water is pumped, or gravity fed, through the pump bypass to the trace oil filter for final oil removal, and then routed to a local equipment drain. At low process flows, the pump bypass allows continuous gravity draining of the tank without having to cycle the pump on and off between the high and low level points.

Turbine Governor Control Valve (Steam Admission Assembly) (Figures 7, 8)

The turbine governor control valve, or steam admission assembly, provides control of the high pressure and low pressure supply steam flow into the turbine to control turbine speed. The feedwater turbines are designed to operate on either high pressure steam from the main steam lines (during startup and low power operation) or low pressure steam from Moisture Separator Reheater 1B (when the main turbine is carrying enough load for this to be an adequate supply of steam - high power operation). To facilitate this design the turbine governor control valve, or steam admission assembly consists of a HP valve having single high pressure nozzle, and a LP valve having five low pressure nozzles. The five low pressure valve nozzles supply steam to the upper half of the first stage inlet nozzles and the high pressure nozzle supplies steam to the lower half of the first stage inlet nozzles. **LO-5749**

A single hydraulic servomotor is connected via hydraulic and mechanical linkage to the governor valve six steam admission components (five LP control nozzles and one HP control nozzle). The electronic RFW turbine control system (Refer to the Feedwater Level Control System text) controls this servomotor.

The governor valve linkage (control valve linkage) is connected such that the 5 LP control nozzles open (in sequence) first and if the turbine does not startup as the Feedwater Level Control System (FWLC) requests, the valve linkage will continue to lift until the HP control nozzle begins to open. The admission of main steam to the RFW turbine will roll the turbine. As load on the main turbine increases the steam pressure in the Moisture Separator Reheaters (MSR's) will increase. This will speed up the RFW turbine since MSR B supplies LP steam to the turbine and the LP control nozzles are wide open at this time. The FWLC system will detect this increase in RFT speed and start running the control linkage closed to slow the RFT back down. This process will continue automatically (no operator input is needed) until the HP control valve and nozzle is completely closed and the RFT is running on LP steam alone. This occurs at approximately 60% power. Spring pressure will completely close the governor valve upon the loss of control oil pressure. An RFT can only attain approximately 60% of normal full power on HP steam alone, due to the small size of the HP control nozzle. LP steam is required to attain full power.

Steam Stop Valve (Figures 6, 8, and 9)

Each turbine is equipped with one HP and one LP hydraulically (oil) operated steam stop valve. They enable rapid isolation of the HP and LP steam supplies to the turbine in case of a turbine trip. The HP stop valve (MS-V-172A/B) is bolted to the HP steam inlet section of the turbine governor. The LP stop valve (BS-V-60A/B) is bolted to the LP steam inlet on the opposite side of the turbine from the HP stop valve. The stop valves are hydraulic-to-open and spring-to-close. They are capable of closing in less then 0.5 seconds. **LO-5749**

Each stop valve has a means of testing the freedom of movement of the valve and actuator moving parts, while the turbine is on line, without actually closing the stop valve. A test circuit is installed which contains a drain line that is connected to the hydraulic actuator, a solenoid valve, and drain piping to the turbine reservoir. The drain line taps off a port located on the hydraulic actuator operating cylinder approximately 1" below the actuator drive piston when it is at its fully extended or open position. Depressing the associated stop valve TEST push-button on Board A in the main control room energizes the test solenoid valve, which causes the drain line to open. When the drain line opens, the control oil from below the actuator piston is drained. This allows the drive piston and its stop valve plug to move in the closed direction until the piston covers the drain line port stopping the oil from draining. This will cause the stop valve to close only about 1" regardless of how long the test push-button is depressed.

Sixth Stage Feedwater Heaters

The discharge header from feedwater pumps divides to supply two 50% capacity feedwater heaters (RFW-HX-6A/6B). These heaters provide the last stage of feedwater heating prior to the reactor pressure vessel.

The heaters are a U-tube-in-shell type heater exchanger. Feedwater enters the lower portion of the water box end of the heater head or channel (inlet), makes a pass down and back through the U-tubes, and then exits by way of the upper head (outlet). Extraction steam enters at the top of the heater shell and heats the feedwater in the tubes. The condensed steam combines with first and second stage moisture separator reheater drains that also enter the top of the heater shell but at the end of the heater shell opposite the water box. The condensed steam and reheater drains combine to form feedwater heater drains. The accumulated drains are then routed to the next set of feedwater heaters for cooling. Additional information on this feedwater heater is available in the Heater Drains and Vents Systems Text and in the feedwater heater procedure.

RFW Pump Turbine Vibration Monitoring

Continuous measurement and monitoring of the RFW pump and turbine bearing vibration, shaft eccentricity and thrust bearing displacement is provided by dual probe sensors mounted on the pump and turbine. The dual probe assembly consists of a non-contacting eddy current proximity transducer and a seismic velocity transducer. Indications and alarms are provided in the control room on PPCRS. Local Panel RFP-VMP-1 located on T441 east outside the RFP rooms, provides individual indications of each probe output and provides red LED alarm lights to indicate an alert and/or alarm condition.

V. CONTROL THEORY AND INTERLOCKS

General

During normal power operation feedwater flow is controlled by the Feedwater Level Control (FWLC) system. It regulates the feedwater flow in order to maintain the proper reactor vessel level. To accomplish this, the FWLC system controls the speed of the two turbine driven reactor feedpumps. During low flow conditions (LT 15% power on startup or LT 25% on shutdown) the FWLC system regulates feedwater flow by progressively positioning two startup flow control valves (RFW-FCV-10A then 10B).

To control the speed of the RFT's the FWLC system regulates the signal going to the RFT servomotor that controls the positioning of the governor (HP and LP control) valves. Prior to placing the RFT's under the control of the FWLC system they must be properly started and warmed up. This requires manual control by the operator and is accomplished by the use of the individual RFT's speed controller (RFT-SC-601A/B).

For startup, warming, and operation of the feedwater pumps using the FWLC system, refer to the Feedwater Level Control Systems text for additional information.

A. Control Room Controls

RFPT A Controls Mounted on Board A (RFW Turbine "B" controls are identical)

Turbine Emergency Trip/Reset (See Figure 5) (3 position momentary- TRIP/NORM/RESET spring return to NORM) **LO-5753**

TRIP - Trips RFT (energizes open RFT-SV-20TT/1A solenoid valve) by causing the HP & LP Stops to close

NORM - Neutral position does nothing

RESET - Resets RFT trip mechanism (opens RFT-SV-20R/1A and closes RFT-SV-20TT/1A), which opens the HP & LP Stop valves (if the HP & LP stop valves and the governor control valves are closed and the governor control signal is at a minimum).

NOTE: The switch must be held in RESET until all parts of the RFT trip circuitry have reset and repressurized. Reset is complete when the RFT HP and LP stop valves are fully open. Takes approximately one minute

The TRIP CIRCUIT AVAILABLE light above the switch should be on at all times indicating DC power is available to the trip circuit.

RFP Turbine Turning Gear RFT-TNG-1A (2 position maintain contact- OFF/AUTO)

OFF - Turns turning gear motor off

AUTO- Allows turning gear to auto engage 10 seconds after both RFT HP and LP stop valves are shut and, the zero speed indicator (LT 1 RPM) is picked up. The turning gear motor will then auto start if bearing lube oil pressure is greater than 5 psig. At present this switch is to be placed in OFF during normal operations to prevent inadvertent engagement, and in AUTO immediately following a RFT trip. **LO-5756**

RFT HP Stop Valve (MS-V-172A) TEST Push-button (Figure 5) (OPEN/CLOSE position indication & IN TEST lamp) **LO-5757**

TEST BUTTON - (Energizes open RFT-SV-20-SST2/1A solenoid valve) Button must be depressed and held to conduct a valid test. The HP stop valve will slowly close approximately 1" and then remain there until the Test button is released. The OPEN indication will go out and the IN TEST light will illuminate when the stop valve leaves its full open position.

IN TEST lamp - Lights when the HP stop valve leaves its full open position whether or not the test button is depressed. This light functions essentially like a "valve not full open" indicator.

Main Oil Pump (RFT-P-MOP/1A) (2 position maintain contact- STOP/RUN)

STOP - Stops main oil pump

RUN - Starts and runs the main oil pump

Main oil pump PRESS NORMAL lamp illuminates (blue lens) when pump discharge pressure is GT 70 psig

Aux. Oil Pump (RFT-P-AOP/1A) (3 position momentary- STOP/AUTO/RUN, spring return to AUTO)

STOP- Stops aux oil pump

AUTO- Allows pump to auto start on low bearing oil pressure (11 psig and decreasing) or on low control oil pressure (70 psig and decreasing). **LO-5758**

RUN-- Starts and runs the aux oil pump

Aux. Oil Pump PRESS NORMAL lamp illuminates (blue lens) when the pump discharge pressure is greater than 70 psig.

Emergency Oil Pump (RFT-P-EOP/1A) (3 position momentary- STOP/AUTO/RUN, spring return to AUTO)

STOP - stops emergency oil pump

AUTO - allows pump to auto start on low lube oil pressure (8 psig and decreasing) **LO-5759**

RUN - starts and runs the emergency oil pump

Emergency Oil Pump PRESS NORMAL lamp illuminates when pump discharge pressure is greater than 5 psig.

Turbine LP Stop Valve (BS-V-60A) TEST Push-button (OPEN/CLOSE position indication & IN TEST lamp) **LO-5757**

TEST BUTTON- (opens RFT-SV-20-SST1/1A solenoid valve) Button must be depressed and held to conduct valid test. The LP stop valve will slowly close approximately 1" and then remain there until the Test button is released. The OPEN indication will go out and the IN TEST light will illuminate when the stop valve leaves its full open position.

IN TEST lamp- lights when the LP stop valve leaves its full open position whether or not the test button is depressed. This light functions essentially like a "valve not full open" limit indicator.

Overspeed Trip Test (4 position switch - NORMAL/RESET/BLOCK/TEST) (spring return to RESET from BLOCK & TEST) (See Figure 5) **LO-5760**

NORMAL-Neutral position, no function

RESET - RFT-SV-20R solenoid valve energizes open, which directs oil to keep the mechanical overspeed trip mechanism reset while solenoid valves RFT-SV-20TBL1 and RFT-SV-20TBL2 shift. RFT-SV-20R solenoid valve is closed in all other positions.

RFT-SV-20TBL1 energizes closed, which blocks the incoming oil supply pressure and provides oil to RFT-SV-20TBL2

3-way pilot valve RFT-SV-20TBL2 energizes to isolate the overspeed trip mechanism trip port from the RFT HP and LP stop valves during the test while connecting all other RFT trip oil paths directly to the RFT HP and LP stop valves therefore maintaining all other trips active during this test.

The "IN TEST" lamp should light when pressure switch RFT-PS-63R picks up at GT 60 psig reset header pressure indicating that the mechanical overspeed trip mechanism is being held in reset. This light also illuminates whenever RFT-SV-20TBL2 is energized (Reset, Block, and Test). The "TURB A/B TEST TRIP HDR PRESSURIZED" annunciator on board A should also come in.

BLOCK - RFT-SV-20R solenoid valve deenergizes closed to remove reset pressure from the overspeed trip device

RFT-SV-20TBL1 remains closed and RFT-SV-20TBL2 remains blocked

In this switch position the overspeed trip mechanism trip port path through RFT-SV-20TBL2 to the RFT HP and LP stop valves is blocked and the reset pressure path via RFT-SV-20R is isolated, such that the turbine overspeed trip device can be tested without actually tripping the RFT.

TEST -RFT-SV-20TL energizes open to direct oil to the turbine overspeed trip device (emergency governor assembly) on the outboard end of the RFT shaft. With the RFT operating at normal speed the oil adds additional weight to an existing throw weight causing the weight to move out towards a plunger that opens to depressurize the trip oil line. The overspeed trip test physically actuates the mechanical overspeed devices in the same manner that an actual overspeed would. Adding the additional weight to the throw weight has the same effect as increasing the weight of the throw weight by centrifugal force (increased speed).

However, with the blocking valve, RFT-SV-20TBL2 in the block position, the trip oil header is prevented from depressurizing. Only that portion of the header between RFT-SV-20TBL1 and the overspeed trip device depressurizes. This causes pressure switch RFT-PS-63TTA to initiate the "TURB A TEST HDR PRESS LOW" annunciator and illuminates the "TRIP TEST" lamp at LT 60 psig. This verifies that the overspeed trip device functioned properly.

Overspeed Test Amber Indicating Lamps:

IN TEST - Lit whenever the test trip header is pressurized as sensed by RFT-PS-63R at GT 60 psig. This light also illuminates whenever RFT-SV-20TBL2 is energized (Reset, Block, and Test positions).

TRIP TEST - Indicates that the trip header has been depressurized by the turbine overspeed trip device (RFT-PS-63TTA LT 60 psig). Should be accompanied with the "TURB A TEST HDR PRESS LOW" annunciator, which is initiated off of the same pressure switch.

Aux Oil Pump (RFT-P-AOP/1A) TEST Push-button **LO-5761**

TEST -repositions a three-way solenoid valve that vents the oil pressure off the pressure switch that auto starts the aux oil pump.

Emergency Oil Pump (RFT-P-EOP/1A) TEST Push-button **LO-5761**

TEST -repositions a three-way solenoid valve that vents the oil pressure off the pressure switch that auto starts the emergency oil pump.

Oil Reservoir Vapor Exhauster (TO-M-EX/3A) (2 position maintain contact-OFF/RUN)

RUN - Starts and runs the vapor exhauster

OFF - Stops the vapor exhauster

RFT A/B Steam Valves Mounted on Board A

Sealing Steam Supply Valves (SS-V-6A/6B and SS-V-7A/7B) (3 position momentary - CLOSE/NOR/OPEN spring return to NOR)

CLOSE - Closes the valves

NOR - Neutral position, no function

OPEN - Opens the valves

Seal Steam Bypass (SS-V-8A/8B) (3 position momentary -CLOSE/NOR/OPEN Spring return to NOR, throttleable)

CLOSE - Closes the valve

NOR - Valve motion stops

OPEN - Opens the valve

Turbine Drains (MS-142A/B, BS-V-44A/B, BS-V-45A/B) (3 position momentary AUTO- CLOSE/AUTO/OPEN, spring return to AUTO)

CLOSE - Closes the air operated valves

AUTO - Allows the valves to auto open when the RFT first stage pressure is LT 10 psig **LO-5762**

OPEN - Opens the air operated valves

HP Steam Supply (MS-V-105A/105B) (3 position - CLOSE/NOR/OPEN spring return to NOR) (no seal-in)

CLOSE - Closes the valve

NOR - Valve motion stops

OPEN - Opens the valve if RFT exhaust valve (ES-V-1A/1B) is open

LP Steam Supply (BS-V-17A/17B) (3 position - CLOSE/NOR/OPEN spring return to NOR) (no seal-in)

CLOSE - Closes valve

NOR - Valve motion stops

OPEN - Opens the valve if RFT exhaust valve (ES-V-1A) is open

Exhaust Steam (ES-V-1A/1B) (3 position momentary - CLOSE/NOR/OPEN, spring return to NOR)

CLOSE - Closes valve if RFT LP and HP steam supply valves (BS-V-17A/17B and MS-V-105A/105B) are closed **LO-5763**

NOR - Neutral position, valve remains as is.

OPEN - Valve opens (seal in)

Exhaust Steam Bypass (ES-V-2A/2B) (3 position momentary - CLOSE/NOR/OPEN, spring return to NOR)

CLOSE - Closes valve

NOR - Neutral position, valve remains as is.

OPEN - Valve opens (seal in)

Feedwater Valve Controls Located on Board A

Feedpump Discharge Valves (RFW-V-102A/102B) (3 position momentary - CLOSE/NOR/OPEN spring return to NOR)

CLOSE Closes valve

NOR Neutral position

OPEN - Opens valve

RFW Pump Startup Bypass (COND-V-149) (3 position momentary - CLOSE/NOR/OPEN spring return to NOR, throttleable)

CLOSE - Closes valve

NOR - Valve movement stops.

OPEN - Opens valve

RFW Pump Minimum Flow Control Valves (RFW-FCV-2A/2B)

The min flow valves are controlled by FWLC via individual Moore flow controllers mounted on the vertical section of board A. These valves modulate open and close to maintain a total RFP flow (min flow + discharge flow) GT 3200 gpm for proper pump cooling. They are fully closed during normal power operation of the plant. They fail open on a loss of air.

Min Flow Valve Air Isolation Valves, RFW-FSPV-2A/2B, auto energize to cut off opening air to the min flow valves when the RFT HP and LP stop valves trip shut after a 30 sec time delay. This is necessary to prevent significant condensate/feedwater flow back to the condenser through the idle feedwater pump(s).

On a scram signal, the FWLC system will fully open the min flow valves in 30 seconds, then return to modulating their position based on RFP total flow. This helps prevent a RPV level 8 trip during the initial RPV level transient.

Cleanup/Startup Flow (RFW-V-117A/117B) (3 position momentary CLOSE/NOR/OPEN spring return to NOR)

CLOSE - Closes valve

NOR - Neutral position

OPEN - Opens valve

Startup Flow Control Valves (RFW-FCV-10A/10B) (mimicked on Board A but controlled from P603)

Valves fail as is on a loss of operating air

Controlled by the FWLC (See the FWLC System Text for details)

Startup Flow Isolation (RFW-V-118) (3 position momentary - CLOSE/NOR/OPEN spring return to NOR throttleable)

CLOSE - Closes valve (isolates startup flow through the startup flow control valves)

NOR - Valve motion stops

OPEN - Opens valve (allows flow through the startup flow control valves).

Condensate Cleanup Flow RFW-V-14 (3 position momentary - CLOSE/AUTO/OPEN spring return to AUTO) **LO-5764**

CLOSE - Valve closes

AUTO - Valve auto closes if either RFW-V-65A or 65B is not fully closed.

OPEN - Valve opens if RFW-V-65A and 65B are both closed.

Condensate Cleanup Flow to RFW-FCV-15 (Bailey flow controller on vertical panel)

Controls flow back to main condenser Long Cycle Cleanup.

Valve fails closed on a loss of air

#6 Feedheater outlet isolation valves (RFW-V-112A/112B) (3 position momentary - CLOSE/NOR/OPEN, spring return to NOR) **LO-5765**

CLOSE - Closes valve

NOR - Neutral position

OPEN - Opens valve if differential pressure across the valve is less than 90 psid.

NOTE:This dP is sensed by DPT-4 between directly upstream of RFW-FCV-10A and downstream of RFW-V-118 and indicated as "MAIN STARTUP VALVE DP" on RFW-DPI-4 on Board A.

#6 Feedwater Heater Bypass (RFW-V-109) (operated by OPEN/CLOSE push-buttons on Board T)

CLOSE - Throttle closes valve

NOR - Neutral position

OPEN - Throttle opens valve

RPV Inlet Isolation (RFW-V-65A/65B) (3 position maintain contact-CLOSE/STOP/OPEN)

NOTE: Feedwater header isolation valves

CLOSE - Closes valve

STOP - Neutral position

OPEN - Opens valve

RPV Inlet Outboard Isolation Check Valves (RFW-V-32A/32B) (2 position maintain contact - CLOSE/OPEN) **LO-5766**

RFW-V-32A/32B are swing check valves with a closure assist spring that can be compressed by means of an externally mounted air actuator. The air actuator does not open and close the valve disc; it only compresses the closure assist spring to verify the springs operability. The closure assist spring provides additional assurance that the valve disc will close when necessary. The closure assist spring is not capable of closing the valve against normal feedwater flow, and does not interfere with the valves normal operation. The valve disc and hinge is supported by a keyed shaft whose key rotates in a slotted keyway in the disc hinge. The shaft is linked by a slotted arm to a rod with the air actuator piston on one end, and the closure assist spring on the other. When the air actuator is not actuated, the disc shaft is keyed to the disc. As the disc opens the slotted arm mounted on the shaft moves. This causes the air actuator cylinder piston/spring rod to move, which compresses the spring. The compressed spring provides a counteracting force to assist disc closure. When the air actuator is actuated, the piston/spring rod moves the slotted arm mounted on the disc shaft. This causes the shaft to rotate, and unkeys (unlocks) the disc hinge arm from the shaft. At the same time, the closure assist spring is compressed. The disc is then able to swing freely on the shaft without the closure assist spring trying to close it.

A (redundant) pair of three-way solenoid valves is used to control air to the air actuator on each valve. When energized, air is supplied to one side of the air actuator, causing the piston/spring rod to extend and compress the spring. When de-energized, air pressure is vented, allowing spring pressure to reposition the piston/spring rod.

Two sets of position switches are installed to monitor the position of the valve disc and the air actuator. Disc position open/closed indication is on Board A in the main control room. There are also position indication lights for the air actuator on Board A, but they are wired such that they only indicate the position of the air actuator hand switch (RFT-RMS-V/32A, V/32B) used to position the air actuator. Actual actuator position indication is found at PDIS computer points X482-02/01, which indicates if the valve actuator is Closed/Not Closed (air actuator piston/spring rod Retracted/Extended).

OPEN - Energizes dual solenoid pilot valves to provide air to the air actuator to compress the closure assist spring and unkey or unlock the disc hinge arm from the shaft.

CLOSE - De- energize dual solenoid pilot valves to vent air from the air actuator to return its piston to the retracted position and activate the disc closure assist spring.

RPV Inlet Inboard Isolation Check (RFW-V-10A, B) Indication only - no controls

Controls Mounted on H13-P832 (Board T, CR Back Panel)

#6 Heater Inlet Valves (RFW-V-108A/108B) (2 position maintain contact - CLOSE/OPEN Push-button)

CLOSE - Closes valve

OPEN - Opens valve

#6 Feedwater Heater Bypass (RFW-V-109) (2 position - CLOSE/OPEN Push-button throttleable)

CLOSE - Closes valve

OPEN - Opens valve

Drain Tank MD-TK-1 Pump (MD-P-1A/1B)

PTL - Pump stops, will not auto start.

STOP - Pump stops

AUTO - Auto Start At 6' tank level, Auto stop at 4'6".

START - Pump starts.

Drain Tank MD-TK-1 Pump Discharge (MD-V-1A/1B) (2 push-buttons maintain contact)

OPEN - Valve opens

CLOSE - Valve closes

B. Local Controls

Turbine local control panel - this panel has two means of tripping the turbine, an electrical Trip push-button that energizes solenoid valve 20TT, and an Emergency Trip Valve push to actuate type valve, which dumps the oil pressure in the trip oil line.

Turbine Skid - each RFT has an Emergency Trip Valve push to actuate type valve, similar to the one located at the local control panel. The valve is located on the west side of the turbine skid adjacent to the main oil filters.

C. Interlocks

Automatic RFW Turbine Trips (Figure 5) **LO-5767**

Automatic turbine trips are generated when a specific turbine parameters are unacceptable. These parameters are monitored by remote sensors, which electrically energize the turbine trip solenoid valve 20TT. When energized 20TT dumps the oil from the trip oil header back to the reservoir, closing the RFPT HP and LP Stop valves. Since the trip logic is an energize to actuate system, a fail-safe trip solenoid (20TPF), that is normally energized, will deenergize to dump the oil from the trip oil header if power to the trip logic is lost (DP-S1-1C from BOP S1-7). There are also two manual mechanical trip valves that can be activated to trip the turbine if power is not available.

The following conditions will automatically energize 20TT to trip the RFT, with the exception of the mechanical overspeed trip which functions strictly mechanically.

HIGH REACTOR WATER LEVEL

Alarm Setpoint - 40.5 inches (RFW-CPU-L010A, L010B)
Trip Setpoint - 54.5 inches (RFW-LS-624A, 624B, 624C)

Trips both RFT's when 2 out of 3 narrow range channels reach the trip setpoint.

EXHAUST PRESSURE HIGH (LOW VACUUM)

Alarm Setpoint- 15 in. Hg VAC (ES-PS-1A1, 1B1 [63EA-1A, 1B])
Trip Setpoint - 0 in. Hg VAC (ES-PS-1A2, 1B2 [63E1-1A, 1B])

Pressure switches are mounted on the turbine exhaust casing to detect low vacuum (high pressure) conditions.

LOW LUBE OIL PRESSURE

Alarm Setpoint - 11 psig (RFT-PS-63QA/1A, 1B)
Trip Setpoint - 8 psig (RFT-PS-63Q1/1A, 1B)

Protects RFPT bearings.

EXCESSIVE THRUST BEARING WEAR

Alarm Setpoint - 20 mils normal direction & 10 mils counter thrust direction (RFT-VMP-1)
Trip Setpoint - 22 mils normal direction & 12 mils counter thrust direction (RFT-VMP-1)

Protects the RFT from internal damage due to mechanical rubbing as a result of excessive axial movement of the shaft.

MD-TK-1 HIGH LEVEL

Alarm Setpoint - 78 inches from bottom tangent line (MD-LS-8)
Trip Setpoint -90 inches from bottom tangent line (MD-LS-7A, 7B)

Trips both RFT's to prevent water from entering the RFT's due to excessive drainwater backing up in the turbine drain lines.

EXHAUST HIGH TEMPERATURE

Alarm Setpoint - 180 °F (ES-TS-1A3, 1B3 [26EA-1A, 1B])
Trip Setpoint -230 °F (ES-TS-1A1, 1B1 [26E1, 26E2])

Temperature elements for thermostatically operated switches are located on the turbine exhaust casing. Prevents damage to RFT blading due to high temperature.

LOW PUMP SUCTION PRESSURE

Alarm Setpoint - 195 psig (COND-PS-28A2, 28B2)
Trip Setpoint - 173 psig (COND-PS-28A, 28B)

Trips the RFT to ensure the RFP does not run with inadequate suction pressure (NPSH), which could damage the pump impeller due to cavitation. This trip is active for 30 seconds after both the RFT HP and LP stop valves have closed at which time it is automatically bypassed. The trip is re-armed when either RFT HP or LP stop valve is taken off its closed seat (i.e. RFT reset).

LOW TRIP OIL HEADER PRESSURE

Alarm Setpoint - N/A
Trip Setpoint – 30 - 35 psig (RFT-PS-TT2/1A, 1B)

This trip is the seal in for the other turbine trips by sending a trip signal when the Trip Oil Header pressure drops below 30-35 psig. This seal-in trip is broken when the Trip/Reset switch on Board A is placed in the RESET position.

ELECTRICAL OVERSPEED TRIP

Alarm Setpoint - 6215 RPM (RFT-ST-1A, 1B)
Trip Setpoint -6215-6243 RPM (RFT-ST-1A, 1B)

Protects the RFT from centrifugal damage due to excessive shaft speed.

MECHANICAL OVERSPEED TRIP

Alarm Setpoint - N/A
Trip Setpoint -6100-6220 RPM

The turbine is protected from overspeeding by a turbine overspeed trip device (emergency governor assembly) actuating a hydraulic trip assembly valve. The hydraulic trip assembly valve is mounted on the inlet end turbine bearing bracket. When the hydraulic trip assembly valve stem is moved by the emergency governor assembly weight, the valve stem is moved into the valve body. This opens the valve and releases the pressure in the trip oil line, causing the emergency trip system to shut the unit down.

A spring in the valve will open the valve if trip oil pressure is lost for any reason and the spring will hold the valve open until reset oil pressure is applied. The valve is held shut by trip oil pressure. The valve is normally reset by the action of the reset solenoid valve (20R) that sends high pressure oil to the stem reset "piston".

CONTROL SYSTEM POWER FAILURE (FAIL-SAFE TRIP)

Alarm Setpoint - N/A
Trip Setpoint - Loss of DP-S1-2C (BOP DC power from S1-7)

A fail-safe trip solenoid valve (20 TPF) is provided in the trip oil line. This valve trips the turbine in the event of a loss of 125 volt DC electrical control and logic power. With electrical power available, the solenoid valve is energized and closed to maintain oil pressure in the trip oil line. On loss of electrical power the solenoid deenergizes, which opens the valve, and depressurizes the trip oil header.

Manual RFW Turbine Trips

Control Room - Trip\Reset switch on board A placed in Trip position energizes solenoid valve (20TT). **LO-9165**

Turbine local control panel - this panel has two means of tripping the turbine, an electrical Trip push-button that energizes solenoid valve 20TT, and an Emergency Trip Valve push to actuate type valve, which dumps the oil pressure in the trip oil line.

Turbine Skid - each RFT has an Emergency Trip Valve push to actuate type valve, similar to the one located at the local control panel. The valve is located on the west side of the turbine skid adjacent to the main oil filters.

VI. INSTRUMENTATION AND ALARMS

A. Control Room

NOTE: Only RFW Pump A instrumentation is listed.

Instrument #	Function
RFW-FIC-15	Condensate Cleanup Flow Controller/Indicator
RFW-FIC-2A	Pump A Minimum Flow Controller
RFW-FI-2A	RFW Pump A Flow
COND-PI-28A	RFW Pump A Suction Press.
COND-POI-26	COND-V-149 Position
RFW-DPI-4	Main Startup Valves ΔP (RFW-FCV-10A/10B)
MS-TI-21A	Turbine HP Steam Supply Temperature

MS-PI-21A	Turbine HP Steam Supply Pressure
BS-TI-17A	Turbine LP Steam Supply Temperature
BS-PI-17A	Turbine LP Steam Supply Pressure
ES-PI-1A	Turbine Exhaust Stm Pressure
MS-PI-22A	Turbine First Stage Pressure
COND-TI-25	Pump Suction Temperature
RFW-TI-5	RPV Inlet Temperature
RFW-PI-5	RPV Inlet Pressure
RFT-SI-1A	Turbine Speed
RFT-POI-1A	Governor Valve Position
SS-PI-1A	Sealing Steam Pressure
RFT-PI-2/1A	Turbine Oil Control Pressure
RFT-PI-3/1A	Turbine Oil Bearing Pressure
TO-LI-14A	Turbine Oil Reservoir Level
TSW-TI-14A	Oil Cooler Outlet Temperature
RFT-DPI-1/1A	Oil Cooler (cooler/filter) ΔP

Annunciators

NOTE: See annunciator procedures for current setpoints.

Location		Description/Function
P603-A8-	1.8	RFW Vlv Control Signal Fail (RFW-V-10A/10B)
	2.8	RFW Turb Control Signal Failure
	3.8	RFW RPV Press High Alert
	4.7	RFW/Turbine RPV Level High Trip
	5.7	RFW Sample Flow Low

NOTE: RFW Turbine "B" Annunciators are laid out in an identical pattern on the right-hand side of P840-A1 starting at drop location 5.1, and are not repeated here. Annunciators shared by both Turbines A and B are listed last.

P840-A1-	1.1	TURB A Trip
	1.2	TURB A Vac. Low Trip
	1.3	TURB A Turning Gear Failure
	2.1	TURB A Trip CKT Fail
	2.2	TURB A EXH Hood Vac Low
	2.3	TURB A Turning GR Oil Press Low
	3.1	TURB A Test HDR Press Low
	3.2	TURB A Exh Hood Temp High
	3.3	TURB A Seal Stm Press Low
	4.1	TURB A Test Trip Hdr Pressurized
	4.2	TURB A Oil Filter ΔP Hi
	4.3	TURB A Aux. Oil Pmp On
	5.1	TURB A Contr Oil Press Low

5.2	TURB A Lube Oil Press Low
5.3	TURB A Emergency Oil Pmp On
6.1	TURB A Overspeed Trip
6.2	TURB A Coupling Brg Oil Temp Hi
6.3	TURB A Resvr Oil Level High
7.1	TURB A Vib High
7.2	TURB A Thrust Brg Oil Temp Hi
7.3	TURB A Resvr Oil Level Low
8.1	TURB A Thrust Brg Wear High
8.2	TURB A Oil Clr Outlet Temp Hi
8.3	RFW Pmp A Suct Press Low
9.2	RFW Pmp A Seal Drain Temp High
9.3	RFW Pmp A Disch Flow Low
10.1	RFW Pmp A Area Temp High
1.4	Startup Flow Valve ΔP High
7.4	RFW Pmp A/B Seal Tk Lvl High
8.4	RFW Pmp A/B Dr Tk Lvl Hi/Lo
9.4	RFW Pmp A/B Seal Filter ΔP Hi
10.4	RFW Pmp-Turb A/B Brg Temp High

B. Local

RFW Pump Turbine Vibration Monitoring

Continuous measurement and monitoring of RFW pump and turbine bearing vibration, thrust bearing displacement and shaft eccentricity is provided by proximity probe sensors mounted on the RFW pump and drive turbine. The probe assembly consists of a non-contacting eddy current proximity transducer and a seismic velocity transducer. Indications and alarms are provided in the control room and on a local panel (RFW-VMP-1). Control Room indications are provided on the PPCRS.

Bearing Vibration Monitors

The RFW turbines have two floating pad "journal" bearings, one on each end, and both are monitored for vibration.

Thrust Bearing Monitor (Rotor Position)

Each RFW Turbine has one Kingsbury thrust bearing at its steam inlet (outboard) end. Turbine rotor axial movement (thrust) is continuously monitored by measuring the clearance between the rotor thrust collar and the thrust bearing mounting support.

Turbine Rotor Eccentricity

This monitor provides a reading of shaft eccentricity or shaft bow, which is read in the peak-to-peak mode. The peak-to-peak indication is the overall amplitude of the rotor bow.

VII. SYSTEM OPERATIONAL SUMMARY

NOTE: This section is designed to give a general overview of the feedwater system operation for training purposes only. The current system operating procedures should be utilized for any control manipulation.

A. Normal

During normal, 100% power operation, the feedwater system is lined up with two reactor feedwater pumps operating and the 6A and 6B heaters in service. The Master Level Controller is normally in the 3 element mode and automatically maintaining reactor water level at +35".

Long Cycle Cleanup (Figure 1)

Prior to performing a reactor startup the condensate and feedwater systems are typically lined up for long cycle recirculation or the "CLEANUP MODE". In this mode condensate is being pumped from the main condenser through the condensate system and most of the feedwater system before being recycled back to the condenser through the feedwater cleanup flow control valve RFW-FCV-15. This line up is as follows: **LO-9168**

At least one condensate pump is running
At least two demineralizer beds are on line
Flow is passing through all the condensate booster pumps
Flow is passing through all the feedwater heaters
The RFPs are secured and bypassed (bypass valve RFW-V-149 is open and RFP discharge valves RFW-V-102A & 102B are closed).
Cleanup/startup valves RFW-V-117A & 117B are open
HP heater discharge valves RFW-V-112A & 112B are closed
Cleanup flow control blocking valve RFW-V-14 is open
Cleanup flow control valve RFW-FCV-15 is controlling the flow returning back to the main condenser
Feedwater reactor isolation valves (RFW-V-65 & 65B) are closed

Reactor level is generally increasing very slowly during this time due to the Control Rod Drive cooling water entering the vessel and no steam leaving the vessel. Reactor level is being controlled by rejecting water to the main condenser or to radwaste via Reactor Water Cleanup system (RWCU), tie-ins to the feedwater system and radwaste system.

Reactor Startup

The condensate and feedwater system remains in the long cycle cleanup mode as the reactor startup progresses until Main Condensate and Feedwater purity is within acceptable limits per PPM 1.13.1, Chemical Process Management and Control. At this point blowdown or water rejection through the RWCU system is stopped and the feedwater system is lined up to send condensate water to the vessel to provide RPV vessel inventory make-up as necessary. The feedwater system is lined up as follows: **LO-5747**

Condensate Cleanup valves RFW-V-15 & 14 are closed
Feedwater reactor isolation valves RFW-V-65A & B are opened
Startup flow control block valve RFW-V-118 is opened
Startup flow control valves RFW-FCV-10A & B are lined up such that the Startup Level Controller can be used to control condensate flow into the vessel.
Condensate flow still bypasses the feedwater pumps via RFW-V-149.
At approximately 70 psig reactor pressure a condensate booster pump is started
At approximately 300 psig reactor pressure a RFP is prepared for operation and is placed on line at about 400 psig. The respective RFP discharge valve RFW-V-102A (B) is opened and the RFP bypass valve RFW-V-149 is shut. RPV injection is now supplied from the RFP.

The startup level control valves are used to maintain level control up to 5 - 15% reactor power. During this time RFP speed and RFP minimum flow are regulated, via their control room controllers, to keep the Startup Flow Control valves somewhere between 10 and 90% open. The Startup Flow Control valves open progressively with RFW-FCV-10B beginning to open when RFW-FCV-10A has opened approximately 75%. LO-5747

At very low flows the automatic feedback signals are very weak so the startup controller may not properly maintain reactor level in the AUTO mode until approximately 5% demand signal.

The operating RFP is switched from manual speed control on the individual Turbine Speed Controller to single element AUTO control on the Master Level Controller at approximately 5 - 15% power. The startup level controller is immediately switched to manual control so that both controllers are not attempting to control vessel level at the same time. In this configuration the startup flow control valves will have been fully opened and the RFPs will automatically change speed as directed by the Master Controller in order to control level. LO-5747

The HP feedwater heaters discharge valves (RFW-V-112A/B) are now opened, one at a time, and the startup flow control valves are isolated (RFW-V-118).
The Master controller should automatically adjust RFP speed to compensate for any level perturbations that occur during this transition. When both of the heater discharge valves are open, the startup flow control valves are isolated (RFW-V-118) and the reactor level is stable at the desired set point. Placing the level controller mode selector switch on P603 into the 3-element position places the Master Controller into three-element control. LO-9168

Prior to exceeding 65% reactor power the second RFW pump is placed into service and their speed controllers are balanced such that the two pumps share the load with one pump slightly in the lead (typically LT 100 rpm).

B. Abnormal

Feedwater system abnormalities will usually result in changes in reactor vessel level. Some significant abnormalities in the feedwater lineup such as a loss of a feedwater pump with a resultant loss in vessel level will result in automatic actions that will tend to stabilize the plant (recirculation runback). In general if any operator action is necessary to address significant deviations in feedwater flow and therefore, in reactor level, the efforts will be directed by the Emergency Operating Procedure "RPV Level Control" (PPM 5.1.1).

If a feedwater heater tube rupture occurs during normal operation, the initial effect would be to increase the heat transferred to the feedwater flowing through the tube due to a spray cooling effect occurring on the shell side of the feedwater heater. This would increase feedwater temperature into the RPV. If the tube rupture escalates to the point where the feedwater heater floods, heat transferred to the feedwater would dramatically decrease causing a marked reduction in feedwater temperature into the RPV. Actions for loss of feedwater heating would have to be taken, reference ABN-POWER.

C. Industry Events

SER 21-95,
Failure of Heater Drain Pump Recirculation Line

SUMMARY
While securing the heater drain pumps for on-line maintenance at Millstone Unit 2, a water hammer occurred, rupturing an 8-inch pump recirculation line several inches downstream from a closed manual isolation valve and releasing steam into the turbine building. Control room operators manually scrammed the reactor and closed the main steam isolation valves to terminate the leak. Nonessential personnel had been previously cleared from the area prior to securing the heater drain pumps; no personnel were injured from the rupture. Portions of the recirculation line were included in the plant's erosion/corrosion monitoring program, but not the section that ruptured.
Following the rupture, plant personnel determined that pipe wall thickness at the point of the break was less than 13 percent of its original design and that the pipe exhibited symptoms of single-phase flow-accelerated corrosion.

Lessons learned from this event:
1. Historical operating information, equipment maintenance records, and operator work-arounds are important considerations when identifying susceptible systems or components where the risk of flow accelerated erosion/corrosion has increased because of changes in past operating configurations. In this event, a manual isolation valve that had normally been open in the past was now required to be closed following plant startup. Difficulties encountered in fully closing the heater drain pump recirculation isolation valves were not reported, recorded, or corrected. Consequently, the system experienced unexpected flow, resulting in unanticipated flow accelerated erosion/corrosion.
2. Multi-discipline technical reviews of procedure revisions, before submittal to the plant review committee, provide an additional barrier to procedure errors. In this event, technical errors in a revised procedure were not detected during review for final approval because the revision was described as one "incorporating previously approved changes."

The Unit Director provided the following insights to this event: "I would encourage all stations to learn from our event. We were extremely fortunate that no one was injured in this event. We attribute this to our operator's practice of announcing the starting or stopping of major equipment on the public address system and checking the area to ensure that people stand clear. I would also urge other stations to expand their review for applicability/susceptibility beyond heater drain pump systems. Our event can occur in any system where there is component leakage or operation of system components in other than their expected configuration.

Never be satisfied with your programs. We thought we had a top notch E/C program, but we still had a problem. Gather all of the operational and maintenance history information you can for your E/C program (ask your system engineers, your operators and your maintenance people and consult history files)."

UNIT	Millstone Unit 2Northeast Utilities
YEAR COMMERCIAL	1975
REACTOR TYPE (SIZE)	PWR (910 MWe)
REACTOR MANUFACTURER	Combustion Engineering
TURBINE MANUFACTURER	General Electric
PLANT DESIGNER	Bechtel
EVENT DATE	August 8, 1995

SER 16-96

Multiple Personnel Injuries Caused By High-Energy Reheater Drain Pipe Failure

EXECUTIVE SUMMARY

On September 24, 1996, during a startup of Oconee Unit 2, with the unit at approximately 55 percent power, an 18-inch second-stage reheater drain pipe failed, injuring seven station personnel. The main steam supply to the moisture separator/reheaters was promptly isolated and the unit was manually scrammed, terminating the steam release. The injured personnel were transported to off-site medical facilities.

The pipe failure was the result of overpressure caused by a water hammer in the second-stage reheater drain piping. Examination of the failed section of the pipe indicated a 100 percent ductile rupture. Erosion/corrosion was not a factor in the pipe failure.

The following are important aspects of this event:

o DESIGN

The reheater drain system was vulnerable to water hammer events caused by backflow. In addition, all three units at Oconee had a history of such events. However, station personnel did not recognize that water hammer conditions had the potential to rupture large bore pipe.

o COMMUNICATION

Shift supervision did not have the technical information needed to make appropriate operational decisions required for safe reheater drain system operation. Technical aspects of changes to system operation were not addressed in the approved operating procedures or effectively communicated to the control room staff.

o OPERATING PROCEDURES

Revised valve lineups, initial conditions, limitations, and precautions necessary for safe reheater drain system operation had been identified for incorporation into the system operating procedures before the next scheduled unit start. However, procedures were not placed on hold per station administrative requirements to prevent use until they were revised and the technical information incorporated, nor were the procedures revised prior to startup following an unscheduled outage.

USE OF OPERATING EXPERIENCE

Personnel in operations, engineering, and management did not have an adequate understanding of how water hammer occurs, and how it can be prevented. As a result, they insufficiently assessed the potential consequences of previous Oconee reheater drain system water hammer events. In 1990, the station corrective action program identified reheater drain system water hammer problems and proposed modifications. However, these modifications received insufficient priority and had not been implemented.

UTILITY MANAGEMENT PERSPECTIVE

The Station Manager, Oconee Nuclear Station, provided the following comments concerning the event:

"It is difficult to convey the personal anguish we experienced when seven members of our team were seriously injured during this event. We are thankful all of those seriously injured are on the road to recovery. One lesson we have learned is that emergency drills should occasionally include multiple, serious casualties in the scenario."

"Another key lesson pointed out by this event was that our managers, engineering personnel, and operators did not realize that water hammer could rupture a large bore pipe. In the past, we had experienced hanger, valve, and insulation damage caused by water hammer; however, gross pressure boundary failure was not considered a likely consequence. This paradigm in our thinking affected the urgency with which we addressed corrective actions dealing with water hammer incidents, and made us vulnerable to this event."

"This event also brought to light a station operating culture that was tolerant of inadequate procedures. Existing procedures did not yet contain the heater drain system alignment practice that would reduce water hammers, but the procedures were not placed on administrative hold. In restoring the unit, we relied on a combination of the inadequate procedures, individuals' memories, and verbal communication. These clearly proved insufficient."

UNIT	Oconee Unit 2(Duke Power Company)
YEAR COMMERCIAL	1974
REACTOR TYPE (SIZE)	860 MWe
REACTOR MANUFACTURER	Babcock and Wilcox
TURBINE MANUFACTURER	General Electric
PLANT DESIGNER	Duke Power Company/Bechtel
EVENT DATE	September 24, 1996

VIII. SYSTEM INTERRELATIONSHIPS

LO-5768

Main Steam System - Supplies HP steam to RFTs

Bleed Steam - Supplies LP steam to RFTs from MSR 1B.

MD-TK-1 and 2 - Receive condensate and seal water leak-off flow from RFW turbines and pumps

Condensate System - Supplies seal water to the RFP seals

Plant Service Water (TSW) - Supplies cooling to the RFT oil coolers

Main Condenser - Receives RFT exhaust

Gland Seal Condenser - Receives gland exhaust from RFT glands and steam admittance valve glands

Cascade Drain System - Heats feedwater in #6 feedwater heater.

Extraction Steam - Heats feedwater in #6 feedwater heater.

Reactor Water Clean Up - Discharges to the feedwater system at thermal sleeves located in the feedwater supply lines

Miscellaneous Drain System - Receives seal steam condensate drain flow (HP and LP stop valves, and governor valve), RFT stage steam condensate flow, and RFP seal leakby flow.

Reactor Recirculation Control - RFT LP and HP Stop valve position information for each feedpump is sent to the Reactor Feedwater Level Control system. A feedpump trip coincident with a low RPV level (+ 31.5"/level 4) will cause a RRC runback to 30 Hz. **LO-7670**

Control and Service air is used for startup flow control valve operation and control.

IX. POWER SUPPLIES

Component	Description	Power Supply
RFW-V-102A	RFW Pump 'A' Discharge Valve	MC-1B
RFW-V-102B	RFW Pump 'B' Discharge Valve	MC-2D
RFW-V-108A	Feed Inlet to Feed Htr 6A	MC-1A
RFW-V-108B	Feed Inlet to Feed Htr 6B	MC-2C
RFW-V-117A	Feed Htr 6A Feed Outlet Valve	MC-1A
RFW-V-117B	Feed Htr 6B Feed Outlet Valve	MC-2C
RFW-V-112A	Feed Htr 6A Feed Outlet Valve	MC-1A
RFW-V-112B	Feed Htr 6B Feed Outlet Valve	MC-2C
RFW-V-109	HP Feed Htrs Feedwater Bypass Valve	MC-1A
RFW-V-14	Condensate Cleanup Flow	MC-3C
ES-V-1A	RFPT A Exhaust Valve	MC-1B

ES-V-1B	RFPT B Exhaust Valve	MC-2D	
BS-V-17A	Bleed Steam to RFPT A	MC-1B	
BS-V-17B	Bleed Steam to RFPT B	MC-2D	
MS-V-105A	Main Steam to RFPT A	MC-1B	
MS-V-105B	Main Steam to RFPT B	MC-2D	
RFW-V-65A	RFW Line 'A' Outbd Isolation Valve	MC-7A	
RFW-V-65B	RFW Line 'B' Outbd. Isolation Valve	MC-7A	
ES-V-2A	RFPT A Exhaust Bypass Valve	MC-1B	
ES-V-2B	RFPT B Exhaust Bypass Valve	MC-3C	
MD-P-1A	MD-TK-1 Pump A	MC-1B	
MD-P-1B	MD-TK-1 Pump B	MC-2P	
RFP-P-MOP/1A	RFW Turbine 'A' Main Oil Pump	MC-1B	
RFP-P-MOP/1B	RFW Turbine 'B' Main Oil Pump	MC-2P	LO-9162
RFP-P-AOP/1A	RFW Turbine 'A' Aux. Oil Pump	MC-2P	
RFP-P-AOP/1B	RFW Turbine 'B' Aux. Oil Pump	MC-1B	
RFP-P-EOP/1A	RFP Turbine 'A' Emergency Oil Pump	MC-S2-1B	
RFP-P-EOP/1B	RFP Turbine 'B' Emergency Oil Pump	MC-S2-1B	
RFP-M-TNG/1A	RFW Turbine 'A' Turning Gear	MC-1B	
RFP-M-TNG/1B	RFW Turbine 'B' Turning Gear	MC-2P	
TO-M-EX/3A	RFPT A Oil Res. Vapor Extractor	MC-1A	
TO-M-EX/3B	RFPT B Oil Res. Vapor Extractor	MC-1A	
RFPT A Control And Trip Logic Power		DP-S1-1C (S1-7)	
RFPT B Control And Trip Logic Power		DP-S1-2C (S1-7)	

X. TECHNICAL AND LICENSE CONTROLLED SPECIFICATIONS

A. Technical Specifications

3.3.2.2 Feedwater and Main Turbine High Water Level Trip Instrumentation

3.6.1.3 Primary Containment Isolation Valves (PCIS)

B. License Controlled Specifications

LCS RFO 1.4.1 Chemistry

XI. REFERENCES

PPM 2.2.4 Condensate and Feedwater System

B&R Drawings:
M502 Main and Exhaust Steam Flow Diagram
M504 Condensate and Feedwater Flow Diagram
M506 Miscellaneous Vents and Drains
M509 Turbine Oil Purification & Transfer System
M529 Nuclear Boiler Main Steam (includes RFW lines)
M985-1 Feedwater Turbine RFW-DT-1A Control and Lube Oil Flow Diagram
M985-2 Feedwater Turbine RFW-DT-1B Control and Lube Oil Flow Diagram
E526 Misc. Equipment Elementary sheets 1,2,3
EWD-72E-003 through 009
EWD-72E-045 & 050

G.E. Elementaries, Nuclear Boiler Process Inst System (807E153TC), sh 2, sh 3, sh 4

FSAR Chapter 10.4

Delaval Drive Turbine Instruction Manual, CVI-02-12-00-Sht16

Ingersoll-Rand Centrifugal Pump Instruction Manual, CVI File 02- 11A-00 Sht 70

SYSTEM LEARNING OBJECTIVES		EO	RO	SRO	STA
5746.	State the purpose of the Feedwater System.	X	X	X	X
5747.	Identify the following RFW flow paths:				
	a. Condensate fill of RPV with RFPs secured.	X	X	X	X
	b. Startup flow through FCV-10.	X	X	X	X
	c. Flow path when controlling using RFP speed control.	X	X	X	X
5749.	State the purpose of each of the following systems/systems components.				
	a. Reactor Feedwater pumps	X	X	X	X
	b. Sealing Steam System	X	X	X	X
	c. Turbine Drain System	X	X	X	X
	d. Turbine Oil System	X	X	X	X
	e. Admission Valve Assembly	X	X	X	X
	f. Steam Stop Valves	X	X	X	X
5750.	State the following pertaining to the Turbine Oil System:				
	a. How lube oil temperature is controlled	X	X	X	X
	b. Normal operating oil pressures	X	X	X	X
	c. Basic relationship between trip oil pressure and steam stops/ hydraulic trip valve during normal and tripped conditions.	X	X	X	X
5751.	State the source of motive steam for the Reactor Feed Pumps and when each is used.	X	X	X	X
5753.	Describe the functions of the RFP Turbine Emerg Trip/Reset switch in each of its positions (TRIP, NORM, and RESET).	X	X	X	X
5756.	Explain the automatic feature associated with the RFP Turbine Turning Gear.	X	X	X	X
5757.	Explain the function of the Turbine HP Stop and LP Stop TEST Push-buttons and associated IN TEST lamps.		X	X	X
5758.	Explain the automatic feature associated with the RFP Aux. Oil Pumps.	X	X	X	X
5759.	Explain the automatic feature associated with the RFP Emergency Oil Pumps.	X	X	X	X

SYSTEM LEARNING OBJECTIVES	EO	RO	SRO	STA
5760. Describe the functions of the RFP Overspeed Trip Test switch in each of its positions (NORMAL/RESET/BLOCK/TEST).		X	X	X
5761. Explain the function of the RFP Emergency Oil Pump and Aux Oil Pump TEST Push-buttons.		X	X	X
5762. Explain the automatic feature associated with the RFP Turbine Drains (MS-142A, BS-V-44A, BS-V-45A)	X	X	X	X
5763. Explain the interlock associated with the RFP Exhaust Steam Valve (ES-V-1A).	X	X	X	X
5764. Describe the functions of the Condensate Cleanup Flow valve RFW-V-14 switch in each of its positions (CLOSE/AUTO/OPEN).		X	X	X
5765. Explain the interlock associated with the #6 Feedheater outlet isolation valves (RFW-V-112A, 112B).		X	X	X
5766. Describe the functions of the RPV Inlet Outboard Isolation Check valve (RFW-V-32A, 32B) switch in each of its positions (CLOSE/OPEN).		X	X	X
5767. Identify the automatic and manual Reactor Feed Pump Turbine Trips (11 automatic, 3 manual), setpoints not required.	X	X	X	X
5768. Describe how the following systems interrelate with the Feedwater System.				
a. MD-TK-1	X	X	X	X
b. TSW	X	X	X	X
c. Main Condenser	X	X	X	X
d. Gland Seal Condenser	X	X	X	X
e. Extraction Steam	X	X	X	X
f. RWCU	X	X	X	X
5770. Given a set of Technical Specifications, locate the LCO's that apply to the feedwater system		X	X	X
7670. Determine the affect of a RFW malfunction on the RRC System.		X	X	X
9157. Describe how RFP glands are sealed. Include source of water, pressure and temperature controls, and destination of the water leaving the glands.	X			
9158. State what the back pressure on RFP seal hot leak-off is maintained at and why.	X			

SYSTEM LEARNING OBJECTIVES	EO	RO	SRO	STA
9159. Describe where the drains from the RFT Stop and Steam Admission valves are drained to.	X			
9160. Describe how the RFT inlet and exhaust glands are sealed.	X			
9161. Describe how MD-TK-1 and MD-TK-2 level is controlled.	X			
9162. State how many RFT Lube Oil Pumps are associated with each RFT skid? Also state the type of power (AC or DC) for each motor and the loads supplied by the turbine oil system.	X			
9165. List four (4) manual devices and locations from which each RFT may be tripped.	X			
9168. Briefly describe how the following Reactor Feedwater evolutions are done:				
a. Long Cycle Cleanup	X			
b. Reactor Startup	X			
c. Warmup of the second feed pump	X			

SYSTEM TEXT REVISION SUMMARY

REV. 9 Author: Donny Hughes Date: Nov. 2002

Reformat to new SD format.

REV. 8 Author: Donny Hughes Date: Nov. 2000

General rewrite to incorporate changes from the system engineer review.

REV. 7 Author: Ken Elliott Date: Oct, 1997

General rewrite to incorporate changes to the FWLC system (Digital Feedwater Control) and Technical Specification changes.

REV. 6 AUTHOR: S. Ackley Date: May 1995

NOTE: All technical revisions are identified with a vertical line located toward the right margin in the text. Format changes are not identified with revision bars.

1. Added Drain tank pumps to controls, discharge valve controls.
2. Removed info on old vibration monitoring system, updated to new. BDC 88-0005.
3. Added power supply info for governors.
4. Corrected FCV-10 to fail as is on loss of air.
5. Corrected figure 2 to match BDC-89-0151, corrected figure 1, 3, 4
6. Added info on affect on RRC System.
7. Added purposes to components
8. Added T.S. 3/4.6.3.

REV. 5 AUTHOR: M. Westergren DATE: February 1992

1. Revised logic on Overspeed Trip Test switch per system engineer and latest dwgs.
2. Revised Figure 5, RFP Unit Oil and Control diag. per current dwgs.

DIC 0023.98

COLUMBIA GENERATING STATION

SYSTEM DESCRIPTION

Volume 2, Chapter 10

PLANT SERVICE WATER

Reviewed by:	[signature] Engineering	11/25/02 Date
Reviewed by:	[signature] Operations	12/4/02 Date
Approved by:	[signature] Operations Training Manager	12/5/02 Date

DISCLAIMER OF RESPONSIBILITY

This document is intended for **training use only**. It is not to be used for verification of Columbia "as-built" conditions or plant control purposes. Controlled plant drawings and approved plant procedures should be used for plant specific reference.

MINOR REVISION RECORD

Minor Rev Number	Description of Revision	Affected Pages	Entered By	Effective Date	Manager Approval

TOPIC: PLANT SERVICE WATER (TSW)

I. PURPOSE

LO-5848

The Plant Service Water System supplies cooling water to auxiliary equipment in the Reactor Building, Turbine Building, Radwaste Building, Circulating Water Pumphouse, and Service Building for removal of equipment heat loads during normal operation. The Plant Service Water System also supplies both the Plant Service Water and the Circulating Water pumps with bearing lubrication and motor cooling water. Additionally, the Circulating Water pump is supplied with priming eductor power water flow.

II. DESIGN BASES (FSAR)

The Plant Service Water system (TSW) is a non-safety related system and is designed to provide cooling water for removal of maximum expected heat rejected from auxiliary (non-essential) equipment, including Turbine-Generator and reactor auxiliaries located throughout the plant.

TSW can be supplied by either off-site power or the emergency diesel generators. TSW functions continuously during all modes of operation except during LOCA conditions coincident with no offsite power available (LOOP). TSW is designed with two pumps, each having 100% system capacity.

III. GENERAL DESCRIPTION (Figure 1)

Each TSW pump's suction is directly connected with the 36" TMU-to-CW basin supply line via a weir box. The TSW pumps discharge into a 30" line which goes to the Turbine Building. There the line splits into a 20" and 18" line. The Reactor Building (Figure 2) is supplied via the 18" line while the Turbine Building is supplied by the 20" line. A 8" line off the 18" Reactor Building supply feeds the Radwaste Building (Figure 3). A 6" line off of the Turbine Building supply feeds the Service Building (Figure 4). The TSW return is via a 30" line which discharges to CW at the Main Condenser CW Discharge Tunnel. The heat picked up by the TSW system is then dissipated along with the CW system in the Cooling Towers. Makeup to the CW basin is from Tower Makeup (TMU).

IV. COMPONENT DESCRIPTION

A. Weir Box (Figure 1)

The TSW pump suctions are connected with the 36" TMU-to-CW basin supply line via a weir box. The weir box provides a cooler TSW pump suction from a TMU (river water) and CW mixture than just CW from the CW basin. Cooler TSW supplied to the Reactor Closed Cooling system (RCC) heat exchangers in turn enables RCC (which cools the primary containment air handler cooling coils) to maintain containment temperatures within Technical Specification limits.

Each TSW pump takes a suction from its own mixing box which receives a portion of warmer water directly from the CW basin. This warmer water is drawn in from beneath the mixing box and is combined with cooler water from a weir box common to both TSW pumps. The weir box receives flow from the TMU System which it then supplies to the mixing boxes with excess TMU makeup flow overflowing out the top of the weir box into the CW basin. Weir gates (TMU-V-103A/B) in each suction line between the weir box and the mixing boxes allow throttling the TMU supply to the mixing boxes to adjust TSW system temperature.

B. Plant Service Water Pumps TSW-P-1A, B

Each TSW pump, located in the CW Pump House, is rated at 21,000 gpm when operated with a total dynamic head of 100 psi. They are each 100% capacity and are normally aligned with one pump running and the other pump in standby.

C. TSW Pump Discharge Valves

The TSW pump discharge valves (TSW-V-53A & B) provide isolation of the TSW pumps to limit starting currents and preclude water hammer during pump starts. Each valve automatically opens on an associated TSW pump start and closes on a pump stop. Discharge check valves (TSW-V-52A & B) limit reverse flow.

D. Lubrication Water Filters (Figure 6) LO-9037A

The Lubrication Water filters supply filtered water for TSW pump motor cooling and pump shaft bearing cooling and lubrication. The source of lubrication water is normally from the TSW system when LO-9041
a TSW pump is running. The Fire Protection system provides lube water during initial TSW system startup.

Lubricating water flow for the TSW pumps passes through lube water filters TSW-F-1A and 1B which are piped in parallel. Each filter is capable of supplying the total flow requirements (18 gpm) for both plant service water pumps. Inside each strainer element (dirty water side) is a motor driven backwash arm. This backwash arm continuously rotates a backwash port to provide a route for reverse flow, clean to dirty. Whenever the backwash valve is open, particles captured on the filter are reverse-flushed through the backwash port and out the backwash valve to the CW basin.

The filters are equipped with an automatic backwash feature which backwashes the strainer elements at regular timed intervals and also if high filter differential pressures occur. Each filter body has a case drain ball valve. Because the backwash cycle only removes debris from the inside surface of the filter media, each filter case drain valve is opened periodically to the flush debris that settles out and accumulates within the filter body

Similarly, the TSW system also supplies lube water to the CW pump motors and CW pump shaft bearings via lube water filters TSW-F-2A and 2B. These are identical to TSW-F-1A and 1B.

<u>Filter Backwash Controls (TSW-CP-F/1A, F/1B, F/2A, and F/2B)</u>: The TSW and CW lubewater filter backwash controls are located at Circ Water Pump House instrument racks E-IR-17 and E-IR-19. The controls for each filter are installed in self contained control boxes which provide the means to operate the filters in a choice of either a manual continuous backwash mode or an automatic timed backwash cycle mode. When in the automatic timed cycle mode, the filters will additionally automatically backwash if filter differential pressure becomes excessive.

The control panels contain all control devices to operate the filter units in either an automatic timed backwash or a manual full time continuous backwash. The panel white light should always be illuminated indicating availability of power. In addition, when the panel control switch is set to "OFF", the backwash ball valve will cycle to the closed position. TSW pump startup with no TSW pumps initially running should be performed with the filter panel selector switch set on "OFF". The switch can then be positioned to either "ON" or "AUTO" after the pump is running.

1. <u>Selector Switch (TSW-RMS-F/1A, F/1B, F/2A and F/2B)</u>: Each control panel has a three position selector switch, three indicator lamps, an internal timer relay, and a control relay. These devices function as follows:

Selector Switch set to "OFF" – The filter backwash motor will de-energize, and the backwash ball valve will cycle to the closed position. The white "power on" lamp will be on, and the red and green lamps should normally be off. In this mode the timer unit within the control panel is not functional.

Selector Switch set to "ON" – This is the "manual mode" of system operation. In this mode the timer unit within the control panel is not functional. The filter backwash motor will be on and run continuously, and the green lamp will be on continuously - indicating that the backwash ball valve (TSW-V-293, TSW-V-294, TSW-V-295, or TSW-V-296) is demanded open continuously. The red lamp – indicating a high differential pressure within the filter should normally be off. However, if it is lit, this would indicate a lube water filter high differential pressure condition exists.

Selector Switch set to "AUTO" - The filter backwash motor will be on and run continuously. The timer unit inside of the control panel will be enabled, controlling the backwash ball valve position with "off" and "on" delay times as set by two dials on the timer unit. The timer controls the panel green lamp and the position of the backwash ball valve only.

When the selector switch is first set to "AUTO", the timer always starts with the countdown of the "off" delay cycle - meaning that the timer relay contacts are not actuated. During this part of the cycle, the green panel lamp will be lit indicating that the backwash valve is demanded open. When the valve is open, lube water filter backwash occurs. When the timer "off" delay clocks out (~50 seconds), the timer relay contacts actuate to extinguish the green lamp and demand closed the backwash ball valve for the duration of the "on" delay (~180 minutes). With the valve closed, no backwash occurs.

If at any time a high lube water filter differential pressure condition occurs, the "Differential Pressure" red lamp will illuminate on the control panel and a backwash will be initiated that will run until the filter differential pressure switch resets. Reset of the filter high differential pressure switch resets the timer unit back to the beginning of a normal automatic backwash cycle – which would be an "off" delay with the ball valve open and the green lamp on.

High lube water filter differential pressure will also cause a second set of contacts in the filter differential pressure switch to cause an alarm in the Main Control Room.

2. Green Lamp: Illuminated – Backwash Cycle On – indicates that the backwash ball valve is demanded open.
3. White Lamp: Illuminated – Power On – indicates power is available to the control panel. It should always be illuminated, regardless of the position of the selector switch. Power to the system can only be turned off at the source panels (E-PP-7ACA, E-PP-8ACA, E-LP-5NA, or E-LP-6NA.)
4. Red Lamp: Illuminated – High Differential Pressure – Functional with the selector switch set to either "ON" or "AUTO". Indicates that the lube water filter differential pressure switch has detected a high differential pressure condition across the filter. This will initiate and maintain backwash (turn on the green lamp and demand open the backwash valve) until the DPIS switch resets.

E. Pressure/Temperature Control (Figure 4)

The Plant Service Water System has two pressure control stations PCV-20 and 25, and six temperature control stations, TCV-4, 8, 9, 11, 14A, and 14B. All of the temperature and pressure regulating control stations listed below can be manually isolated and controlled with a manual bypass valve. The stations function as follows:

1. Pressure Control Station TSW-PCV-20 throttles TSW flow to the Turbine Building to control pressure to components in the Turbine Generator and Service Buildings at about 110 psig. Maintaining a constant pressure prevents excessive cycling of turbine building TCV's and over-pressurization of TSW cooled heat exchangers in the turbine building. LO-9037b
2. Pressure Control Station TSW-PCV-25 controls lube water pressure supplied to the Circ Water pumps. Circ Water lube water pressure is controlled at approximately 55 psig.
3. Temperature Control Station TCV-4, set at approximately 90°F, controls SCW temperature out of the Main Generator stator water coolers.
4. Temperature Control Station TCV-8, set at approximately 110°F, controls Main Turbine oil cooler turbine oil outlet temperature.

5. Temperature Control Station TCV-9, set at approximately 100°F, controls Main Generator hydrogen gas temperature.

6. Temperature Control Station TCV-11 controls cold air outlet temperature for the Main Generator exciter coolers. The valve is set to control at approximately 115°F.

7. Temperature Control Stations TCV-14A and B control turbine oil temperatures out of the Reactor Feedwater pump oil coolers and are set to maintain approximately 110°F.

F. Halogenation (Figure 1A)

The TSW System is periodically treated with halogens (Sodium Hypochlorite or Sodium Hypochlorite plus Sodium Bomide) to retard the growth of algae within the TSW System. Halogens are initially supplied from tank CL-TK-3(4) to injector CL-EJC-2 by CL-P-30, 40, and 50. Ejector motive force is TSW via booster pump CL-P-2. The injection point is the TSW discharge header. LO-9037c

V. CONTROL THEORY AND INTERLOCKS

A. Controls on Board "A" in the Control Room

1. TSW-P-1A(1B) PUMP CONTROL SWITCH LO-5849

(4 position momentary spring return to AUTO switch; locks in PTL)

PTL - Pump stops (regardless of TSW-V-53A[B] position) and auto starts defeated. LO-9045

STOP - Pump Discharge valve TSW-V-53A(B) goes shut. When the valve reaches 15% open, the pump trips.

AUTO - If >8 gpm lube water flow and selected for standby with the EMERG STANDBY PUMP SELECTOR switch, auto starts on any of the following:

- Low discharge pressure on "running" pump (~ 80 psig)
- 15 seconds after UV occurs on "running" pump's bus (SM-75 or SM-85)

- If UV on **both** pumps' buses occurs, the "standby" pump auto starts 10 seconds after its bus is re-powered by TRB or EDG

START - Pump starts if >8 gpm lube water permissive is met.

TSW Pump Trips:

- Overcurrent.
- Undervoltage on SM-75 (85).
- The "B" TSW pump will trip or be prevented from starting, if the "A" TSW pump is running and an "F" or "A" signal (1.68 psig D/W press or -50" RPV level) is received.

2. EMERG STANDBY PUMP SELECTOR

(Three position switch; maintained positions) LO-5850

PP1A - Selects TSW pump 1A for AUTO start.

OFF - Neither pump will auto start. The amber backlit NO PUMP SELECT light will illuminate to alert personnel of this off-normal lineup.

PP1B - Selects TSW pump 1B for AUTO start.

3. PUMP A(B) DISCHARGE VALVE TSW-V-53A(53B)

(3 position momentary spring return to AUTO switch)

CLOSE - Valve closes

AUTO - Valve auto opens/closes when corresponding pump start/stop signals. Closes on PTL position for associated pump.

OPEN - Valve opens

4. CW PUMP A(B,C) EDUCTOR VALVES CW-V-13A(B,C) and TSW-V-115A (B,C)

(3 position momentary spring return to NOR switch)

CLOSE - Valves 13 & 115 close

NOR - Valves 13 & 115 auto close when associated CW pump starts

OPEN - Valves 13 & 115 open

B. Controls on Board "B" in the Control Room

1. RCC HX Outlet valves [TSW-V-64A/B/C] (throttle valve)

(3 position momentary spring return to NOR switch)

CLOSE - Valves throttles closed

NOR - Valve motion stops

OPEN - Valve throttles open

2. Mechanical Vacuum Pump Seal Water HX Inlet Supply Valves TSW-V-88A[B]

(3 position momentary spring return to AUTO switch)

CLOSE - Valve closes

AUTO - Valve auto opens on Vacuum Pump start signal, closes on stop signal.

OPEN - Valve opens

C. Local

1. TSW Pump Lube Water Filter A(B) [TSW-F-1A(B)] (panel E-IR-17(19) LO-15543

(Three position switch; maintained positions)

STOP - Motor for backwash arm stops, automatic backwash valve closes.

ON - Motor for backwash arm starts, automatic backwash valve opens and backwashes continuously.

AUTO - Motor for backwash arm starts, automatic backwash valve cycles open and closed at set intervals to limit differential pressure across the lube water filter screen. Backwash valve will cycle open at any time excessive differential pressure across the filter is sensed.

D. Interlocks

1. TSW response to LOCA and/or Loss of Offsite power LO-5851

TSW pumps 1A and 1B are powered from SM-75 and SM-85 respectively. The SM-75 and SM-85 feeder breakers, 7/75/1 & 8/85/1 will trip when they sense both an "F" or "A" signal (1.68 psig D/W press or -50" RPV level) and a Loss of Offsite power signal (sensed by the DG as the only source of power to its associated bus) in effect at the same time. The TSW Pumps trip on undervoltage when SM-75 and SM-85 are deenergized. To restart the TSW pumps, the LOCA signal must be reset and the feeder breakers 7/75/1 & 8/85/1 must be reclosed. A LOCA or "FA" signal alone will not effect SM-75 or SM-85 if Offsite power remains available. However if both TSW pumps are running, an "FA" signal will cause a trip of the "B" TSW pump.

VI. INSTRUMENTATION AND ALARMS

A. Instrumentation

1. Control Room - Board A

a) Plant SW Disch Hdr Press PI-28 0 - 200 psig

b) Plant SW PP A Amps Ammeter 0 - 250 amps

c) Plant SW PP B Amps Ammeter 0 - 250 amps

d) LOCKOUT CIRCUIT AVAIL lamp (white light above TSW Pump switch) illuminates when the circuit is available (lockout is reset).

e) The amber backlit NO PUMP SELECT light (amber light above pump selector switch) illuminates when no pump is selected (OFF position) providing no standby pump. Neither pump will auto start.

2. CW Pump House

   a) TSW L.W Diff Press (TSW-DPIS-26A[B]) 0-15 psid.

B. Annunciators

NOTE: See associated annunciator procedures for current setpoints.

Annunciator P840.A5

9.6	TSW to TG Bldg Press High/Low
10.6	TSW Pmp B OC Lockout
1.7	TSW Pmp A Motor Trip
2.7	TSW Pmp A Motor OL/GND
3.7	TSW Pmp A Lube Flow Low
4.7	TSW Pmp A Lube Fltr dP Hi
5.7	TSW Header Press Low
6.7	TSW Pmp A OC Lockout
7.7	TSW Pmp B Motor Trip
8.7	TSW Pmp B Motor OL/GND
9.7	TSW Pmp B Lube Flow Low
10.7	TSW Pmp B Lube Fltr dP Hi

VII. SYSTEM OPERATIONAL SUMMARY LO-9041

A. Normal System Operation

The TSW System is operated with one TSW pump in service and one in standby. Lube water is supplied by TSW via two continuously operating Lubrication Water Filters. One RCC heat exchange outlet valve TSW-64A, B, or C is almost throttled closed (left partially open for corrosion concerns) and the other 2 RCC heat exchangers are in service. TSW-PCV-20 is set at approximately 110 psig and controls TSW supply header pressure to equipment in Turbine Generator Building. TCV-4, 8, 9, 11, 14A and 14B control temperature of their respective heat loads.

B. <u>TSW Pump Outage</u> (Figure 5)

During a TSW pump outage, essential TSW loads can still be cooled. These components are cooled by establishing a temporary pump connection between Spray Pond "B" and the 30" TSW pump discharge header. The pump is capable of moving several thousands of gallons of water through the temporary circuit. (Additionally, the CW basin can be dewatered by establishing a temporary connection between the basin and the CW blowdown line to the river. Note also on the figure that circulating water can be pumped to Spray Pond "B" via another temporary flow circuit).

C. <u>Abnormal Operation</u> LO-5854

1. Loss of TSW Pumps (ABN-TSW)

The standby TSW pump starts automatically, on low discharge pressure from the running pump provided seal water flow to the standby pump is GT 8 gpm. If only the TSW pump that tripped is available, it can be restarted if seal water flow to it is GT 8 gpm unless an overcurrent lockout occurred.

If a TSW pump cannot be started, the plant has to be immediately shut down (manual scram) because the components that are cooled by the TSW system are essential for continued operation of the secondary and primary plant. Various supplied system alarms will be received for high temperatures conditions due to loss of cooling.

Backup cooling can be provided to the following components on a Loss of TSW:

a) Isophase Bus Duct Cooling can be realigned for a once through flow path.

b) CAS and SA Air compressors can be realigned to fire water cooling.

c) Fuel Pool Cooling Heat Exchangers, cooled by RCCW which is in turn cooled by TSW, can be realigned to Standby Service Water System cooling.

d) Critical Switchgear Coolers WMA-AH-53A2 & B2 can be aligned to chill water cooling.

2. TSW System Rupture

A rupture in the TSW system can take flow away from cooled components downstream of the rupture causing a loss of cooling to those components. Additionally the equipment in the local area is susceptible to damage from flooding. A leak in the Isophase Bus Duct Heat Exchangers will give a trouble alarm at P800.C4 3-2. A leak in the Main Generator will give an alarm at P820.B3 7-5

3. Loss of Lubrication Water Flow (4.840.A5 9-7)

If Lube Water flow is LT 8 gpm, the TSW pumps will not start manually or automatically. There are no automatic pump trips on loss of lubricating water flow. TSW motor temperatures will increase and pump bearing damage can occur due to a loss of cooling.

4. Failure of TSW-PCV-20 (Figure 4)

TSW-PCV-20 controls pressure to components in the Turbine Generator and Service Building at about 110 psig. A failure can cause a loss of flow to the loads supplied. A malfunction causing a change in controlled pressure will cause a change in flow through components that are flow balanced through throttle valves causing component parameters to reach off normal conditions and generate component temperature alarms. Additionally most of the temperature control valves downstream of PCV-20 rely on a steady supply pressure to allow them to smoothly control their systems temperatures.

TSW-PCV-20 can be manually isolated and pressure can be controlled with a manual bypass valve.

Gross overpressure protection for the system downstream of TSW-PCV-20 is provided by surge protection relief valves TSW-RV-98A and 98B.

5. Failure of TSW-TCV-4 (4.820.B3 9-4)

TSW-TCV-4 controls SCW temperature out of the Main Generator stator water coolers at approximately 90°F. A failure of the valve could cause hi temperature alarms and possible stator damage due to overheating. Main generator load is reduced to maintain LT 176°F, and tripped if GE 194°F.

TSW-TCV-4 can be manually isolated and temperature can be controlled with a manual bypass valve.

6. Failure of TSW-TCV-8 (4.820.B2 3-1)

   TSW-TCV-8 controls Main Turbine oil cooler to outlet temperature at approximately 110°F. A failure of the valve could cause hi temperature alarms and possible bearing damage. The main turbine is tripped if GE 180°F. If TCV-8 overcools the turbine oil, vibration of the main turbine will increase.

   TSW-TCV-8 can be manually isolated and temperature can be controlled with a manual bypass valve.

7. Failure of TSW-TCV-9 (4.820.B3 4-3)

   TSW-TCV-9 controls Main Generator hydrogen temperature at approximately 100°F. A failure of the valve could cause hi temperature alarms and high generator gas temperatures.

   TSW-TCV-9 can be manually isolated and temperature can be controlled with a manual bypass valve.

8. Failure of TSW-TCV-11 (4.820.B3 7-6)

   TSW-TCV-11 controls cold air outlet temperature for the Main Generator exciter coolers at approximately 115□F. A failure of the valve could cause hi temperature alarms and possible exciter damage from overheating. Main generator load is reduced to maintain LT 176°F.

   TSW-TCV-11 can be manually isolated and temperature can be controlled with a manual bypass valve.

9. Failure of TSW-TCV-14A and 14B (4.840.A1 8-2)

   TSW-TCV-14A/14B controls temperature out of the Reactor Feedwater A/B pump oil coolers at approximately 110□F. A failure of the valve could cause hi temperature alarms and possible bearing damage. The Reactor Feedwater pumps are secured if GT 175°F. If TCV-14A/B overcools the RFW turbine oil, vibration of the turbines will increase.

   TSW-TCV-14A and 14B can be manually isolated and temperature can be controlled with manual bypass valves.

VIII. SYSTEM INTERRELATIONSHIPS

LO-5852

The following components are cooled by TSW. A loss of TSW will cause a temperature rise for the components cooled:

A. RCC Heat Exchangers RCC-HX-1A, 1B, 1C

B. Main Turbine Lube Oil Coolers TO-HX-1A, 1B

C. Isophase Bus Duct Heat Exchanger TSW-HX-1A, 1B

D. Exciter Air Coolers TSW-HX-2A, B, C, D

E. Stator Cooling Water Coolers TSW-HX-3A, B

F. Generator Hydrogen Coolers TSW-HX-7A, B, C, D

G. Generator Seal Oil Coolers TSW-HX-8, 9

H. Generator H2 Dryer Cooler H2-HX-1

I. Condensate Pump Motor Coolers TSW-HX-4A, 4B, 4C

J. Condensate Booster Pump Lube Oil Coolers TSW-HX-6A through 6F

K. Reactor Feedwater Pump Turbine Oil Coolers TO-HX-2A, B, C, D

L. Circ. Water Pump Bearings & Motor CW-P-1A, 1B, 1C Pump Start Eductors CW-EDC-1A, 1B, 1C

M. CJW Heat Exchangers (CAS Compressors) CJW-HX-1A,1B

N. Service Air Compressor Cooling System SA-C-1 and Filter Dryer SA-DY-1

O. Mechanical Vacuum Pump Coolers TSW-HX-10A, 10B

P. Steam Tunnel Fan Coil Units RRA-CC-8, 9, 21

Railroad Lock Fan Unit RRA-CC-7

Critical Switch Gear Air Handling Units WMA-CC-53A, B

RW HVAC Chilled Water Condenser Units WCH-CU-51A, 51B

Communications Room AC Condenser WRA-CU-51

Inst Shop AC Condenser WRA-CU-52

Service Building Water Chiller Condenser Unit SCH-CU-51

Guard House Mixed Air Conditioner GMA-CU-1A, 1B

Guard House Core Air Conditioner System GMA-CU-2A, 2B

TB Bldg Sample Rm AC Condenser TRA-CU-52

Q. Sample Racks:

RX Bldg Sample Rack PSR-SR-6

RW Bldg Sample Racks PSR-SR-8, 9, 11

TB Bldg Stm Sample Cooler S-HX-2C

TB Bldg Sample Rack PSR-SR-1 & 2 & RFW Corrosion Monitor (S-TBIT-1)

R. Seal Steam Evaporator Blowdown Coolers SS-HX-1A, 1B

S. Blowdown Heat Exchangers BD-HX-1, 4

T. TSW Pump 1A, 1B Bearings & Motor coolers

IX. POWER SUPPLIES

LO-5853

A.	TSW-P-1A	SM-75
B.	TSW-P-1B	SM-85
C.	TSW-V-53A	PP-7A-C
D.	TSW-V-53B	PP-8A-C
E.	CL-P-2	MC-5N

X. TECHNICAL & LICENSEE CONTROL SPECIFICATIONS

None

XI. REFERENCES

A. FSAR, Section 9.2.1

B. System Operating Procedure 2.8.4

C. TSW Abnormal Operating Procedure ABN-TSW

D. Diagrams: M-507 S1, M-508-1, M-508-2, M-515, M-545, M-546, M-548, M- 550, M-553, M-607, M-888, E502 S2, E-517 S2 S17, E-519 S9 S12, E-527 S2, E-521 S4 S5 S6, E517 S7

E. CVI 02-13-00,6 – Instruction Manual for Plant Service Water Pumps

F. PMRs:

1. 85-0131 TSW/TMU Interface
2. 85-0238 TSW Outage/Alternate Service Connections
3. 84-0190 TSW Response to LOCA Signal

G. MDC 93-0206-0A: TSW Lube Water Filter Replacement

SYSTEM LEARNING OBJECTIVES	E O	R O	S R O	S T A
5848. State the purpose of the Plant Service Water System.	X	X	X	X
5849. Describe the expected response, including permissive signals, when the TSW-P-1A(1B) Pump Control Switch is placed in each switch positions:				
a. PTL	X	X	X	X
b. STOP	X	X	X	X
c. AUTO	X	X	X	X
d. START	X	X	X	X
5850. Describe the expected response when the TSW EMERG STANDBY PUMP SELECTOR switch is placed in each of the following switch positions:				
a. PP1A		X	X	X
b. OFF		X	X	X
c. PP1B		X	X	X
5851. Explain the TSW pump response to an "F" or "A" signal with and without Offsite power available.	X	X	X	X
5852 Given a list of plant equipment, identify the loads cooled by the TSW system.	X	X	X	X
5853. List the power supplies for each of the following:				
a. TSW-P-1A	X	X	X	X
b. TSW-P-1B	X	X	X	X
5854. Given a malfunction of a TSW system component, determine the affect on TSW system operation and interrelated systems.	X	X	X	X
9037. Describe the function of the following Plant Service Water components/systems:				
a. Lube Water Filters	X			
b. Plant Service Water pressure control valve (TSW-PCV-20)	X			
c. Chlorination System	X			
9041 Describe the method of cooling to the TSW pump motor.	X			
9042 Describe the normal pump lineup include the filter operation.	X			
15543 Describe the function of the TSW-F-1A(B) Control Switch TSW Pump Lube Water Filter.	X			

SYSTEM TEXT REVISION SUMMARY

Rev. 9 Author: Ron Hayden Date: November 2002

1. Incorporated System Engineers comments
2. Revised Figure 3

Rev. 8 Author: Ron Hayden Date: October 2000

1. Update TSW lube water filter description
2. Delete reference to chlorination of TSW
3. Added Halognation description
4. Correct references due to abnormal procedure changes
5. Updated various drawings
6. Incorporated Engineering and Operations comments

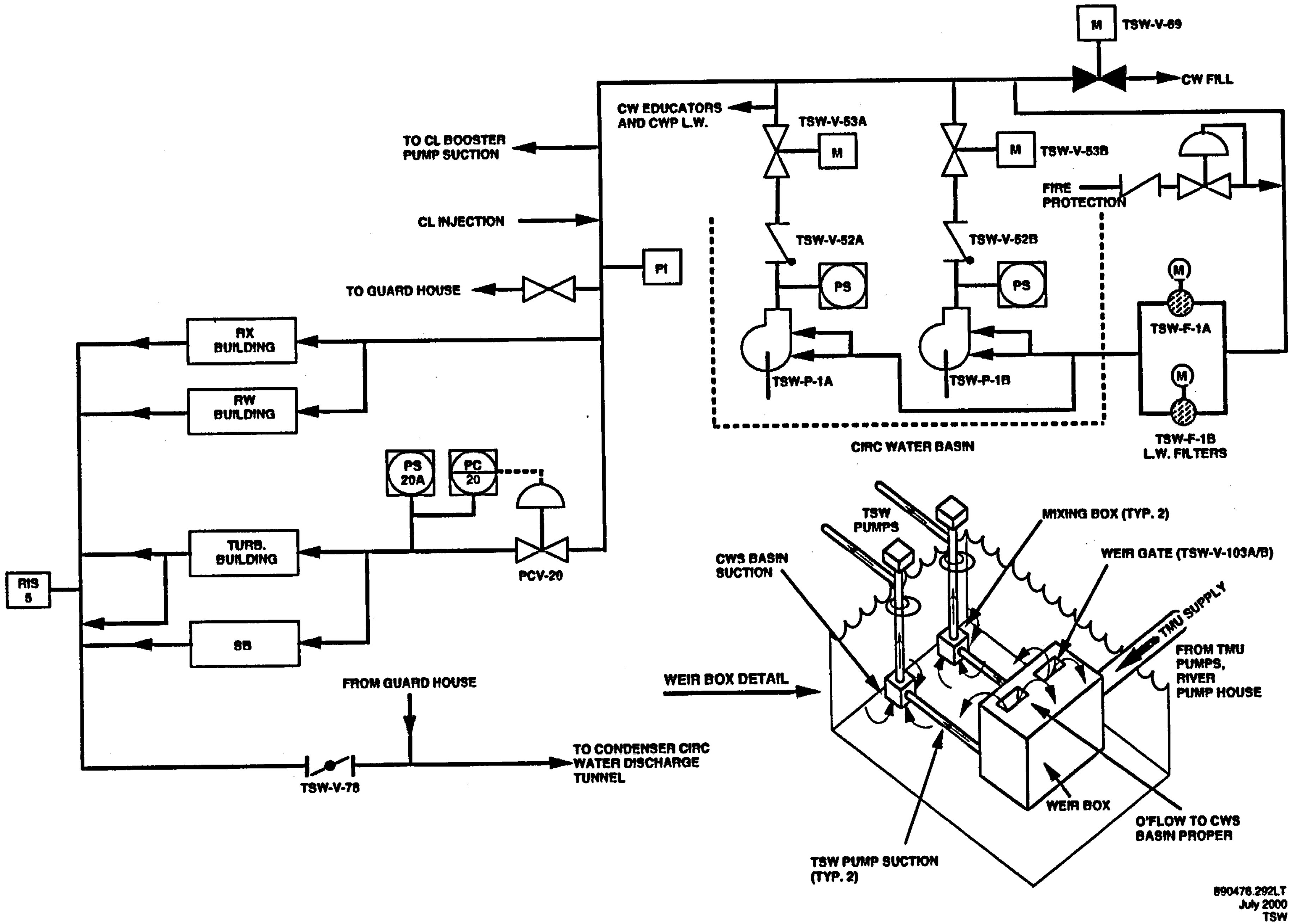
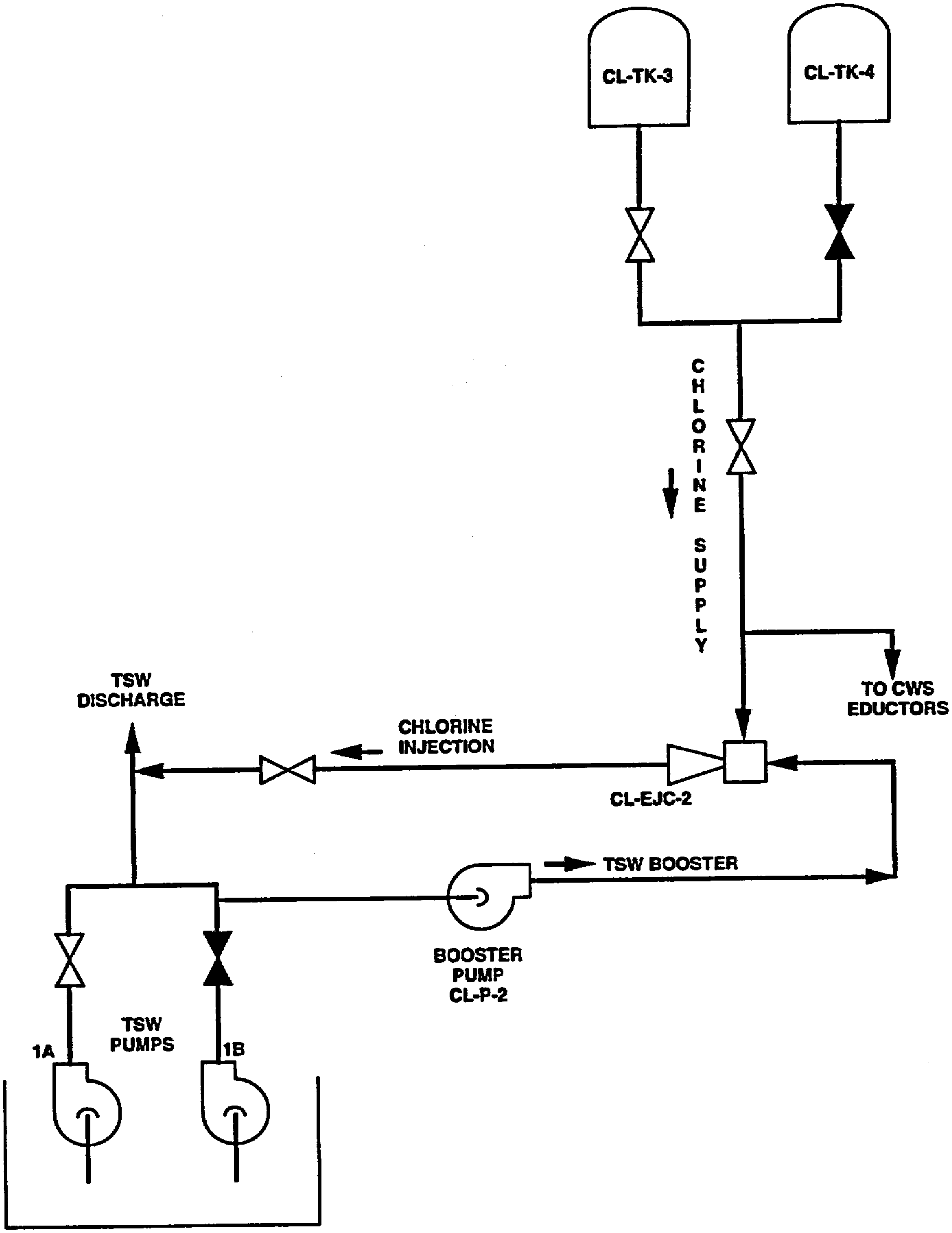


FIGURE 1. PLANT SERVICE WATER SYSTEM



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April 1995
TSW

FIGURE 1A. SIMPLIFIED DIAGRAM OF CHLORINE SUPPLY TO TSW

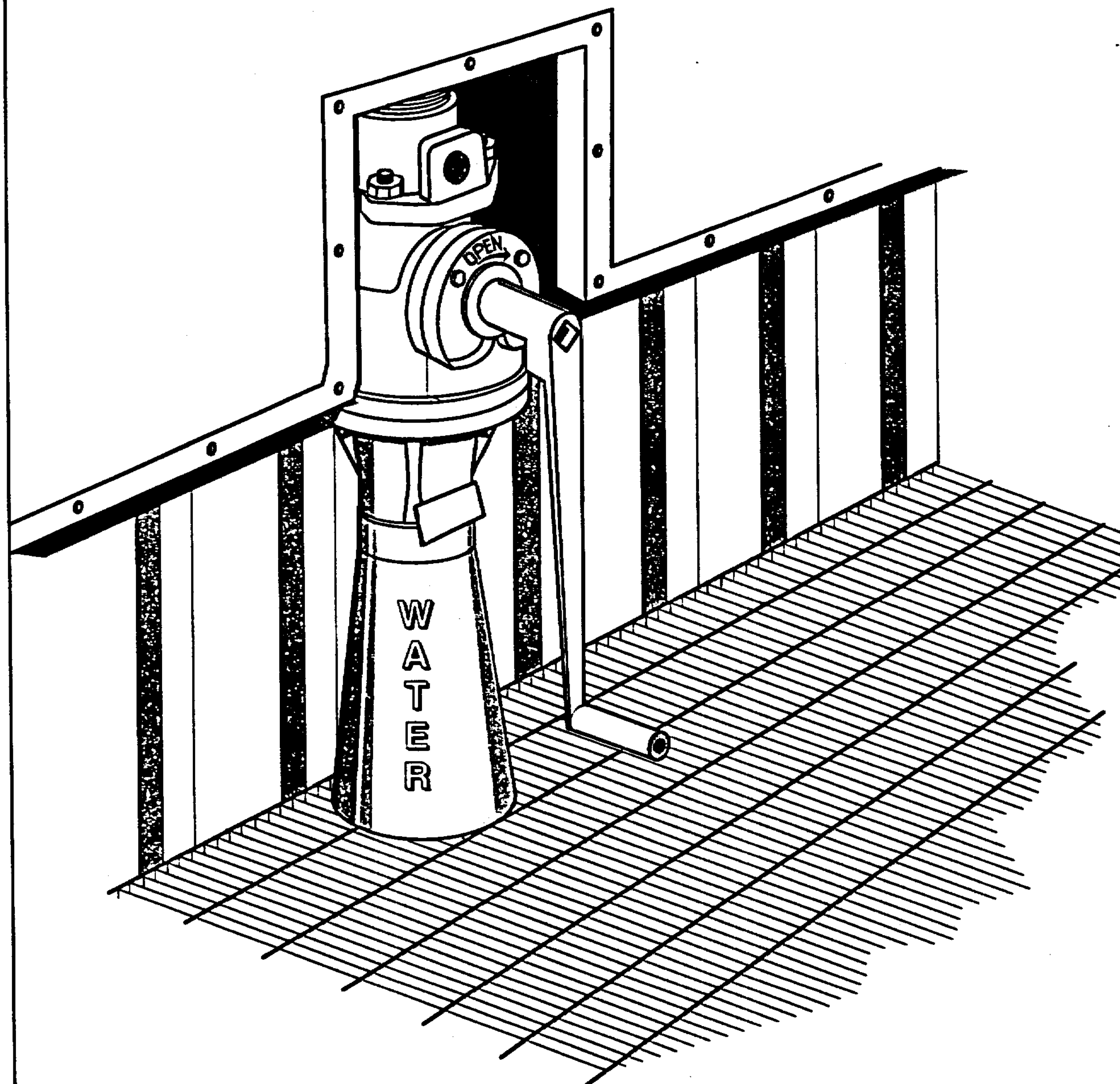

FIGURE 1B. TMU SLUICE GATES

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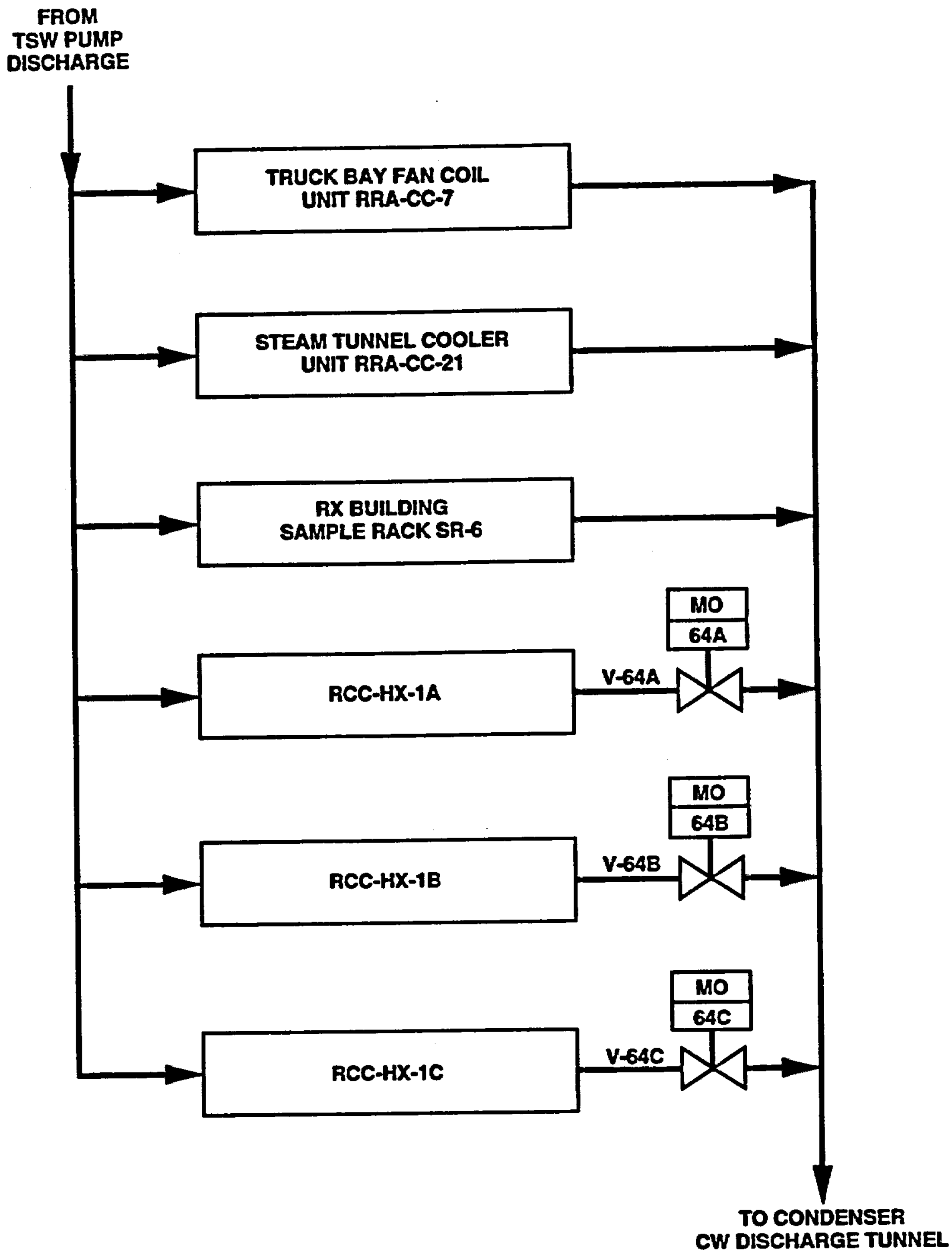
July 2000
TSW



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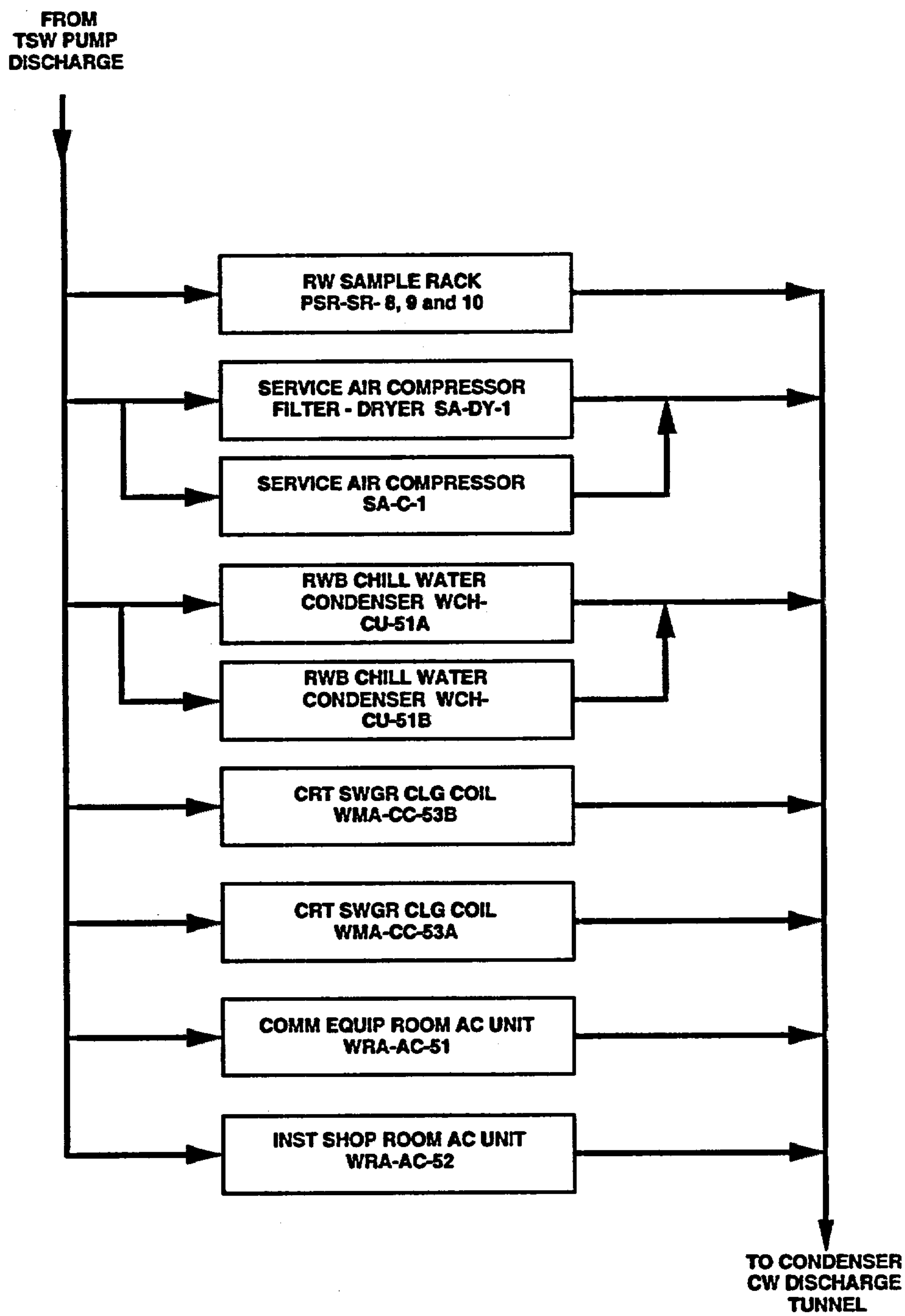
JUNE 1997
TSW

FIGURE 2. TSW COOLED EQUIPMENT - REACTOR BUILDING



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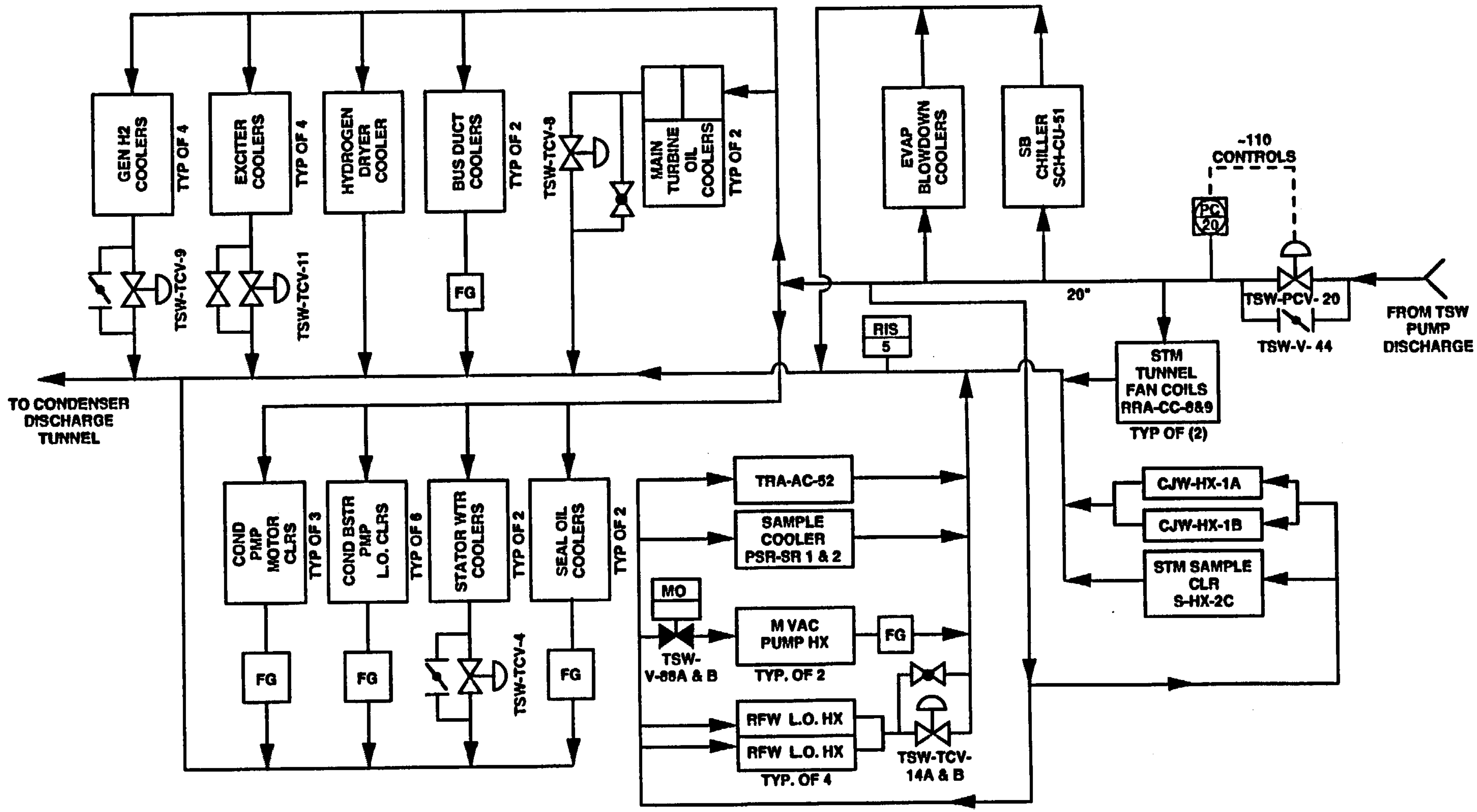
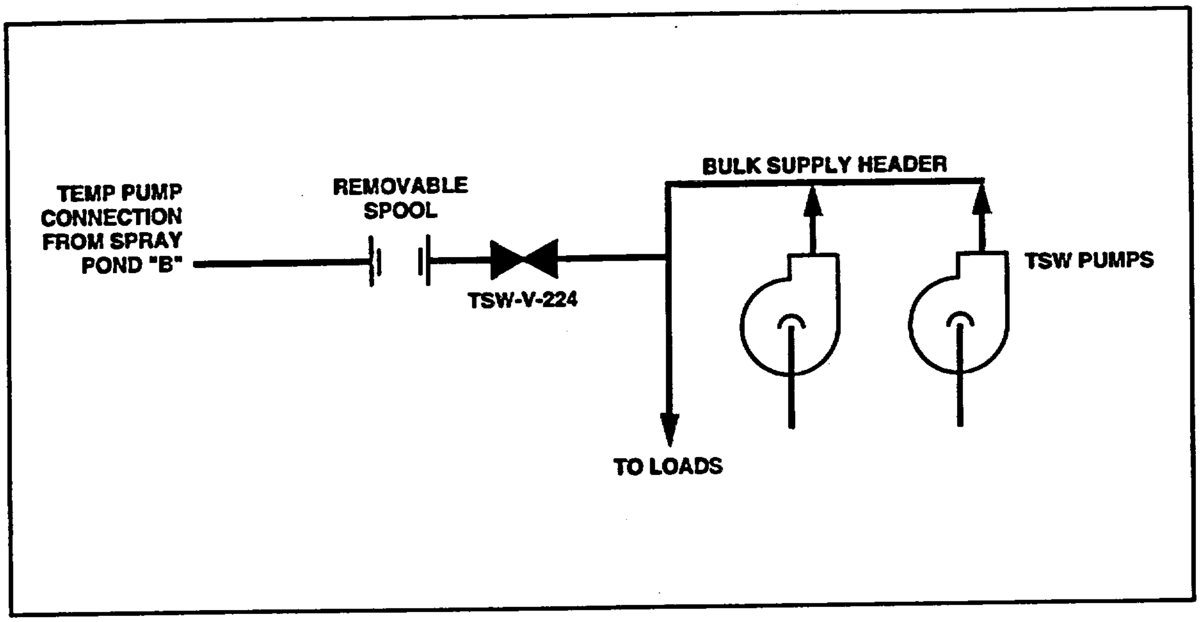
Dec 2002
TSW

FIGURE 3. TSW COOLED EQUIPMENT- RADWASTE BUILDING

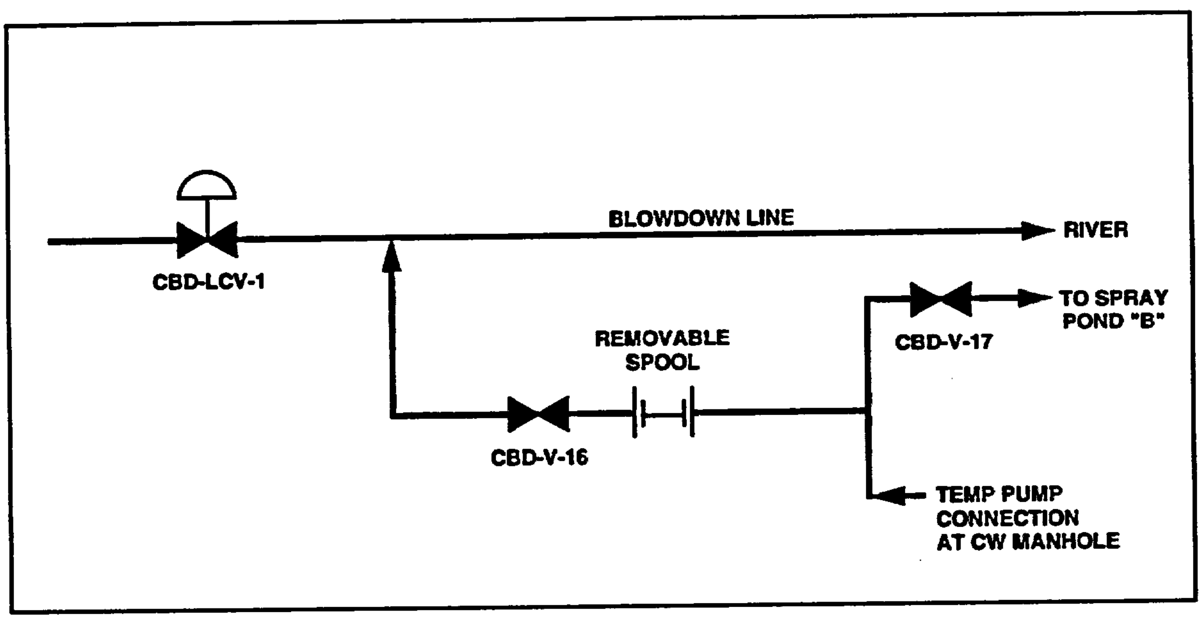


890476.302LT
JULY 2000
TSW

FIGURE 4. TSW COOLED EQUIPMENT-SERVICE BUILDING & TURBINE BUILDING



TEMPORARY COOLING WATER
CONNECTION TO TSW



DEWATER CW BASIN

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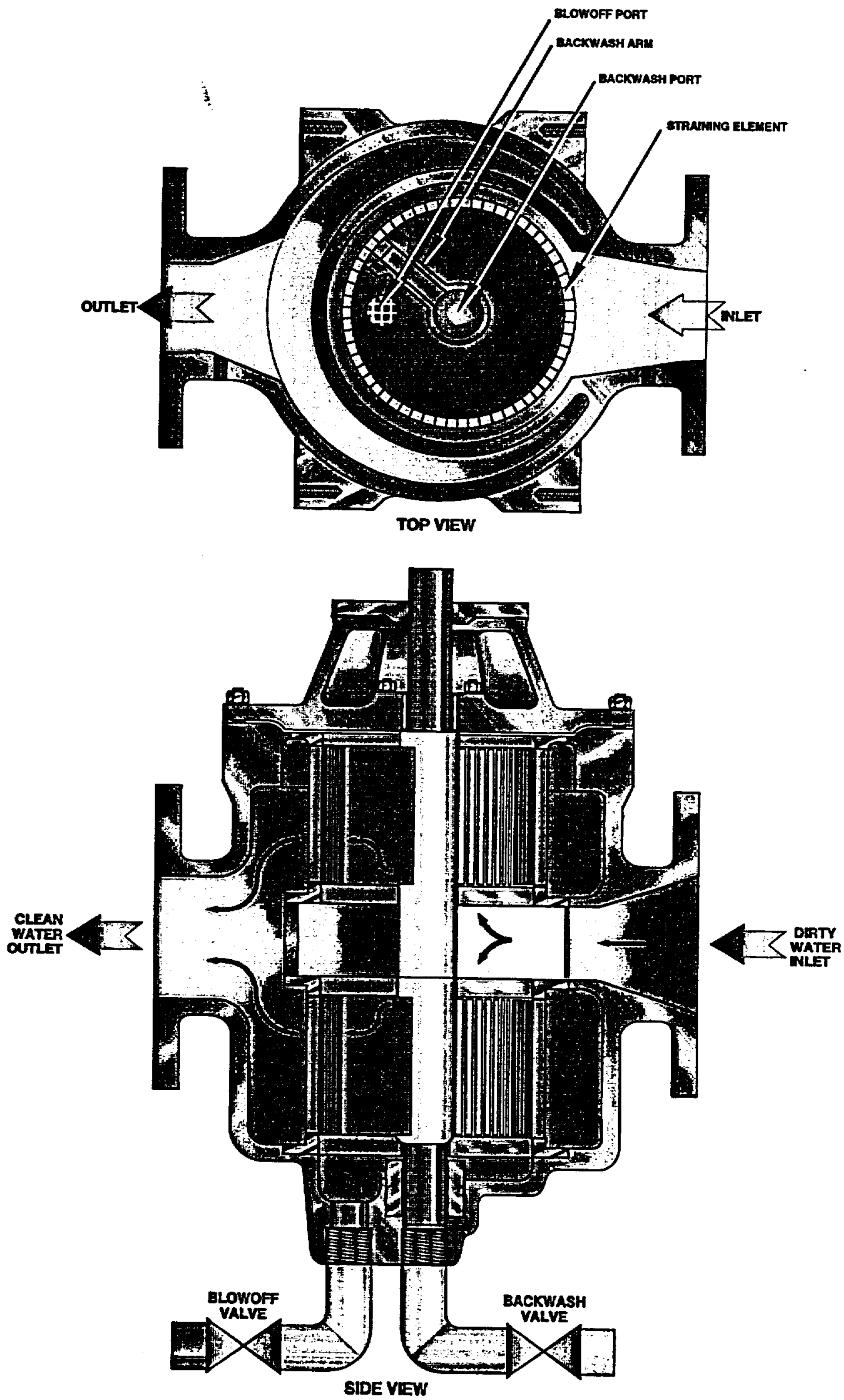
JULY 2000
TSW

FIGURE 5. TSW PUMP OUTAGE - COOLING CAPABILITY



920632.1LT
AUG. 1992
TSW

FIGURE 6. TSW LUBE WATER FILTER

SEPTEMBER, 2002
SD000165
DIC 0023.98

COLUMBIA GENERATING STATION

SYSTEM DESCRIPTION

Volume 3, Chapter 8

POTABLE WATER

Reviewed by:	Roger Callow NI Callow Engineering	11/3/02 Date
Reviewed by:	[signature] Operations	11/13/02 Date
Approved by:	Randy [signature] Operations Training Manager	11/20/02 Date

DISCLAIMER OF RESPONSIBILITY

This document is intended for training use only. It is not to be used for verification of Columbia "as-built" conditions or plant control purposes. Controlled plant drawings and approved plant procedures should be used for plant specific reference.

MINOR REVISION RECORD

Minor Rev Number	Description of Revision	Affected Pages	Entered By	Effective Date	Manager Approval

I. PURPOSE

The potable water system provides a mechanism for using river water to supply filtered and chlorinated potable water to the Potable Water Storage Tank (PWST) PWC-TK-100. This system is comprised of two sub systems: Site Potable Water and the Plant Power Block Water systems. The Site Potable Water System provides water to the following:

L.O.5672 Purpose, Loads

- Site Potable Water Loop (including the plant and protected area)
- Demineralized Water Trailer
- Fire Protection Makeup
- Backwashing of the Flocculator filtration unit
- Sewage Treatment Plant
- Plant Support Facility (PSF)
- Crosstie to WNP-1
- BPA's Ashe Substation

L.O. 9102 Site Potable Water Load

The second subsystem, Plant Power Block Potable Water system, provides water for drinking and sanitary purposes as well as cooling and makeup water to various Heating, Ventilation and Air Conditioning (HVAC) systems and emergency showers and eyewashes throughout the plant and the Main Guardhouse.

II. DESIGN BASES

The potable water system is designed to provide cold and/or hot water to the points of the potable water usage, such as lavatories, toilets, showers, eye washes, sinks and electric drinking water coolers, located in the various plant building. The Plant Power Block Water system is maintained at 80 psig.

III. GENERAL DESCRIPTION (Figure 1)

The plant Potable Water system supplies power block loads while a separate system, Site Potable Water supplies non-power block loads. Site Potable Water supplies the Plant Power Block potable water system tank (PWC-TK-1). From the storage tank, the water flows to the suction header of the plant potable water system's main pumping station, which consists of a jockey pump (PWC-P-1) and the two main pumps (PWC-P-2 and 3). The three pumps all discharge through an individual associated pressure control valve to a common header. This header supplies all the potable water needs to the Service Building, the Reactor Building, the Turbine Generator Building, and the Radwaste Building, Building 62 (P.A.P). Four booster pumps (PWC-P-4A and 4B) were originally designed to boost the water pressure to pressure to supply Reactor Building loads at the higher elevations but are not presently in service. In addition, two hot water circulating pumps (PWH-P-1 and 2) maintain a "circulating" hot water supply to all loads in the Service and Radwaste.

IV. COMPONENT DESCRIPTION

A. System Loads

L.O. 5673 Component purposes

1. Yakima Building
   a. Toilets
   b. Hot Water Heater
   c. Chilled Water System Makeup
   d. Heating Hot Water System Makeup
   e. Emergency Shower
   f. Eye Wash Station
2. Turbine Generator Building
   a. Toilets
3. Reactor Building (Through potable water booster pumps, currently not in service)
   a. Deleted
   b. Reactor Building HVAC Air Washer
4. Radwaste Building
   a. Toilets
   b. Sample Counting Room
   c. Radio-Chem. Lab
   d. Hot Instrument Shop
   e. Chilled Water System Makeup
   f. Control Room Humidifier (deactivated)
   g. HVAC Air Washers
5. Miscellaneous
   a. Ashe Substation
   b. Main Guardhouse

B. Flocculator Filtration Unit (Figure 2)

1. Chemical Treatment and Coagulation of Raw Water

   Coagulation is the formation of particles in the water by adding chemicals that reduce the surface charge of suspended and dissolved solids to keep them apart. The chemical added is alum (aluminum sulfate) in the correct concentration to achieve coagulation in the water being treated.

   The suspended solids in water originate from a number of sources such as eroded soil or silt, algae and various substances that, although not in suspension, are removed by coagulation along with the suspended solids.

The raw water may change with the seasons or after major storms and the treatment and the plant chemist may need to adjust the chemical feed to cope with the changing raw water. The basic tool to determine proper coagulation is visual observation of the floc that is formed. It is necessary to add the right amount coagulant in the right pH zone in order to achieve good coagulation.

Too much or too little coagulant, too high or too low pH will cause poor results, high clarity water will be produced only when coagulation is carried out in the correct pH zone. The water supplied to the Flocculator Filtration Unit from the Columbia River is at the proper pH for good coagulation.

L.O. 9100b Purpose of non-ionic polymer

The chemicals need to be mixed quickly and thoroughly with the incoming raw water. Injecting the chemicals into the turbulent flow in the incoming water pipeline is the most effective method. After the chemicals have been mixed with the water, coagulation is essentially instantaneous. The various suspended solids in the water, along with color and some dissolved substances, react with the alum to produce destabilized particles which will stick together and which can be flocculated and settled.

2. Floculator Operation

In addition to the addition of alum to the raw water, a non-ionic polymer is added to the water. Polymer is not a coagulant and will not makeup for incorrect alum feed. The polymer aids the entrapment of flocculated particles in the filter bed by causing the filter media to be "sticky".

Raw water enters the first flocculator chamber with the coagulant mixed with it. It is further mixed, flocculated, and then flows under the baffle wall to the second chamber. The floc formed in the first chamber is more gently mixed and grows larger as it contacts more particles in the second chamber. The flocculator uses motor-driven horizontal paddles to stir the water and prevent the settling out of the floc.

The flocculated water flows over the submerged weir at the end of the second flocculator chamber into the distribution chamber for the clarifier. The water flows uniformly down through the distribution chamber, out through the bottom into the tube-settling chamber. The flow is directed along the length of the tube chamber and is split and directed toward both sides of the tank by the flow vanes in the bottom of the chamber. The flow is directed up through each of the two stacks of settling tubes. The flow into the tubes is uniformly distributed to all the tube openings by the tapered flow channel formed between the angled face of the tube stack and the tank wall. All of the flow is at a gentle low velocity to prevent the floc from being broken up, which would reduce the settling characteristics.

The settling tubes are made of plastic. They can be considered essentially horizontal to visualize the settling concept

By passing the flocculated water through all of these individual one-inch tubes, the distance any particle has to fall to contact a settling surface is only about one inch

Properly flocculated material will settle in these tubes in less than one minute. The actual settling time provided in the length of the tubes is about ten minutes. The flow of settled water from the tubes is directed over the regulating weirs from both sides into the trough down the center of the tube-settling chamber, where the polyelectrolyte is added. This serves to capture any floc that was not settled on to the mixed media filter.

The final step of the water purification comes in the filtration chamber, where the water passes through a specially designed multi media filter, increasing in size from fine at the top, to very coarse at the bottom in the direction of flow. This is important because after backwashing, the materials must return to their original layer to affect proper filtration.

Three materials are used for the mixed bed: anthracite coal, silica sand, and special high-density sand. The careful size and density ratio provides a filter bed that maintains a stable relationship between the grains during an indefinite period of uses and backwashes. The fine, low-density grains remain at the top, and the coarse, high-density grains at the bottom. There is no distinct layer effect but a gradual decrease in average grain size from the top to the bottom of the filter.

Floc particles first encounter the finer size media, which gradually become coarser with depth. This allows more particles to be held before backwashing is required. More important, however, is the effect of the finely sized media used. The primary mechanism in particle removal by filtration is the adhesion of the particles to the surface area of the media. Fine sand with a relatively large surface area is more effective than coarse sand. Only a small amount is needed to provide efficient filtration, resistance to flow surges and improved bed stability.

L.O.-9100c Purpose of sodium hypochlorite

The filter bed is supported by gravel of several sizes that cover the lateral-header under drain system. The filtered water is collected and pumped to the PWST. The water is treated with sodium hypochlorite to ensure that it remains safe to drink. Potable water is routinely sampled and analyzed by the Benton County Health Department for harmful bacteria. Backwash water is pumped into the under drain system opposite the flow direction during the filtration when the filter has accumulated the optimum amount of solids. The rotating surface wash helps remove or loosen the adhered floc particles from the coal layer at the top of the filter.

C. Power Block Distribution System and Related Components

The power block potable water storage tank acts as a surge volume for system requirements and provides NPSH to the potable water system main pumping station. It is a vertical cylinder 12 feet in diameter and 16.5 feet high located on the 420' level of the Yakima Building. The tank has a capacity of 10,000 gallons. Storage tank level is maintained between 6' and 12' above the bottom of the tank by FW-LCV-102 from the Makeup Water Treatment System at a rate of 50 gpm.

D. Potable Water System Jockey Pump (PWC-P-1)

The jockey pump maintains the potable water system pressurized under no or low load conditions. It is a motor-driven centrifugal pump with a 50 gpm capacity and rated discharge head of 74 psig. The jockey pump is part of the potable water pump package located on the 420' level of the Service Building. An auto-purge valve opens at 100 F internal pump temperature (for pump cooling) to flush hot pump casing water to drain.

E. Potable Water System Main Pumps (PWC-P-2 and PWC-P-3)

The Main Pumps maintain the potable water system pressure and flow during system high demand conditions that are beyond the capacity of the jockey pump. They are motor-driven centrifugal pumps with a 140 gpm capacity and rated discharge head of 83 psig. The main pumps are part of the potable water system pump package located on the 420' level of the Service Building. An auto-purge valve opens at 100°F internal pump temperature (for pump cooling) to flush hot pump casing water to drain.

F. Potable Water System Booster Pumps (PWC-P-4A, 4B)

The Booster Pumps are designed to maintain potable water system pressure and flow to system loads at the high elevations of the Reactor Building. They are motor-driven centrifugal pumps with a 40 gpm capacity and discharge head of 50 psig. The booster pumps are located on the 548' level of the Reactor Building, and are not in service at this time.

G. Hot Water Circulating Pumps (PWH-P-1, 2)

The Hot Water Circulating Pumps provide flow through their associated hot water loops so that the water is continuously recirculated through the water heater. This prevents the loop from cooling to ambient during no-load conditions allowing hot water on demand.

Service Building hot water circulating pump PWH-P-1 is an in-line booster centrifugal pump with a 5 gpm capacity and discharge head of 11 psig. It is located on the 420' level of the Service Building.

Radwaste Building hot water circulating pump PWH-P-2 is an in-line booster centrifugal pump with a 5 gpm capacity and discharge head of 8 psig. It is located on the 487' level of the Radwaste Building.

H. Service Building Hot Water Heater (SPWH-HX-1)

The Yakima Building hot water heater has a storage capacity of 450 gallons and a recovery rate of 270 gallons per hour, based on an incoming temperature of 50F and an outlet temperature of 140 F.

I. Radwaste Building Hot Water Heater (PWH-HX-1)

The Radwaste Building electric hot water heater has a storage capacity of 170 gallons and a recovery rate of 170 gallons per hour, based on an incoming temperature of 50 F and an outlet temperature of 140 F.

J. Backflow Preventor Valve Assemblies

When the potable water system branches to supply services other than drinking or sanitary, the branch lines are equipped with backflow preventor valve assemblies which prevent contamination from backflow into the potable water system

K. Shock Suppressors

All loops and branches of the potable water system are equipped with shock suppressors to prevent any water hammer associated with opening and closing valves and/or the starting and stopping of pumps.

V. CONTROL THEORY AND INTERLOCKS

A. Control Room Controls

All controls are local; there are no controls in the control room

B. Local Controls

1. Jockey Pump (PWC-P-1) maintain position switch – HAND/OFF/AUTO

HAND	Pump starts
OFF	Pump stops
AUTO	Auto-stops at 50 gpm system flow for 16 seconds. Auto-starts when flow LT 50 gpm. (Lead Main Pump starts and is supplying PW).

2. Main Pumps (PWC-P-2 & 3) Lead Selector Switch, maintain position switch - POS 1/POS 2

POS 1	Selects Main Pump 2 as lead pump
POS 2	Selects Main Pump 3 as lead pump

3. Main Pumps (PWC-P-2 & 3) maintain position switch - HAND/OFF/AUTO

HAND	Pump starts
OFF	Pump stops
AUTO	Lead pump: Auto-starts at 50 gpm system flow for 16 seconds. Auto-stops when flow LT 50 gpm. Lag pump: Auto-starts if lead pump is not running with an auto start signal present, if jockey pump is not running with an auto start signal present, if 140 gpm system flow for 10 seconds and lead pump is running, or PW pressure is 65 psig. Auto-stop when all auto-start signal clear (the 140 gpm signal takes 60 seconds to reset).

4. Reactor Building Booster Pumps (PWC-P-4A, 4B) spring return switch STOP/AUTO/START (Not in Service)

STOP	Pump stops
AUTO	Standby booster pump auto-starts at 35 psig system pressure and auto-stops at 60 psig system pressure
START	Pump starts

5. Hot Water Circulating Pumps (PWH-P-1, 2), maintain position switch OFF/AUTO/ON

OFF	Pump stops
AUTO	Auto-start on 110°F suction temperature. Auto-stop on 140°F suction temperature
ON	Pump starts

6. Hot Water Heaters

   a. Each hot water heater is set to maintain 140°F.

   b. Heater high temperature auto-cutout at 195°F.

C. Interlocks

1. Main and Jockey Pumps (PWC-P-1, 2, & 3)

   Trip on low storage tank level (424'5") if control switch is in AUTO.

2. Reactor Building Booster Pumps (PWC-P-4A, 4B)

   Trips on 5 psig suction pressure

VI. INSTRUMENTATION AND ALARMS

A. Control Room

1. Instrumentation

The PW system has no instrumentation in the Control Room.

2. Alarms

NOTE: See associated annunciator procedures for current setpoints.

P851-S1-5.4 MAKEUP WTR TREAT DEMIN TROUBLE

This annunciator is activated by any of the alarms on the local Makeup Water Treatment panel which include those for:

- Potable Water Storage Tank Hi/Low level and PW system Low Pressure

P851-S1-4.1 WATER FILTRATION BUILDING TROUBLE

This annuciator is activated by the following problems at the Flocculator or at PWC-TK-100:

- Flocculator shutdown on high turbidity
- Flocculator shutdown on HIGH-HIGH filter bed headloss
- Flocculator shutdown on low control air pressure
- PWC-TK-100 High Level indicating possible tank overflow conditions
- PWC-TK-100 Low Level conditions, indicating level lower than normal operating range.

B. Local

1. Control Panel (PWC-CP-1)

a. Filter Operation Control Switch – Three position switch MAN/OFF /AUTO

MAN	Allows for filter to be placed in hold during filling while maintaining level in flocculator or for manual operation of the flocculator.
OFF	Filter unit is off
AUTO	Filter plant will start when level is 16' 0" Auto stops when level reaches 30'6"

b. High Turbidity Shutdown Two position switch : OFF/ON, Normally in the ON position.

OFF	Disables auto shutdown of the flocculator when turbidity levels exceed 0.2 NTU (55 sec T.D.)
ON	Auto shutdown of flocculator when turbidity exceed 0.2 NTU after a 55 sec T.D.

c. Backwash Pump Operation : Three position switch: MAN/OFF/AUTO Normally in AUTO. Provides a means to backwash filter media if indication of high effluent turbidity (approaching 0.15 NTU as read on PWC-TBIT-2) or if DP across the bed approaches 6 feet or water.

MAN	Allows manual start of PWC-P-121 Flocculator Backwash pump with levels LT 10'
OFF	Disables pump start with P/B
AUTO	Permits start of PWC-P-121 with 10' level permissive and initiation of AUTO BACKWASH MANUAL INITIATE P/B

d. AUTO BACKWASH MANUAL INITIATE P/B

Starts the PWC-P-121 Flocculator backwash pump and the PWC-P-121, Flocculator Surface Wash pump, opens PWC-V-462 (filtration Settling Unit Drain)

e. HEADLOSS SHUTDOWN RESET P/B

Resets a HI HI HEADLOSS alarm indication after a system backwash and the FILTERING OPERATION switch is placed in AUTO.

f. Plant Operation Control Switch: Three position, MAN/OFF/AUTO. Normally in AUTO

MAN	Allows for testing of valves
OFF	Stops all operations except the flocculator
AUTO	Starts the flocculator and filtration systems

g. Surface Wash Control Switch: Two position switch OFF/AUTO

OFF	Disables surface agitation pumps
AUTO	Starts surface agitation, after a 2 min time delay

h. Alum Pump Operation Control Switch: Three-position switch; MAN/OFF/AUTO

MAN	Disables start circuitry for the alum pump for pump adjustment or maintenance
OFF	Disables start circuitry
AUTO	Enable start of the alum pump

i. POLYELECTROLYTE PUMP OPERATION: Three positions; MAN/AUTO/OFF

MAN	Allows for testing/maintenance of pumps
AUTO	Starts the pump
OFF	Disables normal pump start circuitry

j. SODA ASH PUMP control switch MAN/OFF/AUTO

(No Longer in use)

VII. SYSTEM OPERATIONAL SUMMARY

A. Normal (Figure 2A)

Prior to placing the flocculator into service, the flocculator air compressor PWC-AC-100 should be checked to ensure control air between 65-85 psig is available and that the TMU system is available for makeup. The flocculator chambers are checked full of water and the paddle wheel is started and the control panel switches are checked in accordance with applicable Volume 2 procedures. When the prerequisites are satisfied the INITIATE (Figure 4) FLOCCULATOR pushbutton is depressed and filtration begins.

Filtration consists of the TMU supplying makeup water from Columbia River. This makeup water will have Alum added to it entering the flocculator and then go to Flocculator Chamber #1 where it is agitated by a paddle wheel to promote formation of the floc that function to remove impurities. The floc and water mixture then flows under a weir to Flocculator Chamber #2 where an even gentler agitation results in even larger floc particles. From the second chamber the process flows into the distribution chamber where it will be evenly distributed to the settling tube chamber.

In the settling tube chamber the large particles of floc are settled out into the horizontal settling tubes. Most of the floc will fall out and water will flow out of the settling tubes into a weir, which directs the flow to the filter compartment.

In the filter compartment the water has a polymer added to promote mechanical filtration of any remaining floc. The water passes through three layers (coal, light sand, dense sand) of filter and is delivered to the suction of the effluent pump. The effluent pump discharge is controlled by the Level Control Valve (PWC-LCV-101) to maintain filtration compartment level. The flocculator effluent is manually directed to the either the PWC-TK-100 or storm drains depending on the turbidity. When the turbidity is<0.2 NTU the storm drain dump valve is closed and the PWC-TK-100 inlet valve is opened. The flocculator will run automatically maintain PWC-TK-100 level between 16.5 feet and 30 feet 8 inches until a backwash is required.

1. Backwashing Operations

L.O- 9104 Indications that backwash is necessary

Backwashing of the flocculator is required if turbidity exceeds 0.2 NTU or filter bed dP exceed 6' of water. The backwash is accomplished by verifying greater than 16.5 feet of water in the PWC-TK-100 then securing filtering operations. The backwash is started by depressing the BACKWASH INITIATE pushbutton until the amber backwash light is lit.(Figure 3). When the backwash programmer, the cam timer in the control panel FP-CP-1 (Figure 5) locks in. This causes the influent and effluent valves to close and the polymer pump to trip. Backwash commences when the waste valve (PWC-V-462) open and the surface wash and the backwash pump start

The waste valve opens to rapidly drain water from the distribution and settling tube sections. The rapid draining will remove most of the settled floc from the tubes and allow it to flow to the storm drains. The surface wash pump starts next and functions to remove floc that has adhered to the coal particles by rotating the scouring arm directly above the top layer of charcoal. The backwash pump will start after a short time delay and functions to remove foreign materials from the filter media and floc from settlings tubes by discharging a high volume of water backwards through the filter bed and settling tubes to the storm drains. The surface wash pump will operate for the first 6 minutes of the backwash cycle then the surface wash is automatically stopped.

At about 8 minutes after the backwash initiation was commenced, the waste valve closes to allow refilling of the flocculator by the backwash pump. After approximately 11 minutes from initiation, the backwash pump will shut off if the effluent pump starts along with the alum and polymer pumps to restart filtration.

2. Equipment Operation in Yakima Building basement

The jockey pump is normally in service at all times and maintains the system pressurized. During periods of high system flow, the main pumps automatically will sequence on and the jockey pump secures until system demand is within its capacity, then the jockey pump starts and the main pumps secure. The system is supplied makeup water from the Makeup Water Treatment system via FW-LCV-102, which automatically maintains potable water storage tank level.

B. Abnormal

1. Yakima Building Basement Trouble Alarm

Indication of problems in the PW system in the Control Room is indicated by the annunciators P851-S1-5.4 MAKEUP WTR TREAT DEMIN TROUBLE which will alarm on Potable Water Storage Tank Hi/Low level or PW system Low Pressure and P851-S2-4.1, WATER FILTRATION BUILDING TROUBLE. Corrective actions would include investigation by an Equipment Operator for possible malfunctions of PW system or Makeup Water Treatment system equipment. A failure of the jockey pump will automatically start the lag main pump. A failure of the lead main pump to start when required would also start the lag pump. If the PW Storage Tank (PWC-TK-1) reaches the low level, the jockey and main pumps will auto-stop if their control switches are in AUTO

2. Flocculator Abnormal Conditions

The flocculator will automatically shutdown on high water turbidity (0.20 NTU), head loss in the flocculator or air failure. Turbidity is a measure of suspended material in the effluent of the flocculator. High turbidity influent water can be a result of spring runoff or wind or rainstorms. If influent turbidity has not changed, then equipment related factors such as depletion of chemical tanks or malfunction of the feed pumps, filter breakthrough, turbidity meter malfunction or increased turbidity following a backwash can be investigated as a cause of the problem. Refer to PPM 2.8.10, Site Potable Water for further information regarding resolution of these problems.

C. Industry Events

None

VIII. SYSTEM INTERRELATIONSHIPS

A. The potable water system supports the operation of the following systems:

1. Yakima Building Heating Hot Water and Chilled Water System
2. Turbine Generator Building HVAC System
3. Water Treatment and Machine Shop HVAC System
4. Radwaste Building HVAC System
5. Sanitary Systems--All Buildings
6. Control and Switchgear Rooms HVAC Systems
7. Radwaste Building Chilled Water System
8. Reactor Building HVAC System
9. Site irrigation needs
10. Makeup to Service Water Spray ponds
11. Area cooling for Main Transformers

B. CW/TMU system

The Tower Makeup (TMU) system provides raw water to the flocculator during normal operations.

C. Fire Protection System

The PWC-TK-100 provides a makeup water source for FP-TK-110, which is the supply for the diesel driven fire pump, FP-P-110

IX. POWER SUPPLIES

PWC-P-1	MC-5B
PWC-P-2	MC-5B
PWC-P-3	MC-5B
PWH-P-1	PP-5A-D
PWH-P-2	PP-7F-A-B
PWC-P-4A	MC-7C-B
PWC-P-4B	MC-8C-B
PWC-P-102	FDP-40
PWC-P-103	FDP-40
Flocculator	E-MC-FP

X. TECHNICAL AND LICENSE CONTROLLED SPECIFICATIONS

A. Technical Specifications

None

B. License Controlled Specifications

None

XI. REFERENCES

B&R E-519, Sheet 24, Motor Valve and Miscellaneous Control Elementary Diagram

B&R M-516, Flow Diagram, Plant Makeup Water Treatment System

B&R M-550, Flow Diagram, HVAC Chilled Water Systems--Radwaste Building

B&R M-553, Flow Diagram, Heating Hot Water and Chilled Water System--Service Building

B&R P-541, Flow Diagram, Potable Hot and Cold Water (outside distribution piping and power block distribution piping

PPM 2.9.1, Plant Potable Water System

PPM 2.8.10, Site Potable Water System

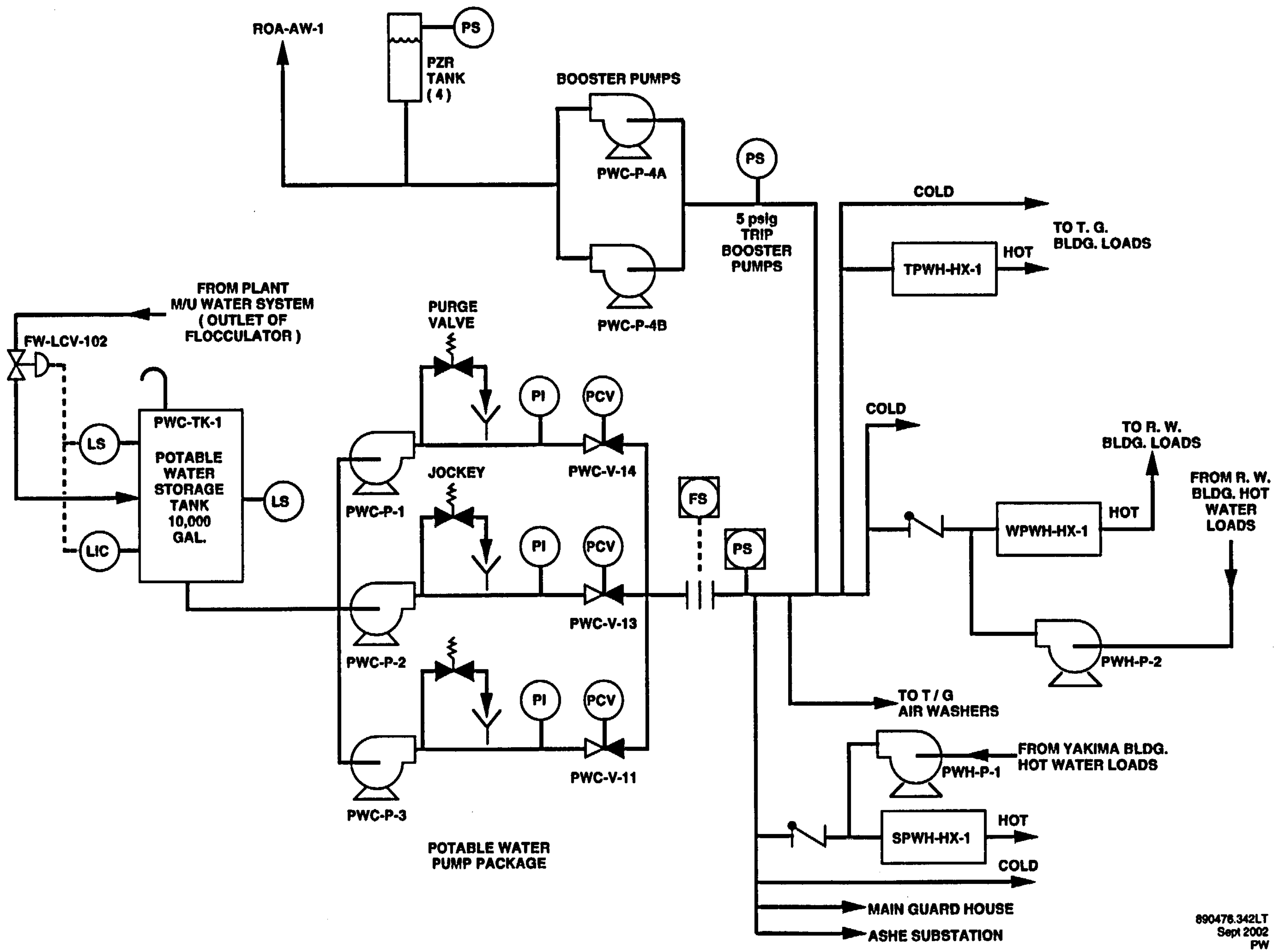
FSAR 9.2.4

M573 Sheet 1, Flow diagram Potable Water Cold and Fire Protection System Pumphouses (Flocculator, PWC-TK-100 and Site Distribution Pumps)

E503, Power to Flocculator

E843, Sheet 3 Power to PWC-P-102 and 103

SYSTEM LEARNING OBJECTIVES	EO	RO	SRO	STA
5672. State the purposes of the Potable Water System, including a brief listing of the loads supplied.	X	X	X	X
5673 State the purpose of the following system components: a. Potable Water Jockey Pump b. Potable Water Main Pump c. Potable Water Booster Pump d. Hot Water Circulating Pump	X	X	X	X
9100 State the purpose for adding the following chemicals a. Alum b. Non-ionic Polymer c. Sodium Hypochlorite	X			
9102 State the loads supplied from the Site Potable Water System	X			
9104 State which parameters give indication that a backwash is needed on the Flocculator Unit	X			
9105 Describe the flowpath through the flocculator discussing what occurs in each of the following areas: a. Chamber 1 b. Chamber 2 c. Distribution Chamber d. Tube Settling Chamber e. Filtration Chamber	X			



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Sept 2002
PW

FIGURE 1. POTABLE WATER

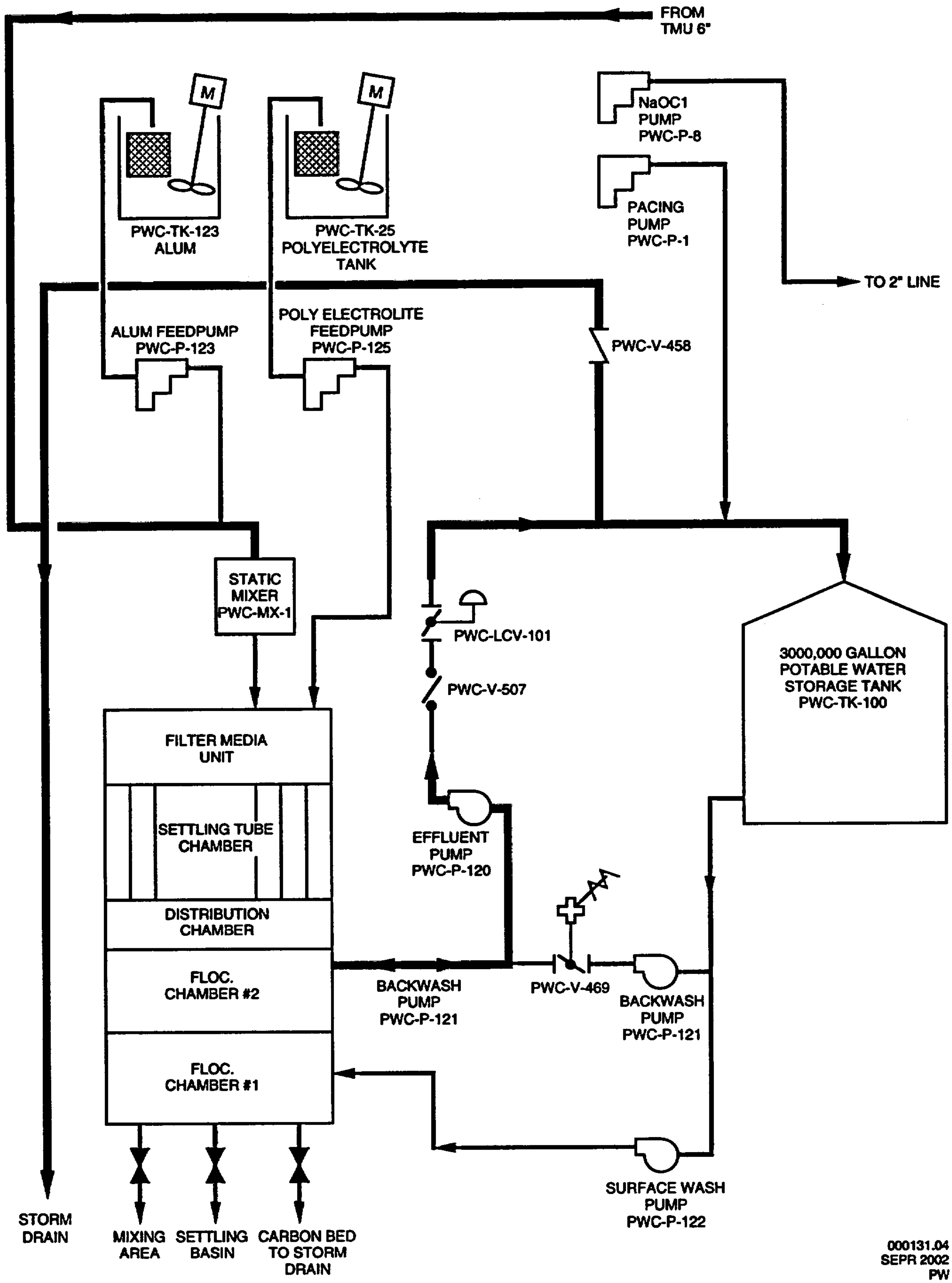

FIGURE 2. FLOCCULATOR

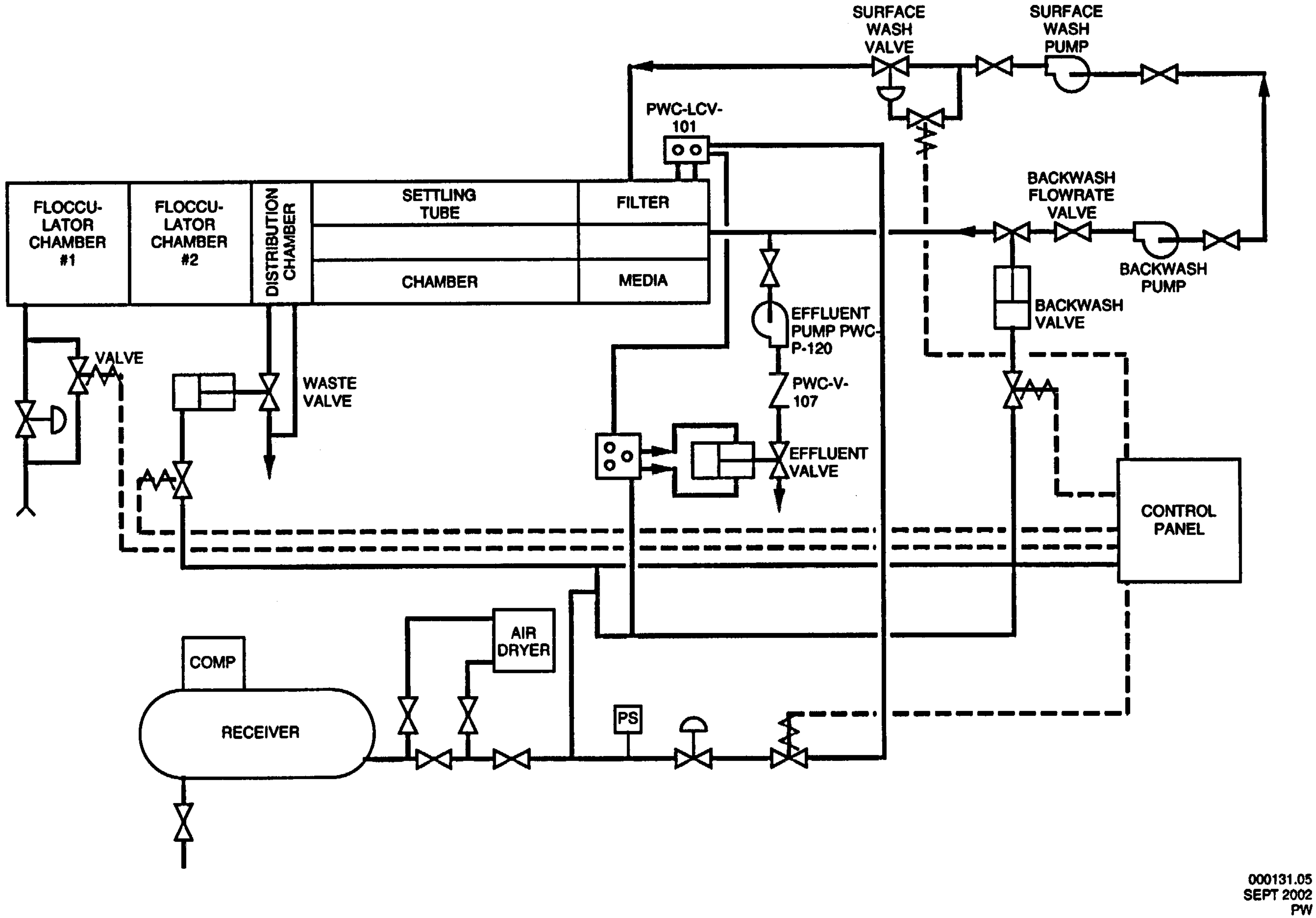

FIGURE 2A. FLOCCULATOR AIR SYSTEM

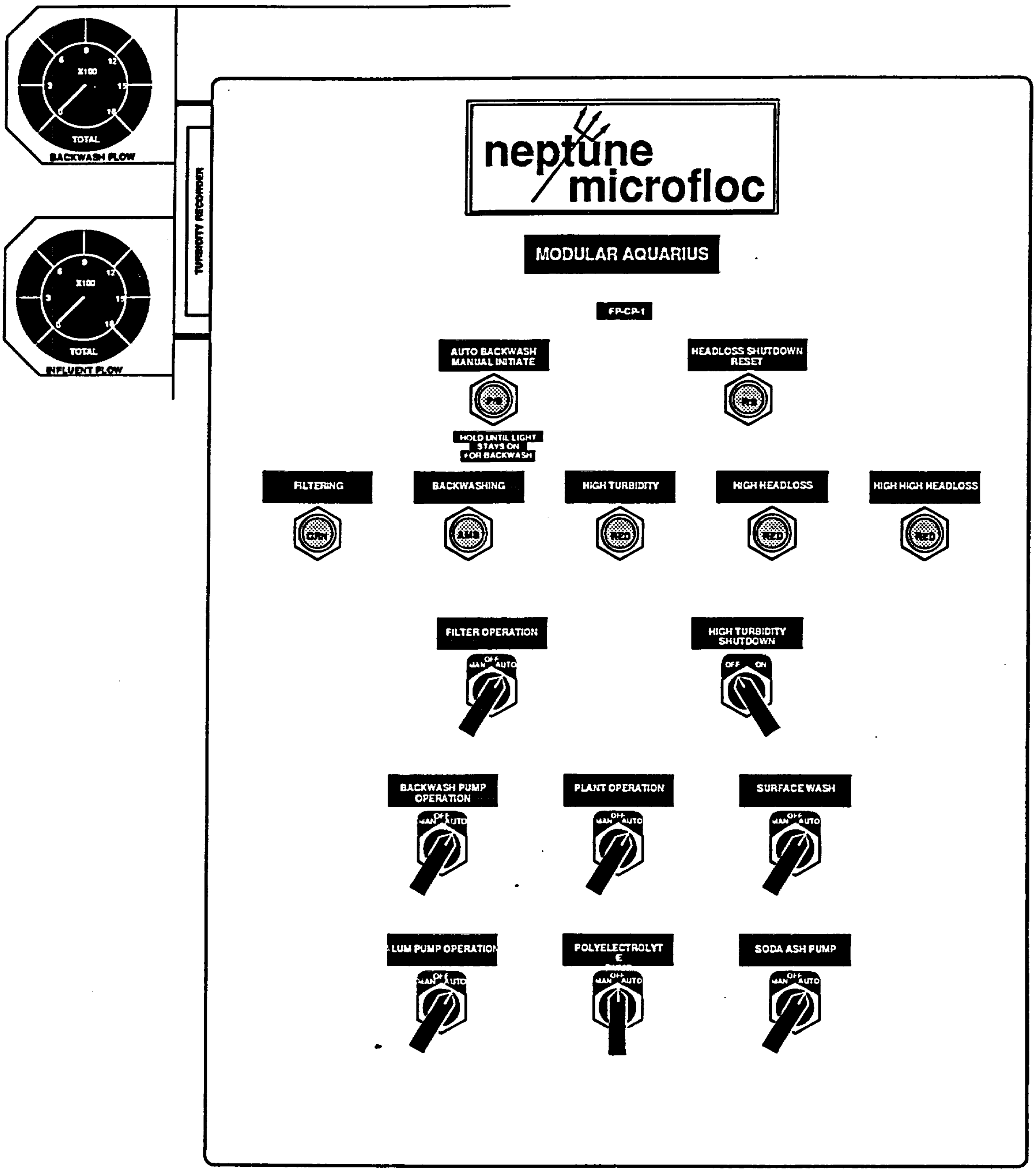

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FIGURE 3. CONTROL PANEL CP-1

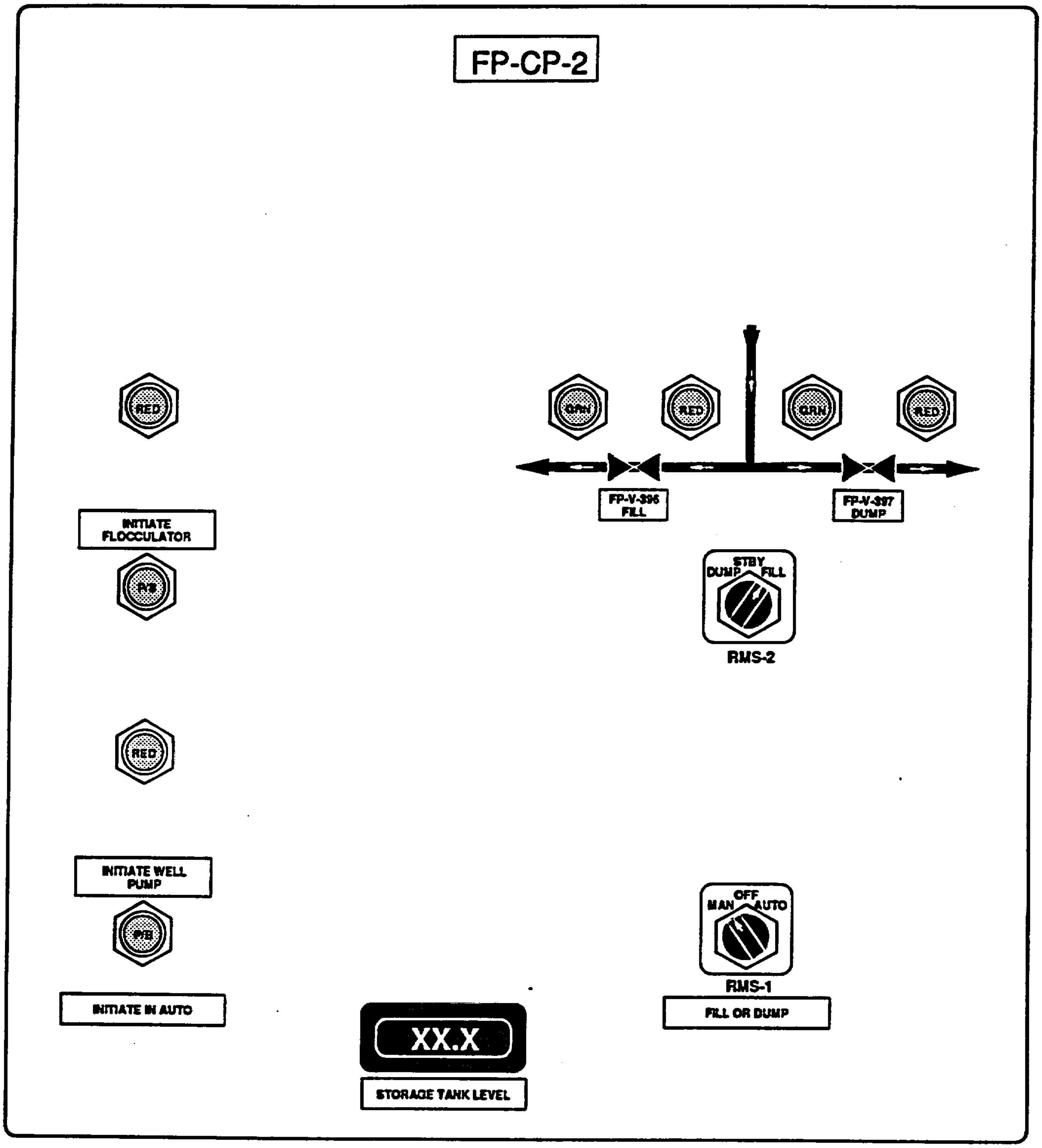

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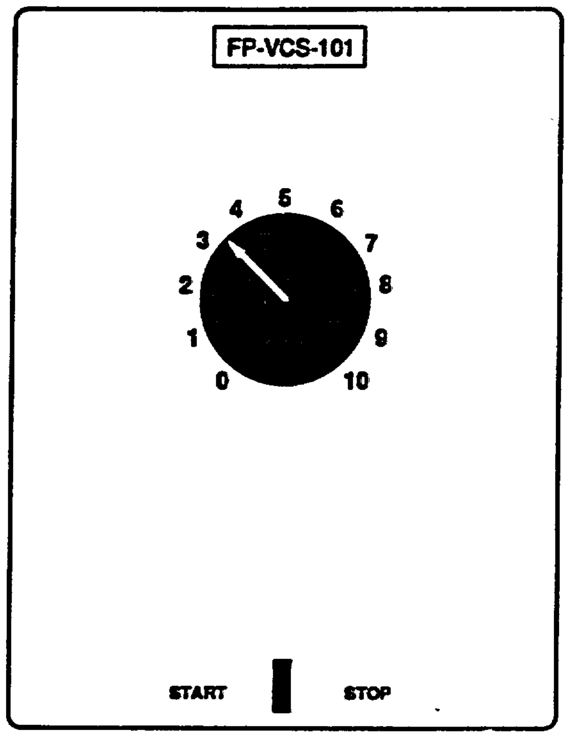
FIGURE 4. CONTROL PANEL CP-2



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July 2000
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FIGURE 5. CONTROL PANEL CP-3

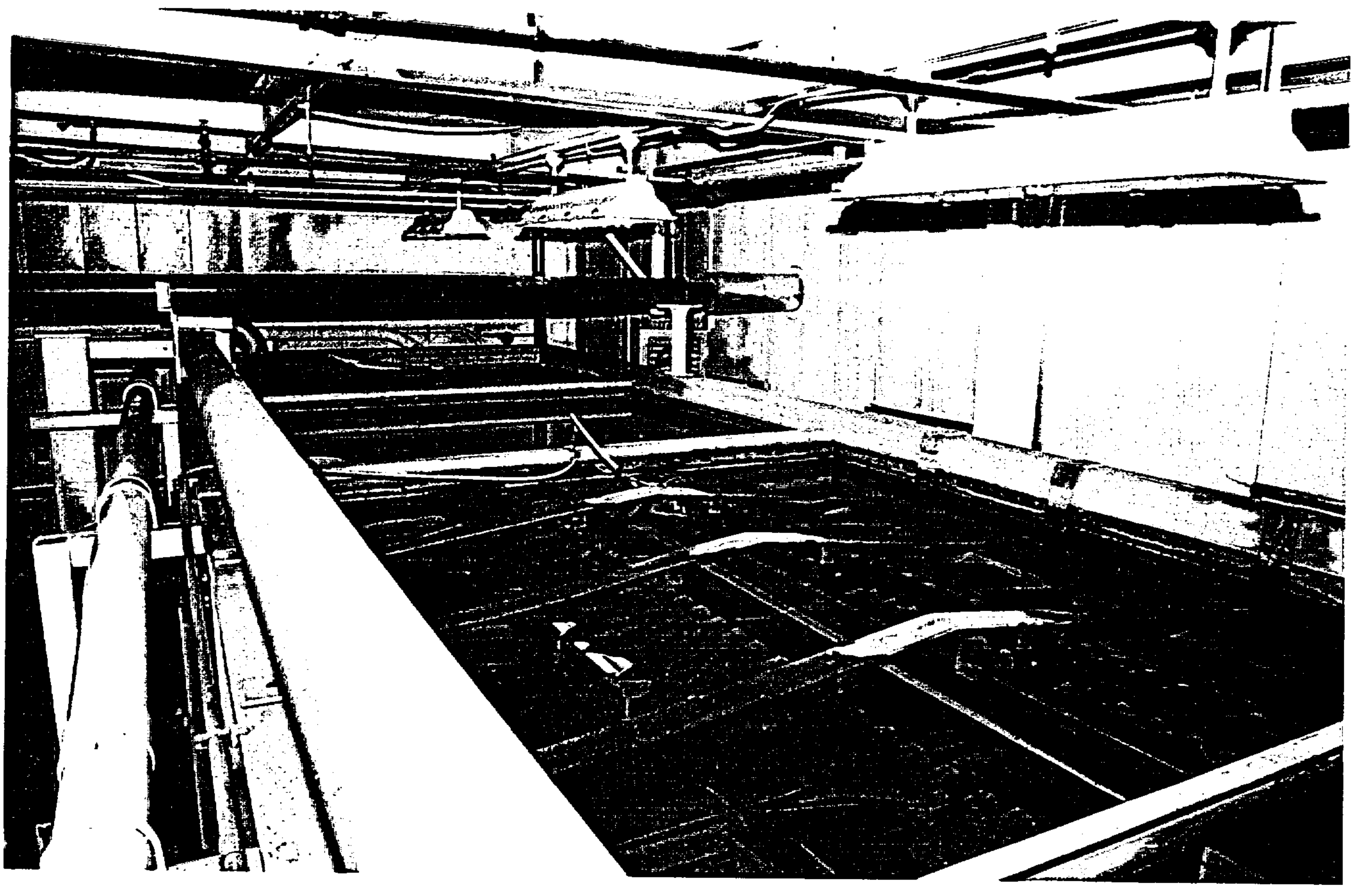

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FIGURE 6. SETTLING TUBE CHAMBER

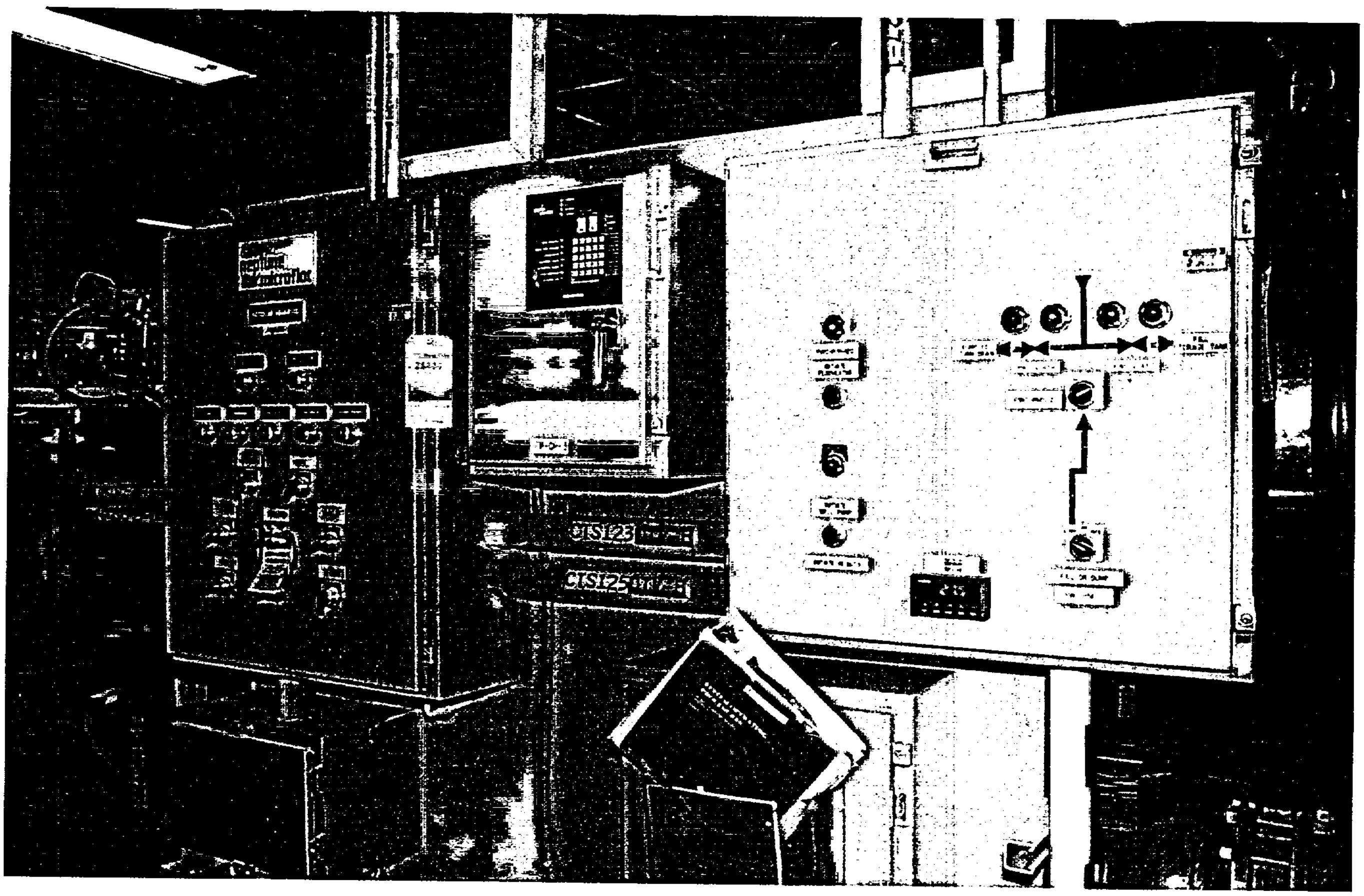

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FIGURE 7. FLOCCULATOR CONTROL PANEL

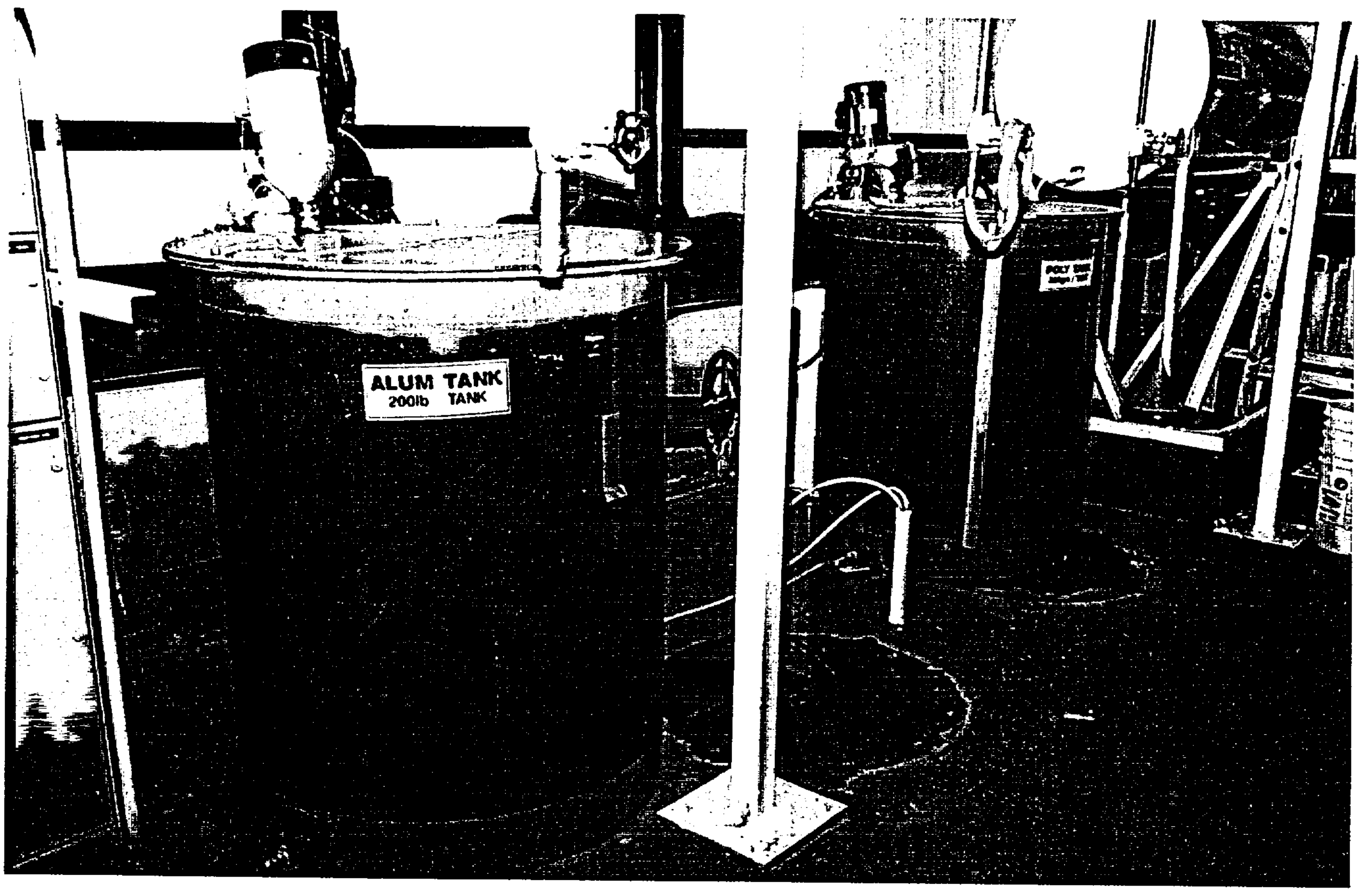

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FIGURE 8. POLYELECTROLITE/ALUM TANKS