NUCLEAR OPERATIONS TRAINING

ELECTRICAL SCIENCES
CHAPTER ES-3
ELECTRICAL COMPONENT CONTROL
REVISION 2

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Approved: Original signed by T. Matlosz Date: 07/07/93
Senior Instructor Development

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I. OBJECTIVES

A. TERMINAL OBJECTIVE: The student shall be able to identify and relate drawing conditions, and symbols, from electrical elementaries, to the component operation.

B. ENABLING OBJECTIVES: The student shall be able to:

		AO	RO	SRO	SE
191.	Summarize the steps required to find an electrical elementary for a specific component.	X	X	X	X
192.	Relate the individual devices and contacts, in an electrical elementary, to the overall component control.	X	X	X	X
193.	Summarize the method by which each type of component is energized.	X	X	X	X
194.	Given a set of conditions, explain how each contact is positioned to position or (de)energize a specific component.	X	X	X	X
195.	Explain how the control circuit for each type of component receives control power.	X	X	X	X
196.	Explain how the indicator lights in each type of control circuit are controlled.	X	X	X	X
197.	Differentiate between the different failure modes for each type of component if control power is lost.	X	X	X	X

		AO	RO	SRO	SE
198.	Differentiate between the different types of overcurrent protection provided to each type of component.		X	X	X
199.	Summarize the conditions necessary to test a pump breaker.	X	X	X	X
200.	Predict the consequences of using the improper size bulb in a specific indicator.		X	X	X
201.	Predict the affect of a device failure in the control circuit for each type of component.		X	X	X

LESSON TEXT

INTRODUCTION

A large power generating station, with centralized control, utilizes many remote control circuits for components in the Plant. These remote control circuits provide control of components located far from the control room, determine that the component's protective devices and interlocks are satisfied, and provide indication to the control room of the component's status. The components being controlled may be air-operated valves, motor-operated valves, high or low voltage motors, electrical supply breakers, or packaged equipment such as diesel generators.

The remote control circuit uses 125 VDC or 120 VAC to affect the control action. The control action may energize a solenoid valve to admit air to a valve operator diaphragm or energize coils which cause breaker operation or motor starter operation.

Electrical elementary diagrams show how the control circuit performs the control action. The diagrams show the remote control stations and their locations, the component's protective devices and interlocks, and the component's indications and alarms. The diagrams also show the source of the control power and isolation devices for the control power.

The electrical elementary diagram provides valuable information about how an electrical component is controlled. Understanding how to read electrical elementary diagrams will assist in verifying component operation, surveillance testing response and component failures.

GENERAL DESCRIPTION

Gilbert Associates drew the major portion of electrical diagrams because the A/E organized the electrical systems. Many vendor components were used throughout the plant. Each component meets the A/E's specifications and is therefore compatible with the electrical system design. The A/E connected these components into the electrical system and added special-design actions to the control circuits. This A/E function ensures overall plant operations which meet all safety standards.

The elementary wiring diagrams represent an individual component's control circuit. The elementary symbols, used on the B-208 series drawings (electrical elementaries), represent small electrical components such as relays, contacts, solenoids, lights, etc. The B-208 series index (Figure ES3.1) lists systems in alphabetical order with a corresponding numerical drawing number (i.e., B-208-082; RC-Reactor Coolant). When an operator references a particular system's elementary diagram, he finds that the first page of the system's series is another index. This index references the individual system's components. Many of the devices and symbols found on B-208 series drawings are shown on Figures ES3.3 and ES3.4.

Working through an electrical elementary requires a good understanding of how the device contacts work. Successfully closing or opening device contacts in the control circuit for a component will allow that component to operate as it is designed. Appendix "A" covers all types of device contacts and the condition (open/closed) they will normally be found in. Identification of the type of contact operated (overcurrent, switch position, etc.) can be found by number (i.e. 1-99) in Appendix "C". Operation of air-operated valves and control of the air solenoids that control them requires an understanding of valve position contacts. Appendix "B" describes in detail the meaning of ao, bc, bo, tc and to contacts for valve operators.

DETAILED DESCRIPTION

Electrical Elementary (B-208 Series) Indexes

The Electrical Elementary Drawings cover the majority of electrically powered equipment in the plant. Equipment that has come from the manufacturer pre-wired, such as HVAC chillers, will have electrical elementaries that have been drafted from the manufacturer's diagrams. Reference to the wiring diagrams in the manufacturer's instruction manual will be necessary for specific relay and component information (i.e. timer information).

The main B-208 series index (B-208-001-I1) lists systems in alphabetical order (i.e. B-208-001 through 128) as shown in Figure ES3.1. Once the system is identified, which contains the system component, the system can be located by the system drawing number (i.e., B-208-082; RC - Reactor Coolant) from the main index. The drawing photo slides which contain all electrical elementary drawings are in drawers, in numerical order. The first card in the B-208 section is the main index with Reactor Coolant (RC) located in B-208 subsection 082 (i.e. B-208-082).

The first card in section 082 is the index for Reactor Coolant (Figure ES3.2). The individual electrical component is located in this section, also in numerical order (i.e., RC04; Reactor Coolant Pump A Oil Lift Pump). Card B-208-082-RC04 will reveal the control diagram for the oil lift pump. Any component in any other system can be found the same way the oil lift pump was found.

Drawing Legend

Understanding the electrical elementary drawings requires that you become familiar with the drawing symbols, abbreviations used, and assumptions made on the drawings. Many commonly used electrical devices are shown in Figures ES3.3 and ES3.4. In addition to the device symbol, there will be a device number to identify the symbols on the drawing. These device numbers are identified in Appendix “C” with a description of what the device function is.

The operation of many components are tied to valve position. A pump may not start unless its discharge valve is open (i.e. circ. water pump) and valve position indication on the main control board will keep an operator aware of system operation. The limit switch tables (Figure ES3.5) cover both limitorque valves and air-operated valves. These tables identify position switch contacts as either 33ao, 33bo, 33ac or 33bc. What distinguishes the limitorque contact from the air-operated valve contact is the contact number (i.e., 4A-4) associated with the limitorque valve. A detailed explanation of these contacts can be found in Appendix “B”. It is of great benefit to commit these tables and initial conditions for elementaries to memory. These tables are not normally available for use unless a copy is printed out or a copy is stored in a convenient spot.

Small Pumps and Fans (<50 HP)

Components of this type are powered from Motor Control Centers (MCC) located throughout the plant. Operation can be from a control switch, level switch etc. Regardless of the type of operation, the component is always energized by a relay similar to the type shown in Figure ES3.6. Electrical power at 480 volts (3 phase) is supplied to the line side of the relay (L1, L2, L3) from the manual breaker in that MCC. When the relay is energized from its control circuit, the relay closes its contacts via a magnetic switch and supplies 480 volts (3 phase) to the component (T1, T2, T3). Control power (120 volts AC) is fed through the control circuit before it reaches the coil terminals to energize the relay. This 120 volt control power originates from a 480 VAC/120 VAC transformer in the respective MCC cubicle.

A good example of MCC component operation of this type can be seen in Figure ES3.7. Reactor Coolant Pump (RCP) “A” oil lift pump is operated as described previous. On the elementary drawing, the first thing to locate is the 120 VAC control power at the top and follow it down to device 42 (middle of drawing). Appendix “C” is used to identify device 42 as a connecting device (relay).

MCC Component Remote Manual Sequence

In order to start the lift pump, the 42 relay must be energized. The following steps will keep the relay (42) energized as long as the lift pump is needed to be running.

1. Contact SS-RC04 (3-4) closed.

   - According to the switch (SS-RC04) contact block, this contact is closed with the switch in the start position.

   - The switch (SS-RC04) is a spring-return-to-center type switch (note under switch block).

   - Contact SS-RC04 (3-4) must be bypassed to keep the relay (42) energized.

2. Contact 49 closed.

   - According to Appendix “C”, this contact is for thermal protection and will open to protect the pump from overheating.

3. Contact SS-RC04 (5-6) closed.

   - According to the switch (SS-RC04) contact block, this contact is closed in both start and spring-return-to-center positions.

4. Contact 42 closed.

- This contact is normally open, but is closed when the relay (42) is energized.
- This completes the bypass of contact SS-RC04 (3-4), when the switch is released, to keep the relay (42) energized.

If the 49 contact opens, it can be reclosed by pressing the reset button on the relay. Going to the stop position with switch SS-RC04 will open contact SS-RC04 (5-6) to deenergize the pump.

In addition to the control circuit there are also indicator lights and auxiliary contacts that need to be addressed. The lower right side of Figure ES3.7 shows several contacts (i.e., 42, SS-RC04, PS-417 etc.). These contacts are either spare contacts (not used) or they are actuated by the device identified by the number (i.e., 42 etc). The note numbers below the contact refer you to the note section on this figure. The notes generally describe what condition will open or close the contact. In the case of contacts like 42 (17-18), they are actuated by a device located on the elementary and usually don't need a note.

This contact (which is normally closed when the relay (42) is deenergized) will open when the relay (42) is energized to start the pump. This contact affects an alarm circuit as noted by note 2 under alarm. The indicator lights are located on the MCB switch (XCP-6109) and will be lit as follows if the bulb isn't burnt out. The white power available lights (WHT) work off of 24 VAC and therefore voltage must be reduced from 120 VAC to 24 VAC through the resistor. As long as power is available and contact 49 is closed (no pump overheating), the white light should be lit. The red and green lights also work off of 24VAC, but they are energized by the operation of the relay (42). When the relay (42) is energized, the red light is lit and the green light is out. When the relay (42) is deenergized the opposite occurs due to the operation of the 42 contacts.

Fans are operated from MCCs exactly the same as pumps. Motor operated valves are also operated via MCCs, but their operation requires two relays which will be covered next.

Motor Operated Valve Control

Motor-operated valves (MOVs) at V. C. Summer Station use a 480 VAC reversible motor (for opening and closing) driven thru gears to change valve position (Figure ES3.8). Without 480VAC (3 phase) power to operate the motor, the valve will stay in its present position. All limitorque valves (motor operated valve) do have a hand wheel that can be engaged thru a clutch lever to manually operate these valves without electrical power.

The direction of a limitorque valve (MOV), to either open or close it, depends on the ability to reverse motor direction. If any 2 of the 3 power leads to a 3-phase AC motor are reversed (i.e., phase A-B-C - A-C-B) in order, then the motor will rotate in the opposite direction. We perform this reversing action by using 2 separate 3 phase relay contactors. Only one contactor will be energized at any time while the valve is being operated (Figure ES3.8). Energizing the opening contactor will supply 480 VAC, 3-phase (in phase order A-B-C) to the motor. Energizing the closing contactor will supply 480 VAC, 3-phase (in phase order A-C-B) to the motor. Limitorque valves also have torque switches, which deenergize the motor, to prevent the motor from jamming the valve into its open or closed valve seat. This will prevent costly valve damage as well as ensuring that the valve is free to operate and not stuck on its valve seat.

Operation of limitorque valves requires varying sizes of motor operators. Limitorque valves range in size from small steam trap isolation valves to large accident sump isolation valves. Regardless of the limitorque size, the operation of the control circuit is always the same. Control power for a limitorque valve open or close contactor is supplied from a 480 VAC/120 VAC transformer in the respective MCC cubicle. The 120 VAC will be used to energize the contact in operating the valve. A screw driver slot in the contactor allows for manual operation of the open or close contactor for cases where remote control (outside MCC) is not possible. This manual method does bypass all interlocks, including torque switch valve stops, and should be performed using Fire Emergency Procedure attachments.

A typical MOV control circuit is shown in Figure ES3.9 which is electrical elementary B-208-097-SP07. The control circuit shown is for RB spray header isolation valve 3003A. As previously discussed a MOV is operated by either an opening or closing contactor. Interlocks prevent operating either contact while the other contact is energized (prevent trying to open and close valve simultaneously) or if the motor is overheating (overloaded).

Remote manual opening and closing of the MOV from the main control board (MCB) is performed, within the control circuit, exactly the same with the exception of switch position. In order to open the valve, a 120 VAC circuit must be completed to both sides of the open contactor (42-0).

MOV Remote Manual Opening Sequence

1. Contacts 49 are closed.

   - Located upper left on Figure ES3.9.
   - Thermal protection contact to prevent motor overload (Appendix “C“).

2. Contact SS-SP07 (3-4) closed (open after bypass).

   - SS identifies it as a selector switch.
   - Contact closed only when switch is in open position.

    a. Note describes SS-SP07 as spring return to auto.

    b. Must hold switch to open position until valve starts to open and bypass contact SS-SP07 (5-6) closes.

3. Contact SS-SP07 (5-6) closed.

   - Contact closed only when switch is in open or auto position.

   - Seals in open signal

4. Contact 42-0 closed.

   - Normally open, but closes when contactor (42-0) is energized.

   - This contact along with contact SS-SP07 (5-6) seal in the open signal to contactor (42-0).

5. Contact 33 B25 closed.

   - Contact closed until valve is >25% open (Appendix “B”).

   - Bypasses torque switch contact 33TO as the valve starts to open.

6. Contact 33TO closed.

   - Contact closed until opened by torque to stop valve opening (Figure ES3.4).

   - Prevents jamming valve on open seat.

   - Only backup to contact 33BO which would normally stop valve opening.

7. Contact 33BO closed.

- Contact closed until reaching open position (Figure ES3.5).

- Normally stops valve opening.

8. Contact 42-C closed.

- Contact is normally closed unless contactor 42-C (for closing valve) is energized.

- Prevents energizing opening contactor (42-0) while the closing contactor (42-C) is already energized.

Through the above contacts, the operator on the MCB will go to open on the switch (SS-SP07) and release it. The valve will travel to its open position where contact 33bo will open and deenergize contactor 42-0.

MOV Remote Manual Closing Sequence

The control sequence for closing the valve from the MCB is the opposite operation from opening the valve. The operators on the MCB will go to close on the switch (SS-SP07) and release it. The valve will travel to its closed position where torque switch 33TC will open and deenergize contactor 42-C.

MOV Auto Opening Sequence

The auto opening sequence bypasses steps 1-4 of the remote manual opening sequence previously described. Step 5-8 and contact K643 are used to auto open the valve. Note-1 for contact K643 states that this contact closes on Phase A containment isolation signal. The closing of this contact sends the valve control circuit through its opening sequence unless the valve is already open.

MOV Indicator Lights

The white (WHT) indicator lights should always be lit as long as there is power available to the MCC cubicle contactors and transformer (manual BKR closed) or the bulb burns out. If power is not available then the MOV cannot be operated. Opening of the thermal overloads (49) would also prevent MOV operation and deenergize the white power available lights.

The red and green MOV position lights are energized and deenergized by valve position contacts (33). A red light indicates that the valve is open while a green light indicates that the valve is closed. As the valve travels open or closed both red and green lights will be lit showing that the valve is in a mid position (not yet fully open or closed). Contact 33bo (Figure ES3.5) for the green light will remain closed until the valve is fully open. The 33AC contact (Figure ES3.5) for the red light will remain closed until the valve is fully closed.

The red and green lights associated with MVG-3003A above are operated by position contacts inside of the MOV operator (Figure ES3.8). Some safety related valves on the otherhand need to have valve position indication available even with power not available to the MCC cubicle (for the MOV). These valves will normally have a separate external position switch that works off of physical valve position and not MOV rotation (position contact block inside operator). As the MOV opens or closes it will hit a position roller switch which will feed 125 VDC through the switch to the MCB position indicator lights.

<u>Air Operated Valve Control</u>

Air-operated valves (AOV) utilize an air-diaphragm operator, connected to the valve stem, for positioning the valve. The 0-100 psig instrument air is either applied directly to the valve, through one or more air solenoids, or controlled through a valve positioner. Air directly to the valve would beat 100 psig whereas air from the positioner can be from 0 - 100 psig.

Regardless of whether air goes through a positioner or is sent directly through air solenoids, air to operate the valve must come through at least one solenoid. In this section operation and control of these air solenoids (Figure ES3.10 and 12) will be discussed.

There are basically 3 types of AOVs at V. C. Summer Station.

- Fail-Open AOV - air is used to close the valve and when air is vented off the air diaphragm or upon loss of air pressure, the valve fails open due to spring pressure.

- Fail-Closed AOV - air is used to open the valve and when air is vented off the air diaphragm or upon loss of air pressure, the valve fails closed due to spring pressure.

- Fail-As-Is AOV - air is used to open and close the valve by applying air to the top or bottom of the air diaphragm. There is no spring to open or close the valve upon loss of air pressure.

AOV remote control circuits use one or more 125 VDC solenoid-operated air valves (SOV) which admit or vent air to the valve operator diaphragm (Figures ES3.10 and 12). The solenoid-operated valve (SOV) is typically a 3-way valve but some 2-way valves are use to provide interlock functions. A simple open-close AOV may have one SOV to operate it whereas a complicated interlocked control circuit, such as a steam generator power-operated relief valve, can use up to 6 SOVs.

In the following sections, a “positioner fed” AOV with one SOV and a open-close type AOV with 2 SOVs will be discussed. Both valves are failed-close type valves and need air to open. The failed close (FC) condition is shown in Figures ES3.10 and 12 on the valve diaphragm. As mentioned previously all SOVs (20 devices-Appendix “C”) are 125 VDC and must be energized or deenergized to allow the positioner to control valve position or open-close the valve. Appendix “A” states that all valves are shown in their failed position with solenoids and relays deenergized.

FCV-4701A will be the first of 2 AOV control circuits examined. Figure ES3.11 (B-208-009-BD04) is the electrical elementary for FCV-4701A (S/G blowdown flow control valve (FCV)). The following control sequences will cover valve operation.

AOV Remote Manual Opening Sequence (4701A) - (Figures ES3.10 & ES3.11)

The objective in this control sequence is to deenergize 20 (SOV) which aligns air to the valve diaphragm. Figure ES3.10 shows the SOV (5) as a 3-way solenoid. The SOV is shown deenergized to allow air to pass through the SOV to the valve diaphragm and open the AOV as the positioner calls for it to. Taking the control switch SS-BD04 to open will open contact SS-BD04 (5-6) auto which will deenergize the SOV (20) (Figure ES3.11). Because SS-BD04 is a spring-return-to-center (auto) switch, contact 33bc (in line with contact SS-BD04 (5-6)) must be open before releasing the switch to mid position. According to Figure ES3.5, contact 33bc (AOP limit switch development) is closed only in the full closed position. Therefore as soon as the valve leaves its closed seat, as indicated by a lit red and green position light, the operator can release the switch and the valve will continue to open.

AOV Remote Manual Closing Sequence (4701A) - (Figures ES3.10 & 3.11)

Closing of the AOV requires energizing the SOV (20) to isolate and vent air off the diaphragm (Figure ES3.10) as follows:

1. Contact SS-BD04 (3-4) closed (Figure ES3.11).

    - According to SS-BD04 contact blocks, contact (3-4) is closed in the closed position.

    - Because SS-BD04 is a spring-return-to-center (auto) switch, there must be a bypass contact to keep the SOV (20) energized when the switch is released.

2. Contact SS-BD04 (5-6) closed.

- According to SS-BD04 contact blocks, contact (5-6) is closed in the close and auto positions.

- This contact will keep the SOV (20) energized and the AOV closed.

3. Contact 33bc closed.

- According to figure ES3.5, this contact is open until the valve is fully closed.

- The control switch SS-BD04 must be held in the closed position until the valve is fully closed to bypass contact SS-BD04 (3-4).

AOV Auto Closing Sequence (4701A) - (Figures ES3.10 & ES3.11)

Auto closing of the AOV requires energizing the SOV (20) through either contact FY/4702G or PY/4702D. Note-2 for contact FY/4702G states that this contact closes on steam generator “A” blowdown high flow. Note-3 for contact PY/4702D states that this contact closes on steam generator “A” blowdown high pressure. They could be reopened by taking SS-BD04 to the open position to break the auto signal keeping the valve closed.

AOV Indicator Lights (4701A)

There are no white (WHT) indicator lights on the local blowdown panel (XPN-029) for power available, but there is open-close indication. The red (open) indicator light is energized when contact 33ac is closed. According to figure ES3.5, contact 33ac is closed whenever the AOV is not fully closed. The green (close) indicator light is energized when contact 33bo is closed. According to figure ES3.5, contact 33bo is closed whenever the AOV is not fully open. Therefore both red and green lights are lit when the AOV is not fully open or closed.

Steam Generator blowdown (BD) isolation valve XVG-503A is an example of a more complex control circuit with bypass features and pushbutton reset for isolation. Figure ES3.12 shows the SOV configuration with the noticeable absence of a positioner. This valve is controlled as either full open or full closed.

Unlike FCV-4701A, this valve requires energizing of the SOV (20) to open the valve. In Figure ES3.12 the SOVs are shown deenergized with air isolated and vented from the valve diaphragm. The AOV control circuit for XVG-503A (S/G BD isol. Valve) is shown in figure ES3.13 (B-208-009-BD07).

AOV Remote Manual Opening Sequence (503A) - (Figures ES3.12 & ES3.13)

The objective in this control sequence is to energize the SOV (20A) which aligns air to the valve diaphragm. Figure ES3.12 shows the SOV (20A) as a 3-way solenoid. The SOV is shown deenergized which blocks air and vents air off the valve diaphragm. The following sequence will open the valve (503A) if the MDEFPs are not running.

1. Contact SS-BD07 (3A-4A) closed.

    - According to SS-BD07 contact block, contact (3A-4A) is closed in open/bypass position.

    - With SS-BD07 spring returning to center (auto), contact SS-BD07 (3C-4C) is used to keep the SOV (20A) energized.

2. Contact SS-BD07 (3C-4C) closed.

- According to SS-BD07 contact block, contact (3C-4C) is closed in open/bypass and auto positions.

- This will keep the SOV (20A) energized when SS-BD07 is released.

3. Contact 33ac closed.

- According to Figure ES3.5, contact 33ac is closed whenever the AOV is not fully closed.

- Therefore the switch SS-BD07 could be released to auto when the AOV moves off its closed seat.

4. Contact K606 closed.

- Note-2 for contact K606 opens on containment isolation phase “A”.

- As long as there has not been a phase “A” signal, this contact should be closed.

5. Contact 2030 AX closed.

- Note-5 for this contact states that it opens on start of EF turbine.

- With TDEFW pump not running, this contact should remain closed.

6. Contact 52 (11-12) closed.

- Note-7 for this contact states that it opens on EF pump start.
- With no MDEFW pump running it will remain closed.
- Appendix “C” describes it as breaker position contact.

With no EFW pumps running the above steps are adequate to open XVG-503A. Start of an EFW pump would open contact 2030 AX (TDEFW pp.) or 52 (MDEFW pp.) would deenergize SOV (20A) and therefore close the valve (503A) by venting air off the valve diaphragm. These 2 contacts would need to be bypassed to manually reopen the valve. The following steps will allow bypassing these 2 contacts to reopen XVG-503A after an EFW pp. start isolation.

1. Contact SS-BD07 (1C-2C) closed.

   - According to SS-BD07 contact block, this contact is closed with the switch in open/bypass or auto positions and not depressed.

   <u>NOTE</u> Depressing this switch deenergizes BD07X (relay), if it was energized to bypass blowdown isolation, to reopen contact BD07X (A-1A) which removes the bypass of contacts 2030AX and 52 (11-12).

2. Contact SS-BD07 (3B - 4B) closed.

   - According to SS-BD07 contact block, this contact is closed with the switch in open/bypass position.

3. Contact BD07X (C-1C) closed.

- This contact closes when BD07X (relay) is energized to keep the relay energized when contact SS-BD07 (3B-4B) opens again after releasing the switch.

4. Contact BD07X(A-1A) closed.

   - This contact closes when relay BD07X is energized by SS-BD07 (1C-2C) bypass contact.

5. Contact SS-BD07 (3A-4A) reclosed.

   - It recloses when the switch (SS-BD07) was taken to the open/bypass position for the bypass circuit. This will reenergize SOV (20A) allowing air to reopen the valve (503A).

6. Contact SS-BD07 (3C-4C) reclosed.

   - It recloses when the switch (SS-BD07) was released to auto from open/bypass position.

7. Contact 33ac reclosed.

   - It reclosed when valve leaves its closed seat (not fully closed).

   - This allows the operator to release the switch to auto and the valve continue to open.

This bypass is required in Mode 2 (Reactor Power <5%) when the S/G's are being fed from EFW. The bypass allows you to run EFW pumps for S/G level control and have blowdown in service for chemistry control.

AOV Remote Manual Closing Sequence (503A) - (Figures ES3.12 & ES3.13)

Manually closing XVG-503 from the MCB only requires you to take switch SS-BD07 to the closed position.

- This breaks the auto contact circuit to deenergize 20A (SOV).
- With no EFW pumps running, the switch would need to be held in the close position until contact 33ac opens (fully closed position).
- With EFW pumps running and isolation bypassed, taking the switch to the closed position opens the reset contact SS-BD07 (1C-2C) to deenergize BD07X (relay).
- Deenergizing BDO7X (relay) reopens contact BDO7X (A-1A) to deenergize 20A (SOV).

AOV Auto Closing Sequence (503A) - (Figures ES3.12 & ES3.13)

Automatic opening of any of the following contacts deenergize 20A (SOV) and close XVG-503A.

1. Contact K606 open.
    - Note-2 for this contact states that it opens on containment isolation phase “A”.
    - Opening this contact will close XVG-503A under all circumstances.
2. Contact 2030AX open.
    - Note-5 for this contact states that it opens on TDEFW pp. start.

- XVG-503A will not close if isolation is bypassed (contact BDO7X (A-1A) is closed).

3. Contact 52 (11-12) open.

- Note-7 for this contact states that it opens on MDEFW pp. start.

- XVG-503A will not close if isolation is bypassed (contact BD07X (A-1A) is closed).

AOV Indicator Lights (503A)

The white (WHT) power available lights will be lit as long as they are not burnt out and 125 VDC is available to the control circuit. The red (open) indicator light is energized when contact 33ac is closed. According to Figure ES3.5, contact 33ac is closed whenever the AOV is not fully closed. The green (closed) indicator light is energized when contact 33bo is closed. In Figure ES3.5, contact 33bo is closed whenever the AOV is not fully open. Therefore both red and green lights are lit when the AOV is not fully open or closed.

More complete control circuits generally also show the air supply and solenoid-operated valve arrangements to the valve operator diaphragm to assist in understanding. Many AOV electrical elementaries require additional drawings for complete understanding of contacts and relays. An example of this is the S/G PORV which requires 4 additional drawings.

<u>Switchgear 480V and 7.2KV Motor Control</u>

Control of large motors (>50 HP) is accomplished by controlling the 480V or 7.2KV switchgear breakers which supply the motors. The switchgear breakers are designed for the high starting currents and faults that could be encountered. The same requirements apply to switchgear supply and cross-connect breakers.

The 480V and 7.2KV breakers are stored energy breakers that are opened and closed by the energy stored in a set of tripping or closing springs. The breaker control circuit use 125 VDC from an external source to operate coils in the breaker which release a latch to allow the spring to open or close the breaker. Local manual operation of the breaker can be performed without control power if the respective tripping or closing springs are compressed and latched. The close and trip buttons on the breaker release the latches directly through mechanical linkage. The closing springs are compressed by a charging motor whenever the breaker trips open. In some cases, the closing springs on a breaker will need to be kept charged when the breaker is open and closed. This allows for a rapid reclosure of a breaker that trips and must be reclosed, such as MCC automatic transfer units. The tripping springs are compressed by the force of the breaker cycling closed and not by a charging motor.

The control circuit connects to the breaker operating coils and charging motor through the connector pins when the breaker is racked in. These connector pins are shown on Figure ES3.14 and 15 (B-208-097-SP01) by the symbol -->>. From the general notes in Appendix “A”. RB spray pump (Figures ES3.14, 15, and 16) is opened and racked into the operate position. You also know that all relays are shown deenergized with their respective contact in a deenergized condition. The various contacts for breaker position (52 device), auto starting (62 device), and tripping will change state as the breaker state is changed from the conditions above. Switchgear breaker (SWGR. BKR.) operation is described in the following sections.

Switchgear Breaker Remote Manual Closing Sequence (Figure ES3.14)

The main objective in being able to close the breaker remotely is to energize the closing coil (CLSE CKT) to release the closing springs. These coils are not rated to be continuously energized and are deenergized after releasing the latch. This sequence is performed as follows:

1. Contact 12A closed (2 contacts).

    - These contacts are part of the 2 pole closing control power breaker which feeds 125 VDC to the closing circuit.

2. Contact cell sw. (2C-2) closed.

    - This is a cell switch contact to tell the control circuit that the breaker is racked in. This switch is mounted on the back of the breaker to indicate racked in, racked out and test positions for the breaker.

3. Contact CS-SP01 (1-1C) closed.

    - According to the switch (CS-SP01) contact blocks, this contact is closed when in the start position (indicated by an X in box).

    - This switch spring returns to NORM-AFTER-START/STOP position when the switch is released.

4. Contact 51X (5-6) closed.

- This is a normally closed overcurrent contact (Appendix “C“) operated by relay 51X(0) on Figure ES3.15. An overcurrent condition on any of the 3 phases would energize 51X(0) relay and open contact 51X (5-6) to prevent pump start.

Switchgear Breaker Auto Closing Sequence

Auto closing the breaker still requires energizing the closing coil (CLSE CKT) long enough to release the latch for the springs. Automatic pump starts (Breaker closing) involves energizing a 62 relay (Appendix “C”) which is a timing relay. The following sequence will auto start the pump when it receives a spray actuation signal.

1. Step 1, 2, and 4 of the remote manual closing sequence are the same for auto closing.

2. Contact CS-SP01 (7-7C) closed.

   - According to the switch (CS-SP01) contact blocks, this contact is closed with the switch in the NORM, AFTER START/STOP position.

   - This implies that as long as the switch isn’t in pull-to-lock (PTL) or held in the open/close positions, you will get an auto start of the pump.

3. Contact K644 (1-2) closed.

   - Note-1 for this contact states that it closes on a spray actuation signal.

- With closing of this contact, relay 62 (L1-L3) is energized and actuates contacts 62 (3-5) and 62 (9-11) to bypass the manual switch closing contact for an auto start.

4. Contact 62 (3-5) closed.

    - Note-2 for this contact states that it opens 3 seconds after pickup (relay 62 energized).

    - This is the contact that replaces the spring open action of CS-SP01. The contact opens after 3 seconds to prevent burning up the closing coil.

5. Contact 62 (9-11) closed.

    - Note-3 for this contact states that it is an instantaneous contact of time delay relay 62 (L1-L2).

    - This contact closes when relay 62 (L1-L2) energizes.

If contact K644 (1-2) is opened (spray actuation signal reset), the closing circuit will be ready for another auto pump start if the pump is tripped. Opening this contact deenergizes relay 62 (LI-L2) to reclose contact 62 (3-5). Another spray actuation signal (contact K644) would auto close the pump breaker per the steps above. Trying to manually turn the pump off without resetting the spray actuation signal will only restart the pump. Relay 62 (L1-L2) deenergizes long enough to reset its contacts (to deenergized state) and reenergize for an auto start when the switch (CS-SP01) is released to NORM. AFTER START/STOP.

Switchgear Breaker Remote Manual Tripping Sequence (Figures ES3.15 & 16)

Tripping of "A" RB Spray Pump (Figure ES3.15 and 16) requires energizing the trip coil (TRIP CKT), for a short period, to release the trip latch and allow the springs to open the breaker. The manual tripping sequence is as follows:

1. Contact 15A closed (top of Figure ES3.15).

    - There are 2 contacts for the 2 poles of the tripping control power breaker.

2. Contact cell switch (4C-4) closed (Figure ES3.16).

    - This is a cell switch contact to tell the control circuit that the breaker is racked in. This switch is mounted on the back of the breaker to indicate racked in, racked out and test positions for the breaker.

3. Contact CS-SP01 (2-2C) closed (Figure ES3.16).

    - According to the switch (CS-SP01) contact blocks (Figure ES3.14), this contact is closed when the switch is in the stop or PTL position.

    - This switch spring returns to NORM. AFTER START/STOP position when the switch is released (unless in PTL).

Switchgear Breaker Auto Overcurrent Tripping Sequence

Auto tripping of the spray pump breaker can occur due to time delayed (TD) overcurrent (51X contact) or instantaneous overcurrent (50G contact). Each of the 3 phases of pump feed are monitored for overcurrent conditions. Overcurrent relays 50-51-74-(1,2,3) are shown in Figure ES3.17. A description of each type of overcurrent (O.C.) relay follows:

- Time-delayed overcurrent relay (51).
  - This relay senses an O.C. condition of approximately 150% for a time period of up to several minutes before activating a pump trip.
- Instantaneous overcurrent relay (50).
  - This relay senses an O.C. condition of approximately 6 times running current and up. If current exceeds this value during pump start (when current is high) or due to an electrical fault the relay (50) activates a trip instantaneously.
- Moderate overcurrent relay (74).
  - This relay actuates if an O.C. condition of approximately 110-120% of normal pump running current as sensed by the overcurrent relay. This alarm relay does not actuate a trip but will light an amber light (above switch) and activate an overcurrent annunciator to alert the operator of the overcurrent conditions (pump runout etc.).

On Figure ES3.15 there are contacts for each of the above type relays.

- Relay 74 (contacts 74-1, 74-2, 74-3).
- Relay 51 (contacts 51-1, 51-2, 51-3).
- Relay 50 (contacts 50-1, 50-2, 50-3).

The seal-in circuit (SI) around each 51 contact is to ensure that an TD-OC condition (51 relay actuation) does not clear before the overcurrent lockout relay 51X(0) can energize. The OC trip sequence is as follows:

1. Contact 15A closed (top of Figure ES3.15).

   - These are contacts for the 2 poles of the tripping control power breaker.

2. Contact 51-1, 51-2, 51-3, 50-1, 50-2, or 50-3 closed.

   - Overcurrent protection for each of the 3 phases to the pump.

3. Contact 52 (25-26) closed.

   - This contact is closed when the pump breaker is closed (Appendix “A“ and “C”).

   - You wouldn’t expect to need overcurrent protection with the pump breaker open.

4. Relay 51X(0) energized.

   - Energizing this relay closes contact 51X (3-4) to trip the breaker (contact on Figure ES3.16).

Contact 50G on Figure ES3.16 will trip the breaker instantaneously while contacts 50-1, 50-2, or 50-3 energize relay 51X(0). This ensures the breaker is tripped immediately while relay 51X(0) locks out remote manual or auto reclosure of the breaker until it is reset. Relay 51X(0) is reset (unlatched) by energizing relay 51X(R) on Figure ES3.15. Resetting a pump overcurrent lockout to allow restart is as follows:

1. Contact 15A closed (top of Figure ES3.15).

    - These are contacts for the 2 poles of the tripping control power breaker.

2. Contact CS-SP01 (3-3C) closed (Figure ES3.15).

    - According to the switch (CS-SP01) contact blocks (Figure ES3.14), this contact is closed when the switch is in the stop or PTL position.

    - In other words, the pump O.C. relay 51X(0) is reset by giving the pump switch a green flag by going to stop.

3. Contact 51X (1-2) closed.

    - This contact is closed by relay 51X(0) when it energized and latched.

4. Relay 51X(R) energized.

    - This resetting relay is internal to relay 51X(0) at the local SWGR unit and removes the latch which is keeping 51X(0) locked out.

Miscellaneous Alarm Circuits

As mentioned previously, contacts 74-1, 74-2, and 74-3 (Figure ES3.15) sense a moderate overcurrent (O.C.) condition on any of the 3 phases to the pump. Actuation of any one of these contacts will energize relay 74X (Appendix “C“) which is an alarm relay. The full contact sequence to energize relay 74X is as follows:

1. Contact 74-1, 74-2, or 74-3 closed.

    - Sense moderate O.C. (≈110-120% nominal) on any of the 3 phases to the pump.

    - This relay is time delayed to insure that alarms are not received on pump start.

2. Contact 74-Y (1-5) closed.

    - This contact is closed by relay 74-Y on figure ES3.14.

3. Contact 52 (21-22) closed (figure ES3.14).

    - This contact is closed whenever the pump breaker is closed (Appendix “A” and “C”).

    - It prevents unnecessary O.C. alarms when the pump is stopped (breaker open).

4. Relay 74-Y energized (Figure ES3.14).

- Energizing this relay closes contact 74-Y (1-5) to set up relay 74X for an O.C alarm and amber light should contacts 74-1, 74-2, or 74-3 close.

The overcurrent alarm (O.L. ALM) is actuated by contact 74X (3-7) located at the bottom left corner of Figure ES3.16. The amber light (AMB) located above the MCB switch is lit by contact 74X (2-8) located in the middle of Figure ES3.16.

An auto start failure alarm on the MCB is an indication that the pump tried to start after receiving an auto start signal, but the breaker did not close. This alarm circuit is located on Figure ES3.16 in the lower right half. The auto start failure alarm (AUTO STR FAIL ALM) is actuated through contacts 62 (4-6) and 52 (17-18). According to note 5 for contact 62 (4-6), it will open 3 seconds after relay 62 energizes (auto start). The alarm will actuate if contact 52 (17-18) is not closed before contact 62 (4-6) opens. Contact 52 (17-18) closes when the pump breaker closes. In other words the pump must start in 3 seconds after receiving an auto start signal to prevent the alarm.

Breaker Test Circuit

A test circuit has been installed in each breaker to locally cycle the breaker open and closed. This test circuit is only active with the breaker racked out to what is called the test position. The test position is racked out far enough to disconnect the main breaker contacts from the bus power. Therefore cycling the pump breaker will not energize the pump.

Test closing circuit - the breaker is closed as follows (Figure ES3.14):

1. Contact 12A closed.

- These are contacts for the 2 poles of the closing control power breaker.

2. Contact cell switch (1C-1) closed.

- This is a cell switch contact to tell the control circuit that the breaker is racked into the test position. This switch is mounted on the back of the breaker to indicate racked in, racked out and test positions for the breaker.

3. Contact 52-TS (1-10) closed.

- This switch is mounted on the front door of the 7.2KV pump breaker cubicle.

- This switch normally only works with the breaker in the test position, but some disconnect breakers are normally operated by the switch on the cubicle door.

- This contact is closed when the switch 52-TS is taken to the close position. It spring returns to center to keep from burning up the closing coil.

Test tripping circuit - the contacts work exactly the same as the test closing circuit and are located on Figure ES3.15 (at bottom).

Indication Light Control Circuits

Regardless of whether the breaker supplies a 7.2KV or 480V pump, the red, green and amber indicating lights associated with a pump switch are powered by the tripping control power circuit. Losing closing control power would only prevent remote closing of the breaker while loss of tripping control power would cause loss of breaker status lights and ability to remotely trip the breaker.

The MCB (XCP-6105) indicating lights require that the breaker be racked in as indicated by closed cell switch (4C-4) and cell switch (6C-6) contacts (Figure ES3.16). A red indication light means that the breaker is closed (pump started). A green indication light means that the breaker is open (pump stopped). A 52 contact (Appendix “C”) tells the light circuit whether the breaker is open or closed. The lights are shown on Figure ES3.16, but most of the 52 contacts are not shown on this drawing. These 52 contacts are internal to the breaker and are shown on a General Electric (GE) internal wiring diagram shown on Figure ES3.18. A full set of GE internal showings are located in the IMS-33-013 drawing series.

Control Board Status Light Indicators

Control Board indicating lights have long been and will continue to be one of our main indicators of system status. Indicating lights vary in size, type, life and especially amperage/voltage ratings. It has always been a normal routine to replace bulbs as they burn out from age and physical shock of switch operation. Which bulbs generally burn out first? The micro switches that are used for operating everything from vacuum breakers to air compressors have four bulbs (Lamp type 1819) that vary in their physical abuse. Each time a switch is turned, it imparts a small shock on the bulbs and each time the component is cycled or turned on and off, subtracts life from a bulb. OHM's Law will be explored as it relates to indicating light circuits and how improper bulb type replacements can change the voltage and current characteristics of a circuit or find a bulb in a circuit beyond its ratings.

Ohm’s Law (Figure ES3.19) shows the relationship between voltage, resistance and current. It also is clear from this formula that one quantity cannot change without affecting another. For example, when voltage is increased there will be an increase in current and when resistance is increased without changing the voltage, there will be less current. Indicating light circuits are designed to handle a certain amount of current at a given voltage in order to operate properly and not degrade circuit components. In certain cases indicating lights are part of an overall control or indication/protection circuit.

In Figure ES3.19 there is a series circuit with a 120 volt supply dropped across two resistors. Resistance in series is additive and therefore we have 25 OHMS of resistance. Each resistor is not seeing 120 volts, but only a portion of the voltage as determined by the proportion of resistance each resistor has. This concept is very useful when there are indicating lights in series with resistors. If the 5 OHM resistor is treated as an indicating light, then the 20 OHM resistor is used to lower voltage to the light down to only 24 volts. This is necessary for low voltage lights in a circuit. A light that is designed for 28 volts and operates at 24 volts will most likely last its design lifetime (i.e. 2,500 HRS. etc.). But placing a 28 volt bulb in a 120 volt circuit directly without the use of a dropping resistor will quickly find that the bulb opens (element melts) or worse it could short inside the bulb after the element melts.

In a parallel circuit with a normally constant voltage power supply (bottom of Figure ES3.10), each component will receive the same voltage level. When a 24 volt bulb is used in a 120 volt circuit you must still use a resistor in series with the 24 volt bulb for that particular parallel line. The current is determined by the resistance of the lamp in each parallel branch because we have a constant voltage power supply. Therefore the total current from the power supply to the bulbs is the sum of the current in the three parallel lines.

If a bulb is replaced with a lower resistance bulb (bulbs are normally rated in amperage not resistance), which implies a higher current, there will be increased current flow in not only that parallel line but also the entire circuit. This increased current flow can degrade components and lines which leads to premature failure of fuses that protect the circuit.

The voltage rating of bulbs is also of extreme importance as mentioned previously. A parallel circuit supplied by 120 volts will not be kind to a bulb that is rated significantly less than 120 volts. The higher voltage will force excess current through the bulb and burn out the element that gives off the light. An example is, a 20 volt bulb supplied by a 120 volt supply will have 6 times as such current flowing through it as it would with a 20 volt supply. (Refer to OHM's Law). When the element burn out, one of two things can happen. Either the element opens and the parallel circuit the bulb is in remains open or when the element opens, the posts that hold the element will flex and come in contact thus shortening out the bulb. Without any other resistance in the line, you have now shorted out your power supply and blown the fuses that protect the circuit.

A direct result of this kind of bulb replacement occurred in the nuclear instrumentation system in drawer N-36 (Figure ES3.20). The lights for the indicating window "Control Power ON"/"Instrument Power ON" are 120 volt NEON bulbs which require a minimal voltage to get these bulbs to light due to the nature of the bulb (i.e. 90 volts min.). When these bulbs were replaced with bulbs rated at 28 volts (.04 amps G1-385 or 387) the result is as described previously. The end result was a reactor trip from deenergizing the protection bistables.

A circuit on the other hand that has greatly over rated bulbs for the voltage supplied (i.e. 120 volt incandescent bulb in a 24 volt circuit) will have a very dim indication or no indication at all for great differences (circuit voltage verses bulb rated voltage). The NEON bulb which requires a minimal voltage similar to the fluorescent bulb would not even function in a low voltage circuit.

The policy of replacing all 4 bulbs in the micro switch modules or annunciator enhances indication reliability provided the correct replacement is used.

In the case where a bulb is placed in a circuit that is only slightly higher than its rated voltage, it will be brighter (indication of increased current for higher voltage) but most likely will last a fairly long period of time (possibly half its design lifetime) but will fail prematurely due to the higher voltage. The opposite is also true in that a 35 volt bulb placed in a 24 volt circuit will not be as bright as design but it will last that much longer, provided it supplies the minimal require illumination.

Unlike the NIS system the MCB indicators are 24 volt indication bulbs. The red, green indication bulbs for the various pump breaker indication have been described in previous sections. The green and red lights are in series with a resistor which reduces 120 volts down to 24 volts for the bulbs. Another restriction on the bulbs is the use of 52 contacts for operation of these bulbs. A bulb socket should not be worked on when energized or else accidental shortening of the socket/resistor terminals could occur. On a MCC component this will lead to blowing fuses and loss of control of that component (deenergizing pumps etc). Extreme caution is warranted on 7.2 KV and 480 V switchgear components (Figure 8) to prevent shortening out the red light/resistor component as this will cause the trip coil to energize with the breaker closed, thus tripping the pump (Figure ES3.18).

SUMMARY

Electrical elementary diagrams show how the control circuit performs the control action. The diagrams show the remote control stations and their locations, the components protective devices and interlocks, and the components indications and alarms. The five major areas covered in this handout are as follows:

Small Pumps and Fans (<50 HP)

These components are operated through a 480V MCC relay (42) and are controlled by 120 VAC power. Operation can be from a control switch, level switch, etc. The relay (42) remains energized as long as the component remains in operation.

Motor-Operated Valve Control

MOVs are open and closed by a 3 phase, 480 VAC reversible motor. Reversing any 2 of the 3 phase leads to the motor will change valve direction.

Opening and closing contactors inside a 480 VAC MCC change the 3 phase lead sequence to the motor. Control power to operate these contactors is from 120 VAC supplied from the respective MCC cubicle. Protective devices (torque switches) prevent a valve from being damaged by traveling too far.

Air-Operated Valve Control

AOVs utilize an air-diaphragm operator, connected to the valve stem, for positioning the valve. Instrument air at 0-100 psig is either applied directly to the valve, through one or more air solenoids, or controlled through a valve positioner. Without air pressure a valve can fail open, closed or as-is depending on whether it has an operating spring. Control power is supplied from a 125 VDC source to operate the air solenoid valves.

Switchgear 480V and 7.2KV Motor Control

Control of large motors (>50 HP) is accomplished by controlling the 480 V or 7.2KV switchgear breakers which supply the motor. These breakers are stored energy breakers, that are opened and closed by the energy stored in a set of tripping or closing springs. The breaker control circuit uses 125 VDC from an external source to operate a latch to allow the springs to open or close the breaker.

Control Board Status Light Indicators

It has been a normal routine to replace bulbs as they burn out from age and physical shock of switch operation. If a bulb is replaced with a lower resistance bulb, which implies a higher current (OHM's Law), there will be increased current flow in the entire circuit. Shortening out the bulb can short out the power supply and blow fuses that protect the circuit.

The ability to read system electrical elementaries is one key to an operator's understanding of system operation. This handout cannot supply all the information that is necessary for proficient use of all system drawings. The operator must use the drawings often to gain experience and proficiency.

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SELF-ASSESSMENT QUESTIONS

1. An advantage of racking out and pulling control power fuses for circuit breakers as opposed to tagging a control switch is

    A. that indication circuits remain energized for breaker position verification

    B. to maintain availability of the control switch and control power for testing

    C. that tagging a control switch would render the equipment inoperable and out of service

    D. that the equipment and its control and indication circuits would be deenergized

2. What should be done to completely deenergize a circuit breaker, including its control and indication power?

    A. Rack out the breaker and pull control power fuses.

    B. Open the breaker and tag it out.

    C. Lift the leads to ensure complete deenergization.

    D. Tag the control switch and post a watch at the breaker.

3. While locally investigating the condition of a large circuit breaker, an operator observes the following indications:

- OPEN/CLOSED mechanical flag indication indicates open
- OPEN/CLOSED indicating lights indicate open
- overcurrent trip flags are actuated on all phases
- load-side voltmeter indicates zero voltage
- load-side ammeter indicates zero amperes

A. open, racked in, with an overload condition indicated

B. open, racked in, with no overload condition indicated

C. open, racked out, with an overload condition indicated

D. open, racked out, with no overload condition indicated

4. Which of the following available local circuit breaker indications would be a positive method for identifying whether a circuit breaker is closed or open?

A. overcurrent trip flags and load-side ammeter

B. OPEN/CLOSED mechanical flag indication and load-side voltage

C. OPEN/CLOSED indicating lights and overcurrent trip flags

D. load-side ammeter and OPEN/CLOSED indicating lights

5. Which of the following available local circuit breaker indications must be reset after operation to ensure reliable indication is being provided?

   A. OPEN/CLOSED mechanical flag

   B. OPEN/CLOSED indicating lights

   C. overcurrent trip flags

   D. spring CHARGE/DISCHARGE flag

6. Circuit breaker local overcurrent trip flag indicators

   A. indicate overcurrent conditions only during the actual overcurrent condition

   B. mean that the associated circuit breaker has failed to trip open, if actuated

   C. are normally disconnected; therefore provide no useful function

   D. should be reported to the control room if found to be actuated

7. Loss of breaker control power on a large operating motor would

   A. trip the breaker

   B. leave the motor operating, but the breaker could be tripped remotely

   C. leave the motor operating, but the breaker could only be tripped locally at the breaker

D. have no effect

8. Which of the following would cause a loss of ability to remotely trip a circuit breaker and a loss of position indication?

   A. loss of breaker control power

   B. failure of breaker control switch

   C. mechanical binding of breaker

   D. breaker in operate position

9. Which of the following would not be a consequence of a loss of circuit breaker control power?

   A. loss of all remote breaker controls

   B. loss of all breaker protective trips

   C. inability to locally close the breaker

   D. loss of remote breaker position indication

10. Which of the following results from a loss of circuit breaker control power to a circuit breaker supplying a motor?

A. Motor ammeter indication would be zero regardless of actual breaker position.

B. Breaker position would remotely indicate closed regardless of actual position.

C. Breaker would trip open due to the actuation of its protective trip device.

D. Close spring charging motor would not charge spring following local tripping of the breaker

11. A thermal overload protective device protects a motor by

A. adding series resistors to limit starting current

B. adding parallel resistors to limit starting current

C. shutting off the motor if current becomes excessive

D. slowing down the motor if current becomes excessive

12. For a motor which condition would not require a thermal overload protective device to function?

A. running speed is too high

B. starting current is too high

C. ambient temperature is too hot

D. intermittent or sudden heavy loads

13. Which of the following consequences is not probable if a motor's thermal overload protective device fails to function?

A. excessive bearing wear due to expanding metals

B. mechanical damage due to overspeeding the motor

C. deterioration of winding insulation due to excessive current flow

D. damaging current flows due to shorting of the windings

14. In a motor, potential damage due to intermittent or sudden heavy loads can best be prevented by which type of protective device?

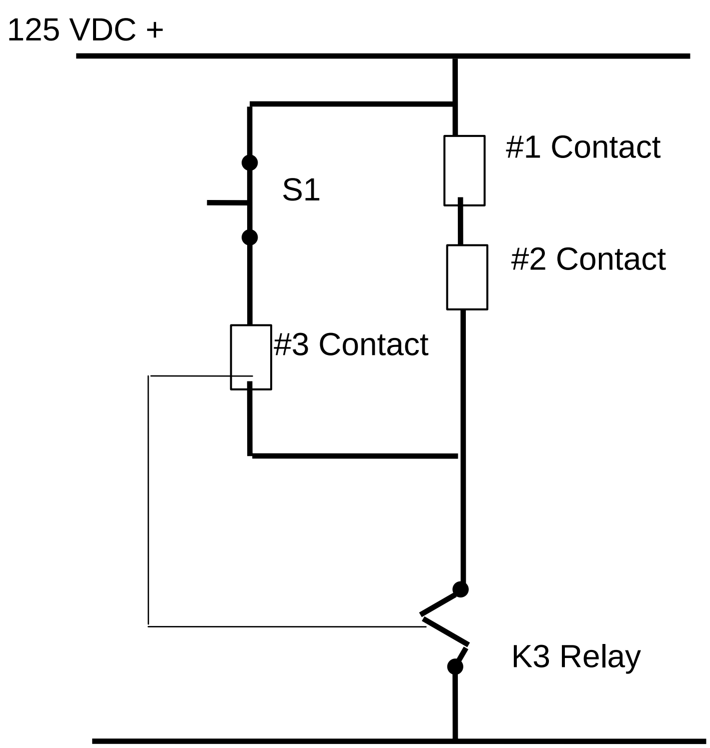
A. thermal overload

B. reverse power

C. underfrequency

D. undervoltage

FIGURE 11



15. Refer to above Figure:

With the K-3 relay energized, pushing the S-1 pushbutton _____ the K-3 relay when contacts #1 and #2 are ___________.

A. tests, closed

B. deenergizers, open

C. defeats, closed

D. has no effect on, open

16. Which best describes the function of the #3 contact in Figure 11?

A. to keep the relay energized

B. to initially energize the relay

C. to reduce inadvertent relay chatter

D. to momentarily energize, then deenergize, the relay

17. Referring to the figure above, select the correct statement regarding the operation of relay K3.

    A. deenergized when the #1 and #2 contacts close

    B. energized when pushbutton S1 is depressed

    C. energized when the #1 <u>or</u> #2 contact closes

    D. energized when the #1 <u>and</u> #2 contacts close

18. What best describes the arrangement of contacts in the above Figure?

    A. 1 & 2 in series and in parallel with 3

    B. 1 & 3 in series and in parallel with 2

    C. 1 & 2 in parallel and in series with 3

    D. 1 & 3 in parallel and in series with 2

19. Which of the following control room indications <u>alone</u> would identify breaker status?

    A. breaker red indicating light

    B. breaker green indicating light

    C. load amps greater than zero

    D. breaker control switch position

20. Using the control room information listed below, determine breaker status

- red (energized) (closed) indicating light “off“
- green (deenergized) (open) indicating light “off“
- load amps indicate normal load current

A. open

B. shut

C. in trip-free position

D. racked-out

APPENDIX A

Representation of Device Contacts on Electrical Diagrams

On Electrical diagrams all contacts should be shown in the de-energized or non-operated position of the main device.

On relays, or other electromagnetically operated devices, the contacts should be shown in the position they assume with all coils deenergized. In the case of relays or devices that operate in response to other than electrical quantities the energizing influences for such devices are considered to be respectively, as follows:

Relay or Device	Engineering Influence
temperature	rising temperature
level	rising level
flow	increasing flow
speed	rising speed
vibration	increasing vibration
pressure	increasing pressure
vacuum	increasing pressure

Hence the contact of these devices should be shown in the position that they assume when the quantities to which they respond are at their lowest value.

High vacuum is merely low pressure and so the contacts of vacuum relays should be shown in the position they assume with a perfect vacuum.

On circuit breakers and disconnecting switches, the main and auxiliary contacts should be shown in the position they assume when these main circuit devices are in the open position. On valves, the auxiliary contacts should be shown with the valve in the closed position.

<u>APPENDIX A</u> (Con't)

On speed, voltage, current load or similar adjusting devices, comprising rheostats, springs, levers or other components for the purpose, the auxiliary contacts should be shown in the position corresponding to the lowest adjustment of the above quantities.

Note: When these adjusting devices are motor operated and are provided with limit switches for the motor circuit, the limit switches used for controlling the motor, and only these, should be shown in the position they assume when the device is in position between the extreme limits of travel.

In the case of devices, which have no deenergized or non-operated position, such as manually-operated transfer or control switches or auxiliary position indicating contacts on the housings or enclosures of a removable circuit breaker unit, the preferred method of showing the contacts of these devices is normally open. Each contact should, however, be identified on the elementary diagram as to when it closes. For example, the contacts of the Manual Automatic Transfer Switch #43 which are closed in the automatic position would be identified with the letter "A", and those that are closed in the manual position would be identified with the letter "M", and the auxiliary position switches on the housing 52H of a removable circuit breaker unit which are closed when the unit is in the connected position may be identified by the suffix letters "IN" and those which are closed when the unit is withdrawn from the housing may be identified by the suffix letters "OUT".

On special types of devices not described above, such as electrically operated latched-in relays or contactors or other devices which have no deenergized or no operated position, their contacts should be shown in the position most suitable for the ready understanding of the operation of the devices in the equipment and sufficient description should be present, as necessary, on the elementary diagram to indicate the contact operation.

APPENDIX B

Valve Position Nomenclature

Device Number 20, the valve, is an extremely important adjunct to pipeline operation. Valves occur in great numbers, varied locations and applications and employ various means of actuation. Even when operated non-electrically they frequently incorporate auxiliary switches carrying electrical circuits for position indication and interlocking in the electric system. It is often desirable to convey knowledge of these conditions in the device number. It is particularly useful to designate the operation of all activated auxiliary switch contacts. To accomplish these objectives a selection of suffixes is recommended for use with Device Number 20.

The proposed use of suffixes ac, ao, bc, bo, tc and to for valve operators is an extension of paragraph 2-9.4.4.2 of C37.1-1956, which provides for special auxiliary switch designators in addition to the standard a, b, aa, and bb auxiliary switches for circuit breakers. The employment of characters is such that the first letter indicates the condition of auxiliary switch, contact corresponding to the position of valve as indicated by the second letter. The following considerations will further clarify the nomenclature employed.

Letters o and c represent respectively the fully-open and fully-closed position of the valve. A percentage figure in lieu of c or o indicates a zone of valve traverse, in percent of full travel, measured from the fully-closed position. A closed valve corresponds to an open breaker (non-operative) and an open valve corresponds to a closed breaker (operative). In the case of a breaker being closed, ordinarily the exact point at which an "a" auxiliary switch closes or a "b" switch opens is not critical. But in the case of a valve being opened it may be necessary to perform separate opening or closing operations of auxiliary switch contacts (1) when the valve leaves the closed position and (2) when the valve reaches the open position. Thus the terminology used with circuit breakers does not suffice for valves, and extensions of the "a" and "b" switch concepts are employed, wherein:

ac - An "a" switch operative at the "closed" valve position. Switch is open in closed valve position, closes when valve leaves closed position, reopens when valve returns to closed position. Switch is open only when valve is fully closed.

ao - An "a" switch operative at the "open" valve position. Switch is open in closed valve position, closes when valve reaches open position, reopens when valve leaves open position. Switch is open except when valve is fully open.

bc - A "b" switch operative at the "closed" valve position. Switch is closed in closed valve position, opens when valve leaves closed position, recloses when valve returns to the closed position. Switch is closed only when valve is fully closed.

bo - A "b" switch operative at the "open" valve position. Switch is closed in closed valve position, opens when valve reaches open position, recloses when valve leaves open position. Switch is closed except when valve is fully open.

APPENDIX B (Con't)

a10% - An "a" switch operative at the "10% open" valve position. Switch is open in closed valve position, close when valve reaches 10% open position, reopens when valve returns to 10% open position. Switch is open except when valve is 10% or more open.

b10% - A "b" switch operative at the "10% open" valve position. Switch is closed in closed valve position, opens when valve reaches 10% open position, recloses when valve returns to 10% open position. Switch is closed except when valve is 10% or more open.

This nomenclature is further clarified by an operation chart incorporated in the Proposed Standard (Figure ES3.5).

It will be observed that the first letter indicates type of auxiliary switch by position of contact when valve is non-operative. While the second character indicates the position of the valve at which the auxiliary switch operates.

APPENDIX C

Electrical Elementary Device Numbers and Functions

1. Master Element is the initiating device, such as a control switch, voltage relay, float switch, etc., which serves either directly, or through such permissive devices as protective and time-delay relays to place an equipment in or out of operation.

2. Time-delay starting, or closing, relay is a device which functions to give a desired amount of time delay before or after any point or operation in a switching sequence or protective relay system, except as specifically provided by device functions 62 and 79 described later.

3. Checking or interlocking relay is a device which operates in response to the position of a number of other devices, or to a number of predetermined conditions in an equipment to allow an operating sequence to proceed, to stop, or to provide a check of the position of these devices or of these conditions for any purpose.

4. Master contactor is a device, generally controlled by device No. 1 or equivalent, and the necessary permissive and protective devices, which serves to make and break the necessary control circuits to place an equipment into operation under the desired conditions and to take it out of operation under other or abnormal conditions.

5. Stopping device functions to place and hold an equipment out of operation.

6. Starting circuit breaker is device whose principal functions is to connect a machine to its source of starting voltage.

7. Anode circuit breaker is one used in the anode circuits of a power rectifier for the primary purpose of interrupting the rectifier circuit if an arc back should occur.

8. Control power disconnecting device is a disconnective device - such as a knife switch, circuit breaker or pullout fuse block - used for the purpose of connecting and disconnecting, respectively, the source of control power to and from the control bus or equipment.

   Note: Control power is considered to include auxiliary power which supplies such apparatus as small motors and heaters.

9. Reversing device is used for the purpose of reversing a machine field or for performing any other reversing functions.

10. Unit sequence switch is used to change the sequence in which units may be placed in and out of service in multiple-unit equipment.

11. Reserved for future application.

12. Over-speed device is usually a direct-connected speed switch which functions on machine over-speed.

13. Synchronous-speed device, such as a centrifugal-speed switch, a slip-frequency relay, a voltage relay, an undercurrent relay or any type of device, operates at approximately synchronous speed of a machine.

14. Under-speed device functions when the speed of a machine fails below a predetermined value.

15. Speed or frequency, matching device functions to match and hold the speed or the frequency of a machine of a system equal to or approximately equal to, that of another machine source or system.

16. Reversed for future application.

17. Shunting or discharge switch serves to open or to close a shunting circuit around any piece of apparatus (except a resistor), such as a machine field, a machine armature, a capacitor or a reactor.

18. Accelerating or decelerating device is used to close or to cause the closing of circuits which are used to increase or to decrease the speed of a machine.

19. Starting-to-running transition contactor is a device which operates to initiate or cause the automatic transfer of a machine from the starting to the running power connection.

20. Electrically operated valve is a solenoid or motor-operated valve which is used in vacuum, air, gas, oil, water, or similar lines.

    Note: The function of the valve may be indicated by the insertion of descriptive words such as "Brake" or "Pressure Reducing" in the function name, such as "Electrically Operated Brake Valve".

21. Distance relay is a device which functions when the circuit admittance, impedance, or reactance increases or decreases beyond predetermined limits.

22. Equalizer circuit breaker is a breaker which serves to control or to make and break the equalizer, or the current-balancing connections for a machine held, or for regulating equipment in a multiple-unit installation.

23. Temperature control device functions to raise or to lower the temperature of a machine or other apparatus, or of any medium, when its temperature falls below, or rises above, a predetermined value.

    Note: An example is a thermostat which switches on a space heater in a switchgear assembly when the temperature fails to a desired value as distinguished from a device which is used to provide automatic temperature regulation between close limits and would be designated as 90T.

24. Reserved for future application.

25. Synchronizing or synchronism-check device operates when two ac circuits are within the desired limits of frequency, phase angel or voltage, to permit or to cause the paralleling of these two circuits.

26. Apparatus thermal device functions when the temperature of the shunt field or the armortisseur winding of a machine, or that of all load limiting or load shifting resistors, or of a liquid or other medium exceeds a predetermined value: or if the temperature of the protected apparatus, such as a power rectifier, or of any medium decreases below a predetermined value.

27. Undervoltage relay is a device which functions on a given value of undervoltage.

28. Reserved for future application.

29. Isolating contactor is used expressly for disconnecting one circuit from another for the purposes of emergency operation, maintenance, or test.

30. Annunciator relay is a non-automatically reset device which gives a number of separate visual indications upon the functioning of protective devices, and which may also be arranged to perform a lockout function.

31. Separate excitation device connects a circuit such as the shunt field of a synchronous converter to a source of separate excitation during the starting sequence; or one which energizes the excitation and ignition circuits of a power rectifier.

32. Directional power relay is one which functions on a desired value of power flow in a given direction, or upon reverse power resulting from arc back in the anode or cathode circuits of power rectifier.

33. Position switch make or breaks contact when the main device or piece of apparatus, which had no device function number reaches a given position.

34. Motor-operated sequence switch is a multi-contact switch which fixes the operating sequence of the major devices during starting and stopping, or during other sequential switching operations.

35. Brush-operating, or slip-ring-short-circuiting, device is used for raising, lowering, or shifting the brushes of a machine, or for short-circuiting its slip rings, or for engaging or disengaging the contacts of a mechanical rectifier.

36. Polarity device operates or permits the operation of another device on a predetermined polarity only.

37. Undercurrent or underpower relay is a device which functions when the current or power flow decreases below a predetermined value.

38. Bearing protective device is one which functions on excessive bearing temperature, or on other abnormal mechanical conditions, such as undue wear, which may eventually result in excessive bearing temperature.

39. Reserved for future application.

40. Field relay is a device that functions on a given or abnormally low value of failure of machine field current, or on an excessive value of the reactive component of armature current in an ac machine indicating abnormally low field excitation.

41. Field circuit breaker is a device which functions to apply, or to remove, the field excitation of a machine.

42. Running circuit breaker is a device whose principal function is to connect a machine to its source of running voltage after having been brought up to the desired speed on the starting connection.

43. Manual transfer or selector device transfers the control circuits so as to modify the plan of operation of the switching equipment or of some of the devices.

44. Unit sequence starting relay is a device which functions to start the next available unit in a multiple-unit equipment on the failure or on the non-availability of the normally preceding unit.

45. Reserved for future application.

46. Reverse-phase, or phase-balance, current relay is a device which functions when the poly-phase currents are of reverse-phase sequence, or when the poly-phase currents are unbalanced or contain negative phase-sequences components above a given amount.

47. Phase-sequence voltage relay is a device which functions upon a predetermined value of poly-phase voltage in the desired phase sequence.

48. Incomplete sequence relay is a device which returns the equipment to the normal, or off, position and locks it out if the normal starting, operating or stopping sequence is not properly completed within a predetermined time.

49. Machine, or transformer, thermal relay is a device which functions when the temperature of an ac machine armature, or of the armature or other load carrying winding or element of a dc machine, or converter or power rectifier or power transformer (including a power rectifier transformer) exceeds a predetermined value.

50. Instantaneous overcurrent, or rate-of-rise relay is a device which functions instantaneously on an excessive value of current, or on an excessive rate of current rise, thus indicating a fault in the apparatus of circuit being protected.

51. AC time overcurrent relay is a device with either a definite or inverse time characteristic which functions when the current in an ac circuit exceeds a predetermined value.

52. Ac circuit breaker is a device which is used to close and interrupt an ac power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

53. Exciter or dc generator relay is a device which forces the dc machine field excitation to build up during starting or which functions when the machine voltage has built up to a given value.

54. High-speed dc circuit breaker is a device which starts to reduce the current in the main circuit in 0.01 second or less, after the occurrence of the dc overcurrent or the excessive rate of current rise.

55. Power factor relay is a device which operates when the power factor in an ac circuit becomes above or below a predetermined value.

56. Field application relay is device which automatically controls the application of the field excitation to an ac motor at some predetermined point in the slip cycle.

57. Short-circuiting or grounding device is a power or stored energy operated device which functions to short-circuit to ground a circuit in response to automatic or manual means.

58. Power rectifier misfire relay is a device which functions if one or more of the power rectifier anodes fails to fire.

59. Overvoltage relay is a device which functions on a given value of overvoltage.

59. Overvoltage relay is a device which functions on a given value of overvoltage.

60. Voltage balance relay is a device which operates on a given difference in voltage between two circuits.

61. Current balance relay is a device which operates on a given difference in current input or output to two circuits.

62. Time-delay stopping or opening relay is time-delay device which serves in conjunction with the device which initiates the shutdown, stopping, or opening operation in an automatic sequence.

63. Liquid or gas pressure, level, or flow relay is device which operates on given values of liquid or gas pressure flow, or level, or on a given rate of change of these values.

64. Ground protective relay is a device which functions on failure of the insulation of a machine, transformer or of other apparatus to ground, or on flashover of a dc machine to ground.

    Note: This function is assigned only to a relay which detects the flow of current from the frame of a machine or enclosing case of structure of a piece of apparatus to ground, or detects a ground on a normally ungrounded winding or circuit. It is not applied to a device connected in the secondary circuit or secondary neutral of a current transformer or current transformers connected in the power circuit of a normally grounded system.

65. Governor is the equipment which controls the gate or valve opening of prime mover.

66. Notching or jogging device functions to allow only a specified number of operations of a given device, or equipment, or a specified number of successive operations within a given time of each other. It also functions to energize a circuit periodically, or which is used to permit intermittent acceleration or jogging of a machine at low speeds for mechanical positioning.

67. Ac directional overcurrent relay is a device which functions on a desired value of ac overcurrent flowing in a predetermined direction.

68. Blocking relay is a device which initiates a pilot signal for blocking or tripping on external faults in a transmission line or in other apparatus under predetermined conditions, or cooperates with other devices to block tripping or to block reclosing on an out-of-step condition or on power swings.

69. Permissive control device is generally a two-position, manually operated switch which in one position permit the closing of a circuit breaker or the placing of an equipment into operation, and in the other position prevents the circuit breaker or the equipment from being operated.

70. Electrically operated theostat is a rheostat which is used to vary the resistance of a circuit in response to some means of electrical control.

71. Reserved for future application.

72. Dc circuit breaker is used to close and interrupt a dc power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

73. Load-resistor contactor is used to shunt or insert a step of load limiting, shifting, or indicating resistance in a power circuit, or to switch a space heater in circuit, or to switch a light, or regenerative, load resistor of a power rectifier or other machine in and out of circuit.

74. Alarm relay is a device other than an annunciator, as covered under device No. 30, which is used to operate, or to operate in connection with, a visual or audible alarm.

75. Position changing mechanism is the mechanism which is used to moving a removable circuit breaker unit to and from the connected, disconnected and test positions.

76. Dc overcurrent relay is a device which functions when the current in a dc circuit exceed a given value.

77. Pulse transmitter is used to generate and transmit pulses over a telemetering or pilot-wire circuit to the remote indicating or receiving device.

78. Phase angle measuring, or out of step protective relay is a device which functions at a predetermined phase angle between two voltage or between two currents or between voltage and current.

79. Ac reclosing relay is device which controls the automatic reclosing and locking out of an ac circuit interrupter.

80. Reserved for future application.

81. Frequency relay is a device which functions on a predetermined value of frequency -either under, or over, or on normal system frequency - or rate of change of frequency.

82. Dc reclosing relay is a device which controls the automatic closing and reclosing of dc circuit interrupter, generally in response to load circuit conditions.

83. Automatic selective control or transfer relay is a device which operates to select automatically between certain sources or conditions in an equipment, or performs a transfer operation automatically.

84. Operating mechanism is the complete electrical mechanism or servo-mechanism, including the operating motor, solenoids position switches, etc., for a tap changer, induction regulator or any piece of apparatus which has no device function number.

APPENDIX C (Con't)

85. Carrier or pilot-wire receiver relay is a device which is operated or restrained by a signal used in connection with carrier-current or dc pilot-wire fault directional relaying.

86. Locking-out relay is an electrically operated hand or electrically reset device which functions to shut down and hold an equipment out of service on the occurrence of abnormal conditions.

87. Differential protective relay is a protective device which functions on a percentage or phase angle or other quantitative difference of two currents or of some other electrical quantities.

88. Auxiliary motor or motor generator is one used for operating auxiliary equipment such as pumps, blowers, exciters, rotating magnetic amplifier, etc.

89. Line switch is used as a disconnecting or isolating switch in an ac or dc power circuit, when this device is electrically operated or has electrical accessories, such as an auxiliary sw switch, magnetic lock, etc.

90. Regulating device functions to regulate a quantity, or quantities, such as voltage, current, power, speed, frequency, temperature, and load, at certain value or between certain limits for machines, tie lines or other apparatus.

91. Voltage directional relay is a device which operates when the voltage across an open circuit breaker or contactor exceeds a given value in a given direction.

92. Voltage and power directional relay is a device which permits or cause the connection of two circuits when the voltage difference between them exceeds a given value in a predetermined direction and causes these two circuits to be disconnected from each other when the power flowing between them exceeds a given value in the opposite direction.

93. Field changing contactor functions to increase or decrease in one step the value of field excitation on a machine.

94. Tripping or trip-free relay is a device which functions to trip a circuit breaker, contactor, or equipment, or to permit immediate tripping by other devices; or to prevent immediate reclosure of a circuit interrupter, in case it should open automatically even though its closing circuit is maintained closed.

95. Used only for specific applications on individual installations where none of the assigned numbered functions from 1 to 94 is suitable.

96. Used only for specific applications on individual installations where none of the assigned numbered functions from 1 to 94 is suitable.

97. Used only for specific applications on individual installations where none of the assigned numbered functions from 1 to 94 is suitable.

98. Used only for specific applications on individual installations where none of the assigned numbered functions from 1 to 94 is suitable.

APPENDIX C (Con't)

99. Used only for specific applications on individual installations where none of the assigned numbered functions from 1 to 94 is suitable.

Note: A similar series of numbers, starting with 201 instead of 1, shall be used for those device functions in a machine, feeder, or other equipment when these are controlled directly from the supervisory system.

Typical examples of such device functions are 201, 205, and 294.

APPENDIX C (Con't)

Devices Performing More Than One Function

These letters denote parts of the main device, divided in the two following categories:

All parts, except auxiliary contacts and limit switches are covered later, such as:

BB	-	bucking bar (for high speed dc circuit breakers)
BK	-	brake
C	-	coil, or condenser, or capacitor
CC	-	closing coil
HC	-	holding coil
IS	-	inductive shunt
L	-	Lower operating coil
M	-	operating motor
MF	-	fly-ball motor
ML	-	load-limit motor
MS	-	speed adjusting, or synchronizing, motor
S	-	solenoid
TC	-	trip coil
U	-	upper operating coil
V	-	valve

All auxiliary contacts and limit switches for such device and equipment as circuit breaker, contactors valve and rheostats. These are designated as follows:

a	-	Auxiliary switch, open when the main device is in the de-energized or non-operated position.
b	-	Auxiliary switch, closed when the main device is in the deenergized or non-operated position.

aa - Auxiliary switch, open when the operating mechanism of the main device in the deenergized or non-operated position.

bb - Auxiliary switch, closed when the operating mechanism of the main device is in the deenergize or non-operated position.

e, f, h, etc., ab, ac, ad, etc., or ba, bc, bd, etc., are special auxiliary switches other than a, b, aa, and bb. Lower-case (small) letters are to be used for the above auxiliary switches.

LC - Latch-checking switch, closed when the circuit breaker-mechanism linkage is relatched after an opening operation of the circuit breaker.

LS - limit switch.

These letters cover all other distinguishing features or characteristics or conditions, which serve to describe the use of the device or its contacts in the equipment such as:

A - accelerating, or automatic
B - blocking, or backup
C - close, or cold
D - decelerating, detonate, or down
E - emergency
F - failure, or forward
H - hot, or high
HR - Hand rest
HS - high speed
L - left, or local, or low, or lower or leading
M - manual
OFF - off
ON - on
O - open

P	-	polarizing
R	-	right, or raise, or reclosing, or receiving, or remote, or reverse
S	-	sending, or swing
T	-	test, or trip, trailing
TDC	-	time-delay closing
TDO	-	time-delay opening
U	-	up

ELECTRICAL ELEMENTARY DIAGRAM GENERAL INDEX

DELETED
(REFER TO DRAWING B-208-001-~-I1)

Figure ES3.1

REACTOR COOLANT (RC)
B-208-082-RCI1

SHEET NO.	TITLE
RCI1	INDEX
RCC1	REACTOR COOLANT PUMP A (XPP30A)
RC02	REACTOR COOLANT PUMP B (XPP30B)
RC03	REACTOR COOLANT PUMP C (XPP30C)
RC04	REACTOR COOLANT PUMP A OIL LIFT PUMP
RC05	REACTOR COOLANT PUMP B OIL LIFT PUMP
RC06	REACTOR COOLANT PUMP C OIL LIFT PUMP
RC07	PRESSURIZER HEATER CONTROL GROUP (APN4103)
RC08	PRESSURIZER HEATER BACKUP CONTROL GROUP 1 (APN4101)
RC09	PRESSURIZER HEATER BACKUP CONTROL GROUP 2 (APN4102)
RC10	PRESSURIZER RELIEF ISOLATION VALVE 8000A (XVG8000A)
RC11	PRESSURIZER RELIEF ISOLATION VALVE 8000B (XVG8000B)
RC12	PRESSURIZER RELIEF ISOLATION VALVE 8000C (XVG8000C)
RC13	REACTOR COOLANT PUMPS A, B, C SPACE HEATERS
RC14	REACTOR HEAD VENT VALVE TO PRESSURIZER RELIEF TANK
RC15	REACTOR HEAD VENT VALVE TO PRESSURIZER RELIEF TANK
RC16	REACTOR HEAD VENT VALVE TO PRESSURIZER RELIEF TANK
RC17	REACTOR HEAD VENT VALVE TO PRESSURIZER RELIEF TANK
RC18	REACTOR COOLANT PUMPS LOCKED ROTOR PROTECTION

SHEET NO.	TITLE
RC50	PRESSURZIER POWER RELIEF VALVE (PCV-444B)
RC51	PRESSURIZER POWER RELIEF VALVE (PCV-445A)
RC52	PRESSURIZER POWER RELIEF VALVE (PCV-445B)
RC53	PRESSURIZER RELIEF TANK PRIMARY WATER (XVD-8028)
RC54	PRESSURIZER RELIEF TANK PRIMARY WATER (XVG-8030)
RC55	PRESSURIZER RELIEF TANK DRAIN (XVG-8031)
RC56	REACTOR VESSEL LEAK-OFF VALVE (XVG-8032)
RC57	PRESSURIZER RELIEF TANK TO GAS DECAY VALVE (XVD-8033)
RC58	PRESSURIZER RELIEF TANK TO GAS DECAY VALVE (XVD-8047)
RC59	NOT USED
RC60	PRESSURIZER SI BLOCK RESET TRAIN A
RC61	PRESSURIZER SI BLOCK RESET TRAIN B
RC62	PRESSURIZER LEVEL CONTROL SWITCH
RC63	PRESSURIZER LEVEL RECORD SWITCH
RC64	DT-TAVG PROTECT SWITCH
RC65	HI-TAVG CONTROL SELECT SWITCH
RC66	HI-DT CONTROL SELECT SWITCH
RC67	TURBINE 1ST STAGE PRESSURE SELECT SWITCH
RC68	PRESSURIZER PRESSURE AND LEVEL
RC69	PRESSURIZER PRESSURE AND LEVEL
RC70	PRESSURIZER PRESSURE AND LEVEL
RC71	REACTOR COOLANT SYSTEM ALARMS
RC72	RCS COLD OVER PRESSURIZATION RELAYS
RC73	RCS COLD OVER PRESSURIZATION ALARM RELAYS
RC74	PRESSURIZER SAFETY VALVE INDICATION
RC77	PRESSURIZER SPRAY VALVE PCV-444C
RC78	PRESSURIZER SPRAY VALVE PCV-444D
RC79	REACTOR COOLANT SYSTEM ALARMS
RC80	REACTOR COOLANT SYSTEM ALARMS
RC81	REACTOR COOLANT SYSTEM ALARMS
RC82	REACTOR COOLANT SYSTEM ALARMS
RC83	REACTOR COOLANT SYSTEM ALARMS
RC84	REACTOR COOLANT SYSTEM ALARMS
RC85	REACTOR COOLANT SYSTEM ALARMS
RC86	RVLIS TRAIN A HYDRAULIC ISOLATOR STATUS
RC87	RVLIS TRAIN B HYDRAULIC ISOLATOR STATUS
RC88	MISCELLANEOUS ALARMS REACTOR COOLANT SYSTEM

Figure ES3.2

WESTINGHOUSE ELECTRICAL SYMBOLS

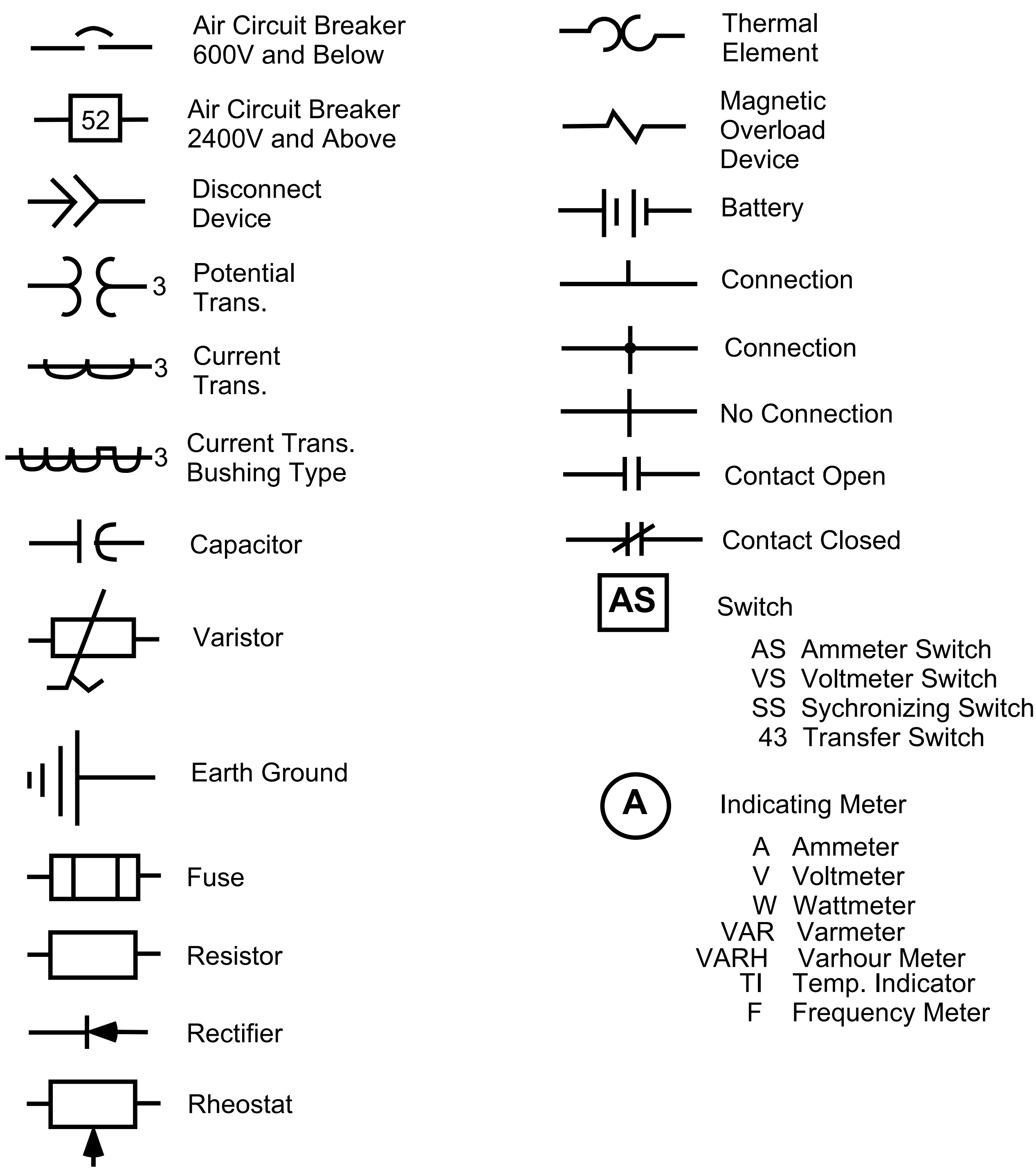
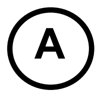


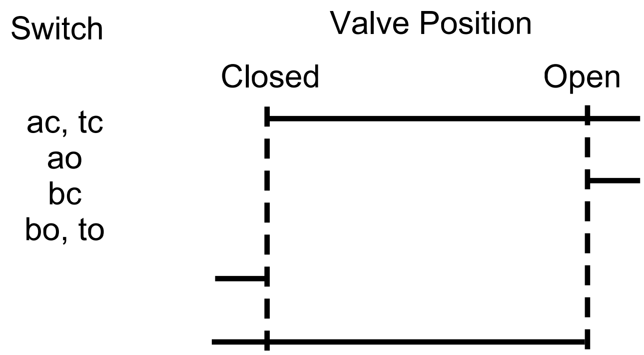
Figure ES3.3

ES3.3*1

WESTINGHOUSE ELECTRICAL SYMBOLS
CONTINUED

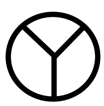


Indicating Light
A Amber
B Blue
C Clear
G Green
R Red
W White

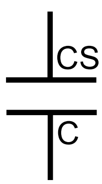


Relay

Motor - 100 hp

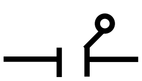


Generator



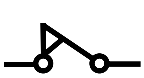
Breaker Control
Switch at Swgr.

C Close
T Trip



Limit Switch - Valve

ac Open only when valve is fully closed
ao Open except when valve is fully open
bc Closed only when valve is fully closed
bo Closed except when valve is fully open



Torque Switch - Valve

tc Open by torque - responsive mechanism, to stop valve closing
to Opened by torque - responsive mechanism, to stop valve opening

Figure ES3.4

ES3.4*1

GAI ELECTRICAL SYMBOLS

CONTINUED

Limit Switch Development for Air Operated Valves and Dampers

	Limit Switch	Device Position: Full Close		Device Position: Full Open
Switch Actuated Device Closed	33 bc	▬		
	33 bc	▬		
	33 ac		▬	▬
	33 ac		▬	▬
Switch Actuated Device Open	33 ao			▬
	33 ao			▬
	33 bo	▬	▬	
	33 bo	▬	▬	

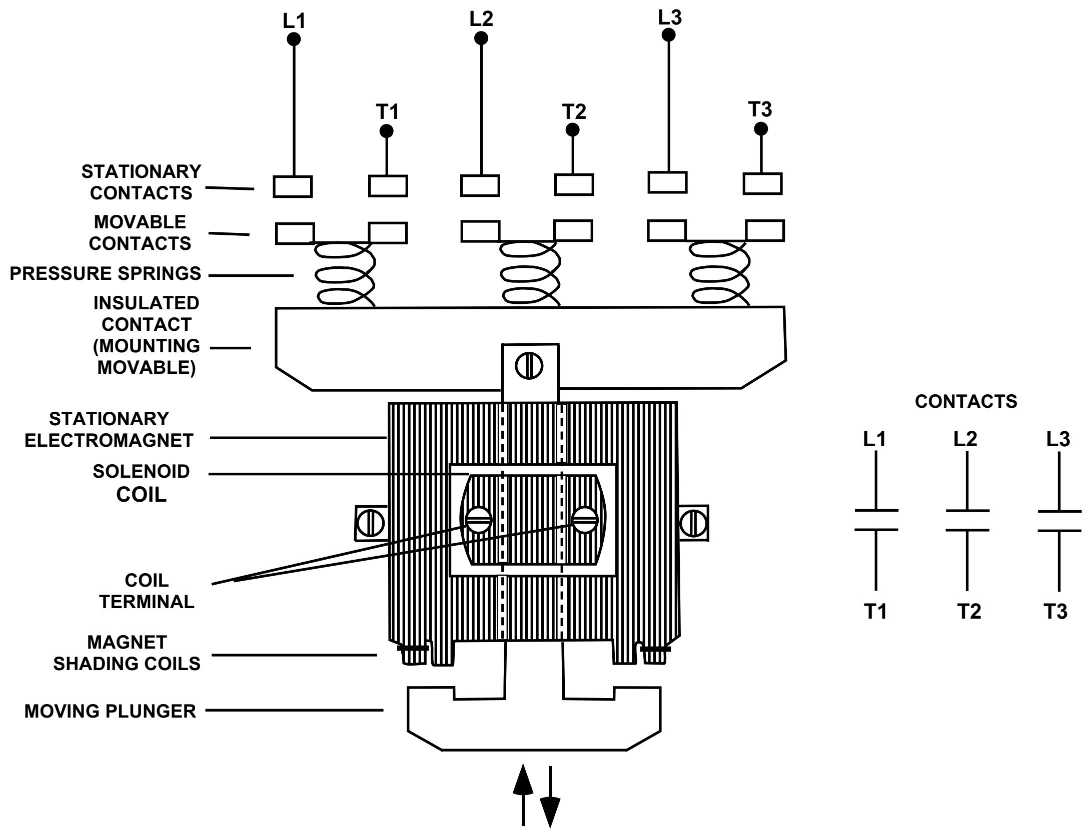
Limit Switch Development - Limitorque Operation

ROTOR	Position Switch	CONT	Device Position: Full Close		Device Position: Full Open
1	33 ao	1			▬
	33 ao	2			▬
	33 bo	3	▬	▬	
	33 bo	4	▬	▬	
2	33 bc	5	▬		
	33 bc	6	▬		
	33 ac	7		▬	▬
	33 ac	8		▬	▬
3	33 ao	9			▬
	33 ao	10			▬
	33 bo	11	▬	▬	
	33 bo	12	▬	▬	
4	33 bc	13	▬		
	33 bc	14	▬		
	33 ac	15		▬	▬
	33 ac	16		▬	▬

Figure ES3.5

ES3.5*1

MOTOR CONTROL CENTER (MCC) RELAYING

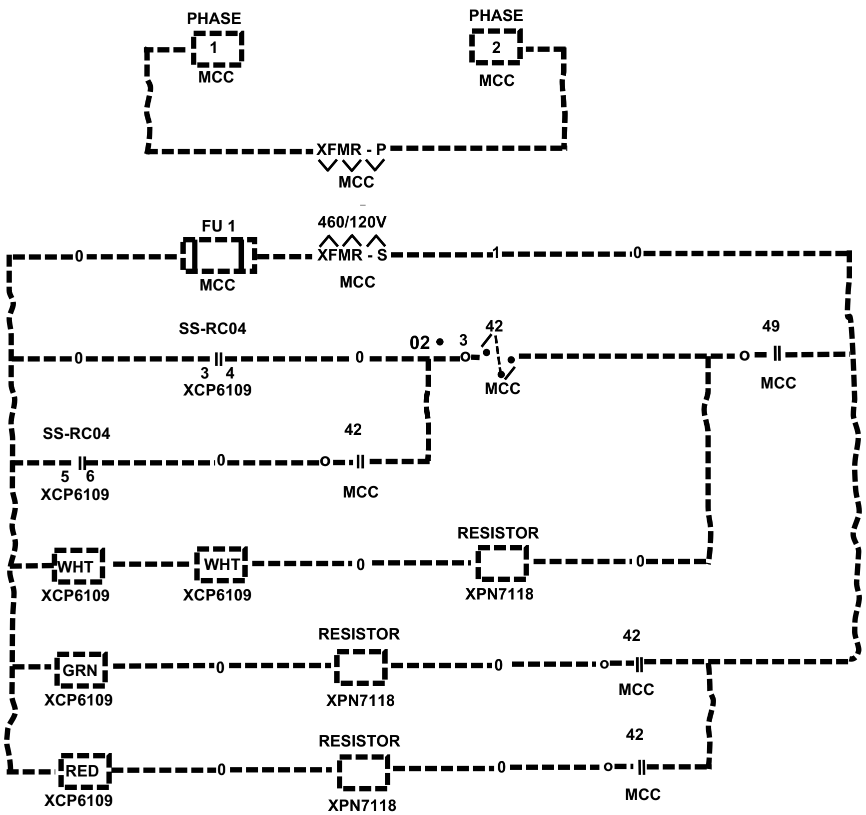


Three-pole, solenoid operated magnetic switch.

Figure ES3.6

ES3.6*1

RCP 'A' OIL LIFT PUMP



COMPONENT RELATED NOTES

01 CLOSE ON 700 PSIG INCR OLP DISCH PRESS (CKT 2) 1MS-07-115-3

02 TO REACTOR COOLANT SYSTEM ALARMS, SEE RC79

03 TO REACTOR COOLANT PUMP A (XPP30A), SEE RC01

GENERAL DRAWING NOTES

A REFERENCE 1MS-41-012-60.

B DEVICES INDICATED IN "MCC" ARE LOCATED IN XMC1C3X UNIT # 6AD

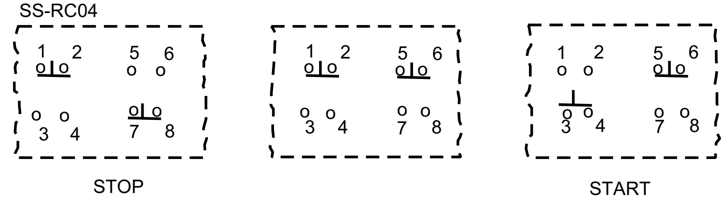
WIRE MARK LISTS

MCC #02, #03, #04, #05, #08, #12

XPN7118 #02, #03, #04, #05, #08, #12

THE LAST WIRE MARK NUMBER 12

SS-RC04



MICROSWITCH CMC #910-PGD-53-3, PTCC
SPRING RETURN START AND STOP TO NORMAL

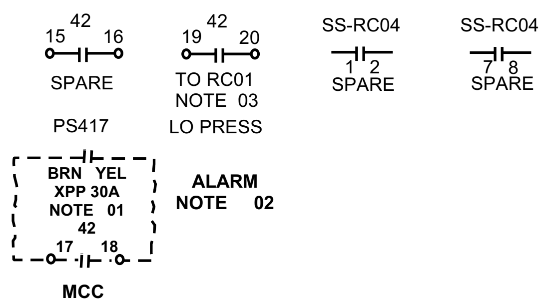


Figure ES3.7

ES3.7*1

LIMITORQUE VALVE OPERATOR

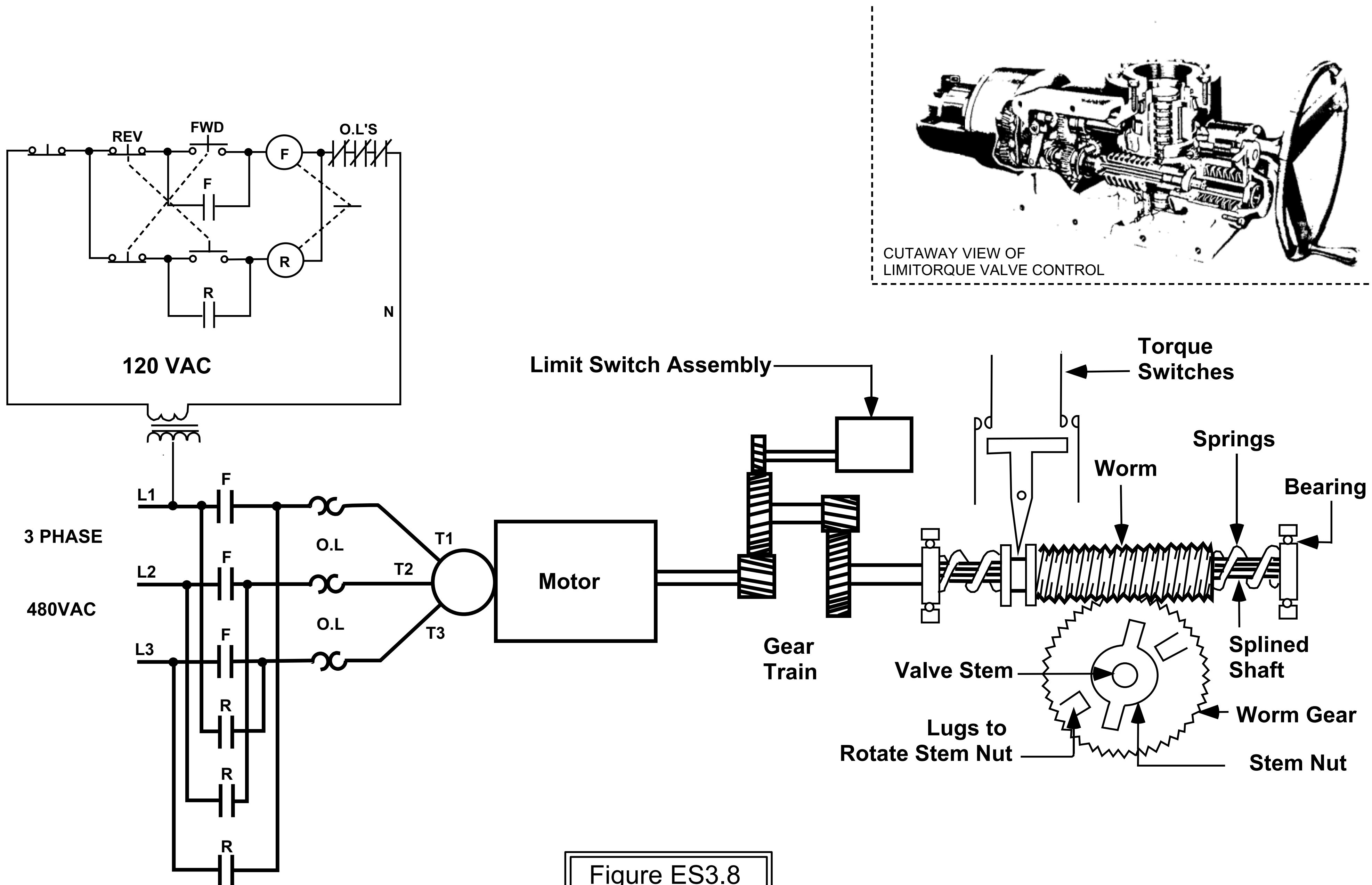
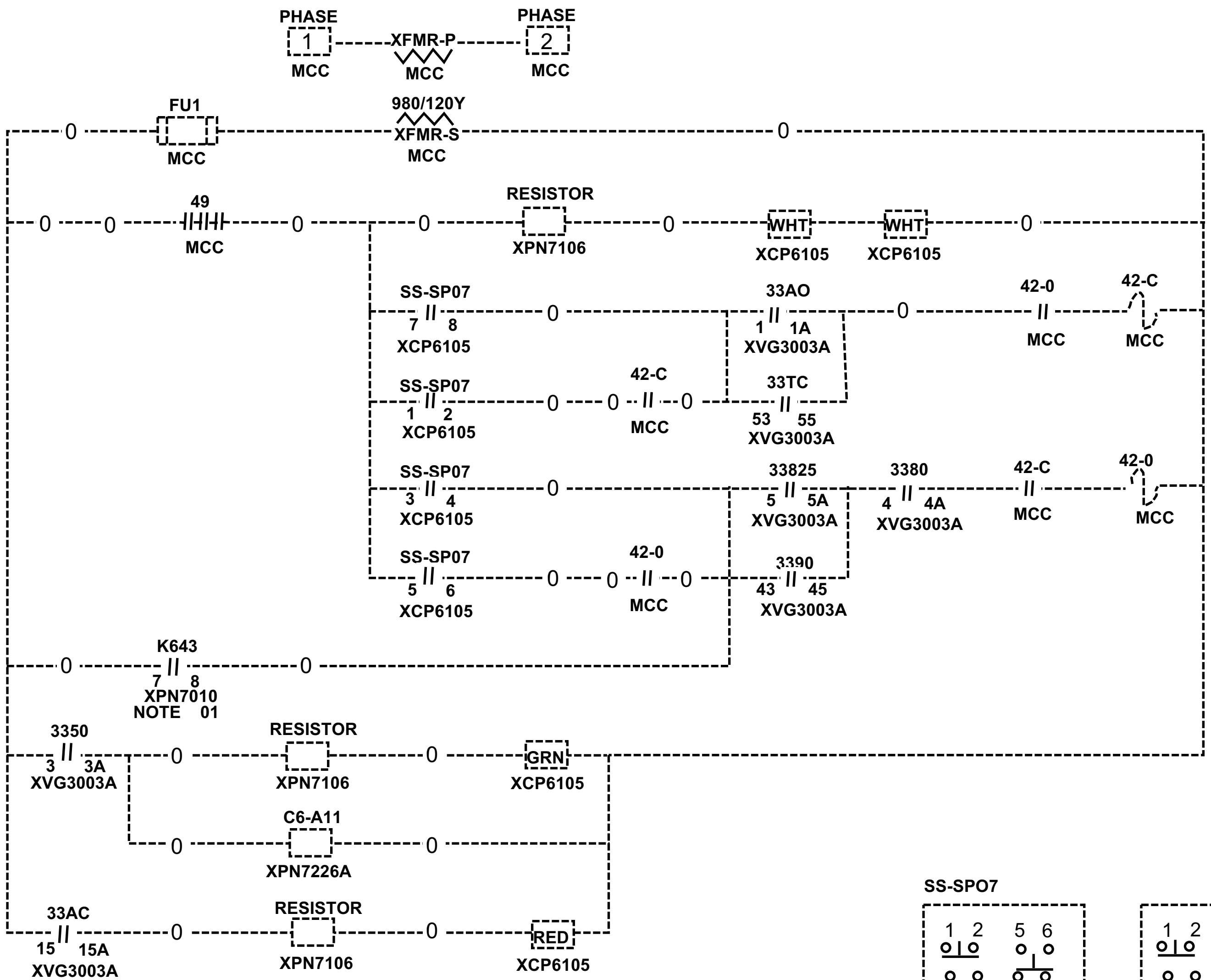
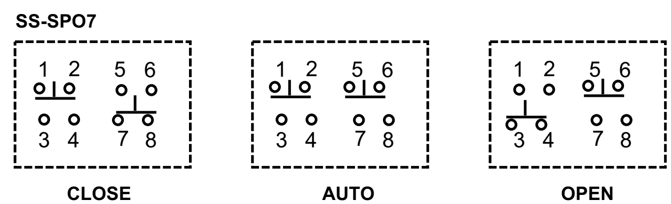


Figure ES3.8

ES3.8*1

R.B. SPRAY HDR. ISOL. VLV. 3003A





MICROSWITCH CMC #910-PGD-53-9, PTCC
SPRING RETURN OPEN AND CLOSE TO AUTO

COMPONENT RELATED NOTES

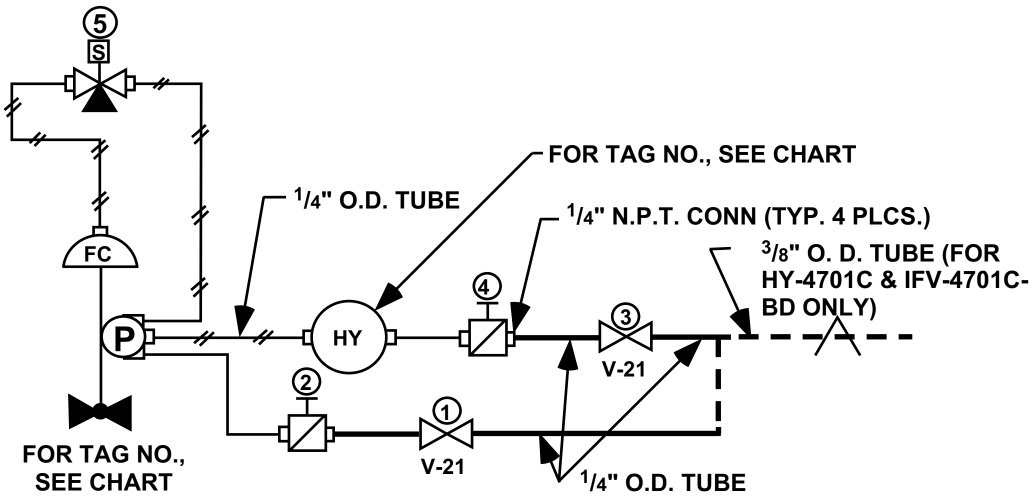
01 CONTACT CLOSES ON PHASE A CONTAINMENT ISOL SIGNAL.
02 REFERENCE WESTINGHOUSE DWG. 1MS-42-001-23.
03 TO ESF MONITOR LIGHTS, SEE B-200-066 SHT. MI03.
04 DELETED
05 DELETED
06 TO TSC COMPUTER, FOR C6-A11 ISOL MODULE, SEE 1MS-28-???
07 TO WESTINGHOUSE SAFEGUARDS TEST CABINET, SEE 1MS-42-017-13
08 FROM B-208-097 SHT. SP05.

GENERAL DRAWING NOTES

Figure ES3.9

ES3.9*1

IFV-4701A-BD (AIR DIAGRAM)



REFERENCES:

TUBE LINE SPEC 161X (PIPE SPEC SP-337-4461-00)
TUBE FITTING B/M RKf
TUBE B/M RKf 4
VALVE B/M RKf 9a
D-302-781 STEAM GENERATOR BLOWDOWN FLOW DIAGRAM

TAG NUMBER	(5) I.D. NUMBER
IFV-4701A-BD	IFV-4701A-20A-BD
IFV-4701B-BD	IFV-4701B-20A-BD
IFV-4701C-BD	IFV-4701C-20A-BD

DETAIL "B"

(1) I.D. NUMBER	(2) I.D. NUMBER	TAG NUMBER	B/M NO.	AIR SUPPLY DRAWING	MANUFACTURER DWG NO.	(3) I.D. NUMBER	(4) I.D. NUMBER
IFV4701A-AVI-BD	IFV4701A-PRI-BD	IFV-4701A-BD	RMa-19	B-816-018	1MS-50-090	————	————
————	————	HY-4701A	RMa-186	B-816-018	1MS-50-135	IHY4701A-AVI-BD	IHY4701A-PRI-BD
IFV4701B-AVI-BD	IFV4701B-PRI-BD	IFV-4701B-BD	RMa-20	B-816-025	1MS-50-090	————	————
————	————	HY-4701B	RMa-187	B-816-025	1MS-50-135	IHY4701B-AVI-BD	IHY4701B-PRI-BD
IFV4701C-AVI-BD	IFV4701C-PRI-BD	IFV-4701C-BD	RMa-21	B-816-025	1MS-50-090	————	————
————	————	HY-4701C	RMa-188	B-816-025	1MS-50-135	IHY4701C-AVI-BD	IHY4701C-PRI-BD

Figure ES3.10

S/G BD FCV-4701A

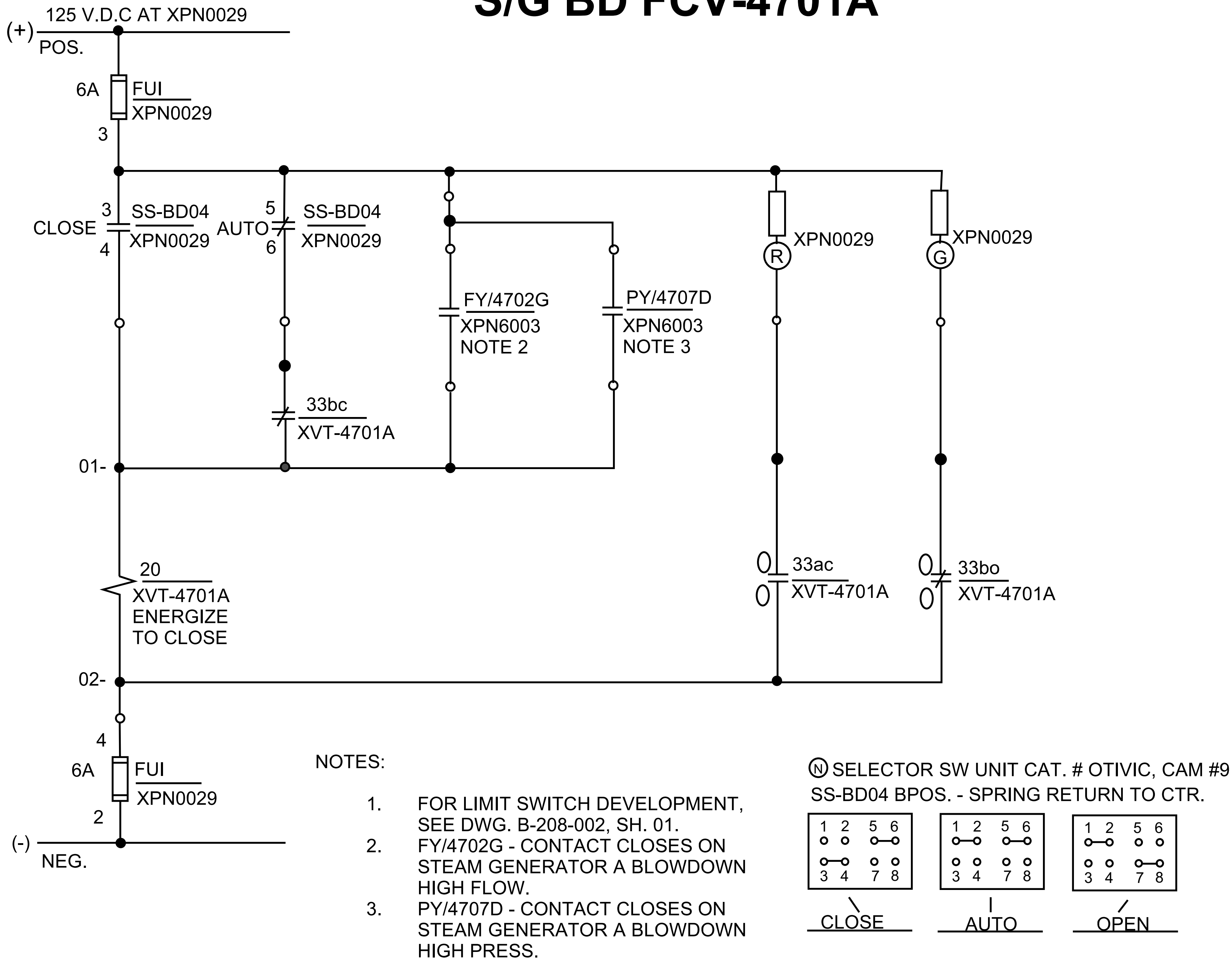
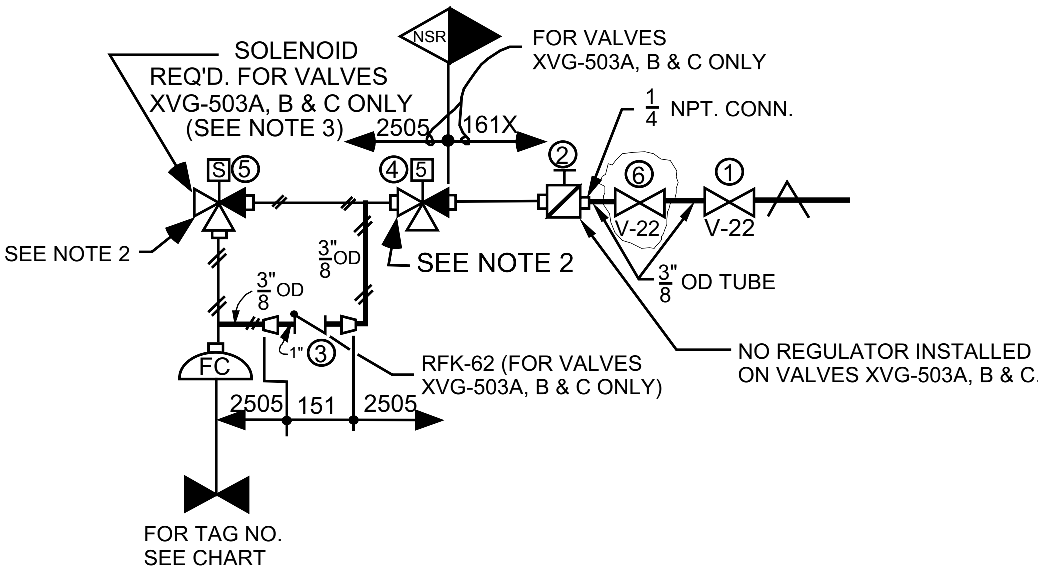


Figure ES3.11

ES3.11*1

XVG-503A-BD (AIR DIAGRAM)



NOTES:

1. FOR PIPE MATERIAL SHOWN ON THIS DRAWING, REFER TO PIPING SPECIFICATIONS SP-337-4461-00, LINE SPEC. 161X; AND SP-545-044461-000 LINE SPEC. 2505 & 151.
2. SOLENOID VALVE TO BE SEISMICALLY MOUNTED.
3 ALL 2505 TUBING TO BE SEISMICALLY SUPPORTED.

REFERENCES:

TUBE FITTING B/M RKF-5 (161X), RKF-1 (2505)
TUBE B/M RKF-4 (161X), RKF-2 (2505)
VALVE B/M RKF-9b
D-302-781 STEAM GENERATOR BLOWDOWN FLOW DIAGRAM
D-302-842 CHILLED WATER TO COOLING COILS "A" FLOW DIAGRAM
D-302-843 CHILLED WATER TO COOLING COILS "B" FLOW DIAGRAM
B-809-478 SOLENOID VALVE SEISMIC MOUNTING DWG.

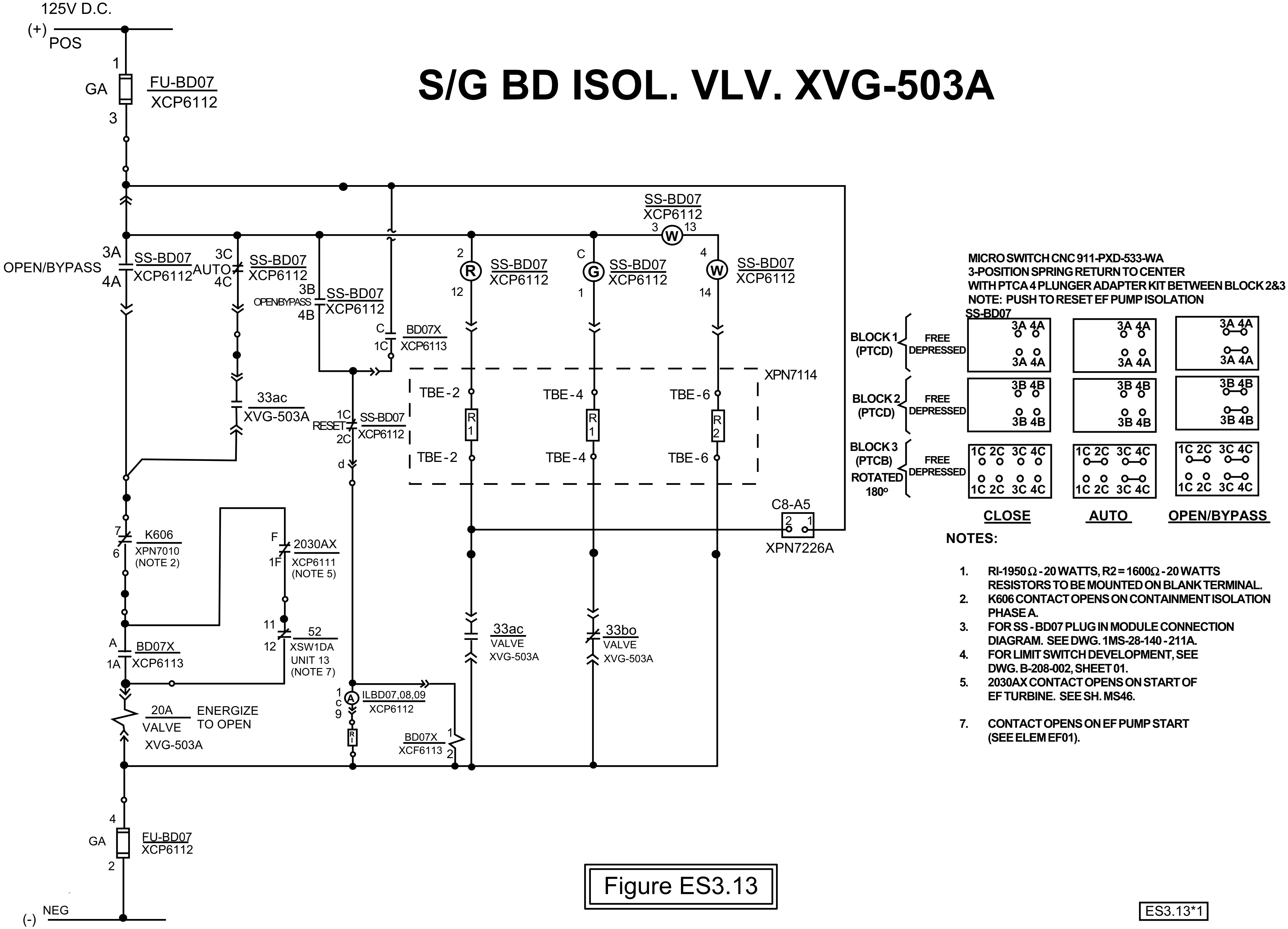
DETAIL "A"

① I.D. NUMBER	② I.D. NUMBER	TAG NUMBER	B/M NO.	AIR SUPPLY DRAWING	MANUFACTURER DWG NO.	③ I.D. NUMBER	④ I.D. NUMBER	⑤ I.D. NUMBER
XVG-503A-AVI-BD	————	XVG-503A-BD	RNn-15	B-816-018	1MS-25-311	XVG-503A-CVI-BD	XVG-503A-20B-BD	XVG-503A-20A-BD
XVG-503B-AVI-BD	————	XVG-503B-BD	RNn-15	B-816-025	1MS-25-311	XVG-503B-CVI-BD	XVG-503B-20B-BD	XVG-503B-20A-BD
XVG-503C-AVI-BD	————	XVG-503C-BD	RNn-15	B-816-025	1MS-25-311	XVG-503C-CVI-BD	XVG-503C-20B-BD	XVG-503C-20A-BD

Figure ES3.12

ES3.12*1

S/G BD ISOL. VLV. XVG-503A



NOTES:

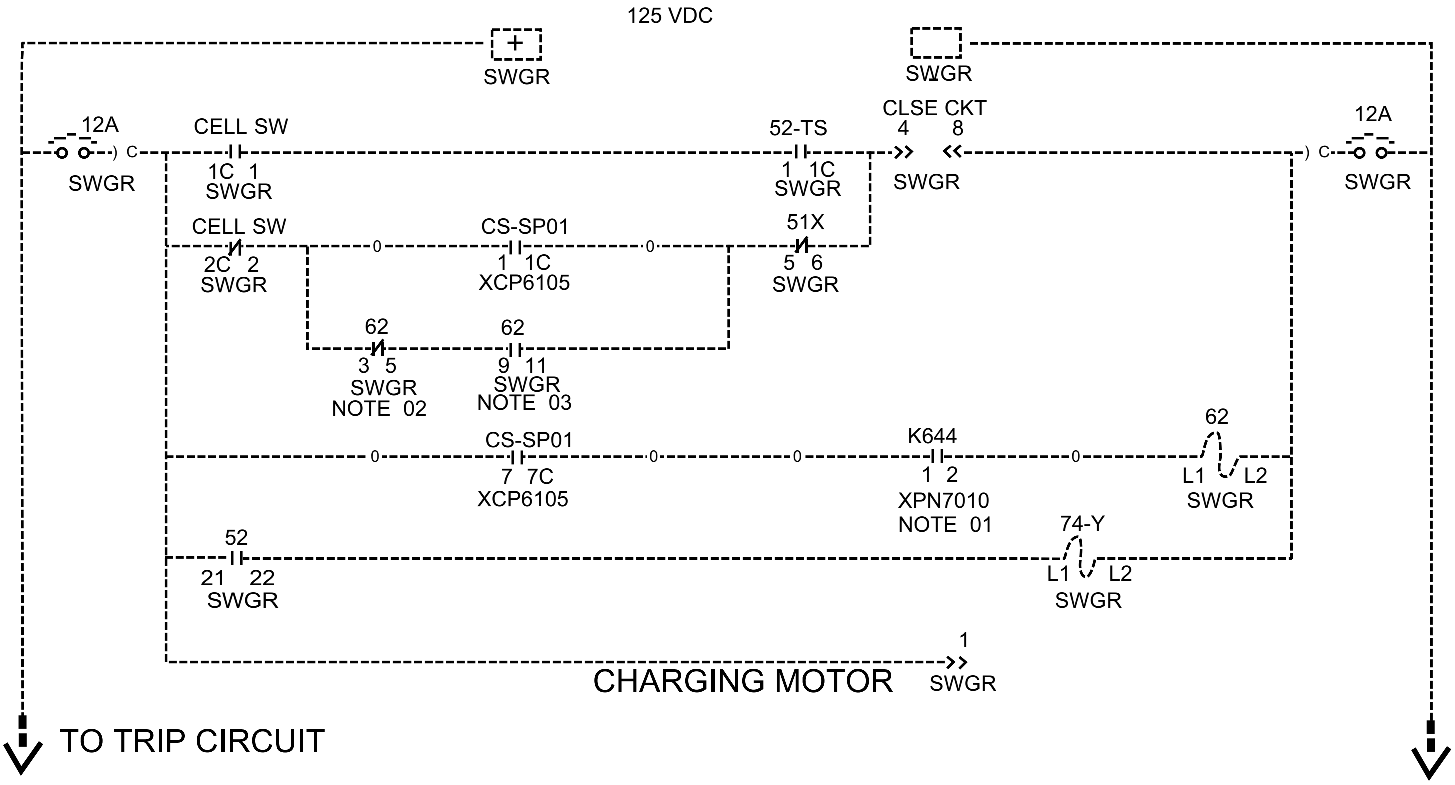
1. RI-1950Ω - 20 WATTS, R2 = 1600Ω - 20 WATTS RESISTORS TO BE MOUNTED ON BLANK TERMINAL.
2. K606 CONTACT OPENS ON CONTAINMENT ISOLATION PHASE A.
3. FOR SS - BD07 PLUG IN MODULE CONNECTION DIAGRAM. SEE DWG. 1MS-28-140 - 211A.
4. FOR LIMIT SWITCH DEVELOPMENT, SEE DWG. B-208-002, SHEET 01.
5. 2030AX CONTACT OPENS ON START OF EF TURBINE. SEE SH. MS46.

7. CONTACT OPENS ON EF PUMP START (SEE ELEM EF01).

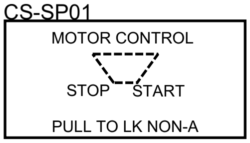
Figure ES3.13

ES3.13*1

'A' R.B. SPRAY PUMP
(CLOSING CIRCUIT)



CS-SP01



CONTACTS HANDLE END		POSITIONS (BACK VIEW) START	NORM. AFTER START	NORM. AFTER STOP	STOP	PULL TO LK NON-A
1 1C 2C 2	1	X				
	2				X	X
3 3C 4C 4	3				X	X
	4				X	X
5 5C 6C 6	5	X	X	X	X	
	6	X	X	X	X	
7 7C 8C 8	7		X	X		
	8	X	X			
9 9C 10C 10	9			X	X	X
	10			X	X	X

G.E.CO. SBM
SPRING RETURN TO NORMAL. RED & GREEN FLAGS
PISTOL GRIP HANDLE

COMPONENT-RELATED NOTES

01 CONTACT CLOSES ON SPRAY ACTUATION SIGNAL.
02 CONTACT OPENS 3 SECONDS AFTER PICKUP.
03 INSTAN. CONTACT OF TIME DELAY RELAY.
04 TO ESF MONITOR LIGHTS, SEE B-208-066, SHT MI19.
05 OPENS AFTER 3 SECS. TIME DELAY.
06 FOR COMPLETE CIRCUIT, SEE SS-208-037, SHT ES107.
07 SEE DWG. B-208-097, SHT. SP20.
08 TO SPRAY/RHR PP RM 1 COOL UNIT FAN (XPN49A), SEE VL08.
09 REFERENCE WESTINGHOUSE DWG. 1MS-42-001-23.
10 TO COMPUTER POINT Y7351D.
11 TO IO FLO ALM T.D. RELAY, SEE SHT. SP20.
12 TO WESTINGHOUSE "STC" PNL. SEE 1MS-42-017-13.
13 PRCM SP03.
14 SPACE HTR 800 W, 240 VAC, SEE 1MS-18-11.
15 TO TSC COMPUTER, C1-A1 INPUT, SEE BI19.
16 TO TSC COMPUTER, C1-A2 INPUT, SEE BI19.

Figure ES3.14

'A' R.B. SPRAY PUMP
TRIPPING CIRCUIT

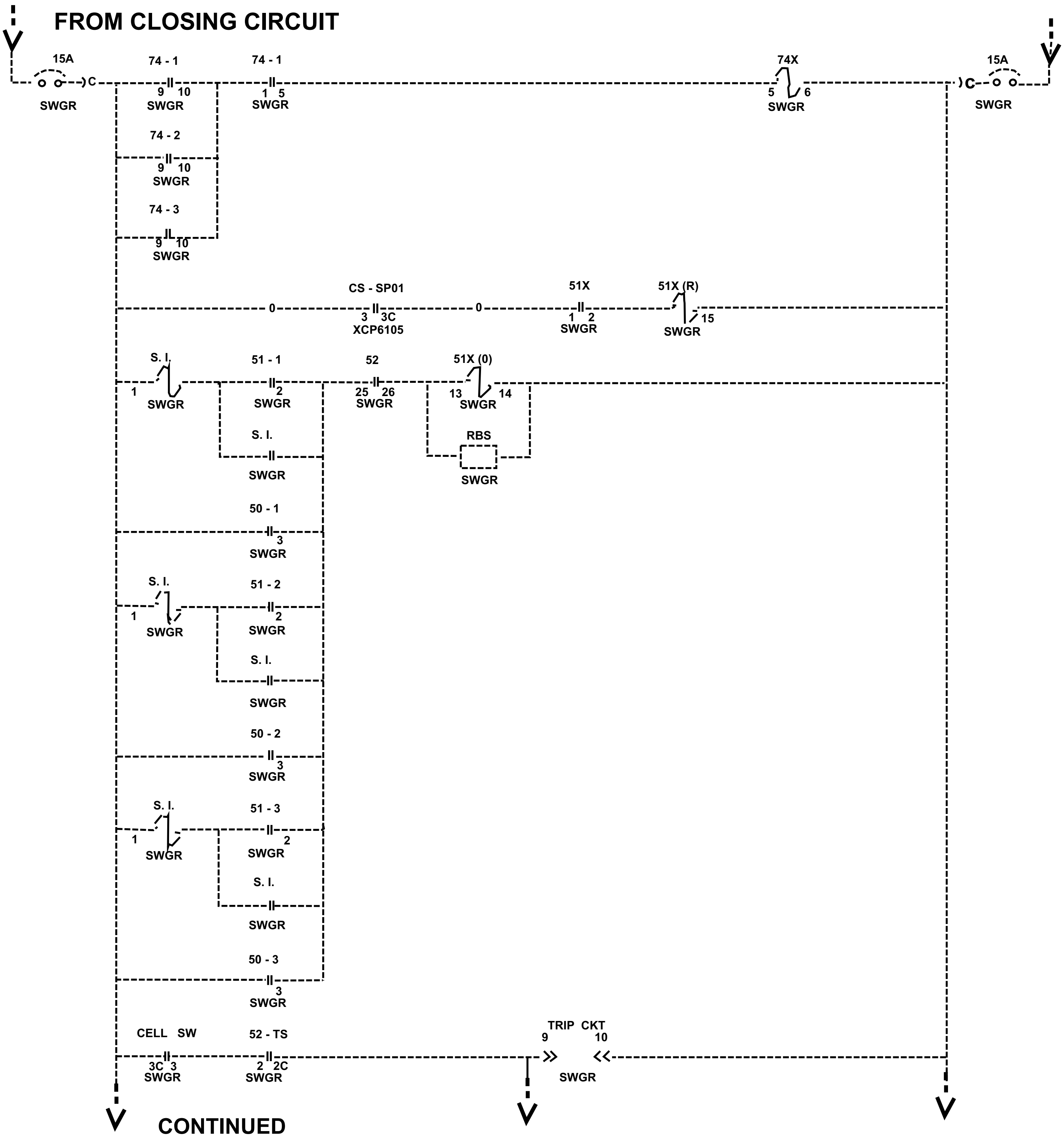


Figure ES3.15

ES3.15*1

'A' R.B. SPRAY PUMP
TRIPPING CIRCUIT

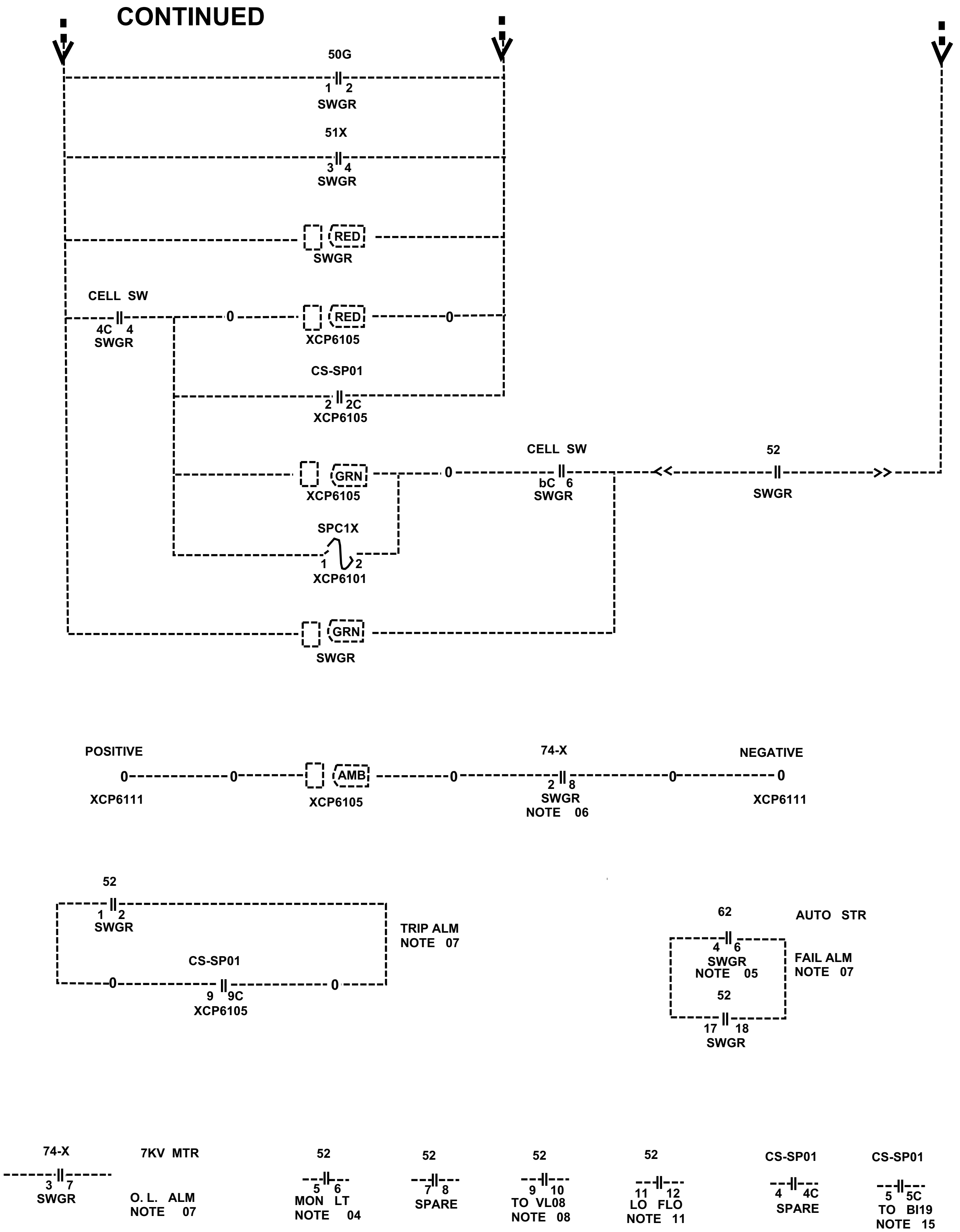


Figure ES3.16

ES3.16*1

OVERCURRENT ALARM & PROTECTION

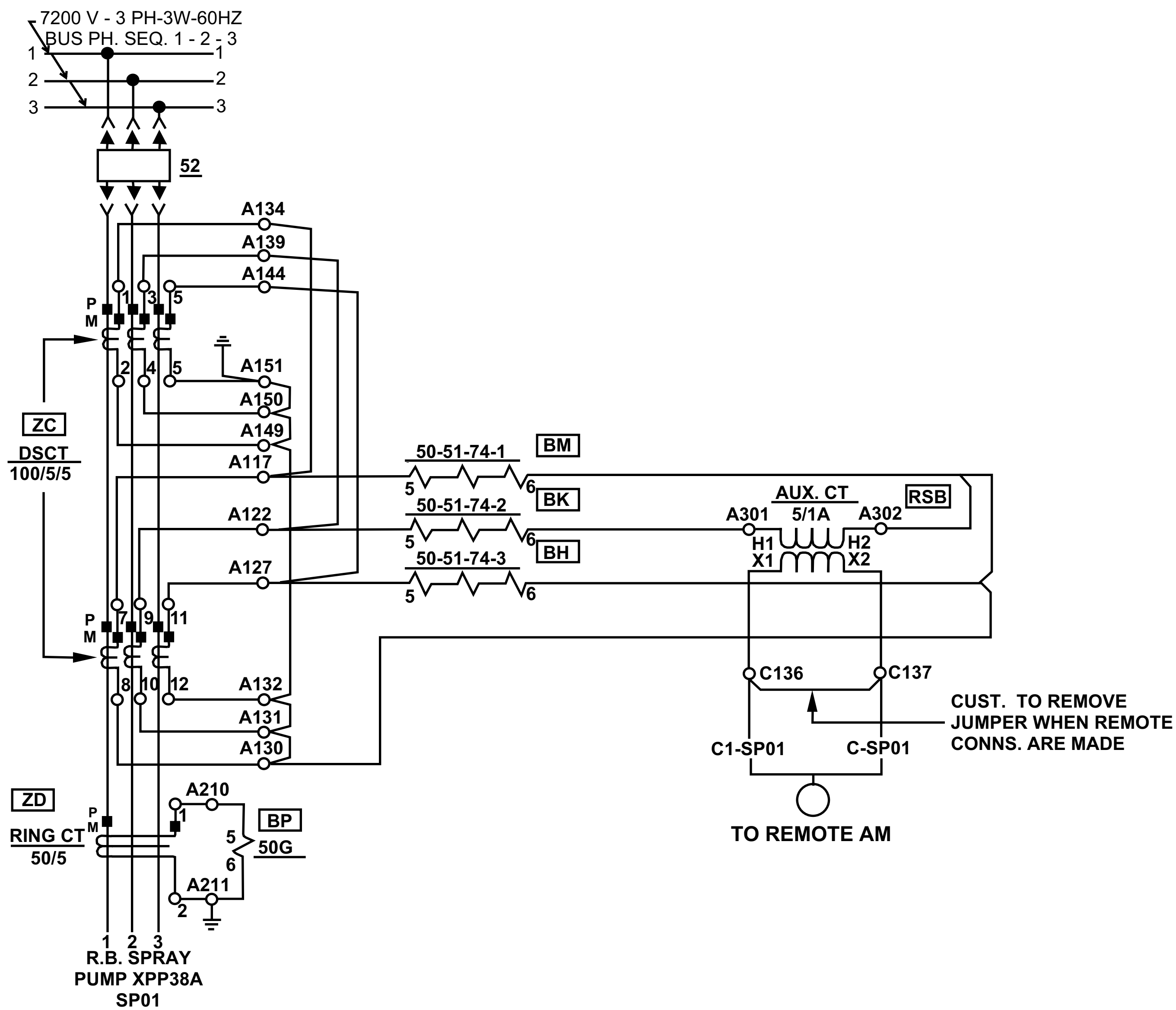


Figure ES3.17

ES3.17*1

7.2KV & 480V BREAKER INTERNAL CONTROL

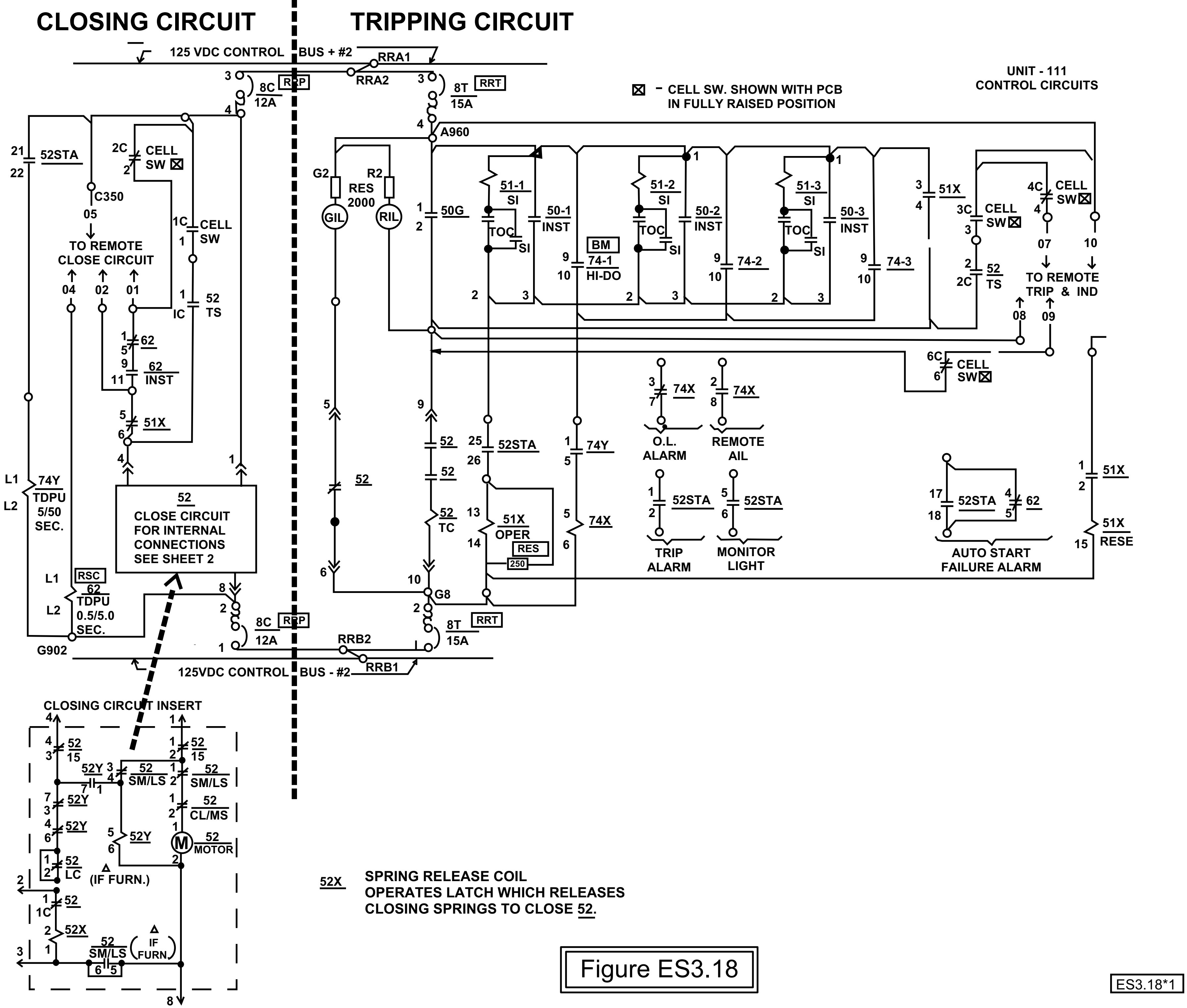
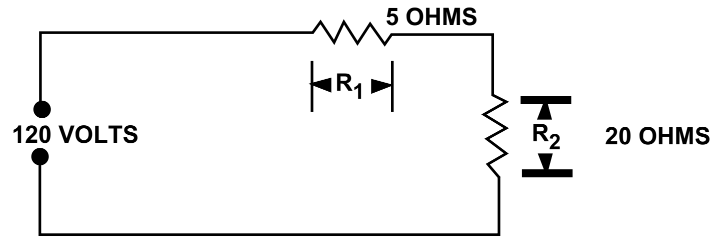


Figure ES3.18

ES3.18*1

OHM'S LAW/SERIES CIRCUIT AND PARALLEL CIRCUIT



GIVEN:

Voltage = 120 volts

Total Resistance $R_1 + R_2 = 5 + 20 = 25$ ohms

$$\text{Current} = \frac{\text{Voltage}}{\text{Resistance}} = \frac{120}{25} = 4.8 \text{ amps}$$

Voltage drop across 5 ohms resistance:

$$E = I R_1 = 4.8 \times 5 = 24 \text{ volts}$$

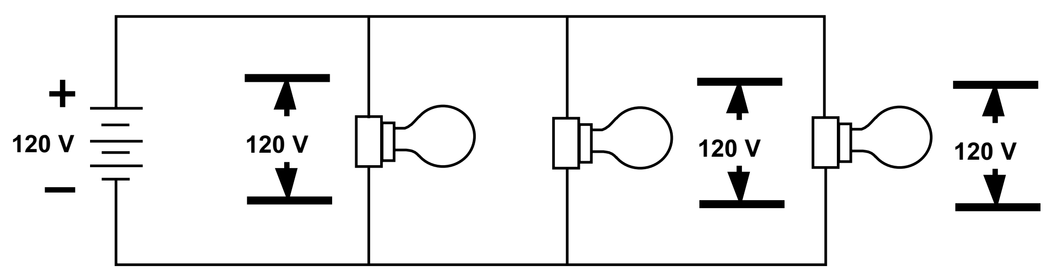
Voltage drop across 20 ohms resistance:

$$E = I R_2 = 4.8 \times 20 = 96 \text{ volts}$$

Total voltage drop = 24 + 96 = 120 volts

The total voltage drop in a circuit is always equal to the voltage applied to the circuit.

VOLTAGE IN A PARALLEL CIRCUIT IS THE SAME ACROSS ALL BRANCHES OF THE CIRCUIT



Voltage in a Parallel Circuit

Figure ES3.19

ES3.19*1

INTERMEDIATE RANGE POWER SUPPLY

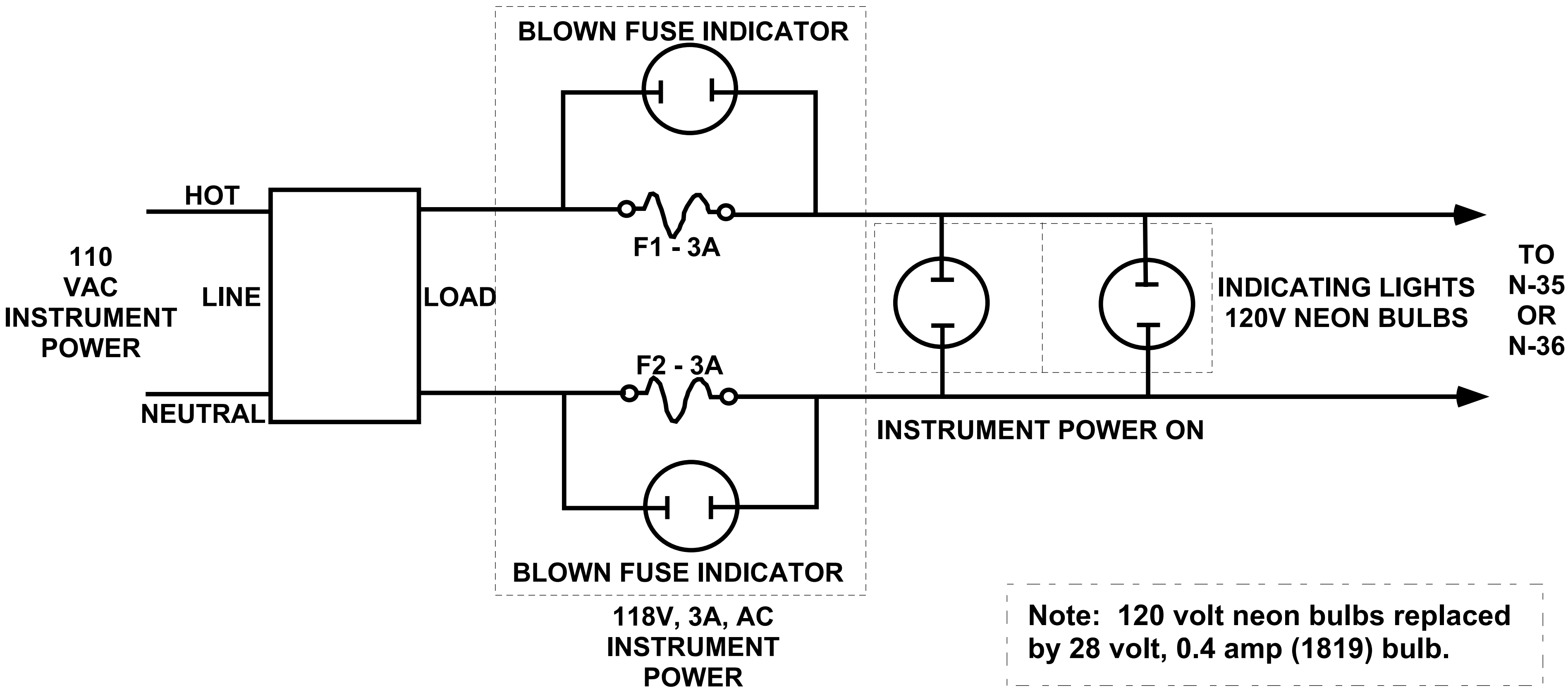


Figure ES3.20

ES3.20*1