STUDENT MANUAL

Site Day 3

Date/Time	Operating Status	Major Equipment Out Of Service	Remarks
Day 3	Mode 1 100%	A EDG OOS	AS 3.8.1.1.a entered effective 1200 Day 1. B EDG was started and run at 900 rpm 1100 day 2.
		P-205A	Returned to service after sat IST 2215 Day 2

The senior resident called you at home to tell you he still had the flu and won't be in today.

At the licensee's work planning meeting this morning, you heard that the problem with the sticking fuel racks on the "West" engine of the "A" emergency diesel generator was attributed to the recent painting of the engine. Both engines had been repainted during the recent outage, but the "East" engine in the tandem unit appeared to operate normally. The Maintenance Department is in the process of removing the paint that appears to be the problem with the "West" engine. The technical specification 72-hour time limit in the action statement for T.S. 3.8.1.1 expires at 12:00 tomorrow.

Your answering machine includes a message from the Plant Security Manager stating that an unescorted former employee who was recently fired was found inside the Protected Area. Security personnel apprehended the person and interrogated him. He told the security personnel that he gained access using his security badge so that he could collect some personal items in his old office. His previous position was with the Health Physics Department. He was fired because he was careless in handling radioactive check sources on more than one occasion. The security personnel confiscated his security badge, told him he was no longer authorized access to the Protected Area, and escorted him offsite.

Your Branch Chief called and left a message saying that a similar plant in another region had a problem last night in which reactor power reduction was not balanced with turbine load reduction and reactor coolant temperature (Tavg) decreased below the minimum for criticality. He wants some specific background information from your plant before he calls the other region to get details. By noon, he would like to have answers to the following questions:

- Is this limit specified in the technical specifications, the Final Safety Analysis Report (FSAR), or both? What are the specific references?
- What is the basis for this temperature limit and where is it specified?
- What action is required if reactor coolant temperature is below the limit during critical operations? Where is this specified in licensing design bases documents?

The last call was from your Project Manager at NRR. He is doing some research on pressure locking and thermal binding of power-operated valves in safety-related systems. He wants to know which safety-related, power-operated valves at your plant are required to open on receipt of a safety injection signal. He wants to know which of these valves are gate valves. He also would like to know which of the gate valves have double disks. He would like to have the information by close-of-business today. Valve numbers, system, and function information would be fine.

There is a draft LER on your desk. It involves last night's failed post-maintenance test of the TDAFW pump. You plan to review it today (the LER is provided at the end of this narrative).

The call from the Project Manager reminded you that you intended to inspect emergency diesel and power-operated valve maintenance, operability assessments, and problem identification and resolution today. In preparation for this inspection, you decided to review three plant trouble reports submitted over the last year involving power-operated valves and an incident involving one of the emergency diesel generators that occurred during the startup following the recent outage. The information contained in these reports with your earlier notes is provided following this narrative. You also review the licensee memorandum in the reference section, SUBJECT: Analysis of Valve Inoperability Caused by Motor-Operator Failures. You decide to look at this information now.

You receive a call from an individual identifying himself as a plant employee with a safety concern. The individual states that he will not come to your office or meet you in the plant, but does want to present his concerns to you personally. He proposes a meeting at a local convenience store.

You had previously decided to observe the post-maintenance testing of RHR cold leg injection isolation valve MO 8809A. The valve operating circuit was modified to ensure motor-valve operability under degraded voltage conditions. A description of the valve-operating circuit and the accompanying figure are included following this narrative. The figure reflects the design change to the circuit. Since the normal mode 1 operating state of this valve is open with control power removed, the licensee saw no problem with the technical specification Action requirement for Residual Heat Removal (RHR) system operability while completing this modification with the valve in the open position. The modification was completed over a five-day period. MO 8809B will be modified next week. When you arrive to observe the test, you are told that the licensee will use this opportunity to conduct the ASME Section XI Inservice Valve Exercising Test, IWV-3410, required at least once every 3 months.

When the test engineer requests the valve to be closed from the Control Room, the motor starts, operates under locked rotor conditions for about 5 seconds, and trips the motor supply breaker with no observed valve stem movement. An operator assisting in the test remembered that the valve was checked fully open using the manual handwheel before the modifications were started. He suggests that excessive torque may have been used in backseating the valve. The engineer decides now to authorize use of the handwheel to move the valve off the backseat. A second attempt to close the valve with the motor-operator is successful, and the stroke time is 15 seconds. The test procedure indicates that the valve should stroke fully closed in 10 $\pm$ 2.5 seconds. When the valve is returned to the open position using the motor-operator to complete the test, the motor again stalls out under locked rotor conditions and trips the motor supply breaker with the valve indicating open after 10 seconds. At this point, the test engineer decides to leave the valve fully open with the control power removed as required for mode 1 operations while an analysis is completed on the observed operational problems of this

You returned to your office to find a call from the Plant General Manager saying that the "B" Emergency Diesel Generator failed during a surveillance test conservatively intended to ensure the EDG's operability. The test involved loading the "B" generator to 2000 KW with the intent of operating it for one hour to meet the requirements of T.S. 4.8.1.1.2.a.6 surveillance.

Approximately 30 minutes into the test run, the "East" engine of the "B" train tandem diesel generator tripped on high jacket cooling water temperature at an indicated 200°F and the "West" engine tripped from an over-temperature condition of 190°F. The initial concern was Asiatic clam fouling of the jacket water coolers for both engines. The "B" train was declared to be inoperable at 16:00. The estimate for cleaning the jacket water coolers is 48 hours. Maintenance to remove the paint on the "West" engine of the "A" emergency diesel generator is estimated to require one more hour, at which time the diesel generator will be tested using T.S. 4.8.1.1.2.a.5. This verifies that the diesels start and reach rated speed. The maintenance crew has started cleaning the jacket water coolers for the "B" train.

The "West" engine of the "A" train emergency generator was subsequently tested using T.S. 4.8.1.1.2.a.5, and the diesels successfully reach rated speed at 17:00. On conclusion of the test, the "A" train generator was declared to be operable. Although the 12 KW cooling water system "keep warm" heater for the "West" engine of the "A" train was noted to be inoperable, this was not considered a problem in the assessment of the capability of the generator to

fulfill its safety-related functions. This heater will be repaired or replaced after the “B” train generator is returned to service.

While considering these events, you recall an issue from the recent outage that you meant to explore at the time, but which was overcome by events. During weekend preparations to startup the reactor plant, an auxiliary operator noticed water dripping from one of the “B” diesel engines in the fuel injector area. One of the small diameter rubber hoses that supply cooling water to the fuel injector pumps was cracked. Upon further investigation, several of the hoses were found to be cracked but not leaking. Since the QA-approved replacement hoses were not available, weekend maintenance workers installed commercial grade hoses with hose clamps and an epoxy sealant. At the next Monday morning licensee meeting, the Plant General Manager announced that plant operational mode change was in progress, and startup would take place the next day. As you left the meeting, you overheard a heated conversation between the Maintenance Supervisor and the QA Manager who both attended the meeting.

The QA representative said:

1. Non quality assurance approved repair parts were installed in the diesel.
2. The supply requisition for approved parts was canceled.
3. Repairs were completed without QA involvement.
4. The diesel generator was not operated following the repairs.

The Maintenance Supervisor countered with the argument that the estimated delivery date for the approved parts was 6 weeks, and the new hoses were commercial grade equipment designed for the same pressure and temperature as the original hoses. The diesel generator was not operated because the “keep warm” system provides pressure to these hoses while the EDG is idle, and leaks would be noted, as occurred during the weekend when the EDG was idle.

LICENSEE EVENT REPORT (LER)

FACILITY NAME
Trojan

TITLE
Turbine-Driven Auxiliary Feedwater (TDAFW) Pump Inoperability

EVENT DATE
11/03

OPERATING MODE
1

POWER LEVEL
90.0

ABSTRACT

On June 6, 2002, at 2000 hours with the plant in mode 1 at an average RCS temperature of 586°F, the TDAFW pump oversped during performance of T.S. Surveillance Test 4.7.1.2.1.c. This test was being conducted to verify operability of the system on completion of maintenance to replace a pump mechanical seal.

The maximum observed turbine speed was 6200 rpm with a resulting pump discharge pressure of 2100 psig. AFW system design pressure is 2000 psig and normal speed is 4650 rpm. The overpressure condition lasted for approximately 2 minutes and ruptured the downstream flow orifice, FO 3123, on the cooling supply line from the second stage impeller of the pump to the TDAFW bearing and lube oil heat exchangers. The test was stopped by shutting the auxiliary feedwater pump turbine stop valve using the remote control switch at Panel C-05 in the Control Room.

This event is being reported under 10 CFR 50.73(a)(2)(vii)(B) because a single condition caused one independent train of a safety-related system (required to remove residual heat) to become inoperable.

BACKGROUND INFORMATION

The Trojan T.S. 3.7.1.2 requires that two independent trains of AFW be operable in modes 1, 2, and 3.

EVENT DESCRIPTION

On June 6, 2002 at 2000 hours, the TDAFW pump oversped while being tested for operability following replacement of a pump mechanical seal. The maximum observed turbine speed during the test was 6200 rpm with a resulting pump discharge pressure of 2100 psig.
T.S. Surveillance Test 4.7.1.2.1.c was being conducted to verify that the pump would develop a discharge pressure of at least 1580 psig at a speed of 4560 rpm on recirculation flow. The system design pressure of 2000 psig was exceeded, which ruptured the casing of flow orifice FO 3123 that regulates the normal cooling water supply to the TDAFW bearing and lube oil heat exchangers. The alternate cooling water supply from the service water system was lined up, and the TDAFW system was declared operable while a replacement flow orifice was being obtained from the vendor.

CAUSE OF THE EVENT

The cause of the overspeed and overpressurization event was the buildup of condensate in the TDAFW steam supply line.

SAFETY ASSESSMENT

The event is reportable under 10 CFR 50.73(a)(2)(vii)(B) since a single condition caused one independent train of a safety-related system, which is required to remove residual heat to become inoperable.

CORRECTIVE ACTION

The leaking orifice was removed and blanked off pending receipt of a new orifice. The alternate cooling water supply from the service water system was lined up, and the system was declared to be operable.

SUMMARY OF PLANT TROUBLE REPORT #1

Stroke Time Test on Motor-Operated Valve MO 112B, Suction from Volume Control Tank

The trouble report indicated that the valve was tested under the following conditions:

1. The charging system was in a normal lineup.
2. Charging pumps were not operating.
3. The plant was in a hot shutdown condition.

The valve did not fully close as required to perform its safety function to isolate charging pump suction on the volume control tank when safety injection is initiated.

The licensee conducted a root cause analysis that determined the cause to be an improperly set torque switch and the use of an unqualified lubricant. The licensee lubricated the valve with a qualified lubricant and reset the torque switch to the proper value. The valve was then retested and met the FSAR table 6.3-7 stroke time. The licensee declared the valve operable and closed out the trouble report. Three months later, the valve failed the stroke time test again, and the earlier corrective action was repeated.

You had some questions in mind after reading this report.

1. What other factors could have contributed to the stroke time test failure?
2. Were the licensee's actions appropriate for the test failures?
3. What additional licensee actions seem to be indicated?
4. What if this valve problem is not an isolated incident?
5. Where do I look for regulatory guidance in this case?
6. Was the valve tested for stroke time under the required conditions?

SUMMARY OF PLANT TROUBLE REPORT #2

Failure of Pressurizer Power-Operated Relief Valve (PORV) Block Valves to Close

The unit was in hot shutdown increasing RCS pressure while preparing for reactor startup when a valve gasket failed in a RCP seal injection line. The RCPs were secured, the charging pumps shut down, and the leak isolated. RCS pressure continued to increase, and PORV block valves were opened to reduce system pressure. (These block valves were closed during power operation to prevent RCS leakage through the PORVs.)

When the PORV block valves were opened, the RCS pressure dropped due to the leaking PORVs. The operator unsuccessfully attempted to close the block valves from the control room. Safety injection was initiated when the pressurizer pressure reached 1715 psig, approximately 13 minutes after the block valves were opened. The minimum pressure reached during the transient was 1460 psig; RCS temperature was 300°F.

A containment entry was made and the PORV block valves were closed manually about one hour after the event began. One block valve was found to be approximately one-quarter turn open, and the other was approximately one and one-quarter turns open. The Limitorque motor operators were determined to have stopped due to premature torque switch actuation. Subsequent investigation revealed the cause to be excessive friction between the packing and valve stem and inadequate gearbox lubrication. To correct these problems, the packing was replaced, the gearbox lubricated, and other general maintenance was performed.

The two PORV block valves were returned to service after PORV leakage was corrected and remained open during normal plant operation until a hydrostatic test procedure required that they be closed 8 months later. Attempts to close the valves from the control room again were unsuccessful. An operator was dispatched to the containment building and manually closed one of the valves on the first attempt. The second valve could not be closed manually using maximum recommended torque.

Eventually, the motor operator was used to unseat the valve from the backseat. When the closed position was reached, however, the motor did not deenergize and continued to apply torque. Continued motor operation caused three of the four yoke-to-bonnet bolts to break.

To correct these problems, the licensee replaced the packing, substituted a different lubricant for the valve stem, replaced the torque switch, and replaced the broken bolts with 125KSI strength rather than the original 70KSI strength bolts.

You had some questions in mind after reading this report:

1. What other factors could have contributed to the failure of the block valves to close and the failure of the yoke-to-bonnet bolts?

2. What was the history of testing during the 8 months between the two failures? What were the surveillance and inservice test requirements during this period?

3. Were the licensee's actions appropriate for the operational failures?

4. What additional actions seem to be indicated?

5. Is it possible that lessons learned from PORV block valve problems could be applied to other valves?

6. Where do you look for regulatory and non-regulatory guidance for these valve problems?

SUMMARY OF PLANT TROUBLE REPORT #3

Pressure Locking of Containment Sump Recirculation Gate Valves

In response to Generic Letter 89-10 “Safety-related, Motor-operated Valve Testing and Surveillance” about two years ago, the licensee concluded that both containment sump recirculation motor-operated gate valves might experience pressure locking during a design-basis loss-of-coolant accident, and could fail in the closed position as a result of increased pressure and temperature inside containment. The licensee submitted a report to the NRC stating that an analysis should be performed to determine the capability of the valves to open against pressure locking forces.

The analytical calculations that verified operability of the valves were performed approximately one year later as noted in a memorandum that closed out the action required by the trouble report. The memorandum did not contain the methods used or the results obtained in the calculations.

After reading the trouble report, you are reminded of 10 CFR Part 50, Appendix B, Criterion XVI, Corrective Action, which requires that “measures shall be established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures shall assure that the cause of the condition is determined and corrective action is taken to preclude repetition.” (EMPHASIS ADDED)

On the other hand, you recall the NRC Inspection Manual Part 9900 Technical Guidance on 10 CFR 50.59 issued April 9, 2002, which states “Regulatory commitments are specific actions that have been voluntarily agreed to or that have been offered by a licensee in docketed correspondence to the Commission on a voluntary basis. Unlike regulatory requirements contained in regulations, technical specifications, licenses and orders, regulatory commitments are not legally binding. Many regulatory commitments are not contained in the FSAR but in other docketed correspondence such as LERs, responses to notices of violations (NOVs) and responses to generic letters. Therefore, those commitments not contained in the FSAR are not controlled by 10 CFR 50.59. Consequently, licensees have the ability to change docketed commitments not contained in the FSAR without informing the Commission.”

These references appear to be at odds in this case, and you wonder if this delay in implementing corrective action warrants a closer look at the licensee’s program for identifying and correcting problems.

MEMORANDUM

From: Director, Onsite Engineering

To: Distribution

Subject: Analysis of Valve Inoperability Caused by Motor-Operator Failures

SUMMARY

The failure of MOVs to actuate fully on demand has caused plant transients, reduced safety system reliability, and reduced plant availability. Successful operation of the valve/operator assembly requires that components be matched to the application and then maintained through a consistently applied maintenance program. Experience to date indicates that in-depth investigation of failures to determine the underlying cause and then upgrade post-maintenance testing, and enhance training for plant personnel also can lead to improved reliability.

ANALYSIS

Due to the number and significance of events caused by failure of MOVs, an investigation was conducted to determine underlying causes of failures. This study has demonstrated that many conditions can lead to valve inoperability. In many cases, however, failures appear to be avoidable if appropriate design, maintenance, and operational practices are used.

A review of identified causes of failures indicates that a contributing factor is the lack of information on and understanding of the motor operator and the valve, and their relationship to the application. This lack of knowledge can lead to incorrect matching of components in the design phase, incorrect operational practices, and incorrect or incomplete maintenance and repair activities. A comprehensive training program emphasizing hands-on disassembly, assembly, and adjustment of motor operators in the classroom to supplement lectures has been started. Since this training has been provided for engineers, operators, and maintenance personnel, the number of valve and motor operator failures has been reduced substantially.

Inadequate preventive maintenance and incorrect or incomplete troubleshooting and repair activities also have resulted in a number of failures. Operability of equipment subjected to strenuous duty, harsh environment, and long periods of inactivity can be enhanced by continuing inspections, servicing, and adjustments. An examination of data has shown that many failures are associated with loose electrical connectors, broken wires, loose bolts, and other loose parts caused by vibration. A number of failures also are caused by inadequate stem and gearbox lubrication, packing problems, dirty electrical contacts, and other problems that could be detected by regular inspection.

A major contributor to repeat failures is the tendency to perform symptomatic repairs rather than identifying and correcting the underlying causes of failures. Analysis of failure data, for example, has shown that torque switch adjustments made to restore a valve to service (rather than identifying the causes of increased drag in the valve/operator assembly) have led to mechanical failures of the motor operator and valve and to motor electrical failures. Detailed maintenance and repair procedures have proven to be effective in preventing problems caused by the complexity of the motor operator and associated disassembly, assembly, adjustments, and troubleshooting requirements.

The practice of manually seating or backseating valves to stop leakage has led to a number of failures during subsequent electrical operation. Failures occur because the amount of torque transmitted to the valve stem and seat through manual seating or backseating operation may exceed the designed torque for the motor operator. Therefore, the motor may not be capable of unseating the valve prior to actuation of the torque switch or thermal overload device. Physical damage to yoke-to-bonnet bolts, valve seats, stems, motors, and other operator components also

have resulted. Because leaking valves must necessarily be seated manually in some cases, it may be advisable to consider such valves inoperable until remote (motor) operation can be demonstrated.

Analysis indicates that many failures could be prevented by post-maintenance testing prior to returning a valve to service. To be effective, testing must be performed after any maintenance activity that could affect valve operability. Equally as important, the valve should be cycled with normal system flow, pressure, and temperature whenever possible since these factors influence the torque required for valve operation. Many failures occur when the valve is stroked for the first time following maintenance; therefore, testing may appear successful but can leave the valve in an inoperable condition. One method to detect such failures is to cycle the valve twice as part of the normal test sequence.

The primary cause of failures associated with design is incorrect matching of the operator to the valve and application. Only a few basic models of Limitorque motor operators are used in the nuclear industry. Basic models are matched to the intended application by selection of motor size, internal gear ratios, and torque switch settings. Factors such as maximum and minimum operating voltages (normally 80 to 110 percent of nominal voltage), time to open or close, torque required to overcome system flows and pressures, and the ability of the valve and operator to withstand locked rotor conditions are all important and must be specified by the purchaser. Where initial specifications have not included all relevant design considerations to match the operator to the valve and to match both of these components to the application, inoperability and even mechanical failure have resulted.

A number of failures appear to be caused by forces generated by operator rotational inertia. When a pre-set torque value is reached, the motor operator is deenergized by the torque switch. However, due to inertia, movement of the motor and gear train continues and torques well in excess of the desired value may be applied. The result can be a stuck valve, bent stem, or damaged operator or valve. Limitorque has developed a compensating spring assembly that can be backfitted to operators to minimize the effects of inertia.

Motor thermal overloads have been sized in many cases for continuous rather than intermittent duty motors. This incorrect sizing has resulted in inadequate protection for motors and has led to a number of motor failures. However, it is important to note that if the operator is properly maintained and adjusted, overload devices should rarely be required to actuate.

RECOMMENDATIONS:

Procedures

1. Troubleshooting procedures should be developed for each motor-operator combination. These procedures should guide troubleshooting efforts toward identification and correction of underlying causes of failures rather than toward symptomatic repair activities (such as torque switch adjustment only) that may not correct causes of failures.

2. Preventive maintenance procedures should be developed and should include specific visual inspection and servicing requirements based on vendor recommendations. A visual inspection of all critical MOVs should be performed during each refueling outage or at other times on an equivalent inspection interval. Examples of items to be inspected include cables, electrical terminations, electrical contacts, grease, stem lubrication, packing, and bolting.

3. Maintenance history records should be maintained for MOVs. As a minimum, the following should be included for each valve.

    a. Torque and limit switch settings and tolerances

    b. Stroke times

c. Updated motor current signature information or other data useful in identifying changes in the torque required for valve operation

d. Summary of maintenance performed and date

4. When valves that perform a safety function must be manually seated or backseated, plant procedures should require an evaluation of valve operability. Where such valves are required to change positions to fulfill a safety function, consideration should be given to declaring the valves inoperable until motor operation can be demonstrated following manual seating or backseating.

Testing

1. Post-maintenance testing should be performed after any maintenance activity that could affect valve operability. This testing should be performed at normal system operating temperature, flow, and differential pressures whenever possible. If testing under these conditions is not feasible, increased torque settings should be considered (not to exceed the recommended maximum) to account for factors that were not present during the actual test. Verification of operability should be accomplished by cycling the valve twice or by other means to verify that the valve will operate properly and that damage has not occurred as a result of the operability test.

Purchasing

When ordering motor operators and valves, the following information should be requested from the vendor:

a. Minimum and maximum torque switch settings

b. Torque value to overcome specified system pressure

c. Torque value to overcome design differential pressure under expected flow conditions.

d. Locked rotor current

e. Verification that the valve and motor operator can withstand mechanical forces, resulting from locked rotor conditions with the maximum expected voltage, including the potential effects of inertia associated with the assembly

VALVE MO 8809A AND MO 8809B OPERATING CIRCUIT
(SEE ATTACHED FIGURE 1)

In the circuit for operating valve MO 8809A, control power is transformed from incoming motor leads. The stop switch is normally closed providing power up to the open and closed switches and contacts. The circuit is shown deenergized with the valve in the fully open position and control power locked out to prevent closing (L01 and L02 are open).

CLOSING OPERATION

When the “close” switch is operated, the closing intermediate relay coil “A” is energized if control power is restored (contacts L01 and L02 are closed). Lockout of control power to prevent valve closure is required in modes 1, 2, and 3 for MO 8809A and 8809B.

When closing intermediate relay coil “A” is energized, contact A1 is closed thereby energizing the main closing relay coil “CL”. This relay coil closes the main line (motor leads) “CL” contacts to start the motor in the “close” direction. The “CL” contact around the close switch is also closed and the “CL” interlock contact in series with the open intermediate relay coil “B” is opened to prevent simultaneous application of power to the open and close main line contacts.

The actuator will continue to move the valve stem in the close direction until the close direction torque or limit switches (L.S.) detect binding or full stem travel. Either of these indications will open a contact thereby deenergizing the closing intermediate coil “A”. This will open the “A1” contact and deenergize the main closing relay coil “CL”. The five “CL” contacts discussed above will then return to their original positions before the closing cycle began and the motor operator will be deenergized.

OPENING OPERATION

The actuator can be operated in the open direction in the same manner as described for the closing cycle.

Starter circuits such as this have two primary functions: 1) to change power phase rotation, which changes the direction of motor rotation, and 2) to provide mechanical and electrical safety interlocks that prevent the contacts for both directions of valve movement being closed at the same time, which would cause a direct short between phases. The operation of the reversing starter is based on using a small control current to control the larger motor current through electromagnetic switching of contacts. The coils shown in figure 1 operate the main contacts of the starter when an open or close pushbutton is pushed.The intermediate relay coils “A” and “B” were added in a design modification to ensure motor-valve operability under degraded voltage conditions.
A design review indicated that under worst case low voltage conditions, the main “CL” and “OP” relay coils, which were located where the new coils “A” and “B” are now, might not receive sufficient operating voltage because of line voltage losses in the cabling between the Control Room and the Motor Control Centers (MCC) where the relays are located. The power requirement for the intermediate coils is much lower in the new design, and the main relay coils receive full line voltage in the modified design.

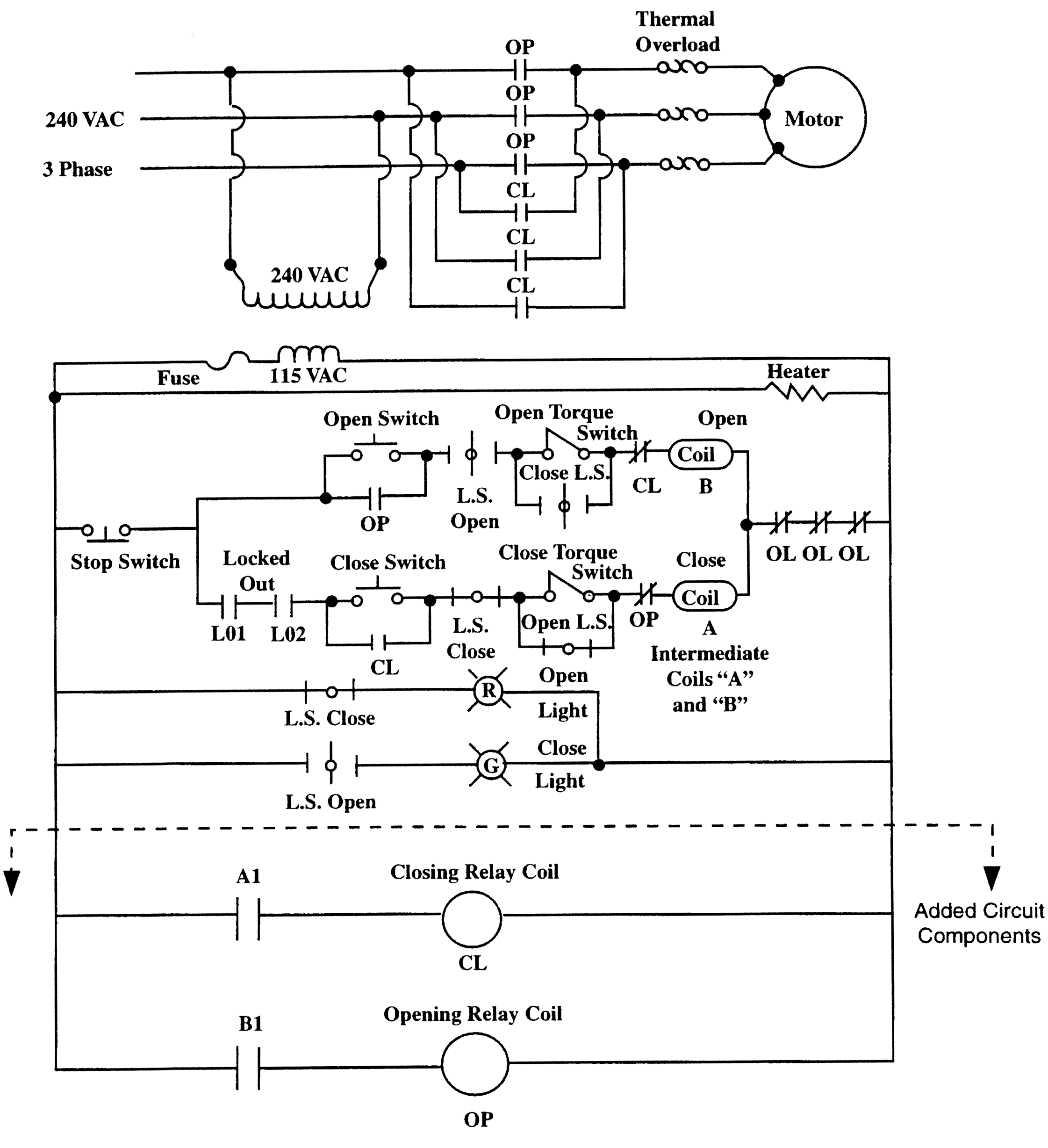

Figure 1. Valve Operating Circuit