



**AUSTRALIAN ATOMIC ENERGY COMMISSION
RESEARCH ESTABLISHMENT
LUCAS HEIGHTS**

REACTOR HIFAR - THE MAIN LIGHT WATER PUMP CIRCUITS (S6)

by

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THE MAIN LIGHT WATER PUMP CIRCUITS (S6)

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W. A. MILLER*

ABSTRACT

This manual describes in detail the operation of the relay circuits associated with the control of the main light water pumps of the reactor HIFAR.

*NOTE: The author was employed by the Commission during the 1968/69 vacation from The University of Sydney.

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1. INTRODUCTION

This manual must be read in conjunction with AAEC/M1, 'An Introduction to HIFAR Guard and Safety Circuits'. It is one of a group of manuals whose titles are listed in the Appendix.

2. THE MAIN LIGHT WATER PUMPS

Four pumps, of which only three are required at any one time, are provided to supply light water circulation for secondary cooling in the reactor HIFAR at powers up to 11 MW. The fourth pump is on standby, or is available for routine maintenance.

The pumps are conventional horizontal shaft centrifugal pumps of 1,750 gallons per minute output, driven at 1,440 rev/min by 40 h.p. three-phase squirrel cage motors through flexible couplings. They are operated from a 415V, three phase, 50 Hz supply and each is started by a star-delta starter (see Figure 3 for its circuit diagram). Each starter has an overload release, an under-voltage release, and an ammeter in one phase. There is an OFF/START/RUN lever and a normal STOP button. To allow for maintenance, the pumps have isolating valves in their suction and delivery lines, and non-return valves in their suction lines to prevent water flowing backwards through a stationary pump.

Two emergency cooling pumps, one of which is always available, are provided to remove fission product heat during an emergency shutdown due to a power failure. (See AAEC/M17 for details of these pumps).

3. THE LIGHT WATER (SECONDARY COOLING) CIRCUIT

Water is drawn from the cooling tower pond through a penstock and filter by the three operating main circulating pumps and delivered to the three heat exchangers via a flow control valve and a flow measuring Dall tube (see AAEC/M37 for a description of the Dall tube).

After leaving the heat exchangers, the water is distributed to eight induced draught cooling tower cells. The number of fans in operation and their speeds are selected according to the prevailing atmospheric conditions.

4. OPERATION OF MAIN PUMPS 4P6/1-4

4.1 General

To simplify this manual, a description is given of the operation of only one pump. The four pumps are identical in operation and only the appropriate subscript need be added to follow the operation of a particular pump.

- (a) The pumps are started and stopped from the star-delta starter in the pumphouse.
- (b) Each pump has the following four relays associated with it;

$$\frac{P6 - A}{8}, \quad \frac{P6 - S}{8}, \quad \frac{P6 - X1}{8} \text{ and } \frac{P6 - X2}{8}$$

(See Figures 1 and 3); the relays for a particular pump are identified by a subscript, for example:

$$\frac{P6_2 - A}{8} \text{ refers to the relay } \frac{P6 - A}{8}$$

associated with pump 4P6/2. Additional circuits are associated with the four relays $\frac{P6 - H}{4}$, $\frac{P6 - WB}{1}$, $\frac{L - 10}{2}$ and $\frac{L10 - LL}{4}$.

The uses of these relays will be outlined in the following sections.

4.2 Initial Starting of a Pump

4.2.1 Pre-starting or Reset condition

The pump when not running will normally be in the RESET condition. Assume for the moment that relays $\frac{P6 - A}{8}$ and $\frac{P6 - S}{8}$ have been de-energised. Provided that the low level trip is in the normal, untripped position the 50V d.c. instrumentation supply to the relays will be live and the following operations will occur

- (a) Relay coil $\frac{P6 - A}{8}$ will be energised through contacts 4, 5 and 6 of relays $\frac{P6 - S}{8}$.
- (b) Now relay $\frac{P6 - S}{8}$ is energised through contacts 4, 5 and 6 of relay $\frac{P6 - A}{8}$ and remains energised through its holding contacts 1, 2 and 3.

Energising of relay P6 - S causes contacts 4, 5 and 6 to open and thus tends to release P6 - A. However, relay P6 - X1 is not energised and its contacts 21, 22 and 23 together with relay P6 - A holding contacts 1, 2 and 3 keep relay P6 - A energised. Also contacts 31, 32 and 33 of relay P6 - S are in series with the undervoltage cutout.

Therefore relay P6 - S must be energised before the starter can operate. Hence in the RESET condition, relays P6 - A and P6 - S are energised.

4.2.2 Starting

For the next stage of starting the pump it is assumed that the mains isolator is closed. The pump may then be started by pulling the handle on the right hand side of the starter unit slowly towards the START position until the no-volt plunger lifts. The handle is then moved smartly into the START position. When the motor has reached approximately the running speed, the handle is quickly shifted backwards to the RUN position. In the RUN position, interlock contacts P2 close, thereby energising P6 - X1 and P6 - X2 (supplied from 50V d.c.) and making available 16 sets of changeover contacts for use in other circuits as described in Section 4.4.

Energising of relay P6 - X1 causes contacts 21, 22 and 23 to release relay P6 - A. This is the normal running condition and relays P6 - S, P6 - X1 and P6 - X2 are energised.

4.2.3 Warning indications

Other contacts on relay P6 - A are used as follows:

(a) Contacts 31, 32 and 33 of P6 - A are used in conjunction with contacts 31, 32 and 33 of P6 - X2 which indicate the RUNNING or FAILED state of the pump by lights on Motor Control Cabinet No. 2. These are the usual 24V a.c. indicator lamps. In the RESET condition when the circuit is ready to be started, neither lamp is lit because the pump is neither running nor failed. This condition is brought about by the insertion of contacts 31, 32 and 33 of relay P6 - A, the relay being energised when the circuit is in the RESET condition.

(b) Relay L10 - LL is energised during normal operation. Should the water level in the tower basin fall to a low level, L10 - LL is de-energised by means of solenoid No. 2 in the 4 - LCA - 10 relay box (see Figure 2).

Contacts of L10 - LL releasing, close and light the COOLING TOWER BASIN LOW lamps on Motor Control Cabinet No. 2 and in Control Room Panel 5. If this warning is unheeded and the level continues to drop, the pumps will be tripped at a lower level by means of solenoid No. 3 in 4 - LCA - 10 relay box, which de-energises relays P6_n - S .

(c) A warning bell in the pumphouse is arranged so that an audible warning is given if one or more of the three operating main pumps (or a shutdown pump) fails. Contacts 21, 22 and 23 of P6 - X2 are connected in parallel with 11, 12 and 13 of P6 - A and with 11, 12 and 13 of P6 - S. These parallel circuits are connected in a guard line in series with relay P6 - WB and its holding contacts 2, 4 and 6. The parallel series of contacts associated with the standby pump will be short circuited by contacts of P6 - S (de-energised) for that pump. If one (or more) of the three running pumps fails, relay P6 - X2 will be released and, during the transit of the contact, the line will be open circuited. During the brief open circuit period, high speed relay P6 - WB and its holding contact will be released, in turn releasing relay P6 - H which, through its contacts 11, 12 and 13, sounds the warning bell. When pumps are in the RESET condition, that is, they have been stopped but have not failed, no alarm is given since relay P6 - A is energised and its contacts 11, 12 and 13 keep the warning bell guard line complete, preventing the alarm from sounding.

The warning bell guard line also contains a series/parallel relay contact set to sound the alarm if a shutdown pump fails (see AAEC/M17 for details).

The warning bell may be cancelled by means of the pumphouse bell cancel pushbutton (or the cancel button on the lid of 4 - LCA - 10 relay box). The cancel pushbutton re-energises P6 - WB and thereby re-energises P6 - H which, through its contacts 11, 12 and 13, stops the bell.

The pumphouse warning bell also sounds if the cooling tower pond level is low. This occurs because, under low level alarm conditions solenoid 2 in 4 - LCA - 10 relay box is released and this activates L - 10 which through contacts 1, 2 and 3 sounds the bell. An alarm due to this

condition may be cancelled by using the pumphouse bell cancel pushbutton or the cancel button on the relay box lid which are arranged to energise solenoid 1, releasing relay $\underline{L - 10}$, and stopping the bell by open circuiting contacts 1, 2 and 3, of relay $\underline{L - 10}$.

(d) An indication of COOLING TOWER BASIN HIGH is given by an indicator lamp controlled by solenoid 4 in 4 - LCA - 10 relay box. This solenoid is energised by means of the 4 - LCA - 10 electrode in the cooling tower basin, and lights the warning lamp.

4.3 Stopping a Pump

A pump can be stopped in the following ways:

- (a) By pressing the normal STOP button (red). This is on the front of a box mounted on top of the starter and releases relay $\underline{P6 - S}$ whose contacts 31, 32 and 33 are in series with the $\frac{8}{8}$ undervoltage release which, upon the opening of the contacts, stops the pump.
- (b) The starter has magnetic overload protection. Its operation stops the pump and the motor should be allowed to cool before re-starting. In this stopped (or FAILED) condition, relays $\underline{P6 - X1}$ and $\underline{P6 - X2}$ are both released.
- (c) By pressing the mushroom headed stop plunger on top of the starter. In this stopped (FAILED) condition, relays $\underline{P6 - X1}$ and $\underline{P6 - X2}$ are both released.

Hence in the FAILED condition, only relay $\underline{P6 - S}$ is energised. To reset the circuit the normal STOP button is pressed and the circuit reverts to the RESET condition as described in Section 4.2.1 above.

4.4 Uses of Contacts from Auxiliary Relays $\underline{P6_n - X1}$ and $\underline{P6_n - X2}$

Contacts from relays $\underline{P6_n - X1}$ and $\underline{P6_n - X2}$ are used as follows:

- (a) Contacts 1, 2 and 3 and 4, 5 and 6 of $\underline{P6_1 - X1}$ are connected in a series/parallel network with similar $\frac{8}{8}$ contacts associated with the other three pumps. This network will be open circuited if any three pumps are not operational. The network is inserted in the RESTRICTED TRIP primary guard line.

- (b) Contacts 1, 2 and 3 and 4, 5 and 6 of $\frac{P6_1 - X2}{8}$ are connected in a series/parallel network with similar contacts associated with the other three pumps. This network will be open circuited if any three pumps are not operational. The network is inserted in series with the RESTRICTED TRIP secondary guard relay $\frac{P6 - Z1}{6}$.
- (c) Contacts 11, 12 and 13 and 14, 15 and 16 of $\frac{P6_1 - X1}{8}$ are connected in a series/parallel network with similar contacts associated with the other three pumps. This network will be open circuited if any two pumps are not operational. The network is inserted in the CONTROL REVERSAL primary guard line.
- (d) Contacts 11, 12 and 13 and 14, 15 and 16 of $\frac{P6_1 - X2}{8}$ are connected in a series/parallel network with similar contacts associated with the other three pumps. This network will be open circuited if any two pumps are not operational. The network is inserted in series with the CONTROL REVERSAL secondary guard relay $\frac{P6 - Z2}{6}$.
- (e) Contacts 24, 25 and 26 of $\frac{P6_1 - X1}{8}$ and contacts 24, 25 and 26 of $\frac{P6_1 - X2}{8}$ are connected in parallel with similar contacts associated with the other three pumps in a network that will be open circuited if all four pumps are not operational. This network causes the light water shutdown pump to start (see AAEC/M17 for details). In addition to starting the shutdown pump, it lights the NO MAIN H₂O PUMPS lamp on the Fault Analysis display on Control Room Panel No. 5.
- (f) Contacts 34, 35 and 36 of $\frac{P6_n - X1}{8}$ and $\frac{P6_n - X2}{8}$ are not used.
- (g) Contacts 21, 22 and 23 of $\frac{P6_n - X1}{8}$ are used in a resetting circuit associated with relay $\frac{P6_n - S}{8}$ as described above in Section 4.2.2.

- (h) Contacts 21, 22 and 23 of $\underline{P6_n - X2}$ are used in the guard line controlling the pumphouse⁸ warning bell, as described above in Section 4.2.3 (c).
- (i) Contacts 31, 32 and 33 of $\underline{P6_n - X1}$ are used to light the 4P6 pump running lamps in the Flow Diagram in Control Room Panel No. 5.
- (j) Contacts 31, 32 and 33 of $\underline{P6_n - X2}$ are used to light RUNNING or FAILED lamps in association with contacts 31, 32 and 33 of $\underline{P6_n - A}$ as described above in Section 4.2.3 (a).⁸

APPENDIX

REACTOR HIFAR - LIST OF INSTRUMENTATION MANUALS

EXPLANATORY NOTE

The status of titles that have not been issued at June 1969 is indicated by the following marks:

- * In draft form
- * Not issued
- Title and serial number cancelled.

- M1 Introduction to HIFAR Guard and Safety Circuits
 - M2 Complete Shutdown Circuits
 - M3 Trip Circuits
 - M4 Control Reversal Circuits
 - M5 Warning Circuits
 - * M6 Primary Search Unit
 - M7 Start Guard Circuits
 - * M8 Flux Trip Circuits
 - * M9 Safety Rod Circuits
 - * M10 Coarse Control Arm Circuits
 - M11 Fine Control Rod Circuit
 - M12 Dump Valve Circuit
 - M13 Main Heavy Water Pump Circuit (S1)
 - M14 Shutdown Heavy Water Pump Circuit (S2)
 - * M15 Liquid Level Pump Circuits (S3 and S4)
 - M16 Main H₂O Pump Circuits (S6)
 - * M17 H₂O Shutdown Circuits (S8)
 - * M18 Cooling Tower Fan Circuits (G8)
 - * M19 Shield Cooling Pump Circuits (S7)
 - M20 Experimental Pump Circuits (S9)
 - M21 Fine Control Rod Pump Circuits (S14)
 - * M22 Miscellaneous Circuits
- | | |
|-------------------|------------------|
| 24V circuits | 4-LLA-10 circuit |
| 50V d.c. circuits | 4-L-15 circuit |
| 240V circuits | Panel N |
- M23 Trip and Warning Alarm Circuits
 - * M24 Ventilation Flow Diagram Circuit
 - * M25 Main Flow Diagram and Cooling Tower Lamp Circuits

continued...

APPENDIX (continued)

- * M26 Annunciator Lamp Circuits
- * M27 Fault Analysis Lamp Circuits
- * M28 Principles of Operation of the Nucleonic Instruments
- M29 The Control Room
- M30 The Coarse Control System
- M31 The Fine Control System
- M32 The Safety System
- M33 Fine Control Drive System
- M34 Leak Detectors
- * M35 Modifications for Low Power Operation
- * M36 Recorders
- M37 Physical Instrumentation of HIFAR
- * M38 Ionisation Chambers and Health Monitors
- M39 Test Schedule for Guard, Safety, and Interlock Circuits