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LUCAS HEIGHTS

REACTOR HIFAR

THE MAIN HEAVY WATER PUMP CIRCUITS (S1)

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ABSTRACT

This manual describes in detail the operation of the relay circuitry associated with the control of the main heavy water pumps.

CONTENTS

1. INTRODUCTION

This manual must be read in conjunction with AAEC/M1 'An Introduction to the Guard and Safety Circuits' and also AAEC/M14 'Shutdown Heavy Water Pump Circuit'. It is one of a group of manuals whose titles are listed in Appendix 1.

2. THE MAIN HEAVY WATER CIRCULATORS

Three pumps are provided, of which only two are necessary to supply heavy water circulation for fuel element cooling at powers up to 11 MW. The third pump is a standby but may be operated continuously at higher reactor power levels. They are operated from a 415 V three phase, 50 c/s supply and are started by a 60 horsepower auto-transformer starter (see Figure 2 for its circuit diagram). Current per phase is about 100A. Each starter has a circuit breaker, STOP/START buttons, automatic start/run changeover and an ammeter in one of the phases.

The motor and impeller are totally immersed in the heavy water so that there are no rotating seals. The bearings are of a suitable type which is lubricated by the heavy water. The stator windings are of high purity aluminium insulated with irradiated polythene. The motor laminations and magnetic circuit are of stainless steel with suitable magnetic properties. A thermocouple in the windings of each motor senses the winding temperature which must not be allowed to exceed 70°C.

3. OPERATION OF THE PUMPS

3.1 General

(a) The pumps can be started from either the Emergency Control Room or the Auto-Transformer Starter.

(b) The pumps can be stopped from either the Emergency Control Room or the Auto-Transformer Starter or Motor Control Panel No. 3.

(c) To simplify the manual, in general a description is given of the operation of only one pump, 1P1/1. The other pumps operate in an identical fashion and only subscripts need to be changed to follow their operation.

(d) Each pump has the following four relays associated with it, $\frac{P1\text{-}A}{4}$, $\frac{P1\text{-}S}{4}$, $\frac{P1\text{-}X1}{8}$, $\frac{P1\text{-}X2}{8}$; the actual pump is identified by a subscript as follows: $\frac{P1_2\text{-}A}{4}$ refers to the $\frac{P1\text{-}A}{4}$ relay associated with pump 1P1/2.

3.2 Initial Starting of a Pump

3.2.1 Reset condition

As the 50 volt d.c. instrumentation supply to relays $\frac{P1\text{-}A}{4}$ and $\frac{P1\text{-}S}{4}$ is live and it is assumed that both these relays are for the moment de-energised, then the following operations will occur putting the pump circuit into a RESET condition:

(a) Relay coil $\frac{P1\text{-}A}{4}$ will be energised through contacts 4, 5 and 6 of relay $\frac{P1\text{-}S}{4}$.

(b) Now relay $\frac{P1\text{-}S}{4}$ is energised via contacts 4, 5 and 6 of relay $\frac{P1\text{-}A}{4}$ and remains energised through its holding contacts 1, 2 and 3.

Energising relay $\frac{P1\text{-}S}{4}$ causes contacts 4, 5 and 6 to open and thus tends to release relay $\frac{P1\text{-}A}{4}$. However, relay $\frac{P1\text{-}X1}{8}$ is not energised and its contacts 24, 25 and 26 together with relay $\frac{P1\text{-}A}{4}$ holding contacts 1, 2 and 3 keep relay $\frac{P1\text{-}A}{4}$ energised. Also contacts 11, 12 and 13 of relay $\frac{P1\text{-}S}{4}$ are in series with the START and STOP contacts of the main starter so that relay $\frac{P1\text{-}S}{4}$ must be energised before the starter can operate.

Hence in this RESET condition relays $\frac{P1\text{-}A}{4}$ and $\frac{P1\text{-}S}{4}$ are energised.

3.2.2 Starting

To proceed to the next stage of starting the pump it is assumed that the mains circuit breaker is closed. When the START button is pressed either in the Emergency Control Room or on the Pump Starter Unit, the starter holding coil $\frac{SC}{2+2}$ is energised (see Figure 2). This in turn energises the TRANSFORMER contactor $\frac{TC}{3+2}$. During this stage, with $\frac{TC}{3+2}$ and $\frac{SC}{2+2}$ both operated, the starting auto-transformer is connected to the pump in an open delta connection. This connection is maintained over the period set by the time delay changeover springset associated with $\frac{TC}{3+2}$. Operation of the time delay changeover contacts releases the START contactor $\frac{SC}{2+2}$ and energises the RUN contactor $\frac{RC}{3+3}$ which applies full mains voltage to the motor winding. Auxiliary contacts RC on the RUN Contactor allow relays $\frac{P1\text{-}X1}{8}$ and $\frac{P1\text{-}X2}{8}$ to be energised from 415 V single phase 50 c/s, thereby making available 16 sets of changeover contacts for use in other circuits as described in Section 3.4 below.

Energising relay $\frac{P1\text{-}X1}{8}$ causes contacts 24, 25 and 26 to release relay $\frac{P1\text{-}A}{4}$. This represents the normal running condition and relays $\frac{P1\text{-}S}{4}$, $\frac{P1\text{-}X1}{8}$ and $\frac{P1\text{-}X2}{8}$ are energised.

3.2.3 Warning indications

Other contacts on relay $\frac{P1\text{-}A}{4}$ are used in the following circuits:

(a) Contacts 11, 12 and 13 of $\frac{P1\text{-}A}{4}$ are used in conjunction with contacts 31, 32 and 33 of relay $\frac{P1\text{-}X2}{8}$ which indicate the RUNNING or FAILED state of the pump 1P1/1 by lights on Motor Control Cubicle No. 3 and also in the Emergency Control Room. These are the usual 24 volt a.c. operated coloured 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 11, 12 and 13 of relay $\frac{P1\text{-}A}{4}$ in this circuit, which relay is energised when the circuit is in the RESET condition.

(b) Contacts 14, 15 and 16 of $\frac{P1\text{-}A}{4}$ are used in conjunction with contacts 34, 35 and 36 of relay $\frac{P1\text{-}X2}{8}$ which give an audible warning (see AAEC/M23 for full details) in the Control Room that a pump has failed. When the pump is restarted, relay $\frac{P1\text{-}A}{4}$ is energised so that contacts 14, 15 and 16 are open circuit and an audible warning is not given as the pump starts.

3.3 Stopping of a Pump

A pump can be stopped in a number of ways:

(a) Pressing the STOP button in Motor Control Panel No. 3 which releases relay $\frac{P1\text{-}S}{4}$ whose contacts 11, 12 and 13 are in series with the holding coil of the pump starter. This releases the Run Contactor and stops the motor.

(b) Pressing either the STOP button in the Emergency Control Room or the STOP button on top of the starter cabinet. This directly open circuits the holding coil of the pump starter thereby stopping the motor.

(c) If the starter becomes overheated, a thermal overload will also directly open circuit the holding coil of the pump starter. Should this occur before the motor has been running for thirty minutes, the starter and motor should be allowed to cool for twenty minutes before attempting to restart the motor. If the motor has been running for longer than thirty minutes, a cooling time of ten minutes should be allowed. In this stopped (or FAILED) condition, relays $\frac{P1\text{-}X1}{8}$ and $\frac{P1\text{-}X2}{8}$ are both released and also relay $\frac{P1\text{-}A}{4}$ is released since contacts 24, 25 and 26 of relay $\frac{P1\text{-}X1}{8}$ open circuit its coil.

Hence in the FAILED condition only relay $\frac{P1\text{-}S}{4}$ is energised.

To reset the circuit the STOP/RESET button in Motor Control Cabinet No. 3 is pressed and the circuit reverts to the RESET condition of Section 3.2.1 above.

3.4 Uses of Contacts from Auxiliary Relays $\frac{P1\text{-}X1}{8}$ and $\frac{P1\text{-}X2}{8}$

Contacts from Auxiliary Relays $\frac{P1\text{-}X1}{8}$ and $\frac{P1\text{-}X2}{8}$ are used in the following circuits:

(a) Contacts 1, 2 and 3 of relay $\frac{P1\text{-}X1}{8}$ are connected into the RESTRICTED TRIP Primary Guard Line in parallel with similar contacts associated with the other two pumps in a simple network such that it open circuits on failure of all pumps.

(b) Contacts 1, 2 and 3 of relay $\frac{P1\text{-}X2}{8}$ are connected into the RESTRICTED TRIP Secondary Guard Line in parallel with similar contacts associated with the other two pumps in a simple network such that it open circuits on failure of all pumps.

(c) Contacts 4, 5 and 6 of each relay are connected in series and incorporated in a network along with similar contacts associated with the other two pumps such that the failure of both pumps open circuits the network. (It should be borne in mind that normal reactor operation requires that only two main heavy water circulators be operating at any one time with the third available on standby.) This network causes the heavy water shutdown pumps to start via release of relays $\frac{P2_1\text{-}A}{2+2}$ or $\frac{P2_2\text{-}A}{2+2}$. Operation of this circuit is described in AAEC/M14.

(d) Contacts 11, 12 and 13, and 14, 15 and 16 of $\frac{P1\text{-}X1}{8}$ are incorporated in a network along with other similar contacts associated with the other two pumps such that failure of one pump, that is, only one operating, causes the network to open circuit. The network is inserted in the CONTROL REVERSAL Primary Guard Line.

(e) Contacts 11, 12 and 13, and 14, 15 and 16 of $\frac{P1\text{-}X2}{8}$ are incorporated in a network along with other similar contacts associated with the other two pumps such that failure of one pump, that is, only one operating, causes the network to open circuit. The network is inserted in the CONTROL REVERSAL Secondary Guard Line.

(f) Contacts 21, 22 and 23 of each relay are not used.

(g) Contacts 24, 25 and 26 of relay $\frac{P1\text{-}X1}{8}$ are used in a resetting circuit associated with relay $\frac{P1\text{-}S}{4}$ and described above in Section 3.2.2.

(h) Contacts 24, 25 and 26 of relay $\frac{P1\text{-}X2}{8}$ are not used.

(i) Contacts 31, 32 and 33 of relay $\frac{P1\text{-}X1}{8}$ are not used.

(j) Contacts 31, 32 and 33 of relay $\frac{P1\text{-}X2}{8}$ are used to light RUNNING and FAILED lights in association with contacts 11, 12 and 13 of relay $\frac{P1\text{-}A}{4}$. Their operation is described in Section 3.2.3(a) above.

(k) Contacts 34, 35 and 36 of relay $\frac{P1\text{-}X1}{8}$ are not used.

(l) Contacts 34, 35 and 36 of relay $\frac{P1\text{-}X2}{8}$ are used in association with contacts 14, 15 and 16 of relay $\frac{P1\text{-}A}{4}$ to light the 1P1 Pump Running light in the Flow Diagram in Control Room Panel No. 5.

APPENDIX 1

REACTOR HIFAR - LIST OF INSTRUMENTATION MANUALS

	M1	Introduction to 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	Transfer and Liquid Level Pump Circuits (S3 and S4)
*	M16	Main H_2O Pump Circuits (S6)
*	M17	H_2O 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-LIA-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
*	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

Continued...

APPENDIX 1 (Continued)

*	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

* Not yet issued