AUSTRALIAN ATOMIC ENERGY COMMISSION

RESEARCH ESTABLISHMENT

LUCAS HEIGHTS

REACTOR HIFAR

THE SHUTDOWN HEAVY WATER PUMP CIRCUITS (S1)

by

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REACTOR HIFAR - THE SHUTDOWN HEAVY WATER PUMP CIRCUITS (S2)

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ABSTRACT

This manual describes in detail the operation of the relay circuitry associated with the control and automatic start-up of the heavy water shutdown pumps.

CONTENTS

1. INTRODUCTION

This manual must be read in conjunction with manual AAEC/M1 'An Introduction to the Guard and Safety Circuits' and also AAEC/M13 'The Main Heavy Water Pump Circuits'. It is one of a group of Manuals whose titles are listed in Appendix 1.

2. THE SHUTDOWN PUMPS

Two pumps are provided, neither of which is operating during normal operation of the reactor. If all the main heavy water circulators stop then one shutdown circulator will be started automatically and if that fails to start the other will be started automatically. There is provision for selection of either pump to start first and also a maintenance test unit to start either pump manually at any time for test purposes.

They are operated from a 415V three phase 50 c/s supply and are started direct on line. Current per phase is about 15A and each pump has a circuit breaker for isolation purposes.

Each pump is fitted with both an undercurrent and an overcurrent protective arrangement. The undercurrent relay releases if the pump motor current is too low. The overcurrent protection is by means of the normal thermal overload bimetallic strip arrangement and requires manual resetting.

The motor is outside the heavy water circuit and is coupled to the impeller by a magnetic coupling through a non-magnetic stainless steel diaphragm. The impeller bearings are ferrobestos and are lubricated by the heavy water.

The flow capacity (340 gallons/minute at 10 ft head) is adequate to remove safely all fission product shutdown heating in the fuel elements up to a reactor power level of 15 MW. In the event of a complete power failure it is only necessary to run these pumps from the standby diesel supply as there is sufficient cooling capacity in the D_2O in the reactor aluminium tank to remove fission product heating for at least an hour before the onset of bulk boiling.

3. OPERATION OF THE PUMPS

3.1 General

One pump is chosen to start first by the Duty Selector Switch. If it fails to start, then the second pump is tried automatically. Reference to Figure 1 indicates that Pump 1P2/1 has been chosen to start first and the sequence of operations on a time basis is as follows:

(a) Before 0 secs

Relays $\frac{P2_1\text{-}A}{2Hg+2}$ and $\frac{P2_2\text{-}A}{2Hg+2}$ are held operated by a network of relay contacts from the auxiliary relays $\frac{P1\text{-}X1}{8}$ and $\frac{P1\text{-}X2}{8}$ associated with the main heavy water circulating pumps. (See AAEC/M13 and Drawing AE4543 for details.)

Relay $\frac{P2_1\text{-}M}{2Hg+2}$ is held operated through the relay $\frac{P2_1\text{-}A}{2Hg+2}$ 1 sec delayed release Hg contacts.

Relay $\frac{P2_2\text{-}M}{2Hg+2}$ is held operated through the relay $\frac{P2_2\text{-}A}{2Hg+2}$ 1 sec delayed release Hg contacts and also through relay $\frac{P2_1\text{-}M}{2Hg+2}$ delayed release Hg contacts in series with contacts E_1 F_1 of the Duty Selector Switch.

(b) At 0 Secs

All the main heavy water circulators fail, causing relays $\frac{P2_1\text{-}A}{2Hg+2}$ and $\frac{P2_2\text{-}A}{2Hg+2}$ to be released. Supply is made to the direct on line motor starter coil $\frac{P2_1\text{-}R}{3+2}$ through $P2_1$-A Hg normal relay contact in series with contacts A_1B_1 of the Duty Selector Switch. Since Duty Selector Switch contacts A_2B_2 are open, and relay $\frac{P2_1\text{-}M}{2Hg+2}$ is energised, supply cannot be completed by a similar route to the starter coil of the other motor.

(c) In the interval 0 to 1 secs

Mains supply is completed to the selected pump 1P2/1 and relay $\frac{P2_1\text{-}T}{1Hg+2}$ is energised through an auxiliary contact on relay $\frac{P2_1\text{-}R}{3+2}$ and undercurrent coil contact $P2_1$-B in series.

The supply to relay $\frac{P2_1\text{-}M}{2Hg+2}$ is now fed through $\frac{P2_1\text{-}T}{1Hg+2}$ 1 sec delayed release Hg contacts so that relay $P2_1$-M will remain energised through these contacts after the 1 sec delay period. Relay $\frac{P2_2\text{-}M}{2Hg+2}$ remains energised through its original circuit.

(d) At 1 second

(i) If pump 1P2/1 is satisfactory it continues to run through circuits just described above.

(ii) If pump 1P2/1 is unsatisfactory either through failure of the overcurrent mechanism or the undercurrent relay $\frac{P2_1\text{-}B}{2}$ then the starter coil will be released and relay $\frac{P2_1\text{-}T}{1Hg+2}$ will also release, due to it being controlled by auxiliary starter contacts. This in turn releases relay $\frac{P2_1\text{-}M}{2Hg+2}$ through the opening of the 1 second delayed Hg

contacts of $\frac{P2_1\text{-}T}{1Hg+2}$. Supply is then made through the normal contacts of relay $P2_2$-A (which are closed since relay $P2_2$-A is released) in series with the $P2_1$-M normal Hg contacts across terminals A_2, B_2 of the Duty Selector Switch to the motor starter coil $\frac{P2_2\text{-}R}{3+2}$ of pump 1P2/2. The circuit route is not via $P2_2$-A delayed release Hg contacts as this relay has already released.

(e) In the interval 1 to 2 secs

Pump 1P2/2 starts and relay $\frac{P2_2\text{-}T}{1Hg+2}$ is energised through an auxiliary contact on relay $\frac{P2_2\text{-}R}{3+2}$ and undercurrent relay coil contact $P2_2$-B in series. Relay $P2_2$-M is held energised by the 1 second delayed release Hg contacts of relay $P2_2$-T so that release of relay $P2_1$-M delayed release Hg contacts does not release relay $\frac{P2_2\text{-}M}{2Hg+2}$.

3.2 Failure of Pump 1P2/1 in Operation

Relay $\frac{P2_1\text{-}T}{1Hg+2}$ releases and after 1 sec, relay $P2_1$-M is released and the starting sequence described above for 1P2/2 commences.

3.3 Warning Indications

When either pump is running, then the appropriate P2-T relay is operated.

When either pump has been tried and has failed to start, then the appropriate P2-M relay is released. These operations are used to operate RUNNING and FAILED lights on Motor Control Cabinet No. 3 and in the Control Room and in the Emergency Control Room.

The RUNNING indication is given directly by contacts 1, 2 and 3 of the appropriate P2-T relay inserted in series with the 24 volt a.c. supply and the lamp. Contacts 11, 12 and 13 of relay P2-T light the appropriate running lamp in the Flow Diagram in Control Room Panel No. 5.

Owing to a shortage of relay contacts on the P2-M relays, auxiliary relays $\frac{P2\text{-}N}{6}$ are operated by the appropriate contacts 11, 12 and 13 of the P2-M relays. Contacts on $\frac{P2_1\text{-}N}{6}$ and $\frac{P2_2\text{-}N}{6}$ are used similarly in the following manner:

(a) Contacts 1, 2 and 3 light the FAILED lamps.

(b) Contacts 4, 5 and 6 light Control Room Panel No. 6 Annunciator L12 D_2O PUMPS.

(c) Contacts 11, 12 and 13 and 14, 15 and 16 are not used.

(d) Contacts 21, 22 and 23 light the FAILED light in the Fault Analysis Panel in Control Room Panel No. 5.

(e) Contacts 24, 25 and 26 give audible warnings of failure of the pump and are used in the Trip and Warning alarm circuits (see AAEC/M23 for details).

(f) Contacts 31, 32 and 33 and 34, 35 and 36 are not used.

3.4 Test Facilities

Two test facilities are provided:

(a) On Motor Control Cabinet No. 3 there are two push buttons $P2_1$-T and $P2_2$-T which complete the supply to the motor starter coils without disturbing the relay circuits. They can be pressed at any time and if the selected pump is not running it will start and the appropriate RUNNING lights will come on. The pump will run for as long as the button is held in manually.

(b) In the Heavy Water Plant Room near the appropriate shutdown pump there is a key operated maintenance test unit. This is operated by key HIFAR No. 6 which normally is trapped in the Lockout-Bypass Panel in Control Room Panel No. 1. When the reactor is shut down then key No. 6 can be removed and taken to the D_2O Plant Room to test start the D_2O shutdown pumps. (If the key is removed from the Lockout - Bypass Panel when the reactor is operating, a CONTROL REVERSAL will be initiated.) On turning the key in the key-operated unit the pumps are removed from their relay circuitry control so that they can be started one at a time by using the appropriate push button.

Note: The Duty Selector Switch cannot be used to start pump 1P2/2 if pump 1P2/1 is running satisfactorily.

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-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
*	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