AAEC/M9

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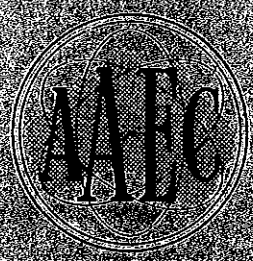

AUSTRALIAN ATOMIC ENERGY COMMISSION

RESEARCH ESTABLISHMENT
LUCAS HEIGHTS

REACTOR HIFAR - THE SAFETY ROD CIRCUITS

by

J.B. HOPKINSON

August 1969

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ABSTRACT

This manual describes the Safety Rod Circuits of the reactor HIFAR.

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APPENDIX List of Manuals on HIFAR Instrumentation

Figure 1 Typical Safety Rod Control Circuit (Drawing BE4004)

1. INTRODUCTION

This manual is one of a series on the control, instrumentation, and safety circuits of the reactor HIFAR. Other titles in the series are listed in the Appendix.

This manual should be read in conjunction with AAEC/M1 'An Introduction to HIFAR Guard and Safety Circuits' and also AAEC/M32 'The Safety Rod System'.

2. BASIC PRINCIPLE OF OPERATION

The safety rods, which together control approximately 2.0 per cent reactivity for a core of 3.0 kg U235 and relatively low control arm angles, are identical and installed on opposite sides of the reactor.

The main features of the design of the safety rod control circuits are as follows:

(a) Each safety rod is controlled independently by a separate mechanism basically consisting of a winding drum, around which passes the cable suspending the safety rod, and capable of being coupled by an electro-magnetic clutch to a shaft driven through appropriate gearing by a 3 phase electric motor.

(b) There are only two rest positions of a safety rod:

(i) completely down or in the reactor, and

(ii) completely up or withdrawn from the reactor.

The two limiting positions are indicated by switches contained in the rod mechanism.

(c) The rods can be held up only if their magnetic clutches are energised. If the clutch circuits are disconnected the winding drums are freed and the safety rods fall, under gravity, to the fully down position. See AAEC/M32 for details.

Under normal conditions both safety rods are withdrawn from the reactor. The safety rod circuits include electrical interlocks which prevent any movement of control elements, that is, coarse control arms, unless this condition is realised.

3. SAFETY ROD CIRCUITS

3.1 Control Circuits

3.1.1 Circuit Drawings

A typical circuit for controlling the safety rods is shown in Figure 1. The two circuits are essentially identical and the corresponding components are coded similarly except for suffixes 1 or 2 added to the general code to indicate with which safety rod they are associated.

In the discussion of the action of the circuits the suffixes are omitted so that the descriptions are applicable to both circuits.

3.1.2 Operational Control of Safety Rods

Although the control circuits are independent of each other, in operation the two rods are effectively controlled in parallel. The clutch circuit of each rod is established via relay contacts and switches, and the following conditions must be met before either rod can be raised from the fully IN position:

(a) All COMPLETE TRIP guard conditions must be safe and the guard circuit monitoring relays X–P1, X–P2, X–Z1 and X–Z2 must be energised.

(b) The safety rod release relay B3-B must be energised.

(c) All of the coarse control arms must be down to energise relay BD-G via contacts on relay B1-D.

(d) Lockout Switch No. 2 must be in the OPERATIONAL position.

(e) Initially the rod itself must be DOWN. This condition ensures that nothing has prevented the completely free drop of the rod on the previous occasion. This check is obtained by initially requiring the down limit switch B3-DL1 to be operated by the rod resting in its fully DOWN position. Operation of switch B3-DL1 completes the circuit to relay B3-D on which two contacts provide the interlock condition. One B3-D contact prepares the clutch circuit and the second B3-D contact prepares a circuit to the motor relay B3-R. The latter interlock primarily facilitates positioning of the three up limit switches fitted to each mechanism, see Section 3.4.

3.1.3 Circuit Action When Raising Safety Rods

Provided that the conditions outlined in Section 3.1.2 are met, the circuits to the electro-magnetic clutches are completed by using the HIFAR Key No. 1 to turn the Master Switch in the safety rod control unit (Unit 5, Control Room Panel 3) to the RAISE position. A relay B3-A shows completion of the clutch circuits.

The sequence of the circuit action is then as follows:

(a) Relay B3-A is energised, and in turn:

(i) Bridges the contact of relay B3-D which was used to prepare the clutch circuit. The clutch circuit is thus maintained when the rod moves off its bottom limit.

(ii) Energises relay B3-R via the up limit switch B3-UL1.

(b) Relay B3-R, on being energised:

(i) Connects the 3 phase 50V supply to the driving motor which then commences to raise the safety rod.

(ii) Bridges the contacts of relay B3-D preparing the motor operating circuit so that the motor circuits are maintained when relay B3-D is de-energised after the safety rod is lifted off its bottom limit.

(c) The rod is withdrawn from the reactor until either,

(i) it reaches the upper limit position where B3-UL1 is operated, or

(ii) the clutch circuit is disconnected.

(d) Upon operation of the upper limit switch B3-UL1 the motor relay B3-R is disconnected, thus stopping the driving motor.

The rod remains in the UP position until the magnetic clutch is released.

(e) When both safety rods are UP the Master Switch is turned to the HOLD position. The clutch circuit is then maintained via a contact of the up limit check relay B3-U1 which is energised by limit switch B3-UL1 when the rod is fully raised. This additional switching sequence:

(i) Ensures that on release the safety rod will not automatically commence to run up again.

(ii) Allows the Master Key (HIFAR Key No. 1), which is mechanically trapped in the Master Switch while the safety rods are being raised, to be removed without releasing the safety rods. Simultaneously the circuits required for the operation of the other control elements are prepared for the first time. Because these circuits are also dependent on the safety rods being UP, this switching sequence involving the Master Switch provides a positive interlock.

3.1.4 Conditions for Maintaining the Safety Rods in the UP Position

The conditions which must be fulfilled for the safety rods to be held UP are related to the position of the Master Switch.

While the Master Switch is in the RAISE position, conditions (a), (b), (c) and (d) of Section 3.1.2 apply.

After the switch has been turned to the HOLD position the only necessary conditions, apart from the need for relay B3–U1 to be energised are (a), (b) and (d) of Section 3.1.2, that is;

(i) all COMPLETE TRIP guard conditions must be safe,

(ii) the safety rods release relay B3–B must be energised, and

(iii) Lock-out Switch No. 2 must be in the OPERATIONAL position.

3.1.5 Current Adjustment in the Clutch Circuits

A resistor B3–R2 is fitted across the coil of relay B3–A to limit the current flowing through this relay. The value of B3–R2 has been determined so that the current through the relay coil lies between 90 and 150 mA.

3.1.6 Manual and Loss of Shutdown Margin Release of Safety Rods

A press switch labelled DROP SAFETY RODS located on Panel 5 in the Control Room, facilitates manual dropping of the safety rods if required. This switch is normally closed to keep relay B3–B energised. Contacts on relay B3–B are included in each safety rod clutch circuit so that operation of this press switch releases relay B3–B and thus both safety rods are released. The Master Switch must be returned to the RAISE position on the safety rod control unit after release of the DROP SAFETY RODS button in order to raise the safety rods again.

The relay B3–B circuit also includes contacts of relay Lϕ-G associated with the log power recorder on Panel 7 in the Control Room. Lϕ-G is energised at powers up to 10^4 watts via the contacts of the log power recorder switch located at the rear of the instrument. Should the log power recorder indicate 10^4 watts while the reactor is shut down, the Lϕ-G contacts open to release relay B3–B causing both safety rods to fall into the reactor. In this event, if the safety rods are to be raised again, the log power recorder must indicate less than 10^4 watts and the Master Switch must be returned to the RAISE position on the safety rod control unit. When starting up the reactor, the turning ON of the Main Control Switch on Panel 5 automatically arranges for the bypassing of the facility for the release of the safety rods due to the loss of shutdown margin; this is done through relays B1–Ba, B1–Bb and Lϕ-A, which arrange for Lϕ-G to remain energised when the log power recorder indicates power greater than 10^4 watts.

It should be noted that if the safety rods are released by either of the abovementioned means, the coarse control arms are released owing to the RESTRICTED TRIP guard circuits being opened by the safety rod upper limit switches B3-UL2 and B3-UL3. These open as soon as the safety rods leave the up limit position.

3.2 Maintenance Facilities

A maintenance switch B3-Q adjacent to each unit allows the testing of each safety rod mechanism while the reactor is shut down. The maintenance switches are operated by HIFAR Key No. 3 which, under operational conditions, is trapped in Lockout Switch No. 2.

The following procedure is necessary before maintenance on either rod can be carried out:

(a) Raise both safety rods under normal operating conditions and when both are up, turn the Master Switch to the HOLD position of the safety rod control unit and leave it in that position.

(b) Set Lockout Switch No. 2 to position 2 (SAFETY ROD MAINTENANCE position). HIFAR Key No. 3 can then be removed from the Lockout Switch and transferred into the appropriate maintenance switch B3-Q.

The maintenance switch appropriate to the safety rod under test can now be operated to release the safety rod and raise it again as required. However, to facilitate this the following precautions are built into the safety rod maintenance circuits.

(i) The safety rod under test can only be released if the other safety rod is fully UP. The circuit to the DROP position of the maintenance switch is via a contact of relay B3-A operated to a normal contact of the up limit relay B3-U1 associated with the other rod. The clutch circuit is broken in the DROP position only if the latter relay is energised.

(ii) Once a safety rod has been released it can only be raised again if:

(1) The COMPLETE TRIP guard circuits are safe, that is, relays X-P1, X-P2, X-Z1 and X-Z2 are all energised.

(2) All coarse control arms are DOWN, that is, relay BD-G is energised.

(3) The rod has dropped completely to its down limit position so that switch B3-DL1 is operated and hence relay B3-D is energised.

(4) The other safety rod is UP.

After the rod has been completely raised a circuit can be completed via a third maintenance switch position labelled HOLD. In this case the clutch circuit becomes independent of all automatic release features. This minimizes the risk of the rod being released during maintenance on the mechanisms.

The maintenance facilities have been designed so that at least one safety rod is always in the UP position in case any danger condition arises. Maintenance is restricted to one safety rod at a time because the same key, HIFAR No. 3, has to be used to actuate both maintenance switches, and the key is trapped in the switches in all positions other than RAISE.

3.3 Position Indicators

3.3.1 Lamp Indicators

Position indicators for both safety rods are fitted on the safety rod control unit on Panel 3 in the Control Room and are designated UP, RISING and DOWN.

The limiting positions of each safety rod are indicated by two lamps.

(a) The DOWN lamp lights when the safety rod is down and relay B3–D is energised by the down limit switch B3–DL1. A contact on relay B3–D controls the lamp.

(b) The UP lamp lights when the safety rod is fully up. This lamp is controlled by a contact on relay B3–U1 which is energised by the up limit switch B3–UL1. For each safety rod the RISING lamp is controlled by a contact on the motor relay B3–R.

A lamp designated SAFETY RODS NOT UP, on Panel 5 lights whenever either or both of the safety rods are not completely raised. This lamp is controlled by contacts of the upper limit relays $B3_1$–U1 and $B3_2$–U1.

When either safety rod falls from its UP position a sign designated SAFETY RODS lights in the trip annunciator display section of Panel 4 in the Control Room. This sign is controlled by contacts in relay B3–Z which is the safety rods RESTRICTED TRIP secondary guard relay and is energised via the two upper limit switches $B3_1$–UL_3 and $B3_2$–UL_3.

3.3.2 Meter Position Indicator

Each safety rod mechanism has a 50,000 ohm potentiometer B3–RV1 driven by gearing from the winding drum shaft in such a way that it rotates through 300 ° over the 150 cm travel of the safety rod, including the overshoot of the safety rod below the normal down limit position following its free fall into the reactor.

A stabilised d.c. supply of 85 volts, built into the safety rod control unit, is connected across the potentiometers in parallel and the voltage tapped off by each potentiometer wiper gives a measure of the position of the appropriate safety rod.

The position meters, of range 0–100 μA are mounted on the front panel of the safety rod control unit. Each meter is connected between the negative line of the 85 volt supply and the wiper arm of the corresponding potentiometer via resistances B3–R3, B3–R4 and variable resistance B3–RV2. The scales on the position meters are calibrated to show the position of the safety rods above their normal down limit position.

3.4 RESTRICTED TRIP Guard Switches

Associated with each safety rod are three upper switches, B3–UL1, B3–UL2 and B3–UL3. B3–UL1 is contained within the circuits relating to the upper limit check relay B3–U1 and the motor relay B3–R. Switches B3–UL2 and B3–UL3 are used in the primary and secondary trip guard circuits respectively. Since both of these switches must be operated when the safety rod is up they are adjusted to actuate just before the switch B3–UL1 operates to stop the drive motor.

3.5 Coarse Control Arm Maintenance Interlock

When both safety rods are up, relay B3–G is energised via contacts from relays $B3_1$–U1 and $B3_2$–U1. Until relay B3–G is energised the circuit to the coil of any coarse control arm magnet under maintenance conditions is broken.

4. ACKNOWLEDGEMENT

This manual includes material from a draft prepared by the late G. Page.

APPENDIX

LIST OF MANUALS ON HIFAR INSTRUMENTATION

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 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

(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