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SAFETY CIRCUIT TRIP IDENTIFICATION SYSTEM

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SCOPE REPORT

SAFETY CIRCUIT TRIP IDENTIFICATION SYSTEM

I. INTRODUCTION

A. Purpose

The purpose¹ of this report is to establish the scope of a project to provide a system which will quickly and accurately identify the sources of all reactor scrams.

B. Background

Some reactor scrams are not accurately identified because events occur so rapidly after a scram that little time can be spent in attempting to identify or evaluate them if scram recoveries are to be accomplished in a minimum length of time. Scram recoveries are often attempted without sufficient information concerning the validity or the source of the scram. Sometimes the human response time is not fast enough to distinguish the first event in a sequence of rapid events following a scram with the present annunciation equipment. In order to insure reactor safety and continue to increase power levels and the continuity of operation, it is necessary that all scrams be properly annunciated to operating personnel.

C. Recommendations

It is recommended that a Safety Circuit Trip Identification System be installed at all production reactors, except 105-DR (105-DR presently has a similar system installed on a prototype test² basis), to provide proper scram annunciation. Such a system in each reactor would tend to increase the continuity of operation by permitting quick identification and evaluation of all types of scrams.

II. STATEMENT OF PROBLEM

A. Scram Analysis

Table I shows a percentage breakdown of the unknown and unexplained reactor scrams for FY-1959 and CY-1959.

¹ The urgent need for this safety circuit identification system was established in HW-62207, "Operating Continuity Analysis of the Hanford Production Reactors". (Confidential)

² During the Acceptance Testing Program at 105-DR, the system immediately found two defective switch bottles. Later, during the reactor startup, it successfully identified a legitimate pressure monitor scram and a pressure monitor scram caused by faulty circuits. It pinpointed the trouble in each instance, thus showing an immediate remedy to a potential scram source and an unsafe operating condition.

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TABLE I

YEAR	NO. OF SCRAMS	NO. OF RECOVERIES	NO. OF OUTAGES	% SCRAM OUTAGES	% OF ALL CAUSES OF OUTAGES	HOURS OF OUTAGE TIMES CHARGED	DOLLAR VALUE OF LOST PRODUCTION
FY-59	62	50	12	23.8%	5.9%	123.2 hrs	\$250,000
CY-59	50	31	19	22.8%	6.4%	138.3 hrs	\$275,000

The following facts can be derived from the above table and an analysis of the causes of all reactor outages:

1. Even though the total number of unknown and unexplained scrams was reduced, the number of resulting outages (minimum and extended) increased 50 per cent.
2. The high percentage of scram recoveries indicates that most of the unknown and unexplained scrams occur in the first three days of operation. Scram recoveries are generally not accomplished after two or three days of operation because of the short recovery time at the present power levels.
3. The percentage of unknown scrams resulting in outages decreased by one per cent even though the actual number rose 12 to 19. If all types of outages causes (scheduled, scrams, ruptures, etc.) were considered, the fraction increases by 0.5 per cent. The reason is that the total number of outages caused by scrams did not decrease while the number of ruptures dropped significantly.
4. The number of outage hours charged to the unknown scrams did not increase by 50 per cent as did the number of outages. This indicates that the scrams occurred when outage time could be used more efficiently.
5. The detailed analysis of the scrams showed that certain types of unknown scrams occurred more often in some reactors than in others. For example, the number of unknown panellit trips in B and C Reactors was approximately four times higher than in the other reactors in FY-1959. These scrams were unexplained at that time but later it was discovered that a faulty set of jumpers had been installed and caused the trouble. If an identification system, such as the proposed one, had been installed, a large portion of these repeated type scrams would have been eliminated by finding the trouble earlier and taking the necessary steps to remedy the situation.

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B. Reactor Safety VS Continuity of Operation

The causes of many reactor scrams are not accurately identified before a reactor is attempted to be restarted following a scram for two main reasons.

1. The gross lack of ^{individual trip} annunciation equipment to identify the specific scrambling device;
2. The length of recovery time at the higher power levels has been shortened to a point where startup preparations must be initiated immediately after a scram and concurrently with the investigation of the cause of the scram, if scram recoveries are to be accomplished.

Exact information as to the source of every scram is needed before a reactor should be restarted in order to continue the emphasis on reactor and nuclear safety. Weak safety circuit components should be detected and replaced before they fail in an unsafe manner.¹ It is felt that a trip identification system would be a definite aid to operating personnel by specifically identifying all sources of scrams, thus permitting safer and quicker recoveries.

III. RECOMMENDATION FOR SOLVING PROBLEM

The Safety Circuit Trip Identification System should be completely a static-magnetic type system. It must be fully prototype tested under full-scale reactor operation and meet with the approval of Research and Engineering Operation. Presently, the only identification system that meets all of the above requirements is the Development Test installation at 105-DR (Development Test No. IP-258-E). This system is shown in block diagram form on SK-1-4120 in the Appendix.

A. Equipment Room

A cabinet containing the input converters, logic functions, and output logic circuits shall be installed in an equipment room.

B. Duct Work

A duct will be installed from the control room to the equipment room to carry the necessary input and output signal wires. If existing duct work is available, it should be utilized if possible.

C. Control Room

Panel space shall be required for the necessary controls and readout panel. In order to minimize the space required, it is suggested that the readout devices be one plane digital displays similar

¹ Reference defective switch bottles, Footnote 2, Page 1.

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to the readout device at 105-DR.

D. Schedule for Doing Work

1. C, H, KE and KW - Pressure Monitor modifications have been scheduled for completion in the C, H, KE and KW Reactors by the end of FY-1961. One result of the modifications will be to provide for a dual tripping circuit to scram the reactor. The trip identification logic circuit shall be connected to the vertical columns and the horizontal rows using suitable means to provide isolation from the safety circuit proper.

The installation of the trip identification system should take place concurrently with the pressure monitor modifications program and be completed at the end of FY-1961 so that full beneficial use may be obtained from both programs at that time.

2. B, D, F - Pressure Monitor modification programs are scheduled to begin at the beginning of FY-1962 or at the completion of the program for C, H, KE, KW. These modifications will include the dual tripping circuit to scram the reactor. Because these modifications will not be completed until July, 1962, it is felt that a two-year delay in obtaining the benefits of a trip identification system is excessive. The logic circuits and readout devices are compatible with both the present and proposed dual system. It is therefore recommended that the trip identification system be installed immediately for present use and be converted after the proposed modifications have been completed. The additional cost of converting the logic circuit is estimated to be approximately \$500 per reactor.

IV. ALTERNATIVE SOLUTIONS

A. First Alternate - Coordinate Relay Matrix System

A coordinate relay system could be installed to accomplish the same end result as the static-magnetic system. The total cost for both systems is approximately equal, except that in order to use the relay system, the present switch bottles on the coolant pressure monitors must be changed, which would postpone any identification system in B, D, and F Reactors until after July, 1962.

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The static-magnetic system provides an extreme flexibility for added functions required by future expansion, as opposed to the fixed contact logic of relay systems. Economically the difference reflects higher costs for expansion and changes in the alternate electromechanical relaying system. Ease of expansion and flexibility are prerequisites in a trip identification system because of the continual changes in process operating characteristics.

B. Second Alternate - Photo-Recorder

There are two main objections to this system: first, the system takes 60 seconds to develop and print a picture; second, the new dual switch bottles are required for this system; in addition, the total response time of the entire system is too slow to be 100 per cent reliable. Also, the system requires operator attention, which is not required by the proposed system. Previous experience with the photo-recorder has pointed out difficulties in operating this system. It is assumed that some of these difficulties can be eliminated; however, the slow overall response time and the requirement for the new switch bottles are sufficient reasons to reject this method.

V. JUSTIFICATION

The justification for this project is based on the following:

A. Improved Control Instrumentation

One of the main control requirements for operating any process is the accurate and quick identification of the sources of shut-down. The present annunciation system does not meet the necessary requirements for identifying both the scrambling device and the reason for the scram.

B. Increased Reactor Safety

The accurate identification of all scrams is essential if the reactors are to continue to be operated safely. It is necessary that weak components be located and replaced before they fail in a nonfail-safe condition. It is essential to the continuation of reactor safety that use be made of the added functions, recently developed and proven in reactor service.

C. Reduction of Outage Time

Considerable outage time may be eliminated by the accurate annunciation of scrams. Repeat scrams show trends in equipment failures which can be corrected long before they would be diagnosed by the

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present annunciation system. More scram recoveries are likely because the time required to identify and evaluate scrams will be minimized.

D. Amortization

The required outage time to amortize the trip identification system is computed below:

$$\frac{\text{Cost per Reactor}}{\text{Dollar Value of Outage Time}} = \text{Outage hours required for economic justification per reactor.}$$

1. B, D, F Reactors = $\frac{\$18,000}{\$1490/\text{hr.}}$ = 12.1 hours per reactor
2. C, H Reactors = $\frac{\$14,400}{\$1490/\text{hr.}}$ = 9.6 hours per reactor
3. KE, KW Reactors = $\frac{\$23,800}{\$3180/\text{hr.}}$ = 7.4 hours per reactor

It is not possible to predict what portion of the outage hours and the associated equilibrium losses would have been saved if this proposed system had been installed previously. It is also impossible to predict the reduction in future scrams, because operating characteristics and parameters change from year to year. However, established trends show that the total number of scrams generally increase with each power level increase and therefore the number of unexplained scrams also increase. There was an average of 16.0 hours of unknown and unexplained outage time at each reactor during FY-1959 and 17.3 hours during CY-1959. This is an 8 per cent increase in unknown outage hours in a six-month overlapping period. If all of the unknown hours could be completely eliminated for CY-1959, the amortization rate would be as follows:

1. B, D, F Reactors = $\frac{12.1 \text{ hr.}}{17.3} \times 1 \text{ year} = 0.70 \text{ years}$
2. C, H Reactors = $\frac{9.6 \text{ hr.}}{17.3} \times 1 \text{ year} = 0.55 \text{ years}$
3. KE, KW Reactors = $\frac{7.4 \text{ hr.}}{17.3} \times 1 \text{ year} = 0.43 \text{ years}$

As a realistic supposition, assume only 25 per cent of the outage time to be eliminated by installing an identification system. The amortization period would be:

1. B, D, F Reactors = $\frac{12.1 \text{ hr.}}{0.25 \times 17.3 \text{ hr.}} \times 1 \text{ year} = 2.8 \text{ years}$

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2. C, H Reactors $= \frac{9.6 \text{ hr.}}{0.25 \times 17.3 \text{ hr.}} \times 1 \text{ year} = 2.2 \text{ years}$

3. KE, KW Reactors $= \frac{7.4 \text{ hr.}}{0.25 \times 17.3 \text{ hr.}} \times 1 \text{ year} = 1.7 \text{ years}$

The average amortization for the project for all seven reactors is 2.3 years, assuming only a 25 per cent reduction in unknown scrams.

VI. PRELIMINARY COST ESTIMATE

A. Cost Estimate - 105-B, D, and F Per Reactor Basis

	<u>Material</u>	<u>Labor</u>	<u>Total</u>
1. Static Switching Modules	\$3,000	\$1,000	\$ 4,000
2. Resistor-jumpers	3,000	200	3,200
3. Cable	500	1,800	2,300
4. Miscellaneous	1,000	1,500	2,500
5. Total Construction Cost	<u>\$7,500</u>	<u>\$4,500</u>	<u>\$12,000</u>
6. Supervision of Construction (5.5%)			660
7. Contingency (10%)			1,200
8. Escalation (5 1/4%)			640
9. Subtotal			<u>\$14,500</u>
10. General Overhead (3.5%)			500
11. Total Installation & Erection Cost			<u>\$15,000</u>
12. Management Services (6%)			1,000
13. Design			2,000
14. Total Preliminary Project Cost/Reactor			<u>\$18,000</u>

B. Cost Estimate - 105-C and H Per Reactor Basis

	<u>Material</u>	<u>Labor</u>	<u>Total</u>
1. Static Switching Modules	\$3,000	\$1,000	\$4,000
2. Cable	500	1,800	2,300
3. Miscellaneous	1,200	1,800	3,000
4. Total Construction Cost	<u>\$4,700</u>	<u>\$4,600</u>	<u>\$ 9,300</u>
5. Supervision of Construction (5.5%)			550
6. Contingency (10%)			950
7. Escalation (5 1/4%)			500
8. Subtotal			<u>\$11,300</u>
9. General Overhead (3.5%)			400
10. Total Installation & Erection Cost			<u>\$11,700</u>
11. Management Services (6%)			700
12. Design			2,000
13. Total Preliminary Project Cost/Reactor			<u>\$14,400</u>

(The column jumpers will be provided under the Pressure Monitor Improvement Program to provide dual electrical tripping circuits.)

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C. Cost Estimate - 105-KE & KW Per Reactor Basis

	<u>Material</u>	<u>Labor</u>	<u>Total</u>
1. Static Switching Modules	\$5,100	\$1,700	\$ 6,800
2. Cable	1,000	3,200	4,200
3. Miscellaneous	1,700	2,800	4,500
4. Total Construction Cost	\$7,800	\$7,700	\$15,500
5. Supervision of Construction (5.5%)			900
6. Contingency (10%)			1,600
7. Escalation (5.4%)			850
8. Subtotal			\$13,850
9. General Overhead (3.5%)			650
10. Total Installation & Erection Cost			\$19,500
11. Management Services (6%)			1,300
12. Design			3,000
13. Total Preliminary Project Cost - 105-KE & KW			\$23,800

(The column jumpers will be provided under the Pressure Monitor Improvement Program to provide dual electrical tripping circuits.)

D. Total Project Cost

1. B, D, and F Reactors @ \$18,000	\$ 54,000
2. C and H Reactors @ \$14,400	28,800
3. KE & KW Reactors @ \$23,800	47,600
4. Total Project Cost (Equipment Budget)	\$130,400

Plant Forces Labor will be used. No off-site inspection is required.

VII. REFERENCES

- A. Safety Circuit Trip Identification System Interim Report - HW-64363.
- B. Design Change 328-DR, Safety Circuit Trip Identification System.
- C. Development Test Authorization, IP-258-E, Evaluation of Safety Circuit Trip Identification Prototype.
- D. Letter D. S. Lewis from R. S. Hammond, January 25, 1960, Safety Circuit and Trip Identification System - Status of Subject System.

VIII. APPENDIX

SK-1-4120, Safety Circuit Trip Identification System - Block Diagram.

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