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HANFORD TECHNICAL RECORD
GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DOCUMENT NO.

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TITLE

**SUMMARY OF THE OPERATIONAL STATUS OF REACTOR
CONTROL INSTRUMENTATION - REPORT NO. 2**

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SUMMARY OF THE OPERATIONAL STATUS OF
REACTOR CONTROL INSTRUMENTATION - REPORT NO. 2

The purpose of this review is to report the operability status of the reactor control instrumentation. This is the second such report; the first/1/ reported the status as of October, 1960. The status of the instruments was determined twice during the first six months of this year, April 1 and June 1, and is reported in Table I. The information contained in this report is not intended to be a complete description of the control instruments, but only as

/1/ "Summary of the Operational Status of Reactor Control Instrumentation," JH Ferguson, GF Owsley, 12-5-60 (HW-67685)

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they apply to reactor control. The assigned Pile Physicist at each reactor reported the status of instrumentation at his reactor.

In order to be reasonably consistent in the evaluation, a common basis was used (See Appendix I). If additional information is required it is suggested that the assigned Pile Physicist be contacted.

Chart I summarizes the operability status of the various instruments. Chart II shows the relative range of reactor power over which these control instruments apply. Appendix II contains a functional description of the instruments and Appendix III lists how each instrument is used during reactor operation.

SL Stewart

Pile Physics Unit
Operational Physics Sub-Section
Research and Engineering Section
IRRADIATION PROCESSING DEPARTMENT

SL Stewart:gs

NFORD REACTOR CONTROL INSTRUMENTATION, 7-10-61

x - April 1 Evaluation
y - June 1 Evaluation

R		F		H		KE		KW		Remarks
P	C	G	F	P	C	G	F	P	C	
		x		x		x		x		
		y		y		y		y		
			x							1) The system is not scheduled for installation.
			y							
		x		x		x		x		
		y		y		y		y		
		x		x		x		x		
		y		y		y		y		
		x		x		x		x		1) Good except gives erroneous gas concentrations at high nitrogen concentrations.
		y		y		y		y		
		x		x		x		x		
		y		y		y		y		

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Chart 2 - Relative Instrument Coverage Ranges

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APPENDIX I

GENERAL BASES FOR DETERMINING STATUS
OF CONTROL INSTRUMENTATION

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Status

Good All components of the instrument function properly and meet the desired reliability requirements.

Fair Some components of the instrument do not function properly at all times, but this is not too restrictive to the general function and use of the instrument. The instrument is out of service occasionally. The instrument can generally be relied upon to perform its function satisfactorily.

Poor The instrument is out of service frequently. The instrument gives incorrect information. It is not reliable and this is used infrequently if at all.

BASES FOR DETERMINING STATUS OF EACH CONTROL INSTRUMENT

	Good	Fair	Poor	Comment
1. SCM:	G - Both chambers functioning properly. (Includes status of positioning mechanisms).			
	F - A chamber has been out of service part of the time during the past one or two months.			
	P - A chamber has been out of service most of the time.			
2. ZTM:	G - Less than 10 RTD's out of service, good correlation between ZTM temperature indications and thermocouple indication.			
	F - Between 10 and 20 RTD's out of service.			
	P - More than 20 RTD's out of service, or poor temperature correlation.			
3. Tube Temp. Dev. Recorder:	G - Functions properly.			
	F - Does not print consistently, is too sensitive, etc., but is used as a main equilibrium control instrument.			
	P - Cannot be relied upon as a control instrument due to malfunction.			
4. Power Recorder:	G - Gives accurate measure of power level, is reliable, and has nearly always been in service for the past three months.			
	F - Has been out of service a few times during past three months and/or occasionally shows unexplained increases or decreases in power level.			
	P - Is frequently out of service, shows unexplained increases or decreases in power, does not check with the calculated power.			
5. Flexo-writer:	G - Gives outlet and delta tube temperatures quickly and accurately. Is reliable.			
	F - Is slow, sometimes stops and/or gives somewhat inconsistent temperatures occasionally.			
	P - Is slow, stops, skips, is inaccurate, and is unreliable.			

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6. Gas Comp. G - Reliable and accurate, maintains a constant gas composition.
Cont. Inst: F - Usually consistent in maintaining constant gas composition, but occasionally is inaccurate and unreliable.
P - Fluctuation in gas composition occurs frequently - is unreliable and inaccurate.
7. Rate-of- G - Gives accurate information, no fluctuation.
Rise Meter: F - Is used but is not too steady or accurate - gives rough idea of power changes.
P - Is not used; gives no reliable information.
8. Galvan- G - Sensitivity is less than 500 W, gives good approximation of
ometer: power level - is reliable.
F - Does not give a good first order approximation of power level.
P - Sensitivity is more than 1000 W, or does not give good power level indications, or is unreliable.
9. Octant G - Functions properly with not more than one chamber out of service.
Monitor: F - Not more than three chambers out of service.
P - More than three chambers out of service.
10. Mltp. Pt. G - Functions properly, gives good first order approximation of bulk
Tube Out- power, is consistent.
let Temp. F - Gives good indication of bulk power, but is erratic occasionally.
Pwr Recorder: P - Is out of service frequently, does not give a reliable approximation of the bulk power.
11. "Corn Popper" or Rapid G - Gives fast accurate zone temperature distribution.
Scanner: F - Temperature indications are somewhat inaccurate but shows trends well.
P - Is frequently out of service, temperatures recorded are inaccurate and inconsistent.
12. Beckman G - At least one chamber with a sensitivity of $\leq$ 1000 W. System is
System: consistent and accurate. Gives a first order approximation of power level.
F - Sensitivity $>$ 1000 W.
P - Is erratic, drift for no apparent reason, are insensitive, and gives no good power indication.
13. Graphite G - Not more than one thermocouple per stringer is burned out. Data
Temp. Re- is consistent and reliable.
corder: F - Process Standards' graphite temperature monitoring requirements are met. Data is occasionally inconsistent.
P - Process Standards graphite temperature monitoring requirements are not met. (Necessary Process Change Authorization has been issued.) Data is frequently inconsistent. Cannot be relied upon.

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14. Proportional Counter: G - Functions correctly, is checked frequently and sensitivity is < 50 watts.
 F - Sensitivity is > 50 watts but functions properly.
 P - Does not function properly but is used.
15. Brown Tube Temp. Recorder: G - Gives accurate, consistent readings using all of the different methods of obtaining the temperature information from the instrument.
 F - Shows some inconsistency in the information supplied.
 P - Is very inaccurate and inconsistent.
-

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APPENDIX II

FUNCTIONAL DESCRIPTION OF CONTROL INSTRUMENTATION

1. Subcritical Monitor

The function of this instrument is to continuously monitor and record the neutron flux level and the exponential rate of change of the flux level from subcritical through the low megawatt range. The system consists of two independent channels.

2. Zone Temperature Monitor

The ZTM serves two principal functions by providing continuous monitoring, by regions, of over 200 process tube outlet temperatures. The first is to actuate an alarm when the temperature at a monitored point exceeds a preset value. The second function is to provide an indication of the temperature differential between a set value and the actual temperature; this latter indication is quite useful for control during rapid changes, since the difference value may be set quickly by the operator with a thumb knob and the readout is instantaneous on a light display panel.

3. Tube Temperature Deviation Recorder

After significant tube outlet water temperatures have been attained, this instrument monitors and presents temperature trends in the radial plane. This instrument has become uniformly accepted for presenting or overcoming flux drifts over minutes to hours to days such as from xenon oscillations.

4. Power Recorder

The power recorder is a temperature-sensitive instrument which provides a measure of the power level and the deviation of the power level from a set point. The instrument has about a one minute lag time.

5. Flexowriter Outlet Tube Temperature Recorder

The flexowriter presents a record of the outlet temperatures of all the tubes in the reactor or of the tubes in a particular section. The record is in the form of a typed temperature map or an eight channel coded tape with the temperature information punched into it.

6. Gas Composition Control Instrumentation

This system indirectly controls graphite temperatures by supplying the gas make-up necessary to maintain a pile atmosphere of constant composition.

7. Power Rate-of-Rise Meter

The rate meter provides a continuous indication of the approximate rate of change of power level linearly with time. The time constant of this instrument is sufficiently short that, if adequately maintained, it will provide good safety protection in the low MW region prior to approach of specific tube limits (See ZTM and "Corn Popper").

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8. Galvanometer System

The galvanometer System is primarily a control aid designed to give information regarding neutron flux levels, but with proper calibration and range changing it may be used to estimate rates of power change and also absolute level. This instrument has the advantage of having a shorter response time than instruments using heat monitoring techniques.

9. Octant Monitor

Where installed, this system continuously monitors and records the flux level in the eight octants of the pile. The average flux in the eight octants also provides the input signal for the galvanometer system.

10. Multiple Point Tube Outlet Temperature Power Level Recorder

This instrument, installed at the 6 older Reactors, records the average of the outlet temperatures of a representative number of tubes and thus provides a measure of power level and deviations of power level with a time lag of a very few seconds.

11. "Corn Popper" or Rapid Tube Temperature Scanner

This device, in conjunction with the Brown recorders, permits continuous monitoring of selected tube outlet temperatures. When a pre-set temperature is reached an alarm normally sounds, warning operations personnel that an excessive temperature has been reached. This system is especially valuable during startup conditions, alerting operating personnel that the rate of rise should be reduced before specific tube power limits are approached.

12. Beckman System

The Beckman system monitors and records the flux level from four locations beneath the active zone of the pile. The system is used only secondarily as control instrumentation but provides the ultimate reactor nuclear safety by automatically shutting the reactor down in the event of a flux excursion.

13. Graphite Temperature Recorder

The graphite temperature recorder is a primary instrument for insuring that the reactor is continuously operated within specified graphite temperature limits for optimum performance with respect to production and reactor life.

14. Proportional Counter

The under-pile P.C. provides low level neutron flux monitoring for low level startup protection; this system, deriving its signal from a BF₃ chamber in a shield access hole, is being supplanted by the more sensitive and movable fission chambers in the subcritical monitor system.

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APPENDIX III

APPLICATION OF CONTROL INSTRUMENTATION DURING REACTOR OPERATION

1. Startup

a. Initial flux level indication and rise to low megawatt level.

(1) Subcritical Monitor

The primary startup instrument; its function of monitoring continuously the neutron flux level and the exponential rate of change of flux level enhances a high level of nuclear safety during reactor startups and (when channels are functioning satisfactorily) should permit faster rod withdrawal rates to supercritical condition for both cold and hot startups. (A Process Standards change currently circulating for approval will permit this rod withdrawal rate modification.)

(2) Proportional Counter, Galvanometer and Beckmans

Whichever of these instruments have a demonstrated sensitivity to a neutron flux level of 500 watts or less may be used as backup low level startup instrumentation when one or both of the subcritical monitors are not operating properly; the present conservative rod withdrawal standards would be required in this case.

b. Rise to Initial Power Level - Rate-of-Rise and Total Power Level Control

(1) Power Rate-of-Rise Meter (Stop-gap Installation)

The primary instrument for controlling the rate-of-rise in the megawatt region up to the initial power level. The possibility of improper functioning of this instrument requires that one or both of the instruments listed below be used during the power rise to confirm rates indicated by the power rate-of-rise meter.

(2) Galvanometer, Multiple Tube Outlet Temperature Recorder

The No. 1 galvanometer is used to establish that the rates-of-rise and power level are reasonable; however, once the galvanometer confirms that the multiple tube outlet temperature power recorder is functioning properly, this latter instrument may be used to monitor actual power rise rates and as a first order approximation of power level at any time during the power rise.

2. Nonequilibrium (Transient) Operation

a. Total Level

(1) Power Recorder

The power recorder is the primary measure of power level for control purposes; however, particularly for nonequilibrium, one or more of the following three

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instruments must be used for monitoring power level deviations because of the significant time lag in the power recorder monitoring of water temperature.

(2) Octant Monitor, Galvanometer, Multiple Tube Outlet Temperature Recorder

Because of the very short delay time requirements for monitoring power level deviations one of these instruments must be continuously monitored.

(3) Power Rate-of-Rise Meter

Although not essential this instrument is very useful for indicating rod action necessary for maintaining power level during supplementary control adjustments.

b. Distribution

(1) Tube Temperature Deviation Recorder

The primary instrument for control adjustments necessary to maintain a steady equilibrium flux distribution.

(2) Flexowriter

An essential instrument for assuring proper calibration of the tube temperature deviation recorder and that individual tube temperature limits are not exceeded. Its use is supplemented by traversing or plugging into the temperature monitor board to measure particular tube temperatures continuously and to determine individual temperatures more accurately.

(3) Zone Temperature Monitor

A primary backup to the tube temperature deviation recorder although independently useful for monitoring rapid distributional trends during supplementary control adjustment.

(4) Octant Monitors, Beckman Recorders, Graphite Temperature Recorders

The only monitors of the front-to-rear flux distribution. Although limited in pile coverage and of secondary benefit for radial distribution control, these instruments are important aids to operation, particularly at the K's.

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