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Released 1995

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
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DOCUMENT NO.

HW-56696

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STATUS REPORT
APPLICATION OF NEUTRON MONITORS TO
PROCESS CONTROL IN RECUPLEX

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STATUS REPORT
APPLICATION OF NEUTRON MONITORS
TO PROCESS CONTROL IN RECUPLEX

by

P. R. Kelly
and
N. T. Hildreth

CLASSIFICATION CANCELLED

Per Doc May 1973

By B. Roberts 5/20/74

Instrument Development
Process Design & Development
Facilities Engineering Operation
CHEMICAL PROCESSING DEPARTMENT

July 14, 1958

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STATUS REPORT
APPLICATION OF NEUTRON MONITORS
TO PROCESS CONTROL IN RECUPLEX

I. INTRODUCTION

A program was initiated early in 1957 to develop a neutron monitor capable of detecting plutonium (Pu) concentration in process vessels in Recuplex. This followed an earlier application by Finished Products Operation and Research and Engineering of neutron monitoring to powder counting which had been successful and was being regularly used. The process vessel monitoring was to be done by the "in tank probe" method, utilizing the monitored solution as its own moderator, and detecting the resulting slow and thermal neutrons with boron trifluoride (BF₃) type proportional counters.

By using Pu concentration monitors, many of the manual samples taken could be eliminated, better efficiency would result from improved process control, and a greater degree of safety could be provided through critical mass control. The application studies of neutron monitoring to process vessels have been carried out in a cooperative effort of Research and Engineering, Instrument Maintenance, Finished Products Operation, and Instrument Design and Development of Facilities Engineering Operation.

II. PURPOSE

This report is intended to present 1) the history of the Recuplex program; 2) a summary of the development work to date; 3) the current status of the monitoring system; and 4) the immediate plans for future installations and work. This report is intended as a design guide for presently scheduled and future monitor installations in Recuplex and elsewhere of the types herein described. The report also includes calibration curves for both D-11 tank and H-3 column monitors, schematic representation of all installations, manual switching panel circuit diagram, pre-amplifier circuit diagram, probe well designs, and KI-2 instrument tank design.

III. SUMMARY OF MONITOR SYSTEM STATUS

The original plans of the Recuplex monitoring systems called for one instrument console as in Figure 5 with manual switching to any one of five detector elements located on five process tanks. The tanks were D-8 and D-9 filtrate receivers from the dissolvers, D-10 and D-11 slurried filter aid receivers from the filter block, and the instrument probe tank in the organic feed line to tanks K-1 and K-2.

Development on the system has progressed to the point that it is now certain that the monitors are not only feasible, but very practical and economical in the slurry and filtrate tanks. Since the original planning, several additional process points have been proposed as good locations for neutron monitors. One application has been made on the H-3 column and has been very successful.

Developmental tests are now scheduled on the L-2 extraction waste receiver tank monitor. Future development is scheduled on the Kl-2 instrument probe tank.

Currently, two monitor systems are scheduled as permanent installations. One of these exists, with the exception of the manual switching panel, on the Recuplex mezzanine floor. The other system is scheduled to be installed on the ground floor of Recuplex (see Figure #1). When current work in progress is completed, the mezzanine system will monitor the H-3 column only and may be expanded to include five additional points. The system on the ground floor will include the tanks D-8, 9, 10, 11, Kl-2, and L-2. The ground floor system will be complete with six points.

IV. HISTORY OF RECUPLEX DEVELOPMENT PROGRAM

The basic philosophy behind the neutron monitors in Recuplex is to detect plutonium (Pu) concentration by neutron measurement, and by so doing reduce or eliminate the manual samples and the necessary time consuming laboratory analysis, provide protection on critically unsafe tanks and vessels, and provide improved efficiency through improved process control.

At a meeting on February 27, 1957,* it was agreed among Product Recovery Operation, Research and Engineering, and Instrument Design and Development (FEO), that the original five monitors were needed, with the Kl-2 instrument probe tank being continuously monitored and the "D" tanks being manually switched in and out of the monitor circuit. The recorder with its alarm would be used in conjunction with the Kl-2 tank. The system was to consist of a rack of instruments for the five points and was to be located on the ground floor opposite hood #40. Instrument Design and Development agreed to provide prototype design work and information for the permanent installation.

Several meetings have been held since the original plans were made and several significant additions have been made to the monitors and equipment needed. The following is a list of all currently existing and scheduled monitors with their general purpose, etc.

<u>Monitor Point</u>	<u>Description</u>	<u>Function of Monitor</u>	<u>Minimum Pu Concentration to be Detected</u>
<u>Existing Monitors</u>			
D-11 Tank	Slurried filter aid receivers, from the filter block.	Be able to discard slurry to cribs without waiting for laboratory assay.	.1 g/l
H-3 Column	Pu stripping column	Provide continuous process control for rapidly changing conditions	40 g/l

* Ref: Letter, MT Slind from LM Knights dated February 28, 1957.

<u>Monitor Point</u>	<u>Description</u>	<u>Function of Monitor</u>	<u>Minimum Pu Concentration to be Detected</u>
<u>Scheduled For Installation For Process Control</u>			
D-10 Tank	Slurried filter aid receivers, from the filter block.	Be able to discard slurry to cribs without waiting for laboratory assay.	.1 g/l
D-8 & 9 Tanks	Filtrate receivers from the dissolvers.	To be able to move solutions onto the column without waiting for laboratory assay.	1.0 g/l

Scheduled For Installation For Development

L-2 Tank	Extraction waste received tank.	Be able to discard waste to cribs without waiting for laboratory.	.01 g/l
K1-2	Auxiliary circulating tank (instrument probes)	Be able to determine need for washing the organic without laboratory assay, and provide critical mass control.	.1 g/l

V. BF₃ Proportional Counters

All the neutron detectors in and intended for Recuplex are the boron trifluoride (BF₃) gas type proportional counters, about 95% enriched B¹⁰, and filled to a pressure of 25 cm Hg. They are all of the Hanford aluminum slug-can type (Ref. drawing H-4-2825, or slightly modified) currently manufactured in the 300 Area. Evaluation is currently scheduled on BF₃ tubes from several different manufacturers including the Hanford type to determine the most applicable type to this form of neutron monitoring.

The BF₃ proportional counters detect only slow and thermal neutrons, with the action of the neutron striking the boron nucleus, releasing an alpha particle which ionizes the gas. The resultant avalanche to the positive high potential center wire anode gives a small negative pulse across a load resistor.

VI. DISCUSSION OF DEVELOPMENT WORK

The powder counter (detecting Pu concentration by neutron emission from PuF₄ powder) located behind the slag and crucible hood, although not a

part of this report, has played a very important role in the initial neutron monitoring research. This counter uses four (4) BF_3 tubes mounted in a paraffin moderator tub to detect neutrons. The PuF_4 powder is placed between the two hemispheres of the moderator in "ice cream" cartons and counted. By substituting polyethylene bottles containing Pu in solution for the ice cream cartons, this counter provided the means of detecting the Pu in solution. The feasibility of the original monitors was, hence, recognized. Although the powder counter uses four BF_3 tubes, all tank and column monitors, as now designed, utilize only one BF_3 tube.

The first in-line neutron monitor was set up in D-11 tank with the arrangement similar to that shown in Figure #2 (see also Figure #8). The tank was initially calibrated by means of samples made up of known concentration of Pu and known volume. Good calibration results were obtained (i.e., a curve increasing in c/m with additions of equal increments of the sample solutions); however, on using these results and comparing the graphical data to laboratory analysis of samples taken on the tank, there appeared a real discrepancy. This was the fact that from day to day there appeared to be no correlation between the two. About this time it was determined that the monitor was operating on the gamma portion of the gamma threshold curve for the BF_3 tube, i.e., the gamma sensitive region of operation. This was corrected and a new calibration was set up. During the second calibration it was determined that the pre-amplifier had failed and the data taken was of no value.

The third calibration was set up using the setup similar to that in Figure #3, with the pre-amplifier outside the hood. This calibration was considered a complete success and the calibration curve is illustrated on Graph #1. A sample was taken on the tank when it contained only Pu in solution and the laboratory analysis indicated 0.836 grams per liter or a total of 18 grams while the graphical data indicated 0.922 grams per liter or a total of 19.81 grams. The plotted points on the curve are all for the Pu solutions; however, a known quantity of PuO_4 was added to the tank to determine the monitors effectiveness with solids. Extrapolating from the curve it was noted that there should be 1.61 grams per liter or 35.9 grams total. The laboratory analysis of a sample taken after the addition of the powder indicated 1.51 grams per liter or 32.5 grams total, while the actual grams per liter was 1.86 or a total of 40.21 grams in 21.6 liters of solution. Taking the correct value of Pu in the tank as 40.21 grams, then the monitor (by extrapolation) is off by 10.7%; whereas, the laboratory assay is off by 19.2%. This illustrates the effectiveness of the monitor for both types of Pu condition, solid and solution.

The large discrepancy between the graphical data and the laboratory analysis for the powder portion of the calibration has possibly two explanations. One of these is the great difficulty noted in the past of getting solids through the 1/8-inch tubing sample lines. The other explanation is the difficulty found in getting a true representative sample from a non-homogenous, solid bearing solution such as the samples from the process

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tank was in this case. Both these facts and the discrepancy itself indicate that the neutron monitor is often the more accurate of the two methods of Pu detection. This, of course, is especially true when solids are involved, which is usually the case with the filtrate receiver tanks, D-10 and 11.

It should also be noted here that the solution in the tank does not cover the BF₃ probe at a volume of twenty (20) liters. For this reason the calibration data obtained at that volume is considered to be inaccurate. This is also true since so few points were taken. Considering the fact that the BF₃ tube is not covered at a volume of 20 liters, it is therefore recommended that a minimum volume maintained in the tank, D-11, be 30 liters while taking readings on the neutron monitor.

The second monitor to be calibrated was the H-3 column (see Figure #4). This was done by setting up the monitor to record and correlate laboratory analysis of samples taken and the readings from the recorder. The BF₃ tube was first tried without a moderator, depending on the liquid in the column to accomplish this. This was determined to be inadequate and also there seemed to be little correlation from one day to the next between moderator readings and lab analysis. It was also determined in this case that the BF₃ tube was being operated in the gamma sensitive portion of its response curve. Both these conditions were corrected and the calibration continued from day to day. It soon became evident that the plotted points were falling in a line on the graph and this graph has been used since for process control. It has been found to be very consistent from day to day. See Graph #2 for calibration curve. Samples are taken from the J-1 receiver tank which takes off from the top of the H-3 column and there are few, if any, solids present.

Additional research is planned on the D-10 and D-11 tanks to verify the calibration curve previously taken. This will consist of watching the data, both graphical (from the neutron monitor) and the laboratory assays day by day for a period of time until it has been determined that the curve as plotted is correct. Even though there is expected a fair degree of discrepancy between the two methods of Pu detection, there should exist over a long period of time some consistency between the two; i.e., the deviation should remain constant. However, on a day by day basis the deviation can be expected to be slightly variable due to the varying amounts of Pu bearing solids present in the solution.

Efforts are currently underway to install two new monitors, one in the L-2 tank (Figures #2 and #8) and one in the new K1-2 instrument tank (Figures #2 and #9). Each of these tanks has a low concentration of Pu to be detected; .01 grams per liter for L-2 and .1 grams per liter for K1-2, and they will both be installed on a prototype basis.

Development and evaluation work is being done on amplifiers, pre-amplifiers, BF₃ tubes, and low and high voltage power supplies. These will be discussed in a later report. This work is needed in conjunction with in-plant prototype tests. Developmental studies of future applicability are also in progress in Hanford Laboratories.

VII. PRESENT STATUS OF EQUIPMENT AND DESIGNS

At present two BF₃ tube installations exist complete. These are the two discussed above, namely, the D-11 tank and the H-3 column monitors. No change is planned for the H-3 monitor; however, the D-11 monitor is expected to be changed to conform to Figure #2. This change will amount to installing a plastic sleeve as shown to protect the cable, connectors, pre-amplifier, etc., from the nitric acid fumes present; and also, it is planned to install the pre-amplifier directly on the BF₃ tube as shown in the Figure. This change will increase the count rate which is greatly attenuated by any cable between the pre-amplifier and the BF₃ tube. This increased sensitivity will make the monitor much more accurate on the lower portion of the calibration curve, i.e., in the region of .1 grams per liter.

Also, one complete rack of instruments is available on the mezzanine, see Figure #1 and #5, with the exception of the manual switching panel which is to be added soon, see Figure #6. All the instruments shown in Figure #5 are commercially available with the exception of the manual switching panel, which is fabricated at shops here. It is the function of the switching panel not only to switch the signal from the BF₃ tubes, but also to provide the additional B+ and filament supply needed by the six pre-amplifiers, to provide a means whereby the high voltage on each individual BF₃ can be varied so as to operate it in the flat portion of its response curve, to switch the high voltage to only one BF₃ tube at a time, and to indicate these functions on the panel itself, see Figure #6.

Currently, efforts are underway to obtain an additional unit or rack of instruments with five new monitor points, D-8, 9, 10, L2, and K1-2. The currently existing unit on the mezzanine would handle only the H-3 column monitor with five (5) spare manually monitored points available. The proposed unit on the ground floor would handle the remainder of the monitors, namely, the tanks D-8, 9, 10, 11, L-2 and K1-2 continuous with the remainder being manually switched in and out of the circuit and monitored one at a time.

As shown in Figure #1 there will be only one monitor point (H-3) on the unit on the mezzanine with the remainder being on that unit on the ground floor. In all cases where the minimum concentration to be detected is less than .1 grams per liter (g/l) every effort possible should be made to place the pre-amplifier at the BF₃ tube itself as shown in Figure #2. Where this is not possible, or the minimum concentration is 1.0 g/l or better, the pre-amplifier is placed outside the process hood for ease of maintainance, as shown in Figure #3. In all cases efforts should be made to completely enclose the probe and cable, etc., in a plastic sheath to prevent damage to them by toxic fumes. This sheath is shown in Figures #2 and #3.

The same pre-amplifier circuit, Figure #7, is used for all installations, with the physical mounting changed to meet the needs of the particular installation. A slug-can mounted pre-amplifier, as utilized in Figure #2, is shown in Figure #10.

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The entire system, as described here, will be capable of handling a total of twelve monitor points and at the present, there will be five spares total, with seven monitors installed. As the circuitry is now set up, only manually monitored points may be added to the system, since it is set up to handle only two continuous monitor points, i.e., one on each unit or rack of instruments, which are the H-3 column and K1-2 tank.

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PR Kelly:NT Hildreth:bp

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Pg. 10

EXISTING NEUTRON MONITOR PANEL

SEE FIGS 546

LOCATION: MEZZANINE
MONITOR POINTS:

H3 COLUMN, SEE FIG 4

PROPOSED NEUTRON MONITOR PANEL

SEE FIGS 546

LOCATION: BEHIND HOOD 40, GND FLOOR
MONITOR POINTS:

D849 TNKS, SEE FIGS 348

D10,114-12 TNKS, SEE FIGS 248

KI-2 INST. TNK., SEE FIGS 249

FIG 1

GENERAL DIAGRAM, NEUTRON MONITOR INSTRUMENTATION
RECUPLEX, 234-5 BLDG.

FIG 2

TYPICAL NEUTRON MONITOR INSTALLATION FOR
TANKS: D10, 11; L2; K1-2

FIG 3
TYPICAL NEUTRON MONITOR INSTALLATION FOR
TANKS: D8 & 9

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FIG 4

TYPICAL NEUTRON MONITOR INSTALLATION FOR
H-3 COLUMN

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FIG 5

TYPICAL RACK COMPONENTS AND CONNECTIONS FOR
NEUTRON MONITOR

[illegible]

PT. #	SLUG CAN MOUNTED	BOX MOUNTED
(1)	CONNECTOR # AN-306A-145-2P - CONNECTOR AMPHENOL #83-15P OR 83-822	CONNECTOR # ANSIOLA-145-2P - CONNECTOR AMPHENOL #83-1P OR 83-798
(2)	CONNECTOR # AN-306A-145-2P - CONNECTOR AMPHENOL #83-15P OR 83-822	CONNECTOR AMPHENOL #83-1P OR 83-798
(3)	CONNECTOR # AN-306A-145-2P - CONNECTOR AMPHENOL #83-15P OR 83-822	CONNECTOR AMPHENOL #83-1P OR 83-798
(4)	CONNECTOR # AN-306A-145-2P - CONNECTOR AMPHENOL #83-15P OR 83-822	CONNECTOR AMPHENOL #83-1P OR 83-798
(5)	NONE	CO-AXIAL CABLE RG 59/U
(6)	CO-AXIAL CABLE RG 59/U	NONE
(7)	CO-AXIAL CABLE RG 59/U	NONE
(8)	BELDEN CABLE SHIELDED & CONNECTOR	NONE

FIGURE NO. 7

FLANGE HOLE LAYOUT

1 ASSEMBLY

2 3 ASS

QTY.	ASSEMBLY	DESCRIPTION	MAT'L	REF.
1	1	ASSEMBLY		
2	2	ASSEMBLY		
3	3	ASSEMBLY		
2	4	MALE LEND. 1/2" TO 1/2" (N.C.T.)	S.S.	KONCENTRA
1	5	MALE LEND. 1/2" TO 1/2" (N.C.T.)	S.S.	KONCENTRA
1	6	BLIND FLANGE - 3" STD. 150"	S.S. 304L	
1	7	GASKET (3/8" ID. x 3/8" DIA. x 1/8" THK)	TEFLON	
1	8	1/2" SCH. 40 PIPE	S.S. 304L	
1	9	1/2" SCH. 40 PIPE	S.S. 304L	
1	10	1/2" L. 900" DIA. x 1/2" THK	S.S. 304L	
2	11	1/2" x 1/2" ECCENTRIC REDUCER-SW	S.S. 304L	
1	12	BLIND FLANGE - 3" STD. 150"	S.S. 304L	
1	13	1/2" TUBING	S.S. 304L	
1	14	GASKET (5" OD. x 3 1/2" ID. x 1/8" THK)	TEFLON	

NGE HOLE LAYOUT

	INSTALLATION.	"A" DIMENSION
ASSEMBLY 1	TK'S-DB & D9	
ASSEMBLY 2	TK'S-L2, L3 & L8	53"
ASSEMBLY 3	TK'S-D10 & D11	21"

NOTES -

- ALL WELDS OF PIPE & TUBING TO FLANGE TO BE LIQUID TIGHT
- ON ASSEMBLIES 2 & 3, OVERALL DIAMETER OF THE LOWER PORTION OF THE WELL SHALL NOT EXCEED 3.000 INCHES AT ANY POINT
- UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON FRACTIONS DECIMALS ANGLES
± 1/16 ± .005 ± 1° 0'
SURFACE ROUGHNESS IN ACCORDANCE WITH ASA B46.1-1995
- S.S. PIPE TO BE IN ACCORDANCE WITH SPEC. NWS 80695 & 8068-5
- S.S. TUBING TO BE IN ACCORDANCE WITH SPEC. NWS 8065-3 & 8068-5
- SH. S.S. TO BE IN ACCORDANCE WITH NWS 8065 & 8068-5
- WELDING TO BE IN ACCORDANCE WITH MW-4924-5
- WELDING FLANGE TO BE IN ACCORDANCE WITH NWS-8066-5
- ON ASS'Y 1, OVERALL DIA OF LOWER PORTION OF WELL SHALL NOT EXCEED 3.000 INCHES AT ANY POINT.

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DESCRIPTION		REV BY	APP'D BY	FOR DATE
REVISIONS				
CLASSIFICATION		CLASSIFIED BY		
NONE		DATE 1/2/50		
H-2-20955		-		
SCALE:		APPROVALS		
DRAWN BY DATE 1-2-50		BY	FOR	DATE
CHECKED BY DATE		DATE	DATE	DATE
ISSUED BY DATE 1-9-50				
DES. ENG. DATE 1-9-50				
INST. NO. 962				
PROJECT NO.				
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC				
NEUTRON MONITOR PROBE WELL ASSEMBLIES RECUPLEX PROCESS				
234-5		5900-04		
H-2-20955		-		

FIGURE NO. 8

MBLY

NO.	OWL NO.	DRAWING TITLE
		REFERENCE DRAWINGS
		1-2-20958

PLAN

ELEVATION A-A

① ASSEMBLY

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QTY.	2	DESCRIPTION	NAT'L	REF.
1	ASSEMBLY			
1	2" SCH. 10 PIPE	S.S. 304L		
1	2" 16 GA. TUBING	S.S. 304L		
1	16 GA. SH. S.S. $\times 2\frac{1}{2}$ " DIA.	S.S. 304L		
1	1" SCH. 40 PIPE	S.S. 304L		
1	2" LRP SCH. 10	S.S. 304L		
1	$\frac{1}{2}$ " $\times 6$ " DIA.	S.S. 304L		
1	MALE CONN. $\frac{1}{2}$ " T TO $\frac{3}{8}$ " P	S.S. 304L		
1	MALE CONN. $\frac{1}{2}$ " T TO $\frac{1}{2}$ " P	S.S. 304L		

NOTES

1. UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES ON
FRACTIONS DECIMALS ANGLES.005
FINISHES SHALL BE IN ACCORDANCE
WITH SPECIFICATION HW3791

2. HYDROSTATIC LEAK TEST: 50 P.S.I.

3. S.S. PIPE TO BE IN ACCORDANCE WITH
SPEC. HWS-8064-S & 8068-S4. S.S. TUBING TO BE IN ACCORDANCE
WITH SPEC. HWS. 8065-S & 8068-S5. $\frac{1}{2}$ " & SH. S.S. TO BE IN ACCORDANCE
WITH HWS. 8061-S & 8068-S6. WELDING TO BE IN ACCORDANCE WITH
HW-4924-S7. WELDING FITTINGS TO BE IN ACCORDANCE
WITH SPEC. HWS-8066-S

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CLASSIFICATION		CLASSIFIED BY			
NONE		DATE 5/18/58			
H-2-20956		2			
SCALE		APPROVAL			
DRAWN J. Y. KED DATE 4-28-58		BY R. R. Kelly DATE 5/8/58			
CHECKED DATE					
REVIEWED DATE 5-9-58					
DES. ENG. DATE 5/1/58					
DWT. NO. 962					
PROJECT NO.					
U. S. ATOMIC ENERGY COMMISSION HANFORD ATOMIC PRODUCTS OPERATION GENERAL ELECTRIC					
NEUTRON PROBE TANK RECUPLEX KI-2					
BLK. 234-5		FORM 5900-04			
H-2-20956					

FIGURE NO. 9

DWG. NO.	DRAWING TITLE	BLK.	FORM
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