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HANFORD CATEGORY C-44C

CPTF RUN 5 FLUX MONITORING

J.R. Divine

FEBRUARY 22, 1971

PREPARED FOR

THE UNITED STATES ATOMIC ENERGY COMMISSION

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BATTELLE-NORTHWEST
PACIFIC NORTHWEST LABORATORIES DIVISION
BATTELLE MEMORIAL INSTITUTE
P. O. BOX 999, RICHLAND, WASHINGTON 99352

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J. R. Divine

Corrosion Research & Engineering Section
Fuels & Materials Department

February 22, 1971

This report is intended primarily for internal use by the sponsoring organization and Battelle-Northwest.

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INTRODUCTION

At the present stage of reactor coolant studies it is possible to say that radiation has an effect on the deposition behavior of corrosion products in the reactor. A quantitative relation between flux and deposition rate or amount is not available, nor is there information as to exactly which component, or combination thereof, of the radiation is of most importance.

To determine these effects and those of other process parameters, Battelle-Northwest (BNW) is conducting an experimental program for the Knolls Atomic Power Laboratory (KAPL) to evaluate the behavior of corrosion products in pressurized, water-cooled nuclear reactor systems. This program is authorized by and is being performed under the terms and conditions of KAPL Purchase Order 7730-A (and Amendments).

The primary experimental system used by BNW to perform these experiments is the Corrosion Product Transport Facility (CPTF). This is a high-temperature, high-pressure, water-cooled, in-reactor loop. It is designed to operate over a wide range of experimental conditions, and to maximize flexibility for experimentation involving formation, transport and deposition of corrosion products. The CPTF is actually operated by the Irradiation Services Unit, Douglas United Nuclear, Inc. (DUN), under the technical direction of BNW.

In-reactor test sections of the CPTF were positioned in a special test facility so that the upstream section, TS4U, was located in a region of essentially flat flux profile and the downstream section, TS4D, was in a region with a flux gradient.

This report is only concerned with transmitting the experimental data for Run 5. There is only a minimum of data analysis done here. A complete analysis will be performed when all data for Runs 4, 5 and 6 have been collected.

SUMMARY

The major difference between the two runs was that in Run 5 the test section located in the shielding of the reactor was five inches further towards the edge than in Run 4. This provided a steeper overall gradient in Run 5. However, the flux at any point in the reactor differed only by about 2 1/2% for the two runs; this was effected by a 2 1/2% lower average power level in Run 5 relative to Run 4.

EXPERIMENTAL

System

The same basic system was used as in Run 4* and will not be described here. Only changes in the relative positions of the test sections were made. In the case of TS4U, the core test section, the distance from the front face flange was increased by 11/16", to a total distance of 218 1/8" to the upstream end of the test section. TS4D, the edge test section, was placed 5 7/8" nearer the front face than in the case of Run 4 for a distance of 83" from the front face flange to the upstream end of the test section. Because these changes are minor, no diagram of the system is presented in this report.

*BNWL-B-42, Dec. 18, 1970, "CPTF Run 4 Flux Monitoring".

Test Sections

The same test section design was used in Run 5 with only one change from Run 4. In the present run, the flux monitor channel in the upper half of the specimen holder was eliminated, leaving only the channel in the bottom half. The positions of the test specimens relative to the flux are as shown in Figures 1 to 8.

Flux Monitors

In this run all of the flux wires for a test section were placed in a single long, 34 inch, tube (0.050 inch O.D., 0.033 inch I.D.). The flux wires were 0.020 inch diameter, approximately 0.25 inch long. Their compositions are given in Table I.

TABLE I

FLUX WIRE COMPOSITION

Wire	Composition (wt %)
Fe	99.99% Fe, 0.003% Si, 0.002% Mg
CoAl	0.1% Co, 99.8% Al, <0.01% Cu, <0.01% Ag
AgAl	0.1% Ag, 99.8% Al
Cu	99.999% Cu

Copper was substituted in Run 5 for the titanium of Run 4 since the daughter product (Co-60) has a longer half-life than the scandium daughters of titanium. This was found to be a necessary safety factor because it has not proven feasible to analyse the flux monitor earlier than two weeks after irradiation is complete.

RESULTS & DISCUSSION

The data are presented in Tables II and III; they are given in dps/mg of total monitor (compensation for composition has not been made), and have all been reduced to the time at which the test sections were removed from the flux. The total exposure period at that time was 840 hours.

Of more interest are Figures 1 through 8. Here the data of Runs 4 and 5 have been plotted relative to positions in the reactor. In order to provide a proper comparison, all data have been converted to saturation values, that is, infinite exposure. The equation used for this was

$$N_\infty = N_t/(1 - \exp(-\lambda t))$$

where N_∞ is the saturation activity, N_t is the activity after an exposure of t hours to a neutron flux and λ is the half-life of the nuclide in question. The Run 5 data have been multiplied by 1.025 to correct for the lower average power level of that run.

Plotted on this basis, the data for the two runs show good agreement with one another. In Figure 1 a reasonably flat profile is obtained for the Fe-58 (n, γ) Fe-59 activity data which indicates a flat thermal flux. Also shown in this figure are the data for the Fe-54 (n, p) Mn-54 reaction. These data indicate a slight depression of the fast flux towards the upstream end of the test section, the end towards the edge of the reactor. The data from other flux monitors, for example Figure 3, corroborate this.

For the edge, TS4D, Figure 4, Fe-58 (n, γ) Fe-59, the data show very clearly the effects of moving from the graphite core, through the various components of the outer shielding. Beginning at about 15" from the edge of the graphite, the thermal flux has a secondary peak due to reflection and slowing of the neutrons in the concrete.

The remaining data are too sparse or scattered to show clearly the effects of the changes from one area of the reactor to another.

A comprehensive report covering Runs 4, 5 and 6 will be prepared shortly. It will describe the results of the unfolding of the flux spectrum from the activity data and compare this with the results of the theoretical calculations. For that reason, no attempt will be made at this time to calculate the flux. It is noted however, that the thermal flux, based on the Fe-58 (n, γ) Fe-59 and Co-59 (n, γ) Co-60 reactions, is approximately 3.5×10^{13} n/cm^2sec for TS4U.

TABLE II

TS4U ACTIVITY DATA

	Activity (dps/mg sample)#				
Position*(in)	Fe-59	Mn-54	Co-60**	Ag-110m	Co-60***
34.1	6.76+5	1.57+4			
33.8	6.5 +5	1.62+4			
33.5			1.97+5		
33.2					1.68+2
33.0				1.25+5	
32.7	6.34+5	1.74+4			
32.0	NA				
31.4	6.38+5	1.72+4			
30.7	NA				
30.0	NA				
29.7	7.00+5	1.68+4			
29.4	6.48+5	1.58+4			
29.1			2.01+5		
28.8					1.60+2
28.6				1.27+5	
28.4	6.64+5	1.48+4			
27.7	NA				
27.1	NA				
26.5	NA				
25.8	6.34+5	1.58+4			
25.2	6.35+5	1.45+4			
24.2	NA				
23.6	NA				
22.9	NA				
22.3	NA				
21.7	6.37+5	1.50+4			
21.1	NA				
20.4	NA				
19.8	NA				
19.2	6.09+5	1.50+4			
18.5	6.20+5	1.47+4			
18.1	6.34+5	1.58+4			
17.9			1.91+5		
17.6					1.73+2
17.3				1.19+5	
17.1	6.26+5	1.58+4			
16.4	NA				
15.8	6.77+5	1.51+4			
15.2	NA				
14.5	NA				
14.2	6.52+5	1.57+4			
14.0			1.96+5		
13.7					1.6+2
13.5				1.24+5	

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TABLE II (Cont)

TS4U ACTIVITY DATA

Position*(in)	Activity (dps/mg sample)# Fe-59	Mn-54	Co-60**	Ag-110m	Co-60***
13.2	6.55+5	1.41+4			
12.5	NA				
11.9	NA				
11.3					
10.7	6.99+5	1.67+4			
10.1	NA				
9.4	6.51+5	1.43+4			
8.8	NA				
8.1	6.10+5	1.45+4			
7.4	NA				
6.8	6.59+5	1.41+4			
6.1	6.23+5	1.55+4			
5.5	NA				
4.9	NA				
4.3	NA				
3.7	NA				
3.0	6.19+5	1.52+4			
2.7			1.86+5		
2.5					2.42+2
2.2				1.14+5	
2.0	6.09+5	1.53+4			
1.6	NA				

NA : Fe wire which was not analysed; used as spacers.

* Measured from upstream end of specimen holder.

** Co-59 (n, γ) Co-60

*** Cu-63 (n, α) Co-60

\# The activity data are presented in a simplified form where 6.55+5 represents 6.55×10^5 and 4.8-1 represents 4.8×10^{-1}.

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TABLE III

TS4D ACTIVITY DATA

Position*(in)	Fe-59	Mn-54	Co-60**	Ag-110m	Co-60***
	Activity (dps/mg sample)#				
0.3	4.10+4	5.02+2			
0.7	4.41+4	3.90+1			
0.9			1.24+4		
1.2					4.2-1 (± 13%)
1.4				2.64+3	
1.7	3.87+4	3.38+1			
2.4	NA				
3.0	NA				
3.6	NA				
4.3	2.51+4	2.45+1			
4.9	NA				
5.5	1.96+4	1.97+1			
5.8	NA				
6.5	1.67+4	1.67+2			
7.2	NA				
7.5	1.33+4	6.32+0			
7.8			3.49+3		
8.1					1.3-1 (± 19%)
8.3				7.25+2	
8.6	1.06+4	9.21+0			
9.2	8.64+3	1.10+2			
9.8	NA				
10.5	NA				
11.1	NA				
11.7	NA				
12.4	3.42+3	5.6+0			
13.0	NA				
13.7	1.74+3	3.45+0			
14.3	NA				
15.0	7.65+2	9.84+1			
15.3	6.37+2	1.88+0			
15.6			1.63+2		
15.9					4. -2 (± 47%)
16.2				2.94+1	
16.4	3.38+2	1.50+0			
17.1	NA				
17.7	2.07+2	3.19+0			
18.4	1.51+2	2.32+0			
19.0	1.22+2	4.8-1			
19.6	1.08+2	1.48+0			
20.3	NA				
20.9	NA				
21.5	1.02+2	1.2-1			
22.2	NA				

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TABLE III (Cont)

TS4D ACTIVITY DATA

Position*(in)	Activity (dps/mg sample)#				
	Fe-59	Mn-54	Co-60**	Ag-110m	Co-60***
22.9	8.3+1	2.13+0			
23.3	5.40+1	3. -1			
23.5			1.32+1		
23.8					<2. -2
24.0				2.44+0	
24.3	2.49+1	8. -2			
25.0	NA				
25.6	NA				
26.3	NA				
26.9	5.23+0	1. -1			
27.1	2.67+0	6. -2			
27.4	NA				
28.0	NA				
28.6	NA				
29.2	NA				
29.9	NA				
30.3	7.4-1	2. -2			
30.6			1.7-1(± 21%)		
30.8					<2. -2
31.1				1.1-1	
31.4	3.9-1	2.-2			
32.0	NA				

NA : Fe wire which was not analysed; used as spacers.

* Measured from upstream end of specimen holder.

** Co-59 (n, γ) Co-60

*** Cu-63 (n, α) Co-60

\# The activity data are presented in a simplified form where 6.55+5 represents 6.55×10^5 and 4.8-1 represents 4.8×10^{-1}.

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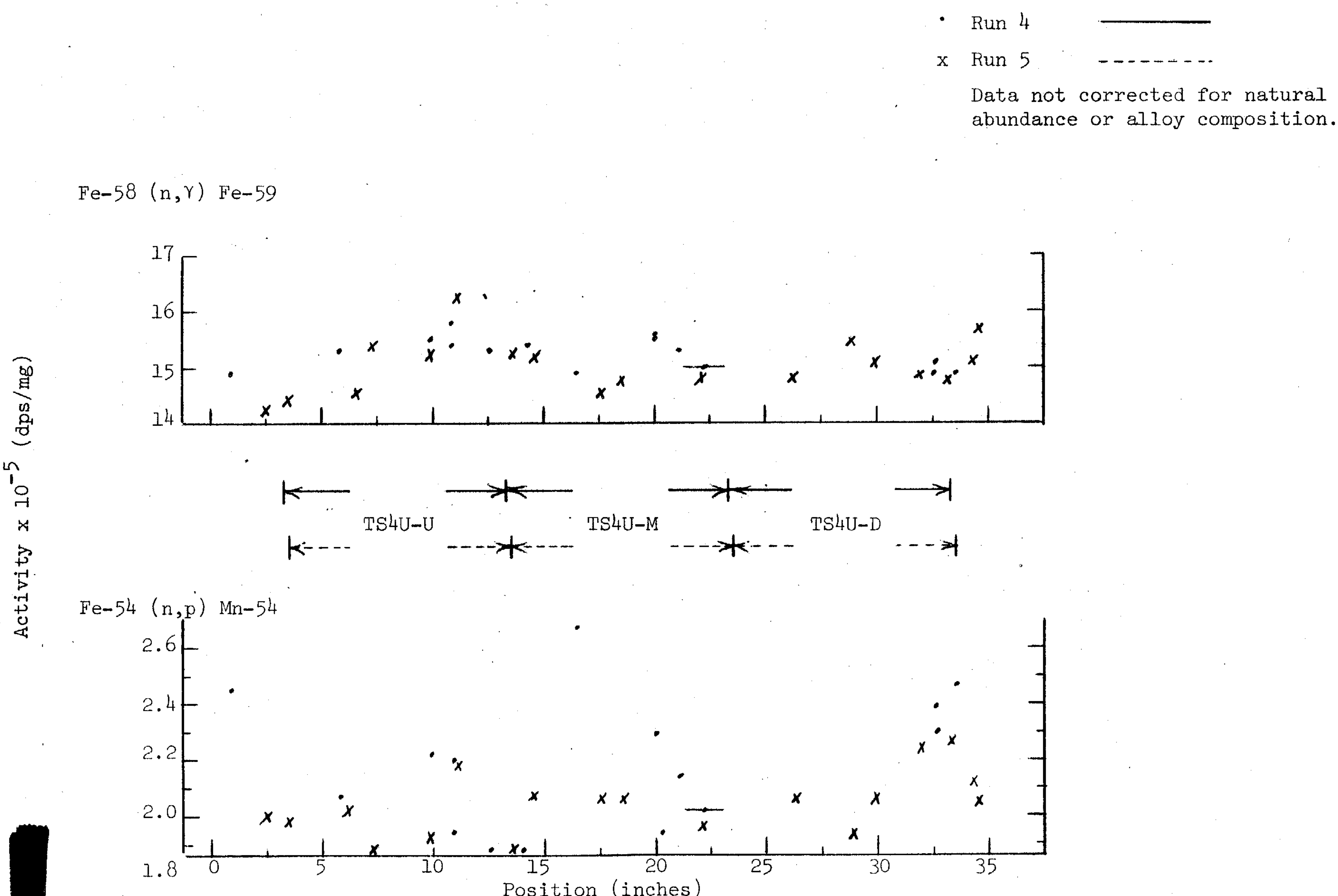

FIGURE 1 - TS4U Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

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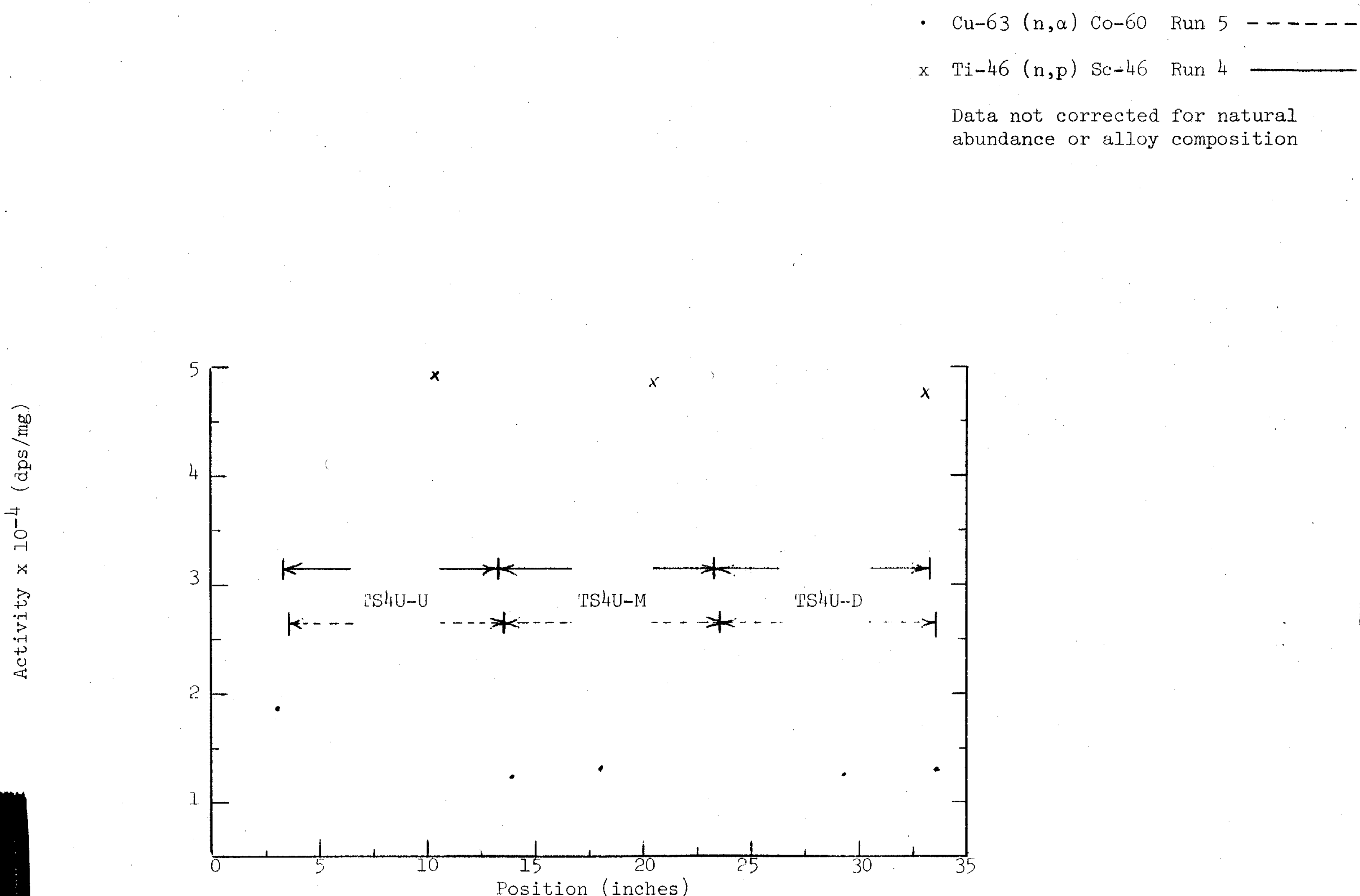

FIGURE 2 - TS4U Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

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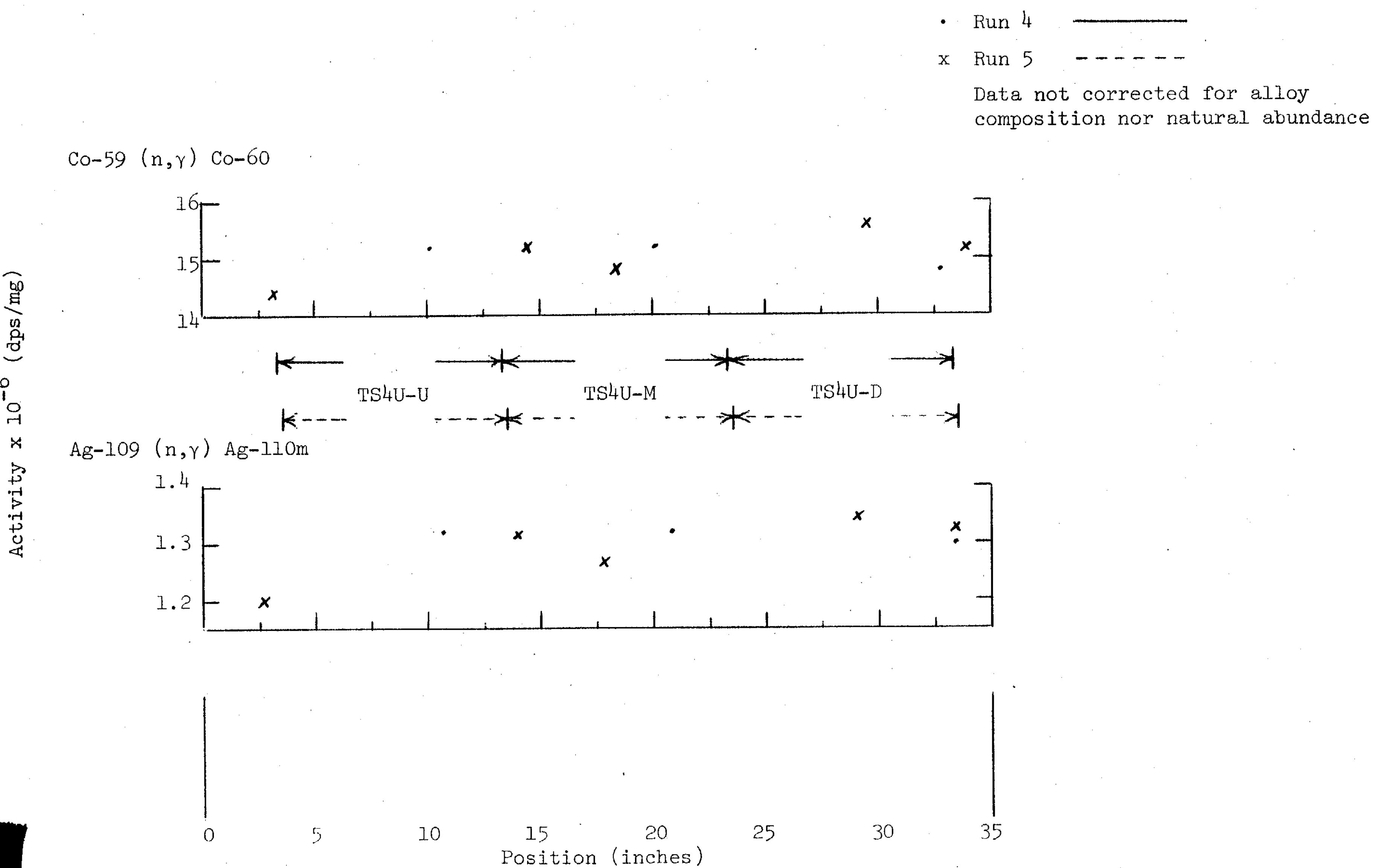

FIGURE 3 - TS4U Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

[redacted]

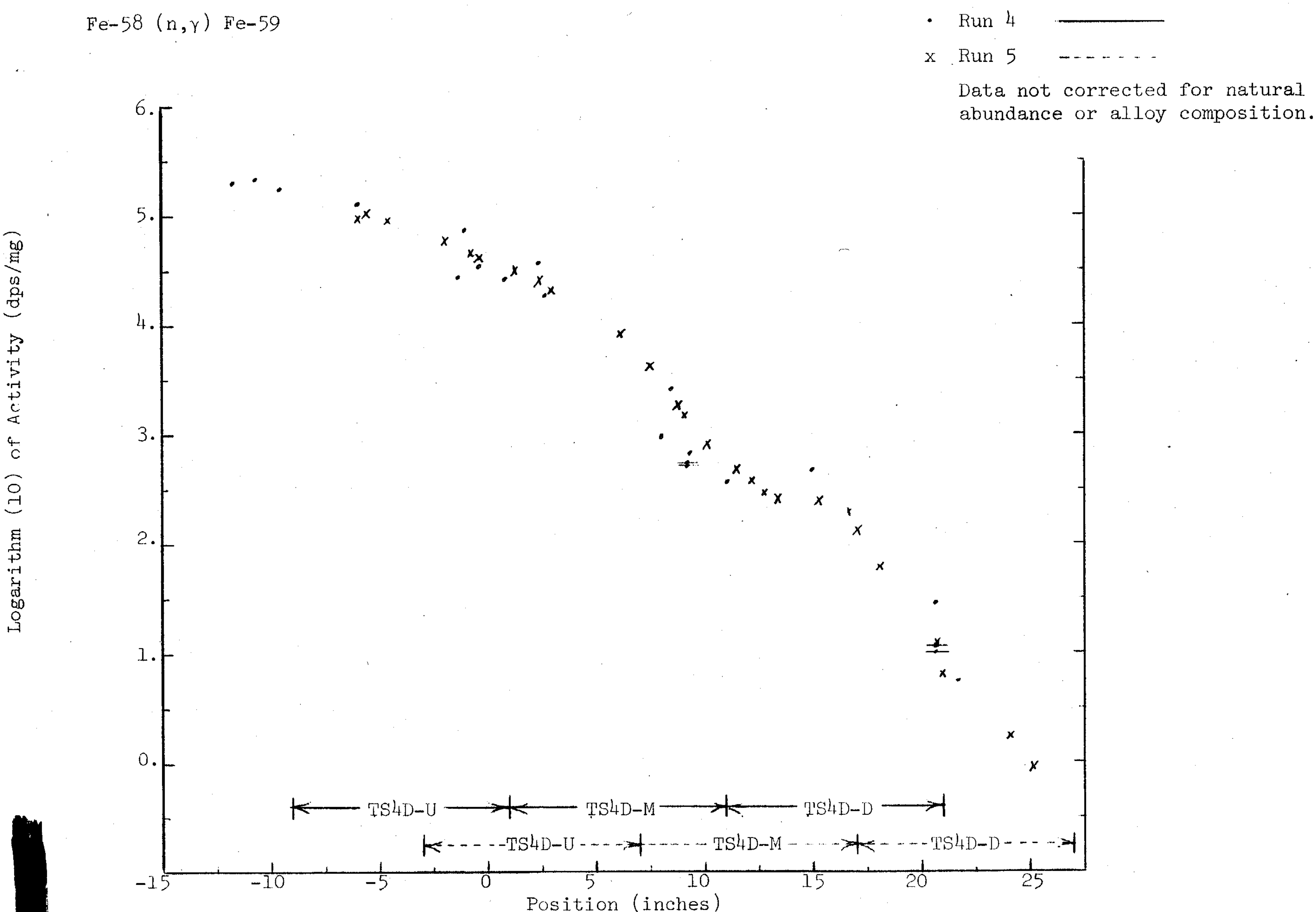

FIGURE 4 - TS4D Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

[redacted]

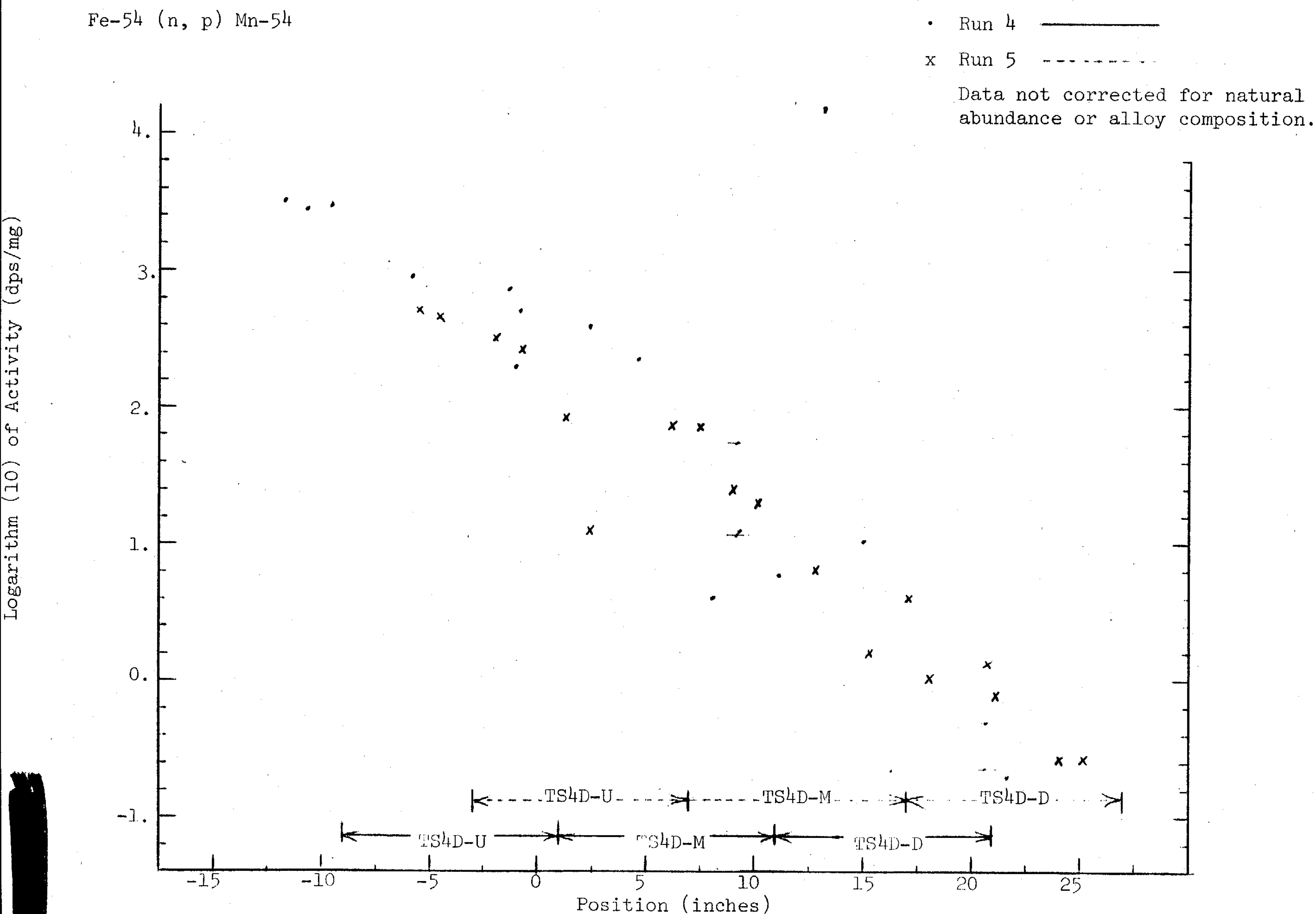

FIGURE 5 - TS4D Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

[redacted]

[redacted]

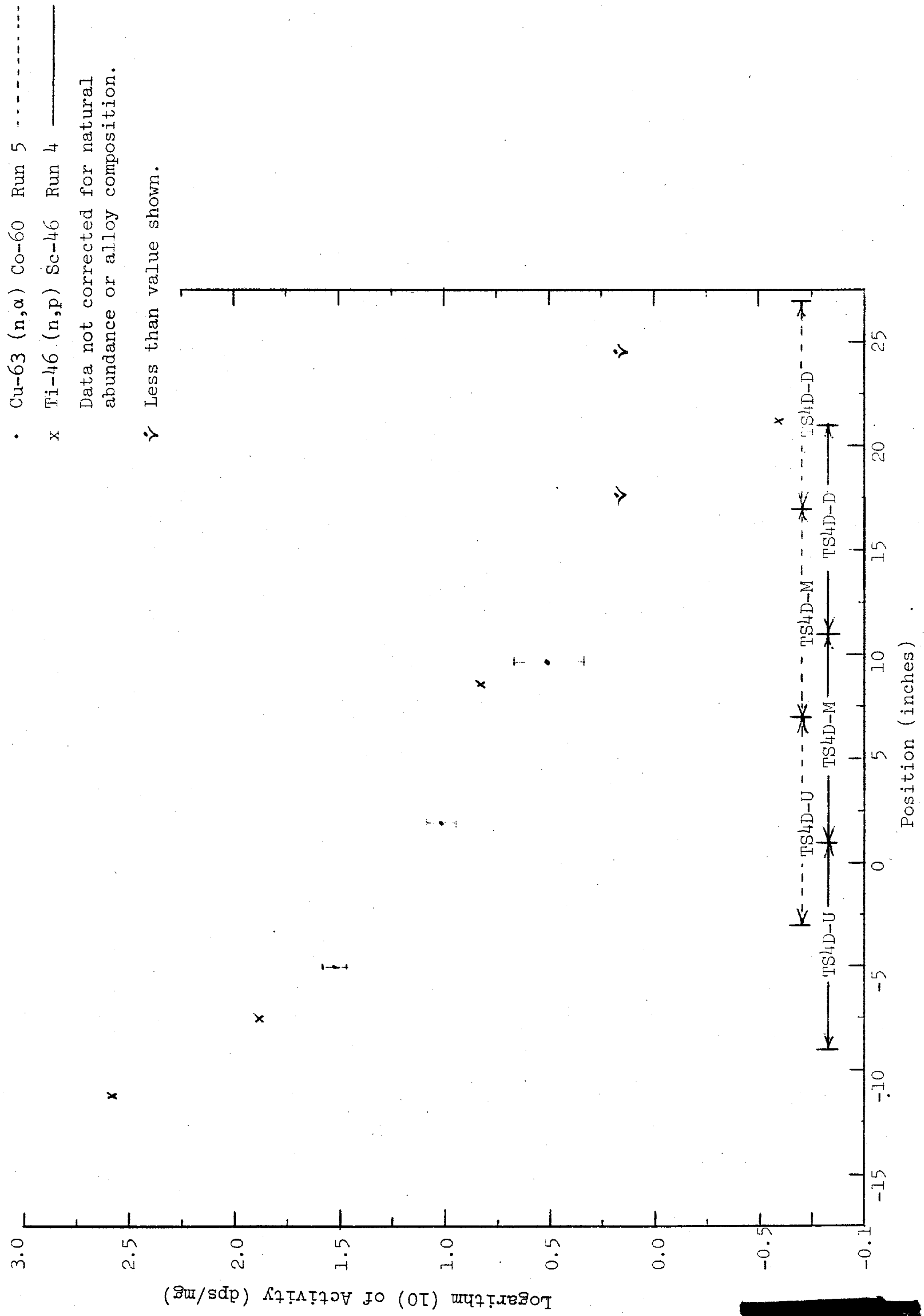

FIGURE 6 - TS4D Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

[redacted]

[redacted]

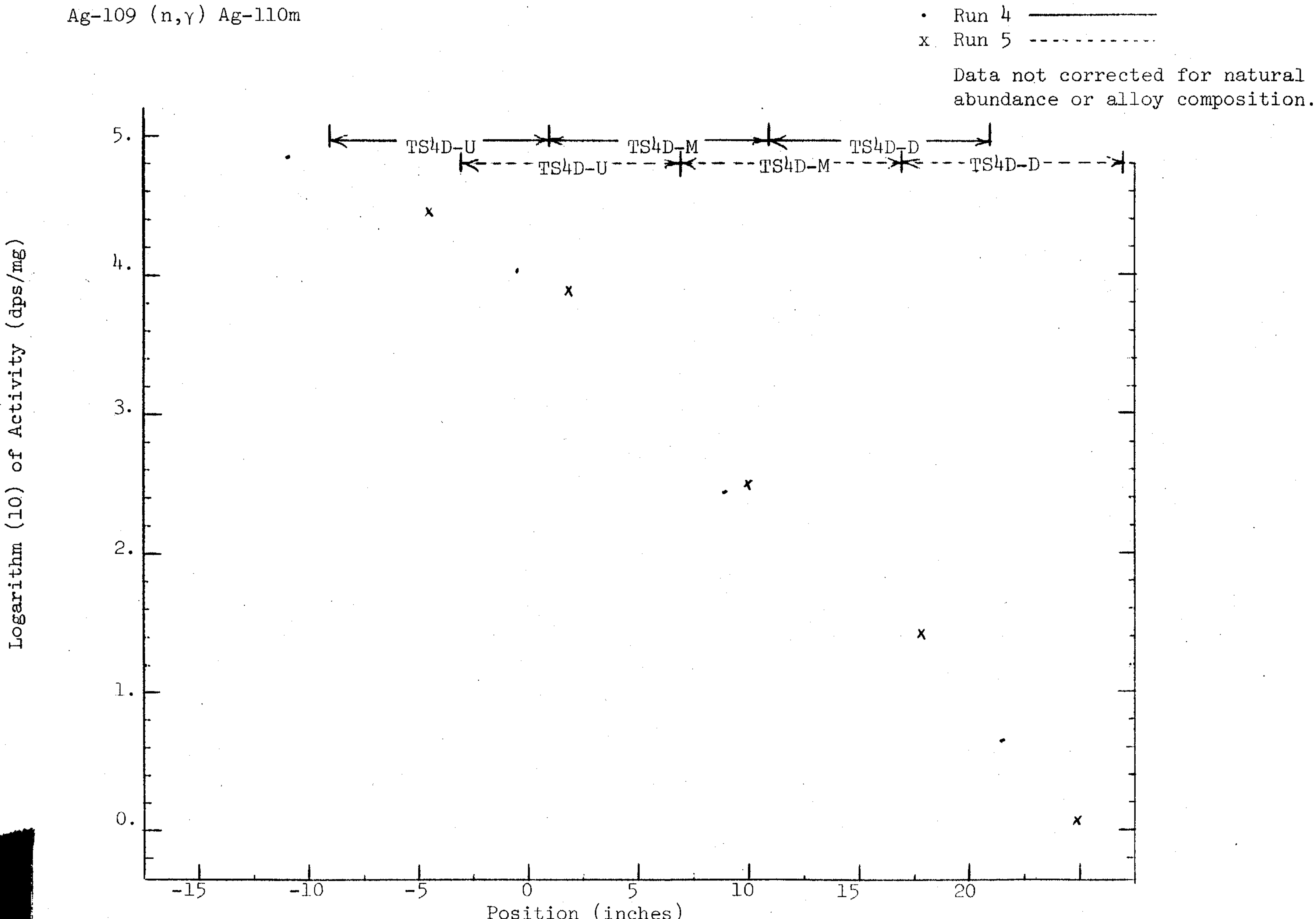

FIGURE 7 - TS4D Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

[redacted]

[redacted]

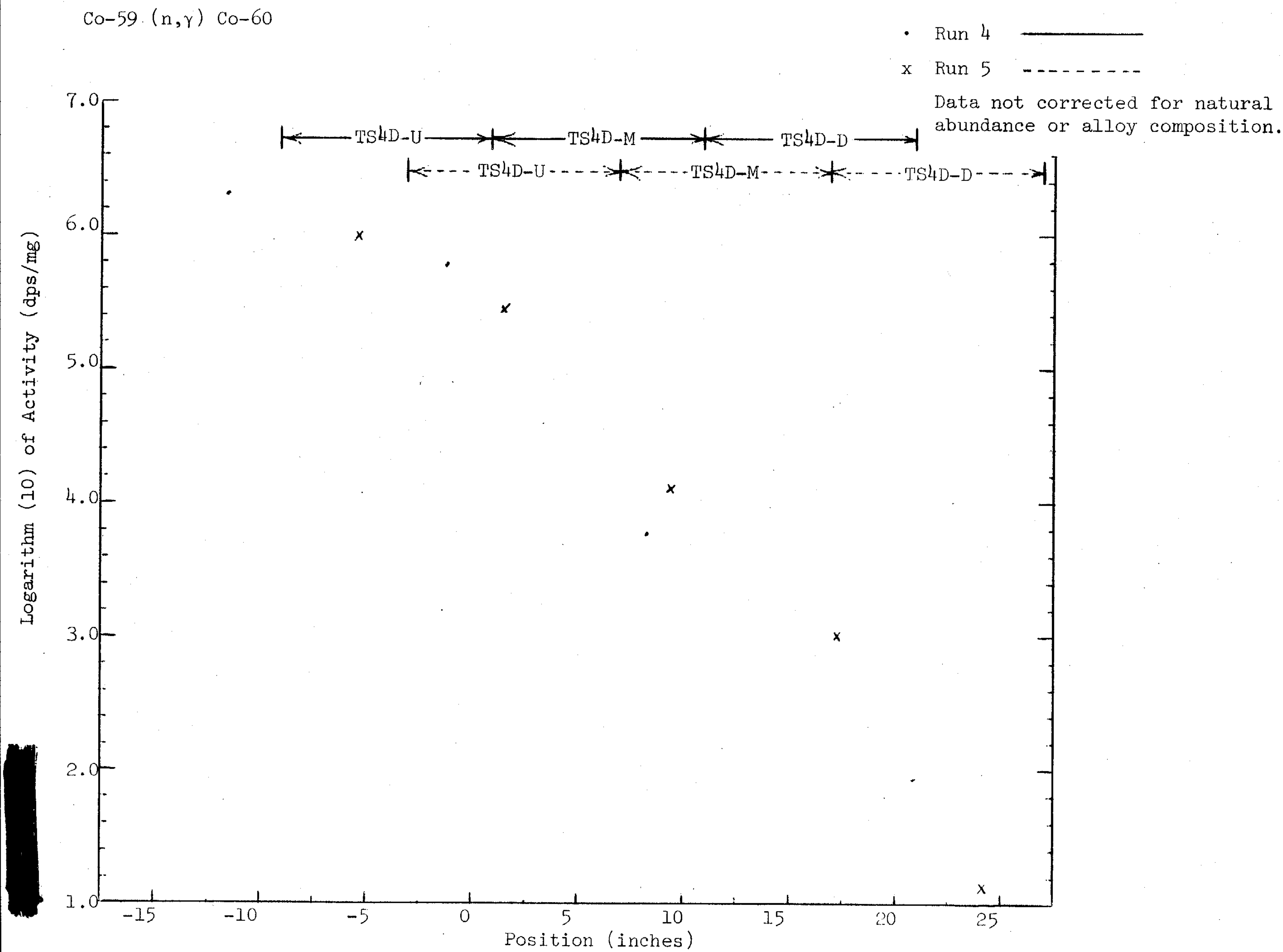

FIGURE 8 - TS4D Saturation Activity Data Relative to a Fixed Point in the Reactor - Runs 4 and 5.

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