ATTACHMENT 4

REPORT RDD:98:55863-003-000:02

McDERMOTT TECHNOLOGY, INC.

McDermott Technology, Inc.

Research & Development Division

NIAGARA MOHAWK'S NINE MILE POINT UNIT 1 BOAT SAMPLE ANALYSES

PART II: DOSIMETRY

PREPARED FOR
B&W SERVICES, INC.
FOR
FRAMATOME TECHNOLOGIES INC.

RDD:98:55863-003-000:02 DECEMBER 1997

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NIAGARA MOHAWK'S NINE MILE POINT UNIT 1
BOAT SAMPLE ANALYSES

PART II: DOSIMETRY

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Report Title: NIAGARA MOHAWK'S NINE MILE POINT UNIT 1 BOAT SAMPLES ANALYSES PART II: DOSIMETRY

Report No.: RDD:98:55863-003-000:02

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1.0 INTRODUCTION

Two boat samples removed from the Nine Mile Point Unit 1 (NMP-1) Core Shroud were sent to McDermott Technology Inc. (MTI) Lynchbrug Research Center (LRC) for root cause failure analysis. The metallurgical investigation was structured to examine the following:

- document microstructural features of both samples,
- evaluate the cracking morphologies and patterns that may be present,
- measure the microhardness for selected locations on the metallurgical sample cross-sections,
- examine oxides that may be present in the cracks, and
- examine the microstructural evidence for degree of sensitization indicated for each sample.

The results of this investigation were documented in PART I: Metallography of the this report. This report documents an additional investigation topic. In particular, MTI measured the flux and fluence associated with different thickness locations of each sample required by Niagara Mohawk Power Corporation (NMPC).

Two shroud boat samples (V-9 and V-10) were packaged in a shielded 55 gallon drum, shipped, and received at McDermott Technology Inc. (MTI) Lynchburg Research Center (LRC) on July 25th, 1997. The out-of-cell air radiological surveys revealed that the radiation level for both specimens was 26 R/hr at 30 cm. Specimens were transferred to the hot cell facility through an underwater canal. Figure 1.1 shows the boat sample locations in the central-mid-cylinder shell course.

The shutdown time for Nine Mile Point Unit 1 was March 3, 1997 at 18:42 hours. This time was used to correct for the decay of isotopes.

2.0 DOSIMETER PREPARATION

Six samples at three depths were removed (two samples from each depth) from specimens V-9 and V-10 for gamma spectrometry analysis to determine the activity of target nuclide after irradiation. Figures 2.1 and 2.2 illustrate the locations from where these samples were taken. At each location as depicted in Figures 2.1 and 2.2, a small piece of metal (~30-60 mg in weight) was removed from the boat sample. The depths of the specimens are summarized in Table 2.1.

Table 2.1 Specimen Depths for the Dosimeters

Specimen Identification	Specimen Depths (in inches, from the flat surface)	Uncertainty (in inches)
V-9 near flat surface	0	±1/64
V-9 mid plane	0.337	±1/32
V-9 specimen tip	0.85	±1/32
V-10 near flat surface	0	±1/64
V-10 mid plane	0.4375	±1/32
V-10 specimen tip	0.618	±1/32

This small piece of metal was then sectioned into two pieces for subsequent analysis. Note that the samples removed from near the flat surface of each boat sample contains oxide that may contaminate the test results. A second cut was performed to remove the flat surface (thus the oxide) from the samples. The thickness of the metal removed was less than 1/64 inch.

These dosimetry samples were then dissolved in a solution[1] that contained 2% nitric acid and 5%

[1] Prior to specimen digestion, the solid samples were counted by detectors at the fartherest calibrated positions. However, the activities of samples were very high and saturated the detectors. A decision was made not to count the samples as solid and this was approved by NMPC.

hydrochloric acid. All of the samples were totally dissolved in 30 minutes. A small portion of the solution was than diluted to 20 ml and placed in a calibrated counting geometry.

3.0 QUANTITATIVE GAMMA SPECTROMETRY

For these dosimeters, the following procedures were used.

1. Prior to the actual counts, background counts were performed to assure that the background is low enough not to interfere with the actual counts.

2. Prior to the actual counts, NIST-traceable sources with known activities were used to check every gamma spectrometer that was used for that specific group of dosimeters[2].

3. Selected dosimeters were given a 300 second preliminary count on a gamma spectrometer. This provided information with which to judge the best distance to count the dosimeter to get a minimum of 10,000 counts in the photopeak of interest while keeping the counter dead time below 15%. The spectra were then measured quantitatively at the appropriate counting positions and for the appropriate count times determined from the preliminary counts.

4. Replicate counts were performed by randomly choosing a dosimeter and counting it at a gamma spectrometer that was different from the one that they were originally counted. The difference between replicate count and original count should be within the normal measurement error which is approximately 5% for most of the dosimeters.

Since the boat samples were made of stainless steel 304, the activities of the dosimeters were quantified by the spectral gamma rays listed in Table 3.1.

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[2] All gamma spectrometers are calibrated annually using the same procedures, this procedure was taken to check the appropriateness of the spectrometers.

Table 3.1 Table of Quantifying Gamma Rays

Dosimeter	Analyte
Cobalt	^{60}Co @ 1332 keV from ^{59}Co
Iron	^{54}Mn @ 834 keV from ^{54}Fe
Nickel	^{58}Co @ 811 keV from ^{58}Ni

4.0 DOSIMETERS SPECIFIC ACTIVITIES RESULTS

The elemental weight fractions of the dosimeters were determined by the Inductively Coupled Plasma (ICP) method and the test results were taken from the Part I of this report [1]. The isotopic weight fractions of the target nuclides were taken from the CRC tables [2]. These parameters are summarized in Table 4.1.

Table 4.1 Isotopic Fractions and Weight Fractions of Target Nuclides

Dosimeter	Target Nuclide	Isotopic Weight Fraction of Target	Elemental Weight Fraction of Target*(%)	
			Specimen V-9	Specimen V-10
Cobalt	^{59}Co	1.0000	0.247	0.220
Iron	^{54}Fe	0.0570	67.9	68.8
Nickel	^{58}Ni	0.6739	8.91	8.71

*Average values from three measurements were used [1].

The weight fraction of the target nuclide is the product of the isotopic weight fraction of the target and the elemental weight fraction of the element in the dosimeter.

Table 4.2 Specific Activity For Various Depths for Specimen V-9

Dosimeter Identification	Target Nuclide	Analyte Nuclide	Specific Activity (uCi/g Target)	Uncertainty (uCi/g Target)
V-9 near flat surface, #1	Co-59	Co-60	1.33E+07	9.73E+05
V-9 near flat surface , #1	Fe-54	Mn-54	1.94E+04	1.05E+03
V-9 near flat surface, #1	Ni-58	Co-58	2.01E+04	1.36E+03
V-9 near flat surface, #2	Co-59	Co-60	1.27E+07	9.31E+05
V-9 near flat surface, #2	Fe-54	Mn-54	1.93E+04	1.06E+03
V-9 near flat surface, #2	Ni-58	Co-58	2.15E+04	1.53E+03
V-9 mid plane, #1	Co-59	Co-60	7.23E+06	5.32E+05
V-9 mid plane, #1	Fe-54	Mn-54	1.60E+04	8.03E+02
V-9 mid plane, #1	Ni-58	Co-58	1.91E+04	1.19E+03
V-9 mid plane, #2	Co-59	Co-60	7.53E+06	5.56E+05
V-9 mid plane, #2	Fe-54	Mn-54	1.68E+04	8.55E+02
V-9 mid plane, #2	Ni-58	Co-58	1.83E+04	1.20E+03
V-9 specimen tip, #1	Co-59	Co-60	4.31E+06	3.15E+05
V-9 specimen tip, #1	Fe-54	Mn-54	1.31E+04	6.80E+02
V-9 specimen tip, #1	Ni-58	Co-58	1.44E+04	8.66E+02
V-9 specimen tip, #2	Co-59	Co-60	4.35E+06	3.16E+05
V-9 specimen tip, #2	Fe-54	Mn-54	1.32E+04	7.03E+02
V-9 specimen tip, #2	Ni-58	Co-58	1.51E+04	9.09E+02

Table 4.3 Specific Acitivity For Varous Depths for Specimen V-10

Dosimeter Identification	Target Nuclide	Analyte Nuclide	Specific Activity (uCi/g Target)	Uncertainty (uCi/g Target)
V-10 near flat surface, #1	Co-59	Co-60	3.17E+06	2.37E+05
V-10 near flat surface, #1	Fe-54	Mn-54	6.74E+03	3.29E+02
V-10 near flat surface, #1	Ni-58	Co-58	6.75E+03	3.97E+02
V-10 near flat surface, #2	Co-59	Co-60	3.20E+06	2.33E+05
V-10 near flat surface, #2	Fe-54	Mn-54	6.74E+03	3.55E+02
V-10 near flat surface, #2	Ni-58	Co-58	6.80E+03	4.59E+02
V-10 mid plane, #1	Co-59	Co-60	2.78E+06	2.04E+05
V-10 mid plane, #1	Fe-54	Mn-54	8.34E+03	4.14E+02
V-10 mid plane, #1	Ni-58	Co-58	8.42E+03	5.07E+02
V-10 mid plane, #2	Co-59	Co-60	2.83E+06	2.07E+05
V-10 mid plane, #2	Fe-54	Mn-54	8.26E+03	4.34E+02
V-10 mid plane, #2	Ni-58	Co-58	8.52E+03	5.22E+02
V-10 specimen tip, #1	Co-59	Co-60	3.13E+06	2.31E+05
V-10 specimen tip, #1	Fe-54	Mn-54	8.98E+03	4.52E+02
V-10 specimen tip, #1	Ni-58	Co-58	9.72E+03	6.03E+02
V-10 specimen tip, #2	Co-59	Co-60	3.13E+06	2.31E+05
V-10 specimen tip, #2	Fe-54	Mn-54	9.14E+03	4.55E+02
V-10 specimen tip, #2	Ni-58	Co-58	9.91E+03	6.03E+02

The dosimeter specific activities were calculated by dividing the corrected activity of the analyte nuclide by the target nuclide mass.

The uncertainty values presented in the above tables include uncertainty from both ICP and gamma spectrometry analysis. These uncertainty values are the combined uncertainty of the following; (1) uncertainty in sample preparation (such as weight of the sample and dilution of the solution), (2) uncertainty of standards used in equipment calibration, (3) uncertainty in calibration curve, and (4) uncertainty in measurements which are not intended to be all-encompassing. Uncertainties in parameters such as half-life, gamma yields, branching ratios, isotope aboundance, etc. are not included in these calculations, but do contribute to the overall uncertainty.

5.0 CONCLUSIONS

A total of 12 dosimetry samples were removed from two boat samples which were removed from Nine Mile Point Unit 1 earlier this year. Both Ni and Fe dosimeters respond to fast neutrons for a (n, p) reaction while Co dosimeters respond to thermal neutrons for a (n, γ) reaction. The lower energy for a (n, p) reaction for Ni and Fe is 2.3 Mev and 2.5 Mev, respectively. The results suggest that the specific activity for both Ni and Fe dosimeters decrease with increasing wall thickness (from shroud ~~O.D.~~ I.D. ?). The ratio between the shroud I.D. and O.D. measurements is 2.99 and 2.88 for Ni and Fe, repectively. Note that the axial location is different between specimen V-9 (shroud I.D.) and V-10 (shroud O.D.). For Co dosimetry, the specific activity dropped off very quickly with increasing wall thickness and did not vary much towards the shroud O.D. This is expected since thermal neutrons do not penetrate the shroud as well as fast neutrons. This is apparent since the ratio between the shroud I.D. and O.D. measurements is 4.08.

Typo ?

The difference in the measurements between the two dosimeters that were removed from the same depth was seen to be very small. This indicates that the scatter in the laboratory measurement was small.

6.0 REFERENCES

1. K. Y. Hour, "Niagara Mohawk's Nine Mile Point Unit 1 Boat Samples Analyses, Part I: Metallography", McDermott Technology Inc. RDD:98:55863-002-000:01, dated September, 1997.

2. R. C. Weast and M. J. Astle, Eds., "CRC Handbook of Chemistry and Physics, 63rd Ed.", CRC Press, Boca Raton, FL, 1982.

7.0 APPENDICES

Weighing of Dosimetry

Balance: Mettler AE240, B&W 1004170
Certified 5/21/97, Expires 5/21/98

Gamma Spectrometer System

Detector: GAMMA01, B&W 1004425
Amplifier: Canberra 2025, B&W 1003986
High Voltage: Canberra 3106D, B&W 1003988
ADC: ND579, B&W 1003987

Detector: GAMMA04, B&W 1004426
Amplifier: Canberra 2025, B&W 1004205
High Voltage: Canberra 3106D, B&W 1004203
ADC: ND583, B&W 1003739

Detector: GAMMA06, B&W 1004428

Amplifier: Canberra 2020, B&W 1004207

High Voltage: Canberra 3160D, B&W 1004202

ADC: ND570, B&W 1004197

Chemical Analysis

Thermo Jarrell Ash ICP, B&W 1006045

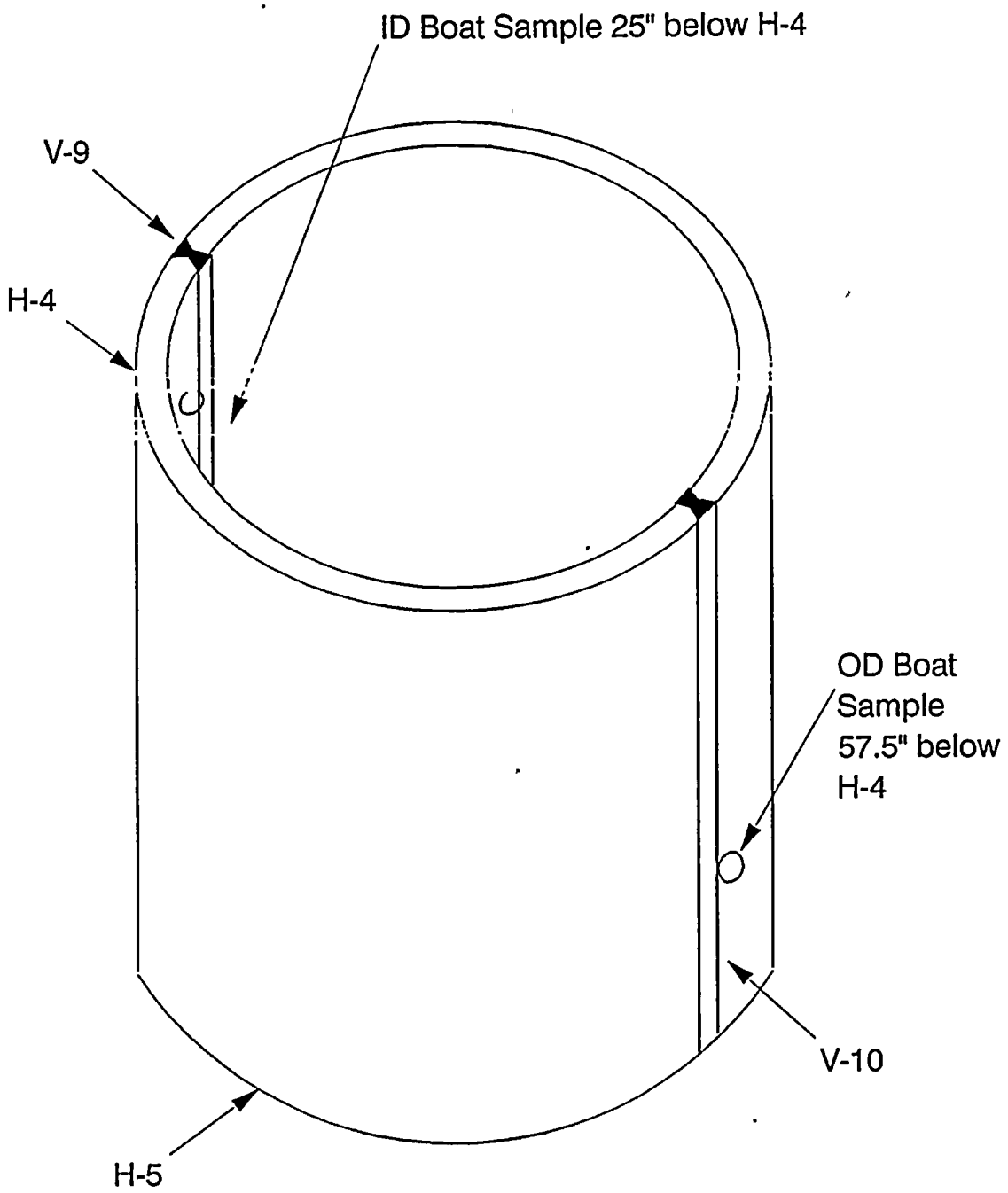

Figure 1-1 - Location of boat samples taken from core shroud at NMP-1. Elevation for center of active fuel is approximately the same as the location of the boat sample taken from vertical weld, V-9.

V - 9 DOSIMETRY ANALYSIS LOCATIONS

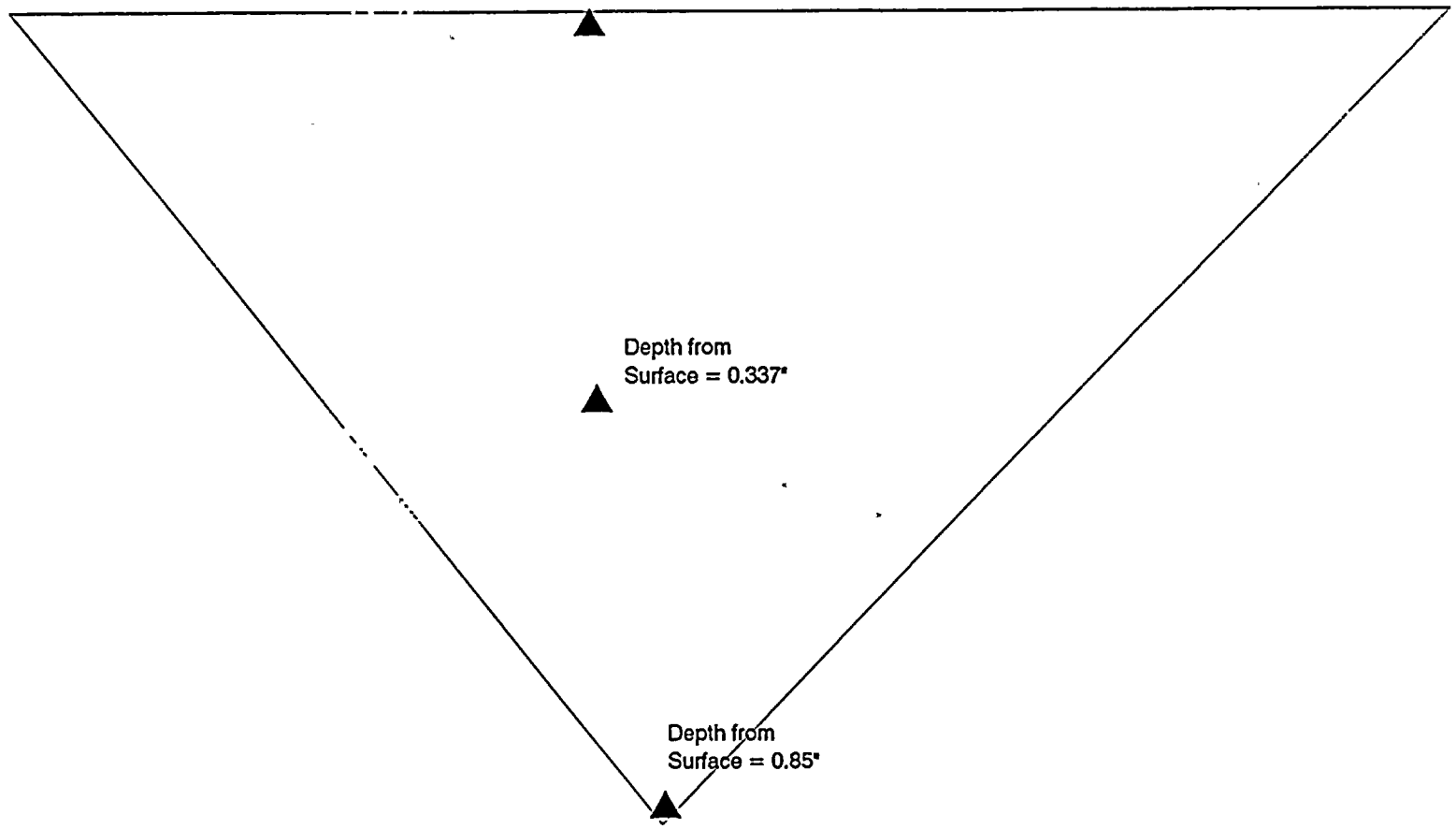

Figure 2.1: **Sketch showing the dosimetry analysis locations on V-9.**

V - 10 DOSIMETRY ANALYSIS LOCATIONS

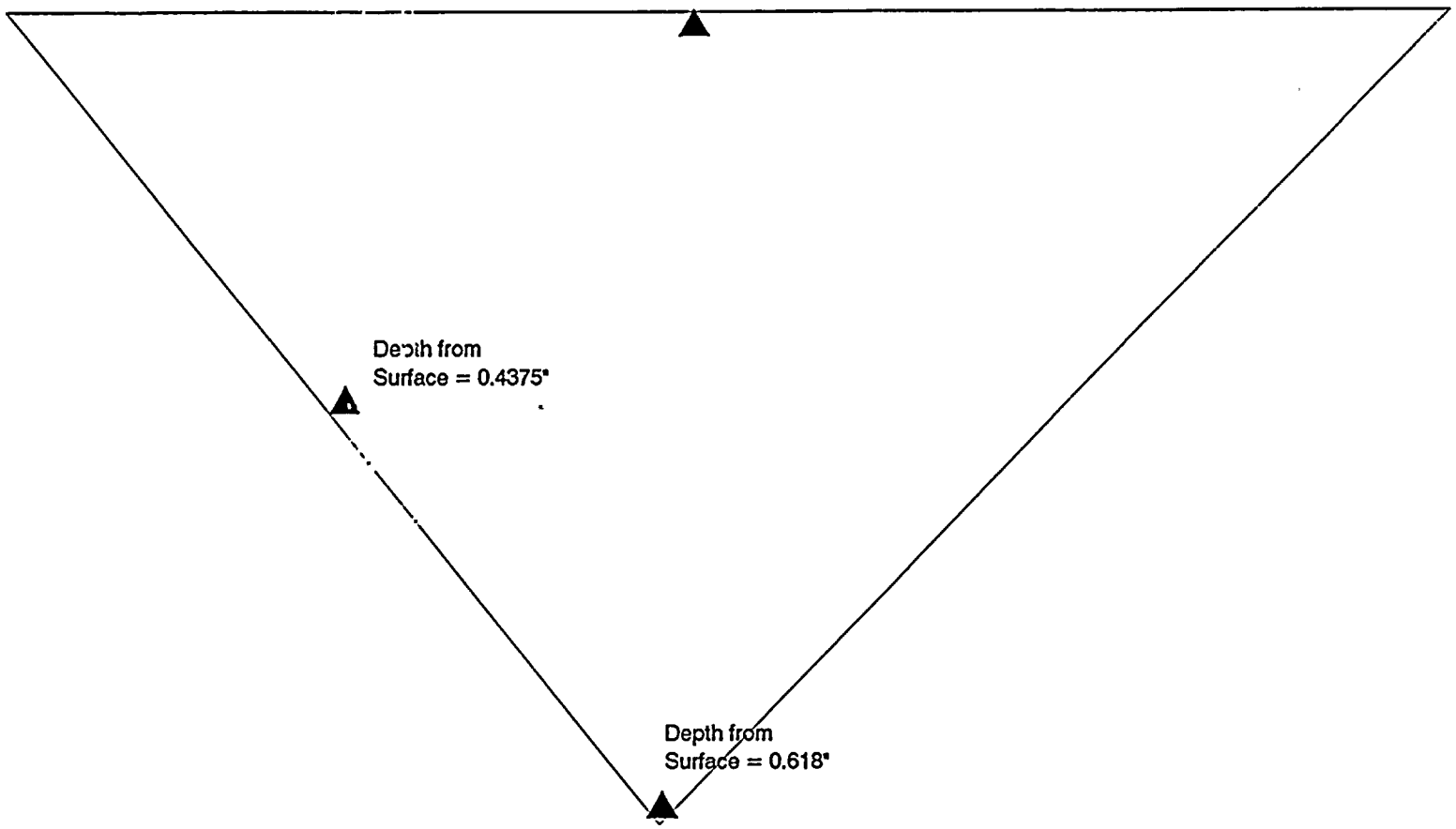

Figure 2.2: **Sketch showing the dosimetry analysis locations on V-10.**

KEY WORDS: Core Shroud, Stainless Steel 304, Niagara Mohawk Power Corporation, Nine Mile Point Unit 1, Dosimetry, Specific Activity

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