WCAP-14570

FORT ST. VRAIN TECHNICAL BASIS DOCUMENTS FOR PIPING SURVEY INSTRUMENTATION

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ABSTRACT

Public Service Company of Colorado has requested NRC approval of three changes to the Fort St. Vrain (FSV) Final Survey Plan for Site Release. These changes are associated with piping systems and suspect affected survey units, as outlined in Public Service Company's letter no. P-95077 dated October 12, 1995 (Fisher to Weber). In that letter, Public Service Company committed to provide Technical Basis Documents for piping survey instrumentation. This information is presented herein as WCAP-14585 (Proprietary) and WCAP-14570 (Non-Proprietary). Each version of the WCAP contains two Technical Basis Documents. Both documents are specific to the Fort St. Vrain decommissioning program.

USE OF TLDs TO ASSESS INTERNAL CONTAMINATION IN PIPING

1.0 OBJECTIVE

This document presents the technical basis for performance of contamination surveys of the internal surfaces of system piping with strings of TLDs. This basis includes the justification for the TLD string design utilized, calibration methodology, and data analysis performed to relate beta dose measured by TLDs while in system piping to a contamination level, including uncertainty and sensitivity of the process. Also included are the survey results performed on Equipment Storage Well (ESW) embedded piping (i.e., 1" and 2" diameter piping runs embedded in concrete) for which the first full-scale testing of the TLD string survey method was conducted.

2.0 REFERENCES & COMMITMENTS

2.1 References

2.1.1 FSV-SC-FRS-I-112, "Piping Surveys With TLD Strings"

2.1.2 TLD Personnel Monitoring Technical Specifications (ICN Model 802), ICN Dosimetry Service, Irvine CA

2.1.3 FSV-FRS-TBD-201, "Site Specific Guideline Values For Surface Activity"

2.1.4 McKinlay A. F., Thermoluminescence Dosimetry, Medical Physics Handbook 5, National Radiological Protection Board, Harwell, 1981

2.1.5 Final Survey Plan, Fort St. Vrain Nuclear Station

2.1.6 Kocher, D.C., "Radioactive Decay Data Tables - A Handbook of Decay Data For Application To Radiation Dosimetry and Radiological Assessments", U.S. Department of Energy, Washington, DC, 1981

2.2 Commitments

None

3.0 DISCUSSION

Assessment of internal contamination in piping is most easily accomplished by using real-time measuring instruments (e.g., GM or cylindrical gas flow probes). However, when dealing with piping embedded in concrete, situations can be encountered where use of conventional equipment is not practical (and in some cases not possible). This is especially true for small

diameter embedded piping (e.g., ≤ 2") that includes multiple bends. In these situations, surface contamination levels on the inside of piping can be measured by strings of TLDs. In this process, TLDs are calibrated by determining the TLDs reported beta dose from a known [ ][a,c] source. Subsequently, beta dose measured by TLDs while in system piping is related to the surface contamination level (dpm/100cm²) in that piping.

The beta dose measured by TLDs in system piping is defined by this document and is not intended to be equivalent to other similar values typically determined by TLDs in personnel exposure situations (e.g., shallow-dose or lens of the eye dose). Rather, the beta dose, as used in this document to measure piping contamination, is equivalent to typical direct methods of measuring contamination (e.g., a direct measurement of contamination with a gas flow proportional detector using the difference between a shielded and unshielded reading). This is a new application for TLDs and has therefore not been addressed by any industry guide or standard. Therefore, the implementation of this method is as described and governed by this document.

To survey a given pipe segment, a TLD string is constructed with a sufficient number of TLDs that are appropriately spaced and centered in the pipe to achieve the desired survey coverage of the internal pipe surfaces. Prior to installing the string in the piping, a survey is performed of the inside pipe surfaces to determine the removable contamination levels and additional decontamination performed, as necessary. After installing the string in the pipe and waiting a designated exposure period to obtain statistically significant reported values, the TLDs are removed and processed, and the individual element readings are related to a contamination level at each survey location. Data analysis performed includes: determining the TLD string average and 95% confidence contamination level for the data obtained from the pipe segment surveyed; and determining the sensitivity (i.e., the MDA) for the pipe (considering location specific background and exposure period). Construction, installation, and removal of the TLD strings are governed by an approved procedure 2.1.1.

4.0 TLD STRING CONSTRUCTION

4.1 TLDs and Shielding

The TLD strings are constructed with Panasonic® Type 802 TLDs (without element holder or hanger) which use thin elements that are good beta detectors. The Panasonic® Type 802 TLD (Figure 1) is a four element TLD with 2 elements each of Lithium Borate ($Li_2B_4O_7$:Cu) and Calcium Sulfate ($CaSO_4$:Tm). Both element types exhibit slow fading characteristics with Lithium Borate rated at < 10% per month and Calcium Sulfate at approximately 3% per month 2.1.2.

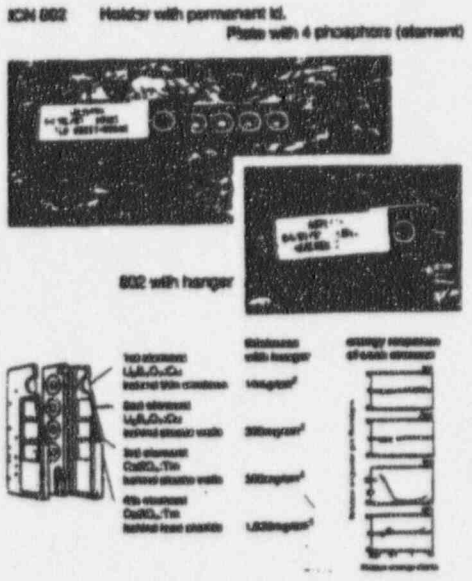

Figure 1 - Panasonic® Type 802 TLD (insert and holder)

To distinguish between beta and gamma dose, the TLD insert is used without its standard holder and is provided with a special filter arrangement. [

]^{a,c} Therefore, the difference between the unfiltered element (which actually contains about 14 mg/cm^2 of plastic filtering that contain the phosphor grains) and filtered element of each phosphor type provides an indication of the beta dose to the TLD. With each of the element types measuring beta contamination, two independent indications of possible contamination are produced at each survey location. [

]^{a,c}

[a,c]

Figure 2 - TLD and Filtering Arrangement on TLD String

4.2 Centering and Spacing of TLDs on the String

Centering of the TLDs in piping is accomplished by using [ ]^{a,c} TLDs may be located at any spacing desired utilizing the [ ]^{a,c} and may be adjusted as needed to optimize centering. In the arrangement tested, the [ ]^{a,c} were located 20" apart with TLDs attached half-way between adjacent [ ]^{a,c} (Figure 3). To provide adequate strength, 1/16" cables, connected by 1/8" round ferrules are used for the string. When the TLD string is installed in system piping, the string is pulled taut and secured to ensure that each TLD is suspended in the center of the pipe. A [ ]^{a,c} cable is used to allow a more precise centering of the TLDs in the pipe without interfering with the TLDs ability to measure beta radiation. Figure 3 illustrates the construction of the TLD string with centering [ ]^{a,c} and TLDs attached.

[

a,c

]

Figure 3 - TLD String Construction

By strategically placing the [ ]^{a,c} the TLDs were distanced 20" apart (for both 1" and 2" diameter piping), a contamination survey over approximately [ ]^{a,c} of the piping was performed. For 1" piping, the pair of TLDs at a location collectively measure the [ ]^{a,c} area around them (i.e., the measured doses from the two TLDs are summed and related to the [ ]^{a,c} area). This is done to enhance measurement efficiency of a [ ]^{a,c} area in 1" diameter piping. For 2" piping, each TLD is defined to measure beta dose from its own adjacent [ ]^{a,c} area (i.e., [ ]^{a,c} are measured by a TLD pair). Therefore, because 20" of 1" diameter piping contains 400 cm^2 of internal surface and 20" of 2" diameter piping contains 800 cm of surface area, the 20" spacing between TLD pairs results in a survey coverage of [ ]^{a,c}. Survey coverage can be increased by decreasing the disc spacing and establishing the desired TLD field of view.

It should be noted that placement of the TLD strings in system piping can not verify the exact location of the TLD at physical piping bends, elbows, etc. with respect to the calibration geometry. However, the number of TLDs chosen on any one string will help to minimize the affect of uncertainty in a specific location. The overall affect of the position of the TLD, from pipe centerline to contact with the pipe surface, will be the subject of subsequent evaluations.

5.0 CALIBRATION OF TLD STRINGS

5.1 Calibration Source

The radionuclide selected for calibration of the TLDs has an average beta energy similar to that anticipated at the measurement location, with a reasonably long half-life (although the latter is only necessary from a cost/replacement perspective). In some piping systems, particularly liquid drains, additional contaminants may have been introduced as a result of decommissioning activities. In fact, Eu-152 and Eu-154, which is found in activated concrete (FSV Prestressed Concrete Reactor Vessel), has been identified in some samples obtained within these drain systems.

Attachment 8.1, "Average Beta Energy (Ebar) for Detectable Plant Contamination At Fort St. Vrain", presents the calculation performed to determine Ebar using 10CFR61 data which may be relevant to plant systems. This provides an indication that the average beta energy (Ebar) expected in "detectable" plant contamination, (i.e., excluding hard to detect nuclides such as Fe-55 and H-3 that are addressed by reducing the Site Guideline Values, SGLV [2.1.3]) at Fort St. Vrain is 113.6 keV.

Therefore, the radionuclide chosen to calibrate the FSV TLDs was Tc-99, a pure beta emitter with an average beta energy of 84.6 keV and a long half-life of 2.13E5 years. Although conservative because of the lower energy of the Tc-99 verses actual in-field energy, a good measurement of piping contamination can be made with a Tc-99 calibrated TLD.

[

]^{a,c}

[ ] a,c

Figure 4 - 1" Pipe Jig, Source and TLD Configuration

a,c

[ ]

Figure 5 - 2" Pipe Jig, Source and TLD Configuration

5.2 Calibration Methodology

5.2.1 General Discussion

Calibration is accomplished by exposing a set of TLDs to a known activity of Tc-99 in a specific geometry [ ]^{a,c}. The net signal (i.e., unshielded element reading minus shielded element reading) is the result of radiations that cannot penetrate the [ ]^{a,c} aluminum filter; therefore, these radiations can not originate outside the pipe which is a much thicker shield (for typical 1" and 2" diameter piping). Consequently, beta background is assumed to be zero during both calibration and actual system tests. Because all beta exposure is assumed to originate from the calibration source or system piping, care is taken with handling of the TLDs and strings to prevent exposure to beta radiation while outside the calibration jig (for calibration TLDs) or piping to be surveyed (for system TLDs). Additionally, "control" TLDs are kept with string TLDs, except during calibration or when in system piping, to identify any additional beta exposure to TLDs should it occur.

The TLDs are calibrated to a pure beta emitter because the primary radiation decay mode of expected "detectable" system contamination will produce a beta (hard to detect nuclides such as Fe-55, H-3 and alpha are accounted for by reducing the Site Guideline Value). Any other radiation types that accompany the decay (i.e., radiations that do not penetrate the beta shielding, since those that penetrate the shielding are accounted for in the background subtraction) can only yield an over-response. Should a high contribution of x-ray or low energy gamma radiation be present this would be indicated by the difference between the unshielded Lithium Borate and Calcium Sulfate readings because the Calcium Sulfate phosphors will over-respond to low energy gamma (by as much as a factor of 15 relative to Lithium Borate). This situation is not expected, however, based on the knowledge of the radionuclides present on the internal surfaces of piping and in contamination found outside of pipes.

Many factors will affect the location and uniformity of contamination on the internal surfaces of system pipes, which may include the temperature and pressure of the fluid processed through the system, system bends (elbows), crud traps (weld joints), etc. Using a [ ]^{a,c} source to determine calibration factors, in effect, assumes that the TLD's measured beta dose came from the [ ]^{a,c} area surrounding it. Any additional beta dose that originate outside of the defined [ ]^{a,c}, would yield a high (i.e., conservative) result. This conservatism, however, is not expected to be significant as the influence to the TLD is rapidly diminished outside the defined area due to the limited beta range.

Additional evaluations are being designed to define the TLD element field of view and the effect of localized contamination on TLD response. The design objective is to define the

optimum TLD spacing considering the possibility of uniform and/or localized contamination on the internal surfaces of piping and gain a more complete understanding of the response capabilities of the TLD arrangement.

5.2.2 Calibration Procedure

To calibrate TLDs used on TLD strings, a set of TLDs are exposed to the [ ]^{a,c} Tc-99 source. Arrangement of the source and TLD during calibration is matched to the actual measurement situation. This is accomplished with a calibration jig, [ ]^{a,c} As is done when the TLD string is installed in system piping, TLD string cables and centering [ ]^{a,c} are also used to center and suspend TLDs in the calibration jig. In this way, the same geometry and scattering effects are achieved during calibration as are experienced inside system piping.

The value of a calibration factor is mathematically determined by [ ]^{a,c}. Therefore, the units of the Average Calibration Factor are: [dis/100 cm^2/mR*].

NOTE

The Average Calibration Factor (dis/100cm^2/mR*) is the average result determined from the set of TLDs exposed to the calibration source. This factor is determined independently for each element type (i.e., Lithium Borate and Calcium Sulfate)

Because string TLDs use two different element types, the results from both calibration exposures and piping exposures are treated separately for each element type (i.e., Lithium Borate and Calcium Sulfate). This allows characteristic statistics of each to be analyzed separately. Once each element type reading is correlated to a contamination level by its Average Calibration Factor, then results may be combined to improve accuracy and precision of the overall result. Attachments 8.2 and 8.3 contain the plots and spreadsheets of calibration data obtained during ESW embedded pipe testing. Attachment 8.2 includes a plot of calibration results from 1" piping calibration tests [ ]^{a,c} and spreadsheets containing the data for each calibration test. Attachment 8.3 contains the same information for calibration tests conducted for 2" piping.

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The value of a calibration factor is mathematically determined by [ ]^{a,c}. Therefore, the units of the Average Calibration Factor are: [ ].

NOTE

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To ensure an accurate Average Calibration Factor is determined for each element type, a sufficient number of calibration tests are conducted such that uncertainty of the Average Calibration Factor is ≤ 20% (at 95% confidence level). The Average Calibration Factor uncertainty is calculated with the following equation:

$$95\%\ \text{Confidence Interval} = \frac{t_{0.95,N-1} * SD}{\sqrt{N}}$$

where N is the number of calibration tests,

$t_{0.95,N-1}$ is Student's t for 95% confidence and N-1 degrees of freedom, and

SD is the sample standard deviation of the sample set.

As indicated in Attachments 8.2 and 8.3, uncertainty (at 95% confidence) of the Average Calibration Factors determined during the ESW embedded pipe testing, which included 12 calibration tests, ranged from [

]^{a,c}

The results of the initial calibration tests are provided in Table 1 and Table 2 below:

[

Table 1

a,b,c

Table 2

]

In addition to the initial testing performed with the ESW piping and as the method is used in the future, the technique will be better defined regarding the range of element response.

5.3 LINEAR RESPONSE TESTING

Published literature for Panasonic® Type 802 TLDs indicate linearity over a wide range of dose. Linear ranges for each element type are 3E-3 to 500 Rad for LiB_2O_7:Cu, and < 2E-4 to 300 Rad for $CaSO_4$:Tm 2.1.4. Nonetheless, linearity was investigated during the ESW testing by irradiating some of the calibration TLDs for longer periods. Specifically, Calibration Tests 1 and 2 were conducted for 9-day and 6-day periods, respectively. A 3-day irradiation time was used for the remaining calibration tests which yielded an average response that would indicate, based on the exposure period of the TLD string in the ESW piping, about 3 kdpm/100 cm^2. Although the first two 1"-piping calibration tests were conducted over 9 and 6-day periods, the calibration factor results were within data scatter of other 3-day calibration results (see plots of Attachment 8.2).

5.4 TLD PROCESSING

NOTE

The quantity mR* is the Panasonic® reader corrected value provided by ICN after the TLD is processed (i.e., data are corrected for each element's individual correction factor but not processed with an algorithm).

TLD processing is performed by ICN Dosimetry Service of Irvine, California, whose performance testing is NVLAP accredited. The process readout/handling of TLDs is as described by their procedures and any special written instructions that are provided to them. For piping survey TLDs, ICN has been instructed to provide the corrected mR* reading for each of the 4 elements of the TLD (i.e., reading that has been corrected by each element's individual correction factor). Corrected mR* readings provide a standardized basis such that comparisons between individual TLDs can be made, while allowing specialized data analysis to be performed as discussed in this document.

Upon removal of TLDs from system piping, inserts are surveyed for removable contamination and returned to their respective holder (i.e., promptly after separating back-to-back elements) and immediately shipped back to ICN for processing. If significant contamination is found on any TLD, it will be decontaminated prior to shipment and the location in the system flagged to identify that the result from this TLD may be high due to contamination on the TLD.

6.0 DATA ANALYSIS

6.1 Contamination Level Determination:

The contamination level measured at a given survey location of the TLD string is determined from beta dose to the TLD(s). To determine beta dose, the net reading from the TLD reader is used for each element type (i.e., element 2 minus element 1 for Lithium Borate and element 3 minus element 4 for Calcium Sulfate). The net reading for each element type is then corrected by its Average Calibration Factor to determine a contamination level (dpm/100 cm^2). The overall contamination level for the location is then the average of the element type dependent readings.

The above analysis is as described for 2" piping TLDs where each TLD is defined to measure its own defined [ ]^{a,c} area. For 1" piping TLDs, however, [ ]^{a,c} TLDs at a given survey location collectively monitor the defined [ ]^{a,c} area around them. Therefore, TLD readings for the [ ]^{a,c} TLDs are first summed [ ]^{a,c} with summed element readings used as described in the preceding paragraph.

The contamination level associated with each element type of a given TLD is determined by multiplying the net reading by its Average Calibration Factor. For example, a TLD is in a pipe for 80,000 minutes and its Lithium Borate elements report a net reading of 30 mR*. If the Average Calibration Factor for Lithium Borate (for a given pipe size) was 6.5E6 dis/100 cm^2/mR*, then the associated contamination level would be equal to 2.4 kdpm/100 cm^2 as shown below:

$$\frac{(6.5E6 \text{ dis}/100\text{cm}^2/\text{mR}^*)(30 \text{ mR}^*)}{(80{,}000 \text{ min})} = 2.4 \text{ (kdpm}/100\text{cm}^2)$$

This type of calculation is performed for both element types with the average contamination level used as the result for the TLD location.

6.2 Error Analysis

For a set of measurements taken (e.g., a set of measurements in a given pipe segment or measurements from a set of pipes of a given survey unit), the average contamination level is determined by the following equation:

$$\bar{X} = \frac{\sum_{1}^{N} X_i}{N}$$

where X_i is the value of the ith measurement (or TLD location), and

N is the total number of measurements.

To determine the acceptability of a pipe or survey unit's average contamination level, uncertainty of the average value must be determined. To perform this determination, the sample standard deviation (SD) of the set of measurements taken is calculated. The equation used to calculate the standard deviation is as follows:

$$SD = \sqrt{\frac{\sum_{1}^{N} (X_i - \bar{X})^2}{N - 1}}$$

Uncertainty of the average contamination level is then determined for 95% confidence by using Student's t equation as previously shown:

$$95\% \text{ Confidence Interval} = \frac{t_{0.95,N-1} * SD}{\sqrt{N}}$$

Upon adding the uncertainty to the average value, an upper limit is then obtained which represents (with 95% confidence) the maximum value of the average contamination level of the pipe or survey unit.

6.3 Sensitivity Analysis (MDA)

To ensure a TLD string is in a given pipe segment for a sufficient period of time, a Minimum Detectable Activity (MDA) level is determined. In particular, MDA is intended to be ≤ 75% of the SGLV (as this survey method is intended for affected piping). Factors that affect MDA, in addition to exposure period, include the Average Calibration Factor and measurement statistics. [

]^{a,b,c}

To present the equation used to calculate MDA, the following analysis is provided. The MDA equation for general survey measurements is as follows:

$$\text{MDA (dpm/100cm}^2\text{)} = \frac{\frac{2.71}{t_s} + 3.29\sqrt{\frac{R_b}{t_s} + \frac{R_b}{t_b}}}{(\text{Efficiency})\left(\frac{A}{100}\right)}$$

where t_s is the sample count time (min),

t_b is the background count time (min),

R_b is the background count rate (cpm),

A is the area of detection in cm^2, and

3.29 is two times the one-tailed 95% confidence factor 1.645.

For TLD strings, A is equal to [ ]^{a,c} by calibration, and sample and background count times are equal (henceforth called t_s). Therefore, the above equation is reduced to:

[ ] ^{a,c}

The 2.71 in the MDA equation is associated with a finite number of counts. To appropriately include this value in the MDA equation would require using raw data (i.e., the number of counts in a TLD's glow curve) which is not provided by the TLD vendor. Nonetheless, it is assumed that this value is negligible in comparison to the variation (i.e., standard deviation of the background element readings) of the total number of "counts" that are observed when the TLDs are read; therefore, the first term is omitted.

The square root term of the equation is in fact the standard deviation of the background (in terms of count rate). By substituting this term with the sample standard deviation of the absolute background measurements (i.e., moving count time to the denominator) and substituting efficiency with its reciprocal (i.e., the Average Calibration Factor that also includes the factor that converts the TLD reader "counts" to a reported mR* value), the MDA equation becomes:

[ ] a,c

Now, the 1.645 factor assumes that the standard deviation of the measurement is well defined (as is the case when measuring counts from radioactive decay where the standard deviation of N counts is equal to $N^{1/2}$). However, since the standard deviation for a given background measurement (i.e., element 1 or 4 reading) is inferred from the set of measurements taken for a given pipe segment, the 95% Student's t value for the number of measurements taken (actually the degrees of freedom) is substituted for 1.645.

This results in the following equation for MDA:

[ ] a,c

This equation is used to determine the MDA for a given Average Calibration Factor, background standard deviation, and exposure period (t_e). MDA is determined separately for both element types (i.e., for both Lithium Borate and Calcium Sulfate). The lowest calculated MDA between the two is considered the MDA for the TLD(s) location. In other words, if one element type measures a result above its critical level and the other measures a result below its critical level, the decision "detected" is rendered.

The critical level mentioned in the preceding paragraph is the reference value for determining which, if any, results are an indication of "detected" radioactivity at 95% confidence ("detected" radioactivity means there is 95% confidence that there is radioactivity present at the location, i.e., there is a 5% chance that the result is a background fluctuation). The

equation used to calculate critical level is derived by the same argument that was used with the MDA equation and can be shown to yield:

[ ] a,c

Critical level is calculated for reference purposes only. The acceptability of a given pipe or collection of pipes is determined by the criteria of Section 6.4.

6.4 Acceptability of Results

To determine if a given pipe or collection of pipes is acceptable for unrestricted use, the average contamination level plus 95% confidence interval (one-sided) is compared to the SGLV. Mathematically stated, the average contamination level of a given pipe or collection of pipes is acceptable if the following is true:

$$\bar{X} + \frac{t_{0.95,N-1} * SD}{\sqrt{N}} \leq SGLV$$

In addition to meeting the above average contamination level limit, each individual measurement may not be greater than a prescribed multiple (currently requirement is 3) times the SGLV as designated in the Final Survey Plan 2.1.5.

6.5 ESW Test Results

Attachments 8.4 and 8.5 contain results from ESW embedded pipe testing. In these attachments are plots for each pipe segment surveyed, that indicate the measured contamination level at various positions in the pipe, and spreadsheets containing the test data for each pipe. Attachment 8.4 contains results for 1"-diameter pipes tested and Attachment 8.5 contains data for the 2"-diameter pipes.

The SGLV for affected plant systems at FSV is established at 4,000 dpm/100 cm^2. Therefore, ESW piping is acceptable for unrestricted use provided the mean (at 95% confidence) is $\leq$ 4,000 dpm/100 cm^2, and all individual measurements are $\leq$ 12,000 dpm/100 cm^2. When evaluating each ESW pipe separately using the data collected with TLDs, 11 of the 20 pipes surveyed yielded results less than the SGLV. The other 9 pipes will require further evaluation or decontamination.

6.6 Comparison Testing Results

To evaluate the TLD string survey method, a comparison study was performed with the SN-050-4K (i.e., an assembly of four 0.5" diameter GM detectors) and TLD strings for two fuel storage well 1" embedded pipes (i.e., lines L1414 and L1416). Measurements were taken at regular intervals in each pipe by both survey methods. Attachment 8.6, "SN-050-4K vs. TLD Survey Comparison Test Results", contains plots of the measurement results.

Compared data for line L1414 is considered very good. Both methods produced the same approximate contamination profile in the pipe. A couple of localized spots (e.g., at 0' and 50') yielded different values by each method as can be expected if localized contamination is present due the small size of the detectors. Highly localized contamination (e.g., a hot particle in a weld) can produce significantly different results depending on the exact detector to hot spot orientation. For example, if a GM detector is located directly over a hot particle in an otherwise clean pipe, the area correction factor (required because the total detection area of the assembly is <100 cm^2), in effect, assumes the balance of a 100 cm^2 area at the location is also contaminated at the same level. This can result in a significant over estimation of the true per 100 cm^2 contamination level at the location. Conversely, the limited detection area of a small GM detector may not detect a given spot of contamination (e.g., a hot spot is between two tubes) and under report the true contamination at a location. Such inherent disadvantages of using small detectors (which are necessary to survey small diameter piping) can be offset by collecting a large amount of data. A large data set will average out individual measurement fluctuations and produce a more accurate determination of the average contamination in a given pipe. This was evidenced by the average results for L1414 where 4.4 kdpm/100 cm^2 and 4.2 kdpm/100 cm^2 were determined for the SN-050-4K assembly and TLD string respectively.

L1416 data was also in good agreement. In this pipe both methods indicated that the pipe was clean (i.e., all measurements < 12 kdpm/100 cm^2, and average < 4 kdpm/100 cm^2). The TLD string did indicate one outlying result of 8.6 kdpm/100 cm^2 that was not detected by the SN-050-4K. However, due to the long count times required for the SN-050-4K, measurements were taken at 40" intervals in this pipe while TLDs were spaced at 20" intervals. This elevated reading was located at a pipe position not monitored by the SN-050-4K; therefore, the GM assembly could not be expected to detect this spot. The average contamination levels determined by each method are in acceptable agreement considering that MDAs for both methods were approximately 2 kdpm/100 cm^2.

7.0 SUMMARY

Using TLDs to survey internal surfaces of plant system piping is a feasible method for providing reasonable estimates of surface contamination in piping. The method is a new application for TLDs and has therefore not been addressed by any guide or standard.

Although attempts were made to be as accurate as possible in the initial testing, conservative measures were taken when exact factors were not known or could not easily be addressed. For example, the use of Tc-99 as the calibration source provides a conservative (i.e., the Tc-99 beta energy is lower than the average beta energy expected in FSV "detectable" contamination) estimate of the calibration factors used to correct the results. Additionally, the beta background (determined from adjacent shielded elements) is assumed to be zero. Should the TLDs be exposed to any natural beta radiation, this would be attributed to piping contamination. Any non-beta radiations that do not penetrate the background shield (e.g., x-ray or low energy gamma) would also yield a conservatively high result.

While use of TLDs to measure surface contamination has its inherent disadvantages (due to small size of the detector), options for surveying small bore embedded pipe with bends are limited. Therefore, using TLD strings can be a viable option. To aid in evaluating the potential feasibility of using TLD strings in a given situation, the following table of major advantages and disadvantages of the method is provided.

Major Advantages and Disadvantages of TLD String Survey Method

Advantages	Disadvantages
Provides as much data with a single TLD string as surveyor desires (determined by the number and spacing of TLDs on string)	Long exposure times required to achieve low MDAs (potential schedule impacts, especially if several iterations of decon/survey are required)
Able to survey a large number of pipes simultaneously (extensive survey can be performed with low cost and minimal number of person-hours)	Low precision in individual measurements if highly localized contamination present due to small size of detector (although such fluctuations would average out in a large data set)
Equipment easily maintained with minimal maintenance	Inability to immediately repeat/redo a measurement should a suspect result be obtained

The principal application of the TLD string survey method is for long lengths of small bore piping (strings and calibrations currently developed for 1" and 2" diameter piping). The method is especially appropriate when a large amount of piping requires survey and immediate results (i.e., within 3 months) are not needed.

8.0 ATTACHMENTS

8.1 Average Beta Energy (Ebar) for Detectable Plant Contamination at Fort St. Vrain

8.2 Calibration Data and Results for 1" Piping TLDs (collected during ESW testing)

8.3 Calibration Data and Results for 2" Piping TLDs (collected during ESW testing)

8.4 ESW 1" Piping TLD Survey Data and Results

8.5 ESW 2" Piping TLD Survey Data and Results

8.6 SN-050-4K vs. TLD Survey Comparison Test Results

ATTACHMENT 8.1

AVERAGE BETA ENERGY (EBAR) FOR DETECTABLE PLANT CONTAMINATION AT FORT ST. VRAIN

Table 1 below presents the relative radionuclide composition of various samples and smears taken at Fort St. Vrain for the "detectable" radionuclides. These particular samples, which are decay corrected to 1/1/96, are the ones used to determine the Site Specific Guideline Values (SGLV). Also presented in the table, is the average radionuclide composition that is determined by assigning equal weight to each of the individual samples. Only the "detectable" (i.e., readily detectable) nuclides are included in the calculation because the hard to detect nuclides and alpha emitters are accounted for by reducing the SGLV.

Table 1 - Relative Radionuclide Composition of Fort St. Vrain Samples/Smears

	Co-60	Sr-90	Cs-134	Cs-137	Eu-152	Eu-154	Tc-99
PCRV Smear	7.25E-1	3.75E-3	3.28E-3	1.02E-1	1.56E-1	1.03E-2	
HSF Smear	9.87E-1	2.75E-4		1.24E-2			
FHM Smear	9.38E-1	4.93E-3	1.30E-3	5.58E-2			
Liquid Waste Resin	3.44E-2	1.39E-3	4.72E-2	9.17E-1			
PCRV Concrete	1.17E-1		4.53E-3		8.08E-1	5.66E-2	1.34E-2
Graphite Dust	3.22E-1	9.15E-5			6.27E-1	5.12E-2	
PCRV Access Flange	9.78E-1	2.26E-3	1.51E-3	1.77E-2			
PCRV Shield Plug	8.56E-1	6.01E-3	1.85E-3	1.36E-1			
Average Fraction	6.20E-1	2.34E-3	7.46E-3	1.55E-1	1.99E-1	1.48E-2	1.68E-3

To determine Ebar for the average radionuclide composition, Ebar for each radionuclide is determined using published tabulations 2.1.6. In the individual nuclide Ebar calculation, electrons from internal conversion, auger electron emission as well as beta decay are considered "beta particles" because each electron of a given energy (without regard to its decay source) has the same probability of interacting

with a detector. In addition, any daughter nuclides that can be assumed to be in equilibrium with the parent are factored into the calculation (e.g., the Sr-90 daughter Y-90 and the Cs-137 daughter Ba-137m).

The equation used to calculate Ebar for a given radionuclide is as follows:

$$Ebar = \frac{\sum_{1}^{N} (Abundance * BetaEnergy)}{\sum_{1}^{N} (Abundance)}$$

where N is the number of individual branches of the radionuclide (i.e., each auger, conversion, or beta decay electron and its associated energy)

The Ebar calculation for each individual radionuclide uses all electron energies, including low energy auger electrons. This was done to ensure a consistent approach is followed with each nuclide and the range of its electron emissions. Most auger electrons and some of the beta decay electrons (which are emitted with an energy spectrum from zero to a characteristic maximum) are unable to reach the detector due to their low energy. To be consistent in omitting electron energies not expected to be detected would require correcting for all low energy electrons, including beta decay. Consequently, the consistent approach of using all energies emitted by a given radionuclide is followed. A summary of the Ebar values for each radionuclide that are used in the overall average Ebar calculation is provided in Table 2 below:

Table 2 - Ebar Data Summary

	Co-60	Sr-90	Cs-134	Cs-137	Eu-152	Eu-154	Tc-99
Average Fraction	6.20E-1	2.34E-3	7.46E-3	1.55E-1	1.99E-1	1.48E-2	1.68E-3
Ebar (keV)	95.8	565.3[2]	159.0[1]	196.8[1,2]	87.2[1]	149.2[1]	84.6
Beta Abundance[3]	1.000	2.000[2]	1.015[1]	1.174[1,2]	1.424[1]	1.838[1]	1.000

NOTES:
[1] Data include contributions from conversion and auger electrons
[2] Data include contribution from daughter
[3] Beta Abundance is the average number of beta particles emitted per decay

To determine the overall Ebar for the average radionuclide composition, the following equation is used:

$$Ebar = \frac{\sum_{1}^{N} (AverageFraction * Abundance * BetaEnergy)}{\sum_{1}^{N} (AverageFraction * Abundance)}$$

where N is the number of detectable radionuclides in the average composition. Using the preceding equation and data from Table 2, the results of Table 3 are obtained.

Note: The denominator of this equation is the beta abundance (i.e., average number of beta particles emitted per decay) for average radionuclide composition at FSV.

Using the preceding equation and data from Table 2, the results of Table 3 are obtained.

Table 3 - Ebar Results For Radionuclide Composition

Ebar (keV)	113.6	**Beta Abundance**	1.126

ATTACHMENT 8.2
CALIBRATION DATA AND RESULTS FOR 1" PIPING TLDS
(collected during ESW testing)

ATTACHMENT 8.2
CALIBRATION DATA AND RESULTS FOR 1" PIPING TLDS (collected during ESW testing)

LiB407 1" Pipe Calibration Data

[ ] a,b,c,f

ATTACHMENT 8.2
CALIBRATION DATA AND RESULTS FOR 2" PIPING TLDS (collected during ESW testing)

CaSO4 1" Pipe Calibration Data

[a,b,c,f]

ATTACHMENT 8.2
CALIBRATION DATA AND RESULTS FOR 1" PIPING TLDS (collected during ESW testing)

[

a,b,c,f

]

ATTACHMENT 8.2
CALIBRATION DATA AND RESULTS FOR 1" PIPING TLDS (collected during ESW testing)

[

]

a,b,c,f

ATTACHMENT 8.2
CALIBRATION DATA AND RESULTS FOR 1" PIPING TLDS (collected during ESW testing)

[

]

a,b,c,f

ATTACHMENT 8.2
CALIBRATION DATA AND RESULTS FOR 1" PIPING TLDS (collected during ESW testing)

[ ] a,b,c,f

ATTACHMENT 8.3
CALIBRATION DATA AND RESULTS FOR 2" PIPING TLDS
(collected during ESW testing)

ATTACHMENT 8.3
CALIBRATION DATA AND RESULTS FOR 2" PIPING TLDS (collected during ESW testing)

Li2B4O7 2" Pipe Calibration Data

[ ] a,b,c,f

ATTACHMENT 8.3
CALIBRATION DATA AND RESULTS FOR 2" PIPING TLDS (collected during ESW testing)

CaSO4 2" Pipe Calibration Data

[ ] a,b,c,f

ATTACHMENT 8.3
CALIBRATION DATA AND RESULTS FOR 2" PIPING TLDS (collected during ESW testing)

[

a,b,c,f

]

ATTACHMENT 8.3
CALIb.`ATION DATA AND RESULTS FOR 2" PIPING TLDS (collected during ESW testing)

[

]

a,b,c,f

ATTACHMENT 8.3
CALIBRATION DATA AND RESULTS FOR 2" PIPING TLDS (collected during ESW testing)

[

]

a,b,c,f

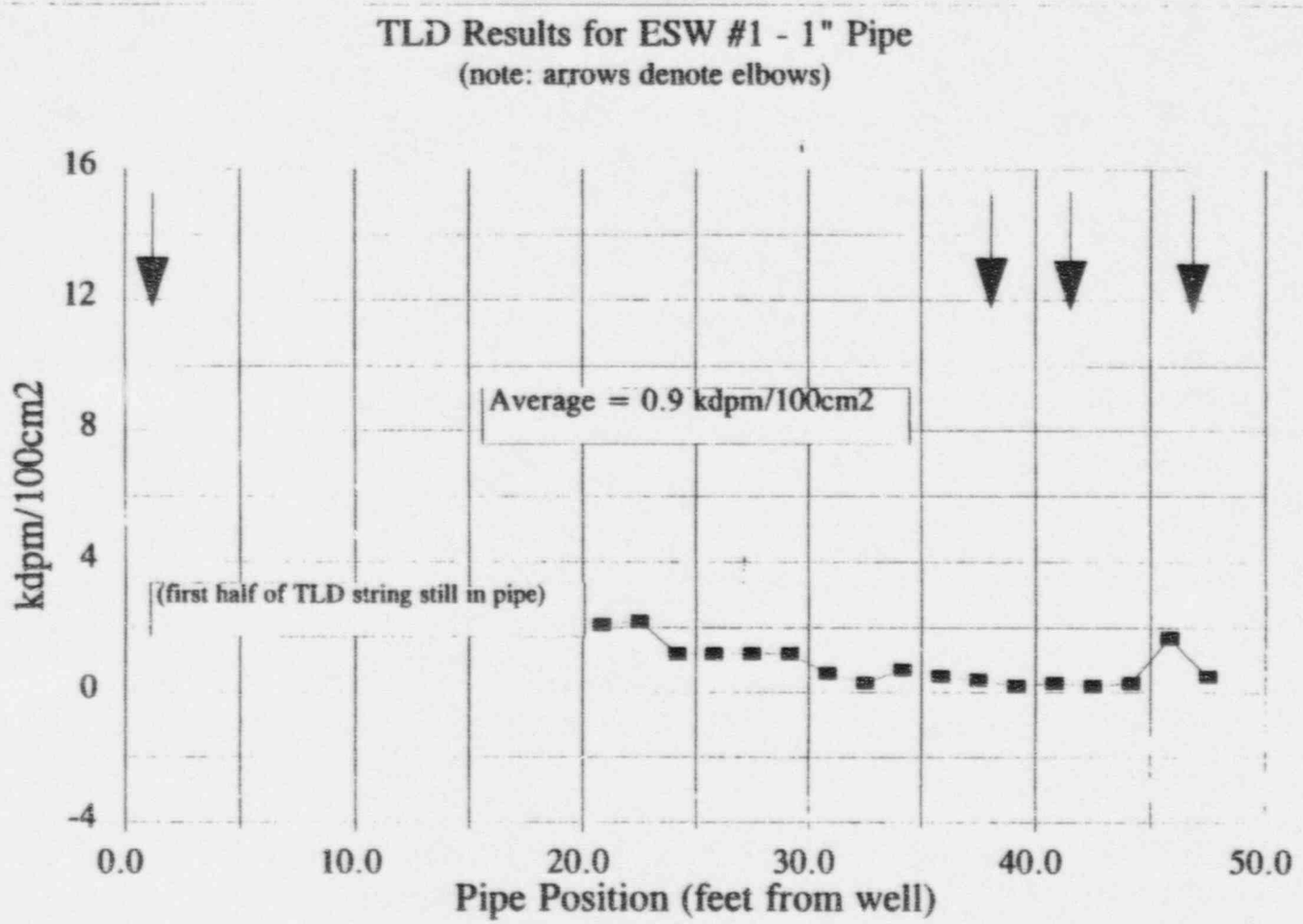
ATTACHMENT 8.3
CALIBRATION DATA AND RESULTS FOR 2" PIPING TLDS (collected during ESW testing)

[

]

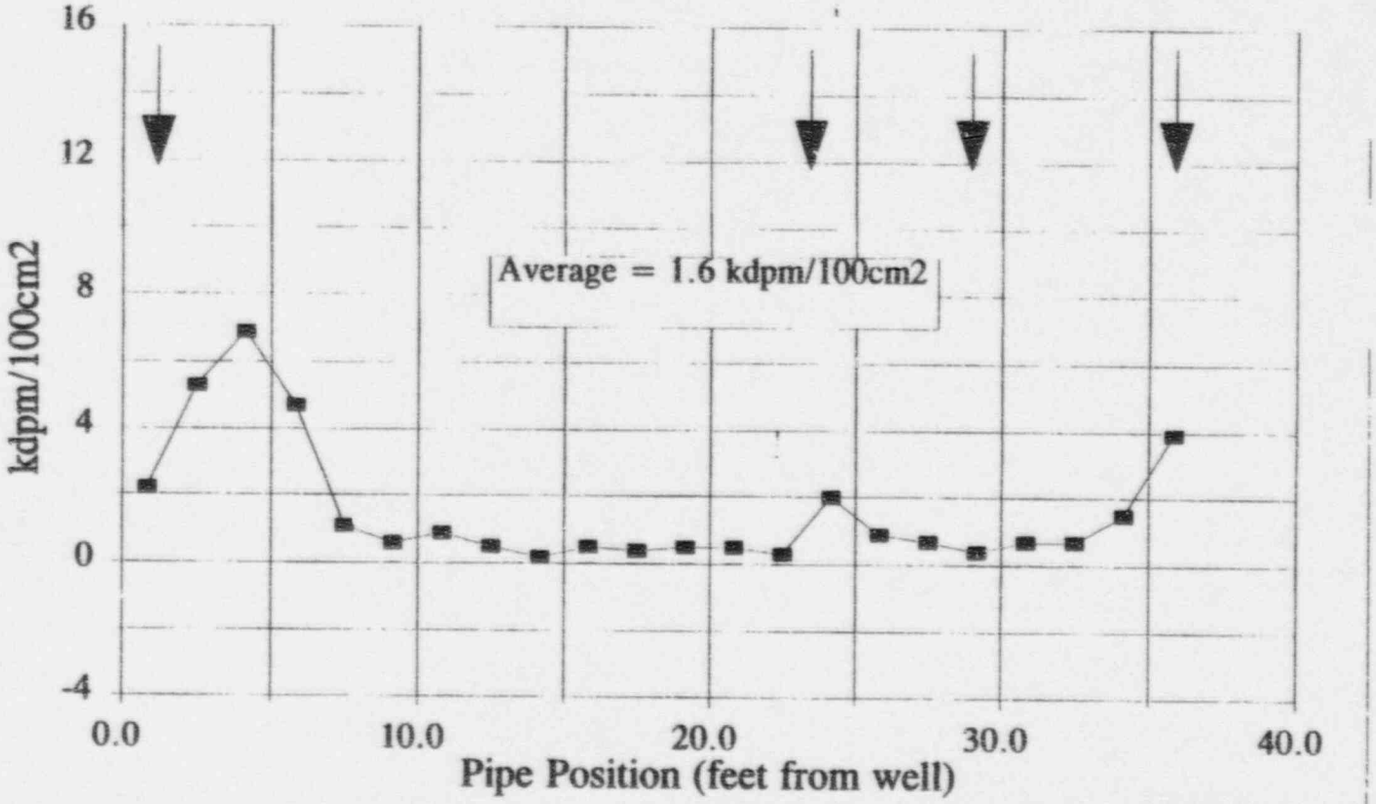
a,b,c,f

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

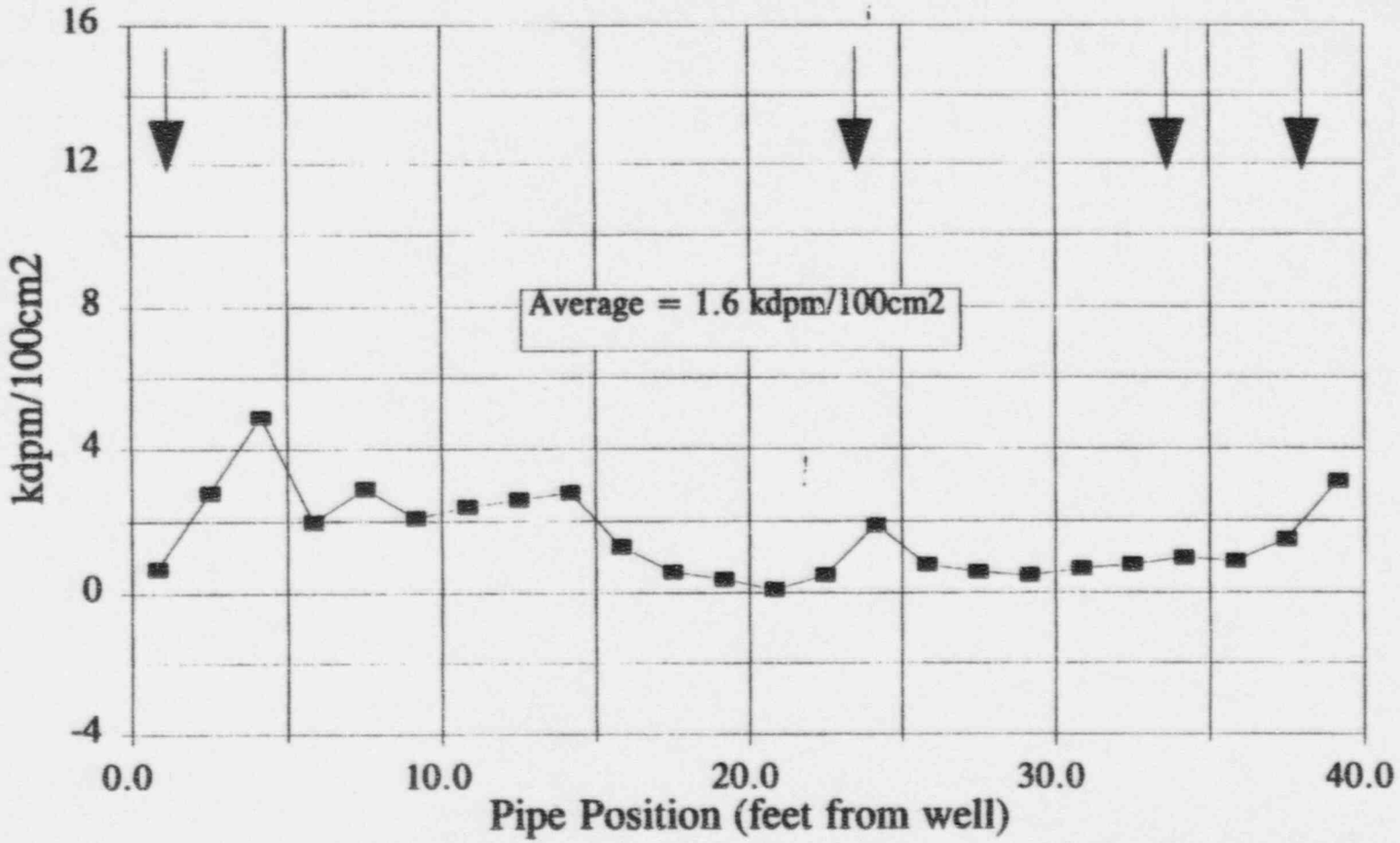

TLD Results for ESW #1 - 1" Pipe
(note: arrows denote elbows)
16
12
8
4
0
-4
kdpm/100cm2
Average = 0.9 kdpm/100cm2
(first half of TLD string still in pipe)
0.0
10.0
20.0
30.0
40.0
50.0
Pipe Position (feet from well)

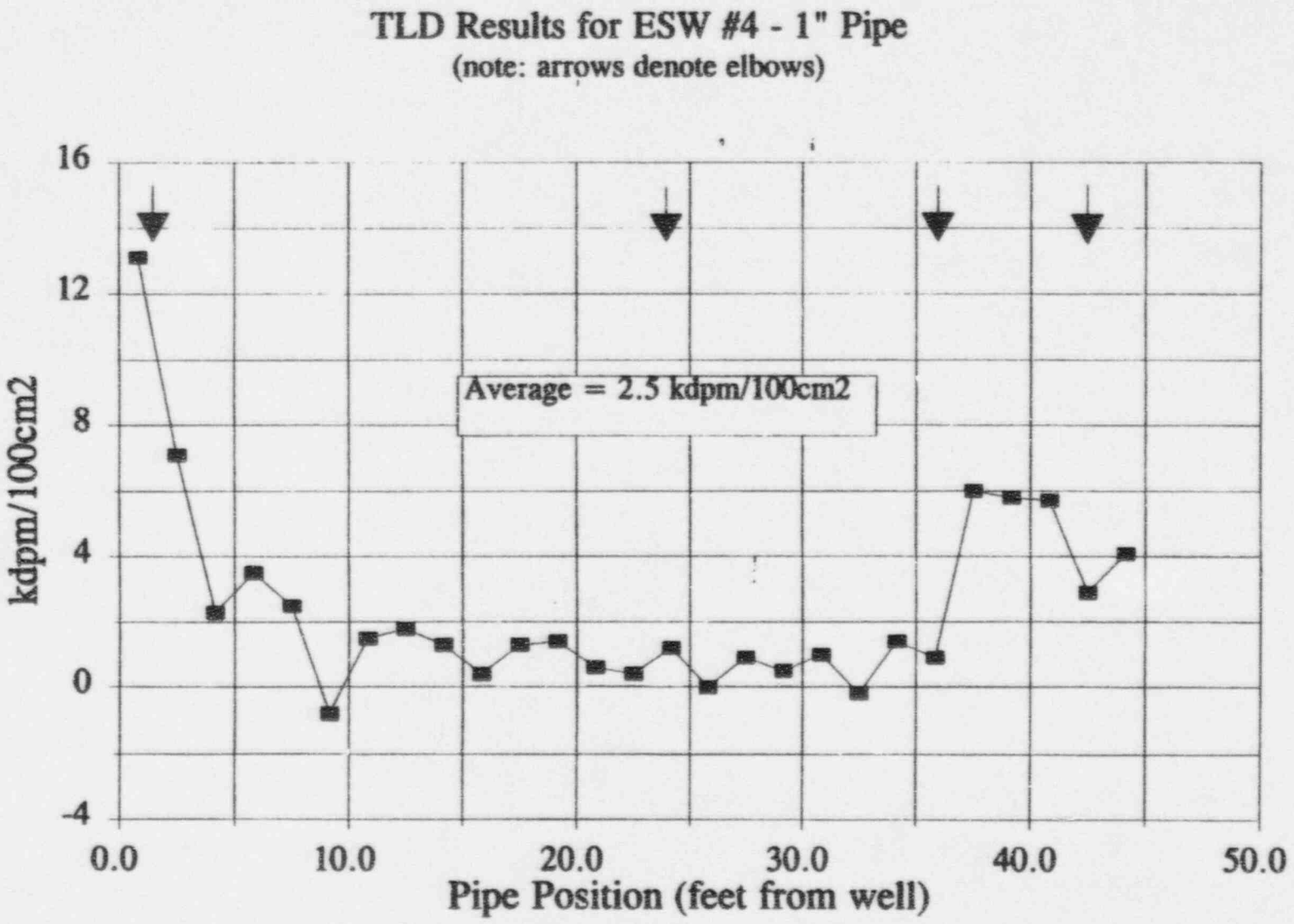
TLD Results for ESW #2 - 1" Pipe

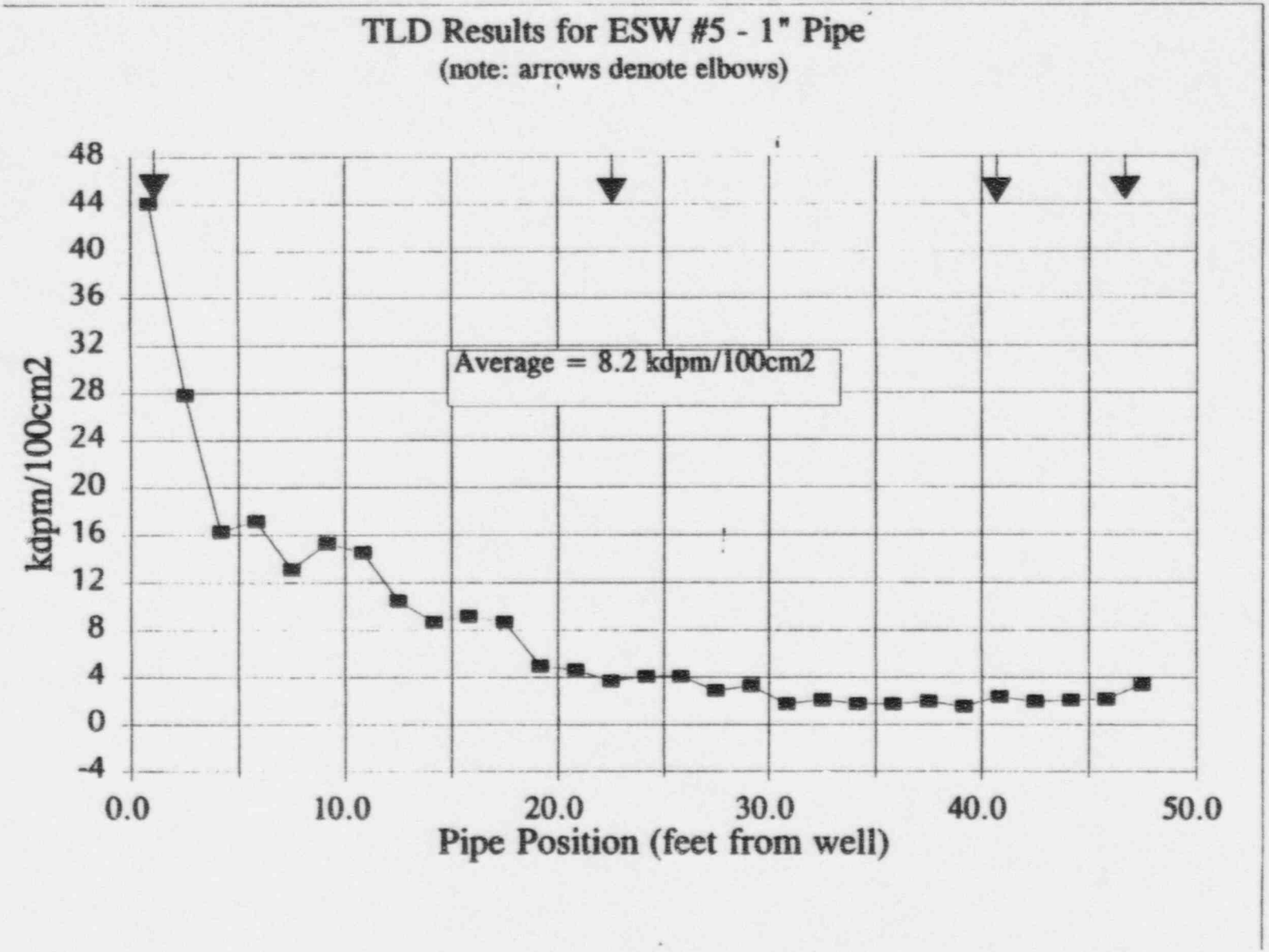
(note: arrows denote elbows)

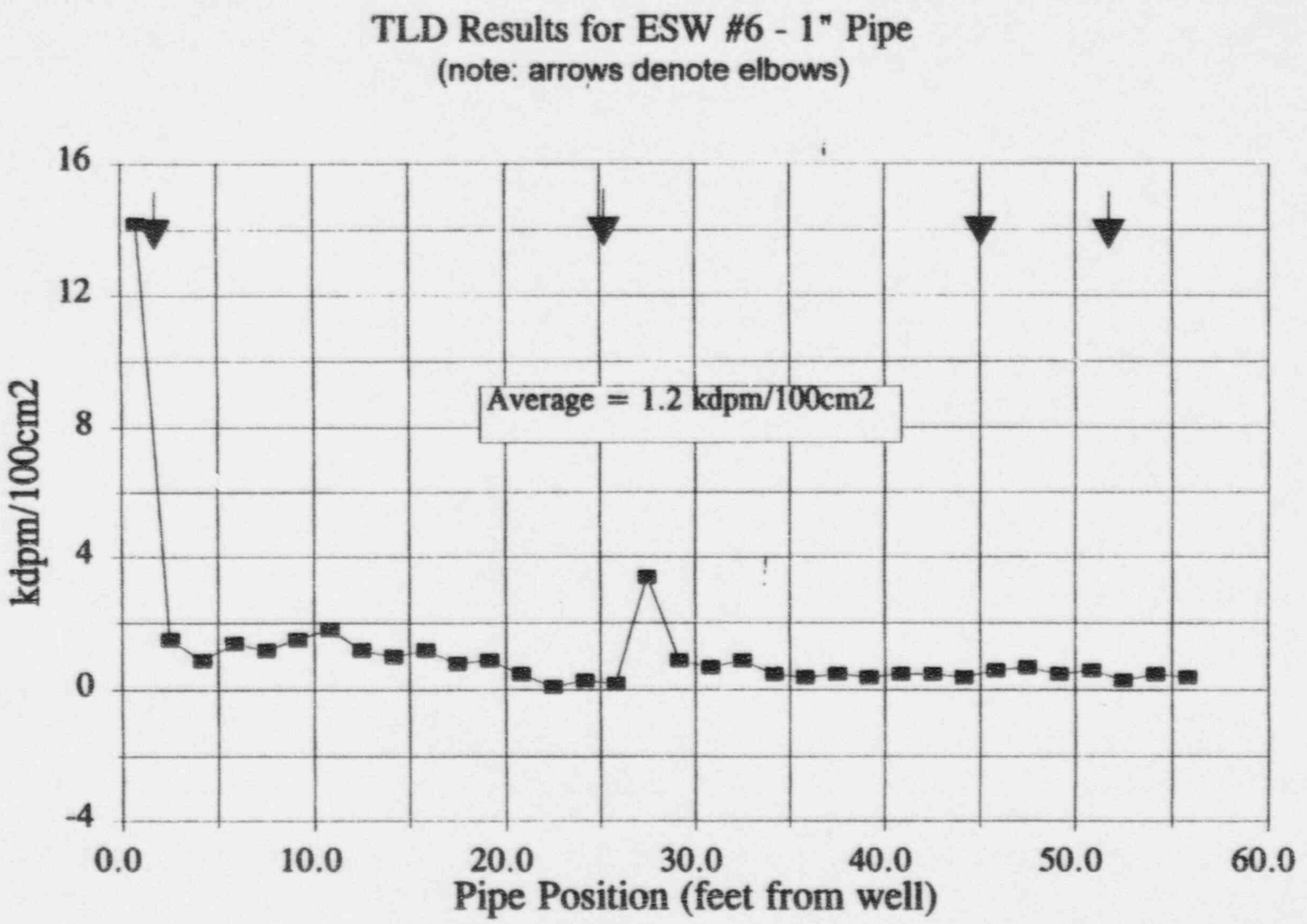


TLD Results for ESW #3 - 1" Pipe
(note: arrows denote elbows)



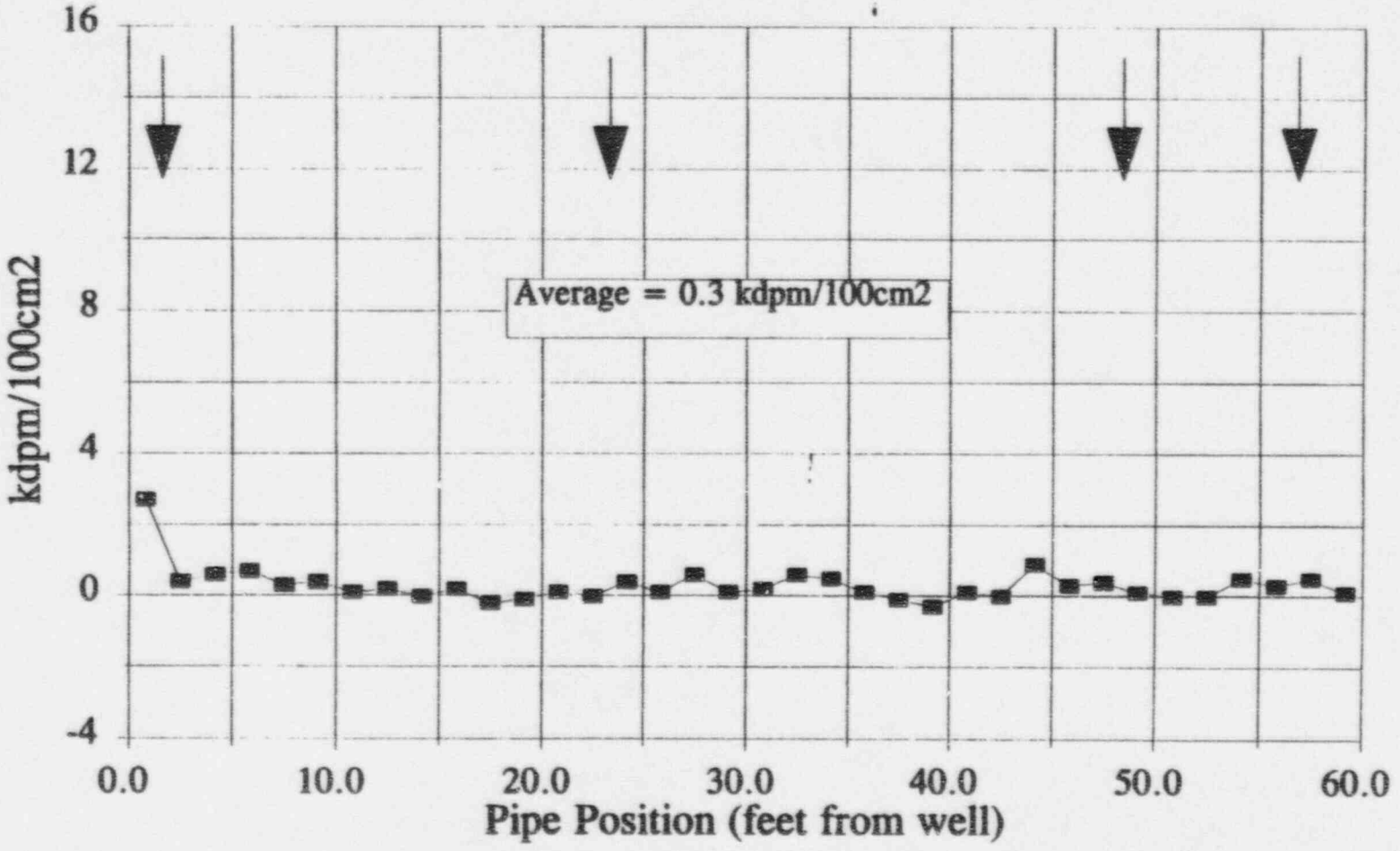

TLD Results for ESW #4 - 1" Pipe
(note: arrows denote elbows)
Average = 2.5 kdpm/100cm2
kdpm/100cm2
16
12
8
4
0
-4
0.0
10.0
20.0
30.0
40.0
50.0
Pipe Position (feet from well)


TLD Results for ESW #5 - 1" Pipe
(note: arrows denote elbows)
Average = 8.2 kdpm/100cm2
kdpm/100cm2
48
44
40
36
32
28
24
20
16
12
8
4
0
-4
0.0
10.0
20.0
30.0
40.0
50.0
Pipe Position (feet from well)


TLD Results for ESW #6 - 1" Pipe
(note: arrows denote elbows)
16
12
8
4
0
-4
kdpm/100cm2
Average = 1.2 kdpm/100cm2
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Pipe Position (feet from well)

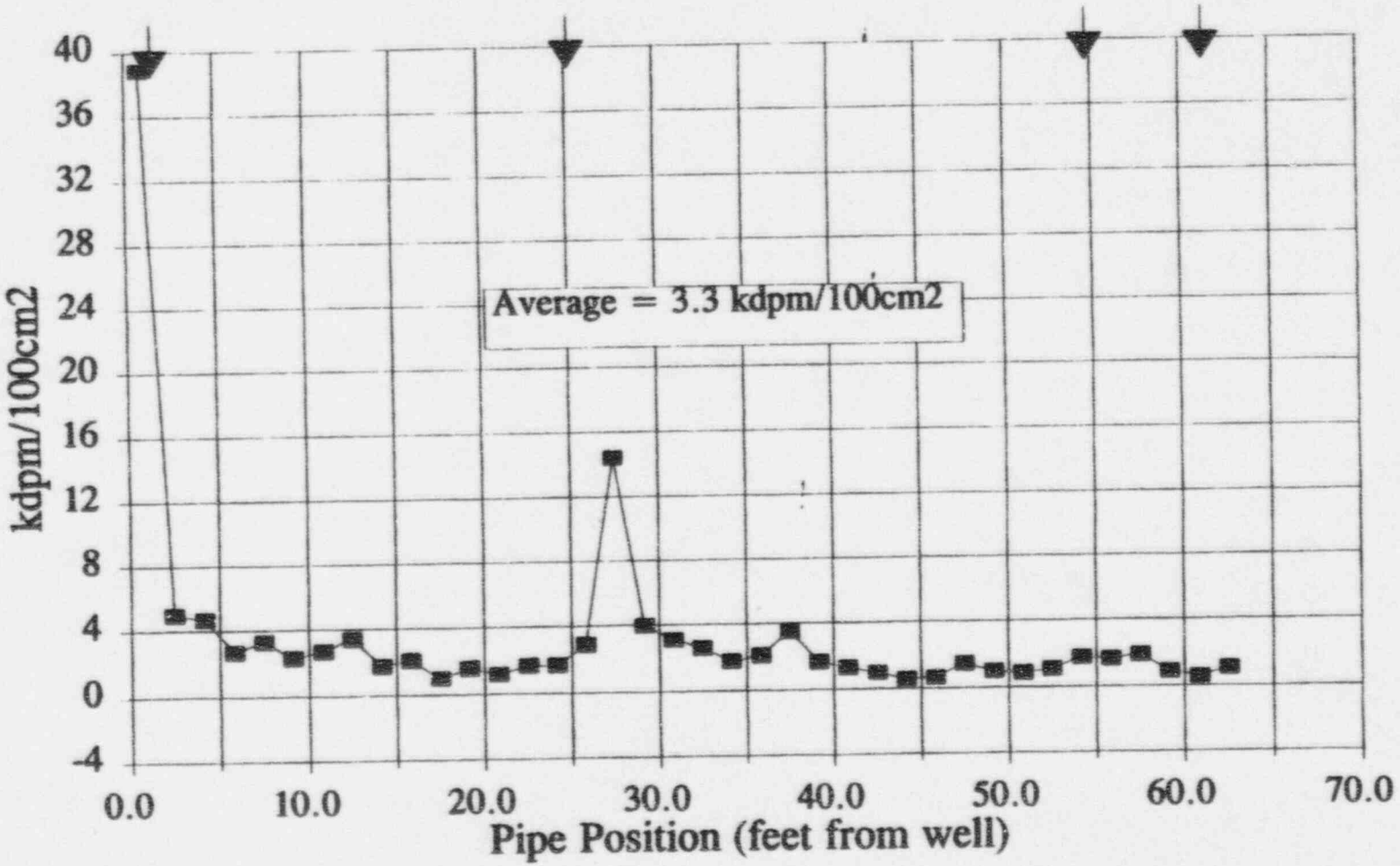
TLD Results for ESW #7 - 1" Pipe

(note: arrows denote elbows)



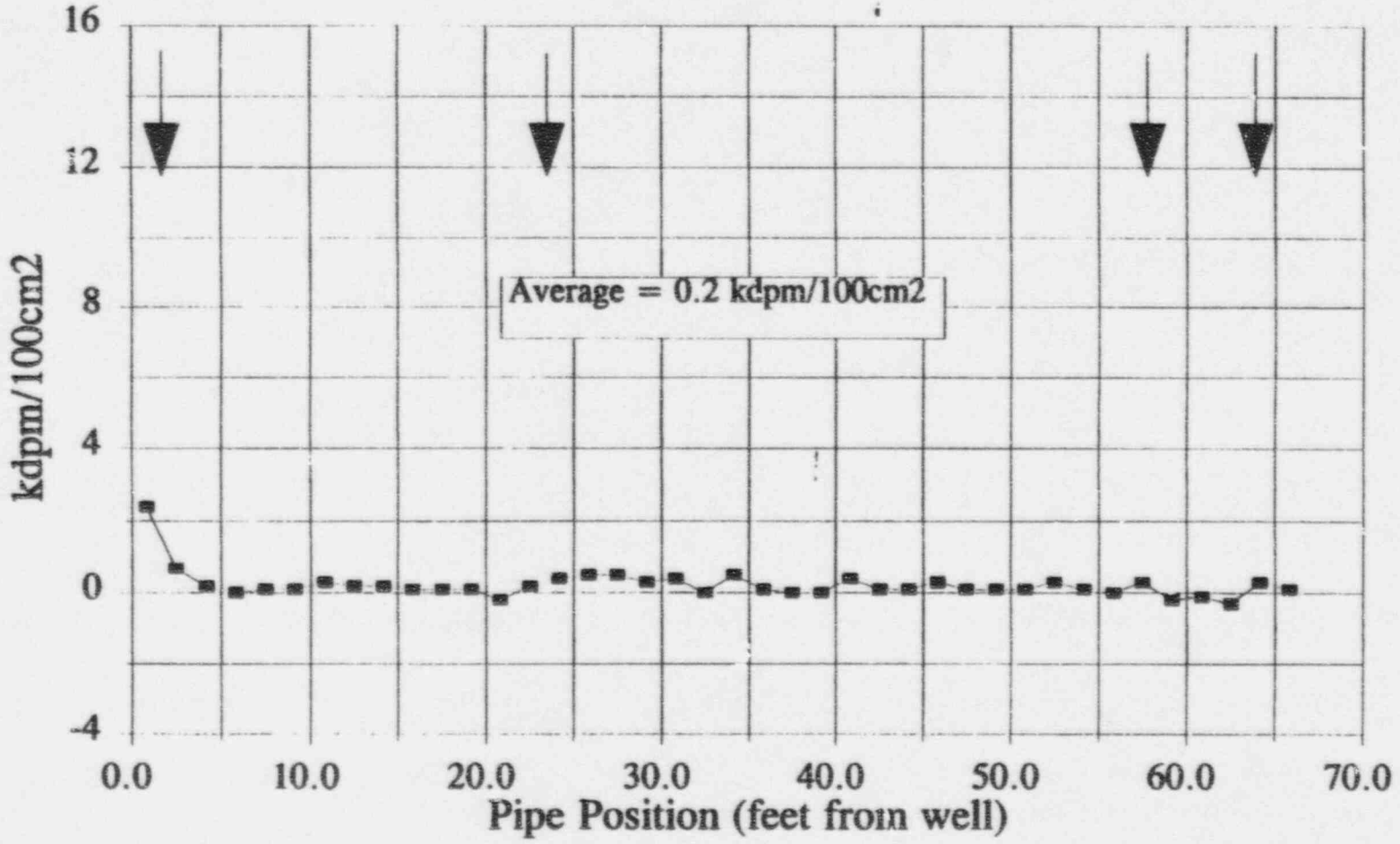
TLD Results for ESW #8 - 1" Pipe

(note: arrows denote elbows)



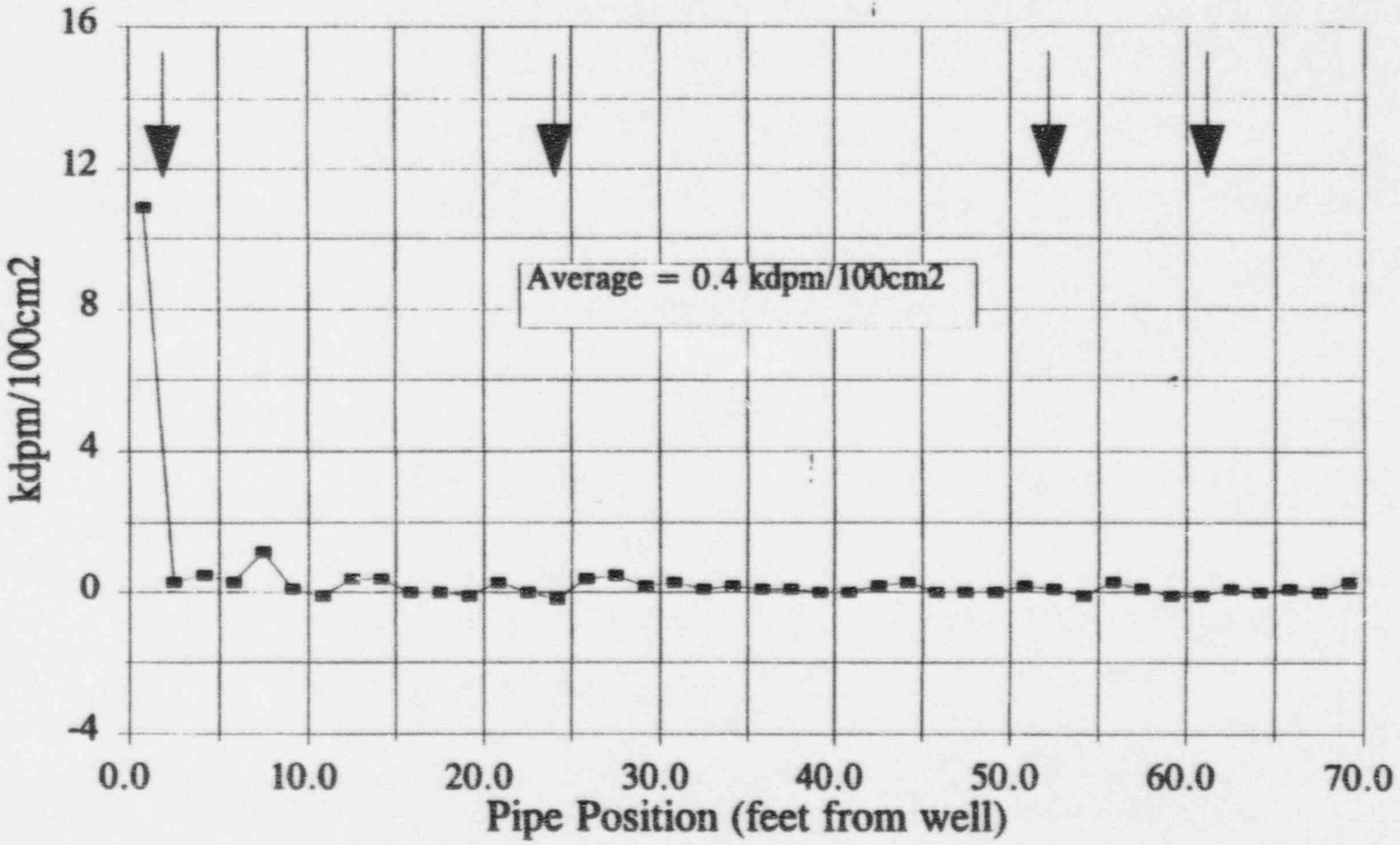
TLD Results for ESW #9 - 1" Pipe

(note: arrows denote elbows)



TLD Results for ESW #10 - 1" Pipe

(note: arrows denote elbows)



ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #1	VENT LINE		50		1	34	2-8-95/1510	4-27-95/1315	112205
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
13-1109	27	43	39	24					
13-1110	26	48	42	25					
13-Total	53	91	81	49	38	32	2.2	2.1	2.1
14-1111	27	48	45	28					
14-1112	31	46	46	28					
14-Total	58	94	91	56	36	35	2.1	2.3	2.2
15-1113	28	32	35	27					
15-1114	29	45	39	28					
15-Total	57	77	74	55	20	19	1.2	1.2	1.2
16-1115	29	40	40	28					
16-1116	38	43	40	29					
16-Total	67	83	80	57	16	23	0.9	1.5	1.2
17-1117	26	35	38	27					
17-1118	25	35	32	24					
17-Total	51	70	70	51	19	19	1.1	1.2	1.2
18-1119	26	36	36	27					
18-1120	25	37	35	28					
18-Total	51	73	71	55	22	16	1.3	1.0	1.2
19-1121	27	32	35	30					
19-1122	25	31	31	28					
19-Total	52	63	66	58	11	8	0.6	0.5	0.6
20-1123	29	29	36	30					
20-1124	29	29	32	28					
20-Total	58	58	68	58	0	10	0.0	0.6	0.3
21-1125	26	32	31	29					
21-1126	31	43	34	30					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #1	VENT LINE		50		1	34	2-8-95/1510	4-27-95/1315	112205
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
21-Total	57	75	65	59	18	6	1.0	0.4	0.7
22-1127	25	31	32	29					
22-1128	25	29	29	27					
22-Total	50	60	61	56	10	5	0.6	0.3	0.5
23-1129	31	35	30	28					
23-1130	26	32	30	29					
23-Total	57	67	60	57	10	3	0.6	0.2	0.4
24-1131	27	27	30	30					
24-1132	34	37	33	29					
24-Total	61	64	63	59	3	4	0.2	0.3	0.2
25-1133	28	31	29	26					
25-1134	26	30	30	29					
25-Total	54	61	59	55	7	4	0.4	0.3	0.3
26-1135	33	29	33	28					
26-1136	25	27	29	27					
26-Total	58	56	62	55	-2	7	-0.1	0.5	0.2
27-1137	30	32	30	27					
27-1138	27	29	30	28					
27-Total	57	61	60	55	4	5	0.2	0.3	0.3
28-1139	29	37	31	28					
28-1140	33	79	29	27					
28-Total	62	116	60	55	54	5	3.1	0.3	1.7
29-1141	25	28	33	27					
29-1142	32	34	33	28					
29-Total	57	62	66	55	5	11	0.3	0.7	0.5

Average Total	56.5	Average Total	55.6			Average	(Kdpm/100cm2)	0.9
Stand. Dev.	4.4	Stand. Dev.	2.6	Student's t value	1.746	Error (95%)	(Kdpm/100cm2)	0.3
						Critical Level	(Kdpm/100cm2)	0.4
						MDA	(Kdpm/100cm2)	0.8

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #2	VENT LINE	38	1	44	2-8-95/1000	4-27-95/0830	112230

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06	
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-935	35	56	49	28					
1-936	32	51	39	28					
1-Total	67	107	88	56	40	32	2.3	2.1	2.2
2-937	44	90	70	30					
2-938	33	81	73	32					
2-Total	77	171	143	62	94	81	5.4	5.2	5.3
3-939	43	96	79	32					
3-940	35	102	90	31					
3-Total	78	198	169	63	120	106	6.9	6.8	6.9
4-941	32	71	65	32					
4-942	35	79	72	33					
4-Total	67	150	137	65	83	72	4.8	4.6	4.7
5-943	42	54	37	31					
5-944	39	50	37	31					
5-Total	81	104	74	62	23	12	1.3	0.8	1.1
6-945	43	44	35	31					
6-946	31	41	37	32					
6-Total	74	85	72	63	11	9	0.6	0.6	0.6
7-947	25	37	32	29					
7-948	27	36	36	31					
7-Total	52	73	68	60	21	8	1.2	0.5	0.9
8-949	36	37	40	35					
8-950	29	35	35	32					
8-Total	65	72	75	67	7	8	0.4	0.5	0.5

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH			PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #2	VENT LINE	38			1	44	2-8-95/1000	4-27-95/0830	112230
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
9-951	35	31	38	36					
9-952	28	34	38	36					
9-Total	63	65	76	72	2	4	0.1	0.3	0.2
10-953	33	40	37	34					
10-954	35	40	39	36					
10-Total	68	80	76	70	12	6	0.7	0.4	0.5
11-955	35	40	39	36					
11-956	27	31	35	33					
11-Total	62	71	74	69	9	5	0.5	0.3	0.4
12-957	34	38	32	32					
12-958	33	39	36	31					
12-Total	67	77	68	63	10	5	0.6	0.3	0.5
13-911	31	36	37	33					
13-912	29	34	36	34					
13-Total	60	70	73	67	10	6	0.6	0.4	0.5
14-913	37	36	39	33					
14-914	31	32	38	34					
14-Total	68	68	77	67	0	10	0.0	0.6	0.3
15-915	40	52	53	34					
15-916	38	58	49	35					
15-Total	78	110	102	69	32	33	1.9	2.1	2.0
16-917	38	51	40	33					
16-918	31	39	35	32					
16-Total	69	90	75	65	21	10	1.2	0.6	0.9
17-919	32	40	31	26					
17-920	30	36	34	31					
17-Total	62	76	65	57	14	8	0.8	0.5	0.7

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH			PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #2	VENT LINE	38			1	44	2-8-95/1000	4-27-95/0830	112230
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
18-921	29	32	34	31					
18-922	42	46	35	32					
18-Total	71	78	69	63	7	6	0.4	0.4	0.4
19-923	37	45	38	35					
19-924	32	40	33	30					
19-Total	69	85	71	65	16	6	0.9	0.4	0.7
20-925	28	43	35	33					
20-926	31	37	33	32					
20-Total	59	80	68	65	21	3	1.2	0.2	0.7
21-927	40	51	40	33					
21-928	38	59	44	33					
21-Total	78	110	84	66	32	18	1.9	1.2	1.5
22-929	33	59	57	32					
22-930	40	86	63	31					
22-Total	73	145	120	63	72	57	4.2	3.7	3.9

Average Total	68.5	Average Total	64.5			Average	(Kdpm/100cm2)	1.6
Stand. Dev.	7.3	Stand. Dev.	3.9	Student's t value	1.721	Error (95%)	(Kdpm/100cm2)	0.7
						Critical Level	(Kdpm/100cm2)	0.6
						MDA	(Kdpm/100cm2)	1.2

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #3	VENT LINE	42	1	48	2-8-95/1020	4-27-95/0850	112230

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06

POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-795	29	40	36	27					
1-796	37	36	34	30					
1-Total	66	76	70	57	10	13	0.6	0.8	0.7
2-797	28	54	66	30					
2-798	42	46	52	29					
2-Total	70	100	118	59	30	59	1.7	3.8	2.8
3-799	35	80	77	30					
3-800	36	75	62	31					
3-Total	71	155	139	61	84	78	4.9	5.0	4.9
4-801	45	52	55	30					
4-802	32	49	45	30					
4-Total	77	101	100	60	24	40	1.4	2.6	2.0
5-803	32	63	63	31					
5-804	32	49	46	30					
5-Total	64	112	109	61	48	48	2.8	3.1	2.9
6-805	31	59	52	33					
6-806	27	44	39	33					
6-Total	58	103	91	66	45	25	2.6	1.6	2.1
7-807	33	58	48	28					
7-808	28	47	47	31					
7-Total	61	105	95	59	44	36	2.5	2.3	2.4
8-809	32	49	49	32					
8-810	30	58	56	32					
8-Total	62	107	105	64	45	41	2.6	2.6	2.6

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH			PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #3	VENT LINE	42			1	48	2-8-95/1020	4-27-95/0850	112230
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
9-811	29	82	64	32					
9-812	38	36	37	29					
9-Total	67	118	101	61	51	40	2.9	2.6	2.8
10-813	28	36	37	29					
10-814	31	46	44	32					
10-Total	59	82	81	61	23	20	1.3	1.3	1.3
11-815	32	38	33	30					
11-816	28	34	39	33					
11-Total	60	72	72	63	12	9	0.7	0.6	0.6
12-817	27	32	31	30					
12-818	33	35	35	29					
12-Total	60	67	66	59	7	7	0.4	0.5	0.4
13-819	34	37	32	31					
13-820	37	33	33	30					
13-Total	71	70	65	61	-1	4	-0.1	0.3	0.1
14-821	37	44	35	32					
14-822	30	32	34	31					
14-Total	67	76	69	63	9	6	0.5	0.4	0.5
15-823	33	53	46	32					
15-824	31	47	43	31					
15-Total	64	100	89	63	36	26	2.1	1.7	1.9
16-825	26	34	34	30					
16-826	30	38	38	31					
16-Total	56	72	72	61	16	11	0.9	0.7	0.8
17-827	35	42	35	31					
17-828	33	35	36	31					
17-Total	68	77	71	62	9	9	0.5	0.6	0.6

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #3	VENT LINE		42		1	48	2-8-95/1020	4-27-95/0850	112230
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
18-829	29	31	33	28					
18-830	29	35	33	29					
18-Total	58	66	66	57	8	9	0.5	0.6	0.5
19-831	30	39	35	29					
19-832	30	35	33	29					
19-Total	60	74	68	58	14	10	0.8	0.6	0.7
20-833	32	41	37	29					
20-834	27	34	31	29					
20-Total	59	75	68	58	16	10	0.9	0.6	0.8
21-835	39	49	43	34					
21-836	29	35	39	31					
21-Total	68	84	82	65	16	17	0.9	1.1	1.0
22-837	26	36	34	31					
22-838	31	40	40	32					
22-Total	57	76	74	63	19	11	1.1	0.7	0.9
23-839	30	41	34	31					
23-840	30	52	45	31					
23-Total	60	93	79	62	33	17	1.9	1.1	1.5
24-841	40	55	52	33					
24-842	49	74	72	32					
24-Total	89	129	124	65	40	59	2.3	3.8	3.1

Average Total	64.7	Average Total	61.2			Average	(Kdpm/100cm2)	1.6
Stand. Dev.	7.5	Stand. Dev.	2.5	Student's t value	1.714	Error (95%)	(Kdpm/100cm2)	0.4
						Critical Level	(Kdpm/100cm2)	0.4
						MDA	(Kdpm/100cm2)	0.8

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #4	VENT LINE		46	1	54	2-7-95/1340	4-27-95/0900	113480
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)			Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06	
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-675	60	195	172	27					
1-676	32	113	98	25					
1-Total	92	308	270	52	216	218	12.4	13.9	13.1
2-677	38	152	71	28					
2-678	84	128	66	29					
2-Total	122	280	137	57	158	80	9.0	5.1	7.1
3-679	160	219	53	29					
3-680	174	143	49	26					
3-Total	334	362	102	55	28	47	1.6	3.0	2.3
4-681	82	133	53	33					
4-682	40	76	44	31					
4-Total	122	209	97	64	87	33	5.0	2.1	3.5
5-683	73	89	37	26					
5-684	57	107	40	32					
5-Total	130	196	77	58	66	19	3.8	1.2	2.5
6-685	97	54	33	30					
6-686	90	93	36	27					
6-Total	187	147	69	57	40	12	-2.3	0.8	-0.8
7-687	60	119	20	19					
7-688	114	104	22	19					
7-Total	174	223	42	38	49	4	2.8	0.3	1.5
8-689	52	83	37	28					
8-690	44	55	40	29					
8-Total	96	138	77	57	42	20	2.4	1.3	1.8
9-691	40	54	41	35					
9-692	40	55	35	26					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #4	VENT LINE	46		1	54	2-7-95/1340	4-27-95/0900	113480
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06
9-Total	80	109	76	61	29	15	1.7	1.0	1.3
10-693	86	58	37	28					
10-694	39	59	42	31					
10-Total	125	117	79	59	-8	20	-0.5	1.3	0.4
11-695	47	96	36	31					
11-696	77	62	40	34					
11-Total	124	158	76	65	34	11	1.9	0.7	1.3
12-697	39	54	37	32					
12-698	50	68	38	29					
12-Total	89	122	75	61	33	14	1.9	0.9	1.4
13-699	65	76	36	32					
13-700	49	51	32	28					
13-Total	114	127	68	60	13	8	0.7	0.5	0.6
14-701	41	48	40	34					
14-702	83	79	39	34					
14-Total	124	127	79	68	3	11	0.2	0.7	0.4
15-703	57	67	41	30					
15-704	70	75	47	34					
15-Total	127	142	88	64	15	24	0.9	1.5	1.2
16-705	59	39	38	32					
16-706	48	52	39	32					
16-Total	107	91	77	64	-16	13	-0.9	0.8	-0.0
17-707	39	50	33	29					
17-708	35	41	40	32					
17-Total	74	91	73	61	17	12	1.0	0.8	0.9
18-709	44	51	35	29					
18-710	37	38	33	29					
18-Total	81	89	68	58	8	10	0.5	0.6	0.5
19-711	39	53	35	30					
19-712	34	46	33	30					
19-Total	73	99	68	60	26	8	1.5	0.5	1.0

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #4	VENT LINE	46		1	54	2-7-95/1340	4-27-95/0900	113480
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06
20-713	38	45	33	30				
20-714	62	43	35	32				
20-Total	100	88	68	62	-12	6	-0.7	0.4	-0.2
21-715	84	111	33	28				
21-716	33	44	32	27				
21-Total	117	155	65	55	38	10	2.2	0.6	1.4
22-717	39	51	40	32				
22-718	33	39	35	32				
22-Total	72	90	75	64	18	11	1.0	0.7	0.9
23-719	41	82	65	34				
23-720	40	95	104	33				
23-Total	81	177	169	67	96	102	5.5	6.5	6.0
24-721	39	69	68	32				
24-722	38	100	96	32				
24-Total	77	169	164	64	92	100	5.3	6.4	5.8
25-723	31	66	53	30				
25-724	40	103	97	30				
25-Total	71	169	150	60	98	90	5.6	5.7	5.7
26-725	51	63	51	30				
26-726	45	82	70	45				
26-Total	96	145	121	75	49	46	2.8	2.9	2.9
27-727	51	82	70	45				
27-728	53	96	80	42				
27-Total	104	178	150	87	74	63	4.2	4.0	4.1

Average Total	114.6	Average Total	61.2			Average	(Kdpm/100cm2)	2.5
Stand. Dev.	52.6	Stand. Dev.	8.3	Student's t value	1.706	Error (95%)	(Kdpm/100cm2)	1.0
						Critical Level	(Kdpm/100cm2)	1.3
						MDA	(Kdpm/100cm2)	2.5

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #5	VENT LINE	50	1	58	2-7-95/1510	4-27-95/1300	113630

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06	
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-585	24	570	510	30					
1-586	33	261	241	29					
1-Total	57	831	751	59	774	692	44.2	44.1	44.1
2-587	30	210	219	30					
2-588	34	313	308	36					
2-Total	64	523	527	66	459	461	26.2	29.4	27.8
3-589	31	148	140	26					
3-590	33	190	179	27					
3-Total	64	338	319	53	274	266	15.6	16.9	16.3
4-591	28	126	132	31					
4-592	31	213	215	28					
4-Total	59	339	347	59	280	288	16.0	18.4	17.2
5-593	26	145	121	26					
5-594	32	140	140	26					
5-Total	58	285	261	52	227	209	13.0	13.3	13.1
6-595	24	179	177	29					
6-596	29	142	118	27					
6-Total	53	321	295	56	268	239	15.3	15.2	15.3
7-597	28	175	168	28					
7-598	32	122	136	33					
7-Total	60	297	304	61	237	243	13.5	15.5	14.5
8-599	30	121	134	27					
8-600	24	107	94	26					
8-Total	54	228	228	53	174	175	9.9	11.2	10.5
9-601	27	104	99	26					
9-602	32	113	81	24					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #5	VENT LINE	50		1	58	2-7-95/1510	4-27-95/1300	113630
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06
9-Total	59	217	180	50	158	130	9.0	8.3	8.7
10-603	27	99	100	28					
10-604	29	103	121	34					
10-Total	56	202	221	62	146	159	8.3	10.1	9.2
11-605	33	107	115	28					
11-606	41	108	89	30					
11-Total	74	215	204	58	141	146	8.1	9.3	8.7
12-607	38	88	83	33					
12-608	38	65	70	31					
12-Total	76	153	153	64	77	89	4.4	5.7	5.0
13-609	44	84	65	30					
13-610	29	73	70	34					
13-Total	73	157	135	64	84	71	4.8	4.5	4.7
14-611	24	68	58	28					
14-612	34	59	53	30					
14-Total	58	127	111	58	69	53	3.9	3.4	3.7
15-613	33	64	58	32					
15-614	35	80	67	32					
15-Total	68	144	125	64	76	61	4.3	3.9	4.1
16-615	33	64	56	32					
16-616	30	74	70	32					
16-Total	63	138	126	64	75	62	4.3	4.0	4.1
17-617	29	58	55	31					
17-618	33	58	53	33					
17-Total	62	116	108	64	54	44	3.1	2.8	2.9
18-619	32	55	52	32					
18-620	30	65	58	25					
18-Total	62	120	110	57	58	53	3.3	3.4	3.3
19-621	23	42	45	30					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #5	VENT LINE	50	1	58	2-7-95/1510	4-27-95/1300	113630

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06	
19-622	29	41	38	25					
19-Total	52	83	83	55	31	28	1.8	1.8	1.8
20-623	27	47	43	26					
20-624	28	50	42	30					
20-Total	55	97	85	56	42	29	2.4	1.8	2.1
21-625	28	50	40	28					
21-626	34	43	45	29					
21-Total	62	93	85	57	31	28	1.8	1.8	1.8
22-627	31	48	47	32					
22-628	34	44	49	31					
22-Total	65	92	96	63	27	33	1.5	2.1	1.8
23-629	20	41	46	29					
23-630	42	55	40	26					
23-Total	62	96	86	55	34	31	1.9	2.0	2.0
24-631	31	49	45	30					
24-632	29	41	35	28					
24-Total	60	90	80	58	30	22	1.7	1.4	1.6
25-633	24	45	40	27					
25-634	28	54	47	28					
25-Total	52	99	87	55	47	32	2.7	2.0	2.4
26-635	28	54	42	26					
26-636	27	37	41	28					
26-Total	55	91	83	54	36	29	2.1	1.8	2.0
27-637	23	42	41	25					
27-638	23	42	44	27					
27-Total	46	84	85	52	38	33	2.2	2.1	2.1
28-639	25	43	39	26					
28-640	24	51	42	26					
28-Total	49	94	81	52	45	29	2.6	1.8	2.2

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #5	VENT LINE	50	1	58	2-7-95/1510	4-27-95/1300	113630

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
29-641	23	49	52	26					
29-642	29	56	58	25					
29-Total	52	105	110	51	53	59	3.0	3.8	3.4

Average Total	59.7	Average Total	57.7			Average	(Kdpm/100cm2)	8.2
Stand. Dev.	7.2	Stand. Dev.	4.7	Student's t value	1.701	Error (95%)	(Kdpm/100cm2)	3.0
						Critical Level	(Kdpm/100cm2)	0.7
						MDA	(Kdpm/100cm2)	1.4

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #6	VENT LINE	54	1	68	2-7-95/1535	4-27-95/0745	113290

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-535	27	187	164	39					
1-536	30	134	117	33					
1-Total	57	321	281	72	264	209	15.1	13.4	14.2
2-537	34	41	49	29					
2-538	29	42	38	29					
2-Total	63	83	87	58	20	29	1.1	1.9	1.5
3-539	27	43	38	31					
3-540	34	35	38	32					
3-Total	61	78	76	63	17	13	1.0	0.8	0.9
4-541	28	42	39	31					
4-542	28	43	41	31					
4-Total	56	85	80	62	29	18	1.7	1.2	1.4
5-543	29	39	37	26					
5-544	25	36	39	30					
5-Total	54	75	76	56	21	20	1.2	1.3	1.2
6-545	28	44	43	30					
6-546	28	38	39	28					
6-Total	56	82	82	58	26	24	1.5	1.5	1.5
7-547	31	49	46	26					
7-548	27	42	29	21					
7-Total	58	91	75	47	33	28	1.9	1.8	1.8
8-549	30	35	48	29					
8-550	26	35	37	31					
8-Total	56	70	85	60	14	25	0.8	1.6	1.2
9-551	30	39	37	29					
9-552	34	39	37	27					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #6	VENT LINE		54		1	68	2-7-95/1535	4-27-95/0745	113290
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
9-Total	64	78	74	56	14	18	0.8	1.2	1.0
10-553	31	48	43	32					
10-554	35	35	36	25					
10-Total	66	83	79	57	17	22	1.0	1.4	1.2
11-555	41	39	38	31					
11-556	29	41	40	32					
11-Total	70	80	78	63	10	15	0.6	1.0	0.8
12-557	29	43	37	30					
12-558	27	29	35	29					
12-Total	56	72	72	59	16	13	0.9	0.8	0.9
13-559	27	29	33	28					
13-560	29	34	33	28					
13-Total	56	63	66	56	7	10	0.4	0.6	0.5
14-561	32	29	32	31					
14-562	29	29	31	27					
14-Total	61	58	63	58	-3	5	-0.2	0.3	0.1
15-563	29	28	29	25					
15-564	29	35	30	30					
15-Total	58	63	59	55	5	4	0.3	0.3	0.3
16-565	25	29	27	27					
16-566	29	28	33	28					
16-Total	54	57	60	55	3	5	0.2	0.3	0.2
17-567	29	46	43	31					
17-568	32	82	57	24					
17-Total	61	128	100	55	67	45	3.8	2.9	3.4
18-569	33	46	37	28					
18-570	27	31	34	30					
18-Total	60	77	71	58	17	13	1.0	0.8	0.9
19-571	26	35	31	30					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #6	VENT LINE	54	1	68	2-7-95/1535	4-27-95/0745	113290

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
19-572	33	41	35	29					
19-Total	59	76	66	59	17	7	1.0	0.4	0.7
20-573	30	32	35	29					
20-574	27	39	38	29					
20-Total	57	71	73	58	14	15	0.8	1.0	0.9
21-575	33	36	38	30					
21-576	28	34	32	32					
21-Total	61	70	70	62	9	8	0.5	0.5	0.5
22-577	30	36	36	32					
22-578	30	29	38	33					
22-Total	60	65	74	65	5	9	0.3	0.6	0.4
23-579	33	37	37	32					
23-580	26	28	26	22					
23-Total	59	65	63	54	6	9	0.3	0.6	0.5
24-581	32	35	34	28					
24-582	27	30	30	28					
24-Total	59	65	64	56	6	8	0.3	0.5	0.4
25-583	25	29	29	26					
25-584	24	29	32	28					
25-Total	49	58	61	54	9	7	0.5	0.4	0.5
26-373	27	28	35	33					
26-374	31	42	36	33					
26-Total	58	70	71	66	12	5	0.7	0.3	0.5
27-375	29	36	33	29					
27-376	25	30	29	30					
27-Total	54	66	62	59	12	3	0.7	0.2	0.4
28-377	28	31	30	24					
28-378	30	41	32	31					
28-Total	58	72	62	55	14	7	0.8	0.4	0.6

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #6	VENT LINE	54	1	68	2-7-95/1535	4-27-95/0745	113290

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
29-379	29	40	35	30					
29-380	34	37	28	25					
29-Total	63	77	63	55	14	8	0.8	0.5	0.7
30-381	29	40	32	26					
30-382	35	30	29	25					
30-Total	64	70	61	51	6	10	0.3	0.6	0.5
31-383	26	37	33	32					
31-384	29	33	30	27					
31-Total	55	70	63	59	15	4	0.9	0.3	0.6
32-385	33	35	29	26					
32-386	29	37	28	30					
32-Total	62	72	57	56	10	1	0.6	0.1	0.3
33-387	33	41	32	30					
33-388	33	36	31	28					
33-Total	66	77	63	58	11	5	0.6	0.3	0.5
34-389	55	63	45	44					
34-390	55	58	62	61					
34-Total	110	121	107	105	11	2	0.6	0.1	0.4

Average Total	60.6	Average Total	59.4		Average	(Kdpm/100cm2)	1.2
Stand. Dev.	4.2	Stand. Dev.	4.6	Student's t value1.693	Error (95%)	(Kdpm/100cm2)	0.7
					Critical Level	(Kdpm/100cm2)	0.6
					MDA	(Kdpm/100cm2)	1.2

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #7	VENT LINE	58	1	72	2-7-95/0810	4-27-95/0800	113750

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06	
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-301	33	62	63	30					
1-302	30	51	43	35					
1-Total	63	113	106	65	50	41	2.9	2.6	2.7
2-303	30	32	32	28					
2-304	32	39	35	34					
2-Total	62	71	67	62	9	5	0.5	0.3	0.4
3-305	37	47	31	31					
3-306	33	43	31	30					
3-Total	70	90	62	61	20	1	1.1	0.1	0.6
4-307	36	53	33	30					
4-308	37	41	31	31					
4-Total	73	94	64	61	21	3	1.2	0.2	0.7
5-309	27	35	30	31					
5-310	30	35	27	29					
5-Total	57	70	57	60	13	-3	0.7	-0.2	0.3
6-311	27	31	26	27					
6-312	26	34	33	29					
6-Total	53	65	59	56	12	3	0.7	0.2	0.4
7-313	31	24	30	28					
7-314	25	35	31	31					
7-Total	56	59	61	59	3	2	0.2	0.1	0.1
8-315	27	37	31	31					
8-316	28	31	27	31					
8-Total	55	68	58	62	13	-4	0.7	-0.3	0.2
9-317	31	31	27	30					
9-318	28	32	28	30					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #7	VENT LINE	58		1	72	2-7-95/0810	4-27-95/0800	113750
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)			Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
9-Total	59	63	55	60	4	-5	0.2	-0.3	-0.0
10-319	29	31	28	30					
10-320	25	33	28	29					
10-Total	54	64	56	59	10	-3	0.6	-0.2	0.2
11-321	36	33	28	30					
11-322	28	28	29	30					
11-Total	64	61	57	60	-3	-3	-0.2	-0.2	-0.2
12-323	25	28	28	30					
12-324	39	37	26	28					
12-Total	64	65	54	58	1	-4	0.1	-0.3	-0.1
13-325	35	37	32	31					
13-326	34	37	30	32					
13-Total	69	74	62	63	5	-1	0.3	-0.1	0.1
14-327	30	30	26	26					
14-328	30	31	29	29					
14-Total	60	61	55	55	1	0	0.1	0.0	0.0
15-329	35	42	29	30					
15-330	29	36	31	30					
15-Total	64	78	60	60	14	0	0.8	0.0	0.4
16-331	37	35	33	30					
16-332	27	29	32	32					
16-Total	64	64	65	62	0	3	0.0	0.2	0.1
17-333	34	37	32	32					
17-334	38	47	37	29					
17-Total	72	84	69	61	12	8	0.7	0.5	0.6
18-335	31	35	31	32					
18-336	36	38	29	31					
18-Total	67	73	60	63	6	-3	0.3	-0.2	0.1
19-337	29	33	34	31					

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #7	VENT LINE	58		1	72	2-7-95/0810	4-27-95/0800	113750
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)			Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06	
19-338	34	32	30	30				
19-Total	63	65	64	61	2	3	0.1	0.2	0.2
20-339	26	38	28	29				
20-340	32	40	30	29				
20-Total	58	78	58	58	20	0	1.1	0.0	0.6
21-341	32	34	31	31				
21-342	29	41	34	31				
21-Total	61	75	65	62	14	3	0.8	0.2	0.5
22-343	32	36	28	30				
22-344	29	34	29	33				
22-Total	61	70	57	63	9	-6	0.5	-0.4	0.1
23-345	29	27	27	28				
23-346	33	33	26	27				
23-Total	62	60	53	55	-2	-2	-0.1	-0.1	-0.1
24-347	36	42	29	32				
24-348	36	29	26	30				
24-Total	72	71	55	62	-1	-7	-0.1	-0.4	-0.3
25-349	31	34	28	30				
25-350	34	38	29	30				
25-Total	65	72	57	60	7	-3	0.4	-0.2	0.1
26-351	28	30	28	29				
26-352	32	30	27	26				
26-Total	60	60	55	55	0	0	0.0	0.0	0.0
27-353	29	32	26	27				
27-354	31	61	26	26				
27-Total	60	93	52	53	33	-1	1.9	-0.1	0.9
28-355	33	39	30	29				
28-356	36	35	31	28				
28-Total	69	74	61	57	5	4	0.3	0.3	0.3

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #7	VENT LINE	58		1	72	2-7-95/0810	4-27-95/0800	113750
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate = 6.49e+06		Calcium Sulfate = 7.24e+06
29-357	25	33	32	32				
29-358	27	32	29	29				
29-Total	52	65	61	61	13	0	0.7	0.0	0.4
30-359	31	33	25	27				
30-360	31	32	30	28				
30-Total	62	65	55	55	3	0	0.2	0.0	0.1
31-361	28	29	27	26				
31-362	30	27	25	25				
31-Total	58	56	52	51	-2	1	-0.1	0.1	-0.0
32-363	29	31	3	33				
32-364	33	32	28	29				
32-Total	62	63	60	62	1	-2	0.1	-0.1	-0.0
33-365	23	28	29	26				
33-366	34	42	31	30				
33-Total	57	70	60	56	13	4	0.7	0.3	0.5
34-367	31	38	28	25				
34-368	29	29	30	29				
34-Total	60	67	58	54	7	4	0.4	0.3	0.3
35-369	40	40	31	28				
35-370	32	40	34	28				
35-Total	72	80	65	56	8	9	0.5	0.6	0.5
36-371	42	34	33	31				
36-372	42	50	32	30				
36-Total	84	84	65	61	0	4	0.0	0.3	0.1

Average Total	62.9	Total Average	59.1			Average	(Kdpm/100cm2)	0.3
Stand. Dev.	6.6	Stand. Dev.	3.3	Student's t value	1.691	Error (95%)	(Kdpm/100cm2)	0.1
						Critical Level	(Kdpm/100cm2)	0.5
						MDA	(Kdpm/100cm2)	1.0

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #8	VENT LINE	62	1	76	2-7-95/0830	4-27-95/0819	113740

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR *)								
						Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-223	41	141	118	41					
1-224	72	540	712	77					
1-Total	113	681	830	118	568	712	32.4	45.9	38.9
2-225	29	85	76	36					
2-226	30	65	69	33					
2-Total	59	150	145	69	91	76	5.2	4.8	5.0
3-227	38	79	70	35					
3-228	42	81	75	33					
3-Total	80	160	145	68	80	77	4.6	4.9	4.7
4-229	32	53	55	33					
4-230	34	61	55	34					
4-Total	66	114	110	67	48	43	2.7	2.7	2.7
5-231	32	66	53	32					
5-232	32	68	60	40					
5-Total	64	134	113	72	70	41	4.0	2.6	3.3
6-233	30	54	59	39					
6-234	32	46	47	30					
6-Total	62	100	106	69	38	37	2.2	2.4	2.3
7-235	32	62	45	30					
7-236	41	66	58	36					
7-Total	73	128	103	66	55	37	3.1	2.4	2.7
8-237	30	66	55	30					
8-238	30	50	63	31					
8-Total	60	116	118	61	56	57	3.2	3.6	3.4

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #8	VENT LINE		62		1	76	2-7-95/0830	4-27-95/0810	113740
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
9-239	42	57	44	28					
9-240	35	55	50	41					
9-Total	77	112	94	69	35	25	2.0	1.6	1.8
10-241	32	58	40	27					
10-242	27	47	42	30					
10-Total	59	105	82	57	46	25	2.6	1.6	2.1
11-243	30	38	39	30					
11-244	29	40	39	33					
11-Total	59	78	78	63	19	15	1.1	1.0	1.0
12-245	25	45	47	32					
12-246	37	43	44	31					
12-Total	62	88	91	63	26	28	1.5	1.8	1.6
13-247	36	49	47	36					
13-248	37	44	38	28					
13-Total	73	93	85	64	20	21	1.1	1.3	1.2
14-249	36	57	46	37					
14-250	39	57	47	38					
14-Total	75	114	93	75	39	18	2.2	1.1	1.7
15-251	37	52	50	34					
15-252	30	45	43	32					
15-Total	67	97	93	66	30	27	1.7	1.7	1.7
16-253	30	53	62	35					
16-254	38	61	59	36					
16-Total	68	114	121	71	46	50	2.6	3.2	2.9
17-255	34	230	193	38					
17-256	40	113	95	40					
17-Total	74	343	288	78	269	210	15.3	13.4	14.4

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #8	VENT LINE		62		1	76	2-7-95/0830	4-27-95/0810	113740
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
18-257	43	95	85	34					
18-258	38	47	50	30					
18-Total	81	142	135	64	61	71	3.5	4.5	4.0
19-259	32	51	53	37					
19-260	33	69	65	34					
19-Total	65	120	118	71	55	47	3.1	3.0	3.1
20-261	32	56	46	34					
20-262	35	65	56	35					
20-Total	67	121	102	69	54	33	3.1	2.1	2.6
21-263	40	55	50	30					
21-264	30	41	43	31					
21-Total	70	96	93	61	26	32	1.5	2.0	1.8
22-265	35	64	52	30					
22-266	30	41	39	31					
22-Total	65	105	91	61	40	30	2.3	1.9	2.1
23-267	30	73	87	32					
23-268	31	47	44	43					
23-Total	61	120	131	75	59	56	3.4	3.6	3.5
24-269	30	56	42	32					
24-270	35	47	45	36					
24-Total	65	103	87	68	38	19	2.2	1.2	1.7
25-271	37	45	37	36					
25-272	26	52	41	32					
25-Total	63	97	78	68	34	10	1.9	0.6	1.3
26-273	25	41	37	35					
26-274	33	45	35	30					
26-Total	58	86	72	65	28	7	1.6	0.4	1.0

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH			PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #8	VENT LINE	62			1	76	2-7-95/0830	4-27-95/0810	113740
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
27-275	30	40	36	29					
27-276	32	35	32	31					
27-Total	62	75	68	60	13	8	0.7	0.5	0.6
28-277	32	34	37	34					
28-278	25	37	37	31					
28-Total	57	71	74	65	14	9	0.8	0.6	0.7
29-279	34	56	45	32					
29-280	36	43	39	31					
29-Total	70	99	84	63	29	21	1.7	1.3	1.5
30-281	27	43	43	33					
30-282	38	41	38	33					
30-Total	65	84	81	66	19	15	1.1	1.0	1.0
31-283	41	44	40	33					
31-284	32	39	44	31					
31-Total	73	83	84	64	10	20	0.6	1.3	0.9
32-285	36	45	39	34					
32-286	32	47	36	27					
32-Total	68	92	75	61	24	14	1.4	0.9	1.1
33-287	28	55	49	36					
33-288	30	47	36	31					
33-Total	58	102	85	67	44	18	2.5	1.1	1.8
34-289	30	51	39	33					
34-290	33	54	41	31					
34-Total	63	105	80	64	42	16	2.4	1.0	1.7
35-291	31	51	43	34					
35-292	32	49	49	32					
35-Total	63	100	92	66	37	26	2.1	1.7	1.9

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #8	VENT LINE		62		1	76	2-7-95/0830	4-27-95/0810	113740
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
36-293	29	50	39	29					
36-294	35	36	33	33					
36-Total	64	86	72	62	22	10	1.3	0.6	0.9
37-529	29	38	34	29					
37-530	29	28	32	26					
37-Total	58	66	66	55	8	11	0.5	0.7	0.6
38-531	29	38	39	32					
38-532	25	38	34	27					
38-Total	54	76	73	59	22	14	1.3	0.9	1.1

Average Total	66.9	Average Total	67.1			Average	(Kdpm/100cm2)	3.3
Stand. Dev.	6.6	Stand. Dev.	5.0	Student's t value	1.688	Error (95%)	(Kdpm/100cm2)	1.7
						Critical Level	(Kdpm/100cm2)	0.8
						MDA	(Kdpm/100cm2)	1.5

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #9	VENT LINE	66	1	80	2-7-95/0855	4-27-95/0815	113720

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06

POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-151	31	47	42	33					
1-152	29	61	54	30					
1-Total	60	108	96	63	48	33	2.7	2.1	2.4
2-153	30	33	34	31					
2-154	27	37	37	31					
2-Total	57	70	71	62	13	9	0.7	0.6	0.7
3-155	28	30	32	31					
3-156	40	41	27	25					
3-Total	68	71	59	56	3	3	0.2	0.2	0.2
4-157	34	35	33	34					
4-158	30	32	31	34					
4-Total	64	67	64	68	3	-4	0.2	-0.3	-0.0
5-159	24	34	28	28					
5-160	33	28	29	30					
5-Total	57	62	57	58	5	-1	0.3	-0.1	0.1
6-161	28	32	30	30					
6-162	33	31	30	30					
6-Total	61	63	60	60	2	0	0.1	0.0	0.1
7-163	26	33	28	28					
7-164	30	30	32	30					
7-Total	56	63	60	58	7	2	0.4	0.1	0.3
8-165	27	34	29	29					
8-166	33	34	30	30					
8-Total	60	68	59	59	8	0	0.5	0.0	0.2

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #9	VENT LINE		66		1	80	2-7-95/0855	4-27-95/0815	113720
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
9-167	29	30	32	31					
9-168	24	32	29	31					
9-Total	53	62	61	62	9	-1	0.5	-0.1	0.2
10-169	36	35	31	33					
10-170	29	32	30	28					
10-Total	65	67	61	61	2	0	0.1	0.0	0.1
11-171	29	33	30	30					
11-172	36	38	34	35					
11-Total	65	71	64	65	6	-1	0.3	-0.1	0.1
12-173	34	35	30	31					
12-174	27	31	29	30					
12-Total	61	66	59	61	5	-2	0.3	-0.1	0.1
13-175	33	32	30	35					
13-176	31	28	32	30					
13-Total	64	60	62	65	-4	-3	-0.2	-0.2	-0.2
14-177	31	33	33	33					
14-178	31	38	32	33					
14-Total	62	71	65	66	9	-1	0.5	-0.1	0.2
15-179	20	29	33	30					
15-180	36	37	35	35					
15-Total	56	66	68	65	10	3	0.6	0.2	0.4
16-181	28	37	33	35					
16-182	31	45	32	34					
16-Total	59	82	65	69	23	-4	1.3	-0.3	0.5
17-183	30	41	32	30					
17-184	29	32	33	33					
17-Total	59	73	65	63	14	2	0.8	0.1	0.5

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH			PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #9	VENT LINE	66			1	80	2-7-95/0855	4-27-95/0815	113720
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
18-185	33	39	34	34					
18-186	28	31	30	30					
18-Total	61	70	64	64	9	0	0.5	0.0	0.3
19-187	30	31	33	35					
19-188	32	45	34	33					
19-Total	62	76	67	68	14	-1	0.8	-0.1	0.4
20-189	30	32	28	30					
20-190	34	37	29	31					
20-Total	64	69	57	61	5	-4	0.3	-0.3	0.0
21-191	32	38	35	35					
21-192	30	44	34	35					
21-Total	62	82	69	70	20	-1	1.1	-0.1	0.5
22-193	34	37	30	30					
22-194	34	38	32	35					
22-Total	68	75	62	65	7	-3	0.4	-0.2	0.1
23-195	30	34	31	30					
23-196	37	32	38	38					
23-Total	67	66	69	68	-1	1	-0.1	0.1	0.0
24-197	33	32	30	32					
24-198	32	36	33	33					
24-Total	65	68	63	65	3	-2	0.2	-0.1	0.0
25-199	35	36	33	30					
25-200	32	39	29	28					
25-Total	67	75	62	58	8	4	0.5	0.3	0.4
26-201	36	36	31	32					
26-202	28	33	31	31					
26-Total	64	69	62	63	5	-1	0.3	-0.1	0.1

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #9	VENT LINE	66	1	80	2-7-95/0855	4-27-95/0815	113720

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)							
						Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
27-203	28	32	32	33					
27-204	29	28	27	27					
27-Total	57	60	59	60	3	-1	0.2	-0.1	0.1
28-205	31	43	30	30					
28-206	30	32	29	33					
28-Total	61	75	59	63	14	-4	0.8	-0.3	0.3
29-207	30	32	31	30					
29-208	30	32	26	28					
29-Total	60	64	57	58	4	-1	0.2	-0.1	0.1
30-209	26	34	28	30					
30-210	29	28	27	28					
30-Total	55	62	55	58	7	-3	0.4	-0.2	0.1
31-211	28	32	28	28					
31-212	29	30	26	27					
31-Total	57	62	54	55	5	-1	0.3	-0.1	0.1
32-213	33	40	33	33					
32-214	35	41	29	30					
32-Total	68	81	62	63	13	-1	0.7	-0.1	0.3
33-215	33	39	31	32					
33-216	34	33	29	30					
33-Total	67	72	60	62	5	-2	0.3	-0.1	0.1
34-217	28	37	34	33					
34-218	38	28	35	36					
34-Total	66	65	69	69	-1	0	-0.1	0.0	-0.0
35-219	30	39	27	27					
35-220	33	34	32	31					
35-Total	63	73	59	58	10	1	0.6	0.1	0.3

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #9	VENT LINE	66	1	80	2-7-95/0855	4-27-95/0815	113720

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)								
						Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06	
36-221	30	28	31	32						
36-222	32	30	32	33						
36-Total	62	58	63	65	-4	-2	-0.2	-0.1	-0.2	
37-517	32	30	26	27						
37-518	30	31	33	34						
37-Total	62	61	59	61	-1	-2	-0.1	-0.1	-0.1	
38-519	31	26	27	28						
38-520	34	28	28	28						
38-Total	65	54	55	56	-11	1	-0.6	-0.1	-0.3	
39-521	28	31	28	28						
39-522	21	29	24	25						
39-Total	49	60	52	53	11	-1	0.6	-0.1	0.3	
40-523	28	31	30	31						
40-524	30	29	28	27						
40-Total	58	60	58	58	2	0	0.1	0.0	0.1	

Average Total	61.4	Total Average	62.1			Average	(Kdpm/100cm2)	0.2
Stand. Dev.	4.4	Stand. Dev.	4.2	Student's t value	1.685	Error (95%)	(Kdpm/100cm2)	0.1
						Critical Level	(Kdpm/100cm2)	0.6
						MDA	(Kdpm/100cm2)	1.2

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #10	VENT LINE	70	1	84	2-6-95/1520	4-27-95/0820	114780

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06

POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-79	39	144	125	31					
1-80	31	120	125	47					
1-Total	70	264	250	78	194	172	11.0	10.8	10.9
2-81	32	31	39	34					
2-82	32	34	37	34					
2-Total	64	65	76	68	1	8	0.1	0.5	0.3
3-83	35	42	33	31					
3-84	32	39	33	31					
3-Total	67	81	66	62	14	4	0.8	0.3	0.5
4-85	29	34	26	27					
4-86	31	35	32	31					
4-Total	60	69	58	58	9	0	0.5	0.0	0.3
5-87	30	31	65	33					
5-88	32	39	34	34					
5-Total	62	70	99	67	8	32	0.5	2.0	1.2
6-89	29	32	34	34					
6-90	34	36	34	34					
6-Total	63	68	68	68	5	0	0.3	0.0	0.1
7-91	33	35	32	29					
7-92	44	36	31	31					
7-Total	77	71	63	60	-6	3	-0.3	0.2	-0.1
8-93	31	31	34	31					
8-94	33	43	32	31					
8-Total	64	74	66	62	10	4	0.6	0.3	0.4

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #10	VENT LINE	70		1	84	2-6-95/1520	4-27-95/0820	114780
TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
9-95	28	38	30	30					
9-96	31	35	32	31					
9-Total	59	73	62	61	14	1	0.8	0.1	0.4
10-97	31	29	29	30					
10-98	31	33	30	28					
10-Total	62	62	59	58	0	1	0.0	0.1	0.0
11-99	35	35	31	30					
11-100	29	32	29	33					
11-Total	64	67	60	63	3	-3	0.2	-0.2	-0.0
12-101	31	33	35	38					
12-102	30	24	34	32					
12-Total	61	57	69	70	-4	-1	-0.2	-0.1	-0.1
13-103	40	47	36	35					
13-104	29	32	34	33					
13-Total	69	79	70	68	10	2	0.6	0.1	0.3
14-105	36	32	30	32					
14-106	34	40	34	34					
14-Total	70	72	64	66	2	-2	0.1	-0.1	-0.0
15-107	37	39	30	35					
15-108	42	38	37	38					
15-Total	79	77	67	73	-2	-6	-0.1	-0.4	-0.2
16-109	32	36	29	32					
16-110	38	47	35	32					
16-Total	70	83	64	64	13	0	0.7	0.0	0.4
17-111	32	40	33	33					
17-112	30	38	35	34					
17-Total	62	78	68	67	16	1	0.9	0.1	0.5

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #10	VENT LINE	70		1	84	2-6-95/1520	4-27-95/0820	114780
TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
18-113	33	39	36	38				
18-114	34	41	34	36				
18-Total	67	80	70	74	13	-4	0.7	-0.3	0.2
19-115	35	37	38	35				
19-116	29	39	35	38				
19-Total	64	76	73	73	12	0	0.7	0.0	0.3
20-117	30	33	31	34				
20-118	33	37	35	34				
20-Total	63	70	66	68	7	-2	0.4	-0.1	0.1
21-119	34	35	34	36				
21-120	29	37	34	33				
21-Total	63	72	68	69	9	-1	0.5	-0.1	0.2
22-121	35	40	32	32				
22-122	34	33	35	36				
22-Total	69	73	67	68	4	-1	0.2	-0.1	0.1
23-123	31	35	36	36				
23-124	31	35	34	37				
23-Total	62	70	70	73	8	-3	0.5	-0.2	0.1
24-125	33	31	32	30				
24-126	31	32	33	33				
24-Total	64	63	65	63	-1	2	-0.1	0.1	0.0
25-127	33	34	33	32				
25-128	34	37	33	37				
25-Total	67	71	66	69	4	-3	0.2	-0.2	0.0
26-129	33	36	35	36				
26-130	33	41	34	35				
26-Total	66	77	69	71	11	-2	0.6	-0.1	0.2

ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #10	VENT LINE	70		1	84	2-6-95/1520	4-27-95/0820	114780
TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
27-131	30	44	37	34				
27-132	35	29	34	34				
27-Total	65	73	71	68	8	3	0.5	0.2	0.3
28-133	34	32	31	32				
28-134	33	36	35	34				
28-Total	67	68	66	66	1	0	0.1	0.0	0.0
29-135	32	32	31	32				
29-136	35	39	31	33				
29-Total	67	71	62	65	4	-3	0.2	-0.2	0.0
30-137	35	36	30	33				
30-138	33	38	32	33				
30-Total	68	74	62	66	6	-4	0.3	-0.3	0.0
31-139	35	38	29	32				
31-140	30	38	31	32				
31-Total	65	76	60	64	11	-4	0.6	-0.3	0.2
32-141	33	36	29	34				
32-142	39	43	33	31				
32-Total	72	79	62	65	7	-3	0.4	-0.2	0.1
33-143	35	32	35	38				
33-144	29	34	34	37				
33-Total	64	66	69	75	2	-6	0.1	-0.4	-0.1
34-145	34	36	27	29				
34-146	36	41	38	34				
34-Total	70	77	65	63	7	2	0.4	0.1	0.3
35-147	34	35	34	31				
35-148	35	36	35	37				
35-Total	69	71	69	68	2	1	0.1	0.1	0.1

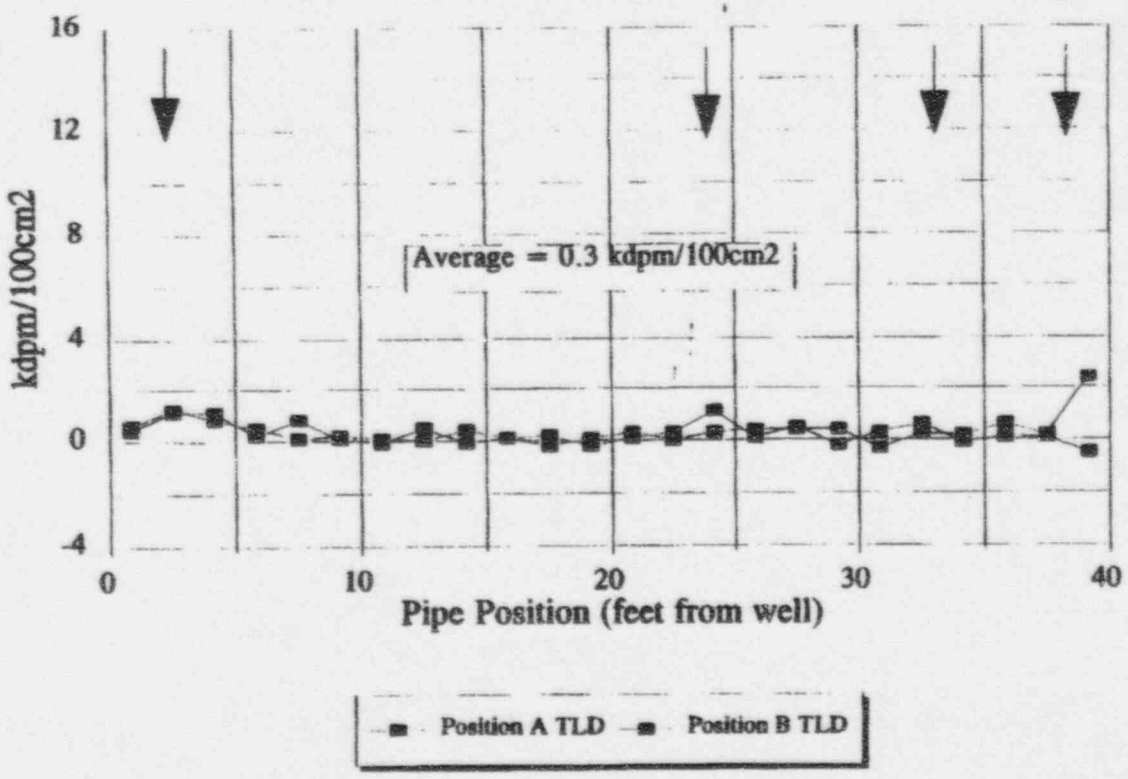
ATTACHMENT 8.4
ESW 1" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #10	VENT LINE		70		1	84	2-6-95/1520	4-27-95/0820	114780
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR *)				Lithium Borate =	6.49e+06	Calcium Sulfate =	7.24e+06
36-149	32	31	32	31					
36-150	35	33	32	33					
36-Total	67	64	64	64	-3	0	-0.2	0.0	-0.1
37-505	28	24	29	29					
37-506	32	29	28	26					
37-Total	60	53	57	55	-7	2	-0.4	0.1	-0.1
38-507	29	25	31	29					
38-508	27	34	30	31					
38-Total	56	59	61	60	3	1	0.2	0.1	0.1
39-509	28	28	29	29					
39-510	29	27	32	30					
39-Total	57	55	61	59	-2	2	-0.1	0.1	0.0
40-511	29	32	28	28					
40-512	29	31	27	29					
40-Total	58	63	55	57	5	-2	0.3	-0.1	0.1
41-513	35	33	28	30					
41-514	27	30	26	26					
41-Total	62	63	54	56	1	-2	0.1	-0.1	-0.0
42-515	27	28	28	25					
42-516	30	32	30	27					
42-Total	57	60	58	52	3	6	0.2	0.4	0.3

Average Total	65.0	Total Average		65.3			Average	(Kdpm/100cm2)	0.4
Stand. Dev.	4.9	Stand. Dev.		5.7	Student's t value	1.683	Error (95%)	(Kdpm/100cm2)	0.4
							Critical Level	(Kdpm/100cm2)	0.7
							MDA	(Kdpm/100cm2)	1.3

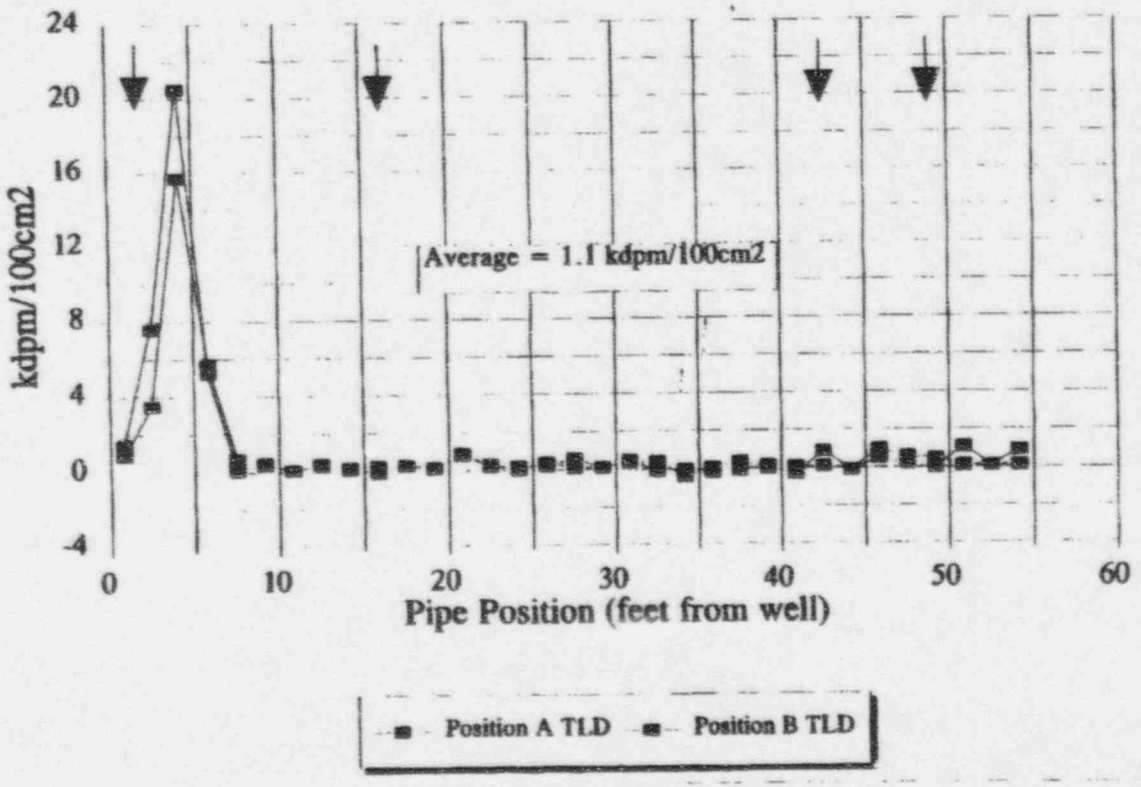
ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

TLD Results for ESW #1 - 2" Pipe
(note: arrows denote elbows)



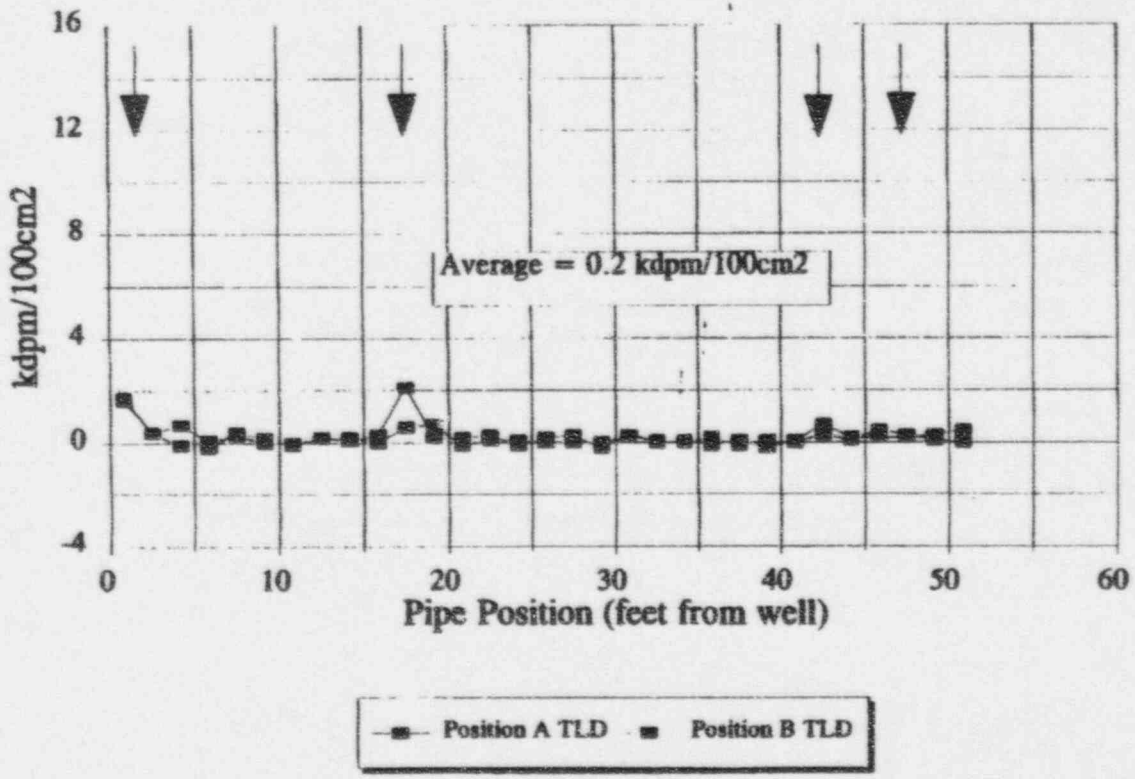
ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

TLD Results for ESW #2 - 2" Pipe
(note: arrows dcnote elbows)



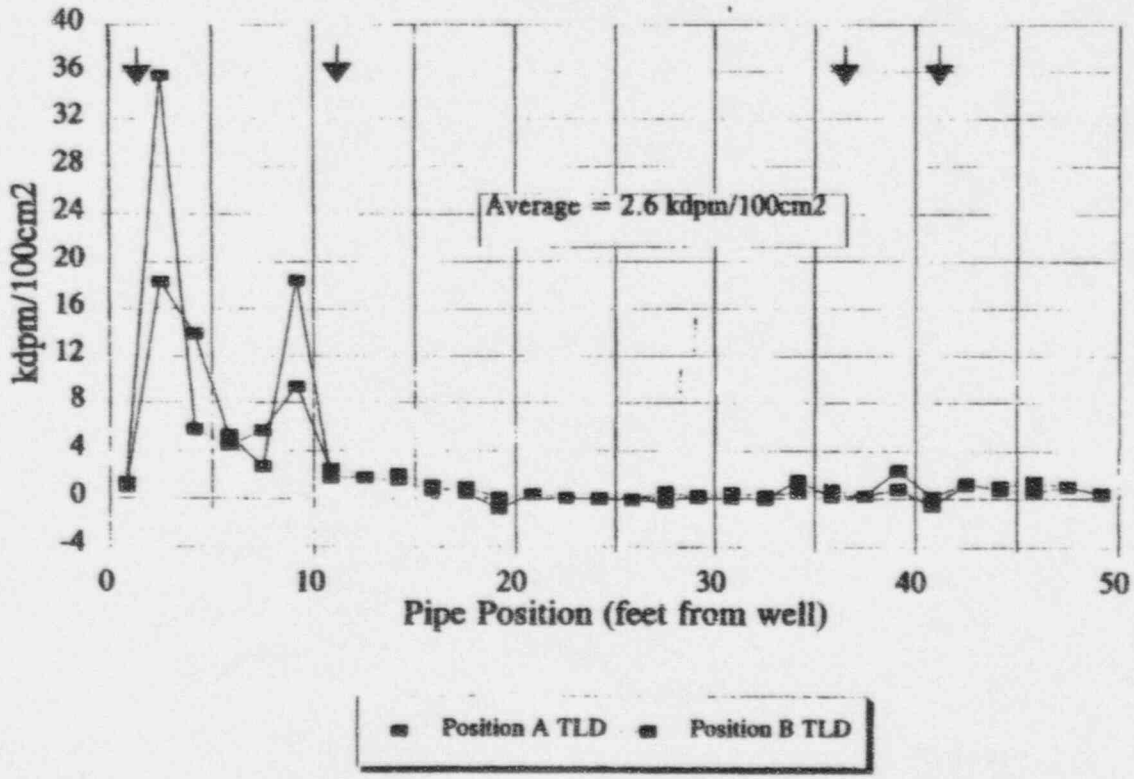
ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

TLD Results for ESW #3 - 2" Pipe
(note: arrows denote elbows)



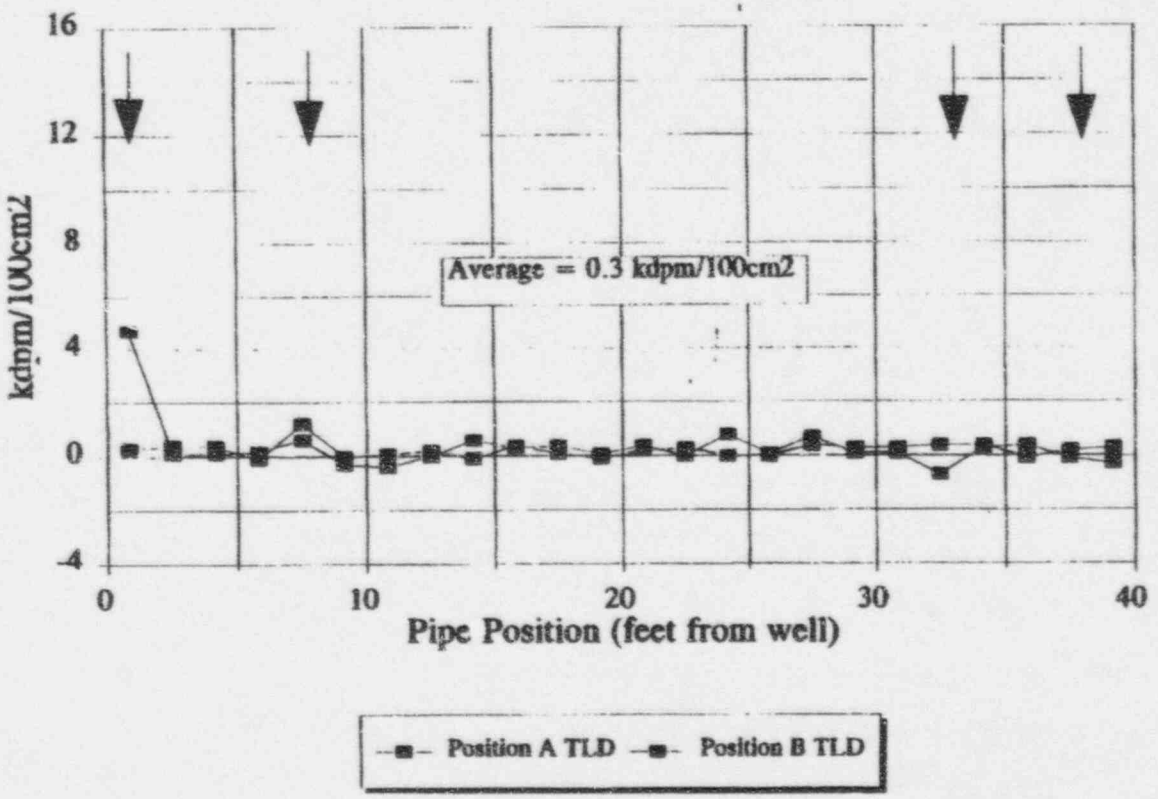
ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

TLDResults for ESW #4 - 2" Pipe
(note: arrows denote elbows)

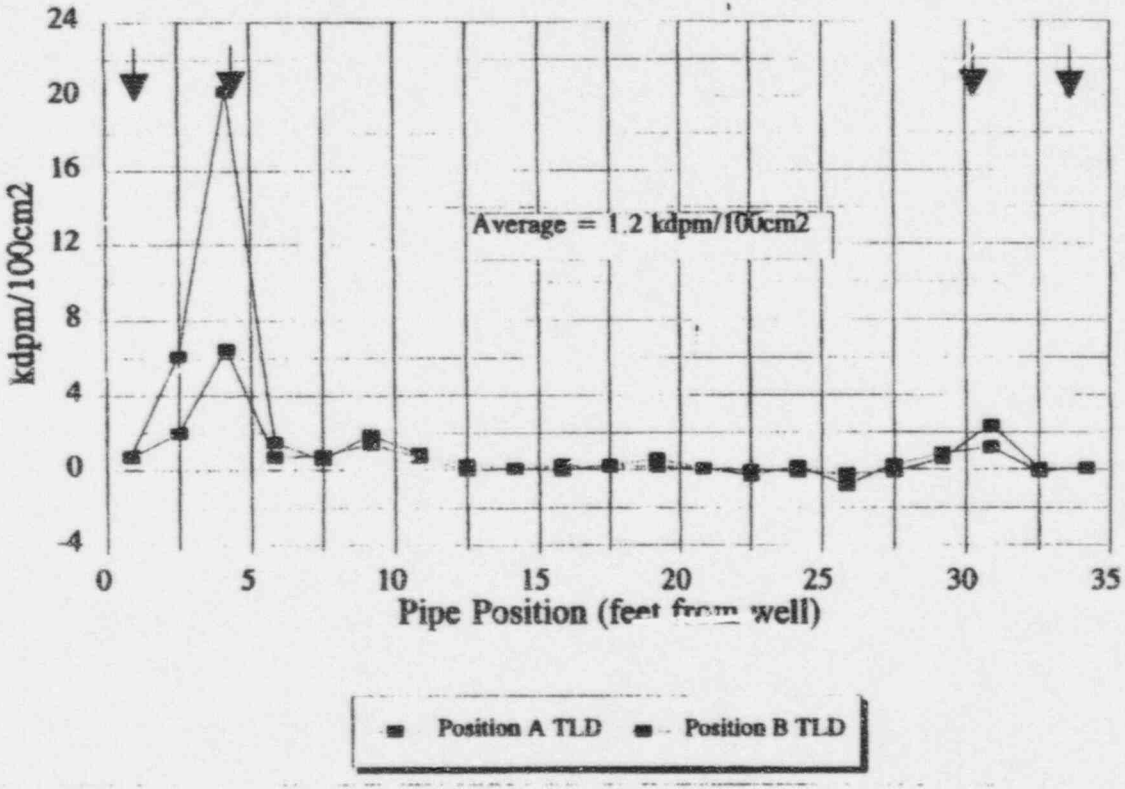


ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

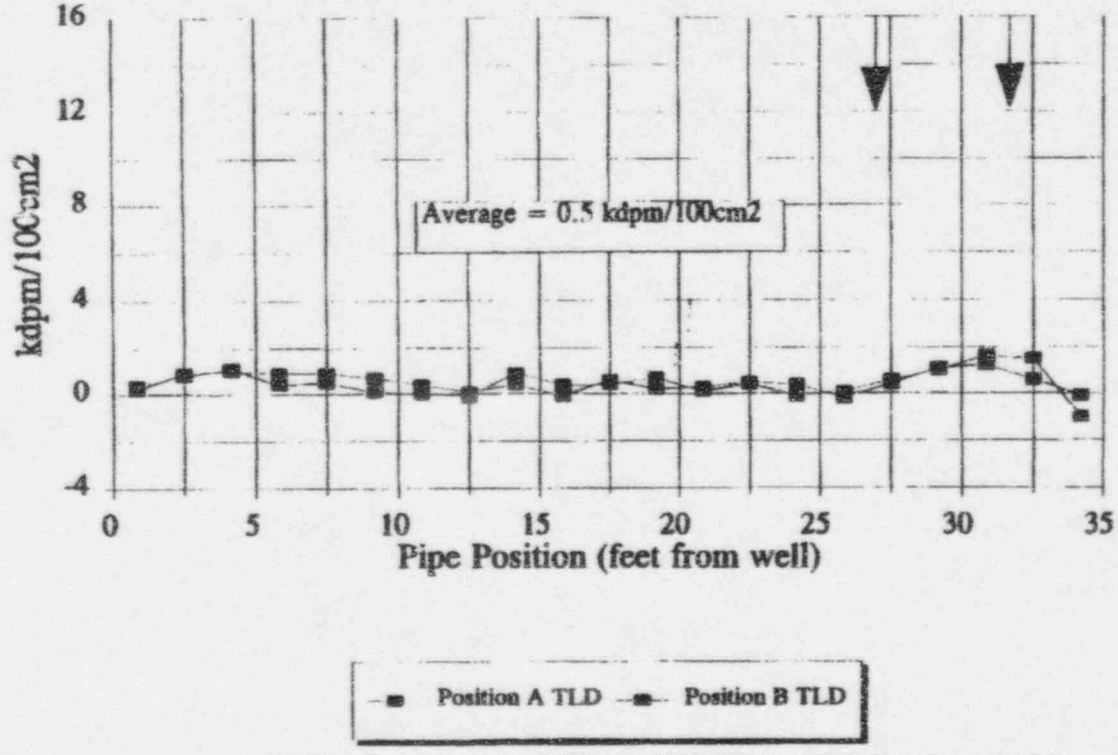
TLD Results for ESW #5 - 2" Pipe
(note: arrows denote elbows)



TLD Results for ESW #6 - 2" Pipe
(note: arrows denote elbows)

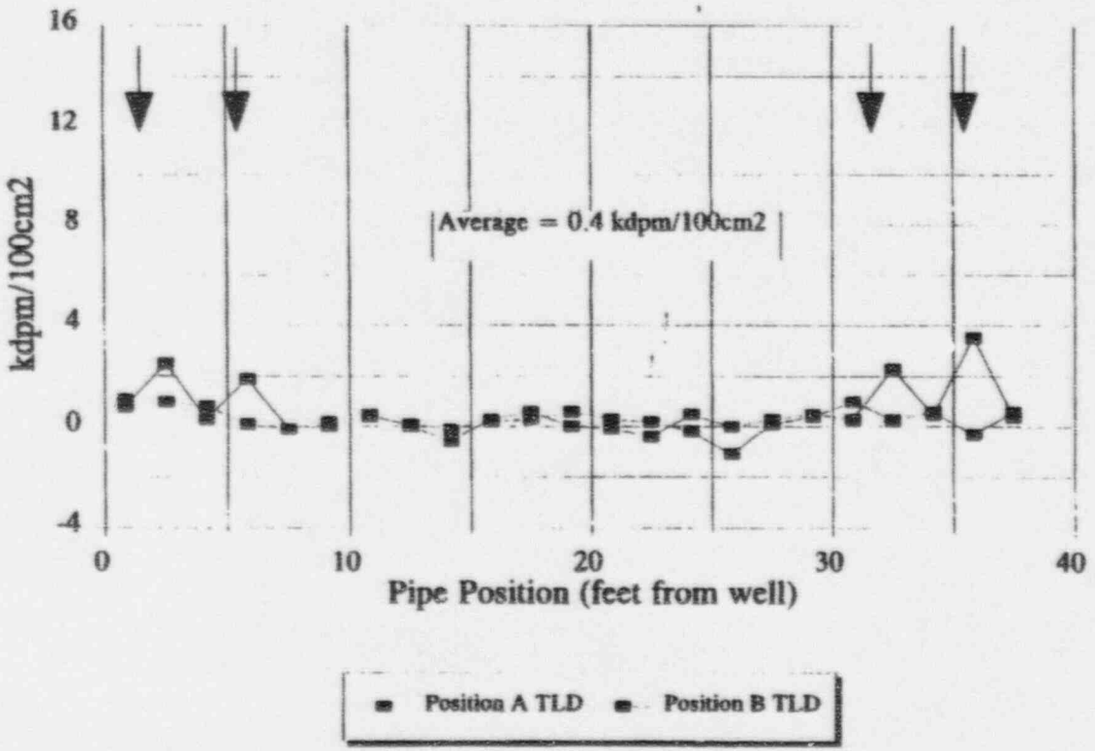


TLD Results for ESW #7 - 2" Pipe
(note: arrows denote elbows)



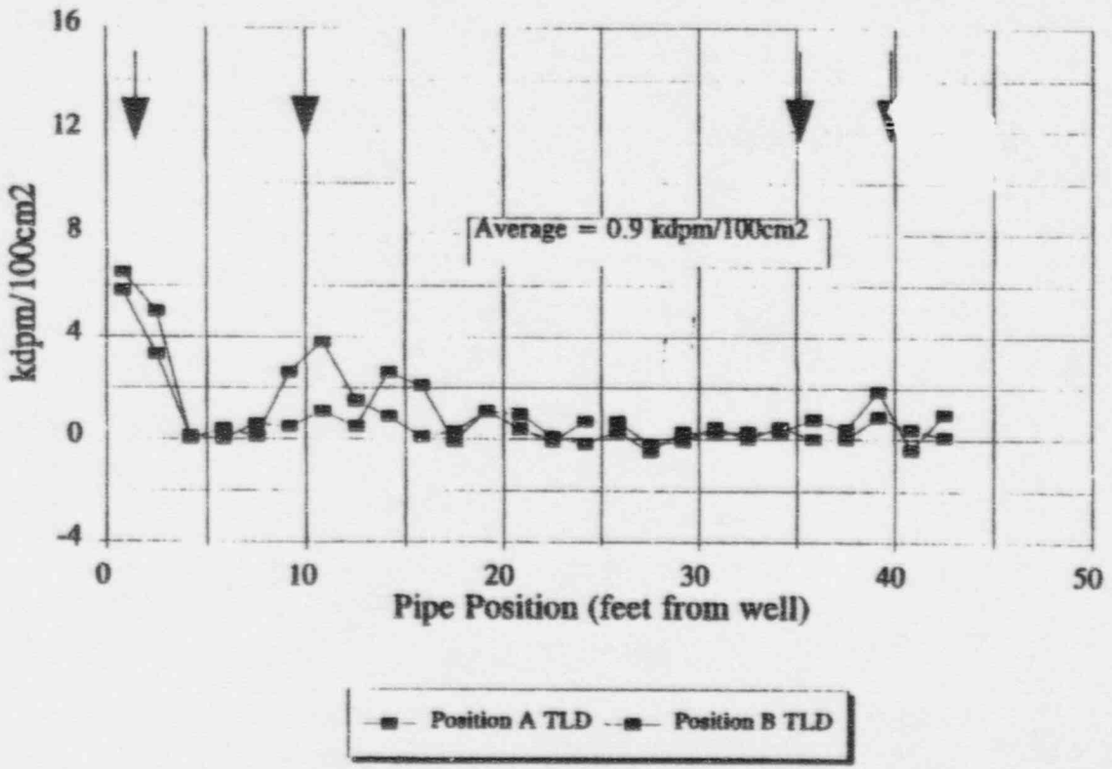
ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

TLD Results for ESW #8 - 2" Pipe
(note: arrows denote elbows)



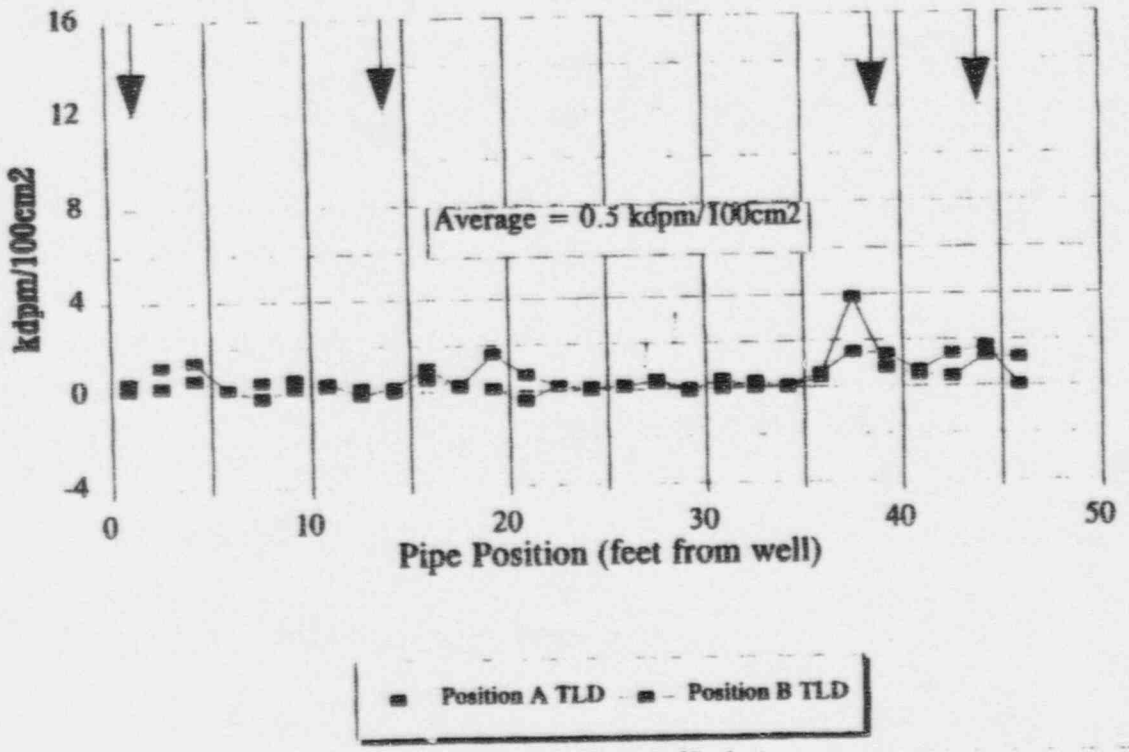
ATTACHMENT 8.3
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

TLD Results for ESW #9 - 2" Pipe
(note: arrows denote elbows)



ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

TLD Results for ESW #10 - 2" Pipe
(note: arrows denote elbows)



ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #1	DRAIN LINE	42	2	48	2-8-95/0815	4-26-95/1030	111015

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)					Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-1031	30	31	33	26	1	7	0.1	1.0	0.6
1-1032	31	34	31	28	3	3	0.4	0.4	0.4
2-1033	28	40	33	26	12	7	1.4	1.0	1.2
2-1034	29	37	36	28	8	8	1.0	1.2	1.1
3-1035	32	35	34	25	3	9	0.4	1.3	0.8
3-1036	27	38	34	28	11	6	1.3	0.9	1.1
4-1037	31	37	30	28	6	2	0.7	0.3	0.5
4-1038	27	27	29	26	0	3	0.0	0.4	0.2
5-1039	28	29	28	28	1	0	0.1	0.0	0.1
5-1040	23	33	30	27	10	3	1.2	0.4	0.8
6-1041	30	32	29	28	2	1	0.2	0.1	0.2
6-1042	25	27	27	27	2	0	0.2	0.0	0.1
7-1043	23	25	26	26	2	0	0.2	0.0	0.1
7-1044	25	27	24	27	2	-3	0.2	-0.4	-0.1
8-1045	25	27	26	27	2	-1	0.2	-0.1	0.0
8-1046	27	34	31	30	7	1	0.8	0.1	0.5
9-1047	31	35	29	27	4	2	0.5	0.3	0.4
9-1048	31	29	28	28	-2	0	-0.2	0.0	-0.1
10-1049	28	30	30	30	2	0	0.2	0.0	0.1
10-1050	28	29	28	28	1	0	0.1	0.0	0.1
11-1051	28	26	27	28	-2	-1	-0.2	-0.1	-0.2
11-1052	25	30	25	27	5	-2	0.6	-0.3	0.2
12-1053	27	29	27	27	2	0	0.2	0.0	0.1
12-1054	31	29	26	27	-2	-1	-0.2	-0.1	-0.2
13-1055	26	29	26	24	3	2	0.4	0.3	0.3
13-1056	26	27	27	27	1	0	0.1	0.0	0.1
14-1057	29	27	26	25	-2	1	-0.2	0.1	-0.0
14-1058	30	33	29	27	3	2	0.4	0.3	0.3
15-1059	29	31	33	30	2	3	0.2	0.4	0.3
15-1060	28	30	48	34	2	14	0.2	2.0	1.1
16-1061	27	32	29	28	5	1	0.6	0.1	0.4
16-1062	31	35	32	34	4	-2	0.5	-0.3	0.1
17-1063	28	34	29	28	6	1	0.7	0.1	0.4
17-1064	29	37	30	30	8	0	1.0	0.0	0.5

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #1	DRAIN LINE		42		2	48	4-95/0815	4-26-95/1030	111015
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR")				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
18-1065	29	36	30	30	7	0	0.8	0.0	0.4
18-1066	32	27	29	28	-5	1	-0.6	0.1	-0.2
19-1067	32	30	26	28	-2	-2	-0.2	-0.3	-0.3
19-1068	31	34	34	33	3	1	0.4	0.1	0.3
20-1069	28	32	31	31	4	0	0.5	0.0	0.2
20-1070	32	40	33	31	8	2	1.0	0.3	0.6
21-1071	30	31	31	29	1	2	0.1	0.3	0.2
21-1072	32	30	28	28	-2	0	-0.2	0.0	-0.1
22-1073	25	32	30	28	7	2	0.8	0.3	0.6
22-1074	36	38	28	28	2	0	0.2	0.0	0.1
23-1075	31	35	29	29	4	0	0.5	0.0	0.2
23-1076	28	29	27	26	1	1	0.1	0.1	0.1
24-1077	35	56	48	33	21	15	2.5	2.2	2.4
24-1078	43	34	35	35	-9	0	-1.1	0.0	-0.5
Average	29.1		Average	28.4			Average	(Kdpm/100cm2)	0.3
							Error (95%)	(Kdpm/100cm2)	0.1
							Critical Level	(Kdpm/100cm2)	0.8
Stsnd. Dev.	3.5		Stand. Dev.	2.4	Student's t value	1.679	MDA	(Kdpm/100cm2)	1.6

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #2	DRAIN LINE	55	2	66	2-8-95/0755	4-26-95/1020	111025

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-959	31	35	34	25	4	9	0.5	1.3	0.9
1-960	28	41	35	25	13	10	1.6	1.5	1.5
2-961	31	61	51	28	30	23	3.6	3.3	3.5
2-962	33	101	73	25	68	48	8.2	7.0	7.6
3-963	32	158	143	32	126	111	15.2	16.1	15.7
3-964	36	196	180	31	160	149	19.3	21.6	20.5
4-965	30	78	67	29	48	38	5.8	5.5	5.7
4-966	32	72	65	27	40	38	4.8	5.5	5.2
5-967	27	31	33	27	4	6	0.5	0.9	0.7
5-968	32	31	32	30	-1	2	-0.1	0.3	0.1
6-969	27	31	29	27	4	2	0.5	0.3	0.4
6-970	27	31	31	28	4	3	0.5	0.4	0.5
7-971	26	29	26	27	3	-1	0.4	-0.1	0.1
7-972	27	30	30	31	3	-1	0.4	-0.1	0.1
8-973	26	33	28	28	7	0	0.8	0.0	0.4
8-974	32	35	29	28	3	1	0.4	0.1	0.3
9-975	25	28	27	27	3	0	0.4	0.0	0.2
9-976	29	28	29	27	-1	2	-0.1	0.3	0.1
10-977	29	27	27	27	-2	0	-0.2	0.0	-0.1
10-978	25	30	28	28	5	0	0.6	0.0	0.3
11-979	26	29	28	27	3	1	0.4	0.1	0.3
11-980	27	32	26	26	5	0	0.6	0.0	0.3
12-981	28	31	29	29	3	0	0.4	0.0	0.2
12-982	27	28	27	26	1	1	0.1	0.1	0.1
13-983	34	42	35	29	8	6	1.0	0.9	0.9
13-984	29	38	33	29	9	4	1.1	0.6	0.8
14-985	33	36	29	28	3	1	0.4	0.1	0.3
14-986	32	34	30	29	2	1	0.2	0.1	0.2
15-987	33	35	28	29	2	-1	0.2	-0.1	0.0
15-988	33	36	28	28	3	0	0.4	0.0	0.2
16-989	29	34	29	28	5	1	0.6	0.1	0.4
16-990	27	29	26	25	2	1	0.2	0.1	0.2
17-991	25	26	26	26	1	0	0.1	0.0	0.1

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #2	DRAIN LINE	55		2	66	2-8-95/0755	4-26-95/1020	111025
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR")			Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
17-992	25	34	29	28	9	1	1.1	0.1	0.6
18-993	27	27	28	27	0	1	0.0	0.1	0.1
18-994	29	30	27	27	1	0	0.1	0.0	0.1
19-995	26	32	28	26	6	2	0.7	0.3	0.5
19-996	29	35	28	27	6	1	0.7	0.1	0.4
20-997	28	27	25	26	-1	-1	-0.1	-0.1	-0.1
20-998	26	31	27	26	5	1	0.6	0.1	0.4
21-999	25	27	25	26	2	-1	0.2	-0.1	0.0
21-1000	28	27	28	32	-1	-4	-0.1	-0.6	-0.4
22-1001	26	25	25	27	-1	-2	-0.1	[illegible]	-0.2
22-1002	25	27	26	26	2	0	0.2	[illegible]	0.1
23-1003	28	27	27	27	-1	0	-0.1	0.0	-0.1
23-1004	28	33	27	26	5	1	0.6	0.1	0.4
24-1005	29	34	25	27	5	-2	0.6	-0.3	0.2
24-1006	26	27	24	25	1	-1	0.1	-0.1	-0.0
25-1007	28	29	28	27	1	1	0.1	0.1	0.1
25-1008	30	28	28	30	-2	-2	-0.2	-0.3	-0.3
26-1009	27	28	26	26	1	0	0.1	0.0	0.1
26-1010	28	27	40	27	-1	13	-0.1	1.9	0.9
27-1011	30	27	27	26	-3	1	-0.4	0.1	-0.1
27-1012	32	31	28	29	-1	-1	-0.1	-0.1	-0.1
28-1013	27	34	30	29	7	1	0.8	0.1	0.5
28-1014	29	37	35	28	8	7	1.0	1.0	1.0
29-1015	27	27	29	26	0	3	0.0	0.4	0.2
29-1016	25	32	30	28	7	2	0.8	0.3	0.6
30-1017	33	30	27	25	-3	2	-0.4	0.3	-0.0
30-1018	29	32	30	26	3	4	0.4	0.6	0.5
31-1019	33	42	36	29	9	7	1.1	1.0	1.1
31-1020	27	27	29	27	0	2	0.0	0.3	0.1
32-1021	31	31	28	27	0	1	0.0	0.1	0.1
32-1022	27	27	28	26	0	2	0.0	0.3	0.1

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #2	DRAIN LINE		55		2	66	2-8-95/0755	4-26-95/1020	111025
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
33-1023	42	47	46	49	5	-3	0.6	-0.4	0.1
33-1024	41	52	44	41	11	3	1.3	0.4	0.9
							Average	(Kdpm/100cm2)	1.1
							Error (95%)	(Kdpm/100cm2)	0.7
Average	29.1	Average		26.0			Critical Level	(Kdpm/100cm2)	1.0
Stand. Dev.	3.5	Stand. Dev.		3.5	Student's t value	1.67	MDA	(Kdpm/100cm2)	2.0

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #3	DRAIN LINE	51	2	62	2-8-95/0655	4-26-95/1015	111080

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)					Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-849	25	38	38	25	13	13	1.6	1.9	1.7
1-850	25	35	39	25	10	14	1.2	2.0	1.6
2-851	26	29	32	29	3	3	0.4	0.4	0.4
2-852	28	28	32	27	0	5	0.0	0.7	0.4
3-853	32	33	28	30	1	-2	0.1	-0.3	-0.1
3-854	27	33	32	27	6	5	0.7	0.7	0.7
4-855	33	28	29	28	-5	1	-0.6	0.1	-0.2
4-856	32	35	28	29	3	-1	0.4	-0.1	0.1
5-587	25	30	30	29	5	1	0.6	0.1	0.4
5-858	26	30	29	28	4	1	0.5	0.1	0.3
6-859	28	30	29	28	2	1	0.2	0.1	0.2
6-860	35	35	29	29	0	0	0.0	0.0	0.0
7-861	32	28	33	31	-4	2	-0.5	0.3	-0.1
7-862	28	29	29	30	1	-1	0.1	-0.1	-0.0
8-863	27	30	30	30	3	0	0.4	0.0	0.2
8-864	28	30	30	29	2	1	0.2	0.1	0.2
9-865	28	29	28	28	1	0	0.1	0.0	0.1
9-866	28	33	28	29	5	-1	0.6	-0.1	0.2
10-867	25	28	30	28	3	2	0.4	0.3	0.3
10-868	30	29	27	26	-1	1	-0.1	0.1	0.0
11-869	33	48	45	28	15	17	1.8	2.5	2.1
11-870	25	32	31	29	7	2	0.8	0.3	0.6
12-871	25	27	28	27	2	1	0.2	0.1	0.2
12-872	27	33	34	30	6	4	0.7	0.6	0.7
13-873	28	30	28	27	2	1	0.2	0.1	0.2
13-874	32	32	28	29	0	-1	0.0	-0.1	-0.1
14-875	28	30	29	27	2	2	0.2	0.3	0.3
14-876	28	30	26	26	2	0	0.2	0.0	0.1
15-877	26	26	25	27	0	-2	0.0	-0.3	-0.1
15-878	26	27	27	26	1	1	0.1	0.1	0.1
16-879	25	29	27	27	4	0	0.5	0.0	0.2
16-880	26	27	26	27	1	-1	0.1	-0.1	-0.0

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #3	DRAIN LINE	51	2	62	2-8-95/0655	4-26-95/1015	111080

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
17-881	26	30	28	27	4	1	0.5	0.1	0.3
17-882	27	27	27	27	0	0	0.0	0.0	0.0
18-883	29	27	24	25	-2	-1	-0.2	-0.1	-0.2
18-884	29	29	24	24	0	0	0.0	0.0	0.0
19-885	26	30	27	26	4	1	0.5	0.1	0.3
19-886	27	29	27	25	2	2	0.2	0.3	0.3
20-887	27	28	27	27	1	0	0.1	0.0	0.1
20-888	26	28	28	29	2	-1	0.2	-0.1	0.0
21-889	25	27	26	27	2	-1	0.2	-0.1	0.0
21-890	27	28	25	25	1	0	0.1	0.0	0.1
22-891	28	33	27	28	5	-1	0.6	-0.1	0.2
22-892	27	27	27	28	0	-1	0.0	-0.1	-0.1
23-893	28	27	27	27	-1	0	-0.1	0.0	-0.1
23-894	27	28	27	26	1	1	0.1	0.1	0.1
24-895	31	32	27	26	1	1	0.1	0.1	0.1
24-896	26	23	24	24	-3	0	-0.4	0.0	-0.2
25-897	25	26	25	26	1	-1	0.1	-0.1	-0.0
25-898	26	27	27	26	1	1	0.1	0.1	0.1
26-899	27	30	31	29	3	2	0.4	0.3	0.3
26-900	29	35	32	28	6	4	0.7	0.6	0.7
27-901	30	31	29	28	1	1	0.1	0.1	0.1
27-902	30	33	28	28	3	0	0.4	0.0	0.2
28-903	26	32	30	26	6	2	0.7	0.3	0.5
28-904	29	30	28	26	1	2	0.1	0.3	0.2
29-905	26	31	26	26	5	0	0.6	0.0	0.3
29-906	30	31	29	27	1	2	0.1	0.3	0.2
30-907	29	29	29	27	0	2	0.0	0.3	0.1
30-908	31	32	32	29	1	3	0.1	0.4	0.3
31-909	47	45	44	43	-2	1	-0.2	0.1	-0.0
31-910	48	49	53	47	1	6	0.1	0.9	0.5

Average	28.5	Average	28.0			Average	(Kdpm/100cm2)	0.2
Stand. Dev.	4.2	Stand. Dev.	3.5	Student's t value	1.671	Error (95%)	(Kdpm/100cm2)	0.1
						Critical Level	(Kdpm/100cm2)	1.2
						MDA	(Kdpm/100cm2)	2.4

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #4	DRAIN LINE	47	2	60	2-8-95/0655	4-26-95/1000	111065

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07

POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-735	27	35	37	30	8	7	1.0	1.0	1.0
1-736	26	38	37	28	12	9	1.4	1.3	1.4
2-737	28	162	173	32	134	141	16.2	20.4	18.3
2-738	29	279	315	30	250	285	30.2	41.3	35.7
3-739	29	129	134	25	100	109	12.1	15.8	13.9
3-740	28	70	73	28	42	45	5.1	6.5	5.8
4-741	29	72	65	27	43	38	5.2	5.5	5.3
4-742	27	60	63	29	33	34	4.0	4.9	4.5
5-743	28	48	50	29	20	21	2.4	3.0	2.7
5-744	34	74	73	27	40	46	4.8	6.7	5.7
6-745	34	169	175	33	135	142	16.3	20.6	18.4
6-746	33	97	106	30	64	76	7.7	11.0	9.4
7-747	29	41	40	25	12	15	1.4	2.2	1.8
7-748	27	46	48	29	19	19	2.3	2.8	2.5
8-749	30	45	39	27	15	12	1.8	1.7	1.8
8-750	29	43	40	27	14	13	1.7	1.9	1.8
9-751	26	42	45	29	16	16	1.9	2.3	2.1
9-752	25	38	37	25	13	11	1.6	1.6	1.6
10-753	27	36	35	28	9	7	1.1	1.0	1.1
10-754	26	31	33	27	5	6	0.6	0.9	0.7
11-755	27	31	30	26	4	4	0.5	0.6	0.5
11-756	25	34	33	27	9	6	1.1	0.9	1.0
12-757	25	27	28	41	2	-13	0.2	-1.9	-0.8
12-758	30	29	29	27	-1	2	-0.1	0.3	0.1
13-759	24	29	28	27	5	1	0.6	0.1	0.4
13-760	25	31	29	28	6	1	0.7	0.1	0.4
14-761	28	28	27	25	0	2	0.0	0.3	0.1
14-762	27	27	27	26	0	1	0.0	0.1	0.1
15-763	24	24	25	25	0	0	0.0	0.0	0.0
15-764	25	27	25	25	2	0	0.2	0.0	0.1
16-765	26	24	25	25	-2	0	-0.2	0.0	-0.1
16-766	25	25	24	24	0	0	0.0	0.0	0.0

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #4	DRAIN LINE		47		2	60	2-8-95/0655	4-26-95/1000	111065
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
17-767	21	14	32	30	-7	2	-0.8	0.3	-0.3
17-768	46	58	25	27	12	-2	1.4	-0.3	0.6
18-769	26	29	27	26	3	1	0.4	0.1	0.3
18-770	29	30	27	26	1	1	0.1	0.1	0.1
19-771	25	31	26	24	6	2	0.7	0.3	0.5
19-772	25	25	25	24	0	1	0.0	0.1	0.1
20-773	25	28	26	24	3	2	0.4	0.3	0.3
20-774	28	26	26	25	-2	1	-0.2	0.1	-0.0
21-775	26	30	29	26	4	3	0.5	0.4	0.5
21-776	25	39	37	27	14	10	1.7	1.4	1.6
22-777	26	35	30	27	9	3	1.1	0.4	0.8
22-778	28	29	28	26	1	2	0.1	0.3	0.2
23-779	25	27	26	24	2	2	0.2	0.3	0.3
23-780	25	27	26	24	3	2	0.4	0.3	0.3
24-781	26	33	30	25	7	5	0.8	0.7	0.8
24-782	27	47	44	27	20	17	2.4	2.5	2.4
25-783	39	38	42	49	-1	-7	-0.1	-1.0	-0.6
25-784	38	39	42	40	1	2	0.1	0.3	0.2
26-785	51	61	64	56	10	8	1.2	1.2	1.2
26-786	51	63	63	55	12	8	1.4	1.2	1.3
27-787	47	54	66	57	7	9	0.8	1.3	1.1
27-788	50	56	62	56	6	6	0.7	0.9	0.8
28-789	47	63	61	54	16	7	1.9	1.0	1.5
28-790	52	58	60	57	6	3	0.7	0.4	0.6
29-791	42	52	56	49	10	7	1.2	1.0	1.1
29-792	44	53	59	52	9	7	1.1	1.0	1.1
30-793	42	51	52	52	9	0	1.1	0.0	0.5
30-794	44	48	51	49	4	2	0.5	0.3	0.4

Average	31.0	Average	32.2			Average	(Kdpm/100cm2)	2.6
Stand. Dev.	8.3	Stand. Dev.	10.6	Student's t value	1.672	Error (95%)	(Kdpm/100cm2)	1.3
						Critical Level	(Kdpm/100cm2)	2.4
						MDA	(Kdpm/100cm2)	4.7

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #5	DRAIN LINE	43	2	48	2-7-95/1230	4-26-95/0955	112165

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07

POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-469	27	31	30	29	4	1	0.5	0.1	0.3
1-470	25	73	52	27	48	25	5.7	3.6	4.7
2-471	26	29	28	25	3	3	0.4	0.4	0.4
2-472	26	27	27	27	1	0	0.1	0.0	0.1
3-473	22	28	26	25	6	1	0.7	0.1	0.4
3-474	28	29	25	25	1	0	0.1	0.0	0.1
4-475	27	27	23	25	0	-2	0.0	-0.3	-0.1
4-476	25	27	26	25	2	1	0.2	0.1	0.2
5-477	25	31	38	26	6	12	0.7	1.7	1.2
5-478	23	28	31	27	5	4	0.6	0.6	0.6
6-479	29	27	23	21	-2	2	-0.2	0.3	0.0
6-480	31	30	20	23	-1	-3	-0.1	-0.4	-0.3
7-481	29	31	24	24	2	0	0.2	0.0	0.1
7-482	30	24	26	26	-6	0	-0.7	0.0	-0.4
8-483	25	27	27	26	2	1	0.2	0.1	0.2
8-484	27	29	29	31	2	-2	0.2	-0.3	-0.0
9-485	24	23	24	25	-1	-1	-0.1	-0.1	-0.1
9-486	29	34	29	25	5	4	0.6	0.6	0.6
10-487	24	28	29	27	4	2	0.5	0.3	0.4
10-488	25	28	26	25	3	1	0.4	0.1	0.3
11-489	26	27	29	28	1	1	0.1	0.1	0.1
11-490	22	27	28	26	5	2	0.6	0.3	0.4
12-491	26	24	23	23	-2	0	-0.2	0.0	-0.1
12-492	25	29	27	29	4	-2	0.5	-0.3	0.1
13-645	32	33	28	26	1	2	0.1	0.3	0.2
13-646	26	30	28	26	4	2	0.5	0.3	0.4
14-647	22	25	23	22	3	1	0.4	0.1	0.3
14-648	27	28	25	26	1	-1	0.1	-0.1	-0.0
15-649	26	28	25	26	2	-1	0.2	-0.1	0.0
15-650	18	30	27	26	12	1	1.4	0.1	0.8
16-651	27	28	25	26	1	-1	0.1	-0.1	-0.0

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #5	DRAIN LINE	43	2	48	2-7-95/1230	4-26-95/0955	112165

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)							
						Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
16-652	24	27	24	25	3	-1	0.4	-0.1	0.1
17-653	21	27	25	24	6	1	0.7	0.1	0.4
17-654	23	21	36	25	-2	11	-0.2	1.6	0.7
18-655	22	27	24	24	5	0	0.6	0.0	0.3
18-656	28	28	25	23	0	2	0.0	0.3	0.1
19-657	26	29	26	25	3	1	0.4	0.1	0.3
19-658	22	23	25	24	1	1	0.1	0.1	0.1
20-659	20	24	23	21	4	2	0.5	0.3	0.4
20-660	28	18	24	25	-10	-1	-1.2	-0.1	-0.7
21-661	22	28	25	24	6	1	0.7	0.1	0.4
21-662	23	30	24	25	7	-1	0.8	-0.1	0.3
22-663	27	27	22	24	0	-2	0.0	-0.3	-0.1
22-664	21	27	21	20	6	1	0.7	0.1	0.4
23-665	23	26	23	23	3	0	0.4	0.0	0.2
23-666	23	21	24	24	-2	0	-0.2	0.0	-0.1
24-667	34	33	43	38	-1	5	-0.1	0.7	0.3
24-668	40	38	34	36	-2	-2	-0.2	-0.3	-0.3

Average	25.6	Average	25.6			Average	(Kdpm/100cm2)	0.3
Stand. Dev.	3.8	Stand. Dev.	3.1	Student's t value	1.679	Error (95%)	(Kdpm/100cm2)	0.2
						Critical Level	(Kdpm/100cm2)	1.1
						MDA	(Kdpm/100cm2)	2.1

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #6	DRAIN LINE	39	2	42	2-7-95/1415	4-26-95/0950	112055

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-11	33	41	39	35	8	4	1.0	0.6	0.8
1-12	33	44	33	32	11	1	1.3	0.1	0.7
2-13	32	84	77	36	52	41	6.2	5.9	6.1
2-14	33	54	45	34	21	11	2.5	1.6	2.0
3-15	39	198	194	44	159	150	19.0	21.6	20.3
3-16	34	82	89	38	48	51	5.7	7.3	6.5
4-17	39	57	42	36	18	6	2.2	0.9	1.5
4-18	40	49	37	35	9	2	1.1	0.3	0.7
5-19	38	44	37	34	6	3	0.7	0.4	0.6
5-20	38	51	40	39	13	1	1.6	0.1	0.8
6-21	36	55	45	35	19	10	2.3	1.4	1.9
6-22	36	53	40	35	17	5	2.0	0.7	1.4
7-23	40	50	38	34	10	4	1.2	0.6	0.9
7-24	41	50	38	36	9	2	1.1	0.3	0.7
8-25	36	42	34	35	6	-1	0.7	-0.1	0.3
8-26	45	45	34	34	0	0	0.0	0.0	0.0
9-27	30	33	33	34	3	-1	0.4	-0.1	0.1
9-28	43	44	35	35	1	0	0.1	0.0	0.1
10-29	37	39	31	33	2	-2	0.2	-0.3	-0.0
10-30	35	41	31	32	6	-1	0.7	-0.1	0.3
11-31	32	39	32	33	7	-1	0.8	-0.1	0.3
11-32	29	33	32	33	4	-1	0.5	-0.1	0.2
12-33	32	38	35	32	6	3	0.7	0.4	0.6
12-34	32	37	32	33	5	-1	0.6	-0.1	0.2
13-35	31	34	31	32	3	-1	0.4	-0.1	0.1
13-36	34	34	34	32	0	2	0.0	0.3	0.1
14-37	29	32	29	32	3	-3	0.4	-0.4	-0.0
14-38	37	36	31	34	-1	-3	-0.1	-0.4	-0.3
15-39	33	32	33	34	-1	-1	-0.1	-0.1	-0.1
15-40	32	38	30	32	6	-2	0.7	-0.3	0.2
16-41	36	35	33	35	-1	-2	-0.1	-0.3	-0.2

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #6	DRAIN LINE	39	2	42	2-7-95/1415	4-26-95/0950	112055

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
16-42	50	38	34	35	-12	-1	-1.4	-0.1	-0.8
17-43	31	33	30	33	2	-3	0.2	-0.4	-0.1
17-44	33	36	32	31	3	1	0.4	0.1	0.3
18-45	31	38	34	32	7	2	0.8	0.3	0.6
18-46	32	41	37	32	9	5	1.1	0.7	0.9
19-47	34	53	51	34	19	17	2.3	2.4	2.4
19-48	36	46	42	34	10	8	1.2	1.1	1.2
20-49	32	35	31	32	3	-1	0.4	-0.1	0.1
20-50	37	37	30	32	0	-2	0.0	-0.3	-0.1
21-51	31	32	32	32	1	0	0.1	0.0	0.1
21-52	35	37	32	32	2	0	0.2	0.0	0.1

Average	35.2	Average	34.0			Average	(Kdpm/100cm2)	1.2
Stand. Dev.	4.4	Stand. Dev.	2.4	Student's t value	1.683	Error (95%)	(Kdpm/100cm2)	0.9
						Critical Level	(Kdpm/100cm2)	0.8
						MDA	(Kdpm/100cm2)	1.6

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #7	DRAIN LINE	35	2	42	2-7-95/0723	4-26-95/0940	112457

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07

POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-421	29	32	31	28	3	3	0.4	0.4	0.4
1-422	33	38	30	32	5	-2	0.6	-0.3	0.2
2-423	25	32	31	25	7	6	0.8	0.9	0.8
2-424	23	33	30	26	10	4	1.2	0.6	0.9
3-425	25	35	32	25	10	7	1.2	1.0	1.1
3-426	28	37	34	28	9	6	1.1	0.9	1.0
4-427	27	39	31	35	12	-4	1.4	-0.6	0.4
4-428	27	41	26	25	14	1	1.7	0.1	0.9
5-429	23	29	27	25	6	2	0.7	0.3	0.5
5-430	30	41	33	29	11	4	1.3	0.6	0.9
6-431	30	29	27	25	-1	2	-0.1	0.3	0.1
6-432	33	44	28	28	11	0	1.3	0.0	0.7
7-433	27	28	27	28	1	-1	0.1	-0.1	0.0
7-434	23	28	26	25	5	1	0.6	0.1	0.4
8-435	29	29	24	25	0	-1	0.0	-0.1	-0.1
8-436	26	27	25	25	1	0	0.1	0.0	0.1
9-437	22	33	31	27	11	4	1.3	0.6	0.9
9-438	35	38	30	27	3	3	0.4	0.4	0.4
10-439	24	32	24	25	8	-1	1.0	-0.1	0.4
10-440	29	28	25	26	-1	-1	-0.1	-0.1	-0.1
11-441	27	35	24	25	8	-1	1.0	-0.1	0.4
11-442	21	30	26	25	9	1	1.1	0.1	0.6
12-443	24	33	29	27	9	2	1.1	0.3	0.7
12-444	25	28	26	26	3	0	0.4	0.0	0.2
13-445	26	26	25	24	0	1	0.0	0.1	0.1
13-446	21	29	26	28	8	-2	1.0	-0.3	0.3
14-447	25	32	24	24	7	0	0.8	0.0	0.4
14-448	25	32	27	26	7	1	0.8	0.1	0.5
15-449	34	33	22	23	-1	-1	-0.1	-0.1	-0.1
15-450	23	28	23	22	5	1	0.6	0.1	0.4
16-451	23	24	25	25	1	0	0.1	0.0	0.1

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #7	DRAIN LINE	35		2	42	2-7-95/0723	4-26-95/0940	112457
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
16-452	29	25	25	24	-4	1	-0.5	0.1	-0.2
17-453	22	29	27	25	7	2	0.8	0.3	0.6
17-454	25	32	28	28	7	0	0.8	0.0	0.4
18-455	27	36	36	29	9	7	1.1	1.0	1.0
18-456	25	37	31	26	12	5	1.4	0.7	1.1
19-457	25	38	38	27	13	11	1.5	1.6	1.6
19-458	36	46	42	34	10	8	1.2	1.1	1.2
20-459	24	41	35	28	17	7	2.0	1.0	1.5
20-460	26	34	29	27	8	2	1.0	0.3	0.6
21-461	41	32	25	32	-9	-7	-1.1	-1.0	-1.0
21-462	28	26	29	29	-2	0	-0.2	0.0	-0.1
Average	26.9		Average	26.7			Average	(Kdpm/100cm2)	0.5
Stand. Dev.	4.3		Stand. Dev.	2.7	Student's t value	1.683	Error (95%)	(Kdpm/100cm2)	0.1
							Critical Level	(Kdpm/100cm2)	0.9
							MDA	(Kdpm/100cm2)	1.9

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #8	DRAIN LINE	39.5	2	46	2-7-95/0855	4-26-95/0935	112480

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-55	20	31	30	24	11	6	1.3	0.9	1.1
1-56	26	29	31	22	3	9	0.4	1.3	0.8
2-57	26	36	32	27	10	5	1.2	0.7	1.0
2-58	25	50	43	29	25	14	3.0	2.0	2.5
3-59	28	36	34	30	8	4	1.0	0.6	0.8
3-60	26	29	29	28	3	1	0.4	0.1	0.3
4-61	32	33	31	30	1	1	0.1	0.1	0.1
4-62	31	44	46	30	13	16	1.5	2.3	1.9
5-63	32	32	29	30	0	-1	0.0	-0.1	-0.1
5-64	28	29	26	28	1	-2	0.1	-0.3	-0.1
6-65	29	30	27	28	1	-1	0.1	-0.1	0.0
6-66	25	29	28	29	4	-1	0.5	-0.1	0.2
7-67	26	32	29	29	6	0	0.7	0.0	0.4
7-68	28	32	30	27	4	3	0.5	0.4	0.5
8-69	31	33	28	28	2	0	0.2	0.0	0.1
8-70	29	31	28	29	2	-1	0.2	-0.1	0.0
9-71	29	25	31	29	-4	2	-0.5	0.3	-0.1
9-72	30	30	29	37	0	-8	0.0	-1.1	-0.6
10-73	25	30	27	28	5	-1	0.6	-0.1	0.2
10-74	22	30	26	29	8	-3	1.0	-0.4	0.3
11-75	28	29	30	29	3	1	0.4	0.1	0.3
11-76	28	40	27	29	12	-2	1.4	-0.3	0.6
12-77	29	40	29	30	11	-1	1.3	-0.1	0.6
12-78	28	32	23	26	4	-3	0.5	-0.4	0.0
13-397	20	27	24	25	7	-1	0.8	-0.1	0.3
13-398	24	28	27	32	4	-5	0.5	-0.7	-0.1
14-399	24	26	24	23	2	1	0.2	0.1	0.2
14-400	27	22	27	29	-5	-2	-0.6	-0.3	-0.4
15-401	27	28	26	29	1	-3	0.1	-0.4	-0.2
15-402	23	32	25	25	9	0	1.1	0.0	0.5
16-403	51	34	28	29	-17	-1	-2.0	-0.1	-1.1

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #8	DRAIN LINE	39.5	2	46	2-7-95/0655	4-26-95/0935	112480

TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.R*e+07
16-404	26	28	24	25	2	-1	0.2	-0.1	0.1
17-405	23	25	23	23	2	0	0.2	0.0	0.1
17-406	24	33	25	28	9	-3	1.1	-0.4	0.3
18-407	23	30	27	27	7	0	0.8	0.0	0.4
18-408	22	30	25	25	8	0	1.0	0.0	0.5
19-409	25	33	33	25	8	8	1.0	1.1	1.0
19-410	26	29	28	26	3	2	0.4	0.3	0.3
20-411	27	30	32	30	3	2	0.4	0.3	0.3
20-412	30	49	42	26	19	16	2.3	2.3	2.3
21-413	23	29	29	25	6	4	0.7	0.6	0.6
21-414	30	31	31	25	1	6	0.1	0.9	0.5
22-415	36	45	52	63	9	-11	1.1	-1.6	-0.3
22-416	34	76	69	55	42	14	5.0	2.0	3.5
23-417	30	31	34	27	1	7	0.1	1.0	0.6
23-418	27	34	30	30	7	0	0.8	0.0	0.4

Average	27.4	Average	29.1			Average	(Kdpm/100cm2)	0.4
Stand. Dev.	4.9	Stand. Dev.	7.0	Student's t value	1.681	Error (95%)	(Kdpm/100cm2)	0.2
						Critical Level	(Kdpm/100cm2)	1.4
						MDA	(Kdpm/100cm2)	2.8

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #9	DRAIN LINE	43	2	52	2-7-95/0635	4-26-95/0728	112373

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-7	33	78	73	30	45	43	5.4	6.2	5.8
1-8	37	72	89	28	35	61	4.2	8.7	6.5
2-9	30	56	57	32	26	25	3.1	3.6	3.3
2-10	26	62	70	30	36	40	4.3	5.7	5.0
3-11	35	32	34	30	-3	4	-0.4	0.6	0.1
3-12	29	29	31	31	0	0	0.0	0.0	0.0
4-13	30	33	29	32	3	-3	0.4	-0.4	-0.0
4-14	34	38	31	29	4	2	0.5	0.3	0.4
5-15	25	37	29	30	12	-1	1.4	-0.1	0.6
5-16	40	37	33	29	-3	4	-0.4	0.6	0.1
6-17	28	32	33	29	4	4	0.5	0.6	0.5
6-18	30	52	49	31	22	18	2.6	2.6	2.6
7-19	32	41	36	28	9	8	1.1	1.1	1.1
7-20	28	67	51	30	39	21	4.7	3.0	3.8
8-21	26	31	33	30	5	3	0.6	0.4	0.5
8-22	27	41	40	31	14	9	1.7	1.3	1.5
9-23	30	55	44	28	25	16	3.0	2.3	2.6
9-24	29	37	34	28	8	6	1.0	0.9	0.9
10-25	27	53	39	32	26	7	3.1	1.0	2.1
10-26	48	43	37	31	-5	6	-0.6	0.9	0.1
11-27	30	27	25	24	-3	1	-0.4	0.1	-0.1
11-28	32	35	28	27	3	1	0.4	0.1	0.3
12-29	29	42	35	30	13	5	1.6	0.7	1.1
12-30	27	46	31	31	19	0	2.3	0.0	1.1
13-31	31	37	30	29	6	1	0.7	0.1	0.4
13-32	27	36	32	26	9	6	1.1	0.9	1.0
14-33	33	33	26	27	0	-1	0.0	-0.1	-0.1
14-34	33	33	29	27	0	2	0.0	0.3	0.1
15-35	27	37	31	30	10	1	1.2	0.1	0.7
15-36	29	28	25	27	-1	-2	-0.1	-0.3	-0.2
16-37	27	36	32	30	9	2	1.1	0.3	0.7

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #9	DRAIN LINE	43	2	52	2-7-95/0635	4-26-95/0728	112373

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR")				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
16-38	28	35	28	30	7	-2	0.8	-0.3	0.3
17-39	26	27	30	33	1	-3	0.1	-0.4	-0.2
17-40	30	24	27	29	-6	-2	-0.7	-0.3	-0.5
18-41	33	31	30	30	-2	0	-0.2	0.0	-0.1
18-42	26	28	30	28	2	2	0.2	0.3	0.3
19-43	26	33	29	28	7	1	0.8	0.1	0.5
19-44	24	30	26	28	6	-2	0.7	-0.3	0.2
20-45	31	32	27	28	1	-1	0.1	-0.1	-0.0
20-46	30	31	26	23	1	3	0.1	0.4	0.3
21-47	30	39	28	29	9	-1	1.1	-0.1	0.5
21-48	39	42	32	31	3	1	0.4	0.1	0.3
22-49	33	34	29	30	1	-1	0.1	-0.1	-0.0
22-50	28	38	32	29	10	3	1.2	0.4	0.8
23-51	32	31	29	28	-1	1	-0.1	0.1	0.0
23-52	29	34	29	27	5	2	0.6	0.3	0.4
24-53	28	40	32	30	12	2	1.4	0.3	0.9
24-54	30	52	37	29	22	8	2.6	1.1	1.9
25-295	37	45	35	36	8	-1	1.0	-0.1	0.4
25-296	34	29	30	31	-5	-1	-0.6	-0.1	-0.4
26-297	46	52	48	52	6	-4	0.7	-0.6	0.1
26-298	39	58	46	48	19	-2	2.3	-0.3	1.0

Average	30.9	Average	30.1			Average	(Kdpm/100cm2)	0.9
Stand. Dev.	4.9	Stand. Dev.	4.6	Student's t value	1.677	Error (95%)	(Kdpm/100cm2)	0.3
						Critical Level	(Kdpm/100cm2)	1.4
						MDA	(Kdpm/100cm2)	2.8

ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION	PIPE LENGTH	PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #10	DRAIN LINE	47	2	56	2-7-95/1453	4-26-95/0708	113295

TLD SURVEY DATA	CALIBRATION FACTORS (dis/100cm2/mR*)				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07

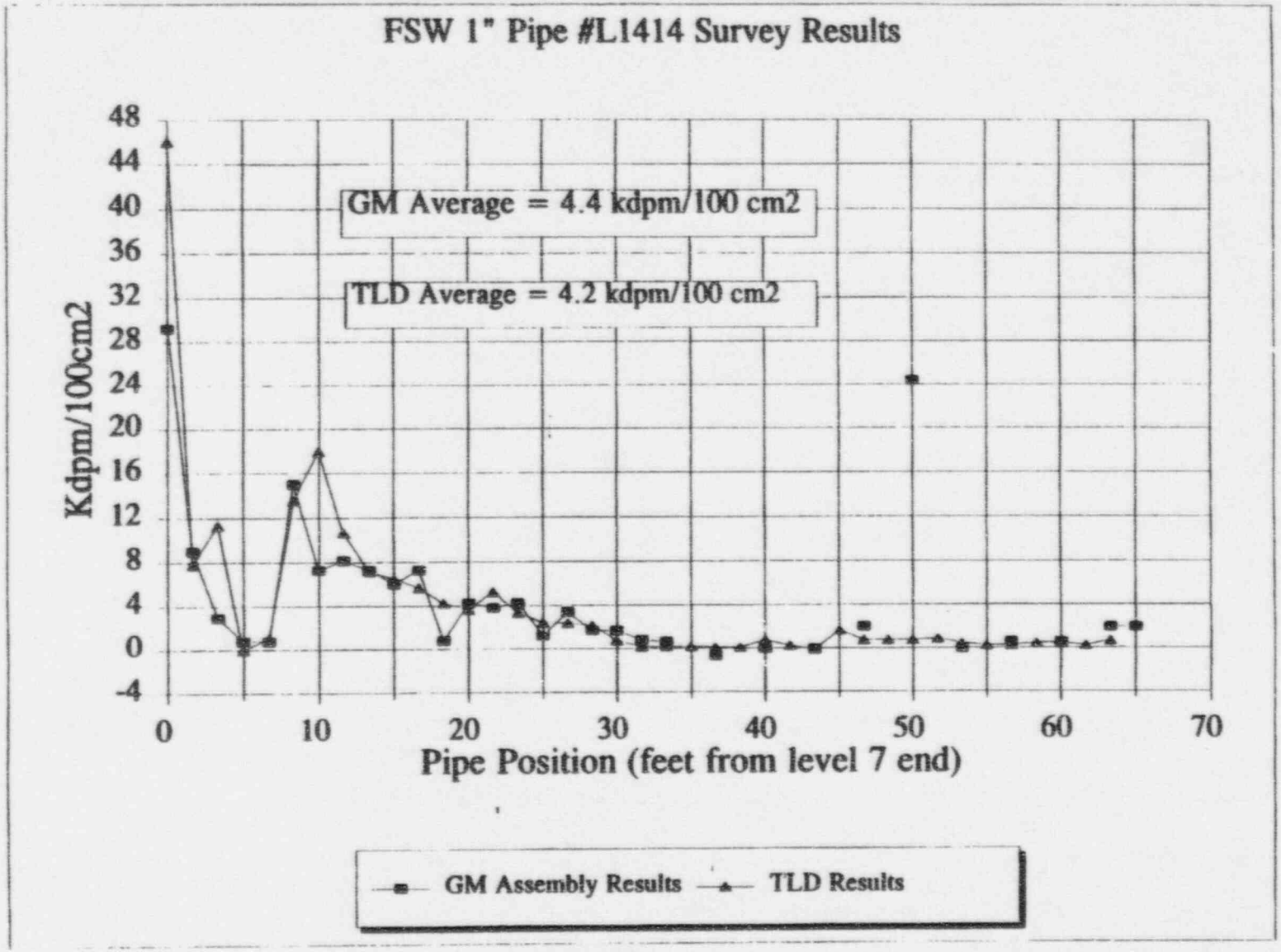
POSITION - BADGE NUMBER	ELEMENT 1 (mR*)	ELEMENT 2 (mR*)	ELEMENT 3 (mR*)	ELEMENT 4 (mR*)	Lithium Borate Net Reading (mR*)	Calcium Sulfate Net Reading (mR*)	Lithium Borate Result (K dpm/100cm2)	Calcium Sulfate Result (K dpm/100cm2)	TLD Average Result (Kdpm/100cm2)
1-59	38	39	37	35	1	2	0.1	0.3	0.2
1-60	31	40	35	36	9	-1	1.1	-0.1	0.5
2-61	41	41	43	39	0	4	0.0	0.6	0.3
2-62	32	45	43	37	13	6	1.5	0.9	1.2
3-63	35	41	38	35	6	3	0.7	0.4	0.6
3-64	32	48	42	36	16	6	1.9	0.9	1.4
4-65	33	36	36	36	3	0	0.4	0.0	0.2
4-66	32	35	36	36	3	0	0.4	0.0	0.2
5-67	37	34	37	37	-3	0	-0.4	0.0	-0.2
5-68	32	40	38	37	8	1	0.9	0.1	0.5
6-69	35	37	38	37	2	1	0.2	0.1	0.2
6-70	32	40	37	35	8	2	0.9	0.3	0.6
7-71	33	38	38	36	5	2	0.6	0.3	0.4
7-72	41	42	41	38	1	3	0.1	0.4	0.3
8-73	46	41	37	34	-5	3	-0.6	0.4	-0.1
8-74	33	36	37	36	3	1	0.4	0.1	0.2
9-75	32	36	33	34	4	-1	0.5	-0.1	0.2
9-76	32	32	34	34	0	0	0.0	0.0	0.0
10-77	38	45	47	39	7	8	0.8	1.1	1.0
10-78	33	40	36	35	7	1	0.8	0.1	0.5
11-79	36	39	38	37	3	1	0.4	0.1	0.2
11-80	36	42	35	36	6	-1	0.7	-0.1	0.3
12-81	34	46	48	35	12	13	1.4	1.8	1.6
12-82	39	39	40	38	0	2	0.0	0.3	0.1
13-83	30	43	36	37	13	-1	1.5	-0.1	0.7
13-84	40	34	35	35	-6	0	-0.7	0.0	-0.4
14-85	33	36	34	34	3	0	0.4	0.0	0.2
14-86	33	38	34	35	5	-1	0.6	-0.1	0.2
15-87	30	35	30	33	5	-3	0.6	-0.4	0.1
15-88	32	32	34	34	0	0	0.0	0.0	0.0
16-89	33	36	34	35	3	-1	0.4	-0.1	0.1

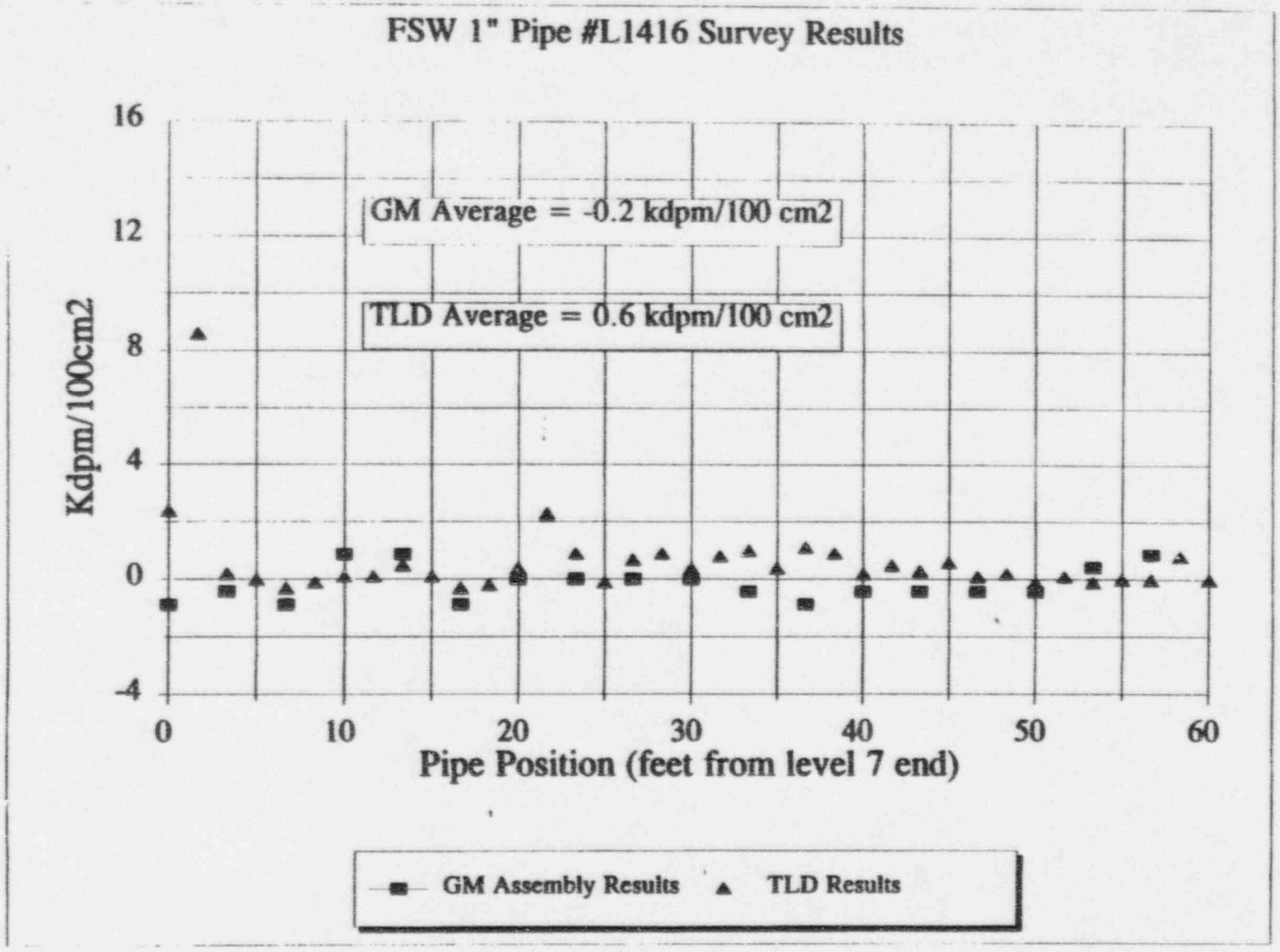
ATTACHMENT 8.5
ESW 2" PIPING TLD SURVEY DATA AND RESULTS

SYSTEM	PIPE IDENTIFICATION OR LOCATION		PIPE LENGTH		PIPE DIAMETER (inches)	# OF TLDS IN STRING	EXPOSURE START DATE/TIME	EXPOSURE STOP DATE/TIME	TOTAL EXPOSURE TIME (minutes)
ESW #10	DRAIN LINE		47		2	56	2-7-95/1453	4-26-95/0708	113295
TLD SURVEY DATA		CALIBRATION FACTORS (dis/100cm2/mR")				Lithium Borate =	1.34e+07	Calcium Sulfate =	1.61e+07
16-90	32	37	33	35	5	-2	0.6	-0.3	0.2
17-91	31	38	33	33	7	0	0.8	0.0	0.4
17-922	34	38	36	35	4	1	0.5	0.1	0.3
18-93	33	34	35	36	1	-1	0.1	-0.1	-0.0
18-94	32	33	32	34	1	-2	0.1	-0.3	-0.1
19-95	29	32	32	34	3	-2	0.4	-0.3	0.0
19-96	32	37	36	35	5	1	0.6	0.1	0.4
20-97	33	40	35	37	7	-2	0.8	-0.3	0.3
20-98	35	37	32	34	2	-2	0.2	-0.3	-0.0
21-99	30	32	32	33	2	-1	0.2	-0.1	0.0
21-100	32	35	31	32	3	-1	0.4	-0.1	0.1
22-1	28	35	25	25	7	0	0.8	0.0	0.4
22-2	32	38	32	29	6	3	0.7	0.4	0.6
23-3	24	57	52	25	33	27	3.9	3.8	3.9
23-4	30	50	36	31	20	5	2.4	0.7	1.5
24-5	30	40	33	30	10	3	1.2	0.4	0.8
24-6	28	44	37	30	16	7	1.9	1.0	1.4
25-493	32	30	34	26	-2	8	-0.2	1.1	0.5
25-494	36	34	35	24	-2	11	-0.2	1.6	0.7
26-495	31	31	31	25	0	6	0.0	0.9	0.4
26-496	28	45	30	24	17	5	2.0	0.9	1.4
27-497	23	38	36	30	15	6	1.8	0.9	1.3
27-498	28	41	43	30	13	13	1.5	1.8	1.7
28-499	40	53	51	45	13	6	1.5	0.9	1.2
28-500	45	41	42	38	-4	4	-0.5	0.6	0.0

Average	33.3	Average	33.9			Average	(Kdpm/100cm2)	0.5
Stand. Dev.	4.4	Stand. Dev	4.1	Student's t value	1.674	Error (95%)	(Kdpm/100cm2)	0.2
						Critical Level	(Kdpm/100cm2)	1.2
						MDA	(Kdpm/100cm2)	2.4

ATTACHMENT 8.6
SN-050-4K VS. TLD SURVEY COMPARISON TEST RESULTS




FSW 1" Pipe #L1416 Survey Results
GM Average = -0.2 kdpm/100 cm2
TLD Average = 0.6 kdpm/100 cm2
Kdpm/100cm2
16
12
8
4
0
-4
0
10
20
30
40
50
60
Pipe Position (feet from level 7 end)
GM Assembly Results
TLD Results

Methods to Evaluate the Final Condition of Plant System Piping Internal Surface

1.0 PURPOSE

This document provides the technical basis by which the measurement of total surface activity on the internal surfaces of plant system piping are performed at Fort St. Vrain (FSV). The protocols and instruments detailed in this document may also be used for other plant system internal surfaces as applicable. Included in this document are descriptions of available instrumentation, calibration methods, testing performed, and the survey techniques to be used. The use of TLDs to determine piping contamination (which is a method also used at FSV) is addressed in a separate Technical Basis Document (FSV-FRS-TBD-207).

2.0 REFERENCES & COMMITMENTS

2.1 References

2.1.1 Final Survey Plan, Fort St. Vrain Nuclear Station.

2.1.2 Kocher, D.C., "Radioactive Decay Data Tables- A Handbook of Decay Data For Application To Radiation Dosimetry and Radiological Assessments", U.S. Department of Energy, Washington, DC, 1981.

2.1.3 Lederer and Shirley, et al., Table of Isotopes, 7th edition, John Wiley & Sons, New York, 1978.

2.1.4 Friedlander, et at., Nuclear and Radiochemistry, 3rd edition, John Wiley & Sons, New York, 1981.

2.1.5 Krane, K.S., Introductory Nuclear Physics, John Wiley & Sons, New York, 1988.

2.1.6 Manufacturer's literature or Operation Manuals for the GM/Gas Flow detectors

2.1.7 FRS-TBD-203, "Use of TLDs to Assess Internal Contamination in Piping"

2.2 Commitments

None

3.0 DISCUSSION

The assessment of total surface activity on internal surfaces of piping is accomplished by using an assortment of detector sizes and types. Cylindrical and standard gas flow detectors designed by Ludlum Measurements Inc. (LMI); standard size Geiger-Mueller (GM) probes; and smaller GM probes (including assemblies of multiple GM probes) are

each used in applicable situations. Each detector is used with a Ludlum Model 2350 Data Logger to provide bias voltage to the detector(s) and measurement recording.

To correct field measurements to meaningful results, the efficiency of a detector must be known. This is determined by response testing a detector in the geometric configuration (or equivalent) that is encountered during actual measurements. With the cylindrical piping detectors, a calibration jig [

]^{a,c} is used. The GM detectors and LMI 43-68 are calibrated with [

]^{a,c} The source to detector gap is equivalent to the survey distance encountered during field measurements.

Based on desired sensitivity, the performance of total surface activity measurements with a given detector requires the determination of appropriate count times and/or scanning rates. Specifically, a Minimum Detectable Activity (MDA) of 1,250 dpm/100 cm^2 for unaffected systems and 3,000 dpm/100 cm^2 for affected systems is required for total surface activity measurements. With the specialized detectors that are often required to survey inside piping or other non-standard survey surfaces encountered in plant systems, this can require very long count times. In some cases, scanning is not practical due to very low sensitivities as a result of small detection areas and low efficiencies. However, fixed point measurements can be performed with any detector and by collecting a sufficient number of measurements (and scanning when possible), plant systems can be adequately surveyed.

4.0 DESCRIPTION OF INSTRUMENTATION

NOTE

Attachment 8.9, Piping Instrumentation Figures, contains figures of each detector described in this section.

4.1 Ludlum Cylindrical Pipe Detectors

The LMI gas flow pipe detectors are cylindrical detectors using P-10 as the detector gas with an overall length of approximately 9 inches. Two different models are available to survey plant system piping at FSV. These are the LMI 43-94 and LMI 43-98 (Figures 1 and 2). The LMI 43-94 is a ½ inch diameter detector with an active length of 6 inches. This detector is considered to be appropriate for making measurements in straight run piping with an inside diameter up to 2 inches. The LMI 43-98 is a 1-½ inch diameter

detector that also has an active length of about 6 inches and is used in up to 3 inch diameter straight run piping. Typical efficiencies for these detectors are from 3 to 7% depending on the particular detector/pipe size.

4.2 Ludlum Model 43-68 Detector

The LMI 43-68 is a 125 cm² gas flow detector (Attachment 8.9, Figure 3). The detector window is rectangular with active face dimensions of about 3-½ by 5-½ inches. Because its area is close to 100 cm² and its efficiency is high (about 20%), this detector is the principal instrument used to perform final surveys of surfaces and structures. Therefore, this detector is used whenever possible to survey plant system internal surfaces. Possible applications include, tanks, sumps, wells, and other large bore (i.e., 7 inch diameter and larger) piping and components.

4.3 GM Detector Assemblies

4.3.1 General

In cases where piping cannot be surveyed with gas flow detectors (i.e., the piping contains bends or is too large for cylindrical pipe detectors but not large enough for the LMI 43-68), GM detectors are used. Assemblies (i.e., multiple detectors connected together) are used to increase the detection sensitivity of measurements by increasing the sensitive area of the measurement system beyond that which is afforded by a single detector. This is accomplished by connecting the detectors in parallel and collecting the signal in a summing mode. Some of the assemblies include the ability to isolate an individual detector(s) to aid to characterizing the distribution of the contamination (i.e., uniform or localized).

To identify each type of GM assembly, a model number is assigned. The model number logic is AA-BBB-CD, where: AA is a 2 letter designation that identifies the basic style of the assembly (i.e., SP for "spider" assemblies that expand radially to the pipe surface and SN for "snake" assemblies where detectors are positioned in different axial positions and are pulled through piping); BBB is the diameter of GM tubes used (e.g., 175 for 1.75 inches, 113 for 1.13 inches, etc.); C designates the number of GM detectors used; and D is an arbitrary letter that designates different versions of the base design. Each of the assemblies developed to date are described in the following sections.

4.3.2 Model SP-175-3M Assembly

The Model SP-175-3M assembly consists of three standard size (i.e., 1-¾ inch diameter) "pancake style" GM detectors (Attachment 8.9, Figure 4). With an area of 15.5 cm² for each GM detector, the total detection area of the assembly is

46.5 cm^2. The signals for each GM detector are individually routed to a summing box where selected detector(s) can be turned on or off. Individual detectors are positioned with a 120 degree azimuthal offset to increase survey coverage during scanning.

Motor control is provided to allow the assembly to be expanded in order to position the detectors in close proximity to the inside surface of the pipe. The assembly is attached to an extendable pole that allows surveying inside straight run piping up to a depth of approximately 6 feet. Applications include surveying piping (or components) with an inside diameter from 4 to 12 inches, although typical use is for 4 to 6 inch piping.

4.3.3 Model SP-113-3 Assemblies

The SP-113-3 assemblies (which include the SP-113-3M and SP-113-3T) consist of three 1.13 inch diameter minature pancake GM detectors (Attachment 8.9, Figures 5 and 6). Each detector has an area of 6.47 cm^2 yielding an area of 19.4 cm^2 for the assembly. With both assemblies, the individual detectors are positioned with a 120 degree offset to increase azimuthal survey coverage. Motor control is provided to allow the assembly to be expanded inside the pipe. A summing box is also provided to turn on or off selected detectors.

The design of the SP-113-3M assembly is similar to the SP-175-3M, except with smaller detectors. The assembly may be attached to an extendable pole to allow surveying inside straight run piping up to a depth of approximately 6 feet. This assembly was especially designed to survey gas bottles by entering the bottle through an end opening and expanding out to the inside surface of the bottle. This assembly is therefore capable of expanding out to 24 inches, although typical applications at FSV are for surveying 3 to 6 inch diameter straight run piping.

With the SP-113-3T assembly, the detectors are positioned at the same axial position and include motor control to allow expansion of the assembly inside the pipe. This assembly is pulled through piping with attached cables and includes the ability to pass through 90 degree piping bends. The assembly is applicable for surveying long runs of piping, including piping with bends, with an inside diameter from 3 to 6 inches.

4.3.4 Model SN-113-3 Assemblies

The SN-113-3 assemblies (which include the SN-113-3C and SN-113-3T) consist of three 1.13 inch diameter GM detectors that are individually enclosed in a special housing that controls the survey distance between detector and survey surface. The detectors are joined in series using flexible connectors so the entire

assembly may be pulled through piping, including 90 degree bends, with attached cables. The detection area for each assembly is 19.4 cm^2.

The housing design for the SN-113-3C assembly [

]^{a,c} The three detectors of the assembly may be positioned with a 120 degree offset to increase azimuthal coverage of the inside pipe surface. This assembly is applicable for 3 or 4 inch diameter piping with bends.

Detector position control for the SN-113-3T [

]^{a,c} The three detectors of this assembly are also positioned with a 120 degree offset to increase azimuthal coverage of the pipes internal surfaces. The assembly is typically set up for surveying 2 inch piping with bends, but may also be adapted [ ]^{a,c} to survey 3 inch piping with bends.

4.3.5 Model SN-050-4K Assembly

The SN-050-4K assembly (Attachment 8.9, Figure 9) is a 4 detector assembly consisting of ½ inch diameter GM tubes with side mounted electrical connectors. [

]^{a,c} The detectors are pulled through piping with attached cables and are applicable for surveying 1 inch diameter piping with bends. Successive detectors are rotated 90° to increase the azimuthal coverage of the assembly in the pipe. With each detector having an area of 1.27 cm^2, the total area of the assembly is 5.1 cm^2.

4.3.6 Model SN-050-6K Assembly

The SN-050-6K assembly (Attachment 8.9, Figure 10) is a 6 detector assembly consisting of ½ inch diameter GM tubes with back mounted electrical connectors. [

]^{a,c} The detectors are pulled through piping with attached cables and are applicable for surveying 1 inch diameter piping with bends. Successive detectors are positioned with a 60 degree offset to increase the azimuthal coverage of the assembly in the pipe. Each detector has an area of 1.27 cm^2 yielding an area of 7.6 cm^2 for the assembly.

4.4 Special Use GM Detectors

Specialty GM detectors have been purchased from LND Inc. to provide a means of surveying unique situations (e.g., bottom of a blind hole). The specialty GM detectors currently in stock include side and end window GM tubes with diameters ranging from 0.38 to 1.42 inches and lengths from 3 to 7 inches. The detectors are used with the M2350 Data Logger to supply the necessary bias voltage and ability to log the measurement result.

5.0 CALIBRATION METHODOLOGIES

5.1 Calibration Sources

The radionuclide selected for calibration of the detectors used in plant system piping is Tc-99. Tc-99 is a pure beta emitter with an average beta energy of 84.6 keV and a long half-life of 2.13E5 years. The Average Beta Energy (Ebar) expected in "detectable" plant contamination, (i.e., excluding hard to detect nuclides such as Fe-55 and H-3 that are addressed by reducing the Site Guideline Values, SGLV) at Fort St. Vrain is 113.6 keV. Attachment 8.1, Average Beta Energy (Ebar) for Detectable Plant Contamination at Fort St. Vrain, presents the calculation performed to determine Ebar, which is based on the same samples used to determine the SGLVs. Therefore, a conservative estimate of piping contamination can be made with a Tc-99 calibrated detector.

[

]^{a,c}

5.2 Calibration Procedures

5.2.1 Cylindrical Pipe Detectors

The operating voltage for the pipe detectors (i.e., LMI 43-94 and 43-98) is determined by generating a response vs. voltage curve and selecting a point on the "plateau" region of the curve. Typical operating voltages for these detectors are approximately 1600 volts. Example plateaus are provided in Attachment 8.2, Plateau Data for LMI Gas Flow Pipe Detectors.

Efficiencies for the pipe detectors are established by determining the detector's response to a source [

]^{a,c}

These particular jig sizes were selected to obtain a balance between minimizing the conservatism of measurements and the complexity of a large number of jig sizes. [

]^{a,c}

The Tc-99 sources used with the piping detectors are approximately [

]^{a,c} During calibration, an initial response ± 20% tolerance band is calculated to which all subsequent source checks are compared to verify operation of the detectors.

5.2.2 LMI 43-68 Detector

When surveying tanks or very large wells or piping (i.e., ≥30 inch diameter) the LMI 43-68 may be used with the standard calibration performed with the detector for walls and floors. The standard efficiency is determined [

]^{a,c}

If the detector will be used to survey wells, piping or components whose diameter is <30 inches (and at least 7 inches as is necessary for accessibility of the detector), an [

]^{a,c}

5.2.3 GM Detector Assemblies and Special Use GM Detectors

Operating voltages for the GM detectors are as specified by the GM detector manufacturer. When a batch of GM tubes are received, initial screening tests are conducted on the tubes to verify their operation. These tests include background and source response checks to verify each tube operates as expected for the given tube design. Additionally, plateaus are generated on a sampling of the purchased GM detectors to confirm that rated voltages are appropriate. Dead time corrections use the value stated by manufacturer. At the count rates these detectors are used (i.e., final survey measurements), dead time corrections will be insignificant.

Efficiencies are determined by taking measurements with a source whose diameter is approximately the same as the detector window. The source is positioned at the distance the detector(s) are to be placed from the survey surface during field measurements. Prior to and after each use, the efficiency of the GM detector(s) is determined. To account for individual tube variances, an allowance band of ±20% of the nominal efficiency value established for the detector is allowed. For the GM detector assemblies, each detector of the assembly is individually verified to be within the tolerance band. Typical efficiencies for the small special use and GM assembly detectors, are approximately 6-8% with a typical survey distance of ¼ inch.

6.0 PERFORMANCE TESTING

6.1 LMI Pipe Detectors

6.1.1 Linearity Testing

To examine the linear operation of the cylindrical gas flow pipe detectors, the response of the detectors was checked with different source strengths. Specifically, the response of the LMI 43-94 and LMI 43-98 was compared for 2, 15, 30 and 60 nCi Tc-99 sources. Attachment 8.4, Linearity Test Results for LMI Gas Flow Pipe Detectors, contains the test results. As indicated by the results, the test data was linear within the allowed tolerance band for both the LMI 43-94 and LMI 43-98. [

]^{a,c}

6.1.2 Uniformity Testing

The Ludlum gas flow pipe detectors were designed to achieve an azimuthally symmetric response. Therefore, there should not be any significant difference in the detector response with respect to rotation. Nonetheless, this was investigated

by performing response checks with the detectors at each of 4 positions by rotating the detector 90 degrees between source measurements.

Attachment 8.5, Uniformity Test Results for LMI Gas Flow Pipe Detectors, contains the test results. As indicated by the results, the test data was within the allowed tolerance band at each azimuthal position for both the LMI 43-94 and LMI 43-98. Consequently, an efficiency determined by placing a flexible source along the active length of the detector is equivalent to the efficiency that would be obtained with a source that encircles the detector.

6.1.3 Gas Flow Testing

The degree of gas amplification within a gas flow detector is dependant on the gas pressure within the detector and therefore can vary with gas flow rate. Due to the limited plateau width of these detectors, potential amplification variances can be especially troubling. Therefore, to confirm that the detector's operation is consistent within the procedurally controlled gas flow rate band (i.e., 60 - 80 cc/min), the detectors response was evaluated at different flow rates within this band. Attachment 8.6, Gas Flow Test Results for LMI Gas Flow Pipe Detectors, contains the test results where the detectors response was evaluated at flow rate increments of 5 cc/min within the allowed band. As indicated by the results, the detectors were very consistent over this flow rate range.

6.2 GM Detector Assemblies

6.2.1 Comparison Study with TLD String Survey Method

To evaluate the measurement method of GM detector assemblies, a comparison study was performed with the SN-050-4K assembly and TLD strings for two fuel storage well 1 inch embedded pipes (i.e., lines L1414 and L1416). Measurements were taken at regular intervals in each pipe by both survey methods. Attachment 8.7, SN-050-4K vs. TLD Survey Comparison Test Results, contains plots of the measurement results.

Compared data for line L1414 is considered very good. Both methods produced the same approximate contamination profile in the pipe. Two localized spots (i.e., at 0 feet and 50 feet) yielded different values by each method as can be expected if localized contamination is present due the small size of the detectors. Highly localized contamination (e.g., a hot particle in a weld) can produce significantly different results depending on the exact detector to hot spot orientation. For example, if a GM detector is located directly over a hot particle in an otherwise clean pipe, the area correction factor (required because the total detection area of the assembly is <100 cm^2), in effect, assumes the balance of a 100 cm^2 area at the

location is also contaminated at the same level. This can result in a significant over estimation of the true per 100 cm^2 contamination level at the location. Conversely, the limited detection area of a small GM detector may not detect a given spot of contamination (e.g., a hot spot is between two tubes) and under report the true contamination at a location.

Such inherent disadvantages of using small detectors (which are necessary to survey small diameter piping) can be offset by collecting a large amount of data. A large number of measurements will average out individual measurement fluctuations and produce a more accurate determination of the average contamination in a given pipe. This was evidenced by the average results for L1414 where 4.4 kdpm/100 cm^2 and 4.2 kdpm/100 cm^2 were determined for the SN-050-4K assembly and TLD string respectively.

L1416 data was also in good agreement. In this pipe both methods indicated that the pipe was clean (i.e., all measurements <12 kdpm/100 cm^2, and average <4 kdpm/100 cm^2). The TLD string did indicate one outlying result of 8.6 kdpm/100 cm^2 that was not detected by the SN-050-4K. However, due to the long count times required for the SN-050-4K, measurements were taken at 40 inch intervals in this pipe while TLDs were spaced at 20 inch intervals. This elevated reading was located at a pipe position not monitored by the SN-050-4K; therefore, the GM assembly could not be expected to detect this spot. The average contamination levels determined by each method are in acceptable agreement considering that MDAs for both methods were approximately 2 kdpm/100 cm^2.

Additional comparison testing is planned with other GM assemblies against TLDs and gas flow detectors and will be included in a later revision of this document.

6.2.2 Comparison Study with Cylindrical Gas Flow Pipe Detectors

Testing is underway to compare the cylindrical gas flow detectors to GM detector assemblies and TLDs and will be included in a later revision of this document

7.0 SURVEY TECHNIQUES

7.1 Detector Sensitivity (MDA)

The sensitivity of detectors used to measure total surface activity in plant system piping is quantified by determining a MDA. Counting sensitivity, or MDA, is targeted to meet action levels as defined in the final survey plan for both unaffected and affected plant system survey units. From the target MDAs, count times for stationary (i.e., fixed point) measurements are calculated.

Fixed point measurements in unaffected plant systems are counted for a sufficient time to achieve a MDA of 1,250 dpm/100 cm^2. This MDA is based on the reclassification action level of 25% of 5,000 dpm/100 cm^2 (i.e., the controlling limit for unaffected plant systems). For affected plant systems, fixed point measurements are counted to achieve an MDA of 3,000 dpm/100 cm^2. This value corresponds to 75% of 4,000 dpm/100 cm^2 (i.e., SGLV for affected plant systems), which is the investigation action level for affected plant systems; however, a MDA of 2,000 dpm/100 cm^2 will be targeted when appropriate (i.e., for detectors with higher sensitivities).

The equation used to calculate MDA is as follows:

$$MDA = \frac{\frac{2.71}{t_s} + 3.29\sqrt{\frac{R_b}{t_s} + \frac{R_b}{t_b}}}{(Efficiency)\left(\frac{A}{100}\right)}$$

where t_s is the sample count time (min),

t_b is the background count time (min),

R_b is the background count rate (cpm), and

A is the detection area in cm^2.

For flat-surfaced detectors, the area of detection is equal to the area of the detector window. With the cylindrical piping detectors, the area of detection is equal to the inside surface area of the pipe over the active length of the detector. For 1 inch diameter and greater piping, this area is greater than 100 cm^2 for the LMI pipe detectors (which have an active length of approximately 6 inches). However, it is assumed that the detectors response originates from contamination that is distributed over only 100 cm^2. Total detection area for GM assemblies is the sum of individual detector areas in the assembly (total detection area is <100 cm^2 for all GM assemblies).

Scanning for surface activity has traditionally been performed at an approximate rate of 2 inches/sec. With this scan rate, standard detectors (e.g., HP-210 "frisker" probes or rectangular gas flow detectors such as the LMI 43-68) can achieve reasonably low MDAs. However, the specialized detectors that are necessary to survey internal surfaces of plant system piping have lower efficiencies and detection areas, both of which limit their sensitivity. Therefore, scanning, in the conventional sense, is considered to be impractical for many of these detectors, but will be performed when measurement

locations allow the use of standard detectors or specialized detectors that can meet or exceed the sensitivity of standard detectors.

7.2 Background Measurements

To determine the net count rate at a given survey location, the background count rate must be known. This is determined by taking a shielded measurement at the survey location, or other location considered equivalent. A 300 mg/cm² shield is used to cover the detectors sensitive area when taking background measurements, which will stop 98% of FSV beta. Attachment 8.8, Shielding Detectable Contamination at Fort St. Vrain, presents the calculation performed to evaluate the shielding used for background measurements.

Generally speaking, shielded background measurements are taken at each measurement location. Therefore, the same count time is used for background and sample measurements to simplify the measurement process and minimize the counting time required to achieve a given MDA. If a single background measurement location is to be applied to multiple measurement locations (e.g., a background measurement in one pipe of a row of pipes of the same size and in the same general configuration and location may be used for the set of pipes), a longer count time or multiple measurements are performed for the background.

Plant system internal surfaces are almost exclusively metal, which, for the metals typically used to construct plant systems, contain insignificant natural beta radioactivity. Accordingly, additional corrections (i.e., background subtractions) to the net survey results are not performed. Should survey surfaces be found or expected to contain natural surface activity (e.g., wall and floor penetrations without steel sleeves), evaluations will be performed to determine the appropriate background subtract values to be applied to plant system survey data so the results reflect only licensed material.

7.3 Surface Activity Measurements

Specific survey instructions and procedures will be used to control the survey and data analysis process for plant system survey units. The basic process will involve scanning at the location (if possible), and the collection of fixed and removable measurements.

Scanning for surface activity (i.e., for those detectors capable of performing scans) in plant system piping is performed by slowly (2 inches/sec or less) moving the probe through or across the pipe or other survey surface. The fixed point measurement is then typically performed at the specific point yielding the highest audible response. If no increase in count rate is noticeable, a biased location is chosen for the fixed point measurement (e.g., at pipe welds, in open valves, etc.). The fixed point measurement is performed by taking an unshielded and shielded reading. Following the collection of

fixed point readings, samples for removable surface activity are collected for laboratory analysis.

To verify the proper operation of the detectors used to perform Final Survey of plant system piping, a pre-use and post-use response check is performed. These checks are performed with the source jigs used to determine the detectors initial response and calibration and are required to be within ±20% of the value observed at time of calibration.

7.4 Summary of Piping Instrumentation Capabilities

Table 1 below summarizes the piping instrumentation developed to date for FSV. Included in the table are the basic parameters, advantages, disadvantages, and applications of the various detector types and assemblies available to survey plant system internal surfaces. The efficiency and background values represent average results from past measurements.

The count times in the table are based on using the same count time for both background and sample measurements and are rounded up to convenient values. The selection of appropriate detectors and specific count times to be used for a given plant system survey unit are identified in specific survey instructions that are prepared in accordance with an approved procedure. The detectors that are considered capable of performing scans (i.e., at 2 inches/sec) include the LMI 43-94, LMI 43-98, LMI 43-68 and the SP-175-3M, which consists of three standard size GM probes.

TABLE 1 - SUMMARY OF PLANT SYSTEM SURVEY DETECTORS

Model Number	Description	Area (cm^2)	Typical [3] Efficiency	Typical BKG	Count Time	Advantages	Disadvantages	Applications
LMI 43-94	0.5" diameter gas flow pipe detector	100	7% in 1"	100 cpm	30 sec[1], 15 sec[2]	large area detector, scanning possible	detector fragile, gas flow equip. required	straight run piping 0.75" to 2"
			5% in 1.5"	100 cpm	1 min[1], 15 sec[2]			
LMI 43-98	1.5" diameter gas flow pipe detector	100	5% in 2"	200 cpm	2 min[1], 30 sec[2]	large area detector, scanning possible	detector fragile, gas flow equip. required	straight run piping 2" to 3"
			3% in 3"	200 cpm	4 min[1], 1 min[2]			
LMI 43-68	3.5" by 5.5" gas flow detector	125	20%	400 cpm	15 sec[1,2]	large area detector, scanning possible, short count time	gas flow equip. required	tanks, sumps, wells, piping >7"
SP-175-3M	3 - 1.75" GM detectors	46.5	8%	200 cpm	3 min[1] 30 sec[2]	ease of operation, scanning possible	detection area <100 cm^2	straight run piping 4" to 6"
SP-113-3M	3 - 1.13" GM detectors	19.4	7%	100 cpm	10 min[1] 2 min[2]	ease of operation	small detection area, long count times, cannot scan	straight run piping 3" to 6"
SP-113-3T	3 - 1.13" GM detectors	19.4	7%	100 cpm	10 min[1] 2 min[2]	able to survey piping with bends	small detection area, long count times, cannot scan	piping straight or with bends 3" to 6"
SN-113-3C	3 - 1.13" GM detectors	19.4	7%	100 cpm	10 min[1] 2 min[2]	able to survey piping with bends	small detection area, long count times, cannot scan	piping with bends 3" to 4"
SN-113-3T	3 - 1.13" GM detectors	19.4	7%	100 cpm	10 min[1] 2 min[2]	able to survey piping with bends	small detection area, long count times, cannot scan	piping with bends 2" or 3"
SN-050-4K	4 - 0.50" GM detectors	5.1	6%	20 cpm	35 min[1] 6 min[2]	able to survey piping with bends	small detection area, very long count times, cannot scan	1" piping with bends
SN-050-6K	6 - 0.50" GM detectors	7.6	6%	30 cpm	22 min[1] 4 min[2]	able to survey piping with bends	small detection area, very long count times, cannot scan	1" piping with bends

Notes:
[1] Based on achieving MDA of 1,250 dpm/100 cm^2
[2] Based on achieving MDA of 3,000 dpm/100 cm^2
[3] Efficiency in counts/dis from Tc-99 source covering detector sensitive area

8.0 ATTACHMENTS

8.1 Average Beta Energy (Ebar) for Detectable Plant Contamination at Fort St. Vrain

8.2 Plateau Data for LMI Gas Flow Pipe Detectors

8.3 Effective Survey Distance in Large Diameter Piping

8.4 Linearity Test Results for LMI Gas Flow Pipe Detectors

8.5 Uniformity Test Results for LMI Gas Flow Pipe Detectors

8.6 Gas Flow Test Results for LMI Gas Flow Pipe Detectors

8.7 SN-050-4K vs. TLD Survey Comparison Test Results

8.8 Shielding Detectable Contamination at Fort St. Vrain

8.9 Piping Instrumentation Figures

ATTACHMENT 8.1
AVERAGE BETA ENERGY (EBAR) FOR DETECTABLE PLANT CONTAMINATION AT FORT ST. VRAIN

Table 1 below presents the relative radionuclide composition of various samples and smears taken at Fort St. Vrain for the "detectable" radionuclides. These particular samples, which are decay corrected to January 1, 1996, are the ones used to determine the Site Specific Guideline Values (SGLV). Also presented in the table, is the average radionuclide composition that is determined by assigning equal weight to each of the individual samples. Only the "detectable" (i.e., readily detectable) nuclides are included in the calculation because the hard to detect nuclides and alpha emitters are accounted for by reducing the SGLV.

TABLE 1 - RELATIVE RADIONUCLIDE COMPOSITION OF FORT ST. VRAIN SAMPLES/SMEARS

	Co-60	Sr-90	Cs-134	Cs-137	Eu-152	Eu-154	Tc-99
PCRV Smear	7.25E-1	3.75E-3	3.28E-3	1.02E-1	1.56E-1	1.03E-2	
HSF Smear	9.87E-1	2.75E-4		1.24E-2			
FHM Smear	9.38E-1	4.93E-3	1.30E-3	5.58E-2			
Liquid Waste Resin	3.44E-2	1.39E-3	4.72E-2	9.17E-1			
PCRV Concrete	1.17E-1		4.53E-3		8.08E-1	5.66E-2	1.34E-2
Graphite Dust	3.22E-1	9.15E-5			6.27E-1	5.12E-2	
PCRV Access Flange	9.78E-1	2.26E-3	1.51E-3	1.77E-2			
PCRV Shield Plug	8.56E-1	6.01E-3	1.85E-3	1.36E-1			
Average Fraction	6.20E-1	2.34E-3	7.46E-3	1.55E-1	1.99E-1	1.48E-2	1.68E-3

To determine Ebar for the average radionuclide composition, Ebar for each radionuclide is determined using published tabulations. In the individual nuclide Ebar calculation, electrons from internal conversion, auger electron emission as well as beta decay are considered "beta particles" because each electron of a given energy (without regard to its decay source) has the same probability of interacting with a detector. In addition, any daughter nuclides that can be

assumed to be in equilibrium with the parent are factored into the calculation (e.g., the Sr-90 daughter Y-90 and the Cs-137 daughter Ba-137m).

The equation used to calculate Ebar for a given radionuclide is as follows:

$$Ebar = \frac{\sum_{1}^{N} (Abundance * BetaEnergy)}{\sum_{1}^{N} (Abundance)}$$

where N is the number of individual branches of the radionuclide (i.e., each auger, conversion, or beta decay electron and its associated energy)

The Ebar calculation for each individual radionuclide uses all electron energies, including low energy auger electrons. This was done to ensure a consistent approach is followed with each nuclide and the range of its electron emissions. Most auger electrons and some of the beta decay electrons (which are emitted with an energy spectrum from zero to a characteristic maximum) are unable to reach the detector due to their low energy. To be consistent in omitting electron energies not expected to be detected would require correcting for all low energy electrons, including beta decay. Consequently, the consistent approach of using all energies emitted by a given radionuclide is followed. A summary of the Ebar values for each radionuclide that are used in the overall average Ebar calculation is provided in Table 2 below:

TABLE 2 - EBAR DATA SUMMARY

	Co-60	Sr-90	Cs-134	Cs-137	Eu-152	Eu-154	Tc-99
Average Fraction	6.20E-1	2.34E-3	7.46E-3	1.55E-1	1.99E-1	1.48E-2	1.68E-3
Ebar (keV)	95.8	565.3[2]	159.6[1]	196.8[1,2]	87.2[1]	149.2[1]	84.6
Beta Abundance[3]	1.000	2.000[2]	1.015[1]	1.174[1,2]	1.424[1]	1.838[1]	1.000

NOTES:
[1] Data include contributions from conversion and auger electrons
[2] Data include contributions from daughter
[3] Beta Abundance is the average number of beta particles emitted per decay

To determine overall Ebar for the average radionuclide composition, the following equation is used:

$$Ebar = \frac{\sum_{1}^{N} (AverageFraction * Abundance * BetaEnergy)}{\sum_{1}^{N} (AverageFraction * Abundance)}$$

where N is the number of detectable radionuclides in the average composition. Using the preceding equation and data from Table 2, the results of Table 3 are obtained.

Note: The denominator of this equation is the beta abundance (i.e., average number of beta particles emitted per decay) for average radionuclide composition at FSV.

Using the preceding equation and data from Table 2, the resuits of Table 3 are obtained.

TABLE 3 - EBAR RESULTS FOR RADIONUCLIDE COMPOSITION

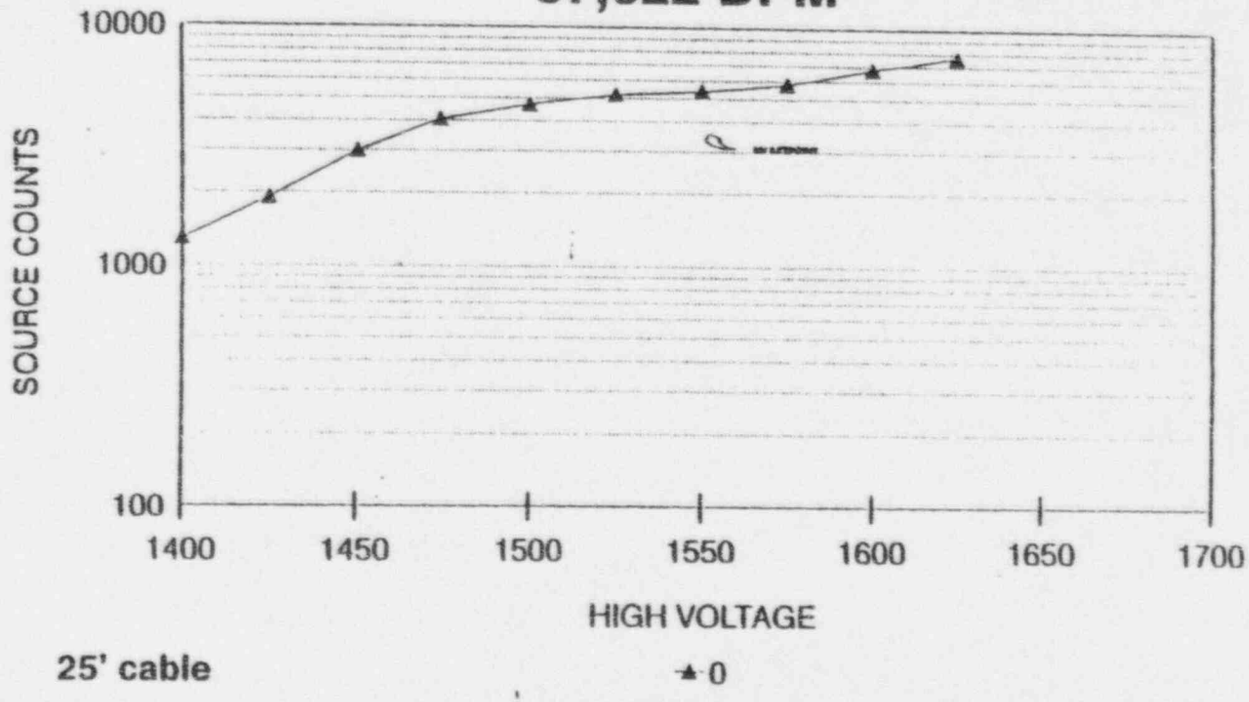
Ebar (keV)	Beta Abundance
113.6	1.126

ATTACHMENT 8.2
PLATEAU DATA FOR LMI GAS FLOW PIPE DETECTORS

43-94 DETECTOR PLATEAU

M2350 #95337 DET. #PR119460 Tc99 #SCN868

67,022 DPM



25' cable

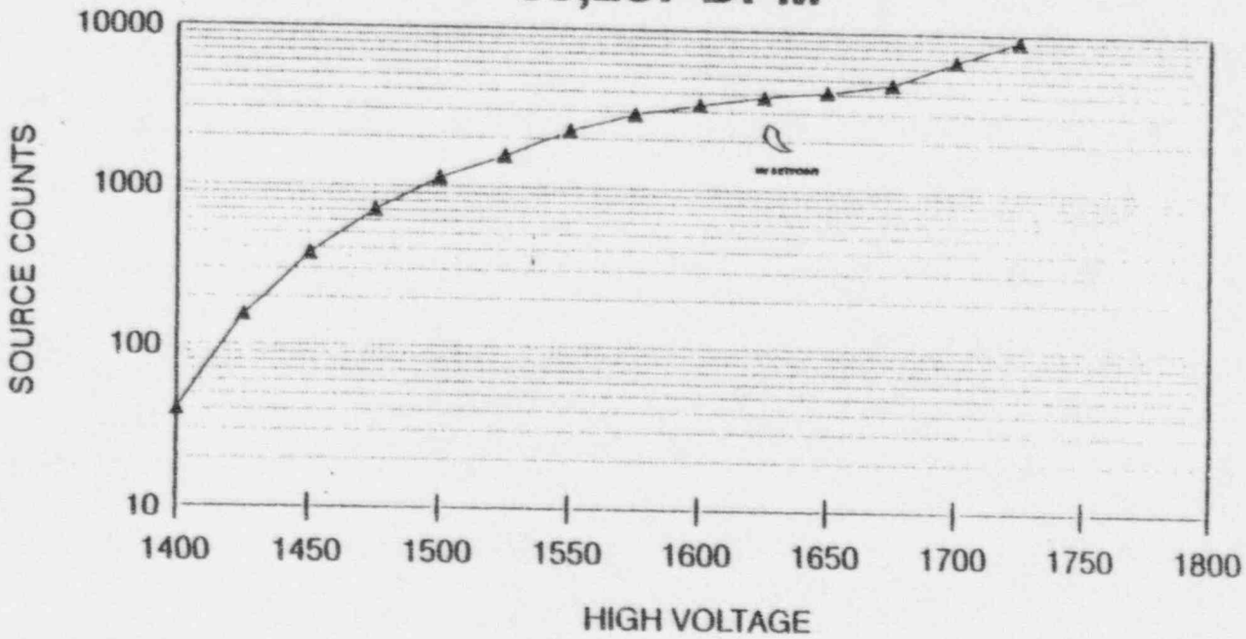
▲ 0

ATTACHMENT 8.2
PLATEAU DATA FOR LMI GAS FLOW PIPE DETECTORS

43-98 DETECTOR PLATEAU

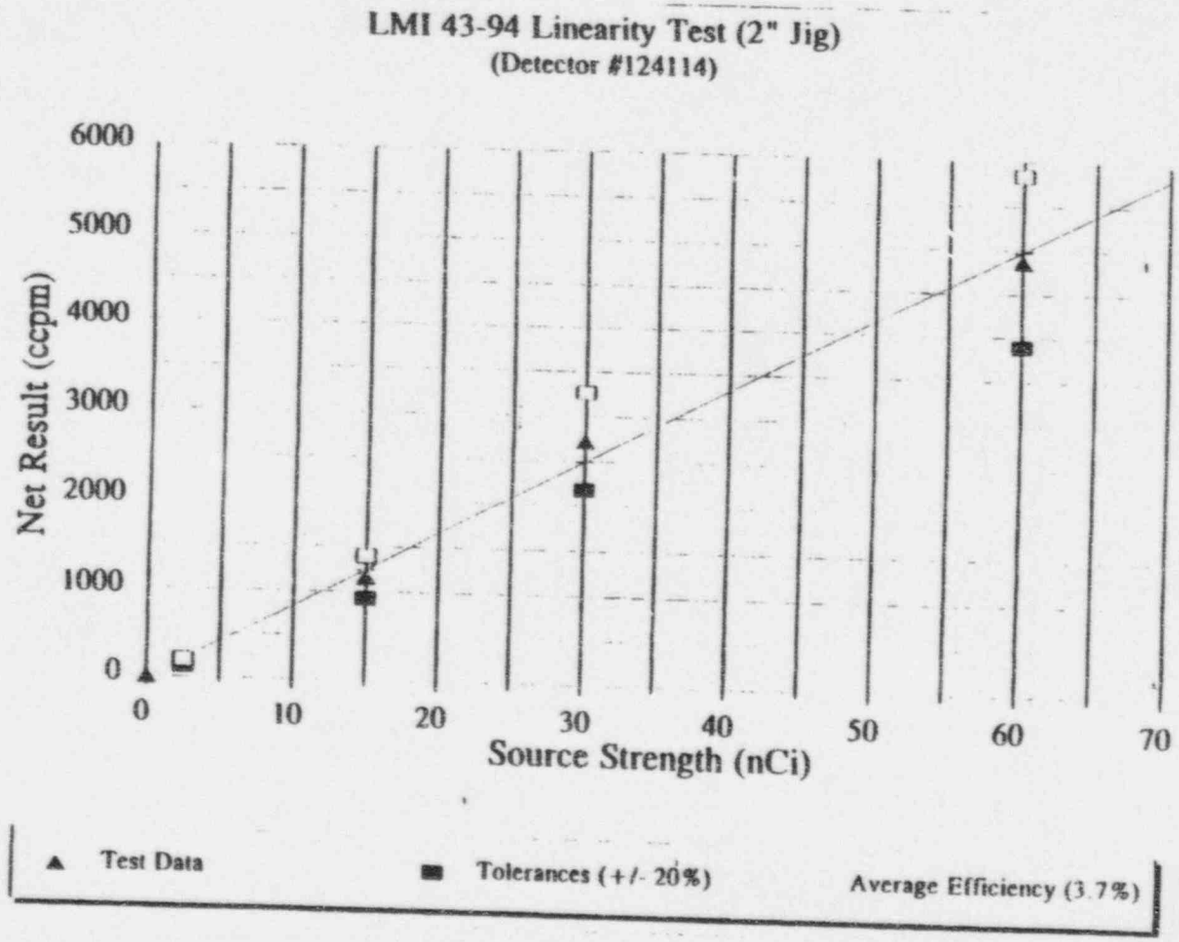
M2350 #95348 DET. #PR117963 Tc99 #SCN867

68,287 DPM



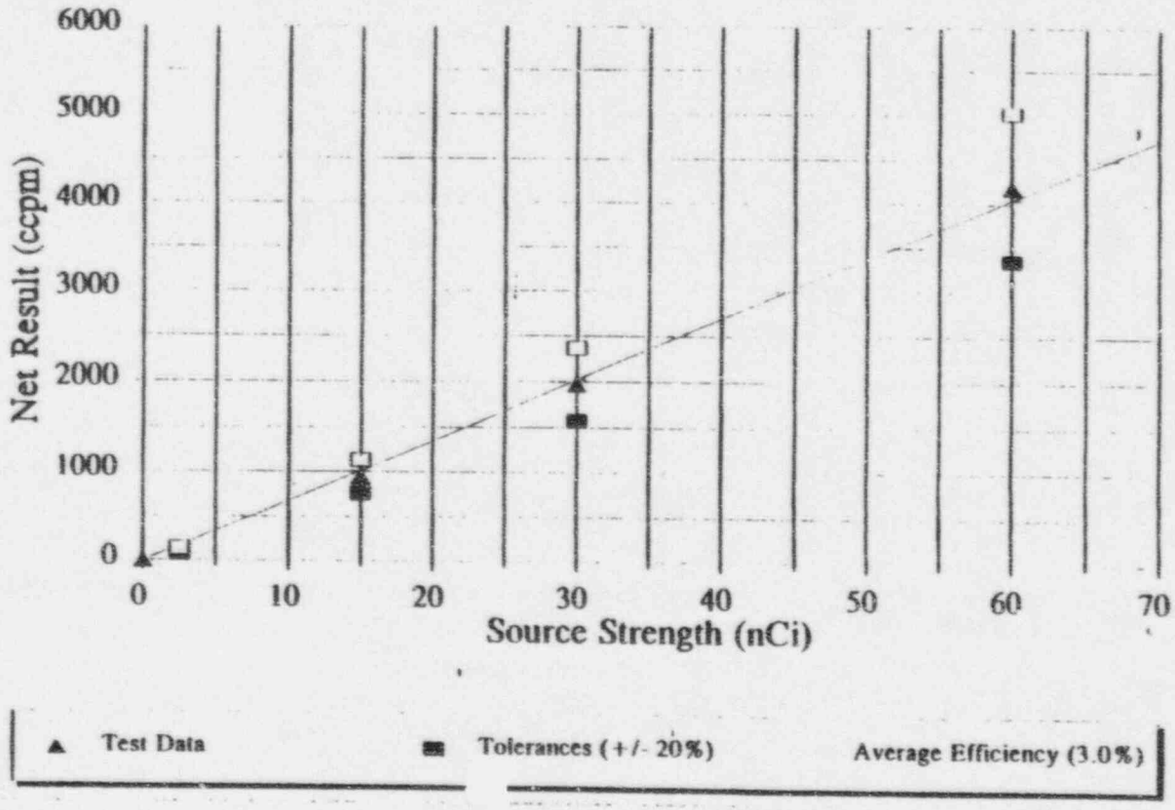
25' cable

ATTACHMENT 8.4
LINEARITY TEST RESULTS FOR LMI GAS FLOW PIPE DETECTORS

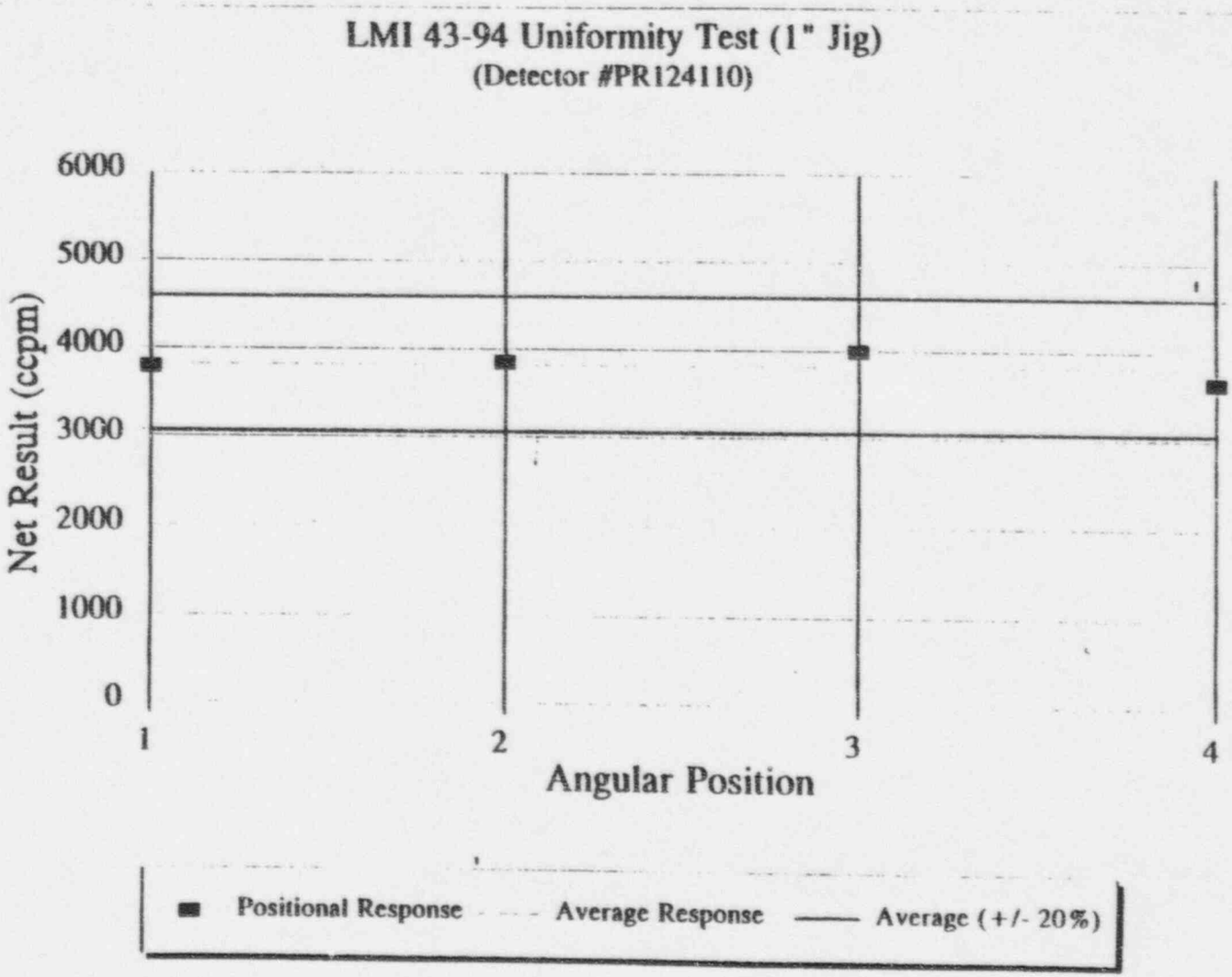


ATTACHMENT 8.4
LINEARITY TEST RESULTS FOR LMI GAS FLOW PIPE DETECTORS

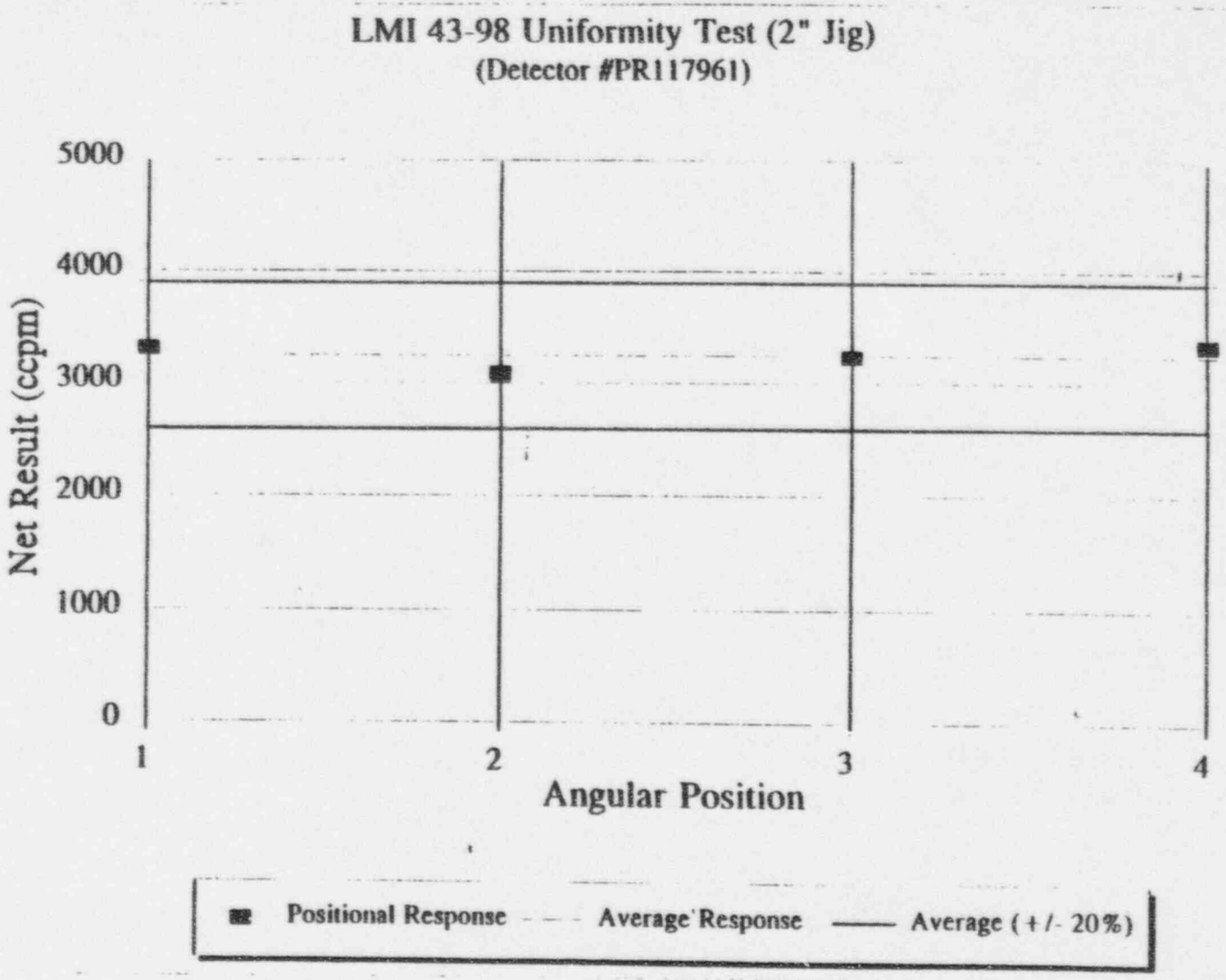
LMI 43-98 Linearity Test (3" Jig)
(Detector #117961)



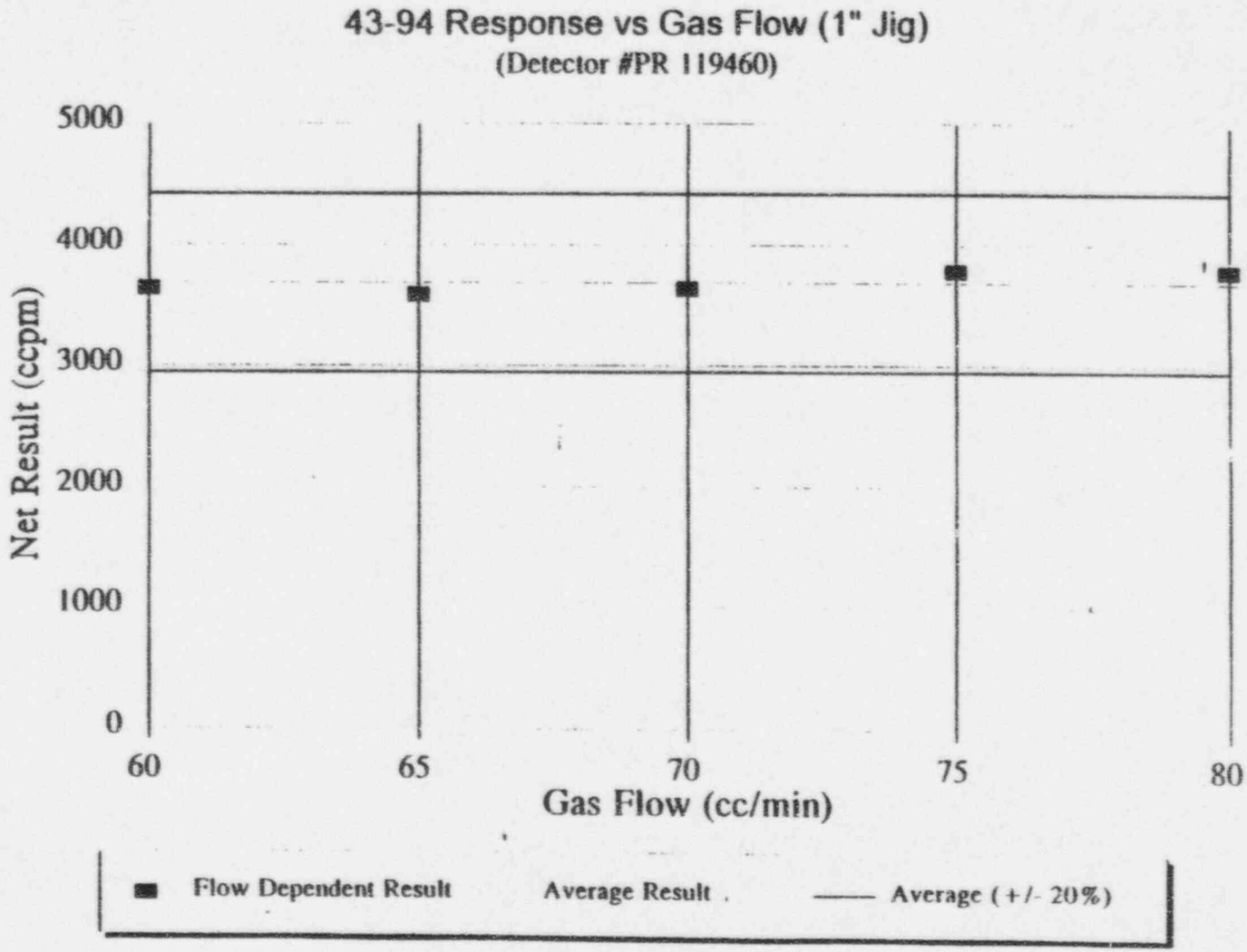
ATTACHMENT 8.5
UNIFORMITY TEST RESULTS FOR LMI GAS FLOW PIPE DETECTORS



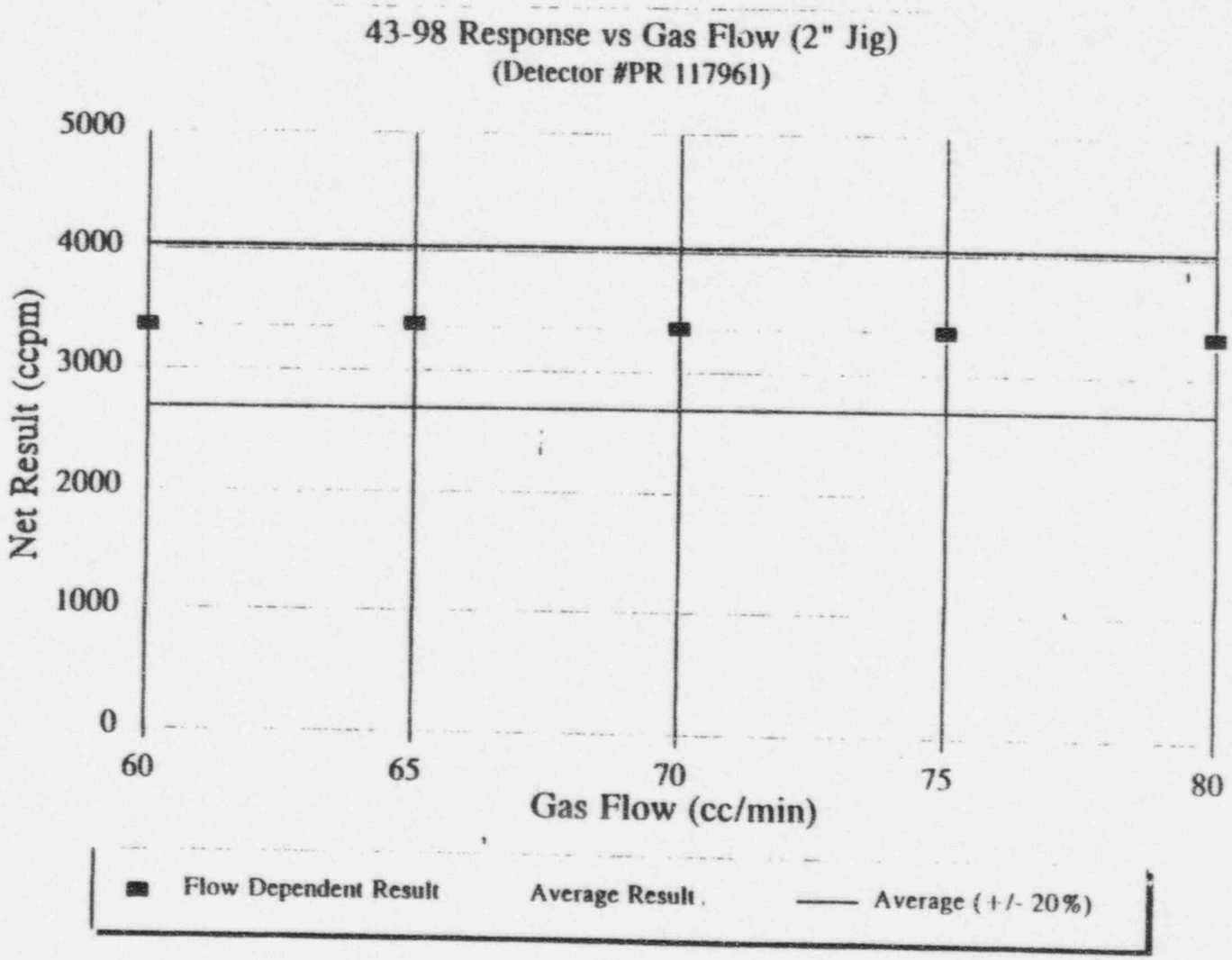
ATTACHMENT 8.5
UNIFORMITY TEST RESULTS FOR LMI GAS FLOW PIPE DETECTORS



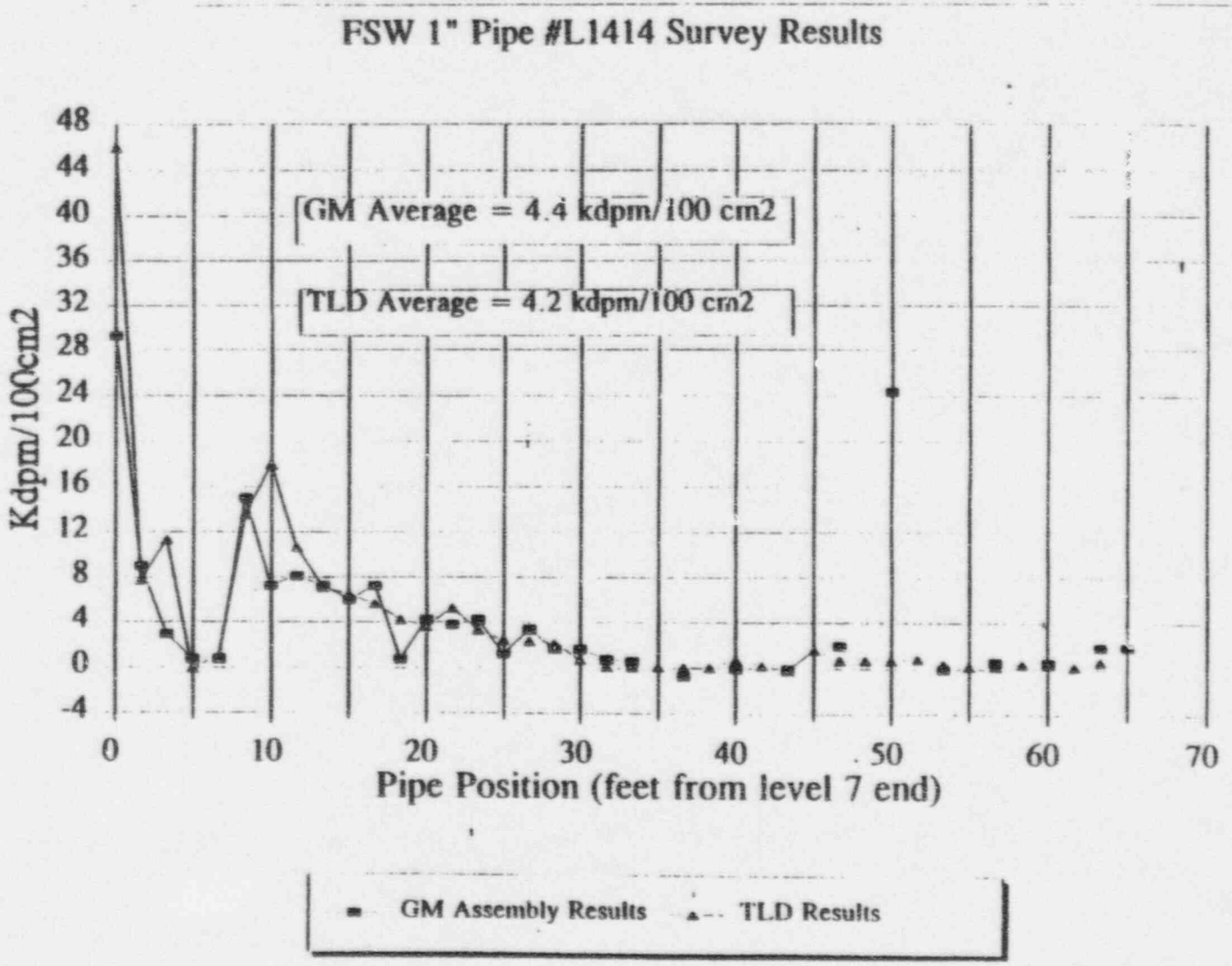
ATTACHMENT 8.6
GAS FLOW TEST RESULTS FOR LMI GAS FLOW PIPE DETECTORS



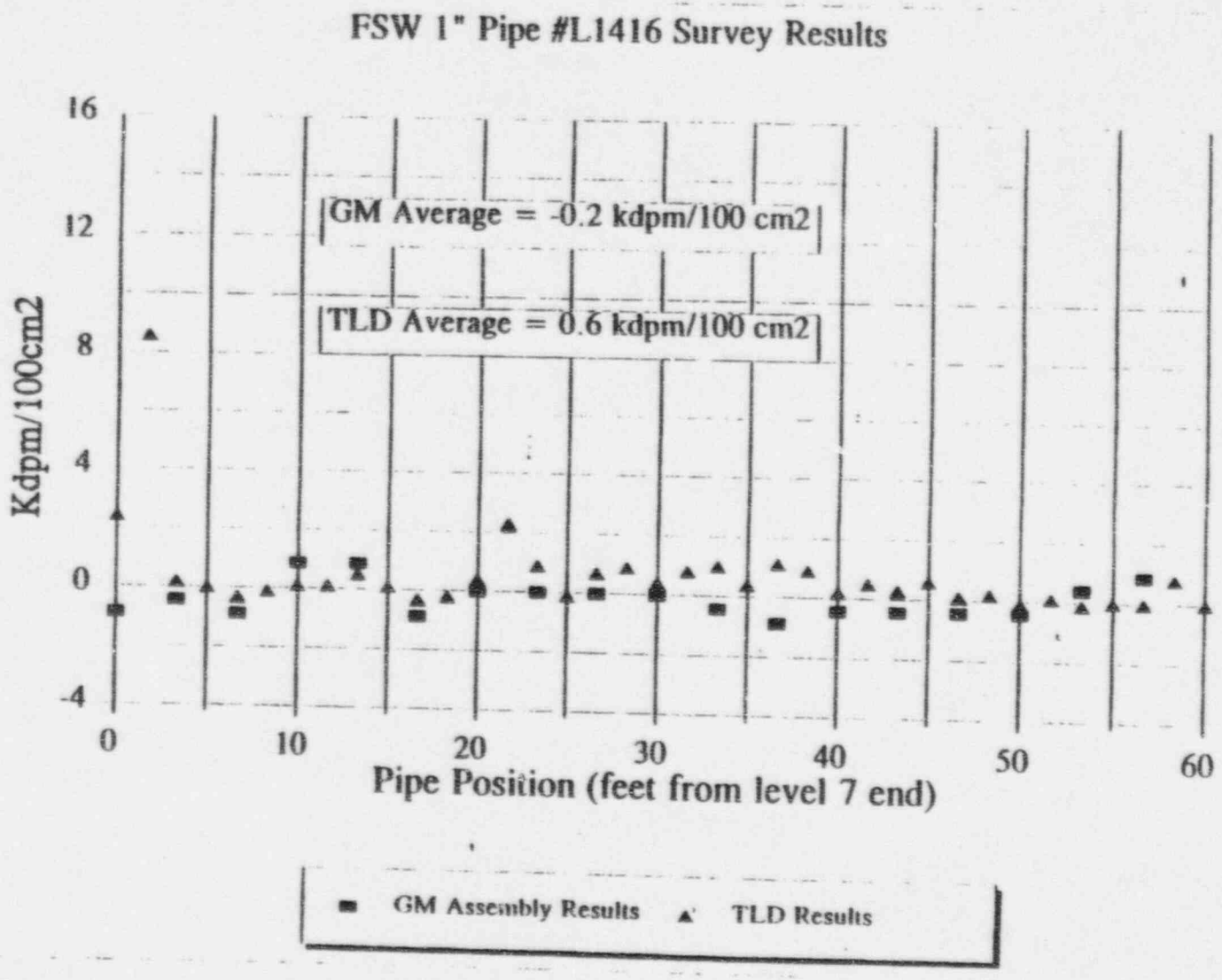
ATTACHMENT 8.6
GAS FLOW TEST RESULTS FOR LMI GAS FLOW PIPE DETECTORS



ATTACHMENT 8.7
SN-050-4K VS. TLD SURVEY COMPARISON TEST RESULTS



ATTACHMENT 8.7
SN-050-4K VS. TLD SURVEY COMPARISON TEST RESULTS



ATTACHMENT 8.8
SHIELDING DETECTABLE CONTAMINATION AT FORT ST. VRAIN

When performing background measurements inside plant system piping, a 300 mg/cm² shield (typically aluminum) is used to cover the detector's sensitive area to measure instrument background. To verify effectiveness of the shielding, the following analysis has been performed.

A 300 mg/cm² shield of aluminum is the range for 600 keV beta particles (Ref. 2.1.3). In other words, only particles with energy greater than 600 keV will be able to penetrate the shield. To determine percentage of beta particles from detectable contamination at Fort St. Vrain that would penetrate this amount of shielding, a decay distribution shape is assumed as shown in Figure 1 below superimposed on a typical (curved line) beta decay distribution (i.e., typical for β^- decay, which is decay scheme of interest at Fort St. Vrain, a β^+ decay distribution would involve a shift to higher energies due to Coulomb interaction with the nucleus) (Ref. 2.1.4 & 2.1.5).

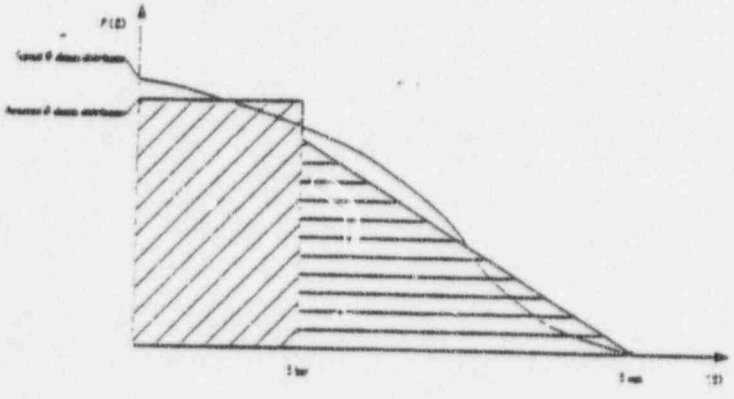


FIGURE 1 - TYPICAL AND ASSUMED β^- DECAY DISTRIBUTIONS

As seen in Figure 1, the distribution is assumed to be composed of two segments. The first segment assumes a uniform energy probability for beta particle energies up to Ebar. The second segment assumes a triangular shape terminating at Emax. Under each segment, the normalized area is defined to be 0.5, which, in effect, assumes that half the beta particles have energy below Ebar and half above Ebar.

To determine attenuated area under the second segment of assumed distribution when Ebar is <600 keV and Emax is >600 keV, the following equation is used:

$$P(E) = P(Ebar) - \frac{P(Ebar)}{(Emax - Ebar)}(E - Ebar)$$

Since area under the second segment of assumed distribution (i.e., triangular region) is by definition equal to 0.5, solving for area of the triangular region results in the following expression for P(Ebar):

$$P(Ebar) = \frac{1}{(Emax - Ebar)}$$

which by substitution results in the following expression for P(E):

$$P(E) = \frac{1}{(Emax - Ebar)} - \frac{(E - Ebar)}{(Emax - Ebar)^2}$$

Using this equation, attenuated area under the second segment of assumed distribution can be determined for a given energy (i.e., 600 keV).

Assumptions used to determine attenuation for each decay line of a given radionuclide are as follows:

1) For beta particle distributions whose Ebar is greater than 600 keV, the fraction of beta particles that are attenuated by the shield is determined by:

$$\% \ attenuated = \left[\frac{600}{Ebar}\right] * 50$$

where Ebar is in keV.

2) Beta decay distributions whose Emax is <600 keV and internal conversion and auger electron emissions whose mono-energetic energies are <600 keV are attenuated 100% (internal conversion and auger electron emissions <600 keV are grouped together with a summed abundance).

3) Internal conversion electron emissions with mono-energetic energies >600 keV are not attenuated.

4) For beta particle distributions whose Ebar is less than 600 keV, but whose Emax is greater than 600 keV, the fraction of beta particles that are attenuated by the shield is determined by:

$$\% \ attenuated = 50 + 100 * \left(0.5 - \frac{(Emax - 600)\left[\frac{1}{(Emax - Ebar)} - \frac{(600 - Ebar)}{(Emax - Ebar)^2}\right]}{2}\right)$$

where Ebar and Emax are in keV.

Total attenuation for a given nuclide is given by weighted averaging of all individual decay lines of the nuclide (i.e., weighted by individual line abundances). Total attenuation for Fort St. Vrain nuclide mix is determined by weighted averaging of individual nuclide total attenuations where weight is based on the fraction present in the average nuclide mix.

The following table lists specific radionuclides identified in "detectable" contamination at Fort St. Vrain and the percent attenuated for each decay line of the nuclide and total effective attenuation for the nuclide. These radionuclides are the values and fractions identified in the sample set used to determine SGLVs (see also Table 2 of Attachment 8.1). Total attenuation for Fort St. Vrain contamination by a 300 mg/cm^2 shield is calculated to be 97.9%.

Nuclide	Average Fraction of Nuclide	Mean # of Beta Particles per Decay	Ebar (keV) per Line	Emax (keV) per Line	% Beta Attenuated per Line	Overall % Attenuated per Nuclide
Co-60	0.62000	1.000	95.8 (100%)	317.9 (100%)	100.0	100.0
Sr-90	0.00234	2.000	195.8 (Sr-90, 100%)	546.0 (Sr-90)	100.0	66.0
			934.8 (Y-90, 100%)	2283.9 (Y-90)	32.1	
Cs-134	0.00746	1.015	2[illegible] (27.4%)	88.5 (27.4%)	100.0	99.2
			123.4 (2.48%)	415.1 (2.48%)	100.0	
			210.1 (70.1%)	657.9 (70.1%)	99.2	
			758.4 (0.22%)	758.4 (0.22%)	0.0	
			< 600 (1.28%)	< 600 (1.28%)	100.0	
Cs-137	0.15500	1.174	156.8 (94.6%)	511.6 (94.6%)	100.0	90.6
			415.2 (5.4%)	1173.2 (5.4%)	71.4	
			624.2 (7.64%)	624.2 (7.64%)	0.0	
			655.7 (1.38%)	655.7 (1.38%)	0.0	
			660.4 (0.45%)	660.4 (0.45%)	0.0	
			< 600 (7.95%)	< 600 (7.95%)	100.0	
Eu-152	0.19900	1.424	47.5 (1.78%))	176 (1.78%)	100.0	97.2
			112.5 (2.4%)	385 (2.4%)	100.0	
			221.8 (13.6%)	696 (13.6%)	99.0	
			227 (0.23%)	710 (0.23%)	97.4	
			295.3 (0.29%)	889 (0.29%)	88.2	
			364.8 (0.89%)	1064 (0.89%)	78.0	
			535.6 (8.44%)	1475 (8.44%)	56.6	
			< 600 (114.4%)	< 600 (114.4%)	100.0	
Eu-154	0.01480	1.838	68.8 (27.9%)	247.4 (27.9%)	100.0	95.3
			86.9 (0.77%)	306.1 (0.77%)	100.0	
			91.7 (0.149%)	321.2 (0.149%)	100.0	
			100.9 (1.58%)	349.8 (1.58%)	100.0	
			119.8 (0.117%)	407.4 (0.117%)	100.0	
			129.3 (0.281%)	435.7 (0.281%)	100.0	
			168.3 (0.188%)	548.6 (0.188%)	100.0	
			175.7 (36.5%)	569.4 (36.5%)	100.0	
			224.5 (0.64%)	703.2 (0.64%)	97.7	
			229 (0.245%)	715.4 (0.245%)	97.2	
			276 (17.4%)	839.2 (17.4%)	91.0	
			327.5 (2.0%)	970.7 (2.0%)	83.4	
			406.4 (0.29%)	1151.5 (0.29%)	73.0	
			587.4(0.24%)	1596 (0.24%)	51.2	
			695 (11.4%)	1843.9 (11.4%)	43.2	
			< 600 (83.6%)	< 600 (83.6%)	100.0	
Tc-99	0.00168	1.000	84.6 (100%)	293.6 (100%)	100.0	100.0
				Overall Attenuation (%) =		97.9

ATTACHMENT 8.9 - PIPING INSTRUMENTATION FIGURES

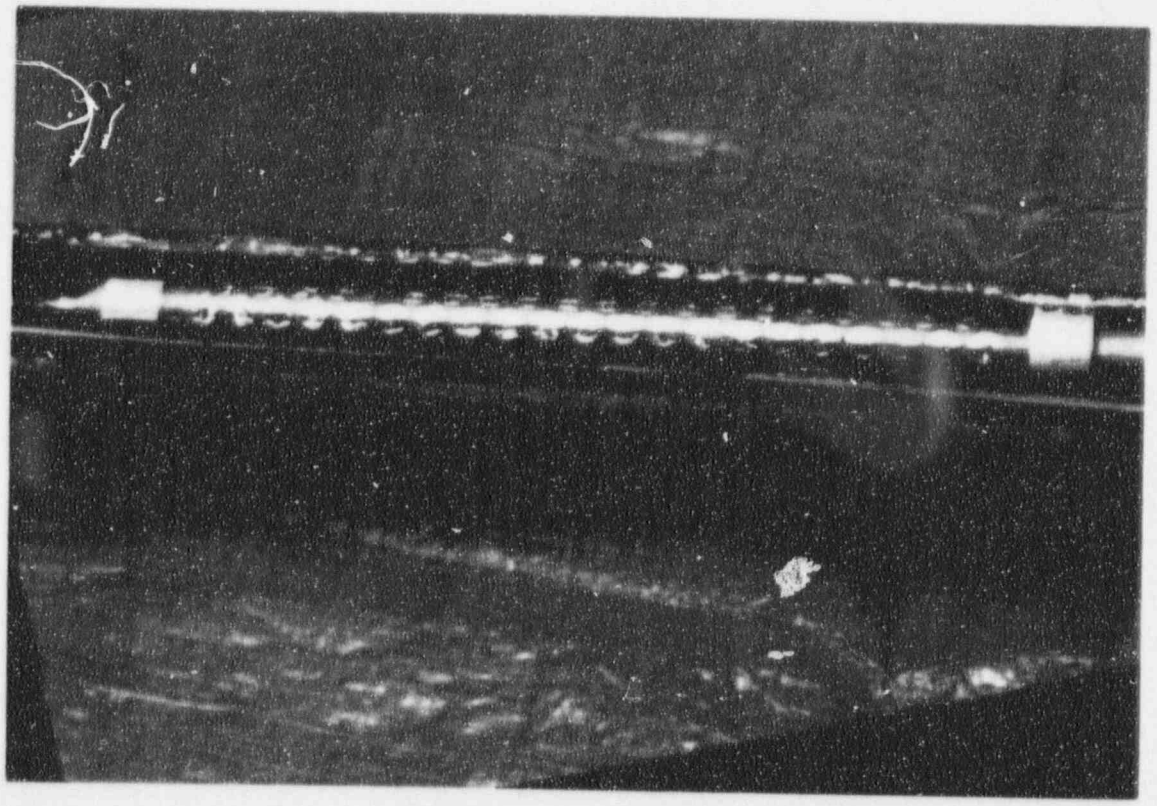


Figure 1: LMI 43-94

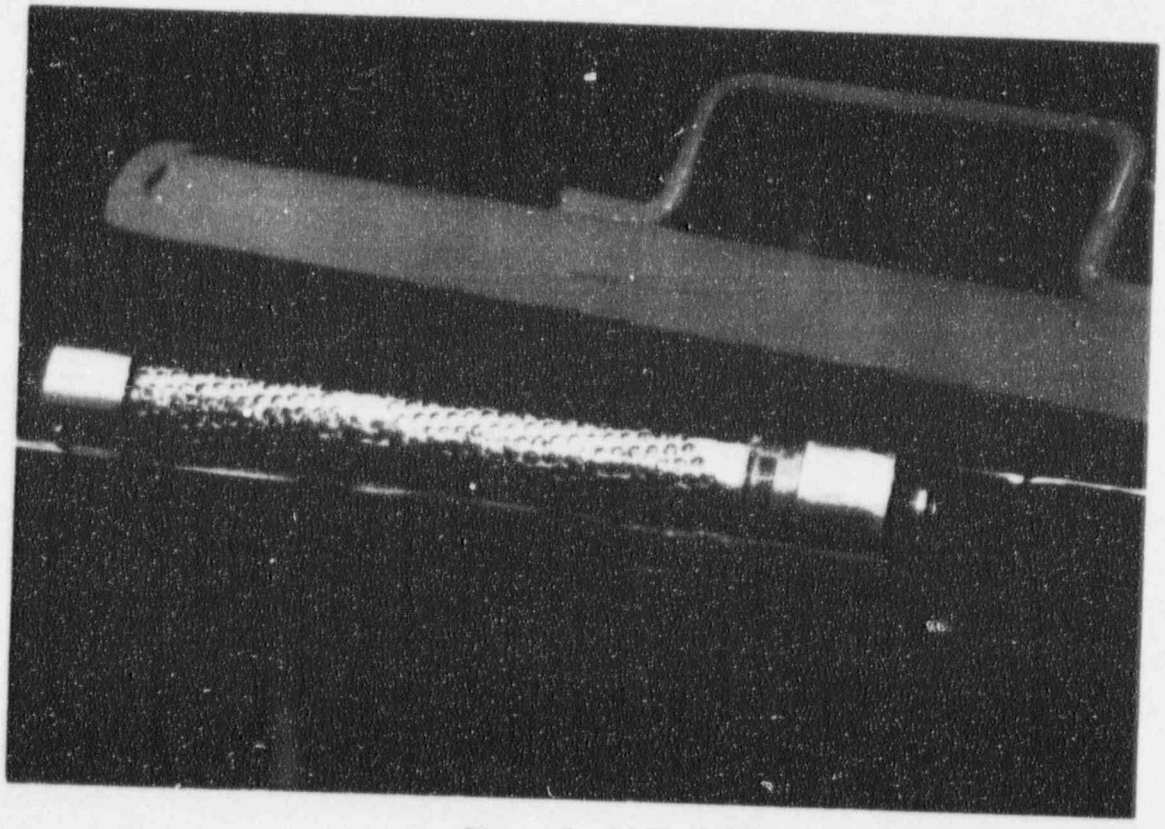


Figure 2: LMI 43-98

ATTACHMENT 8.9
PIPING INSTRUMENTATION FIGURES

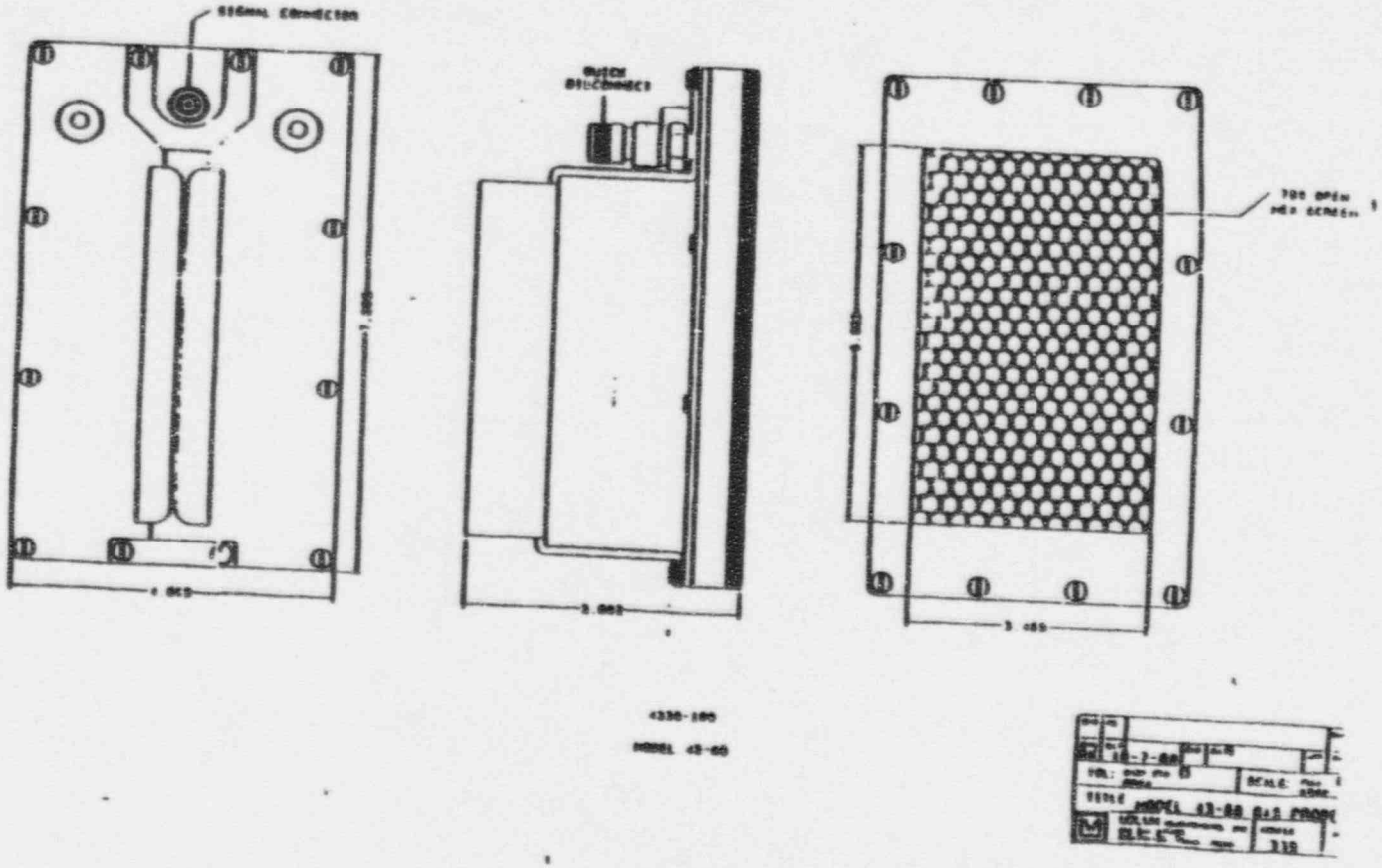


Figure 3 LMI-43-68

ATTACHMENT 8.9 - PIPING INSTRUMENTATION FIGURES

Pages 3 thru 7

Proprietary

ATTACHMENT 2

TO P-96004

FORT ST. VRAIN TECHNICAL BASIS DOCUMENTS FOR PIPING SURVEY INSTRUMENTATION (NON-PROPRIETARY)