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Public Service
Company of Colorado

March 5, 1996
Fort St. Vrain
P-96009

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

ATTN: Mr. Michael F. Weber, Chief
Decommissioning and
Regulatory Issues Branch

Docket No. 50-267

SUBJECT: **Response to NRC Questions Regarding PSCo's Proposed Revisions to Final Survey Plan For Survey of Piping Systems and Suspect Affected Survey Units**

REFERENCES:
1. NRC Letter, Pittiglio to Crawford, dated February 12, 1996 (G-96014)
2. PSCo Letter, Fisher to Weber, dated October 12, 1995 (P-95077)

Dear Mr. Weber:

This letter submits Public Service Company of Colorado's (PSCo) responses to NRC comments provided in your February 12, 1996 letter (Reference 1), regarding proposed revisions to the Fort St. Vrain (FSV) Final Survey Plan that were submitted in our October 12, 1995 letter (Reference 2). The proposed changes involved survey treatments for piping systems and for suspect affected survey units.

The attachment to this letter provides PSCo's responses to the fifteen comments in the referenced letter. Final surveys of affected FSV piping systems have begun, utilizing survey techniques as described in the Reference 2 submittal. In order to minimize the amount of potential rework and avoid impacting the scheduled decommissioning work completion date of August 9, 1996, PSCo requests NRC approval of the proposed treatment methodologies by April 8, 1996.

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Both this letter and PSCo's October 12, 1995 letter (Reference 2) address the decontamination and survey of embedded piping and grouting of certain small diameter pipes, which PSCo defined as 3 inch diameter and smaller. As decontamination and survey efforts of larger diameter embedded piping progress, there may be instances where it could be more consistent with ALARA principles to fill pipes larger than 3 inch diameter with grout where they exceed the site specific guideline values after aggressive decontamination, in the same manner proposed for small diameter piping. As discussed with Mr. Clayton Pittiglio of your staff, any such cases will be addressed to the NRC via future correspondence.

If you have any questions regarding this information, please contact Mr. M. H. Holmes at (303) 620-1701.

Sincerely,

Frederick J. Borst
Decommissioning Program Director

FJB/SWC

Attachment

cc: with attachment

Regional Administrator, Region IV

Mr. Robert M. Quillin, Director
Radiation Control Division
Colorado Department of Public Health and Environment

Attachment to P-96009

The following are PSCo/WT's responses to the NRC's Comments on 1) our October 12, 1995, submittal (P-95077) "Fort St. Vrain Final Survey Plan for Site Release, Proposed Revisions for Survey of Piping Systems and Suspect Affected Survey Units," and 2) the November 15, 1995, submittal (P-95102) "Fort St. Vrain Technical Basis Documents for Piping Survey Instrumentation:"

Comments 1 through 8 Refer to PSCo's October 12, 1995, Submittal (P-95077):

NRC Comment No. 1:

> *As noted in this submittal, the final survey plan calls for a minimum of 30 biased measurements in each system survey unit, and piping is considered a system. One of the reasons that the approved survey protocol for systems is considered acceptable to the staff is because when contamination above 75 percent of the 4000 dpm/100 cm² average guideline value is identified at the biased locations, investigations are required to better define the extent of the contamination in the systems. The staff is confident that investigations at 75 percent of the 4000 dpm/100 cm² average guideline value will identify significant contamination in plant systems. Will the investigation levels for imbedded piping survey results be based on the site guideline values of 4000 dpm/100 cm² average and 12,000 dpm/100 cm² maximum, or on the higher guideline values proposed in the submittal? Please list the investigation levels. What will the investigations entail? When will additional survey coverage of the pipes in a given survey unit be required? Are there anticipated conditions where additional decontamination will be justified?*

PSCo/WT Response:

PSCo/WT propose to investigate any individual measurement in embedded pipes of 50,000 dpm/100 cm² or greater, and any individual pipe with average contamination greater than 25,000 dpm/100 cm², provided this individual pipe is significantly more contaminated than the rest of the pipes in the survey unit, as defined later.

Investigating individual measurements of 50,000 dpm/100 cm² is 50 percent of the 100,000 dpm/100 cm² uniform activity level evaluated in the October 12, 1995 proposal, which was shown to result in dose consequences that are not significant. An investigation level of 50,000 dpm/100 cm² is a reasonable threshold to demonstrate that the piping meets the bounding condition assumed in the submittal. Consistency with non-embedded piping system action levels would only require investigations at 75% of the bounding limit (i.e., 75,000 dpm/100 cm²); however, to provide a greater level of assurance, a general investigation level of 50,000 dpm/100 cm² is proposed (i.e., 50% of the bounding value).

Due to the difficulty of performing investigation surveys in embedded piping, the initial final survey of embedded piping survey units is more comprehensive than a comparable non-embedded piping system. For example, when GM detector assembly or TLD string surveys are conducted of embedded piping, measurements are taken along the entire pipe length (for the selected pipes) instead of just at a biased location. If elevated readings are found, the reading is bounded by the adjacent measurements. A sufficient number of pipes are selected for survey to provide an appropriate representation of the entire survey unit. 20% of the survey unit pipes are surveyed when TLD strings are used and 10% of the survey unit pipes are surveyed when GM detector assemblies are used. A lower percentage is selected when GM assemblies are used because this method requires high equipment maintenance and is labor intensive, but can also provide some indication (although scan MDAs are limited) of surface activity throughout the pipe.

The implementation of investigations will include surveying, with a GM detector assembly (when physically possible) the immediate vicinity of each TLD individual measurement that is greater than 50,000 dpm/100 cm^2. Investigation of individual GM assembly measurements greater than 50,000 dpm/100 cm^2 is not necessary since the immediate vicinity will have already been examined by the initial survey. This investigation is intended to ensure that localized activity greater than 100,000 dpm/100 cm^2 is not present in the vicinity of TLD measurements greater than 50,000 dpm/100 cm^2. Additionally, if greater than 10% of the measurements taken in a survey unit are greater than 50,000 dpm/100 cm^2, an additional 20% of the survey units pipes (if TLD string survey is to be performed) or 10% of the survey units pipes (if GM detector assembly survey is to be performed) will be surveyed.

Additional investigation will be performed if an individual pipe is contaminated to an average level greater than 25,000 dpm/100 cm^2, and is significantly greater than the average of the survey unit (i.e., a factor of two or more greater than the survey unit average, excluding the elevated pipe). This investigation may result in a determination as to why a given pipe was elevated relative to the remaining pipes in the survey unit or additional measurements. If it can be determined why a given pipe was elevated, other pipes that might similarly be elevated will be surveyed. If it cannot be determined why a given pipe is elevated relative to the remaining survey unit, an addition 10% of the survey units pipes (if GM detector assembly survey is to be performed) or 20% of the survey units pipes (if TLD string survey is to be performed) will be surveyed.

Additional decontamination will be necessary if measurements greater than 100,000 dpm/100 cm^2 are obtained (unless a specific case exception is obtained from the NRC).

To assist in an overall understanding of the embedded piping scope at FSV, a summary of each embedded piping survey unit is provided on the following pages. For completeness, this discussion includes all embedded piping survey units, some of which are larger diameter than the 3-inch and under small diameter piping addressed by the October 12, 1995 proposal.

PCRV TOP HEAD AND SIDE WALL COOLING TUBES

Survey Unit Description and Basis:

This survey unit consists of cooling tubes that passed through the PCRV side walls and attached to the PCRV liner or liners on PCRV penetrations. Tubes were field run as necessary around rebar and tendon conduits. During decommissioning, these tubes were cut while making the PCRV concrete cuts. After the concrete cuts were made, there were 460 embedded tube sections consisting of 1" O.D. round pipe varying in length from 10 to 14 feet. Most tubes have sharp bends. In addition there are 52 sections of 1" square pipe attached to six instrument and safety valve penetrations.

Based on characterization surveys performed on piping external to the PCRV, their potential for contamination is from concrete slurry entering the tube during concrete cutting. These pipes are grouped together as a single survey unit due to their common size, configuration and contamination potential.

Characterization Surveys:

Characterization surveys are being performed on approximately 5% to 10% of the tubes after the slurry has been removed. Surveys are being performed using a 0.5" cylindrical gas flow probe (for straight run sections) and a GM assembly that consists of six 0.5" diameter GM tubes (for sections with bends). The maximum measurement for total surface activity was 17,000 dpm/100 cm^2, prior to final cleaning. To date, none of the tubes have surface contamination in excess of the SGLVs.

Decontamination Plans:

The tubes in this survey unit will be decontaminated using a wire brush/absorbent swab to remove slurry and any residual loose surface contamination that might have accumulated in the tubes from concrete cutting. Final swabs of the tubes are surveyed for loose surface contamination to ensure significant removable surface activity will not remain in the tubes. This effort is expected to be sufficient to reduce residual contamination levels below current SGLVs (i.e., 4,000 dpm/100 cm^2 average and 12,000 dpm/100 cm^2 maximum).

Final Survey Plans:

Total surface activity measurements are planned to be taken for twenty percent (slightly over 100 tubes) of the tubes using TLD strings. TLD pairs will be installed at 20" intervals. Approximately 1200 TLDs will be used, which will result in approximately 600 TLD surface activity measurements for the survey unit. Surface activity scanning, due to the inaccessibility of the pipes for detectors capable of scanning, will be limited to the open ends of the pipes surveyed with TLDs (i.e. up to the first elbow at each end). A fixed point

reading will be taken at each end of the pipes, where possible, with the cylindrical gas flow detector (at highest activity level as identified by scan). Removable surface activity measurements are planned to be taken at each end of the pipes surveyed with TLDs.

PCRV TENDON TUBES

Survey Unit Description and Basis:

This survey unit consists of tubes or conduits that housed the PCRV pre-stressing tendons. These tubes pass through the PCRV concrete vertically, circumferentially, and horizontally (cross head). During decommissioning, the tendons were detensioned and removed from the tubes prior to performing the top head and beltline concrete cuts. The tubes were cut inside the PCRV while making the concrete cuts. After the concrete cuts were made, there were 230 embedded tube sections consisting of 4.5" and 7" O.D. pipe varying in length from 10 to 104 feet. Most tubes have gentle bends.

Based on characterization surveys performed on the removed tendons, their potential for contamination is from concrete slurry entering the tube during concrete cutting. These pipes are grouped together as a single survey unit due to their common size, configuration and contamination potential.

Characterization Surveys:

Characterization surveys are being performed on approximately 5% to 10% of the tubes using an expandable GM assembly which consists of three 1.13" diameter GM tubes. To date, most surface activity measurements are below SGLVs with a highest total surface activity measurement of 15,000 dpm/100cm ^{2} obtained prior to final cleaning of the tube.

Decontamination Plans:

The tubes in this survey unit will be decontaminated with a wire brush/absorbent swab to remove slurry and any residual loose surface contamination that might have accumulated in the tubes from concrete cutting. Final swabs of the tubes are surveyed for loose surface contamination to ensure significant removable surface activity will not remain in the tubes. This effort is expected to be sufficient to reduce residual contamination levels below current SGLVs.

Final Survey Plans:

Total surface activity measurements will be taken on a minimum of 30 tubes. The number of total surface activity measurements taken will be between 200 and 250 using an expandable GM assembly which consists of three 1.13" diameter GM tubes. Surface activity scanning, due to the inaccessibility of the pipes for detectors capable of scanning, will be limited to the open ends of the 30 pipes surveyed with TLDs (i.e. up to the first bend at each end). Removable surface activity measurements are planned to be taken at each end of the 30 pipes resulting in 60 individual measurements.

CORE SUPPORT FLOOR COLUMN TUBES

Survey Unit Description and Basis:

The core support floor (CSF) column tube survey unit consists of 276 one inch diameter tubes that passed through the PCRV lower side wall (i.e., below the plenum floor) and up through the bottom head into 12 CSF support columns. 23 pipes were routed to each CSF column. Most of these pipes (214) were previously PCRV cooling tubes. The remaining 58 tubes consisted of 12 vent and 12 grout tubes (one pair per column), 18 thermocouple tubes, and 20 spare tubes. During decommissioning, these tubes were cut and removed when CSF columns were removed (except for the embedded portions). Tube lengths vary from 20' to 60'. Their primary potential for contamination is from PCRV shield water that entered the pipes. These tubes may also have been exposed to primary coolant due to leakage in the CSF cover plate. These pipes are grouped together as a single survey unit due to their common size, configuration and contamination potential.

Characterization Surveys:

Characterization surveys have been conducted by surveying a set of tubes from a cut column and a number of tubes from the outer PCRV surface. Of the cut pipes surveyed, average contamination was approximately 20,000 dpm/100cm^2 (all below 30,000 dpm/100 cm^2), and the ends of pipes surveyed at the PCRV outer surface were about 5,000 dpm/100cm^2.

Decontamination Plans:

Each tube in this survey unit is to be decontaminated by hydrolazing (about 10,000 psi). Four passes are planned for each pipe. Following hydrolazing, the tubes are wiped out to dry and remove residual loose surface contamination and prepare the tube for survey. The final wipes of the tubes are surveyed for loose surface to ensure significant removable surface activity will not remain in the tubes. An exception to this plan is a small number (approximately 10) of pipes whose inside diameters were previously coated with epoxy or which may be sufficiently obstructed to preclude effective hydrolazing; the treatment of these pipes will be documented in the Final Survey Report.

Final Survey Plans:

Total surface activity measurements will be taken by surveying 5 tubes from each column with TLD strings. This will include 4 general tubes and either the vent or grout tube from each column. This will require 60 total TLD strings. A total of about 2,000 TLDs will be used, which will result in about 1,000 individual TLD surface activity measurements for the survey unit. Surface activity scanning, due to the inaccessibility of the pipes for detectors capable of scanning, will be limited to the open ends of the 60 pipes surveyed with TLDs (i.e., up to the first elbow at each end). A fixed point reading will be taken at each end of

the 60 pipes with the cylindrical gas flow detector (at highest activity location as identified by scan). This should result in an additional 120 fixed point measurements (less if some pipe ends bend too quickly to obtain a gas flow reading, but likely more as additional fixed point measurements can be taken in pipes that travel a few feet prior to first bend). Removable surface activity measurements are planned to taken at each end of the 60 pipes resulting in 120 individual measurements.

LARGE DIAMETER PENETRATIONS

Survey Unit Basis:

This survey unit consists of penetrations which housed the helium circulators (4) and secondary side of the steam generators (12), and the center access penetration (1). These penetrations run through the bottom of the PCRV. The circulator penetrations are approximately 16 ft long and 40 in. in diameter, steam generator penetrations are 18 ft. long and 40 in. in diameter, and the center access is 20 ft. long and 72 in. in diameter. During decommissioning, the secondary sides of the circulators and steam generators were removed prior to flooding of the PCRV. All of the penetrations were sealed at the bottom to prevent leakage of shield water from the PCRV. One of the helium circulator penetrations and the center access penetration were modified to provide suction points for the shield water system. These penetrations were grouped together due to their common large size and common contamination potential.

Characterization Surveys:

No characterization surveys have been performed on these penetrations. Characterization surveys, including 100% scans, will be performed as part of the decontamination process.

Decontamination Plans:

The penetrations in this survey unit will decontaminated, primarily using grit blast techniques, to within SGLVs.

Final Survey Plans:

Approximately 10 total surface activity measurements will be performed in each penetration for a total of 170 measurements using the rectangular LMI 43-68 gas flow detector. Surface activity scanning will be performed on 25% of the surface area within each penetration. Removable surface activity measurements will be taken at the location of each total surface activity measurement.

CORE BORE HOLES

Survey Unit Basis:

This survey unit consists of core bore holes in the sides of the PCRV. Core bore holes were made during decommissioning to determine the depth of PCRV side wall activation and as starter holes or drain holes for concrete cutting. The holes are straight and are 4 to 6 in. in diameter and 6 to 8 ft. in length. There are about 30 total core bore holes. These penetrations are grouped together due to their common size, contamination potential (concrete cutting slurry) and material characteristics (i.e., concrete survey surface includes a natural material background component).

Characterization Surveys:

No characterization surveys have been performed to date. Post decontamination surveys will be performed.

Decontamination Plans:

The tubes in this survey unit will be decontaminated with a wire brush/absorbent swab to remove slurry and any residual loose surface contamination that might have accumulated in the tubes from concrete cutting. Final swabs of the tubes are surveyed for loose surface to ensure significant removable surface activity will not remain in the tubes. This effort is expected to be sufficient to reduce residual contamination levels below SGLVs.

Final Survey Plans:

Each penetration will be surveyed by taking approximately 4 or 5 total surface activity measurements in each hole for a total of 120 to 150 measurements using a GM assembly which consists of three 1.75" diameter (standard size) GM tubes. Surface activity scanning will be performed over most of the surface area within the penetrations (at least 25%) using the assembly. Removable surface activity measurements are planned to be taken at each end of the holes.

MISCELLANEOUS PENETRATIONS-PRIMARY COOLANT AFFECTED

Survey Unit Basis:

This survey unit consists of penetrations in the sides of the PCRV which provided for various instrumentation functions. These penetrations are straight and are 4 to 6 inches in diameter and 8 to 10 feet in length. Penetrations in this group include:

Outlet Coolant Thermometer Penetrations (7)
PCRV Relief Valve Penetration (1)
Plateout Probe Penetration (2)
Process and Moisture Instrument Penetrations (6)
Circulator Instrument Penetrations (4)
Thermocouple Penetrations (1)

During plant operation these penetrations were exposed to primary coolant. The penetrations were also exposed to shield water during the decommissioning and the insides were cut during beltline concrete cutting.

Characterization Surveys:

Characterization surveys performed prior to decontamination indicated contamination in the mrad range. Post decontamination surveys indicate contamination levels less than SGLVs.

Decontamination Plans:

The penetrations in this survey unit will decontaminated, primarily using grit blast techniques, to within SGLVs.

Final Survey Plans:

Each penetration will be surveyed by taking 4 or 5 total surface activity measurements for a total of 80 to 100 measurements. Surface activity scanning will be performed over at least 25% of the surface area within each penetration. Removable surface activity measurements will be taken at the ends of each penetration.

MISCELLANEOUS PENETRATIONS-SLURRY AFFECTED

Survey Unit Basis:

This survey unit consists of penetrations in the sides of the PCRV which provided for various instrumentation or monitoring functions. These penetrations are straight with 1 to 4 inch diameters and 8 to 10 feet lengths. Penetrations in this group include:

Horizontal neutron detector wells	2
Material surveillance tubes	8
Helium permeation tubes	9
Ultrasonic test well	1

During plant operation these penetrations did not penetrate the PCRV liner and therefore were not exposed to primary coolant or to shield water during decommissioning. These penetrations were cut during top head or beltline concrete cutting.

Characterization Surveys:

No characterization surveys have been performed to date. Significant surface contamination is not expected. Post decontamination surveys will be performed.

Decontamination Plans:

The tubes in this survey unit will be wiped to remove slurry and any residual loose surface contamination that might have accumulated in the tubes from concrete cutting. This effort is expected to be sufficient to reduce residual contamination levels below SGLVs.

Final Survey Plans:

Each penetration will be surveyed. Approximately 4 or 5 total surface activity measurements will be taken with the detector type appropriate for the penetration size/configuration for a total of 80 to 100 measurements. Surface activity scanning will be performed over at least 25% of the accessible surface of each penetration. Removable surface activity measurements will be taken at the penetration openings (each end).

SYSTEM 13 - EQUIPMENT STORAGE WELL VENTS AND DRAINS

Survey Unit Basis:

This survey unit consists of vent and drain lines for each of the ten equipment storage wells. The vent lines are 1 inch diameter pipe embedded in concrete with lengths varying from 54 to 70 feet. The drain lines are 2 inch diameter pipe with lengths varying from 35 to 51 feet. Each pipe has three to four elbows. The function of the lines was to provide a vent path for nitrogen cover gas and to drain any water which accumulated in the wells. Non-embedded sections of lines were removed and disposed of as radioactive waste during decommissioning.

System 13 also includes 9 sections of straight run embedded pipe which varies in diameter from 1 to 4 in. and 2 to 8 ft. in length. These piping sections were decontaminated using grit blast techniques and were surveyed and found to meet the SGLVs.

Characterization Surveys:

These penetrations were decontaminated prior to development of piping survey equipment. Pre-decon contamination levels are not expected to have been greater than System 14 penetrations (where maximum pre-decon levels were below 250,000 dpm/100 cm^2).

Decontamination Plans:

The drain lines and short straight run sections were decontaminated using grit blast techniques. The vent lines were decontaminated using abrasive balls.

Final Survey Plans:

These pipe sections have been surveyed using TLDs spaced at 20 inch intervals (all 20 penetrations). Six of ten vent lines and seven of the ten drain lines meet the SGLVs (i.e., 4,000 dpm/100 cm^2 average and 12,000 dpm/100 cm^2 maximum). The maximum reading in any line was 44,100 dpm/100 cm^2. The highest readings were at the Equipment Storage Well end of the pipe (location of source). Approximately 2.5% (15 out of 585) of the measurements were greater than 12,000 dpm/100 cm^2 and the average for this survey unit was less than 2,000 dpm/100 cm^2. Scans were performed on the open ends of all of the pipes and no readings significantly greater than TLD results were noted. Measurements for removable activity taken on the final swabs run through the pipes indicated no significant removable surface activity. Additional measurements for removable surface activity will be taken at each end of each pipe section.

SYSTEM 14 - FUEL STORAGE AUXILIARY SYSTEM

Survey Unit Basis:

This survey unit consists of helium purge vent lines for each of the nine fuel storage wells. The lines are 1 inch diameter pipe embedded in concrete with lengths varying from 56 to 73 feet. Each pipe has four elbows. The function of the lines was to provide a vent path for helium cover gas from the Fuel Storage Wells to the gas waste system. Non-embedded sections of lines were removed and disposed of as radioactive waste during decommissioning.

System 14 also includes 32 sections of 1 inch diameter embedded pipe, each of which are approximately 6 feet long. These piping sections were decontaminated using grit blast techniques and were surveyed and found to meet the SGLVs.

Characterization Surveys:

Initial characterization of the ends of the vent lines (up to the first elbow) indicated fixed contamination levels up to 223,000 dpm/100 cm^2.

Decontamination Plans:

The pipe sections in this survey unit were decontaminated using grit blast techniques.

Final Survey Plans:

These pipe sections have been surveyed using TLDs spaced at 20 in. intervals. Eight of the pipe sections meet the SGLVs. The one pipe section which does not meet the SGLVs had a maximum reading of 46,000 dpm/100 cm^2 and an average of 4,200 dpm/100 cm^2. The highest reading was at the Fuel Storage Well end of the pipe. In addition, two of the pipe sections were surveyed using small GM probes (including the one pipe section that did not meet the SGLVs). Less than 1% (3 of 348) of the measurements were greater than 12,000 dpm/100 cm^2 and the average for the survey unit was less than 1000 dpm/100 cm^2. Surface activity scanning was performed on the open ends of all of the pipe sections up to the first elbow and no measurements significantly greater than TLD results were found. Measurements for removable activity taken on the final swabs run through the pipes indicated no significant removable surface activity. Additional measurements for removable surface activity will be taken at each end of each pipe section.

SYSTEM 61 - HOT SERVICE FACILITY DRAINS

Survey Unit Basis:

This survey unit consists of drain lines for the Hot Service Facility. There is approximately 60 feet of 3 inch diameter pipe and 20 feet of 1.5 inch diameter pipe embedded in concrete. All the pipe has elbows. The function of the lines was to drain water used during decontamination activities in the Hot Service Facility. Non-embedded sections of lines were removed and disposed of as radioactive waste during decommissioning.

Characterization Surveys:

Characterization was performed over the entire lengths of these lines was using GM detectors after the lines were decontaminated using grit blast techniques. The survey indicated fixed contamination levels up to 1,250,000 dpm/100 cm^2. Additional decontamination was performed by grit blasting, which was followed by resurveys. The highest fixed contamination point after this additional effort was 54,000 dpm/100 cm^2.

Decontamination Plans:

The pipe sections in this survey unit have been decontaminated using grit blast techniques. At least 4 passes were performed followed by more extensive blasting in hot spot areas.

Final Survey Plans:

All pipe sections have been surveyed using GM detector assemblies (fixed point readings taken at about 1' to 2' increments. Surface activity scanning was performed on the open ends of all of the pipe sections up to the first elbow. Additionally, assembly response was monitored during detector repositioning. Fixed point measurements were taken when elevated readings were noted. The maximum reading was 54,000 dpm/100 cm^2 and the average was approximately 5,000 dpm/100 cm^2. Measurements for removable activity have been taken at the ends of each pipe section and absorbent material swabs taken over the pipe lengths. Removable measurements were well below removable SGLVs.

SYSTEM 72 - REACTOR BUILDING DRAINS EMBEDDED PIPING

Survey Unit Basis:

This survey unit consists of embedded portions of the reactor building drain system. There is approximately 500 ft of 4 to 8 in. diameter pipe embedded in concrete in the floor of the reactor building. All this piping has elbows. The function of the lines was to drain water from various areas of the reactor building to either the liquid waste sump or to the reactor building sump. Drains from known radioactive sources (e.g. Helium purification system, contaminated laundry) were routed to the liquid waste sump. Other drains were routed to the reactor building sump. Non-embedded sections of lines found to be contaminated are being removed and disposed of as radioactive waste.

Characterization Surveys:

Characterization has been performed in various parts of the system. The survey indicated fixed contamination levels up to 80,000 dpm/100 cm^2 in the main drain header to the liquid waste sump. Contamination has also been detected in the drains to the reactor building sump but at much lower levels.

Decontamination Plans:

The pipe sections in the survey units will be decontaminated using primarily high pressure water or grit blast techniques.

Final Survey Plans:

These pipe sections will be surveyed using GM detector assemblies. Most accessible portions of these lines will be surveyed. Surface activity scanning will be performed on the open ends of all of the pipe sections up to the first elbow. Measurements for removable activity will be taken at the ends of each pipe section and absorbent swabs passed through the lines.

OTHER AFFECTED EMBEDDED PIPE SYSTEMS

Other systems containing embedded pipe include System 62 (Liquid Waste), and System 63 (Gas Waste). The remaining pipe sections for these systems are generally straight runs with short lengths. Most of this piping has been decontaminated and surveyed using cylindrical gas flow probes to meet SGLVs.

NRC Comment No. 2:

> *Will the average contamination level be calculated for each pipe that is surveyed or will an average be calculated only for the entire survey unit? Will an investigation be performed if one pipe is contaminated at levels significantly above the other pipes measured in the survey unit?*

PSCo/WT Response:

The general approach is to evaluate plant system survey data on a survey unit basis, which will include an entire system or group of pipes with a similar contamination potential. This would include calculating average contamination values for the entire survey unit. This approach is considered appropriate for plant system internal surfaces because of the sprawling nature of plant systems (i.e., they may extend over many elevations and locations in the plant). In general, limitations on averaging protocols are based on ensuring that an excessive amount of residual contamination is not left in a concentrated location. There is no reasonable equivalent for limiting averaging of plant system survey measurements, which are taken from inaccessible surfaces. For pipe segments that are very short, this could, in effect, preclude use of an elevated area criteria. For very long pipes, averaging could be conducted over piping at different locations and elevations in the plant. It would seem more appropriate to limit averaging to pipes or portions of pipes in a given general area, but this would be impractical to implement. Therefore, the approach proposed is to simply require all measurements be ≤ 12,000 dpm/100 cm^2 and the average (at 95% confidence) of the survey unit to be ≤ 4,000 dpm/100 cm^2.

As far as embedded piping survey units are concerned, the same basic approach for non-embedded systems is applied. The only exception is the survey unit is surveyed to a greater degree initially to reduce the need for follow-up investigation. For example, when TLDs or GM surveys are conducted in an embedded pipe, measurements are taken at regular intervals over the entire pipe length. Therefore, if an elevated reading is obtained at one measurement location, the reading is already bounded by the adjacent readings. After completing an aggressive decontamination effort, embedded piping survey units which cannot meet the criteria described in the preceding paragraph would be filled with grout provided all survey measurements were ≤ 100,000 dpm/100 cm^2 (i.e., all pipes of the survey unit would be grouted).

If a given pipe is contaminated to an average level greater than 25,000 dpm/100 cm^2, and is significantly greater than the average of the survey unit (i.e., a factor of two or more greater than the survey unit average, excluding the elevated pipe) an investigation will be performed to determine the cause. This investigation may result in a determination as to why a given pipe was elevated relative to the remaining pipes in the survey unit or additional measurements. If it can be determined why a given pipe was elevated, other pipes that might similarly be elevated will be surveyed. If no reason is known as to why a given pipe

is elevated relative to the remaining survey unit, an additional 10% of the survey units pipes (if GM detector assembly survey is to be performed) or 20% of the survey units pipes (if TLD string survey is to be performed) will be surveyed.

NRC Comment No. 3: *Please describe each of the embedded piping survey units and the contamination potential in each survey unit.*

PSCo/WT Response:

Response to this comment was provided in the response to Comment No. 1.

NRC Comment No. 4: *Please provide the number of measurements proposed for each survey unit, for both TLDs and other detectors, and the percentage of the survey unit pipe surface area that will be covered by these measurements.*

PSCo/WT Response:

Final survey plans for each embedded pipe survey unit were presented in response to Comment No. 1. Because most of the embedded piping is inaccessible for conventional scanning, the piping is surveyed by taking a collection of fixed point measurements. The actual percentage of plant system internal surfaces surveyed (as computed by ratio of total fixed point measurement area to total pipe surface area) will be understandably low. However, the survey methods and measurement frequencies (as outlined in response to Comment #1) are considered reasonable to determine the amount of residual contamination in embedded piping at FSV.

The actual survey coverage of each survey unit would depend on the survey method. For example, TLDs which by calibration are defined to see 100 cm^2 per location would see about 25% of each pipe surveyed. This would equal about 5% of the survey unit surface (since 20% of the pipes are surveyed). Survey units surveyed by GM detector assemblies would be 10% (if credit is taken for scanning, since about 10% of the pipes are surveyed) or much less if fixed point measurement area is compared to total survey unit area. For example, if 1' incremented measurements are taken with a 7.6 cm^2 detector, only about 3% of each pipe surveyed would be "covered".

NRC Comment No. 5: *How will PSC determine the biased sample locations in the embedded piping survey units?*

PSCo/WT Response:

Biased locations for embedded piping survey units include ends of the piping nearest the source (i.e., point of entry of contamination into the piping), low point piping when settling could have occurred (e.g., embedded drain piping) and regions where concentration may have occurred (e.g., joints, welds, elbows, etc.). It is difficult to pinpoint joints, welds, or elbows in embedded piping with TLD strings or GM tube assemblies (although resistance is sometimes noted when GM tube assemblies are pulled through elbows); however, measurements are taken along the entire pipe length with both methods which is considered sufficient to detect localized regions of contamination (survey data to date indicates that localized contamination is more likely to be regional than pinpointed).

Where possible, the pipe selection for TLD measurement will be biased. For example, if an individual liner cooling system pipe was known to have been exposed to primary coolant due to leakage during operation, this pipe will be selected for TLD measurement.

NRC Comment No. 6: *Will pipes be grouted if either the average or maximum guideline is exceeded? Will all of the pipes in the survey unit be grouted if the results in one pipe exceed the average or maximum guideline?*

PSCo/WT Response:

Yes, all of the pipes in a survey unit will be grouted if any one individual measurement exceeds the maximum guideline value (12,000 dpm/100 cm^2) or if the average contamination level for the survey unit at the 95 percent confidence level exceeds the average guideline value (4000 dpm/100 cm^2).

Any pipes that exceed the 50,000 dpm/100 cm^2 investigation level discussed previously will not be grouted until required investigations are completed, and any pipe that cannot be decontaminated to less than 100,000 dpm/100 cm^2 will not be grouted until NRC approval is obtained.

As explained in the response to question 2 above, the average contamination level will be calculated for the entire survey unit, and not for individual pipes.

NRC Comment No. 7: *PSC states that a scan survey will be performed over 25% of the accessible surface at each embedded piping measurement. Please describe how these scan surveys will be performed.*

PSCo/WT Response:

Scan surveys will be performed in embedded piping where there is an accessible surface, and accessible surfaces are generally considered to be the open ends of pipes selected for measurement, to the first elbow. In each accessible surface, we will scan at least 25 percent of the area. The open pipe ends that are most accessible for surveys are also the areas that are most accessible to future workers and, therefore, would be the portion of embedded pipes most likely to contribute to dose.

For small diameter pipes (3 inch to 1 inch diameter), scan surveys will be performed on pipes selected for measurement with small gas-flow proportional pipe probes that will be inserted into open pipes to the extent reasonably possible, or until the first elbow. Typically, these probes can be reasonably inserted up to about ten feet using a long handled push rod, but they are not flexible and cannot be inserted through elbows.

PSCo/WT does not consider that GM assemblies can reasonably be relied upon for scan surveys of piping systems. Small GM detectors attached to a cable and drawn through small diameter pipes provide a good indication of internal contamination levels, but they do not have the sensitivity to provide a reasonable scan survey. A string of 4 or 6 small GM detectors only sees a limited portion of the piping internal surface and requires a large area correction factor. Also, the GM detector assemblies are still considered developmental in that they are delicate and easily damaged, the maintenance/replacement rate is high, and availability of new detectors is uncertain.

For larger piping, scan surveys are performed with an array of larger GM detectors on an adjustable "spider" assembly that is inserted into open pipe ends, up to the first elbow; the detectors are mounted on pivoted arms that can be adjusted to suit the inside diameter of the pipes.

Comments 8 through 15 Refer to PSCo's November 15, 1995, Submittal (P-95102), Regarding the Technical Basis Documents for Piping Survey Instrumentation:

NRC Comment No. 8: *Please describe the QA/QC program for embedded piping measurements using TLDs and other detectors.*

PSCo/WT Response:

QC verification survey measurements will be performed in embedded pipes as follows:

- For pipes surveyed with TLDs, QC verification measurements will be performed by randomly selecting at least 5 percent of the embedded pipe TLD strings and placing TLDs every 10 inches apart instead of every 20 inches. The odd numbered TLDs will be considered Set 1 and the even numbered TLDs will be considered Set 2, so that essentially there will be two concurrent measurement sets in 5 percent of the surveyed pipes: one QC set and one regular survey set. The QC measurements will be taken approximately 10 inches away from the measurements being checked, but this difference will not be significant for pipe surfaces that have been exposed to the same fluid environment. Concurrent QC measurements will be used in embedded pipes because each survey requires 2 to 3 months and it is not feasible to perform consecutive regular surveys and QC surveys.

- For pipes surveyed with GM detectors, at least 5 percent of the pipes will be resurveyed using another detector assembly, if one is available (in some cases, we may only have one assembly).

- For scan surveys performed on accessible piping surfaces, as discussed in the response to question 7 above, at least 5 percent of the scan survey locations will be rescanned using different instruments and survey personnel than the initial survey team.

In addition, PSCo QA and radiation protection personnel perform oversight and monitoring of ongoing final survey activities. PSCo monitoring activities typically include reviewing survey team activities in the field, instrument control practices, survey package preparation, classification and reclassification, investigation, data analysis, and release record preparation.

PSCo also has retained GPU Nuclear to perform an independent verification survey, as part of our QA efforts. GPU Nuclear performs field observations, document reviews, and independent measurements to assess surveys performed by the WT. GPU Nuclear's reports will be included in the Final Survey Report.

NRC Comment No. 9: *For TLD results in 1" piping, will the up-facing and down-facing TLDs be combined when the results are significantly different, or will the individual results be used to determine hot-spot compliance?*

PSCo/WT Response:

The up-facing and down-facing TLDs in 1" piping are summed together as a single detector. Each TLD of the pair only views (potentially) up to 50 cm^2. Since current regulatory guidance allows surface activity averaging to be performed up to 100 cm^2, it is appropriate to sum the two TLDs and consider the pair as a single 100 cm^2 detector.

NRC Comment No. 10: Regarding TBD-203, Page 4, Paragraph 2:

The statement that 25 percent of the inside surface area of the pipe will be surveyed when the TLDs are spaced 20" apart assumes that the TLD's effective field of view covers the entire 100 cm^2 area for the 2" pipes and the 50 cm^2 for the 1" pipe. Has the effective field of view of the TLDs in 1" and 2" pipes been specifically evaluated to determine whether this assumption is valid?

PSCo/WT Response:

Survey coverage inside piping surveyed with TLD strings is based on obtaining sufficient data to characterize contamination in the piping. Because measurements are reported in units of dpm/100 cm^2, consideration as to what area the background corrected signal originated from is important. TLDs are calibrated with a 100 cm^2 source (i.e., the total dpm that the TLD(s) are considered to have been exposed to is distributed over 100 cm^2). Therefore, the calibration factor correctly reports TLD survey results to a per 100 cm^2 value. If non-uniform contamination is present (e.g., localized areas of contamination), the TLD's reading could vary depending on the exact orientation of the spot of contamination to the TLD. Because a 100 cm^2 source is used to determine the calibration factor, the TLD's response to spotted contamination, on average, is correct over the defined 25% and thereby the basis for the 25% coverage statement (i.e., localized spots over the remaining 75% would not be seen or averaged).

Specific evaluations to determine the effective field of view for TLDs first requires a definition of what is effective field of view. At FSV, TLD field of view is defined to be 100 cm^2 by calibration (i.e., the area over which surface contamination levels are correctly averaged). Because TLDs are very small detectors, field of view does not have the same meaning as a normal surface activity detector, where a detector is placed near a surface and considered to "see" an area equal to its active area. One effective definition of TLD field of view is the area providing 90% of the TLD's total response. Based on this definition, using a simple inverse square model, 1 and 2 inch diameter piping field of view would be on average about 115 cm^2 (i.e., about 90 cm^2 for 1" pipes and 140 cm^2 for 2" pipes). This evaluation is included as Attachment 1 to this Comment Response. This evaluation shows that the FSV defined field of view for TLDs of 100 cm^2 is reasonable. For point particles, measurement uncertainty over the defined 100 cm^2 was calculated to be about a factor of 2 to 3 (for 2 inch diameter piping) and 4 to 6 (for 1 inch diameter piping). Although these uncertainties are significant, actual TLD survey data of contaminated piping at FSV has shown that contamination is not likely to be sparsely spaced point particles. Therefore, a more realistic estimate of maximum contamination uncertainty is appropriate.

To determine whether a 20" spacing for TLDs on a string is appropriate and to estimate the uncertainty and upper bound for maximum piping contamination levels, an analysis of the FSV Equipment Storage Well survey data taken at 20 inch intervals was performed and is included as Attachment 2 to this Comment Response. PSCo/WT divided the measurements into sets of measurements spaced 40, 60, and 80 inches apart, thereby providing four data sets. Estimates of uncertainty, mean values, and the upper bound for maximum contamination level were evaluated for each of these data sets. The attached pages present the details of this evaluation. The result was that with TLDs spaced at 20 inch intervals, the estimated uncertainty is ± 22% at the 95% confidence level for maximum measured contamination level. This level of uncertainty supports the suitability of an investigation level at or below 75%. Therefore, TLD surveys of FSV embedded piping using 20" spacings and investigations at 50% of the embedded piping bounding limit of 100,000 dpm/100 cm^2 (i.e., 50,000 dpm/100 cm^2) are reasonable and appropriate.

ATTACHMENT 1 TO PSCo/WT RESPONSE
TO NRC COMMENT NUMBER 10

TLD RESPONSE TO HIGHLY LOCALIZED CONTAMINATION

TLD RESPONSE TO HIGHLY LOCALIZED CONTAMINATION

1.0 Introduction

This evaluation is performed to estimate the response of a TLD centered in a small diameter pipe to highly localized contamination (i.e., a point source). An Inverse Square model was used to estimate the relative response from a point source located at various positions relative to the centered TLD. It is recognized that this is a simplified model that does not incorporate all factors that could affect the overall response of a TLD to a localized source. However, since an inverse square reduction with increasing distance is a dominant factor, it is considered useful to provide a reasonable estimate of relative TLD response to a point source. Using this model, maximum over and under response factors and the fraction of total response to the TLD for various field of views are determined.

2.0 Calculational Basis

As mentioned, the TLD's relative response to localized contamination is determined by an inverse square relationship. For example, a "point" detector located 1" from a point source would have four times the response of a detector located 2" from the source. To illustrate the possible distances that a point source within a defined field of view could be from a TLD, Figure 1 below is provided. As shown in the figure, the defined field of view, which is shown only for a down-facing TLD, is about 5" by 1/2 the pipe circumference. For 1 inch diameter piping, this is equal to approximately 50 cm^2 and for 2 inch diameter piping about 100 cm^2.

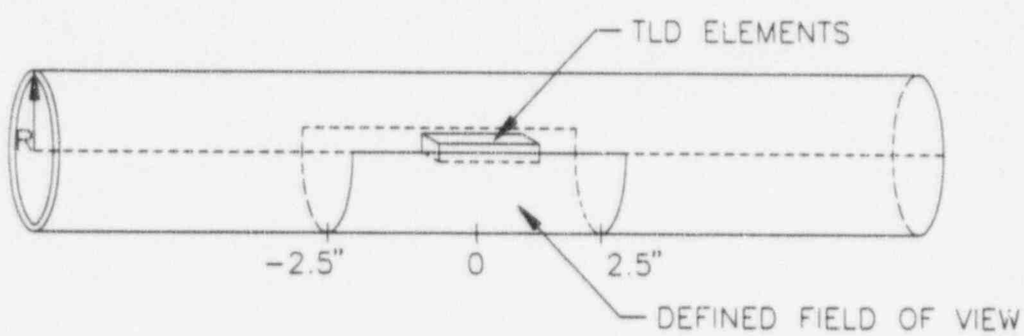


Figure 1 - Down Facing TLD Centered in Pipe With Defined Field of View

To determine maximum over and under response factors, the effective distance of the calibration source must be determined. The effective calibration distance is the distance from the TLD that a point source equal to the total activity of the distributed calibration source would be from the TLD in order to produce the same response produced by the calibration source. To calculate this distance, cylindrical geometry is used as shown by Figure 2 below.

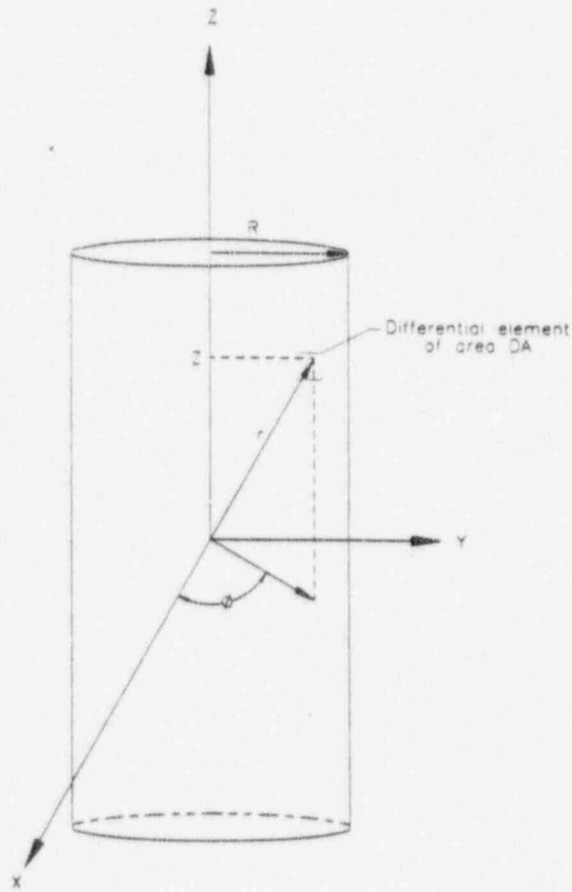


Figure 2 - Cylindrical Geometry

The TLD's response to a point source at a given distance r is proportional to $1/r^2$. The amount of surface activity at a given differential element of a uniformly distributed source is proportional to the area (dA) of the element, where $dA = R d\phi dz$. Total response of the TLD from the distributed source is equal to the sum of responses from each differential element. As the differential element size goes to zero the sum becomes an integral as shown below:

$$Total\ TLD\ Response = C \int_A \frac{1}{r^2}\, dA \qquad (1)$$

where C is the proportionality constant and A is the total area of integration.

For cylindrical geometry this becomes:

$$Total\ TLD\ Response = C \int_z \int_\phi \frac{1}{r^2} R\, d\phi\, dz \qquad (2)$$

TLD response from a single point source at the effective calibration distance is equal to the following:

$$TLD\ Response = \frac{C}{r_{eff}^2} \int_z \int_\phi R\, d\phi\, dz \qquad (3)$$

where r^2_{eff} is the effective calibration distance squared and the integral is proportional to the total source activity which is located at the effective location.

Equating equations (2) and (3) and cancelling the constants C and R, yield the following expression for r^2_{eff}:

$$r_{eff}^2 = \frac{\int_z \int_\phi d\phi\, dz}{\int_z \int_\phi \frac{1}{r^2}\, d\phi\, dz} \qquad (4)$$

Although the immediate 50 cm^2 (for 1" diameter piping) or 100 cm^2 (for 2" diameter piping) is over a length of 5 inches, the calibration source length is 5.6 inches (i.e., resulting in a conservative calibration factor). Therefore, equation (4) is integrated over the actual area of the source, which upon substitution of $R^2 + z^2$ for r^2, results in the following:

$$r_{eff}^2 = \frac{\int_{-2.8}^{2.8} \int_0^{\phi_s} d\phi\, dz}{\int_{-2.8}^{2.8} \int_0^{\phi_s} \frac{1}{(R^2 + z^2)}\, d\phi\, dz} \qquad (5)$$

where ϕ_s is the angular span of the calibration source (slightly less than π). Solving Equation (5) (using a table of integrals [1]) results in the following:

$$r_{eff}^2 = \frac{5.6\ \phi_s}{\frac{\phi_s}{R}\left[\tan^{-1}\left(\frac{2.8}{R}\right) - \tan^{-1}\left(\frac{-2.8}{R}\right)\right]} \qquad (6)$$

Cancelling ϕ_s and solving for r_{eff} yield:

$$r_{eff} = \sqrt{\frac{5.6}{\frac{1}{R}\left[\tan^{-1}\left(\frac{2.8}{R}\right) - \tan^{-1}\left(\frac{-2.8}{R}\right)\right]}} \qquad (7)$$

3.0 Results

Solving Equation (7) for 1 inch diameter piping (i.e., R = 0.5") results in an r_{eff} of 1.00 inches. For 2 inch diameter piping (i.e., R = 1"), r_{eff} is equal to 1.51 inches.

The Maximum Under Response (MUR) factor of a TLD for various fields of view is determined by squaring the ratio of 95% outer edge distance to effective calibration distance. The outer 5% of source area is disregarded to determine, in effect, uncertainty at 95% confidence. An example calculation of MUR is shown below where the field of view is considered to be 100 cm^2 for a TLD in a 2" pipe. In this example, MUR would be 2.91 as shown below:

$$MUR = \frac{\left[(0.95 * 2.5)^2 + 1^2\right]}{(1.51)^2} = 2.91$$

The Maximum Over Response (MOR) factor of a TLD is calculated similarly by squaring the ratio of effective calibration distance to minimum distance between TLD and point source. The minimum distance for a point source directly adjacent to a TLD is 0.5" for 1 inch piping or 1" for 2 inch piping. For the preceding example, MOR would be 2.28 as shown below:

$$MOR = \left(\frac{1.51}{1}\right)^2 = 2.28$$

Maximum over and under response factors are shown in Table 1 for selected fields of view. Also shown in the table is the percentage of total TLD response that comes from the field of view of a uniformly contaminated pipe. This is calculated by the ratio of field of view inverse square response (as shown previously by Equation (2)), to maximum TLD response. Maximum response of the TLD is determined by using Equation (2) and integrating over a 15" pipe length (i.e., 7.5" from TLD center in each direction). This distance was selected for maximum response because it corresponds to the approximate range in air of the average energy of FSV beta (i.e., the range in air of 113.6 keV beta is 7.5") [2].

4.0 Conclusion

As shown in Table 1, 90% of the TLDs total response (based on an inverse square model) comes, on average, from about 115 cm^2 (i.e., about 90 cm^2 for 1 inch diameter piping and 140 cm^2 for 2 inch diameter piping). Therefore, the FSV defined field of view of 100 cm^2 for TLDs is reasonable. Although, the maximum under and over responses from point particles can be more significant for TLDs (or any small detector) than for a larger flat faced detector near a surface, these factors were calculated for a theoretical worse case distribution (i.e., an infinitely small point source in an otherwise clean pipe). If localized contamination is more extensive in physical size than a pure point source, the uncertainty in a given measurement is reduced. Actual TLD survey data from contaminated piping at FSV indicates when contamination levels are high (e.g., greater than SGLVs), contamination is likely to be more extensive than sparsely spaced point particles. Therefore, the methods of survey and data analysis used for TLDs at FSV are appropriate.

5.0 References

[1] Standard Mathematical Tables and Formulae, 29th Edition, CRC Press, 1991.

[2] Attix F. H., Introduction to Radiological Physics and Radiation Dosimetry, Wiley-Interscience, New York, 1978.

Table 1 - Response Factors vs. TLD Fields of View

1" Diameter Piping

Field of View (cm2)	Maximum 95% Distance (")	Minimum Distance (")	Average Cal Distance (")	Maximum Under-response	Maximum Over-response	% of Total Response
150	3.60	0.50	1.00	12.94	4.00	95.6
140	3.36	0.50	1.00	11.31	4.00	95.0
130	3.13	0.50	1.00	9.78	4.00	94.3
120	2.89	0.50	1.00	8.37	4.00	93.4
110	2.66	0.50	1.00	7.08	4.00	92.5
100	2.43	0.50	1.00	5.89	4.00	91.3
90	2.20	0.50	1.00	4.82	4.00	89.9
80	1.96	0.50	1.00	3.86	4.00	88.1
70	1.74	0.50	1.00	3.01	4.00	85.9
60	1.51	0.50	1.00	2.28	4.00	83.0
50	1.29	0.50	1.00	1.66	4.00	79.1
40	1.07	0.50	1.00	1.15	4.00	73.6
30	0.87	0.50	1.00	0.76	4.00	65.3
20	0.69	0.50	1.00	0.48	4.00	52.2
10	0.55	0.50	1.00	0.31	4.00	30.8

2" Diameter Piping

Field of View (cm2)	Maximum 95% Distance (")	Minimum Distance (")	Average Cal Distance (")	Maximum Under-response	Maximum Over-response	% of Total Response
150	3.70	1.00	1.51	6.00	2.28	91.1
140	3.47	1.00	1.51	5.29	2.28	89.9
130	3.25	1.00	1.51	4.62	2.28	88.5
120	3.02	1.00	1.51	4.00	2.28	86.8
110	2.80	1.00	1.51	3.43	2.28	85.0
100	2.58	1.00	1.51	2.91	2.28	82.8
90	2.36	1.00	1.51	2.44	2.28	80.1
80	2.15	1.00	1.51	2.02	2.28	77.0
70	1.94	1.00	1.51	1.65	2.28	73.1
60	1.74	1.00	1.51	1.33	2.28	68.3
50	1.55	1.00	1.51	1.06	2.28	62.3
40	1.38	1.00	1.51	0.83	2.28	54.6
30	1.23	1.00	1.51	0.66	2.28	44.7
20	1.11	1.00	1.51	0.54	2.28	32.2
10	1.03	1.00	1.51	0.46	2.28	17.0

ATTACHMENT 2 TO PSCo/WT RESPONSE
TO NRC COMMENT NUMBER 10

TLD MEASUREMENT DATA STUDY

TLD Measurement Data Study

1.0 Introduction

This study evaluates measurements of surface contamination in small bore embedded piping associated with the Fort St Vrain Reactor Equipment Storage Wells (ESWs). Surface contamination levels inside the piping were measured using thermoluminescent dosimeters (TLDs) systematically placed throughout ESW vent and drain piping as described in the Westinghouse Technical Basis Document WCAP-14570 (WE96). The purpose of this study is to evaluate the effectiveness of the survey technique. Specific questions of interest are:

1. Is 20 inch spacing of TLD elements adequate to reliably detect localized areas of elevated activity?

2. What are the uncertainty and estimated upper bound for maximum piping contamination levels measured by the TLD survey method?

2.0 Results

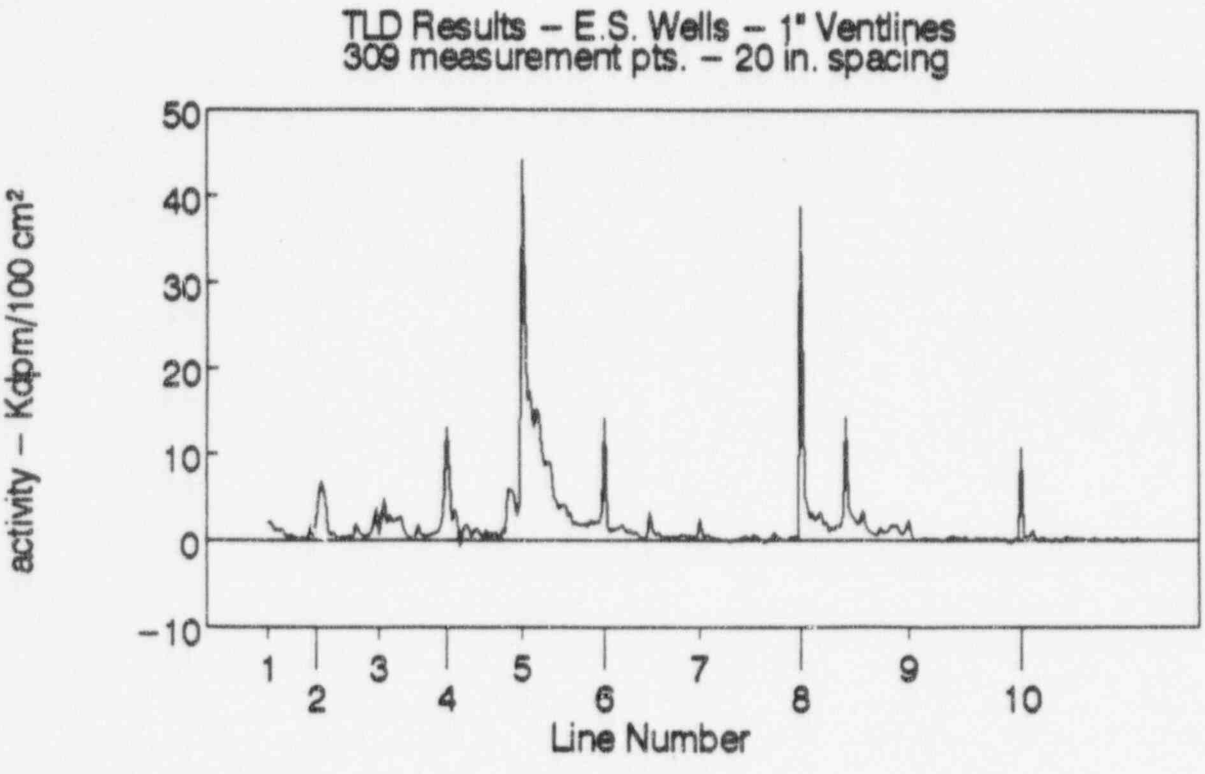
The TLD measurement data obtained from 1 in. ESW piping shows that the contamination in the piping is physically distributed non-uniformly in the piping and that areas of detectable activity typically cover a length of piping on the order of 20 inches or greater. The measured contamination levels are not normally or log-normally distributed but show a highly skewed distribution with a few values in excess of four standard deviations above the mean. Thus, mean values are not good indicators of expected maximum contamination levels. These characteristics are consistent with the history of the ESW one in. vent line piping which has been mechanically decontaminated by remote methods leaving a few scattered locations of resistant residual contamination.

The effect of detector spacing was evaluated and it is concluded that 20 in. spacing gives an estimated uncertainty of ± 22% at the 95% confidence level for maximum measured contamination level. As detector spacing is increased beyond 20 in., on average, the predicted maximum contamination level from measurements spaced at 80 in. falls to 33% of the value predicted by measurements spaced at 20 in. The uncertainty in the predicted maximum value at 80 in. spacing is ± 67%. This evaluation provides a basis for establishing action levels of individual measurement results at 75% of elevated area guideline values using TLDs spaced at 20 in. It also shows the trade-off between TLD spacing and the "safety margin" that must be applied.

3.0 Discussion

The TLD measurements reported in WCAP-14570 for the ten Equipment Storage Well one-inch vent lines were evaluated. Surface contamination was measured in each of the ten lines using a string of TLDs inserted into the piping with the TLD assemblies spaced 20 inches apart (TLD center to TLD center). The average length of piping in the ten sections is 53.6 ft. with an average of 31 measurements taken in each section, a total of 309 measurements. For this study, all 309 measurements were combined into one data set, representative of the contamination levels in the one inch vent lines. This initial data set is illustrated in Figure 1. Presenting the data in this manner provides a useful perspective on overall surface contamination trends.

Figure 1



3.1 Physical Distribution of Surface Contamination

It can be seen from Figure 1 that the piping surface contamination is highly non-uniform along the piping length. From the sample of 309 measurements, approximately one half are considered detectable, i.e., above the critical level, and from inspection it is seen that there are several areas of activity on the order of 5,000 to 15,000 dpm/100 cm^2 and two areas above 30,000 dpm/100 cm^2. The figure also suggests that the majority of occurrences of detectable activity cover an area on the order of 20 inches of pipe length or greater, i.e., that detectable activity is usually seen by at least two adjacent measurements.

The correlation between adjacent measurements of detectable activity was evaluated. The measurement data set was censored by selecting all measurements above the critical level, a total of 149 measurements. From these data, 64 pairs of adjacent measurements each above the critical level were extracted. These paired measurements are shown in Table 1. A least squares-linear regression was performed on the paired values. [1] The result as shown in the Attachment is a coefficient of 0.59. In this application it is called the lag sample autocorrelation coefficient (BOX78). This indicates that areas of detectable activity in the piping are typically of such size that they are detected by more than one adjacent TLD. However, this result is somewhat weakened because of the elimination of 21 individual measurements which had no adjacent measurement of detectable activity. Additional support for the conclusion that the majority of detectable activity events are seen by more than one TLD is provided by a review of all measurements above 1.5 Kdpm/100 cm^2, a level which represents detectable activity at a higher level of significance than the critical level. A total of 96 such measurements were identified. From this group, 22 events were observed which contained one or more contiguous measurements. Seven events contained one measurement and 15, two thirds of the events, contained more than one. The overall average was 5 measurements per event.

3.2 Distribution of Measured Contamination Levels

The frequency distribution for the censored data set is shown in Figure 2. The data has mean and standard deviation of 3.72 and 5.95 Kdpm/100 cm^2, respectively. The data exhibits a highly skewed distribution with a few values in excess of four standard deviations above the mean value. The possibility that the data is log-normally distributed was also investigated. Figure 3 is a histogram of the log transformed (natural logarithm) measurements. It is seen that the log transformed data frequency distribution is much more symmetrical than the untransformed distribution in Figure 1. However, the log data does not provide a good fit (visually) to a normal or Gaussian distribution. Based upon the poor visual fit, particularly noticeable in the right tail of the distribution, standard tests for fitting data to a normal curve were not performed. No attempt was made to estimate the range of expected upper percentile values or confidence intervals using normal distribution properties. Other approaches are followed to estimate the ability of the TLD measurement method to predict upper bounds of contamination levels in the piping.

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[1] The built-in regression function of the Lotus-123 spreadsheet version 2.3 was used.

Table 1

Paired Measurements Above Critical Level

Pipe #	Position	Kdpm/100	Kdpm/100
1	13	2.1	2.2
1	15	1.2	1.2
1	17	1.2	1.2
1	21	0.7	0.5
1	28	1.7	0.5
2	1	2.2	5.3
2	3	6.9	4.7
2	15	2	0.9
2	19	0.7	0.7
2	21	1.5	3.9
3	1	0.7	2.8
3	3	4.9	2
3	5	2.9	2.1
3	7	2.4	2.6
3	9	2.8	1.3
3	15	1.9	0.8
3	17	0.6	0.5
3	19	0.7	0.8
3	21	1	0.9
3	23	1.5	3.1
4	1	13.1	7.1
4	3	2.3	3.5
4	7	1.5	1.8
4	24	5.8	5.7
5	1	44.1	27.8
5	3	16.3	17.2
5	5	13.1	15.3
5	7	14.5	10.5
5	9	8.7	9.2
5	11	8.7	5
5	13	4.7	3.7
5	15	4.1	4.1

Pipe #	Position	Kdpm/100	Kdpm/100
5	17	2.9	3.3
5	19	1.8	2.1
5	21	1.8	1.8
5	23	2	1.6
5	25	2.4	2
5	27	2.1	2.2
6	1	14.2	1.5
6	3	0.9	1.4
6	5	1.2	1.5
6	7	1.8	1.2
6	9	1	1.2
6	11	0.8	0.9
6	17	3.4	0.9
6	19	0.7	0.9
6	28	0.6	0.7
8	1	38.9	5
8	3	4.7	2.7
8	5	3.3	2.3
8	7	2.7	3.4
8	9	1.8	2.1
8	11	1	1.6
8	13	1.2	1.7
8	15	1.7	2.9
8	17	14.4	4
8	19	3.1	2.6
8	21	1.8	2.1
8	23	3.5	1.7
8	25	1.3	1
8	29	1.5	1
8	31	0.9	1.1
8	33	1.8	1.7
8	35	1.9	0.9

Figure 2

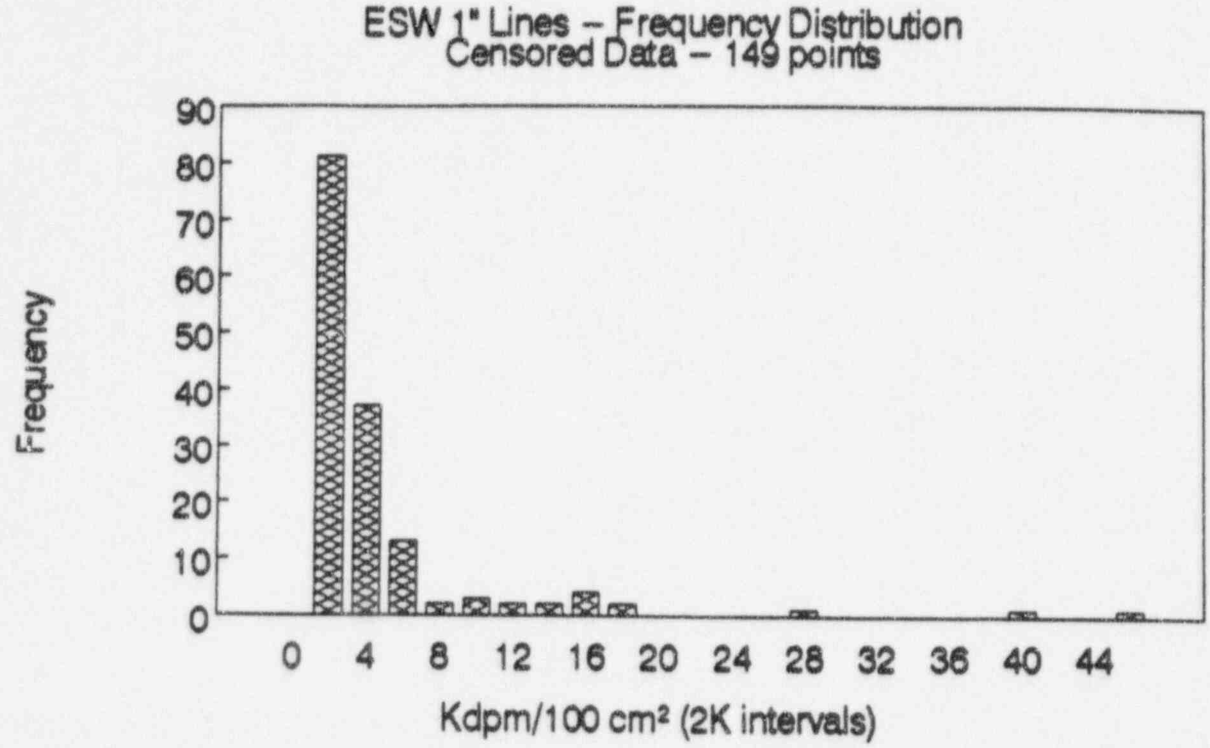
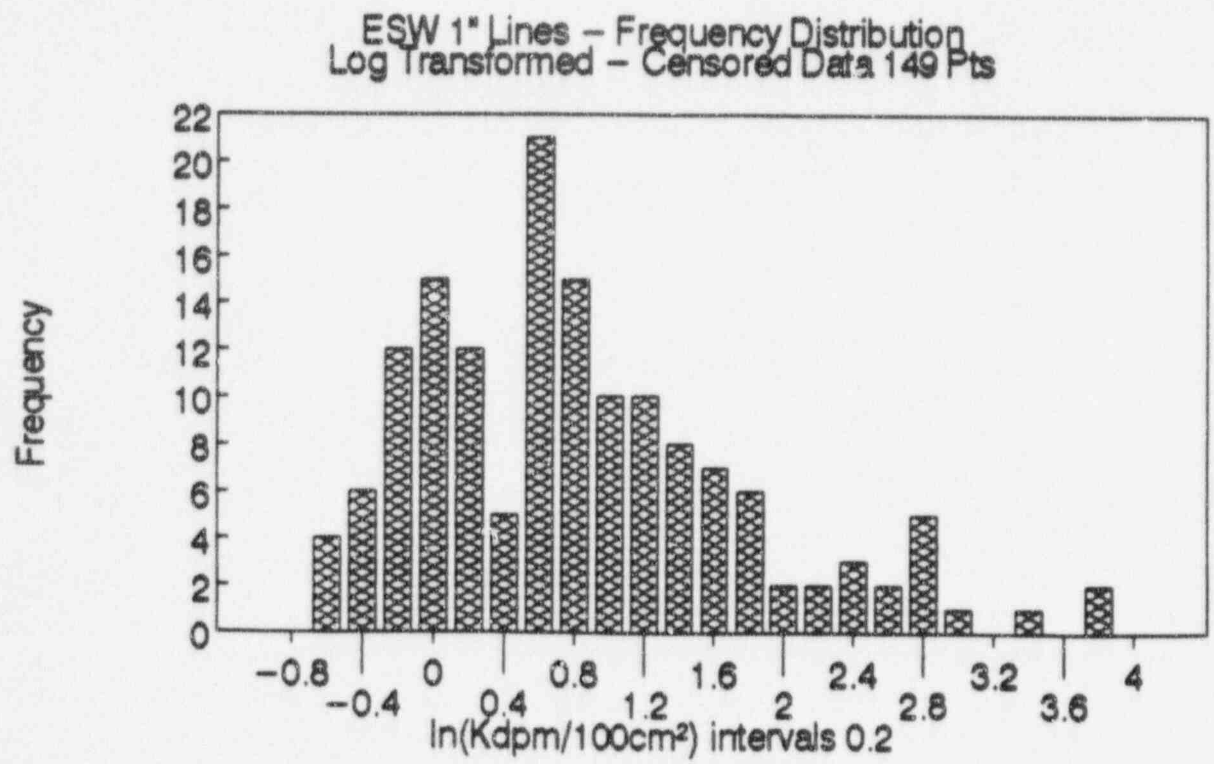


Figure 3



3.2 Uncertainty and upper Bound Estimates

Estimates of the uncertainty and the upper bound for maximum contamination level as a function of TLD spacing are obtained by dividing the measurements into sets of measurements spaced 40, 60 and 80 inches apart. This provides four data sets. The first set is the entire sample of 309 measurements at 20 inches. The 40 inch set comprises two samples of 154 measurements; the 60 inch set comprises three samples of 103 measurements and the 80 inch set comprises four samples of 77 measurements. The summary statistics from these data sets are shown in Table 2.

Table 2

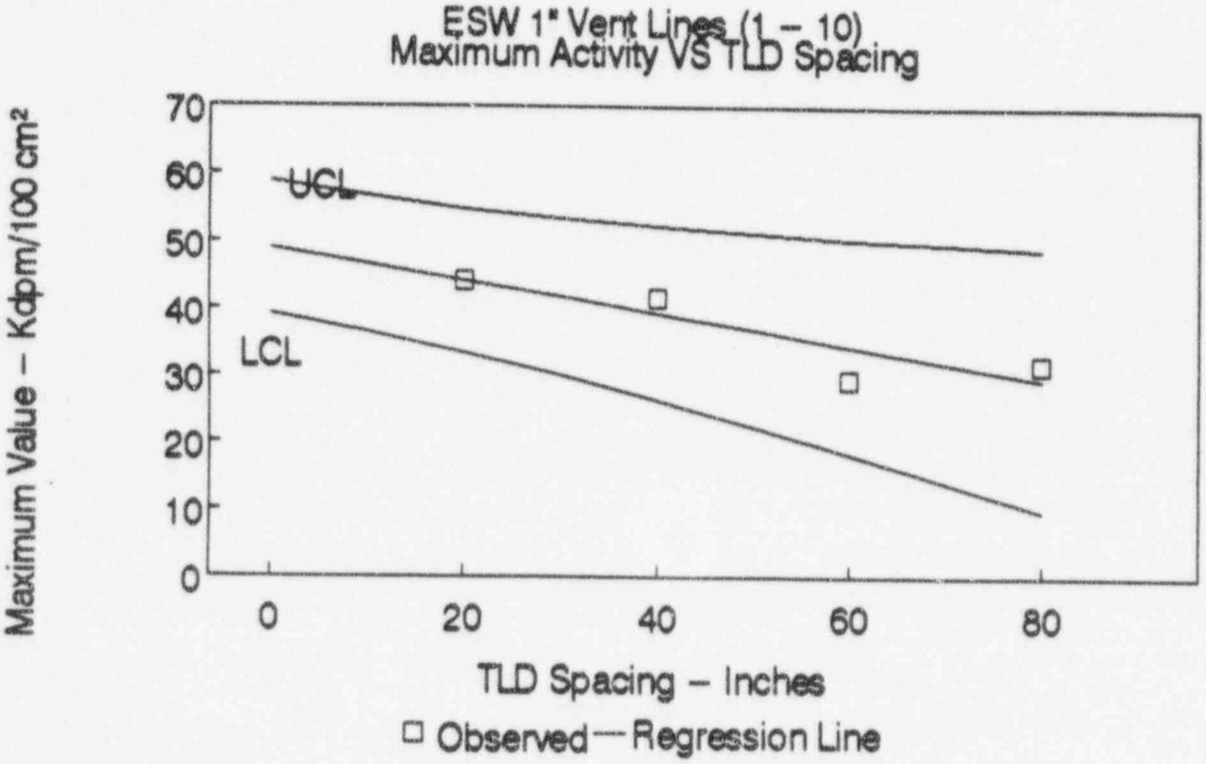
Data for Study of TLD Spacing

Spacing (in)	20		40	40	Avg for 40 in. spacing
Count	309		154	154	
Minimum	-0.8		-0.8	-0.2	
Maximum	44.1		44.1	38.9	41.5
Average	1.9		1.7	2.2	1.9
Std. Dev.	4.5		4.2	4.7	
UCL of Avg.	2.4		2.2	2.8	
Spacing (in)		60	60	60	Avg for 60 in. spacing
Count		103	103	103	
Minimum		-0.3	-0.2	-0.8	
Maximum		44.1	27.8	16.3	29.4
Average		2.4	1.8	1.6	1.9
Std. Dev.		6.3	3.6	2.8	
UCL of Avg.		3.4	2.4	2.1	
Spacing (in)	80	80	80	80	Avg for 80 in. spacing
Count	77	77	77	77	
Minimum	-0.8	-0.2	-0.2	-0.2	
Maximum	16.3	44.1	38.9	27.8	31.2
Average	1.4	1.9	2.1	2.3	1.9
Std. Dev.	2.8	5.3	5.1	4.3	
UCL of Avg.	1.9	2.9	3.1	3.1	

Note: all units are Kdpm/100 cm^2 except count which is unitless.

The maximum values from each data set are plotted against TLD spacing. The maximum values used for this plot are the averages of the maxima in each data set. This plot is shown in Figure 4. A least-squares fit of a straight line through the data is then obtained. The least-squares fitting results are shown in the Attachment, page 8. This model, a straight line with y intercept calculated, provides a good fit to the data (correlation coefficient of 0.775). The 95% confidence interval band for the regression line is also plotted on the figure. These results indicate that, as intuitively expected, decreasing the interval between measurements decreases the uncertainty in the estimated maximum contamination level. The error band for the 20 in. spacing is ± 22%. Thus, the upper bound on the maximum measured result of 44 Kdpm/100 cm^2 is 55K dpm/100 cm^2. This model for detector spacing vs maximum predicted contamination level indicates that an adequate margin is provided if action levels are set at 75% of the elevated area guideline value.

Figure 4



4.0 References

BOX78, George E. P. Box, William G. Hunter and J. Stuart Hunter, "Statistics for Experimenters", John Wiley and Sons, 1978.

WE96, Westinghouse Electric Corp., Nuclear Service Division, "Fort St Vrain Technical Basis Document for Piping Survey Instrumentation", WCAP-14570 (Westinghouse Non-Proprietary Class 3).

Attachment

Linear Regression Results

Regression Output: Autocorrelation study		
64 pairs of adjacent measurements		
Constant		1.233189
Std Err of Y Est		2.840181
R Squared		0.590487
No. of Observations		64
Degrees of Freedom		62
X Coefficient(s)	0.437169	
Std Err of Coef.	0.046236	

Dist (in.)	Max Value (Avg)	Regression Line	LCL	UCL
0		49	39.1	58.9
10		46.55	36.5	56.6
20	44.1	44.1	33.4	54.8
30		41.65	29.9	53.4
40	41.5	39.2	26.2	52.2
50		36.75	22.3	51.2
60	29.4	34.3	18.2	50.4
70		31.85	14.1	49.6
80	31.8	29.4	9.8	49.0

Regression Output: for Avg of max values vs TLD spacing		
Constant		48.9625
Std Err of Y Est		4.178976
R Squared		0.775161
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	−0.24537	
Std Err of Coef.	0.093444	

NRC Comment No. 11: Regarding TBD-203, Page 7, Paragraph 4:

Please provide the results of the additional evaluations performed to determine the TLD's response to localized contamination. How will the results of this evaluation be used to determine optimum TLD spacing in the pipes and to determine investigation levels?

PSCo/WT Response:

The additional evaluations underway to evaluate TLD response to highly localized contamination are not completed. This evaluation involves exposing TLDs from a point source positioned at various axial and angular positions (18 total positions targeted). With exposure periods ranging from about 1/2 to 10 days (depending on position), a total of about 2 months is required to complete a cycle (i.e., one measurement at each position). At least three cycles are considered necessary to collect a sufficient amount of data for meaningful analysis (cycle one is currently about 50% completed). Therefore, collecting and analyzing this special test data is not expected to be completed before the end of the FSV project.

This testing is being conducted to provide additional information for future refinements to the TLD string survey methods. The testing underway will not affect TLD survey protocols at FSV. The current method is considered reasonable to provide sufficient information concerning embedded piping contamination levels. Information concerning the appropriateness of 20" TLD spacing was provided in response to Comment #10.

NRC Comment No. 12: Regarding TBD-203, Page 12, Section 6.3:

Section 4.2 of the FSV Final Survey Plan, Revision 1, commits to an MDA of 50% of the SGLV for affected survey units. Section 6.3 states that the MDA for TLDs is intended to be less than 75% of the SGLV. Please clarify why the 50% MDA criteria does not apply in the affected piping systems.

PSCo/WT Response:

Due to the difficulty in achieving low MDAs with TLD strings, PSCo/WT request NRC approval to increase the 50% SGLV MDA commitment to 75% of SGLV for affected plant systems. This is consistent with the lowest action level for affected plant systems, which is at 75% of the SGLV. This request is considered reasonable due to the long exposure time required for TLD string surveys. Survey of plant system internal surfaces with TLDs requires approximately 2 months of exposure to meet an MDA of 75% of SGLV. To meet an MDA of 50% of SGLV would require about twice the exposure time (i.e., about 4 months), an impractical period of time.

NRC Comment No. 13: Regarding TBD-203, Page 14:

It appears that the first equation listed on page 14 is the final MDA equation, not the second equation. Please verify.

PSCo/WT Response:

Yes, the first equation on page 14 is the final MDA equation (the two equations were inadvertently reversed).

NRC Comment No. 14: Regarding TBD-204, Page 11, Paragraph 2:

Section 4.2 of the FSV Final Survey Plan, Revision 1, commits to an MDA of 50% of the SGLV for affected survey units. However, the target MDA for the pipe survey instrumentation is stated to be 75% of the SGLV for affected survey units. Please clarify why the 50% MDA criteria does not apply in the affected piping systems.

PSCo/WT Response:

Due to the difficulty in achieving low MDAs with specialized detectors necessary to survey plant system internal surfaces, PSCo/WT request NRC approval to increase the 50% SGLV MDA commitment to 75% of SGLV for affected plant systems. This is consistent with the lowest action level for affected plant systems, which is at 75% of the SGLV. This request is considered reasonable due to the low efficiencies and detection areas for plant system survey equipment and the longer count times required (relative to standard survey instruments) to obtain total surface activity measurements (i.e., several minutes versus 15 seconds). Unaffected plant systems will be surveyed with an MDA at 25% of SGLV as currently required (which requires long count times), but for unaffected plant systems, a much lower survey density is performed minimizing the impact of long count times.

NRC Comment No. 15: Regarding TBD-204, Page 12, Paragraph 1:

> *What is the maximum scan sensitivity level at which PSC considers scan surveys to provide meaningful information?*

PSCo/WT Response:

Section 4.3.6 of the FSV Final Survey Plan for Site Release requires scans to be performed at 75% of the SGLV (i.e., 3,000 dpm/100 cm^2). Therefore, only detectors capable of meeting this level of scan sensitivity are considered capable of scanning. This would include the cylindrical gas flow detectors, regular sized GM detector assemblies (i.e., those using 1.75" diameter GM tubes), and the rectangular gas flow LMI 43-68 detector (which can be used in large piping or tanks). For detectors that cannot meet this scan sensitivity, piping is surveyed by taking fixed point measurements at regular intervals along the pipe. During detector repositioning between fixed point measurements, instrument response is monitored to note any increase in signal. If a significant increase is noted, additional fixed point measurements are taken. Although not an "official" scan, it is considered useful to monitor detector response during detector repositioning to allow any real time detector to monitor for surface contamination to the best of its capability.