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Authorized Limits for the Release of the 25-Ton Locomotive, Serial Number 21547, at the Area 25 Engine Maintenance, Assembly, and Disassembly Facility, Nevada Test Site, Nevada

National Security Technologies, LLC
Environmental Restoration Group
Nevada Test Site, Nevada

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PREFACE

Records generated during the radiological assessment and clearance of material and equipment from the Nevada National Security Site (formerly known as the Nevada Test Site, or NTS) have historic value and deserve special attention. These records are maintained in accordance with National Archive and Records Administration approved U.S. Department of Energy (DOE) record schedules, as defined in National Security Technologies, LLC, procedures.

The proposed transfer of this locomotive has been discussed with the Nevada Division of Environmental Protection. DOE attended a Community Advisory Board (CAB) for NTS Programs meeting, which resulted in the CAB discussing the future disposition of the locomotive to the museum. Additional public notification of the release of this locomotive will be included in the NTS Annual Environmental Report.

Independent verification of the radiological clearance of this property was performed by two U.S. Department of Energy, National Nuclear Security Administration/Nevada Site Office Subject Matter Experts, independent of the contractor responsible for the clearance action.

Table of Contents

List of Attachments

List of Figures

List of Tables

Executive Summary

This document contains the process knowledge and radiological data and analysis to support approval for offsite release of the 25-ton locomotive, Serial Number 21547, at the Area 25 Engine Maintenance, Assembly, and Disassembly (EMAD) Facility, located on the Nevada Test Site (NTS) using alternate release limits.

The 25-ton locomotive is a small, one-of-a-kind locomotive previously used to move railcars in support of the Nuclear Engine for Rocket Vehicle Application project. This locomotive was identified as having significant historical value and is now owned by the Nevada State Railroad Museum in Boulder City, Nevada. If offsite release is approved, the locomotive will be moved to the Museum where it will be used as a display piece.

As part of the process for release, a substantial effort to characterize the radiological conditions of the locomotive was undertaken by the NTS Management and Operations Contractor, National Security Technologies, LLC (NSTec). During this characterization process, seven small areas on the locomotive had contamination levels that exceeded the limits of U.S. Department of Energy [DOE] Order DOE O 5400.5, "Radiation Protection of the Public and the Environment". The decision was made to perform radiological decontamination of these known accessible impacted areas to further the release process. On February 9, 2010, NSTec personnel completed decontamination of these seven areas to levels less than the DOE O 5400.5 release criteria.

Although all accessible areas of the locomotive had been successfully decontaminated to within NTS release criteria, it was plausible that inaccessible areas of the locomotive (i.e., those areas on the locomotive where it was not possible to perform radiological surveys) could potentially have contamination above unrestricted release limits. A complete radiological survey would require disassembly of the locomotive to access the majority of these inaccessible areas. Disassembly would destroy parts and would have ruined the historical value of the locomotive. Complete disassembly would also add an unreasonable financial burden for the contractor.

A decision was reached between the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office and NSTec, opting for alternative authorized limits from DOE Headquarters. In doing so, NSTec personnel performed a dose model using the DOE-approved modeling code RESRAD-BUILD v3.5 to evaluate scenarios. The parameters used in the dose model were conservative. NSTec's Radiological Engineering Calculation, REC-2010-001, "Public Dose Estimate from the EMAD 25 Ton Locomotive," concluded that the four scenarios evaluated were below the 25-millirem per year (mrem/yr) dose constraint of DOE Order 5400.5. The likely use scenarios resulted in doses less than 1 mrem/yr, and the worst-case scenarios resulted in doses less than 4 mrem/yr. All scenarios resulted in doses on the order of a few millirem or less in a year, thus meeting the radiological requirements for unrestricted release with residual radioactivity to the public.

Based on the worst case potential dose to a member of the public of approximately 4 mrem/yr, far less than the 25- mrem/yr dose constraint of DOE Order 5400.5, NSTec is requesting the use of "a few millirem or less" criteria as the alternate authorized limit to release the 25-ton locomotive to the public.

1. INTRODUCTION

This document contains process knowledge and radiological data and analysis to support approval for the release of the 25-ton locomotive, Serial Number 21547, located at the Area 25 Engine Maintenance, Assembly, and Disassembly (EMAD) Facility on the Nevada Test Site (NTS). The 25-ton locomotive is a small, one-of-a-kind locomotive used to move railcars in support of the nuclear rocket and jet engine program known as the Nuclear Engine for Rocket Vehicle Application (NERVA) project. This locomotive was identified as having significant historical value by the Nevada State Railroad Museum in Boulder City, Nevada, where it will be used as a display piece.

Figure 1. EMAD 25-Ton Locomotive

1.1. Purpose

With the radiological data and analysis presented in this document, there should be sufficient documentation for the regulator to make an informed decision for or against the approval of performing an unrestricted release of the EMAD locomotive.

1.2. Authorized Limits for Release

The unrestricted release of the locomotive will be based on alternate as low as reasonably achievable (ALARA)/dose-based derived authorized limits in accordance with U.S. Department of Energy (DOE) Order DOE O 5400.5, "Radiation Protection of the Public and the Environment." Since it is impossible to prove that there is no residual contamination in inaccessible areas, it will be necessary to demonstrate that the estimated dose to the public meets the following requirements:

- Authorized limits for release of the item must ensure that doses to the public from all sources are less than the primary dose limit for all sources (100 millirems per year [mrem/yr]).

- Authorized limits for release of the item must be developed and approved by DOE consistent with the ALARA process. These limits will be based on a documented finding that they are as low as practicable as determined through the ALARA process, with a goal of maintaining individual doses low in comparison to background (a few mrem/yr or less). In any case, the limits must be a fraction of the primary dose limit for the public (i.e., meet a dose constraint of 25 mrem/yr or less).

DOE Guidance 441.1-XX, "Control and Release of Property with Residual Radioactive Material for use with DOE 5400.5, Radiation Protection of the Public and the Environment," recommends the following:

- The authorized limits should be selected to ensure doses to individuals using the property under "actual" and "likely use" scenarios will be well below the primary dose limit and at a level that provides a reasonable expectation doses will be less than the dose constraint of 25 mrem/yr. Based on DOE experience gained in applying these requirements under DOE 5400.5, it is expected doses will be on the order of a few millirem or less in a year.
- It is not expected that the worst plausible use of property will occur, and it is not DOE's intent to permit releases expected to cause doses that are a significant fraction of the primary dose limit. In cases where the probability of the worst plausible use scenario is high and reasonably certain, the 25-mrem/yr dose constraint should be applied, ensuring doses associated with the potential release would be limited to a very small fraction of the 100-mrem/yr dose limit.

The DOE dose constraint of 25 mrem/yr is also consistent with the dose requirements in Title 10 Code of Federal Regulations (CFR) Part 20, "Standards for Protection Against Radiation," Subpart E, "Radiological Criteria for License Termination." The 25-mrem/yr dose constraint is also consistent with the Nevada Administrative Code (NAC) 459.3178, "Property of decommissioned facility: Eligibility for release for unrestricted use." A basic dose assessment using the RESRAD-BUILD v3.5 code should be adequate to demonstrate compliance with the dose constraint of 25 mrem/yr.

Release of material to uncontrolled areas at the NTS is completed in accordance with the NTS Radiological Control Manual, DOE/NV/25946--801, Revision 1, Article 422, which states:

> *DOE O 5400.5, "Radiation Protection of the Public and the Environment," describes radiological criteria for releasing material to uncontrolled areas. Values consistent with DOE O 5400.5 are provided in Table 4-2. [Tenant Organizations] must obtain NNSA/NSO approval to use any limits including those in Table 4-2 for releases to uncontrolled areas. Alternate authorized unrestricted release limits may be approved by DOE/NNSA for material, equipment, or real property with surface contamination levels greater than the Table 4-2 limits. The process to obtain approval is described in DOE O 5400.5 and associated guidance documents.*

Table 4-2 of the NTS Radiological Control Manual (see Table 1 below) describes surface contamination criteria for releasing material to uncontrolled areas. This table does not apply to materials that are activated or have volumetric or internal contamination. The values in Table 4-2 are the site-approved release criteria, and the limits are identical to those found in DOE O 5400.5.

According to National Security Technologies, LLC (NSTec), Organization Instruction OI-0441.212, Revision 4, "Controlled and Unrestricted Release," items that are to be released off site and have inaccessible surfaces and have known contamination or the potential for internal contamination require the approval of the Radiological Control Manager, the senior line manager of the project, and the DOE line manager.

Table 1. Table 4-2 from the NTS Radiological Control Manual

Radionuclides	Contamination levels in dpm/100 cm^2		
	Average	Maximum	Removable
Group 1 – Transuranics, I-125, I-129, Ac-227, Ra-226, Ra-228, Th-228, Th-230, Pa-231	100	300	20
Group 2 – Th-natural, Sr-90, I-126, I-131, I-133, Ra-223, Ra-224, U-232, Th-232	1,000	3,000	200
Group 3 – U-natural, U-235, U-238, and associated decay products, alpha emitters	5,000	15,000	1,000
Group 4 – Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000	15,000	1,000
Tritium (applicable to surface and subsurface)	N/A	N/A	10,000

1.3. Site Location and History

The locomotive is currently located at the NTS, at the EMAD facility in Area 25. The locomotive was used to move railcars to support the nuclear rocket/jet engine programs. It is listed at 25 tons and has not been enhanced with shielding. It is a diesel/electric locomotive with an electric motor mounted in the undercarriage. The locomotive utilizes a drive chain to link the motor to the drive wheels.

The locomotive was used to move flat and test cars into position and not for test articles or contaminated equipment. The low traction and poor braking made it undesirable for that type of work. However, there is photographic record of the locomotive being directly coupled to one of the test engines, and some of the rails it operated on are known to have been contaminated.

It also was used at all of the Area 25 test facilities in support of the rocket and jet engine programs. The engine was fully operational at the time that EMAD was shut down and was used to move railcars within the compound after facility closure. The main radionuclides involved in work activities consisted of residual uranium and mixed fission products. It is not known when the locomotive last operated.

2. RADIOLOGICAL CONDITIONS

In the past, the locomotive was posted as a Contamination Area. The reasons for these postings are not known, although a small container of radioactive material, picked up from along the railroad tracks, was temporarily stored in the cab of the locomotive. The container is no longer in the cab. The Contamination Area signs were removed, but it is not known by whom or by what process. Currently, the locomotive is posted as a Radioactive Material Area.

2.1. Scoping Survey

In April 2008, NSTec Radiological Control Technicians (RCTs) performed a scoping survey and identified three locations on the locomotive that had total contamination in excess of the NTS release limits, in accordance with the NTS Radiological Control Manual, DOE/NV/25946--801, Revision 1, Table 4-2. The scoping survey was documented in survey results #08-ER-A25-100. Attachment 1 includes the complete survey results. Two of the locations were on the main deck at the front of the engine under access covers. The third location was on the front coupler. The highest direct reading was approximately 20,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) total beta under the access covers. The portable contamination detector used to perform the surveys was the NE Electra with a DP-6 probe.

2.2. Characterization Survey

In August 2008, after development of Survey Plan #08-028, "EMAD Locomotive Survey to Determine Release from Radiological Controls Criteria," RCTs performed an additional survey of the locomotive. Attachment 2 includes the complete survey plan. This survey was much more detailed and comprehensive than the preliminary scoping survey. The survey plan instructed RCTs to:

- Survey all exposed greased fittings, couplings, joints, etc.
- Perform swipes as indicated by photos in the survey plan (Attachment 2); biased if direct readings indicate fixed contamination present in that area.
- Survey the engine and battery compartments using a biased random technique with a minimum of 40 swipes per compartment.
- Survey the cab interior, biased random, minimum as indicated in attached photographs, focus on floor and pedals.
- Obtain a minimum of four swipes on the cab roof.
- Use large area wipes on all exposed surfaces, especially the wheels and running gear.
- Survey areas that are recessed or have small openings, such as chain drive pathways, by using a tool to push a Maslin cloth, or equivalent, into the space.
- Perform static direct surveys at all locations where swipes were taken.
- Survey for total contamination conducted over 100 percent of the accessible surface areas.
- Perform a dose rate measurement for any elevated direct reading.

Following the execution of the survey plan, the following contamination levels were noted and documented on survey #08-ER-A25-185. Attachment 3 includes the complete survey results.

- Undercarriage Front Brake Assembly – 5,000 dpm/100 cm^2 total beta
- Undercarriage Front Axle and Wheel – 7,200 dpm/100 cm^2 total beta
- Front Coupler – 7,000 dpm/100 cm^2 total beta
- Exterior Right Front Inspection Port – 10,800 dpm/100 cm^2 total beta
- Exterior Left Front Inspection Port – 21,800 dpm/100 cm^2 total beta
- Engine Compartment Right Upper Inside Lip – 11,100 dpm/100 cm^2 total beta
- Engine Compartment Left Upper Inside Lip – 6,800 dpm/100 cm^2 total beta

Note: The radiological units "dpm/100 cm^2" are used when documenting surface area activity.

No removable contamination was found. The locations of the elevated fixed contamination are not immediately adjacent to any of the inaccessible areas of the locomotive. (These inaccessible areas were inaccessible for the portable survey meter.) Most inaccessible areas were surveyed for removable contamination to some extent (swipes), except for the interior portions of the engine and other sealed components. This provided a reasonable assurance that contamination did not migrate to the inaccessible surfaces since the potential intake pathways were not contaminated and the locations with elevated contamination were remote to those pathways.

The intent of the survey plan was to evaluate the locomotive for unrestricted release. After the survey results were analyzed, the locomotive did not meet the NTS release criteria for unrestricted release. The survey results were then used as a thorough characterization survey. With the discovery of multiple areas being impacted, the intended disposition of the locomotive to an offsite museum was postponed until a path forward for unrestricted release could be determined.

2.3. Decontamination

As part of the path forward for unrestricted release, the identified areas of known fixed contamination on the locomotive were decontaminated in January–February 2010 under Survey Plan #09-037, "Post Remediation Survey Requirements for the 25 Ton Locomotive at the Engine Maintenance, Assembly and Disassembly (EMAD) Rail Yard Serial Number 21547." Attachment 4 includes the complete survey plan. After decontamination, a post-remediation survey was performed, and the results were documented on survey #10-ER-A25-097. Attachment 5 includes the complete survey results. In addition, the locomotive was drained of all remaining fluids.

The decontamination process effectively removed known contamination from the surfaces of the locomotive to less than detectable limits of the survey instrument, with the exception of one location. The right upper inside lip of the engine compartment was decontaminated to a beta activity of 3,000 dpm/100 cm^2. The area of the fixed contamination was less than 1 square meter. It is important to note that after the decontamination was performed, the accessible areas of the locomotive met the NTS release criteria.

A sample of decontamination effluent and trash was given to NSTec Radiological Engineering to perform an isotopic identification. Performing gamma spectroscopy, the isotopes of Cs-137 and U-235 were identified. It was assumed that the beta activity is composed of a mixture of fission products (Cs-137 and Sr/Y-90). The U-235 was identified by gamma spectroscopy but is present on the locomotive at or below the detectable limits of the portable survey instruments.

With decontamination of the accessible areas completed, there was a concern about the radiological conditions of the inaccessible areas of the locomotive. Although all accessible areas of the locomotive had been successfully decontaminated to within NTS release criteria, it was plausible that inaccessible areas of the locomotive (i.e., those areas on the locomotive where it was not possible to perform radiological surveys) could potentially have contamination above unrestricted release limits.

To access the majority of these inaccessible areas, the locomotive would have to be disassembled. Performing a complete disassembly of the locomotive would allow total access for a radiological survey but would require a substantial amount of cutting and welding on portions of the locomotive that might permanently destroy parts. These parts would have to be custom fabricated to replace, and the historical value of the locomotive would be ruined. With the possibility of destroying the historical value of the train, disassembly was not determined to be a viable option.

3. DOSE ASSESSMENT

With the accessible areas of the locomotive meeting the NTS release criteria, but with the unknown radiological condition of the inaccessible areas, a decision was reached between the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office and NSTec to pursue alternative authorized limits from DOE Headquarters. In order to obtain alternative authorized limits, a dose assessment would have to be performed in order to demonstrate that the dose to the public would meet regulations and be ALARA. NSTec personnel performed various dose models using the DOE-approved modeling code RESRAD-BUILD v3.5 to evaluate different likely use and worst case scenarios, as required by DOE O 5400.5.

The dose model is included in Attachment 6, Radiological Engineering Calculation REC-2010-001, Revision 1, "Public Dose Estimate from the EMAD 25 Ton Locomotive." REC-2010-001 contains the detailed descriptions of the scenarios, parameters, assumptions, and results. In short, four use

scenarios were developed under conservative assumptions and incorporated into the dose modeling of the EMAD locomotive. The four scenarios are summarized below.

1. **Likely Use Scenario 1:** The dose to an individual under a likely use scenario was modeled as a member of the public, the "museum enthusiast," who attends the museum once a week for 2 hours. The entire 2 hours are spent 0.3 meters from the side of the locomotive. For conservatism, the entire side of the locomotive was assumed to be uniformly contaminated with the maximum activity that was found on previous surveys.
2. **Likely Use Scenario 2:** Another likely use scenario involved a "museum worker" who refurbishes or moves the locomotive for 10 hours a day for 30 days. The time was spent 0.3 meters away from the sides of the locomotive, partially surrounded by a contaminated engine compartment.
3. **Worst-Case Scenario 1:** A dose under worst plausible use scenarios, or "worst-case" scenario, would represent a situation if all controls failed. A scenario was hypothesized and involved an individual spending an unreasonable amount of time in close proximity to a contaminated engine compartment. This person would spend 8 hours a day, every day, at an average distance of 0.3 meters from the side of the "contaminated" compartment.
4. **Worst-Case Scenario 2:** Another worst-case scenario involved a museum employee who mechanically removes (by grinding or sanding) the small area of fixed contamination that remains on the locomotive. This scenario assumed that the total amount of known contamination becomes airborne, that the employee is 0.3 meters away, and spends 6 hours performing work.

The RESRAD-BUILD detailed results for each scenario are included in Appendices B–E of Attachment 6. A summary of the doses received for each scenario over time is presented in Table 2. The Radiological Engineering Calculation concluded that all four scenarios evaluated were below the 25-mrem/yr limit and met the "few millirem in a year" criteria.

Table 2. Summary of Dose Received for Use Scenarios

	Annual Dose Received for the Maximum Exposed Individual (mrem)			
Scenario	***End of the 1st year***	***End of the 2nd year***	***End of the 10th year***	***End of the 30th year***
Likely Use 1	0.109	0.105	0.085	0.0536
Likely Use 2	0.512	0.491	0.399	0.252
Worst Case 1	3.83	3.30	2.68	1.69
Worst Case 2	1.16	0	0	0

4. CONCLUSIONS

The Nevada State Railroad Museum in Boulder City, Nevada, intends to use the locomotive as a public display only. This locomotive will not be operational; it will just be used as a static display for the public to view. Current rules at the rail yard prohibit the public from climbing on any of the displays. The rail yard has a fence around the train displays and is locked after business hours. The only foreseeable direct contact with the locomotive is from museum workers if they have to move it or refurbish it.

The scenarios modeled in RESRAD-BUILD v3.5 are very conservative. The conservative assumptions, including the exaggerated source term and the amount of time spent in close contact with the

locomotive, have a high probability of overestimating the dose to the individual. Even with these conservative assumptions, the maximum dose to an individual for the likely use scenarios was less than 1 mrem/yr, and the maximum dose for the worst-case scenarios was less than 4 mrem/yr.

The "Likely Use Scenario 1" represents members of the public visiting the museum and viewing the locomotive. The "museum enthusiast" could receive a maximum dose of 0.109 mrem/yr. This scenario has the highest probability of occurring out of the four scenarios. This individual would spend 2 hours per week, every week for 30 years, standing 0.3 meters from the exterior surface of the locomotive. The expected dose to an individual in this group would be a fraction of the calculated dose because the source term was exaggerated in the RESRAD-BUILD code. The calculated maximum dose under this likely use scenario is well under the 25-mrem/yr dose constraint and meets the criteria of a "few millirem or less in a year" established in DOE O 5400.5.

The "Likely Use Scenario 2" represents employees of the museum who refurbish or move the locomotive. The "museum worker" could receive a maximum dose of 0.512 mrem/yr. This scenario is less probable than "Likely Use Scenario 1." The museum employee would spend 10 hours a day, for 30 days a year, positioned partially enclosed between three contaminated surfaces at 0.3 meters from each surface. The expected dose to an individual in this group would be a fraction of the calculated dose because the source term was exaggerated in the RESRAD-BUILD code. The calculated maximum dose under the likely use scenario is well under the 25-mrem/yr dose constraint and meets the criteria of a "few millirem or less in a year" established in DOE O 5400.5.

Under the "Worst-Case Scenario 1," an individual could receive a maximum dose of 3.83 mrem/yr. The worst-case scenario represented the dose to an individual if all controls failed. This individual would spend 8 hours per day, every day for 30 years, in close proximity to a surface contaminated engine compartment. The shielding thickness was decreased, and the source activity for the "contaminated" engine compartment was exaggerated, thus increasing the dose to the individual. The probability of this scenario occurring is low. The calculated maximum dose under the worst-case scenario is well under the 25-mrem/yr dose constraint established in DOE O 5400.5.

Under the "Worst-Case Scenario 2," an individual could receive a maximum dose of 1.16 mrem/yr. The individual would receive a one-time 1.16-mrem dose during a 6 hour exposure. This individual would spend a total of 6 hours mechanically removing a small surface contaminated area. The source activity for the contaminated area mimicked actual conditions. The airborne respirable fraction was set at 50 percent, which equates to half of the total source activity becoming airborne and existing as respirable particulate. This was a conservative assumption because most of the source activity would not exist as respirable fractions during mechanical removal (i.e., mechanical removal fragments would be too large to become respirable). The probability of this scenario occurring is low. The calculated maximum dose under this scenario is well under the 25-mrem/yr dose constraint established in DOE O 5400.5.

With all four scenarios less than the 25-mrem/yr limit and with the likely dose scenarios meeting the "few millirem in a year" criteria, the EMAD 25-ton locomotive, as it currently exists, meets the radiological requirements of DOE O 5400.5 to have an unrestricted release to the public. NSTec is requesting the use of "a few millirem or less" criteria as the alternate authorized limit to release the 25-ton locomotive to the public.

5. REFERENCES

Code of Federal Regulations, 2008. Title 10, Part 835, "Occupational Radiation Protection." Washington, D.C.

Code of Federal Regulations, 1998. Title 10, Part 20, "Standard for Protection Against Radiation." Washington, D.C.

U.S. Department of Energy, 1993. DOE O 5400.5, "Radiation Protection of the Public and the Environment." Washington, D.C.

U.S. Department of Energy, 1999. DOE Guidance 441.1-XX, "Control and Release of Property with Residual Radioactive Material for use with DOE 5400.5, Radiation Protection of the Public and the Environment." Washington, D.C.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, 2010. *Nevada Test Site Radiological Control Manual*, Revision 1. DOE/NV/25946--801. Las Vegas, NV.

National Security Technologies, LLC, 2008. Company Document CD-0441.004, "Material Release Program." Las Vegas, NV.

National Security Technologies, LLC, 2008. Organization Instruction OI-0441.212, "Controlled and Unrestricted Release," Revision 4. Las Vegas, NV.

ATTACHMENT 1
Scoping Survey Results #08-ER-A25-100

COPY

NSTec

RADIOLOGICAL SURVEY REPORT – DATA

SURVEY # 08-ER-A25-100

Location:	Purpose:	Comments:	Date/Time:
Area 25, E-MAD	Cursory survey of train engine to be transferred off site to a museum	All Swipes Field Checked Highest Readings Noted. Train is within a posted controlled area and RMA	3/12/08 / 1330

Instrument:	Serial #:	Cal Due:	Eff in %: Alpha / Beta	BKG in dpm: Alpha / Beta	MDA in dpm: Alpha / Beta		
2929	157336	12/31/08	35.39 / 42.03	0.85 / 224.8	13.0 / 86.5	RWP # N / A	
Electra	2224	9/13/08	15.2 / 24.1	32.9 / 2828	80 / 500	RCT Name: S. Munns	Signature:
Model-3	197130	4/26/08	N / A	N / A	N / A	RCT Name: N / A	Signature: N / A
N / A	N / A	N / A	N / A	N / A	N / A	RCT Name: N/A	Signature: N/A
N / A	N / A	N / A	N / A	N / A	N / A	RCT Name: N/A	Signature: N/A

Survey Point	Description/Comments	Removable dpm/100cm²		Fixed + Removable dpm/100cm²		Gamma mrem/hr	Neutron mrem/hr	Total mrem/hr
		Alpha	Beta	Alpha	Beta			
1	Front coupler mechanism	<MDA	<MDA	<MDA	8000	N / A	N / A	N / A
2	Rectangular inspection port left front deck	<MDA	<MDA	<MDA	20,000	N / A	N / A	N / A
3	Rectangular inspection port right front deck	<MDA	<MDA	<MDA	10,000	N / A	N / A	N / A
4	Sample Prep Area	<MDA	<MDA	N / A	N / A	N / A	N / A	N / A
N / A	No other contamination found at this time; but there are a vast	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	majority of areas of the unit that are inaccessible.	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	Also once these three areas were found the survey was terminated	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	due to the reason for performing the survey to begin with.	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A

Reviewed By (Print):	Signature:	Date:
D. Frantz		3/13/08

ATTACHMENT 2
Survey Plan #08-028, "EMAD Locomotive Survey to Determine Release from Radiological Controls Criteria"

Radiological Survey Plan
for Environmental Restoration

Engine Maintenance, Assembly, and Disassembly (EMAD)
Locomotive Survey to Determine
Release from Radiological Controls Criteria

Plan Number 08-028

July 22, 2008

Prepared by _____ Date 7/22/08
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Concurred by _____ Date 7/27/2008
Douglas H. McBride, NSTec
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Concurred by _____ Date 7/29/08
Annette L. Primrose, NSTec
Environmental Restoration Manager

Approved by _____ Date 7/29/08
Mark McMahon, NSTec
Radiological Control Manager

Purpose

This plan provides Radiological Control Technicians (RCTs) with the survey instructions required to determine whether the small rail locomotive, serial number 21547 may be provided a restricted release to the Nevada State Railroad Museum in Boulder City, Nevada under U.S. Department of Energy Order DOE O 5400.5, "Radiation Protection of the Public and the Environment."

Scope

This plan pertains to the small rail locomotive, serial number 21547, currently located in the EMAD yard, just north of the facility. Results of this survey will be used to determine appropriate release from radiological control levels. These levels will be evaluated with consideration for the proposed use restrictions and deemed ALARA prior to relinquishing site control.

The methodology utilized in the development of this plan was obtained from DOE 5400.5, "Radiation Protection of the Public and the Environment," DOE G 441.1-XX, "Implementation Guide for Control and Release of Property with Residual Radioactive Material," DOE-XXXX, "Environmental Implementation Guide for Radiological Survey Procedures," February 1997, and DOE/NV/11718-079-Rev 5, "NV/YMP Radiological Control Manual."

History

The small locomotive was used to move railcars in support of the nuclear rocket/jet engine programs. It is listed at 25 tons and has not been enhanced with added shielding. It is a diesel/electric locomotive with an electric motor mounted in the undercarriage. The locomotive utilizes a drive chain to link the motor to the drive wheels. Testimony states that it was used to move flat and test cars into position and not for test articles or contaminated equipment. The low traction and poor braking made it undesirable for that type of work. However, there is photographic record of the locomotive being directly coupled to one of the test engines and some of the rails it operated on are known to have been contaminated. It also was used at all of the Area 25 test facilities in support of the rocket and jet engine programs. The engine was fully operational at the time that EMAD was shut down and was used to move railcars within the compound after facility closure. It is not known when it last operated. Recently, it was posted as a contamination area and as a radioactive material area. The reasons for these postings are not really known, although there is testimony that a small container of radioactive material, picked up from along the railroad tracks, was temporarily stored in the cab of the locomotive. The container is no longer in the cab and to the best knowledge available no longer on the EMAD Site. The contamination area signs were removed but it is not known by whom or by what process. RCTs performing a casual survey identified three locations on the locomotive that had direct reading contamination in excess of the release limits. Two of the locations were on the main deck at the front of the engine under access covers. The third location was on the front coupler. The highest direct reading was ~20,000 dpm/100cm^2 beta under the access

covers. No further surveys were conducted at that time and the levels have not been verified. Previous surveys of the locomotive have not identified contamination above posting criteria of Table 2-2 of the Radiological Control Manual.

Contamination characterization for this equipment is based on IT 2000, "Cesium 137 Scaling Factors for Concrete, Insulation, Wood, and Concrete Surfaces for the Former ROVER Project and NERVA Facilities in Area 25 Nevada Test Site, Nevada." This document shows Cs^{137} and enriched uranium (EU) to be the predominant contaminants of concern; Sr^{90} appears in equilibrium with Cs^{137}.

Instructions

Radiological surveys shall be performed by qualified personnel in compliance with OI-0441.211, "Direct and Indirect Surveys." Personnel must use their experience, knowledge of the area in which they are working, and workplace indicators to assure adequate surveys are being performed, in addition to the information provided in this document.

The batteries and fluids will be removed from the locomotive prior to release from the site. The batteries will need to be removed prior to completion of the survey. Some locations, such as the wood floor in the cab, are not ideally suited for survey. However, since one of the dominant contaminants of concern is Cs^{137} the porosity of the wood should not greatly hinder detection of contamination if present above the release criteria. Dose rate surveys will also verify whether there is an issue with these surfaces regarding release of the locomotive from radiological control.

Minimum survey requirements are also found in Organizational Instruction OI-0441.212, "Controlled and Uncontrolled Release." This document is not intended to conflict with the aforementioned OI, but to provide additional guidance. This procedure also contains the specifications of the instruments' detection capabilities.

All access doors shall be opened to facilitate survey and moving parts shall be articulated or rotated to expose concealed elements. If background radiation levels are too high to allow direct measurements and dose rate surveys to be performed, then the locomotive shall be relocated to an area suitable for survey.

Contamination Surveys

The following survey methodology is consistent with the requirements of DOE-XXXX, "Environmental Implementation Guide for Radiological Survey Procedures," February 1997. The survey points selected were based on the one per square meter recommendation of the referenced guidance document and then biased, with additional points added, to increase the probability of locating contaminated areas. Random surveys shall be conducted on the equipment for removable contamination. White dots on the attached pictures indicate the locations for swipe surveys to be taken. These are the minimum required and the RCT is encouraged to take more if an area looks suspicious or if direct readings indicate a potential exists. Surveys for removable contamination shall be performed on:

- All exposed greased fittings, couplings, joints, etc.
- Swipes at a minimum as indicated on the attached pictures, biased if direct readings indicate fixed contamination present in that area
- The engine and battery compartments using biased random technique; minimum of 40 swipes per compartment
- The cab interior, biased random, minimum as indicated in attached photographs, focus on floor and pedals
- Minimum of four swipes on the cab roof
- Large area wipes shall be taken on all exposed surfaces, especially the wheels and running gear
- Areas that are recessed or have small openings, such as chain drive pathways, shall be surveyed using a tool to push a Maslin cloth or equivalent into the space
- Static direct surveys shall be performed at all locations where swipes are taken

Surveys for total contamination shall be conducted over 100 % of the accessible surface areas to the extent possible using an Electra survey meter. Swipes shall be counted in a Tennelec or other approved swipe counter. Locations with elevated direct readings shall be surveyed using a micro rem meter and a general dose rate of the locomotive shall be recorded. The rigor of this survey plan provides assurance that any inaccessible areas not surveyed are either identified or are below the release limits of Table 4-2.

Disposition

Survey results shall be recorded on a FRM-0108, “Radiological Survey Report,” and approved by Project Health Physics Supervisor. Final approval for the release of this locomotive will be made by NNSA based on the projected dose consequence and use controls to be implemented when released for DOE control.


CAUTION
RADIOACTIVE
MATERIAL
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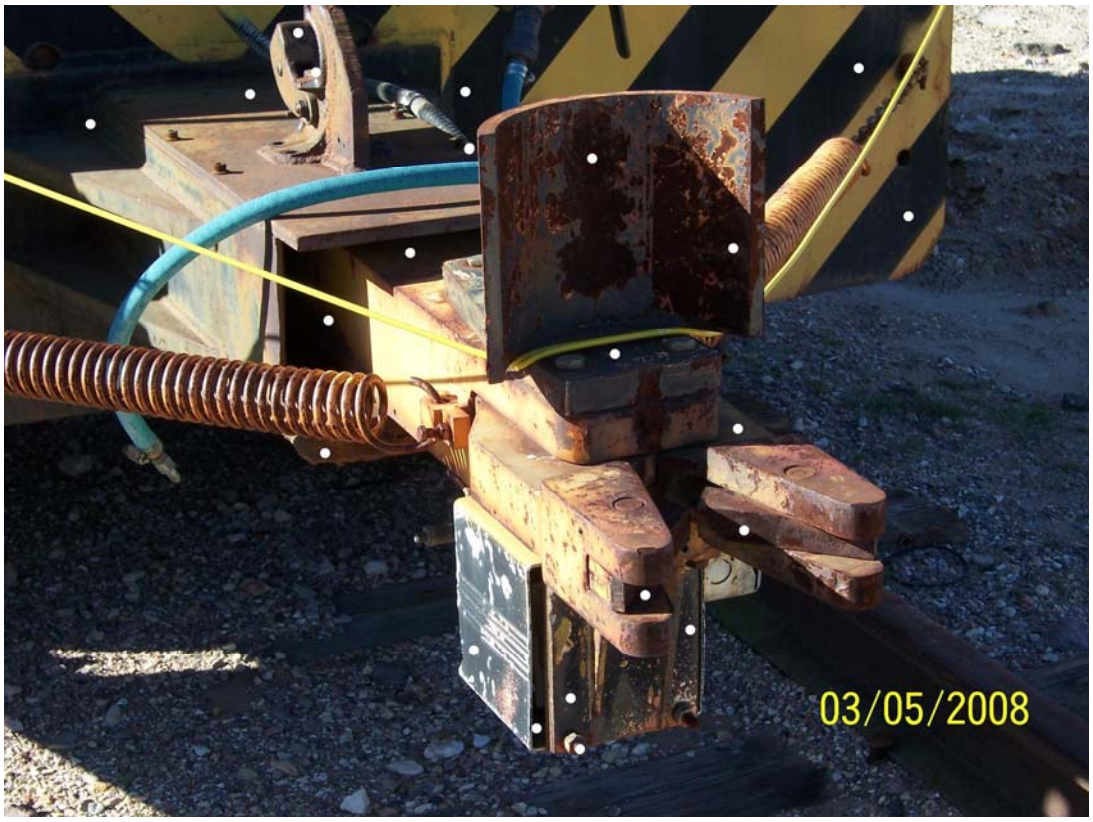
03/05/2008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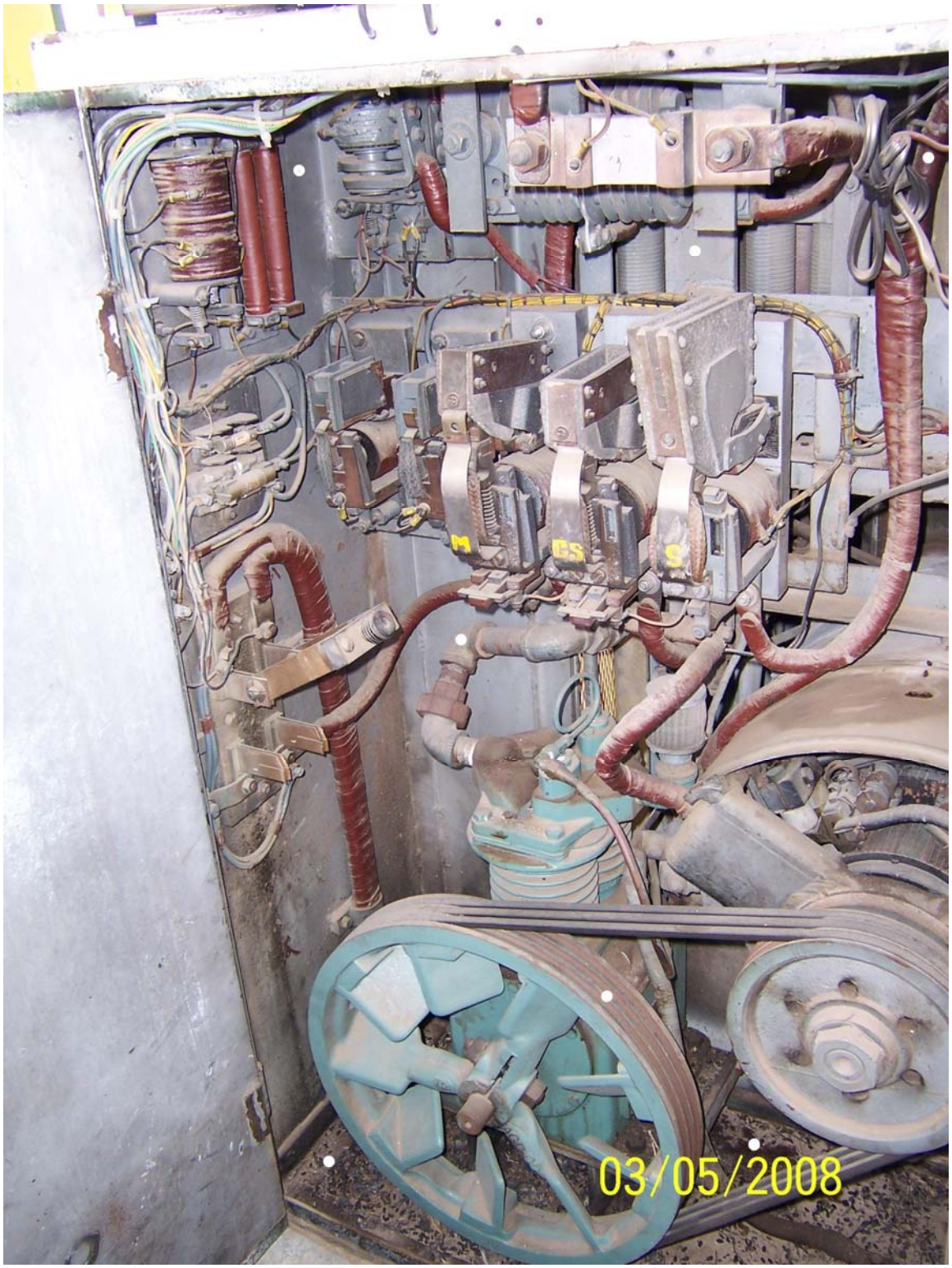
LOG
BOOK
Electro
MODEL NFB
AMPS ADJUST CONTROL
SET AT 2.5 AMPS
LEAVE THIS
OUTPUT
SWITCH ON
8 AMP. FUSE
ON
OFF
POSITIVE
NEGATIVE
TURN OFF BATTERY CHARGER BEFORE
03/05/2008


03/05/2008


START
PULL TO STOP
03/05/2008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ATTACHMENT 3
Survey Results #08-ER-A25-185 for Survey Plan #08-028

NSTec

RADIOLOGICAL SURVEY REPORT – DATA

SURVEY # 08-ER-A25-185

Location:	Purpose:	Comments:	Date/Time:
Area 25 EMAD	Locomotive #21547 Release From Radiological Controls	Survey Plan# 08-028. Micro Rem bkgd 0.02 mr/hr. **See attached Tennelec printout	8/25/08 0700-1630

Instrument:	Serial #:	Cal Due:	Eff in %: Alpha / Beta	BKG in dpm: Alpha / Beta	MDA in dpm: Alpha / Beta		
						RWP # None	
Tennelec	70147	03/10/09	26.99/40.25	0.37/3.98	14.07/17.57	Work Package # ERFY-08-RCT-008 REV 2	
Electra	4676	07/09/09	14.6/26.1	14/2126	80/500	RCT Name: Paul Perez	Signature: [signature]
Electra	4388	04/07/09	15.7/26.2	13/2004	80/500	RCT Name: Shannon Sauers	Signature: [signature]
Micro Rem	264	02/28/09	N/A	N/A	N/A	RCT Name: N/A	Signature: N/A
N/A	N/A	N/A	N/A	N/A	N/A	RCT Name: N/A	Signature: N/A

Survey Point	Description/Comments	Removable dpm/100cm²		Fixed + Removable dpm/100cm²		Contact Gamma mrem/hr	Neutron mrem/hr	Total mrem/hr
		Alpha	Beta	Alpha	Beta			
1-20	3 each Large Lead-Acid Batteries Batch 8930	**	**	<MDA	<MDA	0.02	N/A	0.02
21-40	Cab Interior Floor Batch 8930	**	**	<MDA	<MDA	0.02	N/A	0.02
41-60	Cab Interior Ceiling Batch 8930	**	**	<MDA	800	0.02	N/A	0.02
61-80	Cab Interior Forward Controls Batch 8930	**	**	<MDA	<MDA	0.02	N/A	0.02
81-100	Cab Interior Rear Controls Batch 8930	**	**	<MDA	<MDA	0.02	N/A	0.02
N/A	Cab Interior General Area Dose is 0.02 mr/hr gamma	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Reviewed By (Print): D. Grantham Signature: [signature] Date: 9/8/08

Device: Tennelec 70147

Batch ID: Swipes - 200808251627 **Count Date:** 8/25/2008 4:27:14PM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.37	**Alpha:**	26.99	**Alpha:**	14.07	1.00 **Minutes**
Beta Rate:	3.98	**Beta:**	40.25	**Beta:**	17.57	

Results Report: Page 1 of 2 **Swipes** **Survey #** 08-ER-A25-185

Batch Key: 8930 **Device:** Tennelec 70147

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080825162714-A1	-0.37	-1.49	3 Each Large Lead acid batteries (1-20)
20080825162854-A2	-0.37	3.48	
20080825163004-A3	-0.37	8.45	
20080825163124-A4	-0.37	5.96	
20080825163244-A5	-0.37	3.48	
20080825163354-A6	-0.37	0.99	
20080825163514-A7	-0.37	3.48	
20080825163634-A8	3.33	8.45	
20080825163744-A9	-0.37	3.48	
20080825163904-A10	3.33	3.48	
20080825164024-A11	-0.37	0.99	
20080825164134-A12	-0.37	0.99	
20080825164254-A13	-0.37	-1.49	
20080825164414-A14	-0.37	3.48	
20080825164524-A15	-0.37	-3.98	
20080825164644-A16	-0.37	0.99	
20080825164804-A17	-0.37	3.48	
20080825164914-A18	-0.37	-1.49	
20080825165034-A19	-0.37	0.99	
20080825165154-A20	-0.37	0.99	
20080825165314-A21	-0.37	-1.49	Cab Interior Floor (21-40)
20080825165424-A22	3.33	-3.98	
20080825165544-A23	-0.37	0.99	
20080825165704-A24	-0.37	-3.98	
20080825165814-A25	3.33	5.96	
20080825165934-A26	-0.37	0.99	
20080825170054-A27	-0.37	-3.98	
20080825170204-A28	-0.37	8.45	
20080825170324-A29	3.33	0.99	
20080825170444-A30	-0.37	-1.49	
20080825170554-A31	-0.37	0.99	
20080825170714-A32	-0.37	0.99	
20080825170834-A33	-0.37	-3.98	
20080825170944-A34	-0.37	0.99	
20080825171104-A35	-0.37	-3.98	
20080825171224-A36	-0.37	0.99	
20080825171334-A37	-0.37	-1.49	
20080825171454-A38	-0.37	3.48	
20080825171614-A39	-0.37	-1.49	
20080825171724-A40	-0.37	-3.98	
20080825171844-A41	3.33	3.48	Cab Interior Ceiling (41-60)
20080825172004-A42	3.33	3.48	
20080825172124-A43	-0.37	3.48	
20080825172234-A44	-0.37	0.99	
20080825172354-A45	-0.37	-3.98	
20080825172514-A46	-0.37	0.99	
20080825172624-A47	-0.37	3.48	
20080825172744-A48	-0.37	3.48	
20080825172904-A49	-0.37	-3.98	
20080825173014-A50	-0.37	-1.49	

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080825173134-A51	-0.37	-1.49	
20080825173254-A52	-0.37	-1.49	
20080825173404-A53	-0.37	0.99	
20080825173524-A54	-0.37	-1.49	
20080825173644-A55	-0.37	-3.98	
20080825173754-A56	-0.37	-3.98	
20080825173914-A57	-0.37	0.99	
20080825174034-A58	-0.37	-1.49	
20080825174144-A59	-0.37	-1.49	
20080825174304-A60	-0.37	-1.49	
20080825174424-A61	-0.37	-1.49	Cab Interior FWD Controls (61-80)
20080825174544-A62	-0.37	8.45	
20080825174654-A63	-0.37	-1.49	
20080825174814-A64	-0.37	-1.49	
20080825174934-A65	-0.37	-1.49	
20080825175044-A66	-0.37	-1.49	
20080825175204-A67	-0.37	10.93	
20080825175324-A68	-0.37	3.48	
20080825175434-A69	-0.37	-3.98	
20080825175554-A70	-0.37	-3.98	
20080825175714-A71	-0.37	5.96	
20080825175824-A72	-0.37	0.99	
20080825175944-A73	3.33	3.48	
20080825180104-A74	-0.37	5.96	
20080825180214-A75	-0.37	0.99	
20080825180334-A76	-0.37	-3.98	
20080825180454-A77	-0.37	5.96	
20080825180604-A78	-0.37	3.48	
20080825180724-A79	-0.37	3.48	
20080825180844-A80	-0.37	-3.98	
20080825181004-A81	-0.37	0.99	Cab Interior Rear Controls (81-100)
20080825181114-A82	-0.37	0.99	
20080825181234-A83	3.33	0.99	
20080825181354-A84	-0.37	0.99	
20080825181504-A85	-0.37	8.45	
20080825181624-A86	-0.37	-1.49	
20080825181744-A87	-0.37	0.99	
20080825181854-A88	-0.37	20.87	
20080825182014-A89	7.04	3.48	
20080825182134-A90	-0.37	0.99	
20080825182244-A91	-0.37	0.99	
20080825182404-A92	-0.37	-1.49	
20080825182524-A93	-0.37	-3.98	
20080825182634-A94	-0.37	0.99	
20080825182754-A95	-0.37	0.99	
20080825182914-A96	-0.37	3.48	
20080825183024-A97	-0.37	-1.49	
20080825183144-A98	-0.37	0.99	
20080825183304-A99	-0.37	0.99	
20080825183424-A100	-0.37	0.99	

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RADIOLOGICAL SURVEY REPORT – DATA

SURVEY # 08-ER-A25-185

Location:	Purpose:	Comments:	Date/Time:
Area 25 EMAD	Locomotive #21547 Release From Radiological Controls	Survey Plan# 08-028. Micro Rem bkgd 0.02 mr/hr. **See attached Tennelec printout	8/26/08 0700-1630

Instrument:	Serial #:	Cal Due:	Eff in %: Alpha / Beta	BKG in dpm: Alpha / Beta	MDA in dpm: Alpha / Beta
Tennelec	70147	03/10/09	26.99/40.25	0.37/4.72	14.07/18.54
Tennelec	7842720	5/27/09	26.43/40.16	0.0/2.24	10.24/14.89
Electra	4676	7/09/09	14.6/26.1	0.0/2157	80/500
Electra	4388	4/07/09	15.7/26.2	8/2021	80/500
Micro Rem	264	02/28/09	N/A	N/A	N/A

RWP # None

Work Package # ERFY-08-RCT-008 REV 2

RCT Name: Paul Perez Signature: PAP

RCT Name: Shannon Sauers Signature: S. Sauers

RCT Name: N/A Signature: N/A

RCT Name: N/A Signature: N/A

Survey Point	Description/Comments	Removable dpm/100cm² Alpha	Removable dpm/100cm² Beta	Fixed + Removable dpm/100cm² Alpha	Fixed + Removable dpm/100cm² Beta	Contact Gamma mrem/hr	Neutron mrem/hr	Total mrem/hr
1-20	Undercarriage Front Tongue & Bumper Batch 8935	**	**	<MDA	2000	0.02	N/A	0.02
21-40	Undercarriage Chain & Front Sprocket Batch 8935	**	**	<MDA	4000	0.02	N/A	0.02
41-60	Undercarriage Front Brake Assemblies Batch 8935	**	**	<MDA	5000	0.02	N/A	0.02
61-80	Undercarriage Front Fluid Tanks Batch 8935	**	**	<MDA	<MDA	0.02	N/A	0.02
81-100	Undercarriage Front Axle & Wheel Batch 8935	**	**	<MDA	7200	0.02	N/A	0.02
1-20	Undercarriage Rear Deck, Tank, Bumper Batch 4534	**	**	<MDA	<MDA	0.02	N/A	0.02
21-40	Undercarriage Electric Motor Batch 4534	**	**	<MDA	<MDA	0.02	N/A	0.02
41-60	Undercarriage Middle Deck Batch 4534	**	**	<MDA	<MDA	0.02	N/A	0.02
61-80	Undercarriage Rear Brake Assembly Batch 4534	**	**	<MDA	<MDA	0.02	N/A	0.02
81-100	Undercarriage Rear Wheels, Axle, Sprocket Batch 4534	**	**	<MDA	<MDA	0.02	N/A	0.02
1-20	Train Exterior, Left Side Batch 4535	**	**	<MDA	<MDA	0.02	N/A	0.02
21-40	Train Exterior, Front Batch 4535	**	**	<MDA	<MDA	0.02	N/A	0.02
41-60	Train Exterior, Right Side Batch 4535	**	**	<MDA	<MDA	0.02	N/A	0.02
61-80	Train Exterior, Rear & Roof Batch 4535	**	**	<MDA	<MDA	0.02	N/A	0.02
81-90	Front Coupler Batch 4535	**	**	<MDA	7000	0.02	N/A	0.02
91-100	Rear Coupler Batch 4535	**	**	<MDA	<MDA	0.02	N/A	0.02

Reviewed By (Print): D. Fountain Signature: Date: 9/8/08

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RADIOLOGICAL SURVEY REPORT – DATA (CONTINUATION)

SURVEY # 08-ER-A25-185

Survey Point	Description/Comments	Removable dpm/100cm²		Fixed + Removable dpm/100cm²		Gamma mrem/hr	Neutron mrem/hr	Total mrem/hr
		Alpha	Beta	Alpha	Beta			
1-60	Cab Interior Walls Batch 8937	**	**	<MDA	<MDA	0.02	N/A	0.02
61-80	Cab Interior Electrical Cabinet Batch 8937	**	**	<MDA	<MDA	0.02	N/A	0.02
81-100	Exterior RT Front Platform & Inspection Port (under lid) Batch 8937	**	**	<MDA	10,800	0.02	N/A	0.02
101-109	Exterior LT Front Platform Batch 8937	**	**	<MDA	<MDA	0.02	N/A	0.02
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Device: Tennelec 70147

Batch ID: Swipes - 200808260644 **Count Date:** 8/26/2008 6:44:09AM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.37	**Alpha:**	26.99	**Alpha:**	14.07	1.00 **Minutes**
Beta Rate:	4.72	**Beta:**	40.25	**Beta:**	18.54	

Results Report: Page 1 of 2 **Swipes**

Batch Key: 8935 **Device:** Tennelec 70147 **Survey #** 08-ER-A25-185

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826064409-A1	-0.37	5.22	Undercarriage, Front Tongue and Bumper (1-20)
20080826064550-A2	-0.37	0.25	
20080826064700-A3	3.33	-4.72	
20080826064820-A4	-0.37	7.70	
20080826064940-A5	-0.37	0.25	
20080826065050-A6	-0.37	-2.24	
20080826065210-A7	-0.37	-2.24	
20080826065330-A8	-0.37	-2.24	
20080826065440-A9	3.33	0.25	
20080826065600-A10	3.33	0.25	
20080826065720-A11	-0.37	-2.24	
20080826065830-A12	-0.37	-4.72	
20080826065950-A13	-0.37	0.25	
20080826070110-A14	-0.37	-2.24	
20080826070220-A15	-0.37	2.73	
20080826070340-A16	-0.37	5.22	
20080826070500-A17	-0.37	0.25	
20080826070610-A18	3.33	-2.24	
20080826070730-A19	-0.37	-2.24	
20080826070850-A20	3.33	0.25	
20080826071010-A21	-0.37	-4.72	Undercarriage, Drive Chain and Sprockets (21-40)
20080826071120-A22	-0.37	-2.24	
20080826071240-A23	3.33	0.25	
20080826071400-A24	-0.37	7.70	
20080826071510-A25	-0.37	-2.24	
20080826071630-A26	3.33	0.25	
20080826071750-A27	-0.37	0.25	
20080826071900-A28	-0.37	-4.72	
20080826072020-A29	-0.37	0.25	
20080826072140-A30	3.33	0.25	
20080826072250-A31	3.33	2.73	
20080826072410-A32	-0.37	5.22	
20080826072530-A33	-0.37	0.25	
20080826072640-A34	-0.37	0.25	
20080826072800-A35	-0.37	5.22	
20080826072920-A36	3.33	-2.24	
20080826073040-A37	-0.37	2.73	
20080826073150-A38	3.33	20.12	
20080826073310-A39	3.33	5.22	
20080826073430-A40	-0.37	-4.72	
20080826073540-A41	-0.37	12.67	Undercarriage, Front Brake Assemblies, Front Deck (41-60)
20080826073700-A42	-0.37	15.16	
20080826073820-A43	-0.37	0.25	
20080826073930-A44	3.33	2.73	
20080826074050-A45	-0.37	0.25	
20080826074210-A46	-0.37	5.22	
20080826074320-A47	-0.37	0.25	
20080826074440-A48	-0.37	7.70	
20080826074600-A49	-0.37	-2.24	
20080826074720-A50	-0.37	0.25	

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826074830-A51	-0.37	0.25	
20080826074950-A52	7.04	5.22	
20080826075110-A53	7.04	0.25	
20080826075220-A54	-0.37	5.22	
20080826075340-A55	-0.37	-2.24	
20080826075500-A56	-0.37	5.22	
20080826075610-A57	-0.37	0.25	
20080826075730-A58	3.33	7.70	
20080826075850-A59	-0.37	0.25	
20080826080000-A60	-0.37	-4.72	
20080826080120-A61	-0.37	0.25	Undercarriage, Front Fluid Tanks (61-80)
20080826080240-A62	-0.37	2.73	
20080826080400-A63	-0.37	12.67	
20080826080510-A64	-0.37	7.70	
20080826080630-A65	-0.37	2.73	
20080826080750-A66	-0.37	0.25	
20080826080900-A67	3.33	0.25	
20080826081020-A68	-0.37	-2.24	
20080826081140-A69	3.33	0.25	
20080826081250-A70	3.33	2.73	
20080826081410-A71	-0.37	7.70	
20080826081530-A72	-0.37	0.25	
20080826081640-A73	-0.37	2.73	
20080826081800-A74	-0.37	-2.24	
20080826081920-A75	-0.37	2.73	
20080826082030-A76	-0.37	2.73	
20080826082150-A77	-0.37	5.22	
20080826082310-A78	-0.37	2.73	
20080826082430-A79	-0.37	2.73	
20080826082540-A80	-0.37	-4.72	
20080826082700-A81	-0.37	2.73	Undercarriage, Front Wheel Assembly and Axle (81-100)
20080826082820-A82	-0.37	0.25	
20080826082930-A83	3.33	-2.24	
20080826083050-A84	7.04	7.70	
20080826083210-A85	3.33	0.25	
20080826083320-A86	-0.37	2.73	
20080826083440-A87	-0.37	-2.24	
20080826083600-A88	-0.37	7.70	
20080826083710-A89	-0.37	0.25	
20080826083830-A90	-0.37	-4.72	
20080826083950-A91	-0.37	-4.72	
20080826084100-A92	-0.37	5.22	
20080826084220-A93	-0.37	-2.24	
20080826084340-A94	-0.37	7.70	
20080826084450-A95	3.33	10.19	
20080826084610-A96	-0.37	2.73	
20080826084730-A97	-0.37	5.22	
20080826084850-A98	3.33	-2.24	
20080826085000-A99	-0.37	2.73	
20080826085120-A100	-0.37	0.25	

Device: SMS ID: 7842720

Batch ID: Swipes - 200808261342 **Count Date:** 8/26/2008 1:42:27PM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.00	**Alpha:**	26.43	**Alpha:**	10.24	1.00 **Minutes**
Beta Rate:	2.24	**Beta:**	40.16	**Beta:**	14.89	

Results Report: Page 1 of 2

Swipes

Batch Key: 4534 **Device:** SMS ID: 7842720 **Survey #** 08-ER-A25-185

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826134227-A1	0	5.23	Rear Deck , Fluid Tank, Bumper Undercarriage (1-20)
20080826134528-A2	3.78	0.25	
20080826134638-A3	3.78	-2.24	
20080826134758-A4	3.78	10.21	
20080826134908-A5	0	0.25	
20080826135018-A6	7.57	0.25	
20080826135128-A7	0	10.21	
20080826135248-A8	0	0.25	
20080826135358-A9	0	-2.24	
20080826135508-A10	3.78	2.74	
20080826135628-A11	0	2.74	
20080826135738-A12	0	0.25	
20080826135848-A13	0	5.23	
20080826140008-A14	3.78	7.72	
20080826140118-A15	7.57	5.23	
20080826140228-A16	0	2.74	
20080826140338-A17	0	2.74	
20080826140458-A18	0	7.72	
20080826140608-A19	0	7.72	
20080826140718-A20	0	0.25	
20080826140838-A21	0	2.74	Electric Motor (21-40)
20080826140948-A22	0	-2.24	
20080826141058-A23	0	5.23	
20080826141208-A24	0	2.74	
20080826141328-A25	0	0.25	
20080826141438-A26	0	2.74	
20080826141548-A27	3.78	10.21	
20080826141708-A28	0	0.25	
20080826141818-A29	3.78	2.74	
20080826141928-A30	0	0.25	
20080826142048-A31	0	2.74	
20080826142158-A32	0	2.74	
20080826142308-A33	0	0.25	
20080826142418-A34	3.78	7.72	
20080826142538-A35	0	2.74	
20080826142648-A36	0	-2.24	
20080826142758-A37	3.78	2.74	
20080826142918-A38	0	-2.24	
20080826143028-A39	0	2.74	
20080826143138-A40	0	10.21	
20080826143248-A41	3.78	5.23	Middle of Train Deck Bottom, Undercarriage (41-60)
20080826143408-A42	0	0.25	
20080826143518-A43	0	0.25	
20080826143628-A44	0	0.25	
20080826143748-A45	0	2.74	
20080826143858-A46	0	2.74	
20080826144008-A47	0	2.74	
20080826144118-A48	0	2.74	
20080826144238-A49	3.78	0.25	
20080826144348-A50	0	0.25	
20080826144458-A51	0	2.74	
20080826144618-A52	0	0.25	
20080826144728-A53	0	2.74	

Batch Key: 4534 **Device:**SMS ID: 7842720 08-ER-A25-185

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826144838-A54	0	2.74	
20080826144948-A55	3.78	7.72	
20080826145108-A56	0	0.25	
20080826145218-A57	0	-2.24	
20080826145328-A58	0	2.74	
20080826145448-A59	0	-2.24	
20080826145558-A60	3.78	2.74	
20080826145708-A61	0	0.25	Rear Brake Assemblies (61-80)
20080826145818-A62	0	-2.24	
20080826145938-A63	0	5.23	
20080826150048-A64	0	0.25	
20080826150158-A65	0	2.74	
20080826150318-A66	0	-2.24	
20080826150428-A67	0	-2.24	
20080826150538-A68	0	5.23	
20080826150658-A69	3.78	0.25	
20080826150808-A70	0	2.74	
20080826150918-A71	3.78	0.25	
20080826151028-A72	0	0.25	
20080826151148-A73	0	5.23	
20080826151258-A74	0	0.25	
20080826151408-A75	0	2.74	
20080826151528-A76	0	2.74	
20080826151638-A77	0	5.23	
20080826151748-A78	0	-2.24	
20080826151858-A79	0	0.25	
20080826152018-A80	0	2.74	
20080826152128-A81	0	-2.24	Rear Wheels, Axel, Drive Sprocket, Undercarriage (81-100)
20080826152238-A82	0	2.74	
20080826152358-A83	0	0.25	
20080826152508-A84	0	0.25	
20080826152618-A85	0	0.25	
20080826152738-A86	0	0.25	
20080826152848-A87	0	-2.24	
20080826152958-A88	3.78	10.21	
20080826153108-A89	0	5.23	
20080826153229-A90	0	5.23	
20080826153338-A91	0	2.74	
20080826153448-A92	0	-2.24	
20080826153559-A93	0	0.25	
20080826153718-A94	0	-2.24	
20080826153828-A95	0	-2.24	
20080826153938-A96	3.78	2.74	
20080826154058-A97	0	0.25	
20080826154208-A98	0	7.72	
20080826154318-A99	0	2.74	
20080826154438-A100	0	0.25	

Device: SMS ID: 7842720

Batch ID: Swipes - 200808261549 **Count Date:** 8/26/2008 3:49:27PM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.00	**Alpha:**	26.43	**Alpha:**	10.24	1.00 **Minutes**
Beta Rate:	2.24	**Beta:**	40.16	**Beta:**	14.89	

Results Report: Page 1 of 2

Swipes

Batch Key: 4535 **Device:** SMS ID: 7842720 **Survey #** 08-ER-A25-185

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826154927-A1	3.78	2.74	Train Exterior, Left Side (1-20)
20080826155058-A2	0	-2.24	
20080826155208-A3	0	-2.24	
20080826155328-A4	0	-2.24	
20080826155438-A5	0	0.25	
20080826155548-A6	0	0.25	
20080826155708-A7	0	2.74	
20080826155818-A8	3.78	12.70	
20080826155928-A9	0	2.74	
20080826160038-A10	0	0.25	
20080826160158-A11	0	0.25	
20080826160308-A12	0	5.23	
20080826160418-A13	3.78	5.23	
20080826160538-A14	3.78	-2.24	
20080826160648-A15	3.78	2.74	
20080826160758-A16	0	7.72	
20080826160908-A17	3.78	0.25	
20080826161028-A18	0	-2.24	
20080826161138-A19	0	10.21	
20080826161248-A20	0	7.72	PAP 8/26/08
20080826161408-A21	0	-2.24	Train Exterior, Front ~~and Coupler~~ (21-40)
20080826161518-A22	0	2.74	
20080826161628-A23	0	7.72	
20080826161748-A24	0	0.25	
20080826161858-A25	0	5.23	
20080826162008-A26	0	-2.24	
20080826162118-A27	0	2.74	
20080826162238-A28	0	0.25	
20080826162348-A29	0	-2.24	
20080826162458-A30	0	0.25	
20080826162618-A31	0	2.74	
20080826162728-A32	0	-2.24	
20080826162838-A33	0	2.74	
20080826162948-A34	0	0.25	
20080826163108-A35	0	2.74	
20080826163218-A36	0	-2.24	
20080826163328-A37	0	0.25	
20080826163448-A38	3.78	-2.24	
20080826163558-A39	0	0.25	
20080826163708-A40	3.78	2.74	
20080826163828-A41	0	2.74	Train Exterior, Right Side (41-60)
20080826163938-A42	0	2.74	
20080826164048-A43	0	0.25	
20080826164158-A44	0	0.25	
20080826164318-A45	0	2.74	
20080826164428-A46	0	5.23	
20080826164538-A47	0	5.23	
20080826164658-A48	3.78	7.72	
20080826164808-A49	3.78	0.25	
20080826164918-A50	0	0.25	
20080826165028-A51	0	-2.24	
20080826165148-A52	0	0.25	
20080826165258-A53	0	2.74	

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826165408-A54	0	-2.24	
20080826165528-A55	0	-2.24	
20080826165638-A56	0	0.25	
20080826165748-A57	0	0.25	
20080826165908-A58	0	-2.24	
20080826170018-A59	0	5.23	
20080826170128-A60	3.78	10.21	
20080826170238-A61	3.78	7.72	Train Exterior, Rear and Roof (61-80)
20080826170358-A62	0	5.23	
20080826170508-A63	0	2.74	
20080826170618-A64	0	0.25	
20080826170738-A65	3.78	0.25	
20080826170848-A66	3.78	7.72	
20080826170958-A67	0	2.74	
20080826171108-A68	11.35	2.74	
20080826171228-A69	3.78	17.68	
20080826171338-A70	0	5.23	
20080826171448-A71	0	0.25	
20080826171608-A72	3.78	0.25	
20080826171718-A73	0	7.72	
20080826171828-A74	7.57	0.25	
20080826171948-A75	0	-2.24	
20080826172058-A76	0	5.23	
20080826172208-A77	0	0.25	
20080826172318-A78	0	0.25	
20080826172438-A79	0	2.74	
20080826172548-A80	0	2.74	
20080826172658-A81	11.35	0.25	Front Coupler (81-90)
20080826172818-A82	3.78	-2.24	
20080826172928-A83	0	0.25	
20080826173038-A84	0	0.25	
20080826173148-A85	0	5.23	
20080826173308-A86	0	5.23	
20080826173418-A87	0	2.74	
20080826173528-A88	0	-2.24	
20080826173648-A89	3.78	2.74	
20080826173758-A90	0	10.21	
20080826173908-A91	3.78	0.25	Rear Coupler (91-100)
20080826174028-A92	0	5.23	
20080826174138-A93	0	2.74	
20080826174248-A94	3.78	0.25	
20080826174358-A95	0	0.25	
20080826174518-A96	3.78	-2.24	
20080826174628-A97	3.78	0.25	
20080826174738-A98	0	10.21	
20080826174858-A99	0	0.25	
20080826175008-A100	0	2.74	

Device: Tennelec 70147

Batch ID: Swipes - 200808261327

Count Date: 8/26/2008 1:27:38PM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.37	**Alpha:**	26.99	**Alpha:**	14.07	1.00 **Minutes**
Beta Rate:	4.72	**Beta:**	40.25	**Beta:**	18.54	

Results Report: Page 1 of 3

Swipes

Batch Key: 8937

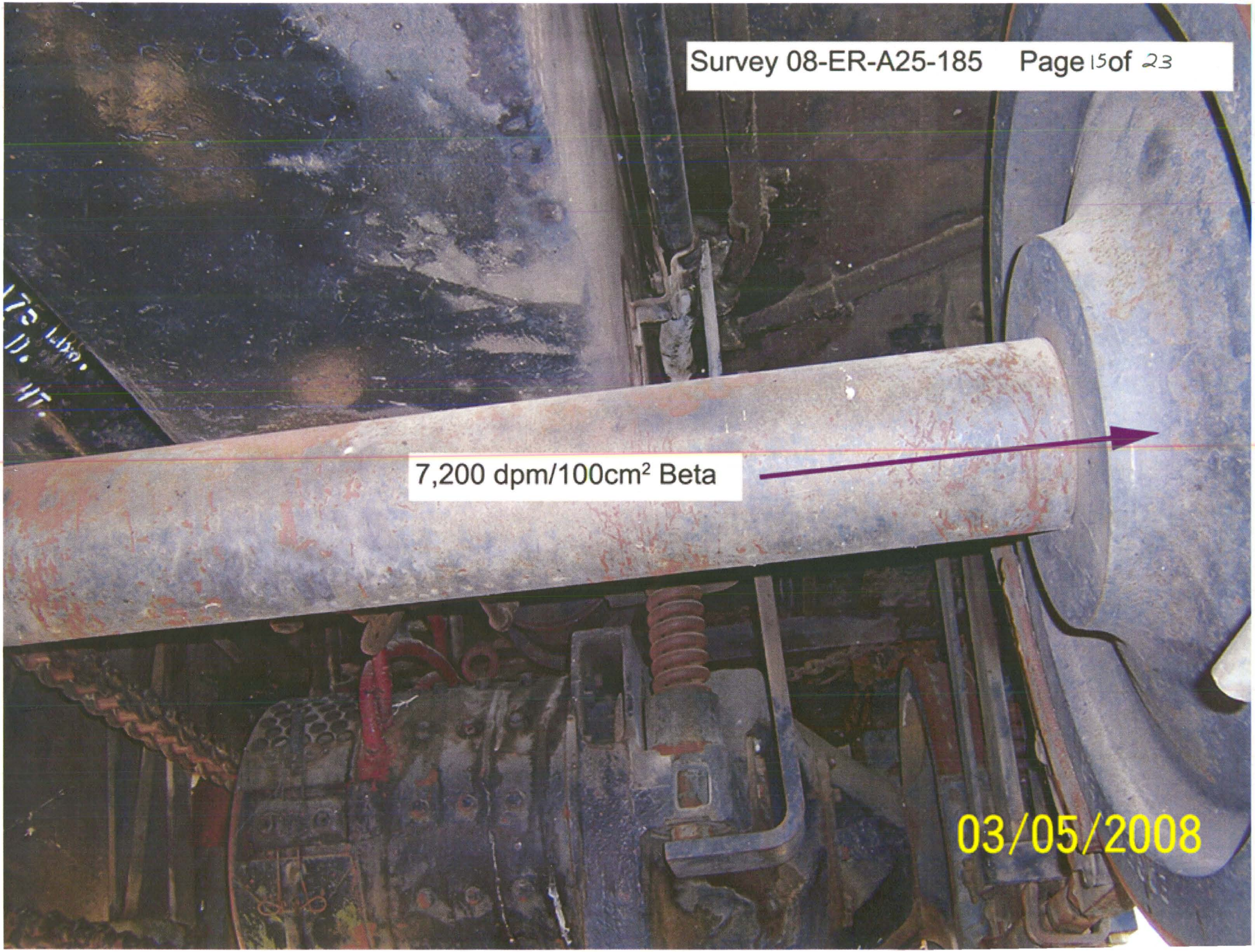
Device: Tennelec 70147

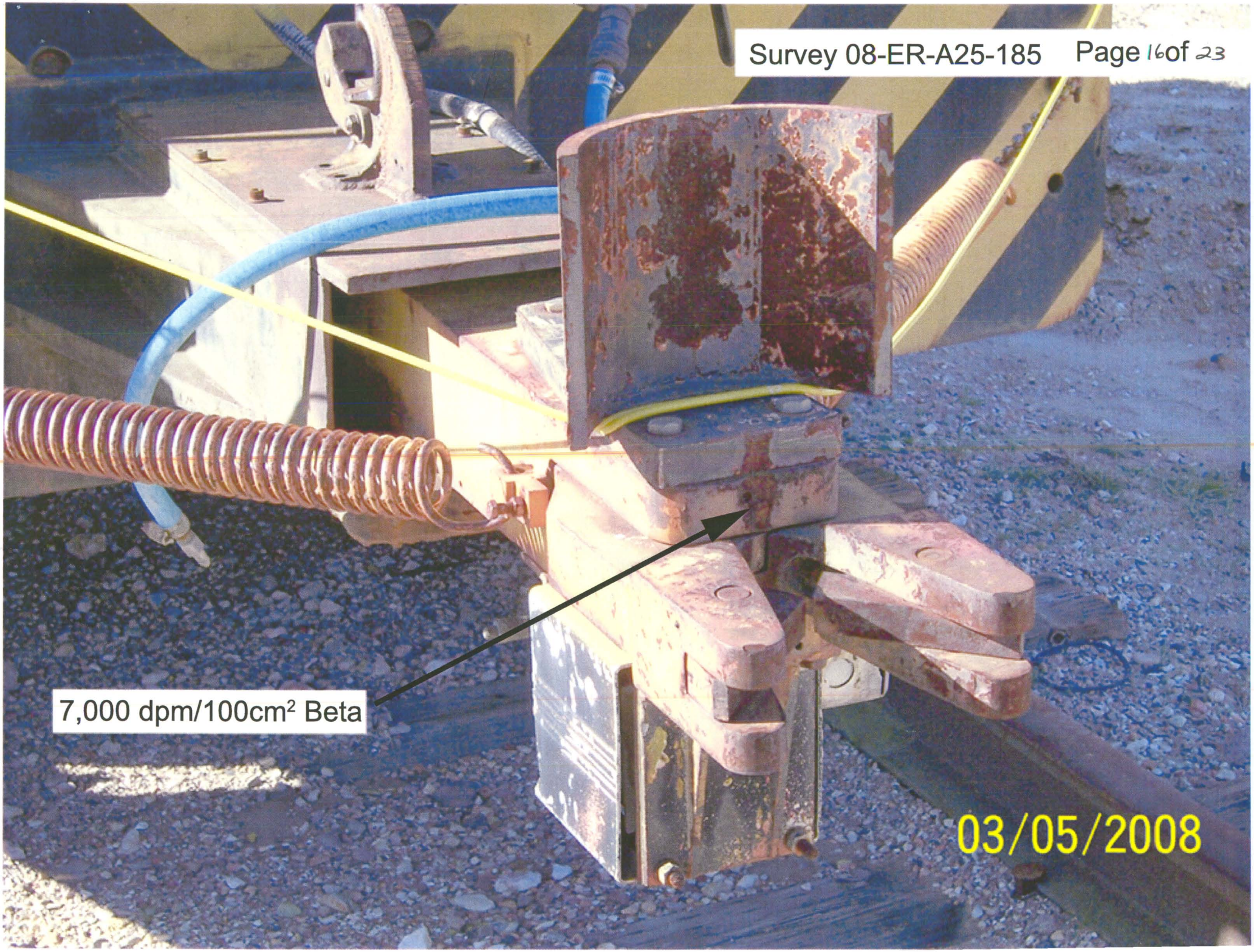
Survey # 08-ER-A25-185

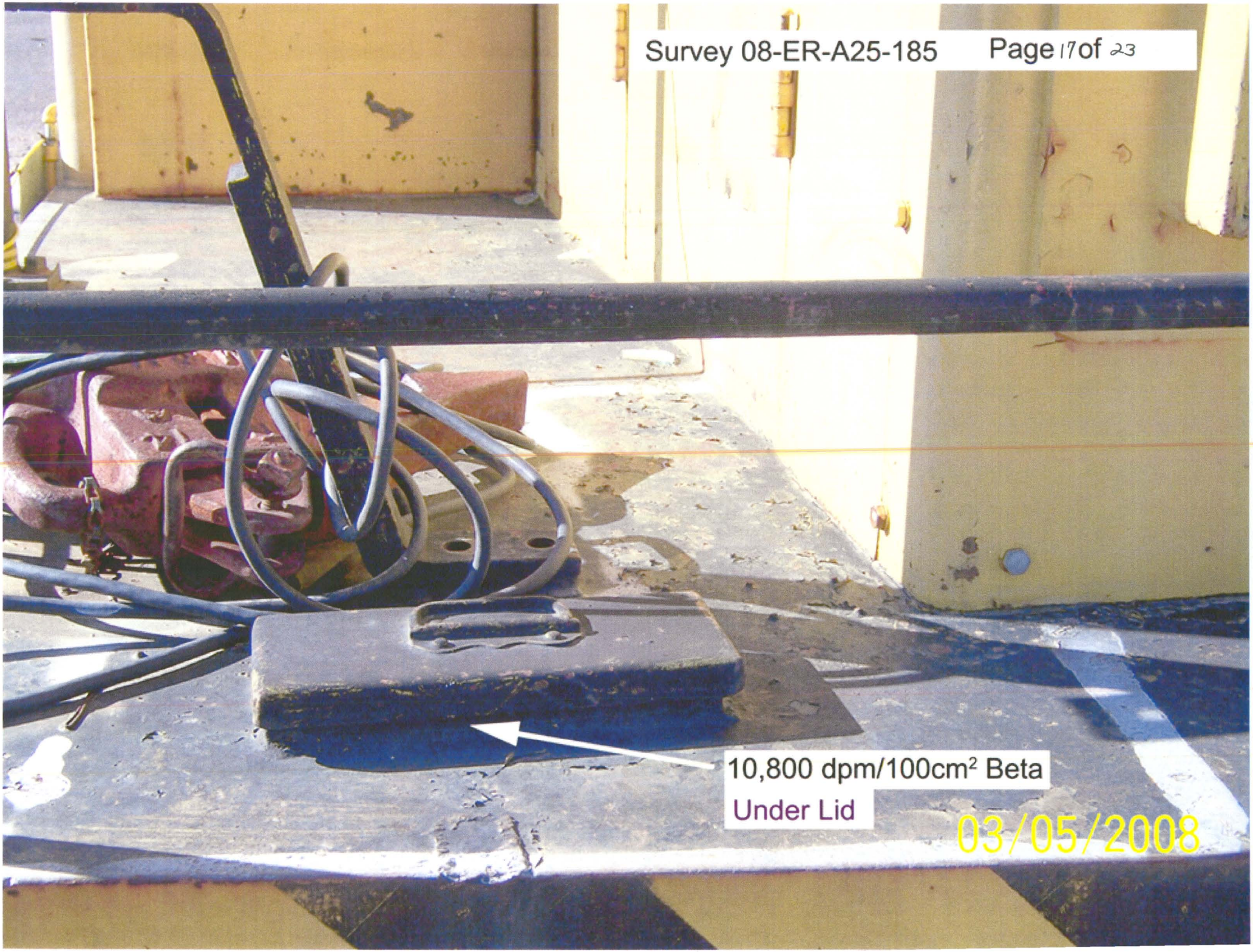
Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826132738-A1	-0.37	2.73	Cab Interior walls (1-60)
20080826133039-A2	-0.37	5.22	
20080826133159-A3	3.33	0.25	
20080826133319-A4	-0.37	-2.24	
20080826133439-A5	-0.37	0.25	
20080826133549-A6	3.33	0.25	
20080826133709-A7	-0.37	-2.24	
20080826133829-A8	-0.37	-4.72	
20080826133939-A9	-0.37	5.22	
20080826134059-A10	-0.37	-4.72	
20080826134219-A11	-0.37	0.25	
20080826134329-A12	-0.37	0.25	
20080826134449-A13	-0.37	-2.24	
20080826134609-A14	-0.37	-4.72	
20080826134719-A15	-0.37	-2.24	
20080826134839-A16	-0.37	-2.24	
20080826134959-A17	-0.37	5.22	
20080826135109-A18	10.74	2.73	
20080826135229-A19	-0.37	0.25	
20080826135349-A20	-0.37	0.25	
20080826135459-A21	-0.37	-2.24	
20080826135619-A22	-0.37	-2.24	
20080826135739-A23	-0.37	-4.72	
20080826135859-A24	-0.37	-2.24	
20080826140009-A25	-0.37	-2.24	
20080826140129-A26	3.33	2.73	
20080826140249-A27	-0.37	5.22	
20080826140359-A28	-0.37	2.73	
20080826140519-A29	-0.37	0.25	
20080826140639-A30	-0.37	-4.72	
20080826140749-A31	-0.37	0.25	
20080826140909-A32	-0.37	2.73	
20080826141029-A33	-0.37	0.25	
20080826141139-A34	-0.37	0.25	
20080826141259-A35	-0.37	0.25	
20080826141419-A36	3.33	0.25	
20080826141529-A37	-0.37	0.25	
20080826141649-A38	-0.37	0.25	
20080826141809-A39	-0.37	2.73	
20080826141919-A40	-0.37	-4.72	
20080826142039-A41	3.33	7.70	
20080826142159-A42	3.33	0.25	
20080826142319-A43	-0.37	-2.24	
20080826142429-A44	-0.37	0.25	
20080826142549-A45	-0.37	-2.24	
20080826142709-A46	3.33	0.25	
20080826142819-A47	-0.37	-2.24	
20080826142939-A48	3.33	0.25	
20080826143059-A49	-0.37	2.73	
20080826143209-A50	-0.37	2.73	

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826143329-A51	-0.37	5.22	
20080826143449-A52	-0.37	-4.72	
20080826143559-A53	-0.37	5.22	
20080826143719-A54	3.33	-2.24	
20080826143839-A55	3.33	5.22	
20080826143949-A56	-0.37	0.25	
20080826144109-A57	-0.37	5.22	
20080826144229-A58	-0.37	7.70	
20080826144339-A59	-0.37	2.73	
20080826144459-A60	-0.37	2.73	
20080826144619-A61	-0.37	-2.24	Cab Interior Electrical Cabinet (61-80)
20080826144739-A62	3.33	5.22	
20080826144849-A63	-0.37	2.73	
20080826145009-A64	-0.37	-2.24	
20080826145129-A65	-0.37	10.19	
20080826145239-A66	-0.37	-4.72	
20080826145359-A67	-0.37	5.22	
20080826145519-A68	-0.37	-2.24	
20080826145629-A69	-0.37	2.73	
20080826145749-A70	-0.37	-2.24	
20080826145909-A71	-0.37	-2.24	
20080826150019-A72	-0.37	0.25	
20080826150139-A73	-0.37	-2.24	
20080826150259-A74	-0.37	0.25	
20080826150409-A75	-0.37	0.25	
20080826150529-A76	-0.37	0.25	
20080826150649-A77	-0.37	5.22	
20080826150759-A78	-0.37	2.73	
20080826150919-A79	-0.37	-2.24	
20080826151039-A80	-0.37	0.25	
20080826151159-A81	-0.37	5.22	Right Front Platform and Inspection Ports (81-100)
20080826151309-A82	-0.37	0.25	
20080826151429-A83	-0.37	-2.24	
20080826151549-A84	-0.37	2.73	
20080826151659-A85	-0.37	2.73	
20080826151819-A86	-0.37	0.25	
20080826151939-A87	-0.37	-4.72	
20080826152049-A88	-0.37	-2.24	
20080826152209-A89	3.33	0.25	
20080826152329-A90	-0.37	-4.72	
20080826152439-A91	-0.37	2.73	
20080826152559-A92	-0.37	-2.24	
20080826152719-A93	-0.37	-2.24	
20080826152839-A94	-0.37	0.25	
20080826152949-A95	-0.37	0.25	
20080826153109-A96	-0.37	-2.24	
20080826153229-A97	-0.37	5.22	
20080826153339-A98	-0.37	-2.24	
20080826153459-A99	3.33	0.25	
20080826153619-A100	-0.37	2.73	
20080826153729-A1	-0.37	7.70	Left Front Platform (101-109)
20080826153849-A2	-0.37	5.22	
20080826154009-A3	3.33	2.73	
20080826154119-A4	-0.37	-2.24	
20080826154239-A5	3.33	-4.72	
20080826154359-A6	-0.37	-4.72	
20080826154509-A7	-0.37	-4.72	
20080826154629-A8	-0.37	-4.72	

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080826154749-A9	-0.37	5.22	


7,200 dpm/100cm² Beta
03/05/2008


7,000 dpm/100cm² Beta
03/05/2008


10,800 dpm/100cm² Beta
Under Lid
03/05/2008

NSTec

RADIOLOGICAL SURVEY REPORT – DATA

SURVEY # 08-ER-A25-185

Location: Area 25 EMAD	Purpose: Locomotive #21547 Release From Radiological Controls	Comments: Survey Plan# 08-028. Micro Rem bkgd 0.02 mr/hr. **See attached Tennelec printout	Date/Time: 8/27/08 0700-1630

Instrument:	Serial #:	Cal Due:	Eff in %: Alpha / Beta	BKG in dpm: Alpha / Beta	MDA in dpm: Alpha / Beta		
						RWP # None	
Tennelec	70147	03/10/09	26.99/40.25	0.37/3.98	14.07/17.57	Work Package # ERFY-08-RCT-008 REV 2	
Electra	1694	7/03/09	15.1/26.8	4/2151	80/500	RCT Name: Paul Perez	Signature: PAPerez
Electra	2136	7/17/09	13.7/23.8	0/2138	80/500	RCT Name: Shannon Sauers	Signature: S. Sauers
Micro Rem	264	02/28/09	N/A	N/A	N/A	RCT Name: N/A	Signature: N/A
N/A	N/A	N/A	N/A	N/A	N/A	RCT Name: N/A	Signature: N/A

Survey Point	Description/Comments	Removable dpm/100cm²		Fixed + Removable dpm/100cm²		Contact Gamma mrem/hr	Neutron mrem/hr	Total mrem/hr
		Alpha	Beta	Alpha	Beta			
10-20	Train Exterior LT Front Platform Inspection Port (under lid) Batch 8943	**	**	<MDA	21,800	0.02	N/A	0.02
1-20	Engine Compartment RT Side Batch 8944	**	**	<MDA	2,500	0.02	N/A	0.02
21-40	Engine Compartment LT Side Batch8944	**	**	<MDA	<MDA	0.02	N/A	0.02
41-44	Engine Compartment RT Upper Inside Lip Batch 8944	**	**	<MDA	11,100	0.02	N/A	0.02
45-48	Engine Compartment LT Upper Inside Lip Batch 8944	**	**	<MDA	6,800	0.02	N/A	0.02
49	Swipe Prep Area	**	**	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Reviewed By (Print): D. Frentto	Signature: [signature]	Date: 9/8/08

Device: Tennelec 70147

Batch ID: Swipes - 200808270634 **Count Date:** 8/27/2008 6:34:37AM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.37	**Alpha:**	26.99	**Alpha:**	14.07	1.00 **Minutes**
Beta Rate:	3.98	**Beta:**	40.25	**Beta:**	17.57	

Results Report: Page 1 of 1

Swipes

Batch Key: 8943 **Device:** Tennelec 70147

Survey # 08-ER-A25-185

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080827063437-A10	-0.37	3.48	Exterior LT Platform Inspection Port (10-20)
20080827063618-A11	-0.37	0.99	
20080827063728-A12	-0.37	3.48	
20080827063848-A13	3.33	5.96	
20080827064008-A14	-0.37	0.99	
20080827064118-A15	-0.37	0.99	
20080827064238-A16	-0.37	-1.49	
20080827064358-A17	-0.37	0.99	
20080827064508-A18	-0.37	-1.49	
20080827064628-A19	-0.37	-1.49	
20080827064748-A20	-0.37	-1.49	

Device: Tennelec 70147

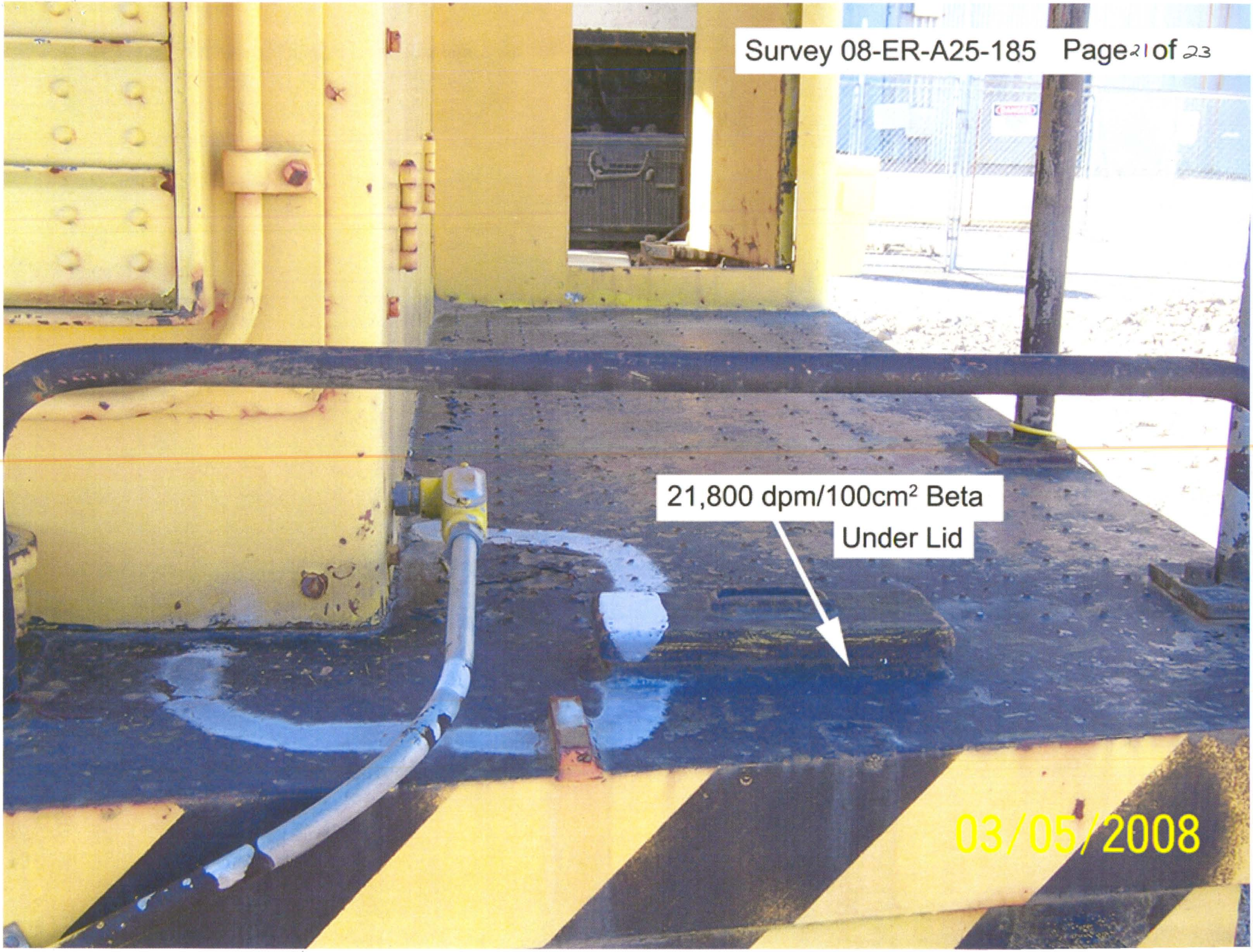
Batch ID: Swipes - 200808270726 **Count Date:** 8/27/2008 7:26:22AM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.37	**Alpha:**	26.99	**Alpha:**	14.07	1.00 **Minutes**
Beta Rate:	3.98	**Beta:**	40.25	**Beta:**	17.57	

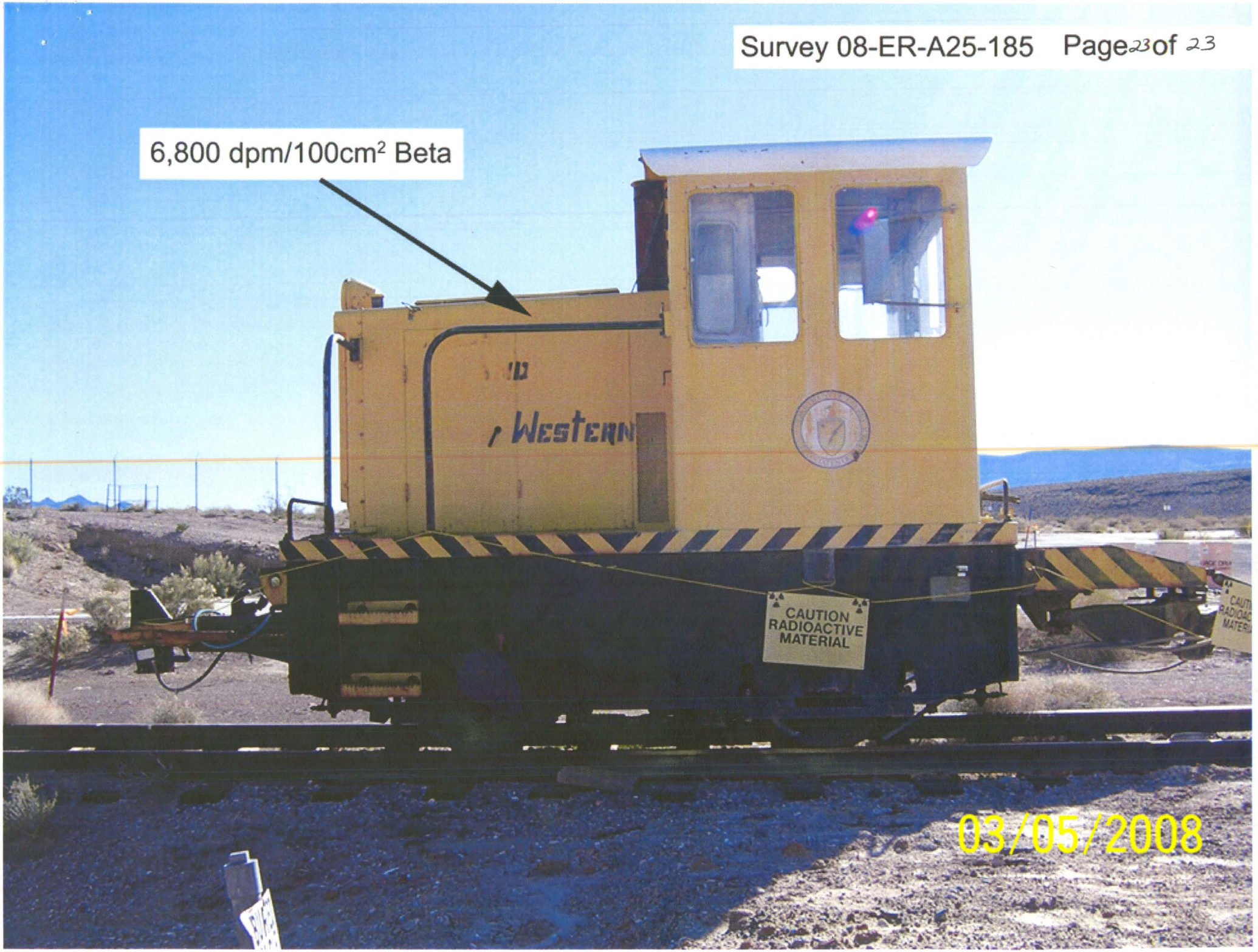
Results Report: Page 1 of 1 **Swipes**

Batch Key: 8944 **Device:** Tennelec 70147 **Survey #** 08-ER-A25-185

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
20080827072622-A1	-0.37	5.96	Eng Compartment Rt Side (1-20)
20080827072923-A2	-0.37	-1.49	
20080827073043-A3	-0.37	0.99	
20080827073203-A4	-0.37	0.99	
20080827073323-A5	-0.37	0.99	
20080827073433-A6	3.33	0.99	
20080827073553-A7	-0.37	0.99	
20080827073703-A8	-0.37	3.48	
20080827073823-A9	-0.37	-1.49	
20080827073943-A10	-0.37	0.99	
20080827074103-A11	-0.37	0.99	
20080827074213-A12	-0.37	-1.49	
20080827074333-A13	-0.37	-3.98	
20080827074453-A14	-0.37	3.48	
20080827074603-A15	-0.37	3.48	
20080827074723-A16	3.33	-1.49	
20080827074843-A17	-0.37	-1.49	
20080827075003-A18	-0.37	5.96	
20080827075113-A19	-0.37	0.99	
20080827075233-A20	-0.37	8.45	
20080827075353-A21	3.33	-1.49	Eng Compartment LT Side (21-40)
20080827075503-A22	3.33	-1.49	
20080827075623-A23	-0.37	0.99	
20080827075743-A24	-0.37	5.96	
20080827075853-A25	-0.37	0.99	
20080827080013-A26	3.33	-1.49	
20080827080133-A27	-0.37	3.48	
20080827080243-A28	-0.37	0.99	
20080827080403-A29	3.33	5.96	
20080827080523-A30	3.33	10.93	
20080827080633-A31	-0.37	-1.49	
20080827080753-A32	-0.37	5.96	
20080827080913-A33	-0.37	3.48	
20080827081023-A34	3.33	-1.49	
20080827081143-A35	-0.37	-3.98	
20080827081303-A36	-0.37	0.99	
20080827081423-A37	-0.37	-1.49	
20080827081533-A38	-0.37	5.96	
20080827081653-A39	3.33	8.45	
20080827081813-A40	3.33	0.99	
20080827081923-A41	-0.37	-3.98	RT Upper Insde Lip (41-44)
20080827082043-A42	3.33	-1.49	
20080827082203-A43	-0.37	3.48	
20080827082313-A44	-0.37	-3.98	
20080827082433-A45	-0.37	0.99	LT Upper Inside Lip (45-58)
20080827082553-A46	7.04	0.99	
20080827082703-A47	-0.37	-1.49	
20080827082823-A48	-0.37	-3.98	
20080827082943-A49	3.33	10.93	Swipe Prep Area


21,800 dpm/100cm² Beta
Under Lid
03/05/2008


Survey 08-ER-A25-185 Page 22 of 23
11,100 dpm/100cm² Beta
CAUTION RADIOACTIVE MATERIAL
CAUTION RADIOACTIVE MATERIAL
03/05/2008


6,800 dpm/100cm² Beta
Western
CAUTION
RADIOACTIVE
MATERIAL
03/05/2008

ATTACHMENT 4
Survey Plan #09-037, "Post Remediation Survey requirements for the 25 Ton Locomotive at the Engine Maintenance, Assembly and Disassembly (EMAD) Rail Yard Serial Number 21547"

National Security Technologies LLC
Vision • Service • Partnership

Radiological Operations
Survey Plan

Post Remediation Survey requirements for the 25 Ton Locomotive at the Engine Maintenance, Assembly and Disassembly (EMAD) Rail Yard Serial Number 21547

09-037

January 14, 2010

Prepared by: _____ 1/14/10
Douglas E. Frenette, Health Physics Supervisor — Date

Reviewed by: _____ 1/14/2010
Jeremy Gwin, Radiological Engineer — Date

Approved by: _____ 1-14-10
Robert L. Stueckrath, EM Radiological Operations Manager — Date

I. Purpose

This plan is to provide Radiological Control Technicians (RCTs) with the survey criteria required to provide an unrestricted release of the 25 Ton Locomotive, Serial Number 21547.

II. Scope

This plan pertains to the small 25 Ton Locomotive, Serial Number 21547, located in the Area 25 Engine Maintenance, Assembly and Disassembly (EMAD) rail yard.

III. History

The small locomotive was used to move railcars in support of the nuclear rocket/jet engine programs. It is listed at 25 tons and has ***not*** been enhanced with added shielding. It is a diesel/electric locomotive with an electric motor mounted in the undercarriage. The locomotive utilizes a drive chain to link the motor to the drive wheels.

Testimony states that it was used to move flat and test cars into position and not for test articles or contaminated equipment. The low traction and poor braking made it undesirable for that type of work. However, there is photographic record of the locomotive being directly coupled to one of the test engines and some of the rails it operated on are known to have been contaminated.

It also was used at all of the Area 25 test facilities in support of the rocket and jet engine programs. The engine was fully operational at the time that EMAD was shut down and was used to move railcars within the compound after facility closure. It is not known when it was last operated.

Recently, it was posted as a Contamination Area and as a Radioactive Material Area. The reasons for these postings are not really known, although there is testimony that a small container of radioactive material, picked up from along the railroad tracks, was temporarily stored in the cab of the locomotive. The container is no longer in the cab and to the best knowledge available no longer on the EMAD Site. The contamination area signs were removed, but it is not known by whom or by what process.

In April 2008, RCTs performing a casual survey identified three locations on the locomotive that had direct reading contamination in excess of the release limits.

In August 2008, after the development of Survey Plan 08-028, "EMAD Locomotive Survey to Determine Release from Radiological Controls Criteria," RCTs again performed additional surveys of the locomotive and were documented on Survey Report 08-ER-A25-185. Following the requirements of Survey Plan 08-028, this second survey was much more detailed and comprehensive. Based on the surveys conducted from Survey Plan 08-028, the following areas were found to be impacted:

- Undercarriage Front Brake Assembly - 5,000 dpm/100cm^2 beta
- Undercarriage Front Axle and Wheel - 7,200 dpm/100cm^2 beta
- Front Coupler - 7,000 dpm/100cm^2 beta
- Exterior Right Front Inspection Port - 10,800 dpm/100cm^2 beta
- Exterior Left Front Inspection Port - 21,800 dpm/100cm^2 beta
- Engine Compartment Right Upper Inside Lip - 11,100 dpm/100cm^2 beta
- Engine Compartment Left Upper Inside Lip - 6,800 dpm/100cm^2 beta

With the discovery of the multiple areas being impacted, the intended disposition of the train to an offsite museum was postponed until a path forward could be determined.

IV. Instructions

All surveys shall be performed by qualified personnel. Personnel must use their experience, knowledge of the area in which they are working, and workplace indicators to ensure adequate surveys are being performed, in addition to the information provided in this document.

Background levels for direct surveys shall be less than 4,000 dpm/100cm^2 beta using the NE Electra.

Based on process knowledge and sufficient characterization data, surveys will consist of measurements for Beta contamination only. All surveys shall be performed and documented in accordance with Organization Instruction OI-0441.211, "Direct and Indirect Surveys." Survey results shall be recorded on a form FRM-0108, "Radiological Survey Report," and approved by a Health Physics Supervisor or designee.

During this survey process, if contamination is found that is above the suspension limits of the Radiological Work Permit, work shall be paused, personnel will immediately stop all decontamination efforts and follow the RCT's instructions. RCTs will immediately notify the Environmental Restoration Health Physics Supervisor and survey any personnel who were in the affected room or area. Based on the levels encountered, RCTs will also adjust radiological postings to be commensurate with actual area conditions.

V. Contamination Surveys

NSTec Environmental Restoration has been tasked with decontaminating the 25 Ton Locomotive at the Area 25 EMAD rail yard. The decontamination performed will be to the extent and rigor required to reduce the level of contamination on the seven impacted areas to meet the requirements of DOE/NV/25946--801, "Nevada Test Site Radiological Control Manual," Table 4-2. Successful completion of this activity will be documented on the pre and post decontamination surveys of each of the seven impacted locations.

RCTs will survey and document a pre decontamination survey and post decontamination survey for each of the following locations:

1. Undercarriage Front Brake Assembly
2. Undercarriage Front Axle and Wheel
3. Front Coupler
4. Exterior Right Front Inspection Port
5. Exterior Left Front Inspection Port
6. Engine Compartment Right Upper Inside Lip
7. Engine Compartment Left Upper Inside Lip

Note: A copy of Survey Report 08-ER-A25-185 will provide exact locations of impacted areas.

When performing decontamination, extreme care should be given to prevent the spread of contamination to additional areas on the locomotive. Post decontamination surveys shall include surveying a small radius (~6") immediately adjacent to the remediated area. In some cases, this may not be feasible due to physical constraints of the area being remediated so the RCT should use their experience and knowledge to evaluate any surface area that could have potentially been cross contaminated during the decontamination process.

To the extent practical, RCTs shall collect the decontamination byproduct for isotopic validation using gamma spectroscopy. Gamma spectroscopy shall be performed by qualified personnel and the results reviewed and approved by Radiological Engineering.

VI. Disposition

This survey plan is only to demonstrate the successful completion of decontamination of the known impacted areas of the locomotive. There is no intended disposition in regards to the criteria set forth in this survey plan. Disposition may be evaluated and criteria set forth in future survey plans and documentation.

ATTACHMENT 5
Survey Results #10-ER-A25-097 for Survey Plan #09-037

COPY

NSTec

RADIOLOGICAL SURVEY REPORT – DATA

SURVEY # 10-ER-A25-097

Location:	Purpose:	Comments:	Date/Time:
E-Mad / CAU 114	Post Decon of Locomotive # 21547	Survey and decon performed in accordance with Survey Plan 09-037 Each location surveyed includes the area immediately adjacent to the remediated area.	02-9-10 / 1000

Instrument:	Serial #:	Cal Due:	Eff in %: Alpha / Beta	BKG in dpm: Alpha / Beta	MDA in dpm: Alpha / Beta		
						RWP # 10-0025-02	
Tennelec	72306-3	12-17-10	22.61 / 38.32	0 / 2.61	11.97 / 16.07	Work Package # ENV-10-CAU114-0012	
Electra	1568	06-23-10	14.7 / 22.8	20.4 / 1713	80 / 500	RCT Name: S. Munns	Signature: [signature]
N / A	N / A	N / A	N / A	N / A	N / A	RCT Name N / A	Signature: N / A
N / A	N / A	N / A	N / A	N / A	N / A	RCT Name: N / A	Signature: N / A
N / A	N / A	N / A	N / A	N / A	N / A	RCT Name: N / A	Signature: N / A

Survey Point	Description/Comments	Removable dpm/100cm^2		Fixed + Removable dpm/100cm^2		Gamma mrem/hr	Neutron mrem/hr	Total mrem/hr
		Alpha	Beta	Alpha	Beta			
1-3	Undercarriage Front Brake Assembly (Previously 5Kdpm)	See	Attached	<MDA	<MDA	N / A	N / A	N / A
4-6	Undercarriage Front Axel and Wheel (Previously 7.2Kdpm)	See	Attached	<MDA	<MDA	N / A	N / A	N / A
7-9	Front Coupler (Previous 7Kdpm)	See	Attached	<MDA	<MDA	N / A	N / A	N / A
10-14	Exterior Right Front Inspection Port (Previously 16Kdpm)	See	Attached	<MDA	<MDA	N / A	N / A	N / A
15-19	Exterior Left Front Inspection Port (Previously 21.8Kdpm)	See	Attached	<MDA	<MDA	N / A	N / A	N / A
20-25	Engine Compartment Right Upper Inside Lip (Previously 20Kdpm)	See	Attached	<MDA	3K	N / A	N / A	N / A
26-29	Engine Compartment Left Upper Inside Lip (Previously 6.8Kdpm)	See	Attached	<MDA	<MDA	N / A	N / A	N / A
30	Sample Prep Area	See	Attached	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A
N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A	N / A

Reviewed By (Print):	Signature:	Date:
D. Frenette	[signature]	2/11/10

Device: 72306-3

Batch ID: Swipes - 201002091142 **Count Date:** 2/9/2010 11:42:58AM

Background (dpm)		Efficiency (%)		MDA (DPM)		Sample Count Time:
Alpha Rate:	0.00	Alpha:	22.61	Alpha:	11.97	1.00 Minutes
Beta Rate:	2.61	Beta:	38.32	Beta:	16.07	

Results Report: Page 1 of 1

Swipes

Batch Key: 1065 **Device:** 72306-3 **Survey #** 10-ER-A25-097

Sample ID	Alpha (dpm)	Beta (dpm)	Comments
0100209114258-A1	0	7.83	Undercarriage Front Brake Assy
0100209114429-A2	0	5.22	
0100209114539-A3	0	0.00	
0100209114649-A4	0	0.00	Undercarriage Front Axel and Wheel
0100209114809-A5	0	10.44	
0100209114919-A6	0	-2.61	
0100209115029-A7	0	2.61	Front Coupler
0100209115139-A8	4.42	2.61	
0100209115259-A9	0	2.61	
0100209115409-A10	0	2.61	Exterior Right Front ~~Inspectoin~~ Inspection Port
0100209115519-A11	0	0.00	
0100209115629-A12	0	-2.61	
0100209115749-A13	4.42	-2.61	
0100209115859-A14	0	2.61	
0100209120009-A15	0	5.22	Exterior Left Front Inspection Port
0100209120119-A16	0	7.83	
0100209120229-A17	0	5.22	
0100209120349-A18	0	-2.61	
0100209120459-A19	4.42	0.00	
0100209120609-A20	0	5.22	Engine Compartment Right Upper Inside Lip
0100209120719-A21	0	0.00	
0100209120839-A22	4.42	0.00	
0100209120949-A23	0	2.61	
0100209121059-A24	0	0.00	
0100209121209-A25	0	7.83	
0100209121329-A26	4.42	0.00	Engine Compartment Left Upper Inside Lip
0100209121439-A27	0	13.05	
0100209121549-A28	4.42	-2.61	
0100209121659-A29	0	5.22	
0100209121809-A30	0	0.00	Sample Prep Area

ATTACHMENT 6
REC-2010-001, "Public Dose Estimate from the EMAD 25 Ton Locomotive"

National Security Technologies LLC
Vision • Service • Partnership

Radiological Engineering Calculation

Environmental Restoration

PUBLIC DOSE ESTIMATE FROM THE EMAD 25 TON LOCOMOTIVE

REC-2010-001
Revision 1

Prepared by: _____ 5/13/2010
Jeremy S. Gwin, Radiological Engineering Scientist — Date

Reviewed by: _____ 5/13/10
William J Bair, Radiological Engineering Senior Scientist — Date

Reviewed by: _____ 5/17/2010
Douglas H. McBride, Radiological Engineering Manager — Date

1. INTRODUCTION

1.1. Purpose

This National Security Technologies, LLC (NSTec) Radiological Engineering Calculation is to estimate the radiation dose originating from residual radioactivity within a small 25 ton locomotive, Serial Number 21547, currently located at the Engine Maintenance Assembly and Disassembly (EMAD) rail yard in Area 25 of the Nevada Test Site (NTS) pictured in Figure 1. This locomotive is planned for unrestricted release to the Nevada State Railroad Museum in Boulder City, NV where it will be used as a display piece. The dose will be calculated using the U.S. Department of Energy (DOE) approved modeling code RESRAD-BUILD v3.5.

Figure 1. EMAD 25 Ton Locomotive

1.2. History

The small locomotive was used to move railcars in support of the nuclear rocket and jet engine programs. It is listed at 25 tons and has not been enhanced with added shielding. It is a diesel/electric locomotive with an electric motor mounted in the undercarriage. The locomotive utilizes a drive chain to link the motor to the drive wheels.

Testimony states that it was used to move flat and test cars into position and not for test articles or contaminated equipment. The low traction and poor braking made it undesirable for that type of work. However, there is a photographic record of the locomotive being directly coupled to one of the test engines. In addition, some of the rails it operated on are known to have been contaminated.

The locomotive was used at all of the Area 25 test facilities in support of the rocket and jet engine programs. The engine was fully operational at the time that EMAD was shut down and was used to move railcars within the compound after facility closure. It is not known when it last operated.

1.3. Radiological Conditions

In the past, the locomotive was posted as a contamination area. The reasons for these postings are not known, although there was testimony that a small container of radioactive material, picked up from along the railroad tracks, was temporarily stored in the cab of the locomotive. The container is no longer in the cab and to the best knowledge available no longer at the EMAD Site. The contamination area signs were removed, but it is not known by whom or by what process. Currently, the locomotive is posted as a radioactive material area.

In April 2008, Radiological Control Technicians (RCTs) performing a casual survey identified three locations on the locomotive that had contamination in excess of the release limits.

In August 2008, after the development of Survey Plan 08-028, “EMAD Locomotive Survey to Determine Release from Radiological Controls Criteria,” RCTs performed an additional survey of the locomotive which was documented on Survey Report Number 08-ER-A25-185. Following the requirements of Survey Plan 08-028, this survey was much more detailed and comprehensive. Based on the survey conducted from Survey Plan 08-028, the following areas were found to be impacted:

- *Undercarriage Front Brake Assembly - 5,000 dpm/100 cm^2 total beta*
- *Undercarriage Front Axle and Wheel - 7,200 dpm/100 cm^2 total beta*
- *Front Coupler - 7,000 dpm/100 cm^2 total beta*
- *Exterior Right Front Inspection Port - 10,800 dpm/100 cm^2 total beta*
- *Exterior Left Front Inspection Port - 21,800 dpm/100 cm^2 total beta*
- *Engine Compartment Right Upper Inside Lip - 11,100 dpm/100 cm^2 total beta*
- *Engine Compartment Left Upper Inside Lip - 6,800 dpm/100 cm^2 total beta*

No removable contamination was found. The locations of the elevated fixed contamination are not immediately adjacent to any of the inaccessible areas of the locomotive. These inaccessible areas were inaccessible for the portable survey meter. Inaccessible areas were surveyed for removable contamination to some extent (swipes), except for the interior portions of the engine and other sealed components. This provided a reasonable assurance that contamination did not migrate to the inaccessible surfaces since the pathways were not contaminated and the locations with elevated contamination were remote to these pathways.

With the discovery of the multiple areas being impacted, the intended disposition of the locomotive to an offsite museum was postponed until a path forward for unrestricted release could be determined.

As part of the path forward for unrestricted release, the identified areas of known fixed contamination on the locomotive were decontaminated in January-February 2010 under Survey Plan 09-037, "Post Remediation Survey Requirements for the 25 Ton Locomotive at the Engine Maintenance, Assembly and Disassembly (EMAD) Rail Yard Serial Number 21547." This decontamination process effectively removed the areas of known contamination on the surfaces of the locomotive to less than detectable limits of the survey instrument, with the exception of one location. The right upper inside lip of the engine compartment was decontaminated to a beta activity of 3000 dpm/100cm^2. The area of the fixed contamination was less than one square meter.

A sample of decontamination effluent and trash was given to Radiological Engineering to perform an isotopic identification. Performing gamma spectroscopy, the isotopes of Cs-137 and U-235 were identified. It was assumed that the beta activity is comprised of a mixture of fission products (Cs-137 and Sr/Y-90). The U-235 was identified by gamma spectroscopy, but is present on the locomotive at or below the detectable limits for portable survey instruments.

1.4. Requirements for DOE Authorized Release

The unrestricted release of the locomotive will be based on alternate As Low As Reasonably Achievable (ALARA)/dose-based derived authorized limits in accordance with DOE Order 5400.5, "Radiation Protection of the Public and the Environment." Since it is impossible to prove that there is no residual contamination in inaccessible areas, it will be necessary to demonstrate that the estimated dose to the public meet the following requirements:

- Authorized limits for release of the item must ensure that doses to the public from all sources are less than the primary dose limit for all sources (100 mrem/year).
- Authorized limits for release of the item must be developed and approved by DOE consistent with the ALARA process. These limits will be based on a documented finding that they are as low as practicable as determined through the ALARA process, with a goal of maintaining individual doses low in comparison to background (e.g., a few mrem/year or less). In any case, the limits must be a fraction of the primary dose limit for the public (e.g., 25 mrem/year or less).

The DOE dose constraint of 25 mrem/year is also consistent with the dose requirements in Title 10 Code of Federal Regulations (CFR) Part 20, “Standards for Protection Against Radiation,” Subpart E, “Radiological Criteria for License Termination.” The 25 mrem/year dose constraint is also consistent with the Nevada Administrative Code (NAC) 459.3178, “Property of decommissioned facility: Eligibility for release for unrestricted use.” A basic dose assessment using the RESRAD-BUILD v3.5 code should be adequate to demonstrate compliance with the dose constraint of 25 mrem/year.

Per NTS Organization Instruction OI-0441.212 Revision 4, “Controlled and Unrestricted Release,” items that are to be released offsite and have inaccessible surfaces and have known contamination or the potential for internal contamination require the approval of the Radiological Control Manager, the senior line manager of the project, and the DOE/NNSA line manager.

2. DOSE ASSESSMENT INFORMATION

2.1. Computer Model: RESRAD-BUILD

The RESRAD-BUILD computer code is a pathway analysis model developed to evaluate the potential radiological dose incurred by an individual who works or lives in a building contaminated with radioactive material. The radioactive material in the building structure can be released into the indoor air by mechanisms such as diffusion (radon gas and tritiated water), mechanical removal (decontamination activities), or erosion (removable surface contamination). The transport of radioactive material within the building from one compartment to another is calculated with an indoor air quality model. The air quality model evaluates the transport of radioactive dust particulates and radon progeny due to (1) air exchange between compartments and with outdoor air, (2) the deposition and resuspension of particulates, and (3) radioactive decay and ingrowth. RESRAD-BUILD can model up to three compartments in a building, thereby making it possible to evaluate situations ranging from a one-room warehouse to a three-story house, for example (Argonne National Laboratory, 2003).

As mentioned before, RESRAD-BUILD v3.5 was the code used to model dose from residual radioactivity. This code was chosen because it was the best fit for this type of dose calculation. Although the code is used for residual radioactivity in buildings, the locomotive can be visualized as a radioactive source within a building (a warehouse). As with all dose models, many assumptions were made. A discussion of scenarios and assumptions will now be addressed.

2.2. Scenarios

Per telephone conversation, the Museum Director of the Nevada State Railroad Museum in Boulder City, NV informed NSTec Radiological Engineering that the locomotive would be for public display only. This locomotive will not be operational; it will just be used as a static display for the public to view. Current rules at the rail yard prohibit the public from climbing on any of the displays. The rail yard has a fence around the train displays and is locked after business hours. The only foreseeable direct contact with the locomotive is from museum workers, if they have to move it or refurbish it. Although, the director commented that this locomotive looked good and did not need refurbishing, after decontamination, it may need some touch up work on the exterior.

Four use scenarios were developed from this information and incorporated into the dose modeling of the EMAD locomotive.

- **Likely Use Scenario 1:** The dose to an individual under a likely use scenario was modeled as a member of the public, the "museum enthusiast," who attends the museum once a week for two hours. The whole two hours were spent 0.3 meters away from the side of the locomotive. For conservatism, the entire side of the locomotive was assumed to be uniformly contaminated with the maximum activity that was found on previous surveys.
- **Likely Use Scenario 2:** Another likely use scenario involved a "museum worker" who refurbishes or moves the locomotive for 10 hours a day for 30 days. The time was spent 0.3 meters away from the sides of the locomotive, partially surrounded by a contaminated engine compartment.
- **Worst Case Scenario 1:** A dose under worst plausible use scenarios, or "worst case" scenario, would represent a situation if all controls failed. A scenario was hypothesized and involved an individual spending an unreasonable amount of time in close proximity to a contaminated engine compartment. This person would spend eight hours a day, every day, at 0.3 meters away from the side of the "contaminated" compartment.
- **Worst Case Scenario 2:** Another worst case scenario involved a museum employee who mechanically removes (by grinding or sanding) the small area of fixed contamination which remains on the locomotive. This scenario assumed that the total amount of known contamination becomes airborne, that the employee is 0.3 meters away, and spends six hours performing work.

2.3. Assumptions

With RESRAD-BUILD, the locomotive was modeled as an area source, or multiple area sources. The source activity was assumed as the highest fixed contamination found on the exterior of the locomotive (22,000 dpm/100 cm^2 total beta) and was assumed to consist of the isotopes Sr/Y-90, Cs-137, and 80 dpm/100 cm^2 of U-235. The entire surface of the locomotive was assumed to have uniform contamination. This was a conservative assumption because all but one of the known areas of fixed contamination on the exterior were decontaminated to values less than the Minimum Detectable Activity for the portable survey instruments used at the NTS (<80 dpm alpha and <500 dpm beta). The right upper inside lip of the engine compartment was decontaminated to a beta activity of 3000 dpm/100cm^2. The area of the fixed contamination spot was less than 1 square meter.

For each scenario, the source in the dose model varied. Some of the assumptions are discussed below.

- For the "Likely Use Scenario 1" model, a 3.66 x 2.44 meter (12 x 8 ft) area source was assumed to contain the maximum fixed contamination underneath 0.4 cm of steel shielding. The thickness of the shield is representative of the steel, exterior frame of the locomotive. The removable fraction of the source was set at 1%. A 1 x 1 meter area source was used to mimic the small area of fixed contamination

remaining on the train (no shielding used). The removable fraction of this source was set at 10%. The receptor was then positioned 0.3 meters away from the area sources.

- For the "Likely Use Scenario 2" model, the source was actually three, 2 x 2 meter area sources positioned in front, on the left, and right side of the worker. This configuration was made to mimic two open engine compartment doors and another surface in close contact with the employee. This would also work for an employee in the cab of the locomotive, with the floor, ceiling, and wall of the engine compartment represented as the three sources. Two of the area sources were assumed to contain the maximum fixed contamination underneath 0.4 cm of steel shielding. The removable fraction of these sources was set at 1%. The other source was used to mimic the small area of fixed contamination remaining on the train (no shielding used). The removable fraction of the source was set at 10%. The receptor was then positioned 0.3 meters away from the area sources.

- The "Worst Case Scenario 1" model entailed six sources, essentially forming a box. This configuration was used to model the engine compartment. Five of the area sources were assumed to contain the maximum fixed contamination underneath 0.1 cm of steel shielding. The removable fraction of the sources was set at 10%. The other source was used to mimic the small area of fixed contamination remaining on the train (no shielding used). The removable fraction of this source was set at 10%. The receptor was then positioned 0.3 meters away from the area sources.

- For the "Worst Case Scenario 2" model, a 1 x 1 meter area source was used to mimic the small area of fixed contamination remaining on the train (no shielding used). The individual would mechanically remove the total activity without using protective measures. The removable fraction of the source was set at 100%. The respirable fraction of the source was set at 50%.

Though the locomotive will be in an outside environment, the RESRAD-BUILD v3.5 code was appropriate. The assumption that the locomotive resides inside a warehouse was a conservative assumption. The radionuclide resuspension rate and air flow in the building increased the potential for an internal dose compared to having the locomotive exposed to the outside atmosphere. The code only calculates external and internal dose to individuals from a source of radiation.

For a complete list of all input parameters for each scenario used in the RESRAD-BUILD v3.5 code to perform the dose calculation, see Appendix A.

3. Work

RESRAD-BUILD v3.5 was used to perform the dose calculations. No hand calculations were performed.

4. Results

The RESRAD-BUILD detailed results for each scenario may be found in Appendix B - Appendix E. A summary of the doses received for each scenario over time is presented in Table 1.

Table 1

	Dose Received for the Exposure Duration (mrem)			
Scenario	End of the 1st year	End of the 2nd year	End of the 10th year	End of the 30th year
Likely Use 1	0.109	0.105	0.085	0.0536
Likely Use 2	0.512	0.491	0.399	0.252
Worst Case 1	3.83	3.30	2.68	1.69
Worst Case 2	1.16	0	0	0

The “Worst Case Scenario 2” model assumed that 100% of the source activity was removed in a day (complete mechanical removal of the source activity within six hours). With the source completely removed after six hours, the dose received from that time after was null.

5. Conclusion

The “Likely Use Scenario 1” represented members of the public visiting the museum and viewing the locomotive. The “museum enthusiast” could receive a maximum dose of 0.109 mrem in any given year. This scenario had the highest probability of occurring out of the four scenarios. This individual would spend two hours per week, every week for 30 years, standing 30 cm away from the exterior surface of the locomotive. The expected dose to an individual in this group would be a fraction of the calculated dose because the source term was exaggerated in the RESRAD-BUILD code. The calculated maximum dose under this likely use scenario is well under the 25 mrem/year dose constraint and meets the criteria of a “few millirem or less in a year” established in DOE O 5400.5.

The “Likely Use Scenario 2” represented those employees of the museum who need to refurbish or move the locomotive. The “museum worker” could receive a maximum dose of 0.523 mrem in any given year. This scenario was less probable than “Likely Use Scenario 1.” The museum employee would spend 10 hours a day, for 30 days a year, positioned partially enclosed between three contaminated surfaces at 30 cm away from each surface. The expected dose to an individual in this group would be a fraction of the calculated dose because the source term was exaggerated in the RESRAD-BUILD code. The calculated maximum dose under the likely use scenario is well under the 25 mrem/year dose constraint and meets the criteria of a “few millirem or less in a year” established in DOE O 5400.5.

Under the “Worst Case Scenario 1” scenario, an individual could receive a maximum dose of 3.83 mrem in any given year. Again, the worst case scenario represented the dose to an individual if all controls failed. This individual would spend 8 hours per day, every day for 30 years, in close proximity to a surface contaminated engine compartment. The source activity for the “contaminated” engine compartment was exaggerated, thus increasing the dose to the individual. The probability of this scenario occurring is extremely low. The calculated maximum dose under the worst case scenario is well under the 25 mrem/year dose constraint established in DOE O 5400.5.

Under the “Worst Case Scenario 2,” an individual could receive a maximum dose of 1.16 mrem in any given year. Essentially, the individual would receive a one-time 1.16 mrem dose during a six hour exposure. This individual would spend a total of six hours mechanically removing a small surface contaminated area. The source activity for the contaminated area mimicked actual conditions. The airborne respirable fraction was set at 50%, which equates to half of the total source activity becoming airborne and existing as respirable particulate. This was a conservative assumption because most of the source activity would not exist as respirable fractions during mechanical removal (i.e., mechanical removal fragments would be too large to become respirable). The probability of this scenario occurring is low. The calculated maximum dose under this scenario is well under the 25 mrem/year dose constraint established in DOE O 5400.5.

With all four scenarios below the 25 mrem/year dose constraint and meeting the “few millirem in a year” criteria, the EMAD 25 ton locomotive meets radiological requirements to be released with residual radioactivity to the public.

Appendix A
Input Parameters in RESRAD-BUILD for Each Scenario

I. List of Assumptions and Parameters for Likely Use Scenario 1

Any parameter that is not specifically mentioned uses the RESRAD-BUILD default value.

1. Case
   - Case
     - Dose Risk Library: ICRP 72 (Adult)
   - Time Parameters
     - Exposure Duration (days): 365
     - Indoor fraction: 0.5
   - Evaluation Times – Time Integration
     - Maximum number of points for Dose/Risk: 17
2. Building Parameters
   - Number of Rooms: 1
   - Deposition Velocity: 0.01 m/s
   - Resuspension Rate: 0.0000005 (1/s)
   - Air Flow
     - Building Exchange Rate: 0.8 (1/h)
     - Room 1
       - Area (m^2): 36
       - Height (m): 2.5
3. Radiological Units
   - Activity: dpm
   - Dose: mrem
4. Receptor Parameters
   - Receptor: 1
   - Room: 1
   - Time fraction: 0.025
   - Breathing Rate: 18 m^3/d
   - Ingestion Rate: 0.0001 m^2/h
   - Location:
   - X: 1.3, Y: 1, Z: 1
5. Shielding Parameters
   - Source 1 / Receptor 1
     - Thickness: 0.4 cm
     - Density: 7.6 g/cc
     - Material: Iron
   - Source 2 / Receptor 1
     - Thickness: 0 cm
     - Density: 7.6 g/cc
     - Material: Iron

6. Source Parameters
   - Area sources
   - Details (source 1)
     - Location: X: 1, Y: 1, Z: 1
     - Rectangular Geometry
     - Length along (m) Y: 3.66, Z: 2.44
     - Release
       - Air fraction: 0.1
       - Direct Ingestion: 0 1/h
       - Removable fraction: 0.01
       - Lifetime (d): 365
     - Radionuclide: Sr-90 Activity: 1.1E6 dpm/m^2
     - Radionuclide: Cs-137 Activity: 1.1E6 dpm/m^2
     - Radionuclide: U-235 Activity: 8.0E3 dpm/m^2
   - Details (source 2)
     - Location: X: 1.6, Y: 1, Z: 1
     - Rectangular Geometry
     - Length along (m) Y: 1, Z: 1
     - Release
       - Air fraction: 0.1
       - Direct Ingestion: 0 1/h
       - Removable fraction: 0.1
       - Lifetime (d): 365
     - Radionuclide: Sr-90 Activity: 1.5E5 dpm/m^2
     - Radionuclide: Cs-137 Activity: 1.5E5 dpm/m^2
     - Radionuclide: U-235 Activity: 8.0E3 dpm/m^2

II. List of Assumptions and Parameters for Likely Use Scenario 2

Any parameter that is not specifically mentioned uses the RESRAD-BUILD default value.

1. Case
   - Case
     - Dose Risk Library: ICRP 72 (Adult)
   - Time Parameters
     - Exposure Duration (days): 365
     - Indoor fraction: 0.5
   - Evaluation Times – Time Integration
     - Maximum number of points for Dose/Risk: 17
2. Building Parameters
   - Number of Rooms: 1
   - Deposition Velocity: 0.01 m/s
   - Resuspension Rate: 0.0000005 (1/s)
   - Air Flow
     - Building Exchange Rate: 0.8 (1/h)
     - Room 1
       - Area (m^2): 36
       - Height (m): 2.5

3. Radiological Units
   - Activity: dpm
   - Dose: mrem
4. Receptor Parameters
   - Receptor: 1
   - Room: 1
   - Time fraction: 0.069
   - Breathing Rate: 18 m^3/d
   - Ingestion Rate: 0.0001 m^2/h
   - Location:
   - X: 1, Y: 1, Z: 1
5. Shielding Parameters
   - Source 1 / Receptor 1
     - Thickness: 0.4 cm
     - Density: 7.6 g/cc
     - Material: Iron
   - Source 2 / Receptor 1
     - Thickness: 0.4 cm
     - Density: 7.6 g/cc
     - Material: Iron
   - Source 3 / Receptor 1
     - Thickness: 0 cm
     - Density: 7.6 g/cc
     - Material: Iron
6. Source Parameters
   - Area sources
   - Details (source 1 and 2)
     - Location Source 1: X: 0.7, Y: 1, Z: 1
     - Location Source 1: X: 1.3, Y: 1, Z: 1
     - Rectangular Geometry
     - Length along (m) Y: 2, Z: 2
     - Release
       - Air fraction: 0.1
       - Direct Ingestion: 0 1/h
       - Removable fraction: 0.01
       - Lifetime (d): 365
     - Radionuclide: Sr-90 Activity: 1.1E6 dpm/m^2
     - Radionuclide: Cs-137 Activity: 1.1E6 dpm/m^2
     - Radionuclide: U-235 Activity: 8.0E3 dpm/m^2
   - Details (source 3)
     - Location Source 1: X: 1, Y: 1.3, Z: 1
     - Rectangular Geometry
     - Length along (m) X: 2, Z: 2
     - Release
       - Air fraction: 0.1
       - Direct Ingestion: 0 1/h
       - Removable fraction: 0.1
       - Lifetime (d): 365

- Radionuclide: Sr-90 Activity: 1.5E5 dpm/m^2
- Radionuclide: Cs-137 Activity: 1.5E5 dpm/m^2
- Radionuclide: U-235 Activity: 8.0E3 dpm/m^2

III. List of Assumptions and Parameters for Worst Case Scenario 1

Any parameter that is not specifically mentioned uses the RESRAD-BUILD default value.

1. Case
   - Case
     - Dose Risk Library: ICRP 72 (Adult)
   - Time Parameters
     - Exposure Duration (days): 365
     - Indoor fraction: 0.5
   - Evaluation Times – Time Integration
     - Maximum number of points for Dose/Risk: 17
2. Building Parameters
   - Number of Rooms: 1
   - Deposition Velocity: 0.01 m/s
   - Resuspension Rate: 0.0000005 (1/s)
   - Air Flow
     - Building Exchange Rate: 0.8 (1/h)
     - Room 1
       - Area (m^2): 36
       - Height (m): 2.5
3. Radiological Units
   - Activity: dpm
   - Dose: mrem
4. Receptor Parameters
   - Receptor: 1
   - Room: 1
   - Time fraction: 0.67
   - Breathing Rate: 18 m^3/d
   - Ingestion Rate: 0.0001 m^2/h
   - Location:
   - X: .915, Y: 2.5, Z: .6
5. Shielding Parameters
   - Sources 2-6 / Receptor 1
     - Thickness: 0.1 cm
     - Density: 7.6 g/cc
     - Material: Iron
   - Source 1 / Receptor 1
     - Thickness: 0 cm
     - Density: 7.6 g/cc
     - Material: Concrete

6. Source Parameters
   - Area sources
   - Details (source 1)
     - Rectangular Geometry
     - Length along (m) Y: 1.2, Z: 1.2
     - Release
       - Air fraction: 0.1
       - Direct Ingestion: 0 1/h
       - Removable fraction: 0.1
       - Lifetime (d): 365
     - Radionuclide: Sr-90 Activity: 1.5E5 dpm/m^2
     - Radionuclide: Cs-137 Activity: 1.5E5 dpm/m^2
     - Radionuclide: U-235 Activity: 8.0E3 dpm/m^2
   - Details (source 2)
     - Rectangular Geometry
     - Length along (m) Y: 1.2, Z: 1.2
     - Release
       - Air fraction: 0.1
       - Direct Ingestion: 0 1/h
       - Removable fraction: 0.1
       - Lifetime (d): 365
     - Radionuclide: Sr-90 Activity: 1.1E6 dpm/m^2
     - Radionuclide: Cs-137 Activity: 1.1E6 dpm/m^2
     - Radionuclide: U-235 Activity: 8.0E3 dpm/m^2
   - Details (source 3-6)
     - Rectangular Geometry
     - Length along (m) X: 1.2, Y or Z: 1.83
     - Release
       - Air fraction: 0.1
       - Direct Ingestion: 0 1/h
       - Removable fraction: 0.1
       - Lifetime (d): 365
     - Radionuclide: Sr-90 Activity: 1.1E6 dpm/m^2
     - Radionuclide: Cs-137 Activity: 1.1E6 dpm/m^2
     - Radionuclide: U-235 Activity: 8.0E3 dpm/m^2
   - Source locations

Source Number	*X*	*Y*	*Z*
1	1.82	1.6	.6
2	0	1.6	.6
3	.915	1	.6
4	.915	2.2	.6
5	.915	1.6	0
6	.915	1.6	1.2

IV. List of Assumptions and Parameters for Worst Case Scenario 2

Any parameter that is not specifically mentioned uses the RESRAD-BUILD default value.

1. Case
   - Case
     - Dose Risk Library: ICRP 72 (Adult)
   - Time Parameters
     - Exposure Duration (days): 1
     - Indoor fraction: 0.5
   - Evaluation Times – Time Integration
     - Maximum number of points for Dose/Risk: 17
2. Building Parameters
   - Number of Rooms: 1
   - Deposition Velocity: 0.01 m/s
   - Resuspension Rate: 0.0000005 (1/s)
   - Air Flow
     - Building Exchange Rate: 0.8 (1/h)
     - Room 1
       - Area (m^2): 36
       - Height (m): 2.5
3. Radiological Units
   - Activity: dpm
   - Dose: mrem
4. Receptor Parameters
   - Receptor: 1
   - Room: 1
   - Time fraction: 0.5
   - Breathing Rate: 18 m^3/d
   - Ingestion Rate: 0.0001 m^2/h
   - Location:
   - X: 1, Y: 1, Z: 1
5. Shielding Parameters
   - Source/Receptor
   - Thickness: 0 cm
   - Density: 2.4 g/cc
   - Material: Concrete
6. Source Parameters
   - Area sources
   - Details
     - Rectangular Geometry
     - Length along (m) Y: 1, Z: 1
     - Release
       - Air fraction: 0.5
       - Direct Ingestion: 0.1 1/h
       - Removable fraction: 1
       - Lifetime (d): 0.25
     - Radionuclide: Sr-90 Activity: 1.5E5 dpm/m^2
     - Radionuclide: Cs-137 Activity: 1.5E5 dpm/m^2
     - Radionuclide: U-235 Activity: 8.0E3 dpm/m^2

Appendix B
Results from RESRAD-BUILD
Likely Use Scenario 1

Title : Likely Use 1 - Enthusiast
Input File : site1.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 2
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 5.000000E-01

Receptor Information

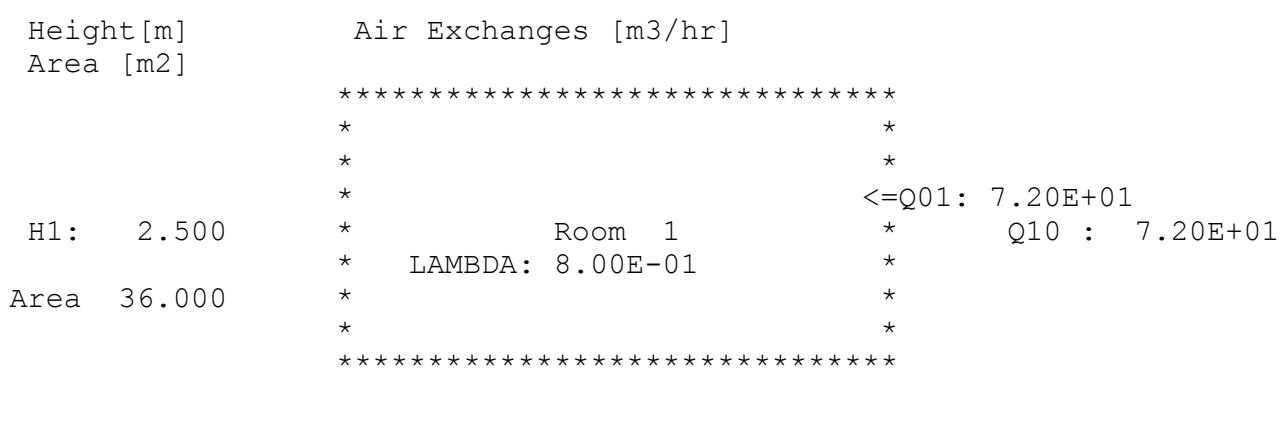
Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.300	1.000	1.000	0.025	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	7.60E+00	4.00E-01	Fe
1	2	7.60E+00	0.00E+00	Fe

Building Information

Building Air Exchange Rate: 8.00E-01 1/hr



Deposition velocity: 1.00E-02 [m/s] Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1

Location:: Room : 1 x: 1.00 y: 1.00 z: 1.00[m]
Geometry:: Type: Area Length[m]:3.66E+00 Width[m]:2.44E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-02
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Source: 2

Location:: Room : 1 x: 1.60 y: 1.00 z: 1.00[m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04

PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.500E+05	2.167E-05	6.500E-05	1.434E-03
SR-90	1.500E+05	5.117E-05	2.692E-04	1.039E-05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.00 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:3.66E+00 Width[m]:2.44E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-02
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Source: 2
Location:: Room : 1 x: 1.60 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.500E+05
SR-90	1.500E+05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Total
Receptor 1	1.01E-01	7.78E-03	1.09E-01
Total	1.01E-01	7.78E-03	1.09E-01

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.00E-01	5.42E-05	2.66E-07	5.32E-04	0.00E+00	2.36E-04
Total	1.00E-01	5.42E-05	2.66E-07	5.32E-04	0.00E+00	2.36E-04

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	7.53E-03	8.40E-06	4.12E-08	2.06E-04	0.00E+00	3.78E-05
Total	7.53E-03	8.40E-06	4.12E-08	2.06E-04	0.00E+00	3.78E-05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	2.47E-04	2.47E-04
PA-231	2.27E-08	2.27E-08
AC-227	9.33E-10	9.33E-10
CS-137	9.97E-02	9.97E-02
SR-90	1.29E-03	1.29E-03

Source: 2

Nuclide	Receptor 1	Total
U-235	2.73E-04	2.73E-04
PA-231	2.53E-08	2.53E-08
AC-227	1.03E-09	1.03E-09
CS-137	7.36E-03	7.36E-03
SR-90	1.49E-04	1.49E-04

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 1.00000000 years

Assessment for Time: 2
Time =1.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.00 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:3.66E+00 Width[m]:2.44E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	1.674E-01
AC-227	2.633E-03
CS-137	1.064E+06
SR-90	1.063E+06

Source: 2
Location:: Room : 1 x: 1.60 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.522E-01
AC-227	2.393E-03
CS-137	1.319E+05
SR-90	1.318E+05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 1.00000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Total
Receptor 1	9.76E-02	6.97E-03	1.05E-01
Total	9.76E-02	6.97E-03	1.05E-01

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 1.00000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	9.76E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	9.76E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	6.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	6.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 1.00000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	1.16E-04	1.16E-04
PA-231	1.27E-09	1.27E-09
AC-227	2.94E-10	2.94E-10
CS-137	9.67E-02	9.67E-02
SR-90	7.82E-04	7.82E-04

Source: 2

Nuclide	Receptor 1	Total
U-235	1.19E-04	1.19E-04
PA-231	1.09E-09	1.09E-09
AC-227	2.03E-10	2.03E-10
CS-137	6.78E-03	6.78E-03
SR-90	6.87E-05	6.87E-05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 10.0000000 years

Assessment for Time: 3
Time =1.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.00 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:3.66E+00 Width[m]:2.44E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	1.674E+00
AC-227	2.400E-01
CS-137	8.643E+05
SR-90	8.582E+05

Source: 2
Location:: Room : 1 x: 1.60 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.521E+00
AC-227	2.182E-01
CS-137	1.071E+05
SR-90	1.064E+05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 10.0000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Total
Receptor 1	7.93E-02	5.68E-03	8.50E-02
Total	7.93E-02	5.68E-03	8.50E-02

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 10.0000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	7.93E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	7.93E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	5.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	5.68E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 10.0000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	1.16E-04	1.16E-04
PA-231	8.88E-09	8.88E-09
AC-227	1.27E-08	1.27E-08
CS-137	7.86E-02	7.86E-02
SR-90	6.31E-04	6.31E-04

Source: 2

Nuclide	Receptor 1	Total
U-235	1.19E-04	1.19E-04
PA-231	7.63E-09	7.63E-09
AC-227	8.78E-09	8.78E-09
CS-137	5.51E-03	5.51E-03
SR-90	5.55E-05	5.55E-05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 30.0000000 years

Assessment for Time: 4
Time =3.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.00 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:3.66E+00 Width[m]:2.44E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	5.019E+00
AC-227	1.785E+00
CS-137	5.445E+05
SR-90	5.330E+05

Source: 2
Location:: Room : 1 x: 1.60 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	4.563E+00
AC-227	1.622E+00
CS-137	6.750E+04
SR-90	6.607E+04

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 30.0000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Total
Receptor 1	5.00E-02	3.62E-03	5.36E-02
Total	5.00E-02	3.62E-03	5.36E-02

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 30.0000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	5.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	5.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.62E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.62E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Evaluation Time: 30.0000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	1.16E-04	1.16E-04
PA-231	2.58E-08	2.58E-08
AC-227	8.85E-08	8.85E-08
CS-137	4.95E-02	4.95E-02
SR-90	3.92E-04	3.92E-04

Source: 2

Nuclide	Receptor 1	Total
U-235	1.19E-04	1.19E-04
PA-231	2.22E-08	2.22E-08
AC-227	6.12E-08	6.12E-08
CS-137	3.47E-03	3.47E-03
SR-90	3.45E-05	3.45E-05

Title : Likely Use 1 - Enthusiast
Input File : site1.bld
Full Summary

RESRAD-BUILD Dose (Time) Tables

Receptor Dose Received for the Exposure Duration

(mrem)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	1.09E-01	1.05E-01	8.50E-02	5.36E-02

Receptor Dose/Yr Averaged Over Exposure Duration

(mrem/yr)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	1.09E-01	1.05E-01	8.50E-02	5.37E-02

Appendix C
Results from RESRAD-BUILD
Likely Use Scenario 2

Title : Likely Use 2 - Employee
Input File : site1.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 3
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 5.000000E-01

Receptor Information

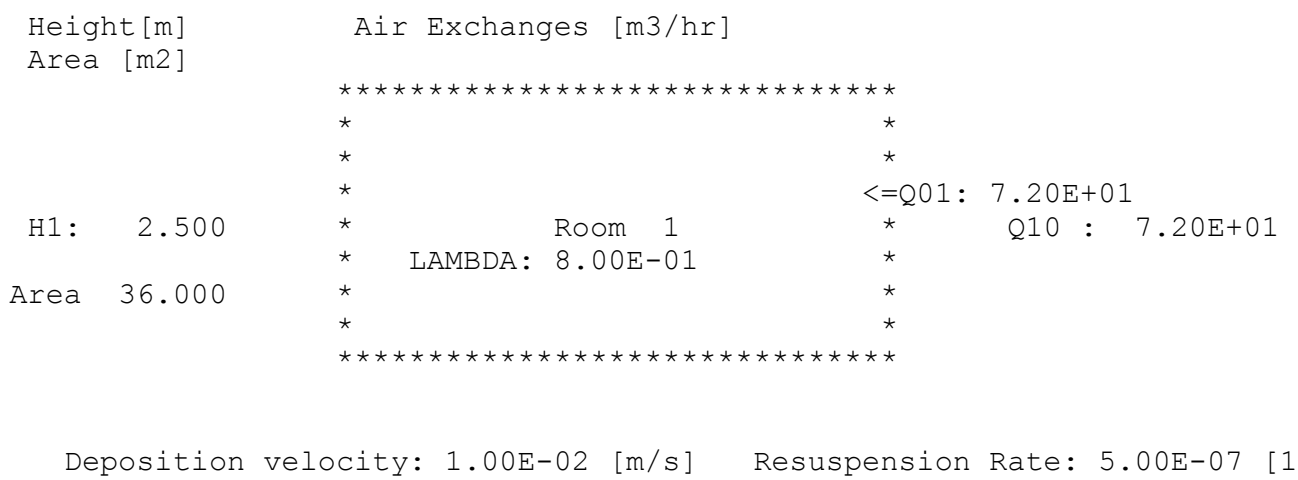
Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.000	1.000	1.000	0.069	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	7.60E+00	4.00E-01	Concrete
1	2	7.60E+00	4.00E-01	Fe
1	3	7.60E+00	0.00E+00	Fe

Building Information

Building Air Exchange Rate: 8.00E-01 1/hr



Deposition velocity: 1.00E-02 [m/s] Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1
Location:: Room : 1 x: 0.70 y: 1.00 z: 1.00[m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-02
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Source: 2
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00[m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-02
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04

PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Source: 3
Location:: Room : 1 x: 1.00 y: 1.30 z: 1.00[m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.500E+05	2.167E-05	6.500E-05	1.434E-03
SR-90	1.500E+05	5.117E-05	2.692E-04	1.039E-05

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 0.70 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-02
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Source: 2
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-02
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Source: 3
Location:: Room : 1 x: 1.00 y: 1.30 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	8.000E+03
	PA-231	0.000E+00
	AC-227	0.000E+00
	CS-137	1.500E+05
	SR-90	1.500E+05

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Total
Receptor 1	2.41E-01	2.31E-01	4.02E-02	5.12E-01
Total	2.41E-01	2.31E-01	4.02E-02	5.12E-01

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.40E-01	9.32E-05	3.29E-07	6.58E-04	0.00E+00	2.91E-04
Total	2.40E-01	9.32E-05	3.29E-07	6.58E-04	0.00E+00	2.91E-04

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.29E-01	9.32E-05	3.29E-07	6.58E-04	0.00E+00	2.91E-04
Total	2.29E-01	9.32E-05	3.29E-07	6.58E-04	0.00E+00	2.91E-04

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.74E-02	1.29E-04	4.55E-07	2.27E-03	0.00E+00	4.18E-04
Total	3.74E-02	1.29E-04	4.55E-07	2.27E-03	0.00E+00	4.18E-04

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	7.08E-04	7.08E-04
PA-231	2.88E-08	2.88E-08
AC-227	1.24E-09	1.24E-09
CS-137	2.38E-01	2.38E-01
SR-90	2.51E-03	2.51E-03

Source: 2

Nuclide	Receptor 1	Total
U-235	4.58E-04	4.58E-04
PA-231	2.85E-08	2.85E-08
AC-227	1.20E-09	1.20E-09
CS-137	2.28E-01	2.28E-01
SR-90	2.44E-03	2.44E-03

Source: 3

Nuclide	Receptor 1	Total
U-235	2.24E-03	2.24E-03
PA-231	2.77E-07	2.77E-07
AC-227	1.12E-08	1.12E-08
CS-137	3.68E-02	3.68E-02
SR-90	1.19E-03	1.19E-03

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 1.00000000 years

Assessment for Time: 2
Time =1.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 0.70 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	1.674E-01
AC-227	2.633E-03
CS-137	1.064E+06
SR-90	1.063E+06

Source: 2
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	1.674E-01
AC-227	2.633E-03
CS-137	1.064E+06
SR-90	1.063E+06

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 1.00000000 years

Source: 3
Location:: Room : 1 x: 1.00 y: 1.30 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.522E-01
AC-227	2.393E-03
CS-137	1.319E+05
SR-90	1.318E+05

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 1.00000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Total
Receptor 1	2.33E-01	2.23E-01	3.46E-02	4.91E-01
Total	2.33E-01	2.23E-01	3.46E-02	4.91E-01

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 1.00000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.23E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.23E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.46E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.46E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 1.00000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	5.43E-04	5.43E-04
PA-231	3.74E-09	3.74E-09
AC-227	9.71E-10	9.71E-10
CS-137	2.31E-01	2.31E-01
SR-90	1.85E-03	1.85E-03

Source: 2

Nuclide	Receptor 1	Total
U-235	2.94E-04	2.94E-04
PA-231	3.01E-09	3.01E-09
AC-227	6.94E-10	6.94E-10
CS-137	2.21E-01	2.21E-01
SR-90	1.78E-03	1.78E-03

Source: 3

Nuclide	Receptor 1	Total
U-235	5.90E-04	5.90E-04
PA-231	5.34E-09	5.34E-09
AC-227	1.01E-09	1.01E-09
CS-137	3.37E-02	3.37E-02
SR-90	3.41E-04	3.41E-04

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 10.0000000 years

Assessment for Time: 3
Time =1.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 0.70 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	1.674E+00
AC-227	2.400E-01
CS-137	8.643E+05
SR-90	8.582E+05

Source: 2
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	1.674E+00
AC-227	2.400E-01
CS-137	8.643E+05
SR-90	8.582E+05

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 10.0000000 years

Source: 3
Location:: Room : 1 x: 1.00 y: 1.30 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.521E+00
AC-227	2.182E-01
CS-137	1.071E+05
SR-90	1.064E+05

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 10.0000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Total
Receptor 1	1.90E-01	1.81E-01	2.82E-02	3.99E-01
Total	1.90E-01	1.81E-01	2.82E-02	3.99E-01

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 10.0000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.81E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.81E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.82E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.82E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 10.0000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	5.43E-04	5.43E-04
PA-231	2.62E-08	2.62E-08
AC-227	4.19E-08	4.19E-08
CS-137	1.88E-01	1.88E-01
SR-90	1.49E-03	1.49E-03

Source: 2

Nuclide	Receptor 1	Total
U-235	2.94E-04	2.94E-04
PA-231	2.11E-08	2.11E-08
AC-227	3.00E-08	3.00E-08
CS-137	1.80E-01	1.80E-01
SR-90	1.44E-03	1.44E-03

Source: 3

Nuclide	Receptor 1	Total
U-235	5.90E-04	5.90E-04
PA-231	3.74E-08	3.74E-08
AC-227	4.36E-08	4.36E-08
CS-137	2.74E-02	2.74E-02
SR-90	2.76E-04	2.76E-04

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 30.0000000 years

Assessment for Time: 4
Time =3.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 0.70 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	5.019E+00
AC-227	1.785E+00
CS-137	5.445E+05
SR-90	5.330E+05

Source: 2
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.920E+03
PA-231	5.019E+00
AC-227	1.785E+00
CS-137	5.445E+05
SR-90	5.330E+05

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 30.0000000 years

Source: 3
Location:: Room : 1 x: 1.00 y: 1.30 z: 1.00 [m]
Geometry:: Type: Area Length[m]:2.00E+00 Width[m]:2.00E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	4.563E+00
AC-227	1.622E+00
CS-137	6.750E+04
SR-90	6.607E+04

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 30.0000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Total
Receptor 1	1.20E-01	1.14E-01	1.80E-02	2.52E-01
Total	1.20E-01	1.14E-01	1.80E-02	2.52E-01

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 30.0000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.14E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.14E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Likely Use 2 - Employee
Input File : site1.bld
Evaluation Time: 30.0000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	5.43E-04	5.43E-04
PA-231	7.61E-08	7.61E-08
AC-227	2.92E-07	2.92E-07
CS-137	1.18E-01	1.18E-01
SR-90	9.27E-04	9.27E-04

Source: 2

Nuclide	Receptor 1	Total
U-235	2.94E-04	2.94E-04
PA-231	6.12E-08	6.12E-08
AC-227	2.09E-07	2.09E-07
CS-137	1.13E-01	1.13E-01
SR-90	8.92E-04	8.92E-04

Source: 3

Nuclide	Receptor 1	Total
U-235	5.90E-04	5.90E-04
PA-231	1.09E-07	1.09E-07
AC-227	3.04E-07	3.04E-07
CS-137	1.72E-02	1.72E-02
SR-90	1.71E-04	1.71E-04

Title : Likely Use 2 - Employee
Input File : site1.bld
Full Summary

RESRAD-BUILD Dose (Time) Tables

Receptor Dose Received for the Exposure Duration

(mrem)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	5.12E-01	4.91E-01	3.99E-01	2.52E-01

Receptor Dose/Yr Averaged Over Exposure Duration

(mrem/yr)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	5.12E-01	4.91E-01	3.99E-01	2.52E-01

Appendix D
Results from RESRAD-BUILD
Worst Case Scenario 1

Title : Worst Case 1
Input File : site1.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 6
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 5.000000E-01

Receptor Information

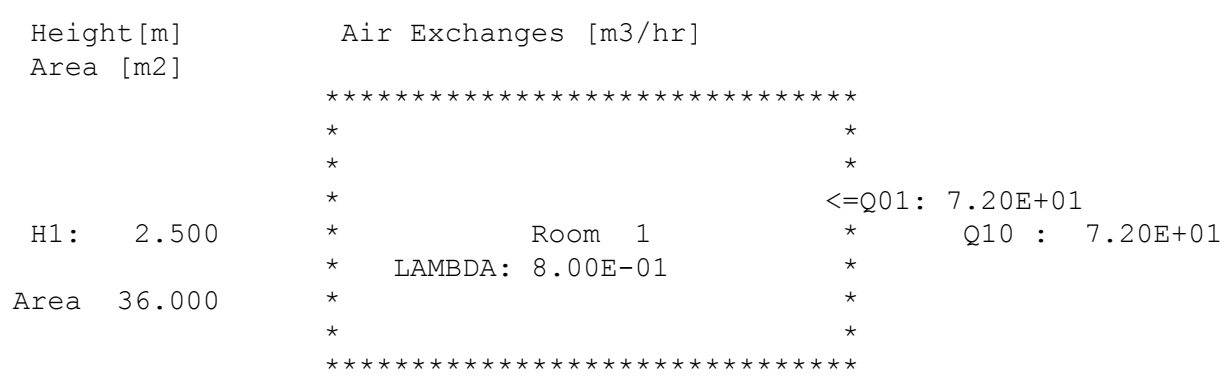
Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	0.915	2.500	0.600	0.670	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	7.60E+00	0.00E+00	Concrete
1	2	7.60E+00	1.00E-01	Fe
1	3	7.60E+00	1.00E-01	Fe
1	4	7.60E+00	1.00E-01	Fe
1	5	7.60E+00	1.00E-01	Fe
1	6	7.60E+00	1.00E-01	Fe

Building Information

Building Air Exchange Rate: 8.00E-01 1/hr



Deposition velocity: 1.00E-02 [m/s] Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1

Location:: Room : 1 x: 1.82 y: 1.60 z: 0.60[m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
		Ingestion	Inhalation	Submersion
	[dpm/m2]	[mrem/dpm]	[mrem/dpm]	[mrem/yr/(dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.500E+05	2.167E-05	6.500E-05	1.434E-03
SR-90	1.500E+05	5.117E-05	2.692E-04	1.039E-05

Source: 2

Location:: Room : 1 x: 0.00 y: 1.60 z: 0.60[m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
		Ingestion	Inhalation	Submersion
	[dpm/m2]	[mrem/dpm]	[mrem/dpm]	[mrem/yr/(dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04

PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Source: 3
Location:: Room : 1 x: 0.92 y: 1.00 z: 0.60[m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Source: 4
Location:: Room : 1 x: 0.92 y: 2.20 z: 0.60[m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]

U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Source: 5
Location:: Room : 1 x: 0.92 y: 1.60 z: 0.00[m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Source: 6
Location:: Room : 1 x: 0.92 y: 1.60 z: 1.20[m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.100E+06	2.167E-05	6.500E-05	1.434E-03
SR-90	1.100E+06	5.117E-05	2.692E-04	1.039E-05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.82 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.500E+05
SR-90	1.500E+05

Source: 2
Location:: Room : 1 x: 0.00 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Source: 3
Location:: Room : 1 x: 0.92 y: 1.00 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Source: 4
Location:: Room : 1 x: 0.92 y: 2.20 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Source: 5
Location:: Room : 1 x: 0.92 y: 1.60 z: 0.00 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Source: 6
Location:: Room : 1 x: 0.92 y: 1.60 z: 1.20 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 1.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.100E+06
SR-90	1.100E+06

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Total
Receptor 1	4.69E-02	2.94E-01	3.07E-01	2.04E+00	5.74E-01	5.74E-01	3.83E+00
Total	4.69E-02	2.94E-01	3.07E-01	2.04E+00	5.74E-01	5.74E-01	3.83E+00

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.71E-02	3.79E-04	1.59E-06	7.95E-03	0.00E+00	1.46E-03
Total	3.71E-02	3.79E-04	1.59E-06	7.95E-03	0.00E+00	1.46E-03

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.58E-01	2.74E-03	1.15E-05	2.30E-02	0.00E+00	1.02E-02
Total	2.58E-01	2.74E-03	1.15E-05	2.30E-02	0.00E+00	1.02E-02

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.52E-01	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02
Total	2.52E-01	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.98E+00	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02
Total	1.98E+00	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	5.20E-01	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02
Total	5.20E-01	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02

Source: 6

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	5.20E-01	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02
Total	5.20E-01	4.17E-03	1.75E-05	3.51E-02	0.00E+00	1.55E-02

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	6.29E-03	6.29E-03
PA-231	9.64E-07	9.64E-07
AC-227	3.86E-08	3.86E-08
CS-137	3.73E-02	3.73E-02
SR-90	3.25E-03	3.25E-03

Source: 2

Nuclide	Receptor 1	Total
U-235	6.15E-03	6.15E-03
PA-231	9.63E-07	9.63E-07
AC-227	3.86E-08	3.86E-08
CS-137	2.64E-01	2.64E-01
SR-90	2.34E-02	2.34E-02

Source: 3

Nuclide	Receptor 1	Total
U-235	9.12E-03	9.12E-03
PA-231	1.47E-06	1.47E-06
AC-227	5.88E-08	5.88E-08
CS-137	2.63E-01	2.63E-01
SR-90	3.44E-02	3.44E-02

 Title : Worst Case 1
 Input File : site1.bld
 Evaluation Time: 0.00000000E+00 years

Source: 4

Nuclide	Receptor 1	Total
U-235	1.23E-02	1.23E-02
PA-231	1.48E-06	1.48E-06
AC-227	5.97E-08	5.97E-08
CS-137	1.97E+00	1.97E+00
SR-90	4.94E-02	4.94E-02

Source: 5

Nuclide	Receptor 1	Total
U-235	9.60E-03	9.60E-03
PA-231	1.47E-06	1.47E-06
AC-227	5.89E-08	5.89E-08
CS-137	5.28E-01	5.28E-01
SR-90	3.67E-02	3.67E-02

Source: 6

Nuclide	Receptor 1	Total
U-235	9.60E-03	9.60E-03
PA-231	1.47E-06	1.47E-06
AC-227	5.89E-08	5.89E-08
CS-137	5.28E-01	5.28E-01
SR-90	3.67E-02	3.67E-02

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 1.00000000 years

Assessment for Time: 2
Time =1.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.82 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.522E-01
AC-227	2.393E-03
CS-137	1.319E+05
SR-90	1.318E+05

Source: 2
Location:: Room : 1 x: 0.00 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.522E-01
AC-227	2.393E-03
CS-137	9.674E+05
SR-90	9.667E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 1.00000000 years

Source: 3
Location:: Room : 1 x: 0.92 y: 1.00 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.522E-01
	AC-227	2.393E-03
	CS-137	9.674E+05
	SR-90	9.667E+05

Source: 4
Location:: Room : 1 x: 0.92 y: 2.20 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.522E-01
	AC-227	2.393E-03
	CS-137	9.674E+05
	SR-90	9.667E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 1.00000000 years

Source: 5
Location:: Room : 1 x: 0.92 y: 1.60 z: 0.00 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.522E-01
	AC-227	2.393E-03
	CS-137	9.674E+05
	SR-90	9.667E+05

Source: 6
Location:: Room : 1 x: 0.92 y: 1.60 z: 1.20 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.522E-01
	AC-227	2.393E-03
	CS-137	9.674E+05
	SR-90	9.667E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 1.00000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Total
Receptor 1	3.43E-02	2.38E-01	2.33E-01	1.83E+00	4.81E-01	4.81E-01	3.30E+00
Total	3.43E-02	2.38E-01	2.33E-01	1.83E+00	4.81E-01	4.81E-01	3.30E+00

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 1.00000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.43E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.83E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.83E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	4.81E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	4.81E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 6

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	4.81E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	4.81E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 1.00000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	5.87E-04	5.87E-04
PA-231	5.28E-09	5.28E-09
AC-227	1.00E-09	1.00E-09
CS-137	3.34E-02	3.34E-02
SR-90	3.39E-04	3.39E-04

Source: 2

Nuclide	Receptor 1	Total
U-235	4.59E-04	4.59E-04
PA-231	3.43E-09	3.43E-09
AC-227	8.88E-10	8.88E-10
CS-137	2.36E-01	2.36E-01
SR-90	2.07E-03	2.07E-03

Source: 3

Nuclide	Receptor 1	Total
U-235	4.54E-04	4.54E-04
PA-231	3.37E-09	3.37E-09
AC-227	8.79E-10	8.79E-10
CS-137	2.31E-01	2.31E-01
SR-90	2.02E-03	2.02E-03

 Title : Worst Case 1
 Input File : site1.bld
 Evaluation Time: 1.00000000 years

Source: 4

Nuclide	Receptor 1	Total
U-235	3.47E-03	3.47E-03
PA-231	2.63E-08	2.63E-08
AC-227	6.74E-09	6.74E-09
CS-137	1.81E+00	1.81E+00
SR-90	1.59E-02	1.59E-02

Source: 5

Nuclide	Receptor 1	Total
U-235	9.09E-04	9.09E-04
PA-231	6.90E-09	6.90E-09
AC-227	1.76E-09	1.76E-09
CS-137	4.76E-01	4.76E-01
SR-90	4.16E-03	4.16E-03

Source: 6

Nuclide	Receptor 1	Total
U-235	9.09E-04	9.09E-04
PA-231	6.90E-09	6.90E-09
AC-227	1.76E-09	1.76E-09
CS-137	4.76E-01	4.76E-01
SR-90	4.16E-03	4.16E-03

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 10.0000000 years

Assessment for Time: 3
Time =1.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.82 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.521E+00
AC-227	2.182E-01
CS-137	1.071E+05
SR-90	1.064E+05

Source: 2
Location:: Room : 1 x: 0.00 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	1.521E+00
AC-227	2.182E-01
CS-137	7.858E+05
SR-90	7.802E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 10.0000000 years

Source: 3
Location:: Room : 1 x: 0.92 y: 1.00 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.521E+00
	AC-227	2.182E-01
	CS-137	7.858E+05
	SR-90	7.802E+05

Source: 4
Location:: Room : 1 x: 0.92 y: 2.20 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.521E+00
	AC-227	2.182E-01
	CS-137	7.858E+05
	SR-90	7.802E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 10.0000000 years

Source: 5
Location:: Room : 1 x: 0.92 y: 1.60 z: 0.00 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.521E+00
	AC-227	2.182E-01
	CS-137	7.858E+05
	SR-90	7.802E+05

Source: 6
Location:: Room : 1 x: 0.92 y: 1.60 z: 1.20 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	1.521E+00
	AC-227	2.182E-01
	CS-137	7.858E+05
	SR-90	7.802E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 10.0000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Total
Receptor 1	2.80E-02	1.94E-01	1.90E-01	1.49E+00	3.91E-01	3.91E-01	2.68E+00
Total	2.80E-02	1.94E-01	1.90E-01	1.49E+00	3.91E-01	3.91E-01	2.68E+00

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 10.0000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.94E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.94E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.49E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.49E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.91E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.91E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 6

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.91E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	3.91E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 10.0000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	5.87E-04	5.87E-04
PA-231	3.70E-08	3.70E-08
AC-227	4.33E-08	4.33E-08
CS-137	2.71E-02	2.71E-02
SR-90	2.73E-04	2.73E-04

Source: 2

Nuclide	Receptor 1	Total
U-235	4.59E-04	4.59E-04
PA-231	2.40E-08	2.40E-08
AC-227	3.83E-08	3.83E-08
CS-137	1.92E-01	1.92E-01
SR-90	1.67E-03	1.67E-03

Source: 3

Nuclide	Receptor 1	Total
U-235	4.54E-04	4.54E-04
PA-231	2.36E-08	2.36E-08
AC-227	3.80E-08	3.80E-08
CS-137	1.88E-01	1.88E-01
SR-90	1.63E-03	1.63E-03

 Title : Worst Case 1
 Input File : site1.bld
 Evaluation Time: 10.0000000 years

Source: 4

Nuclide	Receptor 1	Total
U-235	3.47E-03	3.47E-03
PA-231	1.84E-07	1.84E-07
AC-227	2.91E-07	2.91E-07
CS-137	1.47E+00	1.47E+00
SR-90	1.28E-02	1.28E-02

Source: 5

Nuclide	Receptor 1	Total
U-235	9.09E-04	9.09E-04
PA-231	4.83E-08	4.83E-08
AC-227	7.61E-08	7.61E-08
CS-137	3.86E-01	3.86E-01
SR-90	3.36E-03	3.36E-03

Source: 6

Nuclide	Receptor 1	Total
U-235	9.09E-04	9.09E-04
PA-231	4.83E-08	4.83E-08
AC-227	7.61E-08	7.61E-08
CS-137	3.86E-01	3.86E-01
SR-90	3.36E-03	3.36E-03

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 30.0000000 years

Assessment for Time: 4
Time =3.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.82 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	4.563E+00
AC-227	1.622E+00
CS-137	6.750E+04
SR-90	6.607E+04

Source: 2
Location:: Room : 1 x: 0.00 y: 1.60 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.20E+00 Width[m]:1.20E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	7.200E+03
PA-231	4.563E+00
AC-227	1.622E+00
CS-137	4.950E+05
SR-90	4.845E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 30.0000000 years

Source: 3
Location:: Room : 1 x: 0.92 y: 1.00 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	4.563E+00
	AC-227	1.622E+00
	CS-137	4.950E+05
	SR-90	4.845E+05

Source: 4
Location:: Room : 1 x: 0.92 y: 2.20 z: 0.60 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	4.563E+00
	AC-227	1.622E+00
	CS-137	4.950E+05
	SR-90	4.845E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 30.0000000 years

Source: 5
Location:: Room : 1 x: 0.92 y: 1.60 z: 0.00 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	4.563E+00
	AC-227	1.622E+00
	CS-137	4.950E+05
	SR-90	4.845E+05

Source: 6
Location:: Room : 1 x: 0.92 y: 1.60 z: 1.20 [m]
Geometry:: Type: Area Length[m]:1.83E+00 Width[m]:1.20E+00 Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::	Nuclide	Concentration [dpm/m2]
	U-235	7.200E+03
	PA-231	4.563E+00
	AC-227	1.622E+00
	CS-137	4.950E+05
	SR-90	4.845E+05

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 30.0000000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Source 6	Total
Receptor 1	1.79E-02	1.22E-01	1.20E-01	9.39E-01	2.46E-01	2.46E-01	1.69E+00
Total	1.79E-02	1.22E-01	1.20E-01	9.39E-01	2.46E-01	2.46E-01	1.69E+00

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 30.0000000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.79E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.79E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.22E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.22E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	1.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	9.39E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	9.39E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.46E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.46E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Source: 6

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.46E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	2.46E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Title : Worst Case 1
Input File : site1.bld
Evaluation Time: 30.0000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	5.87E-04	5.87E-04
PA-231	1.07E-07	1.07E-07
AC-227	3.02E-07	3.02E-07
CS-137	1.71E-02	1.71E-02
SR-90	1.70E-04	1.70E-04

Source: 2

Nuclide	Receptor 1	Total
U-235	4.59E-04	4.59E-04
PA-231	6.98E-08	6.98E-08
AC-227	2.67E-07	2.67E-07
CS-137	1.21E-01	1.21E-01
SR-90	1.04E-03	1.04E-03

Source: 3

Nuclide	Receptor 1	Total
U-235	4.54E-04	4.54E-04
PA-231	6.84E-08	6.84E-08
AC-227	2.65E-07	2.65E-07
CS-137	1.18E-01	1.18E-01
SR-90	1.01E-03	1.01E-03

 Title : Worst Case 1
 Input File : site1.bld
 Evaluation Time: 30.0000000 years

Source: 4

Nuclide	Receptor 1	Total
U-235	3.47E-03	3.47E-03
PA-231	5.35E-07	5.35E-07
AC-227	2.03E-06	2.03E-06
CS-137	9.28E-01	9.28E-01
SR-90	7.96E-03	7.96E-03

Source: 5

Nuclide	Receptor 1	Total
U-235	9.09E-04	9.09E-04
PA-231	1.40E-07	1.40E-07
AC-227	5.30E-07	5.30E-07
CS-137	2.43E-01	2.43E-01
SR-90	2.09E-03	2.09E-03

Source: 6

Nuclide	Receptor 1	Total
U-235	9.09E-04	9.09E-04
PA-231	1.40E-07	1.40E-07
AC-227	5.30E-07	5.30E-07
CS-137	2.43E-01	2.43E-01
SR-90	2.09E-03	2.09E-03

Title : Worst Case 1
Input File : site1.bld
Full Summary

RESRAD-BUILD Dose (Time) Tables

Receptor Dose Received for the Exposure Duration

(mrem)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	3.83E+00	3.30E+00	2.68E+00	1.69E+00

Receptor Dose/Yr Averaged Over Exposure Duration

(mrem/yr)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	3.83E+00	3.30E+00	2.68E+00	1.69E+00

Appendix E
Results from RESRAD-BUILD
Worst Case Scenario 2

Title : Worst Case 2 - Grind
Input File : site1.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 1.000000E+00 days
Fraction Inside : 5.000000E-01

Receptor Information

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	1.000	1.000	1.000	0.500	1.80E+01	1.00E-04

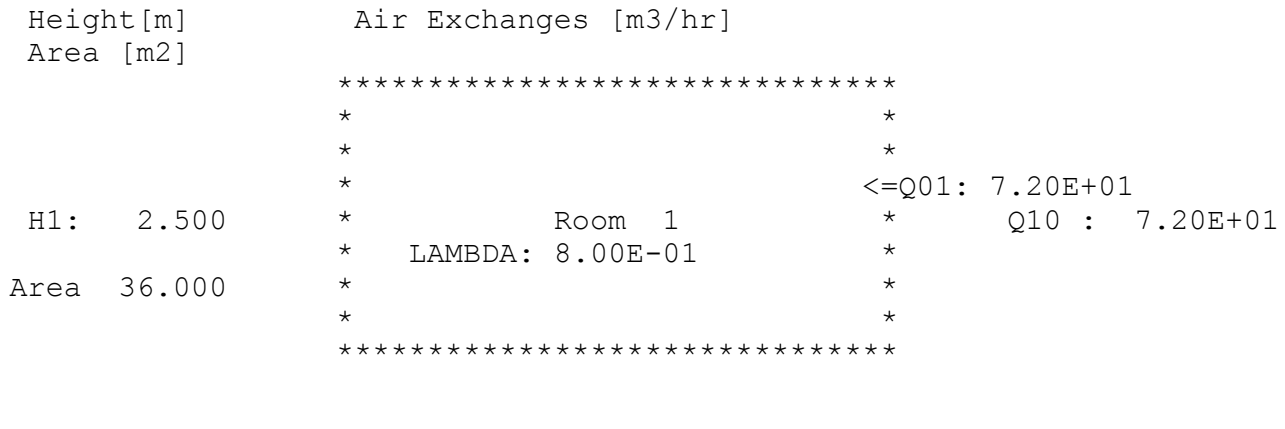
Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete

Title : Worst Case 2 - Grind
Input File : site1.bld

Building Information

Building Air Exchange Rate: 8.00E-01 1/hr



Deposition velocity: 1.00E-02 [m/s] Resuspension Rate: 5.00E-07 [1/s]

Source Information

Source: 1
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00[m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 1.000E-01 [1/hr]
Fraction released to air: 5.000E-01
Removable fraction: 1.000E+00
Time to Remove: 2.500E-01 [day]

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: ICRP 72 (Adult))		
	[dpm/m2]	Ingestion [mrem/dpm]	Inhalation [mrem/dpm]	Submersion [mrem/yr/ (dpm/m3)]
U-235	8.000E+03	7.890E-05	1.417E-02	4.063E-04
PA-231	0.000E+00	1.183E-03	2.333E-01	9.049E-05
AC-227	0.000E+00	2.015E-03	9.476E-01	9.734E-04
CS-137	1.500E+05	2.167E-05	6.500E-05	1.434E-03
SR-90	1.500E+05	5.117E-05	2.692E-04	1.039E-05

Title : Worst Case 2 - Grind
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Assessment for Time: 1
Time =0.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 1.000E-01 [1/hr]
Fraction released to air: 5.000E-01
Removable fraction: 1.000E+00
Time to Remove: 2.500E-01 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	8.000E+03
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	1.500E+05
SR-90	1.500E+05

Title : Worst Case 2 - Grind
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	1.16E+00	1.16E+00
Total	1.16E+00	1.16E+00

Title : Worst Case 2 - Grind
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	5.49E-05	1.77E-02	4.61E-05	2.29E-01	0.00E+00	9.09E-01
Total	5.49E-05	1.77E-02	4.61E-05	2.29E-01	0.00E+00	9.09E-01

Title : Worst Case 2 - Grind
Input File : site1.bld
Evaluation Time: 0.00000000E+00 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-235	2.10E-01	2.10E-01
PA-231	3.23E-08	3.23E-08
AC-227	1.17E-12	1.17E-12
CS-137	2.86E-01	2.86E-01
SR-90	6.59E-01	6.59E-01

Title : Worst Case 2 - Grind
Input File : site1.bld
Evaluation Time: 1.00000000 years

Assessment for Time: 2
Time =1.00E+00 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 1.000E-01 [1/hr]
Fraction released to air: 5.000E-01
Removable fraction: 0.000E+00
Time to Remove: 2.500E-01 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	0.000E+00
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	0.000E+00
SR-90	0.000E+00

Title : Worst Case 2 - Grind
Input File : site1.bld
Evaluation Time: 10.0000000 years

Assessment for Time: 3
Time =1.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 1.000E-01 [1/hr]
Fraction released to air: 5.000E-01
Removable fraction: 0.000E+00
Time to Remove: 2.500E-01 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	0.000E+00
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	0.000E+00
SR-90	0.000E+00

Title : Worst Case 2 - Grind
Input File : site1.bld
Evaluation Time: 30.0000000 years

Assessment for Time: 4
Time =3.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 1.30 y: 1.00 z: 1.00 [m]
Geometry:: Type: Area Length[m]:1.00E+00 Width[m]:1.00E+00 Direction: x
Pathway ::
Direct Ingestion Rate: 1.000E-01 [1/hr]
Fraction released to air: 5.000E-01
Removable fraction: 0.000E+00
Time to Remove: 2.500E-01 [day]

Contamination::

Nuclide	Concentration [dpm/m2]
U-235	0.000E+00
PA-231	0.000E+00
AC-227	0.000E+00
CS-137	0.000E+00
SR-90	0.000E+00

Title : Worst Case 2 - Grind
Input File : site1.bld
Full Summary

RESRAD-BUILD Dose (Time) Tables

Receptor Dose Received for the Exposure Duration

(mrem)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	1.16E+00	0.00E+00	0.00E+00	0.00E+00

Receptor Dose/Yr Averaged Over Exposure Duration

(mrem/yr)

	Evaluation Time [yr]			
	0.00E+00	1.00E+00	1.00E+01	3.00E+01
1	4.22E+02	0.00E+00	0.00E+00	0.00E+00