START

DOCUMENT CLEARANCE REQUEST

START

Part 1 – Issuing Manager's Approval 80

SECTION 1 – Clearance Information

1. Date Clearance Required	2. Document Identification	3. Previous Document Identification
June 19, 1989	WHC-SA-0503FP	WHC-SA-0503A

3. Title (Include UC Category)	4. Author's Name(s)	5. Phone	6. MSIN
Control of Tritium at the FFTF	P. R. Prevo	6-5667	N1-73

7. Desired Clearance/Release: Public Clearance ☐ Open Literature ☒ Oral Public; Limited Clearance ☐ Applied Technology ☐ Foreign Exchange; DOE Directed Release ☐ FOIA ☐ Media ☐ Other

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9. Meeting Name, Location, Date: 34th Annual Meeting of the Health Physics Society, June 25-29, 1989, Albuquerque, NM

10. ☐ To Be Published in Journal ☒ Handouts for Attendees Official Publishing Month:

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Document is approved as conforming to all applicable requirements. The above information is certified to be correct.

	23. Author	Immediate Manager	Issuing Manager (Level III)	24. Date
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DOCUMENT CLEARANCE REQUEST
Part 2 – Clearance Reviews and Approvals

Document Identification: WHC-SA-0503FP

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Reviewer	Required (✓ if yes)	Approve Yes	Approve No	Mandatory Changes Yes	Mandatory Changes No	See Remarks (✓ if yes)	Signature	Date
Publications Services	✓	✓					Carolyn Wheelwright	6/22/89
WHC Classification	✓	✓			✓	*	MA Williams	6/20/89
WHC Patent/Legal	✓	✓			✓		JE Bergdin	6/21/89
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Westinghouse Corporate	N/A						[illegible]	6/21/89
WHC Public Relations	✓	✓					Jean McKenna	6/21/89
References	✓	✓					Carolyn Wheelwright	6/22/89
WHC Int. Prog. Coord.	✓	✓			✓		JH Watkins	6/13/89
WHC Prog. Office/or Working Group Rep.	✓						DJ Newland	6-14-89
DOE Program Sponsor	✓						D Braun	6-19-89
DOE Working Group Chairman	✓						D Braun for MKK	6-19-89

Working Group Name: FFTF – Plant Experience

Remarks: * Not UCNI – MA Williams 6/20/89

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Date Request Received: 5-26-89 DOE F 1332.15 Form Date: 7/7/89

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Location (city/st/ctry) ALBUQUERQUE, NEW MEXICO
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Control of Tritium at the Fast Flux Test Facility

P. R. Prevo

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CONTROL OF TRITIUM AT THE FAST FLUX TEST FACILITY

INTRODUCTION

The Fast Flux Test Facility (FFTF) is located on the Hanford Site near Richland, Washington, and is operated by the Westinghouse Hanford Company for the U.S. Department of Energy (DOE). The facility features a 400 MW(t) three-loop sodium-cooled, mixed-oxide-fueled reactor that was designed for irradiation testing of fuels and materials to support the commercial development of liquid metal fast reactors. The mission has subsequently been expanded to include a passive safety test program, irradiation of fusion and space reactor materials, and isotope production.

The FFTF has been in operation for about 7 yr, which includes over 1,600 d of full power operation of the fast test reactor (FTR). Radiological operating experience at the FFTF has been excellent. Collective dose equivalents received by operating personnel have been very low (5 person-rem/yr average). No major contamination problems have been encountered in operating and maintaining the plant, and release of radioactivity to the environment has been well below acceptable limits (Bunch and Prevo 1987). Skin contamination events have averaged less than two per year. There have been no internal depositions.

This paper discusses the generation, transport and distribution, and radiological aspects of tritium control at the FFTF.

TRITIUM GENERATION

Tritium is a byproduct of fission and activation and is not purposely generated in the FFTF, except during experimental irradiation of some fusion materials. The three main methods of tritium generation in the FFTF are ternary fission in fuel, neutron reaction with boron in control rods, and neutron reaction with lithium in fuel. Table 1 shows the calculated tritium generation in the FFTF.

Table 1. Tritium Generation in the Fast Flux Test Facility.

Source	Curies per full power day*
B_4C control rods**	6.7
Ternary fission	6.6
Lithium impurities in fuel	3.6
Test assemblies	2.3
Safety rods	0.7
Lithium impurities in sodium	0.2
Boron impurities in fuel	0.0
Total	20.0

*Upper limit values.
**Average over cycle.

TRITIUM TRANSPORT AND DISTRIBUTION

The following discussion on tritium transport refers to Figure 1 that shows, greatly simplified, one of the three sodium cooling circuits of the FFTF heat transport system. Argon is used as a cover gas in both the primary and secondary sodium cooling circuits.

The high mobility and small atomic size of tritium allows it to diffuse readily through many solid materials. A fraction of the tritium generated in fuel and control assemblies diffuses through the stainless steel cladding into the primary sodium coolant. Once in the primary coolant, the tritium diffuses through the intermediate heat exchanger (IHX) to the secondary coolant. From there it can diffuse through the dump heat exchangers (DHX) to the atmosphere. Small amounts of tritium also diffuse through the walls of the primary and secondary piping to surrounding cells, where it is eventually released to the atmosphere.

A high percentage of the tritium generated in the fuel (95 to 99%) escapes mixed oxide fuel clad with stainless steel (Wozadlo, Rubin, and Roy 1972). A high percentage (~80%) of tritium is retained in B_4C control rods (Hollenberg 1977). Approximately 70%, or 14 Ci of tritium enters the primary sodium per day. Of the 14 Ci/d entering the primary sodium, most, ~11 Ci/d, is removed by precipitation as sodium tritide in the primary sodium cold trap. About 3 Ci/d enters the secondary sodium. Of the 3 Ci/d entering the secondary sodium, essentially all is removed by the three secondary sodium cold traps, 1 Ci/d by each cold trap. Less than 0.1 Ci/d diffuses through the piping and the DHXs to be released to the environment. Tritium distribution is summarized in Table 2. The oxide film on stainless steel exposed to oxidizing atmospheres significantly retards tritium penetration. This effect should reduce the diffusion of tritium through the primary and secondary sodium pipes and limit release to the atmosphere by this pathway.

Levels of tritium in the primary sodium are low compared with levels of activation products. Hence, standard procedures required to control personnel exposure and contamination are adequate for tritium. However, tritium is the only radionuclide transferred to secondary sodium and is the only reason for imposing radiological controls on that system. Tritium in the primary sodium range from about 300 to 400 nCi/g of sodium. Levels in the primary sodium cover gas range from about 40 to 70 pCi/cm^3. Levels in the secondary sodium range from about 50 to 130 nCi/g of sodium and from about 8 to 14 pCi/cm^3 in the secondary cover gas. Radiological controls are required if the specific activity exceeds 2 nCi/g. Hence, the transfer of tritium into the secondary sodium results in the need to impose radiological controls on an otherwise nonradioactive system.

Measured tritium levels in the primary and secondary sodium are consistent with calculated results. Calculated levels range from 160 to 520 nCi/g of primary sodium and 10 to 100 nCi/g of secondary sodium. The lower values correspond to a cold trap efficiency of 73% and the higher values to a 20% cold trap efficiency.

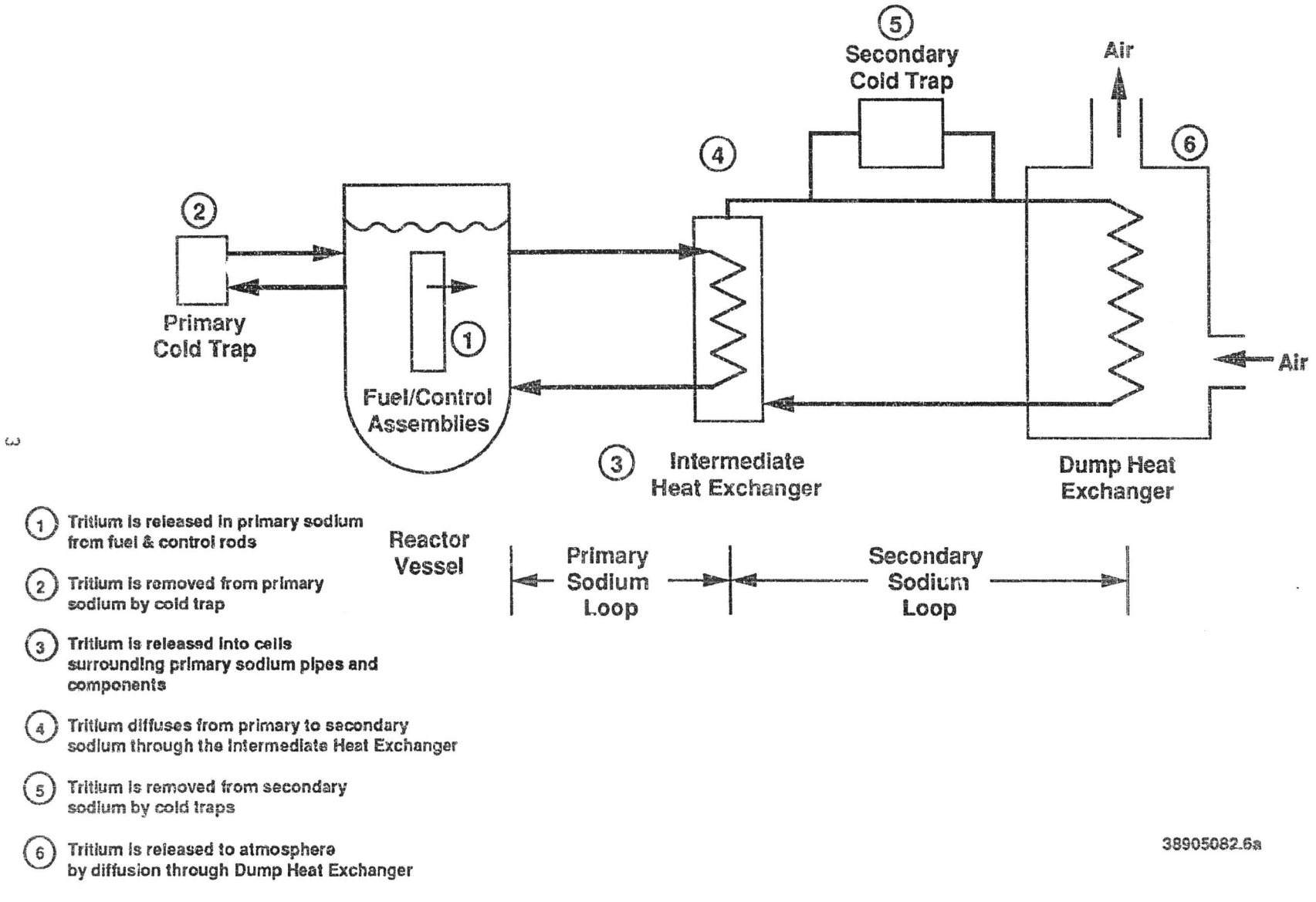

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Figure 1. Fast Flux Test Facility Heat Transport System Sodium Cooling Circuit.

Table 2. Tritium Distribution in the Fast Flux Test Facility.

Source	Curies per full power day
Generated	20
Entering primary sodium	14
Removed by primary sodium cold trap	11
Removed by secondary sodium cold traps	3
Released to atmosphere	<0.1

TRITIUM AND RADIOACTIVE WASTE

Tritium-contaminated waste does not add significantly to the volume or cost of handling and disposal of radioactive waste generated during operation of the FFTF. However, tritium-contaminated waste will be of concern during decontamination and decommissioning activities, principally in conjunction with disposal of the primary and secondary sodium cold traps.

No tritium-contaminated solid waste requiring disposal has been generated at the FFTF. However, as discussed above, tritium is accumulating in the sodium coolant cold traps, which will require disposal. The cold traps are designed for the life of the plant and could, therefore, contain several thousand curies of tritium. Plans and procedures will have to be developed during decontamination and decommissioning activities to ensure safe handling and disposal of these components.

There are no radioactive liquid waste streams from the FFTF to the environment. However, small volumes of liquid waste contaminated with tritium are generated in the plant. Small volumes of water condensed by coolers that remove heat from cells surrounding the primary sodium components and piping are contaminated with low levels of tritium. About 10 gal of water with a maximum tritium concentration of 300 nCi/g are generated per year. This waste is transferred to the plant radioactive liquid waste system. This represents a small addition to the approximately 6,000 gal/yr of radioactive liquid waste generated at the FFTF that is transferred to the radioactive waste processing facilities located in another area of the Hanford Site.

Calculations, discussed earlier, show that <0.1 Ci of tritium per day is released to the environment. Results of all effluent air samples have shown tritium concentrations below minimum detection levels, which is consistent with the calculated 0.1 Ci/d release rate. Effluent air concentrations are at least two orders of magnitude below uncontrolled area concentration guides. The calculated offsite maximum individual whole body dose, as a result of this release rate, is <0.001 mrem/yr, which is not of environmental concern. Results of environmental air samples taken near the FFTF and analyzed for tritium have shown no increase above normal atmospheric levels of about 2 pCi/m^3.

TRITIUM AND PERSONNEL EXPOSURE

No internal tritium depositions have occurred at the FFTF. Results of in-plant air samples, except those taken in the cells surrounding the primary sodium pipes and components, have shown tritium concentrations below minimum detection levels. The cells surrounding the primary sodium piping and components are inerted with nitrogen during reactor operation as a precaution against sodium fires. These cells are purged with air before personnel entry and are well ventilated during personnel access, which reduces tritium air concentrations well below derived air concentration (DAC) levels. Results of air samples taken in cells surrounding the primary sodium pipes and components have shown tritium concentrations up to 1×10^{-6} $\mu Ci/cm^3$. This is one thirtieth of the DAC value of 3×10^{-5} $\mu Ci/cm^3$. As discussed earlier, the secondary sodium is contaminated with low levels of tritium. The primary concern is contamination control. Due to the low specific activity, quantities of sodium with enough tritium to be of concern are visible. Thus, instrument survey in the field is not necessary. Good housekeeping, periodic wipe tests, and minimal protective clothing are adequate to ensure contamination control.

The combination of low personnel occupancy and low tritium concentration in the cells surrounding the primary sodium pipes and components has resulted in no detectable (<10 mrem) personnel exposures.

CONCLUSIONS

Essentially all of the approximately 20 Ci/d of tritium generated is contained in the sodium heat transport system. Less than 0.1 Ci/d is released from the heat transport system to cause potential personnel exposure and environmental concerns. Only minor radiological control concerns have resulted. No detectable personnel exposures or environmental releases have occurred.

REFERENCES

Bunch, W. L. and P. R. Prevo, 1987, "Radiological Operating Experience," in *International Conference on Fast Breeder Systems*, American Nuclear Society, 12.20-1-5, Richland, Washington.

Hollenberg, G. W., 1977, *Tritium Release from Fast Neutron Irradiated Boron Carbide*, HEDL-SA-1164-FP, Hanford Engineering Development Laboratory, Richland, Washington.

Wozadlo, G. P., B. F. Rubin, and P. Roy, 1972, *Tritium Analysis of Mixed Oxide Fuel Rods Irradiated in a Fast Flux*, GEAP-13864, General Electric Co., Sunnyvale, California.

Control of Tritium at the Fast Flux Test Facility

P.R. Prevo

Westinghouse Hanford Company
Richland, Washington

Outline

- Radiological and Environmental Protection Experience
- Tritium Generation
- Tritium Transport and Distribution
- Tritium and Radioactive Waste
- Tritium and Personnel Exposure

38905082.2M

Radiological and Environmental Protection Experience

- Experience has been excellent.
- Total personnel exposure has averaged 5 person-rem/yr.
- There have been no internal depositions.
- Skin contaminations have averaged less than two per year.
- Street clothes are worn in most areas of plant.

38905082.3M

Tritium Generation

- Tritium is a byproduct of fission and activation, not purposely generated

- Generation by
  - Ternary fission
  - Boron in control rods
  - Lithium in fuel

38905082.4M

Tritium Generation in the Fast Flux Test Facility

Source	Curies per Full Power Day
B_4C Control Rods	6.7
Ternary Fission	6.6
Lithium Impurities in Fuel	3.6
Test Assemblies	2.3
Safety Rods	0.7
Lithium Impurities in Sodium	0.2
Boron Impurities in Fuel	0.0
Total	20

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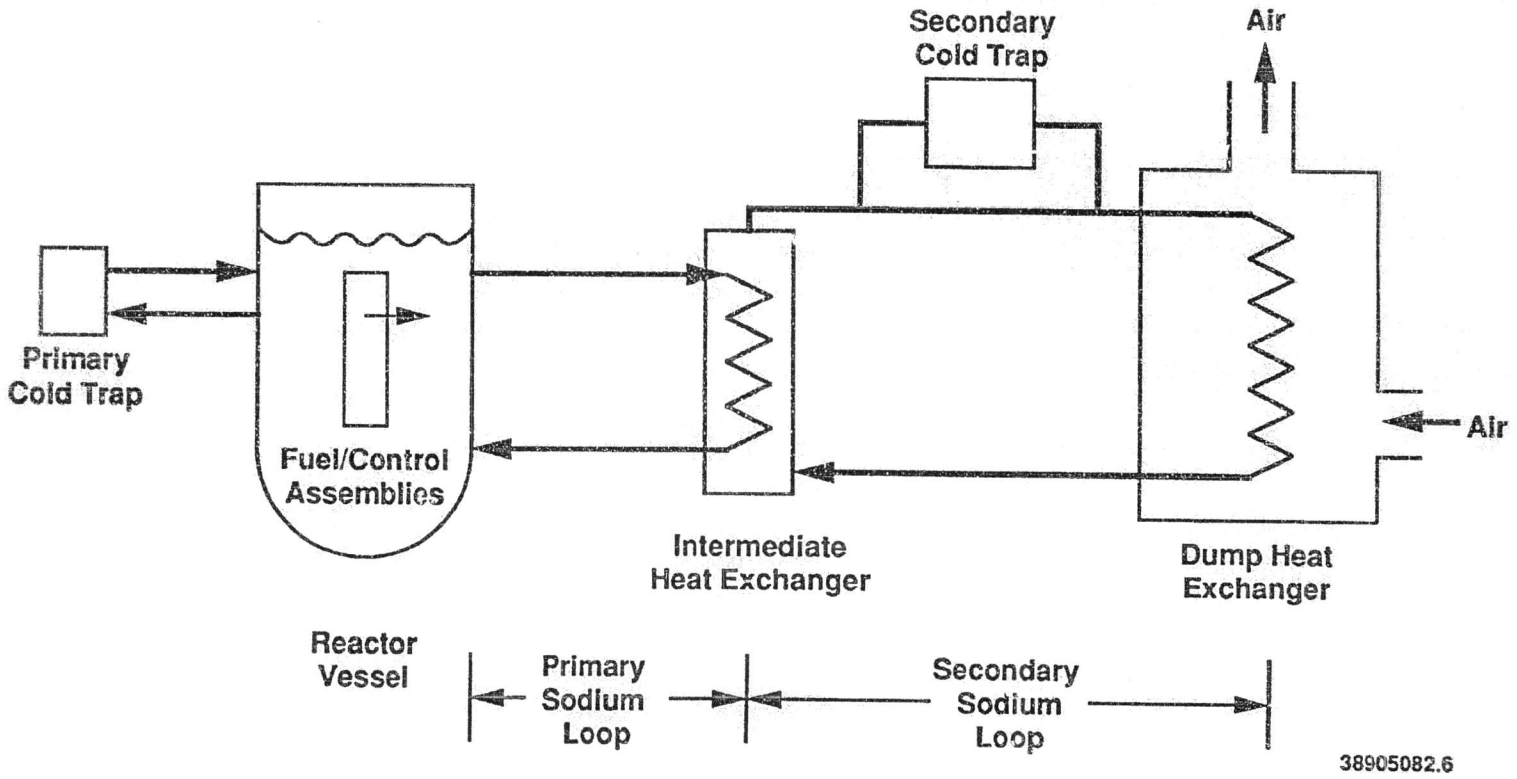

Tritium Distribution in the Fast Flux Test Facility

Source/Location	Curies per Full Power Day
Generated	20
Entering Primary Sodium	14
Removed by Primary Sodium Cold Trap	11
Removed by Secondary Sodium Cold Traps	3
Released to Atmosphere	<0.1

38905082.7M

Tritium Concentrations

Location	Concentration
Primary Sodium	300-400 nCi/g
Primary Cover Gas	40-70 pCi/cm^3
Secondary Sodium	50-130 nCi/g
Secondary Cover Gas	8-14 pCi/cm^3

38905082.8M

Tritium and Radioactive Waste

- Solid
  - No routine waste
  - Cold traps will be of concern during decontamination and decommissioning
  - Up to several thousand curies in each cold trap
- Liquid
  - Very little generated (10 gal/yr)
  - 300 nCi/g
  - No significant impact
- Gas
  - All effluent air sample results for ^{3}H less than detectable
  - Release <0.1 Ci/d
  - Dose <0.001 mrem/yr to maximum offsite individual

038905082.9M

Tritium and Personnel Exposure

- No detectable personnel exposures from tritium (<10 mrem)
- Only measurable air concentrations in cells surrounding primary sodium components
- Cells ventilated before entry
- Entry infrequent
- Standard contamination control procedures adequate for tritium

38905082.10M

Summary

- Essentially all 20 Ci/d of tritium contained
- <0.1 Ci/d released – not detectable
- Minor contaminated waste and contamination concerns
- No detectable personnel exposures

38905082.11M