Responses to Action Items Introduced During the Mound Work Group Meeting of June 5, 2012

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Background and Summary:

In the DOE defense programs there was an effort to produce stable compounds of tritium (i.e., materials that would effectively bind tritium without decomposing or degassing) by combining tritium with various metals. Mound was involved with these programs and thirty-one (31) different tritide compounds were investigated in the 1960s and 70s (Ref. #6, SRDB Ref. ID #39682). Because of the chemical reactivity of hydrogen, many of the compounds were "reactive" and basically chemically unstable in so far as they would readily disassociate and release the tritium (hydrogen). In addition, the handling of tritium resulted in the creation of compounds of tritium with other materials present in the workplace, such as organically bound tritium (OBT), and other non-metallic materials. The "reactivity" of these compounds was variable for different compounds, ranging from readily soluble to functionally "stable" in body fluids (water, etc.). Thus the term Stable Metal Tritides (SMT) has meaning as it relates to the chemical stability of some metal tritides, although many of the metal tritides fall in the "reactive" range.

The term SMT also has a dosimetric significance due to the difficulties of performing internal dosimetry following intake of these particles. Tritium is a unique element due to its high chemical reactivity and its very low maximum energy beta emission of approximately 19 keV. The very low energy beta particles require special counting capabilities, such as Liquid Scintillation Counting, and the metallic compound particles of which the tritium is a part are an effective shield in preventing many of the betas from depositing energy in the cells of the body. Hence there is uncertainty of detection and dosimetry of the tritium in these particles in the body. Elemental tritium and reactive compounds of tritium are readily absorbed in body fluids and become systemic, and are also readily eliminated through urine and other body excretions, which are easily analyzed by a liquid scintillation counter (LSC), while tritium as an SMT is not (at least not while it is bound in the tritide particle). Even the materials identified as SMT are fundamentally insoluble to varying degrees, with urinary elimination patterns specific to each SMT material.

Further uncertainties result from the fact that SMT materials were never present in the work place alone, i.e. there were always reactive tritium compounds present in the SMT work zone, making straightforward interpretation of the class of tritium compounds in the body uncertain. Hence interpretation of internal dose from the urine samples, air samples or any of the standard internal dosimetry analytical tools is problematic due a number of uncertainties.

The relatively small quantities of SMT materials present at any given time compared to other sources of free tritium or reactive compounds, coupled with the need to control the metal tritides as classified materials, reduced the exposure potential. The review of the uncertainties associated with possible SMT exposure has resulted in questions from the Mound Working Group of the ability of NIOSH to bound the doses from these sources in the facilities in which they were handled/processed. These difficulties and uncertainties were known through the years and documented in the internal Technical Basis Document and other publications in the 1990s.

NIOSH Approach:

SC&A (Ref. #10 and #11) has reviewed the stated uncertainties and has raised questions regarding NIOSH's approach and conclusions in the reconstruction of tritides. This paper addresses these concerns and presents an approach to conservatively bound the internal dose to those individuals who might have been exposed to the SMT of interest (compound identified at the most insoluble/stable).

In addition to the urine sampling program, air sampling and smear survey results were always a part of the radiological control programs at Mound for tritium detection and analyses. The survey data from these control activities provide a database from which to develop bounding estimates of maximum internal dose.

NIOSH has determined the approach to bound the potential doses to ancillary workers in the facilities in which SMTs may be present is to utilize the large number of smear samples, which were routinely taken in the facilities. Using these smears, NIOSH will then make a number of conservative assumptions related to calculating worker intakes and resulting bounding internal doses, as stated below:

1. The bounding doses will be applied to all ancillary workers who were monitored for tritium exposure at Mound. The primary workers (operational and scrap recovery) involved with the SMT of interest are known and their doses will be determined through dose reconstruction using urine bioassay results.
2. The bounding dose to all support and ancillary workers will be the 95th percentile doses estimated by using the data from the tritium smears.
3. It will be assumed that all the tritium on the smears were from SMT materials of interest.
4. A conservative resuspension factor is chosen to derive the work place air concentrations expected.
5. Workers are assumed to be exposed continuously for their entire work periods.
6. Doses from SMT of interest materials will be calculated as described in the NIOSH model and/or other approved dose calculation methodologies.
7. Gaps in the smear data will be assumed to be continuous concentrations determined from prior and post gap periods.
8. Doses will be calculated from the SMT of interest using the NIOSH model and assign the 95th percentile doses to all monitored workers.

NIOSH's position is that doses to support and ancillary workers, from possible exposure to the SMT of interest, can be bounded using the swipe data. The model uses measured surface contamiantion data from rooms at Mound where the work on the SMT of interest was conducted and uses these contamination levels as if it were 100% of the SMT of interest. It is assumed that any resuspended material was breathed in by workers as an intake of the SMT material of interest. It must be noted that with the exception of two well known accidental exposures, Mound never handled this material outside containment. The assumption is that the tritium measured on swipes is 100% SMT's which is very conservative and bounding. These estimated intakes are then used to calculate doses to the worker. .

SC&A (Ref. #10 and #11) has questioned the use of swipe data because it is not 100% contiguous over the entire operational and D&D periods of time. Interviews with the research chemists and radiological health personnel that have firsthand knowledge of the operations were specifically asked if any working situations occurred or they were made aware of that would have caused the missing swipe data to be different than the data on either side of the gap. The overall agreement was the data from both sides of the gaps should be adequate to extrapolate the data within the gaps. To confirm that workers did not have significantly elevated potential for erxposure during the gap periods, the bioassay data over these time periods was examined. The bioassay data suggest that the there were no unusual events that resulted in increased tritium uptake by workers. NIOSH believes that the swipe data can be used to reconstruct exposures to the tritides of interest and that these resulting doses are adequately and conservatively bounded (see resosne 1c below for additional discuission on this topic).

The following discussion responds to the four action items raised during the June 5, 2012 working group meeting for the Mound SEC petition evaluation. The action items #1 (a-d) were developed during the discussion of NIOSH's paper, *Potential Stable Metal Tritide Exposures at the Mound Laboratory, Rev. 0* issued on March 14, 2012.

(1a) Address treatment of uncertainties in the tritide model (e.g., 50th vs. 95th percentile) distribution and review SC&A's treatment.

Treatment of Uncertainty

SC&A's evaluation (Ref. #10 and #11) of the variables and uncertainties associated with NIOSH's approach to the reconstruction of tritide dose for support staff workers at Mound (i.e., those not directly involved in the handling of highly insoluble stable metal tritides) raises two major points. The first of these is the uncertainly associated with the parameters used in the dose calculation. The SC&A review systematically evaluated uncertainty in the 6 variables used in the calculation of dose. The main conclusion derived from this review is that the dose calculation is most impacted by the choice of the resuspension factor and the dose conversion factor (DCF). It should be pointed out that the selection of input parameter values is a site profile issue, assuming that one accepts the fundamental intake model put forth by NIOSH. NIOSH would like to address several of the comments made regarding several of the parameters.

While NIOSH acknowledges that each parameter in the dose calculation equation carries an inherent uncertainty, we maintain that it is not reasonable to employ worst case assumptions for each of these variables. The rationale for this lies in the bounding nature of the methodology itself. NIOSH will use the 95th percentile value[1] to establish an intake and assumes that all the activity measured on the smear samples is due entirely to the presence of a highly insoluble metal tritide. This is certainly a considerable overestimate, as there were only two known contamination incidents involving the least soluble tritide compound. This use of reasonable input parameters (or claimant favorable values when two equally plausible alternatives exist) is consistent with how other bounding models using the 95th percentile have been developed. The dose calculated in this manner, will be entered into IREP as a constant value.

Because SC&A specifically questioned the reasonableness of NIOSH's resuspension factor (RF) of 5E-05/m (SC&A report, section 4.3 (Ref. #10), a separate discussion of this input parameter is warranted. This report recommends that the value used by NIOSH should be increased by "about a factor of 5" to account for the fact that the RF's cited in various source documents are not based on removable smear data but on total surface contamination measurements. In fact, the logic behind the recommendation contained in NUREG/CR-5512 states:

> *The parameter RF_0 is therefore assumed to describe loose (resuspendable) contamination and the licensee can reduce this value by demonstrating that the fraction of loose contamination at their facility is less than a specified fraction of total contamination.*

Further, a distinction must be made between the application of an acute and a chronic resuspension factor. NIOSH is applying an acute resuspension factor to a chronic exposure situation. This assumes that not only was the worker in the area containing the 95th percentile contamination for every work hour of the year, but also assumes that the material was disturbed by moderate work activity over the entire time period. For these reasons, NIOSH believes that our proposed value of 5E-05/m is appropriate.

<u>Use of the 95th percentile values</u>

As mentioned above, NIOSH proposes that for all workers who could have been exposed to insoluble metal tritides the 95th percentile smear data will be used to bound intakes. For those workers who have tritium bioassay data, the dose to the affected organ will be calculated

[1] While the tritide white paper, issued on March 14, 2012, provided values using the 50th and 95th percentile, NIOSH has decided to use the 95th percentile surface contamination values to bound tritide intakes.

assuming the bioassay data represents exposure to soluble tritium and then compared to the dose estimated using the tritide model. The higher of these two doses will be used in the dose reconstruction. For most cases evaluated up to 1980 (where an SEC class already exists for those monitored for tritium) it is quite likely that, for non-presumptive cancers, the bounding dose will be that based on urine data.

In section 4.1.3 of SC&A's reports (Ref. #10 and #11), SC&A points out some logical inconsistency in the calculation of annual doses. The inconsistency centered on monthly data missing in the annual doses. The annual doses failed to account for the gaps in the data. NIOSH acknowledges this shortcoming and agrees that an approach similar to that described by equation 4.5-1 (Ref. #10 and #11) would be appropriate.

(1b) Ascertain the identity of the small number of operator and scrap recovery workers post 1980. Under what conditions were the SMT's of interest used after 1980?

The identities of the small number of research (operational) and scrap recovery workers are known (Ref. #3, SRDB #107797 and Ref. #12, SRDB #55962). Based on documented interviews with personnel associated with research and scrap recovery operations, and in Mound progress reports the SMT of interest was processed in the scrap recovery line only in 1984 (Ref. #3, SRDB #107797).

Some clarification of tritide terminology is in order. Technically, a metal tritide compound is any compound that is chemically formed stoichiometrically by the chemical combination of a metal and tritium atoms. As different metal tritiated compounds are produced they exhibit different physical and chemical properties. Most metal tritides are reactive compounds and are not stable. The primary ones of interest to the DOE have been lithium and uranium tritides. These compounds react readily with air, water and bodily fluids and are quite soluble and adequately monitored via urine bioassay analyses. Reactive types of metal tritides are not "stable metal tritides". Stable metal tritides are ones that are non-reactive in that they do not oxidize easily nor are they pyrophoric and are insoluble in water and body fluids. Other non-metal tritides provided, by far, more potential for exposures included T_2, HTO and OBT and are monitored easily by urine bioassay (Ref. #1, SRDB # 116978). The stable metal tritides of interest worked at Mound are the ones that NIOSH will use to bound doses. The quantities of these compounds used at Mound were trivial in comparison to the more common, but reactive, tritide compounds (e.g. lithium and uranium tritides).

The tritium bioassay program requirements were driven by the soluble forms of tritium worked at the plant and not the SMT forms since the soluble forms represented the much greater hazard to workers (Ref. #9, SRDB #107056 and Ref. #2, SRDB #108244). Over Mound's history of working with the SMT of interest, two incidents (Ref. #12, SRDB #55962 and Ref. #4, #48837) occurred, one during the 1970s and the other in 1993 that resulted in direct exposures to two workers.

(1c) Address identified gaps in available swipes. What work (if any) was being performed during the gap periods?

The developmental and production work with the SMT of interest occurred at Mound, with the first couple of batches of SMTs in SW-13 but primarily in SW-150. This work was done between 1968 through 1974 when the campaign ended (Ref. #3, SRDB # 107797). The tritium scrap recovery work was the primary work during the intermittent gap periods beginning in the 1980s. The work involving the SMTs of interest occurred in the tritium scrap recovery operations in R-108 in 1984, (Ref. #3, SRDB # 107797, Ref. #1, SRDB # 116979).

Most of the work actually occurred in SW-150 during the research period of working on the SMTs of interest. Figure 1 shows the relationship between the swipes and the average dose, by period, for Room 108 from 1983-1989. Figure 2 shows the relationship between the swipes and average dose, by period, for Room SW-8 for years 1980-1989. Both of these graphs indicate that the actual tritium doses, as determined through urine analyses, to workers, for years following the SEC period, were extremely low. These graphs also indicate that there were no unusual events or activities that contributed to increases in bioassay results during the gap periods. This supports the NIOSH position that the swipe results on either side of the gap periods can be used to extrapolate data in the gap periods.

The Section 4.1.1 (Ref. #10) and its revision (Ref. #11) dated July 6, 2012 provide three graphs of the NIOSH-developed swipe data, showing data "gaps." The following section of the report, Availability of Additional Data Sources (4.1.2), claims to point out data that was not considered by NIOSH. If true, this would mean that data gaps are actually smaller than presented below, which reproduce Figures 4-6 in SC&A's report. Each figure has dose data plotted against the right hand axis. The parameter plotted was the average dose for the top 50% of annual doses. The source of the data is the HP_TRITIUM Table from the MESH database. Prior to October 1, 1981 only annual dose data is available in MESH. The doses for all samples collected during the fiscal year were summed and assigned to September 30th. For October 1, 1981 and later, monthly intakes in microcuries as well as the doses are available.

The trends indicated from the graph of the average doses clearly indicates that the dose trends were not increasing as a result of unusual high activity during operations or scrap recovery that resulted in increased biological uptakes of tritium. These also corroborate that the swipe data from both sides of the gaps can be used to extrapolate the swipe data to within the gaps for R-108 and SW-8.

Additionally, SC&A has provided in section 4.2.1 (Ref. #11) of their report the sources where additional swipe source data are available to fill in some of data gaps in the NIOSH report. Tables of some of this additional data are shown in Tables 3 through 7 and should populate about two-thirds of the missing data in R-108 for 1980. NIOSH will revise our whitepaper before dose reconstructions are performed with this empirical data for Mound workers using our model. In reviewing this new data, our expectation is that the 95th percentile intakes will not effectively change, and any changes would not affect the fact that the doses can be bounded.

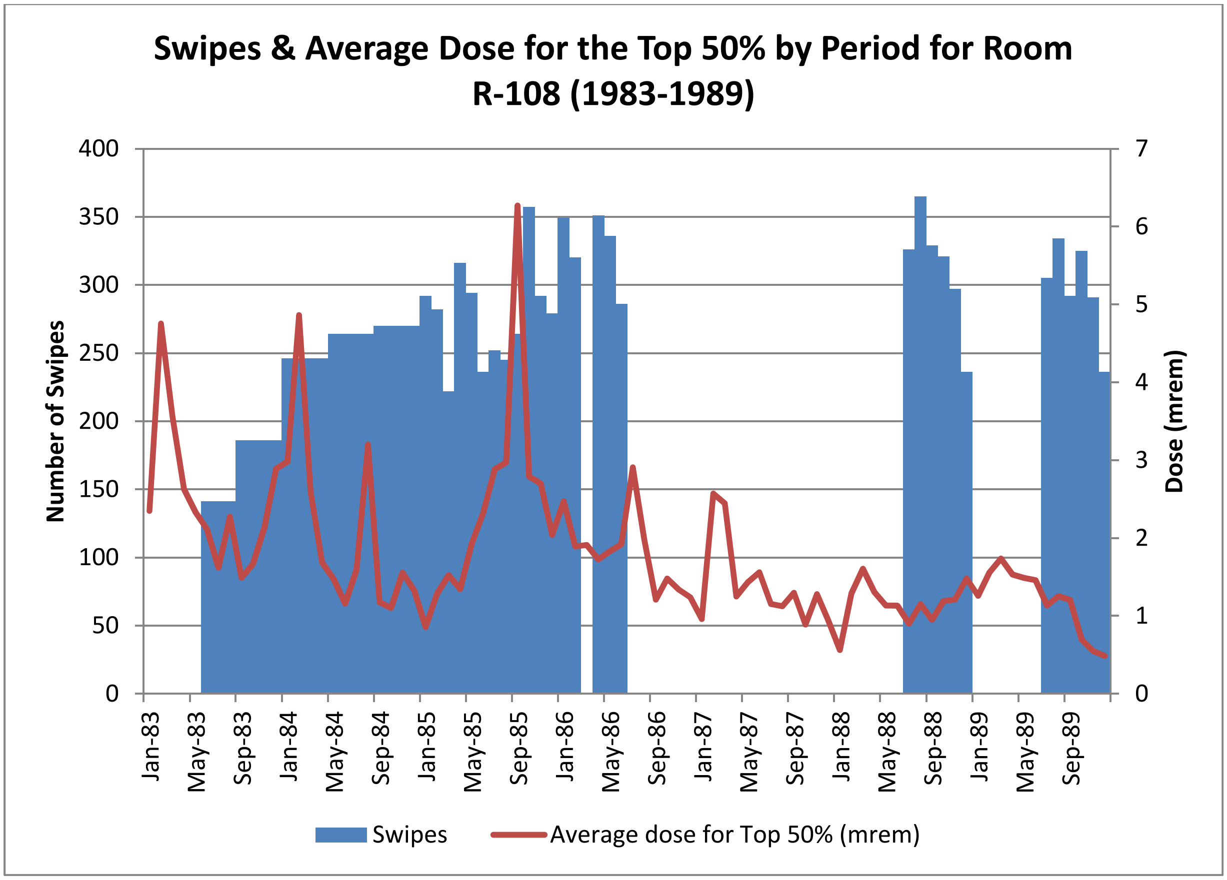

Figure 1. Swipes and average dose for the top 50% by period for Room R-108 (1983-1989)

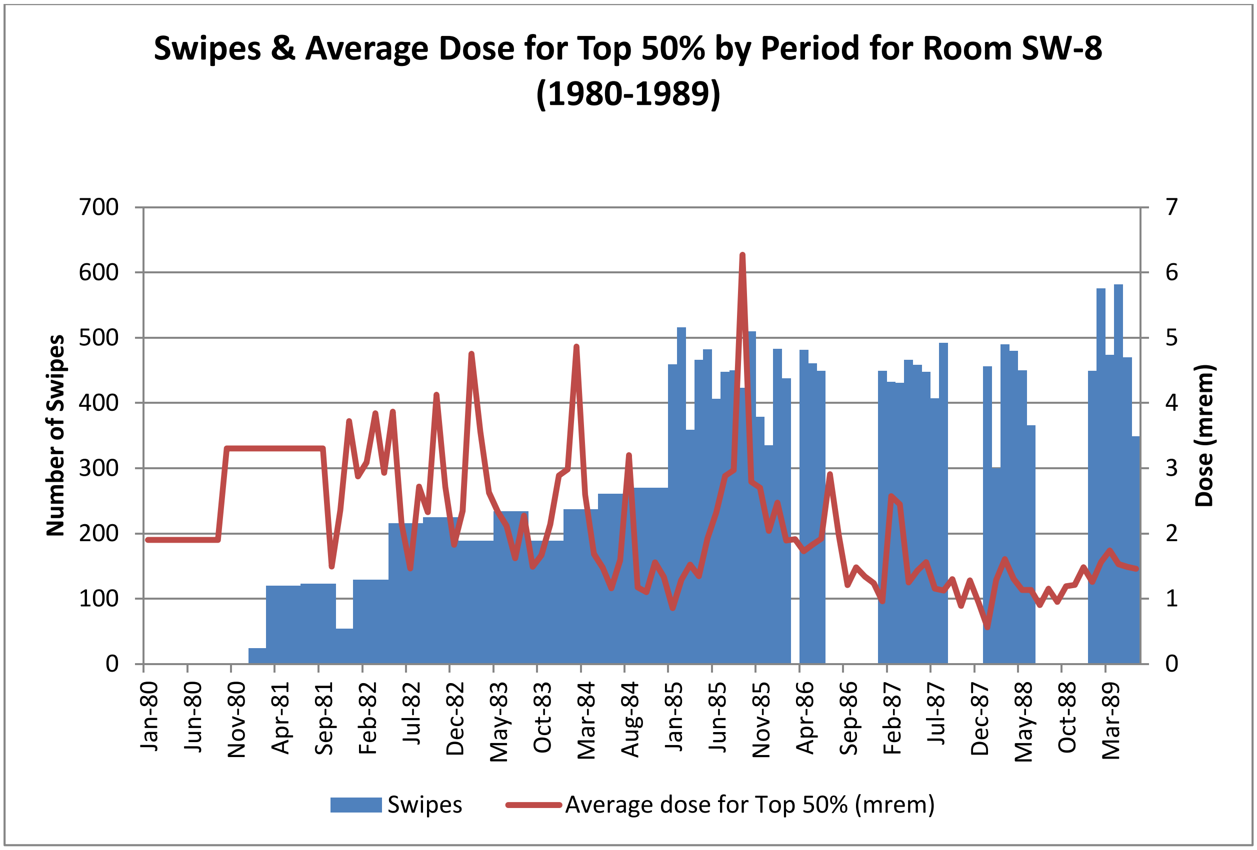

Figure 2 Swipes and average dose for top 50% by period for Room SW-8 (1980-1989)

(1d) Discuss dose reconstruction during the Decommissioning and Decontamination periods.

Decommissioning and decontamination (D&D) was a continuous activity at Mound, but the "full blown" D&D period for the Mound plant did not start until 1998 or 1999 (Ref. #7, SRDB #110988). During the D&D period, there was the recognition for a "technology shortfall" with respect to the ability to detect highly insoluble tritides through bioassay monitoring (Ref. #6, SRDB #39682), that is, existing bioassay methods were not sensitive enough to detect the regulatory limit of 100 mrem/yr. Interviews with Mound staff which were responsible for the monitoring workers for tritides during the D&D period indicated that all workers with the potential to inhale insoluble tritides wore breathing zone (BZ) air samplers and their exposure was monitored through DAC-Hr tracking. This additional monitoring was instituted around 1999. The assumption was made that tritium activity measured in the urine represented intakes of soluble forms, whereas beta activity detected on the BZ particulate samplers represented the insoluble forms. The BZ filters were counted using either liquid scintillation or proportional counting. A Mound technical basis document was developed which documented the methodology behind this practice and dose reconstruction (Ref. #8, SRDB # 32921).

A Research Chemist interviewed indicated that the SMTs of interest would have been worked only in the glove boxes and that the this equipment was surveyed and deconned to “cold” standards by the laboratory workers prior to D&D activities were undertaken for reasons of classification (Ref. #1, SRDB # 116978).

The following is an example of Mound Interoffice Correspondence instructions describing RWPs which reflects the typical understanding that the radiological protection program managers had implemented as a result of their understanding, hazards and concerns in order to restrict exposures from the tritide work being conducted at Mound during the late 1990s (Ref. #6, SRDB # 39682).

ATTACHMENT 2

MOUND

INTEROFFICE CORRESPONDENCE

From: Ernest Stormann 07/10/97

Radiological Protection Plan and Special Instructions for RWP SW-049-97 & SW-050-97

The following is an outline for the air monitoring, surveys, and deposting of the special repack in R 130, 129, 128, and 127. Further information may be found in the identified RWP's and MD-80036, Radiological Operations Procedures.

The following table lists requirements according to general steps of procedure. Under requirements there is a listing of the condition of importance, which is the reason for the requirements.

Requirements by Task

	Step	Requirements
1	Remove storage containers from glovebox in R-127	PPE per SW-049-97. Alpha air monitoring via full time R-128 CAM. Metal tritide air monitoring via R-127 FASH. CAM and FASH filters removed at end of each day this step of work is done. FASH filter analyzed for metal tritides using SEM. Alpha and beta analysis via count room done normally on CAM Filter. Volatile tritium air monitoring via tritium CAMs. Conditions of importance: Units outside of engineered containment device (glovebox / closed fumehood) resulting in increased likelihood of release to breathing air and lab.
2	Transfer storage containers to R-130 through R-129	PPE per SW-049-97. Post transfer smears per deposting instruction at the end of this plan. Condition of importance: Same as Step #1

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Step		Requirements
3	Place storage containers into R-130 fumehood and / or remove trash from fumehood.	PPE per SW-049-97. Alpha air monitoring via full time R-130 CAM. Metal tritide air monitoring via R-130 FASH. CAM and FASH filters must be removed at the end of each day this step of work is done. FASH filter analyzed for metal tritides using SEM. Alpha and beta analysis via count room done normally on CAM Filter. Volatile tritium air monitoring via tritium CAMs. Smears may be taken on units being placed into fumehood for informational purposes. Condition of importance: Same as Step #1, including the use of a fumehood in the open configuration.
4	Pass units from fumehood to glovebox and Repack units in glovebox	PPE per SW-050-97. Alpha air monitoring via full time R-130 CAM. Metal tritide air monitoring via R-130 FASH. FASH filter analyzed for metal tritides using SEM. CAM and FASH filters removed at end of each week this step of work is done. Alpha and beta analysis via count room done normally on CAM Filter. Volatile tritium air monitoring via tritium CAMS. Condition of importance: Radiological operations through glovebox gloves (engineered containment) in a Contamination Area.
5	Pass repacked units into fumehood and decontaminate to lower than HCA limits	PPE per SW-050-97. Same air monitoring as step #4. No respiratory protection is required to pass clean items in or wipes out of fumehood if fumehood sash is not raised above certified level. Condition of importance: Radiological operations through glovebox or fumehood gloves (engineered containment) in a Contamination Area. Limited use of certified fumehood.

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Step		Requirement
6	Remove re-packed units from fumehood and decontaminate to free release surface contamination levels on benchtop.	PPE per SW-050-97. Wipes must be taken on cans and in fumehood. Wipes are to be analyzed to determine if cans are less than 100 times table 2-2 of MD-10019 to be removed from fumehood. One large area wipe of cans must be submitted to SEM to determine if metal tritides are present. Positive results from SEM must be reviewed by Radiological Engineer before cans may be removed from fumehood. All radiological surveys must be complete prior to removal. Alpha air monitoring via full time R-130 CAM. Metal tritide air monitoring via R-130 FASH. Cam and FASH filters removed at the end of each week this step of work is done. FASH filter analyzed for metal tritides using SEM. Alpha and beta analysis via count room done normally on CAM Filter. Volatile tritium air monitoring via tritium CAMs. Benchtop or floor space used for decontamination efforts must be prepared with appropriate covering to aid in contamination control. Surveys for restricted release of rad material must be completed per operation 400 of MD-80043 before leaving the contamination area. Tritide surveys via SEM may be required if previous surveys indicated their presence. Condition of importance: Handling of contaminated items in a contamination area as per table 2-2 of MD-10019.
7	Movement and handling of Radioactive Material in a controlled area	No PPE required. Follow operation 400 of MD-80043 for transport of Rad Material. Condition of importance: Handling of surveyed sealed radioactive material per operation 400 of MD-80043.

Air Monitoring Setpoints

RWP# SW-050-97 - Required Components

- No respiratory protection required
- Alpha Continuous Air Monitors (CAM)s
  Setpoint at 21 counts above background.
- Tritium CAMs
  10 $\mu Ci/m^3$ low alarm setpoint
  100 $\mu Ci/m^3$ high alarm setpoint

RWP# SW-049-97 - Required Components

- Full Face Respirators required
- Alpha CAMs
  Setpoint at 640 counts above background.
- Tritium CAMs
  10 $\mu Ci/m^3$ low alarm setpoint
  100 $\mu Ci/m^3$ high alarm setpoint

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General Instructions

All air samples submitted to the count room must be saved for possible further analysis later. Count room technicians and RCTs must ensure these samples are not discarded.

All work for the special repack will be done under RWPs SW-049-97 and SW-050-97.

Any work done under RWP SW-049-97 will have all air sampling filters collected at the end of each day for analysis as proscribed above. Work done under RWP SW-050-97 will be collected weekly. When daily collections fall within the weekly collection period, end the weekly sample just prior to the work requiring daily collections and submit the air samples at that time. Weekly collection may resume following the daily collection tasks with whatever routine the RCT deems appropriate, provided that no sample is collected for greater than a week. Shorter duration sampling for scheduling convenience with the weekly air samples is acceptable (i.e. weekly samples that are collected every Thursday).

Bioassay for work done under RWPs SW-049-97 and SW-050-97 will require daily urine samples for tritium. Samples must continue for a week after work completion.

All samples that require SEM analysis will be for SEM analysis only. The technique used to analyze the samples leaves them unfit for other radiation detection techniques. Air Samples must be submitted to the count room with an attached Air Sample Worksheet (ML-9644). This will ensure that samples are not discarded after use. The counting labs should be notified that the samples are from the Special Repack Project.

Posting

R129 will be temporarily posted as an Radiological Buffer Area (RBA) with a Contamination Area (CA) pathway from R-130 to R-128. This will facilitate the transfer of materials from one lab to the other. In order to facilitate the de-posting of this lab once the transfer step is completed, it will be prepared with plastic and paper prior to posting as an RBA/CA. Areas in the RBA will be covered with plastic and considered inaccessible. The CA will be papered on the floor. The attached diagram (Figure 1) illustrates the areas within the lab.

The following plan will be used to depost the area:

2 large area wipes are to be taken on floor with prepared wipe paper for submittal to SEM for tritide analysis. Any positive results require Radiological Engineering to decide on deposting area for tritides.

30 wipes will be taken randomly on the papered floor area; 20 wipes will be taken randomly on the walls and plastic covering the areas, ranging from the floor to as high as an individual can reach. While the wipes are random, do not neglect any large portions of the area, taking extra wipes if necessary. These will be analyzed for alpha, beta, and tritium by normal count room procedures. Floor and walls will be scanned with an NE Electra for fixed alpha and beta contamination.

If the survey shows no contamination greater than Table 2-2 of MD-10019, the area may be deposted to a Controlled Area with no restrictions.

If the survey shows spotty contamination, decontaminate thoroughly. Remove floor paper if necessary and repeat survey. Depost if second survey shows no contamination. If the second survey shows contamination, consult with the Area Radiological Engineer.

If wide spread contamination is found, as indicated by more than 10% of wipes positive, greater than 10% of a surface area is positive, or any positive areas greater than 100 times table 2-2; consult radiological engineer and **do not** depost the area.
Further information may be found in RWPs SW-050-97 and SW-049-97.

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4. Investigation of the Contamination Tracking Incident in SW/R Tritium Complex, July 1993, SRDB Ref. ID #48837
5. SW-209 Contamination Incident Report, March 1994, SRDB Ref. ID #48857
6. Information Regarding the Health and Safety of Metal Tritides, July 1998, SRDB Ref. ID #39682
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9. Documented Communication with [redacted]on Summary of Health Physics Tritium Swipe Practices at Mound during 1980 through 1084 Follow-up Interview, January 2012, SRDB Ref. ID #107056
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11. SC&A Report - Mound Laboratory Site Potential Exposures to Stable Metal Tritides, Revision 1, July 2012
12. Interview Notes Discussing Source Terms and Solubility of Tritides/ H-3, Dec.2008, SRDB # 55962