NIOSH Draft White Paper

Investigation of "Hot Particles" and the Health Physics Programs at the Idaho National Laboratory (INL)

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Revision 0-E

March 18, 2014

This white paper has been generated to support the

NIOSH Response to Comments 9 and 23 in SCA-TR-TASK1-0005

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Investigation of "Hot Particles" and the Health Physics Programs at the INL

1.0 PURPOSE

The purpose of this white paper is to summarize the results of an investigation that was performed by NIOSH in regards to the presence of "hot particles" and the likelihood that these particles would go undetected on workers. The results of this investigation are intended to assist NIOSH with its response to Comments 9 and 23 in SCA-TR-TASK1-0005 (SC&A 2006).

2.0 BACKGROUND

Comments 9 and 23 were made in regards to the information provided in Revision 00 of the document titled *Technical Basis Document for the Idaho National Engineering and Environmental Laboratory (INEEL) – Occupational External Dosimetry* (ORAUT 2004). Even though the current version of this document is Revision 03, Comments 9 and 23 are still considered to be valid comments, since no significant changes have been made to the method in which "hot" particles are addressed. However, it should be noted that the title of this technical basis document has been changed to *Technical Basis Document for the Idaho National Laboratory and Argonne National Laboratory West – Occupational External Dosimetry* for Revision 03.

In addition, to simplify identifying and/or referring to this technical basis document (TBD) in the subsequent sections of this white paper, all versions of this document will be referred to as the INL TBD.

2.1 Summary of the Issue

Comment 9 as stated in the INL Issue Resolution Matrix for Findings and Key Observations (i.e. Attachment 5 of SCA-TR-TASK1-0005) (SC&A 2006).

> Issue 9: (5.1.2.6) Skin and Facial Contamination - This TBD does not consider incidents with workers having skin contamination, facial contamination, and positive nasal swipes in the INL facilities. These kinds of problems would be compounded by the deficiencies in air sampling systems and ineffective respiratory protection programs. Guidance should be provided to a dose reconstructor to account for the missed dose due to the unaccounted uptake.

Comment 23 as stated in the INL Issue Resolution Matrix for Findings and Key Observations (i.e. Attachment 5 of SCA-TR-TASK1-0005) (SC&A 2006).

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Issue 23: (5.1.4.1.8) High-Risk Jobs (Beta/Gamma Exposure) - Site experts interviewed by SC&A classified INL as an “acute dose” site, with a significant number of facilities, operations, experiments, and occurrences providing the possibility of personnel receiving dangerous levels of radiation. NIOSH did not evaluate comprehensively the facility and field data to identify and separate out the high-risk or high-dose jobs for worker external exposures. This information is essential for dose reconstructors to fill in the data gap when dose records in a claimant’s file are not complete.

Section regarding Comment 9 that is in the main body of the INL site profile review (i.e. Section 5.1.2.6 of SCA-TR-TASK1-0005) (SC&A 2006).

5.1.2.6 Skin and Facial Contamination

This TBD does not consider incidents with workers having skin contamination, facial contamination, and positive nasal swipes in the INL facilities. These kinds of problems would be compounded by the deficiencies in air sampling systems and ineffective respiratory protection programs, some of which have been discussed previously. Consequently, a bioassay may not be triggered for the workers. Guidance should be provided to a dose reconstructor to account for the missed dose due to the unaccounted uptake.

Section regarding Comment 23 that is in the main body of the INL site profile review (i.e. Section 5.1.4.18 of SCA-TR-TASK1-0005) (SC&A 2006).

5.1.4.1.8 High-Risk (Dose) Jobs

The TBD indicates that there are facilities at INL (e.g., INTEC) where high beta fields exist. NIOSH should develop a list of high-risk (dose) jobs and provide corresponding beta/gamma dose rates and worker job doses. This information will be helpful for dose reconstructions for personnel who had worked in such jobs and areas. Working in areas where there are fragments or “hot particles” of fission products, for example, during the cleanup of a reactor destruction experiment or SL-1 accident, may lead to the deposition of hot particles with high beta dose rates (above 50 rad hr-1) on the clothing and, possibly, directly on the skin of the face or hands. The beta radiation emitted from these hot particles will not be detected by the film or TLD dosimeters.

For workers at fuel element or reactor cleanup operations, for small localized areas, the beta dose could be as high as 100–1,000 rads when calculated over a working day. For claimants with skin cancer, location and job-specific information should be taken into account.

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2.2 Actions from 2011 Working Group Meeting

SC&A agreed that comments 9 and 23 dealt with "hot particles" and were to be merged into the same issue.

NIOSH: Look into the possibility that a "hot particle" could be deposited on the skin and go undetected by investigating the facility health physics practices.

3.0 NIOSH INVESTIGATION RESULTS

ICPP

Concern was expressed regarding the potential for "hot particle" exposures at INTEC also known as ICPP and CPP. In addition, to simplify identifying and/or referring to this area in the subsequent sections of this white paper, all versions of this document will be referred to as the ICPP.

It was expected that ICPP employees would be exposed to radiation and work in areas where radioactive contamination was present. For this reason, employees were issued plant clothing to wear in lieu of personal clothing and additional protective clothing to be worn over this was issued to personnel working with radioactive materials and in contaminated areas. Plant clothing was only worn eight hours per day and laundered frequently (ACC 1952). Employees were required to survey themselves and their clothing when leaving areas and when contamination was suspected.

Special work permits were required to perform maintenance in all areas where radiation and contamination was present. Surveys of the work area, equipment and personnel were required upon completion of work (ACC 1952).

The contamination control program detailed in the *CPP Health Physics Manual* served to prevent inadvertent worker contamination incidents. Measures were in place to prevent worker contamination incidents and to detect them in a timely manner should they occur. Portal monitors were present at the plant exits to prevent contamination being spread from the plant on clothing or equipment (Stroschein and Maeser 1967). These portal monitors were capable of detecting hot particles on employees entering and exiting the facility.

When contamination incidents occurred, they were identified, documented, rectified and measures were taken to prevent recurrence. Some examples of this follow.

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A report issued in 1973 (ANC 1973) reviewed the potential hazards of radioactive particles. It was noted that particles were found on the facility buses with activities as high as $2x10^5$ dpm. Most particles had activities in the range of 2,000 – 20,000 dpm.

An internal report issued in 1974 identified a deterioration of the health physics program at the ICPP (Rich 1974). Contamination control and personnel attitude and adherence to procedures were cited as issues. The study identified the comingling of personal and plant protective clothing in the locker rooms as an issue. A detailed plan involving area contamination control improvement, upgraded facilities, enhanced protective clothing control, improved instrumentation and worker training was devised and implemented to remedy the situation.

It was noted that radioactive particles were released from the ICPP stack in February of 1972 and that ground surveys conducted in April of 1972 showed a heavy concentration of particles on sidewalks, at the entrance of the cafeteria and on facility buses (AEC 1972). An AEC-appointed committee studied the problem and determined that the particles did not present a significant hazard. A report was not issued (Rich 1974). As part of the 1974 assessment of the ICPP health physics program, particles emitted from the stack were again evaluated. Part of the health physics program upgrade was to improve effluent control.

Health and safety manuals for later years continue to address access control, personnel surveys, area surveys, training, protective clothing, contamination control and decontamination (WINCO 1990).

A report detailing the status of the ICPP health physics program and upgrades was issued in 1979 (Rich 1979). INL management issued annual reports documenting the status of ongoing activities on site. The report issued in 1979 indicated that major progress had been made on the ICPP upgrade and that many action items were completed.

<u>SL-1</u>

Concern was expressed regarding the potential for "hot particle" exposures during the cleanup of the SL-1 accident.

Entry into the SL-1 facility after the accident exposed individuals to high levels of radiation and contamination. In order to protect workers from contamination, detailed entry procedures were followed. Following exit from the contaminated area, protective clothing was removed, individuals were surveyed and decontamination was performed as necessary (AEC 1961).

After initial recovery operations were completed, more detailed surveys were performed of the area. A contamination control zone was established and entry procedure developed. This

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procedure involved access control, limited vehicle access, protective clothing, respiratory protection as deemed necessary by health physics personnel, exits surveys and decontamination as necessary (Gammill 1961).

A detailed report on the health physics aspects of the SL-1 accident was compiled. This report summarized the doses received by those individuals responding to the incident. Both internal and external doses and thyroid doses were provided. No "hot particle" contaminations were noted (Horan and Gammill 1961).

"Hot particles" were discovered on site roads and U.S. Highway 20 in the aftermath of the SL-1 accident. An extensive road survey and decontamination process was implemented. One hundred particles were collected from U.S. Highway 20 and 75 were collected from site roads. Dose rates from particles on U.S. Highway 20 were estimated to range from 10 mR/hr to 5 R/hr and dose rates from particles on site roads were estimated to be from 10 mR/hr to 15 R/hr (Horan 1962).

Because entry procedures were developed after the initial response to the SL-1 accident, SL-1 first responder claims are looked at very closely and the special circumstances for their exposures are handled on a case by case basis. Also, SL-1 first responders were surveyed upon exiting the building.

ANP

Specific information on the health physics practices at the air craft nuclear propulsion (ANP) site was not available; however, the general operating rules state that health, safety and fire protection control are vested in the Idaho Operations Office (Levine 1959). This indicates that the same controls present at the rest of the site would be present at ANP.

Contamination Incidents

Personnel contamination surveys were conducted and documented at the TRA in 1974. Multiple instances of personnel contamination were documented. Of these, the highest was 100,000 cpm on an employee exiting the ATR. There was no indication that "hot particles" were discovered. In response to these occurrences, management implemented additional training on personnel contamination protocols and required that explanations be provided as to why the contamination was not found by the employee during his personal exit survey and what actions are being taken to prevent recurrence (ANC 1974b).

Contamination incident reports for the ICPP for 1979 and 1980 were reviewed. Personnel and area contaminations were documented. All incidents were investigated and corrective actions

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implemented. Hand contaminations were the most prevalent; however, foot, knee, upper arm, chest and facial contamination incidents also occurred (ACC 1980).

On August 31, 1979 a WCF operator alarmed the portal monitor as he was entering the plant. A survey revealed 20,000 cpm on the left knee of the employee's underclothing. The contamination was fixed in the clothing requiring that a portion be cut away. The clothing had been laundered at the employee's home prior to wearing. A survey of the home showed no additional contamination. Later in the report the contamination is referred to as a "particle" and identified as being cesium-134 and cesium-137. The incident was investigated and corrective actions were implemented (ACC 1980).

On September 17, 1979 a pipe fitter alarmed the portal monitor as he was entering CPP 669. A 100,000 cpm particle was discovered on the chest area of his undershirt. A survey of his home revealed no contamination. The subsequent investigation revealed that the employee was involved in a job the previous day in which he was contaminated. A miscommunication resulted in the employee being allowed to leave the facility with fixed contamination (ACC 1980). Management reviewed the incident and the involved parties were retrained on survey and decontamination procedures. Also, higher quality protective coveralls were procured and protective clothing usage and survey procedures were modified.

On July 1, 1991, a discrete radioactive particle was discovered on the outer surface of the plant coveralls being worn by an equipment operator. The operator was involved in the movement of a cask at the TRA. The particle was estimated to have been on the garment for a maximum of 1.25 hours. Skin dose to the employee was calculated using several different accepted methodologies. Based on technical judgment, a dose of 60 rem/cm^2 was assigned to a three square centimeter area on the front of the left shoulder. The "hot particle" was believed to have originated from capsules of iridium that were irradiated at the ATR and transferred to the TRA Hot Cells. An iridium capsule was known to have ruptured in May. Subsequent handling of the capsule resulted in the contamination of the cask the operator was moving (WINCO 1991).

The incidents listed above are examples of contamination incidents that occurred, were identified, quantified and documented. If one of the energy employees involved in one of the incidents above were to develop a skin cancer on the location that the contamination occurred, the dose reconstructor would calculate the dose to the affected area from the contamination incident and the document *Technical Information Bulletin: Interpretation of Dosimetry Data for Assignment of Shallow Dose.*

<u>Hot Particles on Roadways and Buses</u>

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In addition to the hot particles found on roadways due to the SL-1 accident and 1972 ICPP ruthenium release, five hot particles were discovered on roadways in August of 1963. The particles consisted of the radioisotopes cobalt-60, cerium-144, ruthenium-106, cesium-134 and cesium-137. The maximum dose rate recorded was 75 mrad/hr, beta (AEC 1963).The semi-annual bus surveys for 1974 were performed in June and November. One hundred six buses were surveyed in June and 222 particles were found. The total activity of all the particles was 1.22 µCi. In the November survey, one hundred ten buses were surveyed. There were 122 particles found. The total activity of all particles was 0.57 µCi. The predominant isotopes were cesium-137, cerium-144, cobalt-60, ruthenium-106 and cesium-134. The highest particle identified was 10,000 cpm (ANC 1974a). Additional survey data from 1974 was analyzed (ANC 1974a). Figure 1 shows the distribution of the particles as a function of cpm. Sixty five percent of the particles discovered were less than 1000 cpm.

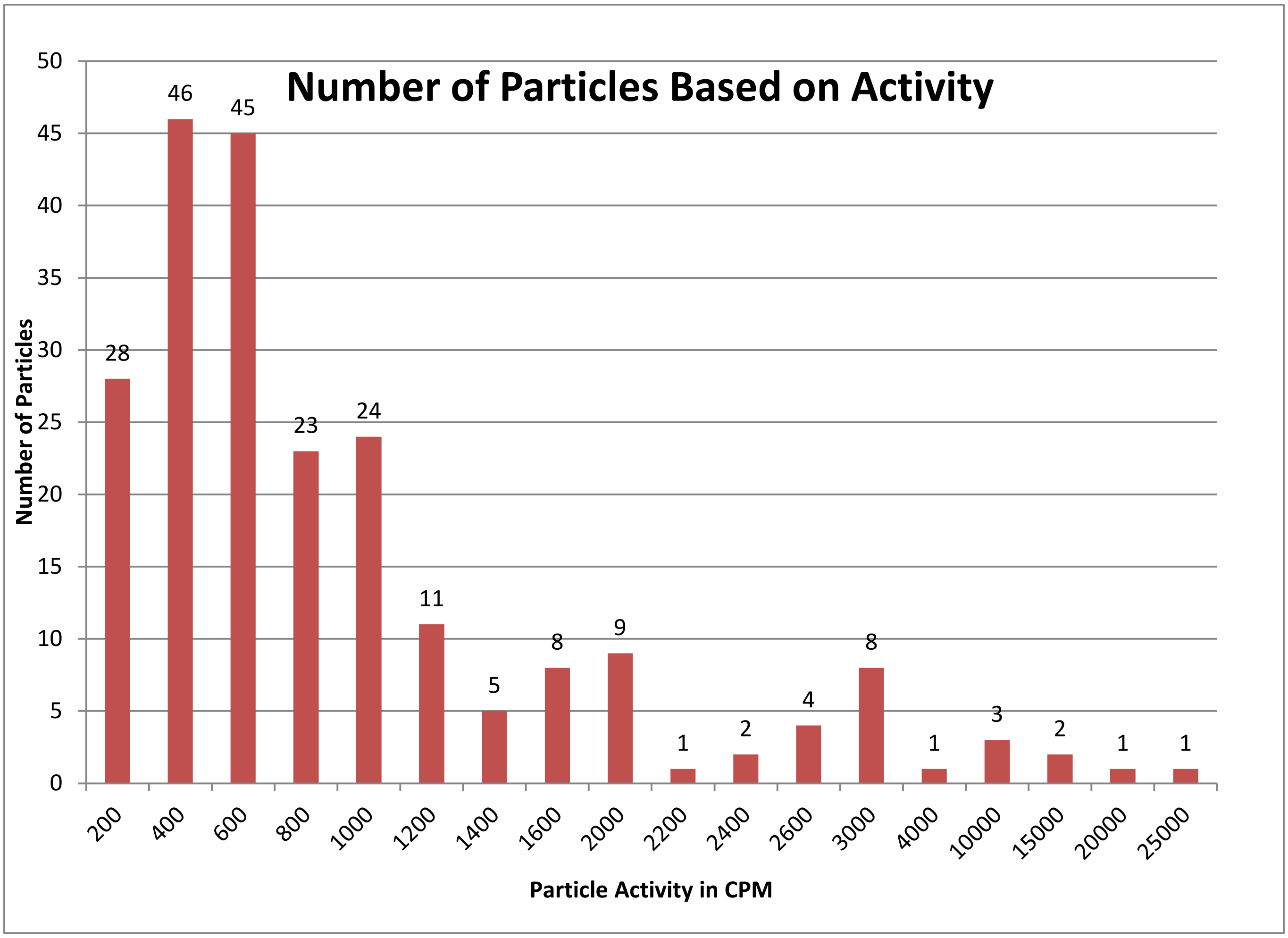

Figure 1. Number of Particles Based on Activity.

Figure 2 illustrates the number of particles found on each area's buses. The most particles were found on spare buses that serviced all areas. NRF and CPP buses had particle counts of 39 and 37, respectively.

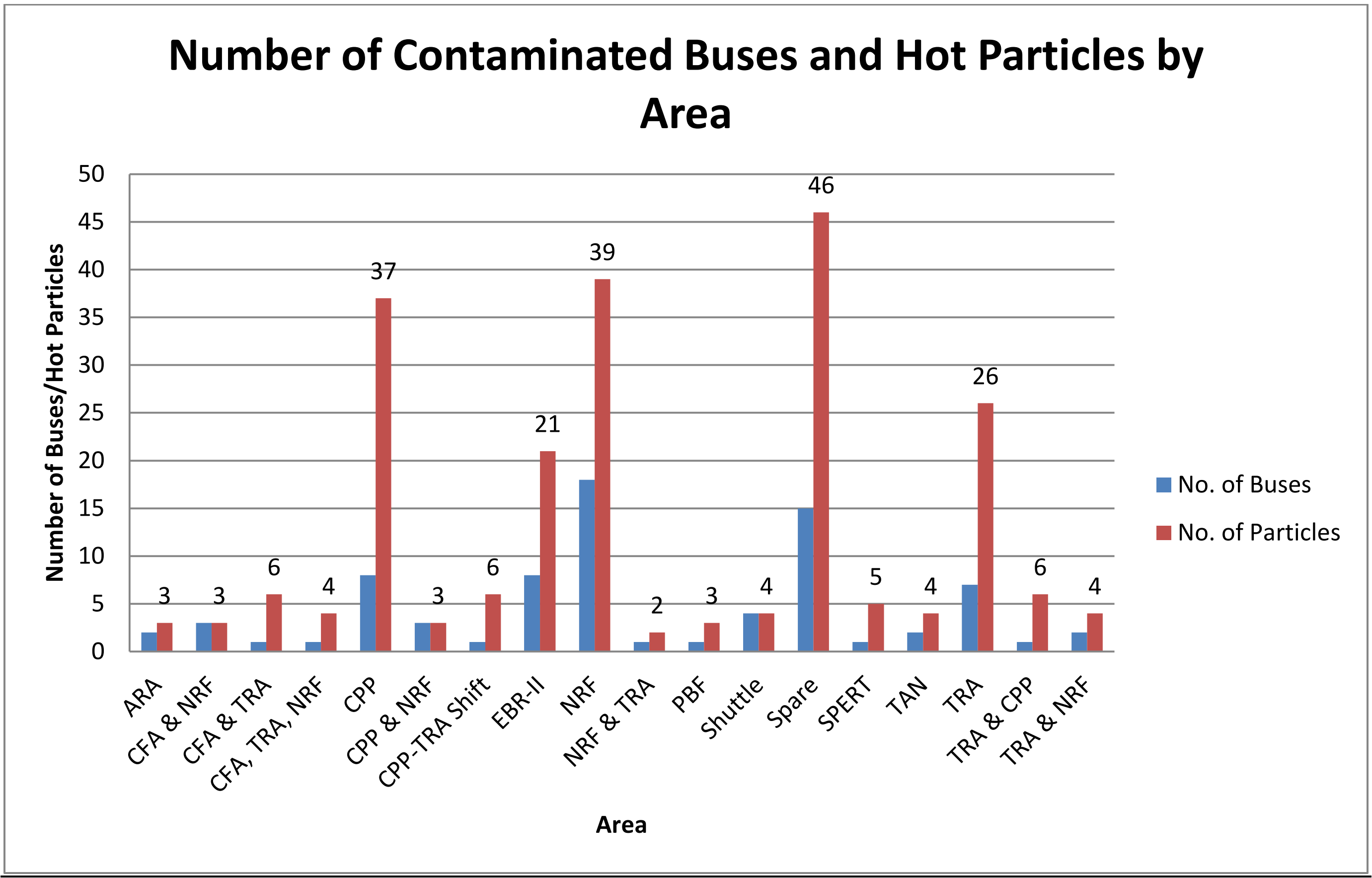

Figure 2. Number of Contaminated Buses and Hot Particles by Area.

<u>General INL Health Physics Practices</u>

From the beginning of operation, the INL Radiological Control Manuals have had provisions for personnel surveys, area surveys, access control, protective clothing and contamination control. Later versions of the manual specifically address "hot particles" and their control. Periodic personnel monitoring and additional protective clothing are utilized as methods to prevent personnel exposure. In addition, all access to "hot particle" areas is controlled by radiation work permits. Facility buses and vehicles are surveyed multiple times per year. Response to "hot particle" skin or clothing contamination is specifically addressed and includes the following:

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immediate removal of the particle, particle analysis, worker dose assessment and evaluation of work controls to prevent recurrence (Bechtel 1999). In 2011, INL issued a procedure that specifically addressed ”hot particles.” This procedure included area controls, such as the use of sticky pads, enhanced personnel monitoring, area surveys and response to “hot particle” contaminations (INL 2011).

4.0 CONCLUSIONS/RECOMMENDATONS

The claim made in Issue 9 that the INL TBD does not consider incidents with workers having skin contamination, facial contamination, and positive nasal swipes in the INL facilities is not an issue specific to INL. No other site-specific TBDs do this either. In addition, nasal smear data is uncommon for INL/ANL-W claims, and when there is nasal smear data for a claim, it is unlikely that the energy employee would not have a urine sample, fecal sample, and/or whole body count measurement performed after a positive nasal smear is reported. Given that 90% or more of the INL’s bioassay measurements were below their detection limits, it is unlikely that any significant intakes/uptakes were unaccounted for; since it appears that the site was monitoring the workers well above and beyond the requirements for monitoring.

NIOSH was to look at the possibility that a “hot particle” could go undetected on an employee’s skin by investigating the health physics practices at INL. There is no evidence that INL employees were contaminated with undetected “hot particles” for significant periods of time. This investigation has determined that INL’s health physics program stressed contamination control and personnel surveys. Employees were required to survey themselves prior to exiting areas and trained on proper survey techniques. In addition, portal monitors were in place as a final survey measure.

When contamination incidents (both area and personnel) occurred, they were discovered and documented. The documents reviewed contained personnel survey results that included employee name, location of contamination and activity. In addition to the examples of contamination documentation provided previously, ANC 1974b pages 12 and 15-18 provides examples of personnel survey results. This information is adequate to reconstruct dose to the contaminated area using the *Technical Information Bulletin: Interpretation of Dosimetry Data for Assignment of Shallow Dose.*

When contamination control and personnel survey problems were identified, corrective actions were implemented to prevent recurrence and evaluations of the incidents were performed. Occurrences of employees entering or exiting the facility carrying “hot particles” on their skin or clothing were documented. These “hot particles” were detected by portal monitors at the area

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entrances. The documentation of these types of incidents is an indication of the INL's health physics program's ability to detect "hot particles."

In general, skin contaminations are handled on a case-by-case basis, due to the intricacies of the calculations and how uncommon it is to encounter a skin cancer claim where that part of the worker's skin was contaminated. The document *Technical Information Bulletin: Interpretation of Dosimetry Data for Assignment of Shallow Dose* provides a claimant favorable approach for situations in which the precise location of a skin contamination is unknown and it is unclear whether the irradiated area included the skin cancer location (ORAUT 2005). Also, there is evidence that hot particle doses are less effective than whole body doses in inducing cancer (Merwin and Moeller 1989; Charles et al. 1988).

Based upon the above, NIOSH concludes that the likelihood of a "hot particle" going undetected on an employee's skin for a significant period of time is remote. There is no evidence that INL employees were contaminated with undetected "hot particles" for significant periods of time. When contamination incidents occurred at the INL, they were discovered by area surveys and personnel monitoring and documented. Also, no other site-specific TBDs, with the exception of Hanford, provide guidance for undetected "hot particles." The Hanford "hot particle" situation is unique and the same issue did not exist at INL. In addition, there is complex wide guidance in place that addresses skin contaminations and "hot particle" exposures as they relate to skin cancers.

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