PERFORMING PERSONNEL DOSIMETRY INVESTIGATIONS AND RECORDS QUALITY ASSURANCE

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INTRODUCTION

Radiation Safety Officers (RSOs) sometimes face situations in which personnel dosimetry estimates are required after dosimeters issued to radiation workers (film or TLD badges, extremity dosimeters, etc.) are lost or damaged before processing. This article was prepared to help those involved with personnel dosimetry investigations became aquatinted with this process.

A factor that contributes to the anxiety of those unfamiliar with dosimetry investigations is the lack of published guidance available in this subject. More printed resources are needed to help radiation safety professionals familiarize themselves and understand personnel dosimetry investigations.

Topics discussed in this presentation include the justification of performing dosimetry investigations, recommendations on how to perform them and the advantages of performing such investigations.

WHEN INVESTIGATIONS ARE NEEDED

Situations that may require an investigation include the following:

1. A lost dosimeter
2. A dosimeter is worn by more than one individual during the same wear period
3. A dosimeter is worn incorrectly (such as not in the proper geometry with respect to the source of irradiation, film worn not in the holder or worn in the wrong body location)
4. A dosimeter is inadvertently irradiated while not worn
5. A dosimeter is damaged within the facility, during transportation or processing
6. A dosimeter is environmentally degraded.

The dose being investigated could be for an unexpectedly high, or lower than expected dose.

TRADITIONAL METHODS

Methods traditionally used to assign an occupational dose to workers are typically based on one, or a combination, of the following methods:

1. **The previous dose history of the individual in question.** The dosimetry history of the worker that lost his or her dosimeter or was damaged is reviewed by the RSO. An official dose is assigned based on an average from previous monitoring periods or the highest dose recorded during his or her employment.
2. **The dose received by a co-worker performing similar tasks.** The RSO assigns a dose to the individual in question based on the dose received by a co-worker who performed similar tasks during the monitoring period in question.

3. **Known or estimated dose rates and occupancy times.** The RSO assigns a dose based on known area dose rates and estimating the time spent by the individual in question in such area or areas.
4. **The highest dose received by a co-worker during the period in question.** The dose assigned to the individual in question is equivalent to the highest dose received by a co-worker during the monitoring period in question.

WHY INVESTIGATIONS ARE IMPORTANT

Even though any of the methods shown above could generate accurate dose estimates in some cases; RSOs should never rely on any of them before performing a thorough dosimetry investigation. By performing these investigations, RSOs are able to determine with more certainty the factors that have contributed to the occupational dose of radiation workers. In most cases, RSOs find out that they are justified to use one or a combination of these methods. But on occasions, situations arise which require special attention.

The following list shows some good examples of such situations. This information was obtained from informal communication with radiation safety professionals in the United States. Since the following examples are used only for illustration purposes, the author has elected to leave out specific names of individuals or institutions involved.

RSO # 1: "A worker reported a lost extremity dosimeter for a monitoring period last year. Before performing an investigation, I requested the vendor to estimate the shallow dose equivalent to this worker. The dosimetry history records for this individual showed a very consistent average monthly dose of about 2 mSv during his employment with our institution. Before assigning any dose to this worker, I interviewed him. After a short discussion I learned the worker was on vacation during the first half of the monitoring and that he did not work with radiation during the other half. With this information, I concluded that the worker could not have received any occupational exposure to radiation and I assigned no dose for the monitoring period in question."

RSO #2: "Our administrative annual occupational dose limit is 5 mSv. About 95% of our workers receive less than 200 μSv. Last month our dosimetry vendor notified us that one of our quarterly badges indicated 10 mSv. Upon investigation, we found a World War II Army compass in the glove compartment of his vehicle where he stored his badge after work. The compass contained a radium dial and read about 50 μSv/h on contact. We assigned to this person the highest dose any of his co-workers had received for the same quarter."

RSO #3: "A man in our maintenance facility came up with a whole body one of about 50 mSv during a quarter a year ago. We were able to build a case acceptable to the regulators that the exposure did not come from our site, and therefore was not occupational. We never found out how or to what the TLD exposed to, but during an investigation we uncover a few interesting facts. This worker was on psychiatric leave all but two weeks that quarter. One of the few days he was at work he accused the RSO of not reporting TLD results to him honestly. He went on to say that he knew how to put something on the TLD and he was going to do it just to see what we would do."

Situations like these help to justify the performance of thorough dosimetry investigations. Following a wrong approach would lead to inaccurate dose estimates if no investigation were performed.

PERFORMING THE INVESTIGATION

While performing an investigation, RSOs need to make sure to interview the affected worker, his co-workers and their supervisor. The objective of these interviews is to obtain as much information as possible and help in determining accurate dose estimates.

The investigation steps outlined below should be followed for any investigation, regardless of the dosimeter type, or, isotopes worked with:

1. **A review of the dosimetry history of the affected individual and his co-workers.** The dosimetry history is a key element in that it provides the assessor with appropriate data as to what is the "norm" for the individual in question. Statistical variation within the dose history is to be expected. When the dose in question exceeds the statistically acceptable limits, the investigation must be performed.
2. **A review of the inventory records for that particular laboratory.** If the dosimeter identifies that the radiation type is not from the inventory in the facility, it is highly probable that the dosimeter was irradiated outside of the facility, either inadvertently, or, intentionally.
3. **Types of isotopes used compared with previous dosimetry periods.** This checklist item is related to the inventory records addressed in the step above.
4. **Isotope amounts used compared with previous dosimetry periods.** Did the individual work with larger amounts of radioactive material than compared to previous monitoring periods?
5. **Types of procedures performed compared with previous dosimetry periods.** If the dosimeter in question is an extremity dosimeter, did the individual handle the isotopes differently? If the dosimeter is a whole body badge, was it worn in the proper orientation, and, at the proper body location?
6. **Number of procedures performed compared with previous dosimetry periods.** Dose is directly proportional to time of exposure. If the individual's total time of exposure is significantly higher or lower than expected, the root cause could very well be related to this element.
7. **Occurrences of unusual events during the dosimetry period in question.** This includes contamination events, worker absences, etc.
8. **Surveys performed in the work areas.** This element addresses if there is an identifiable trend in the laboratory, either more exposure, or less exposure.
9. **Security in the lab.** Where are the dosimeters kept when not be worn? Do all individuals in the facility have access to each other's dosimeter?

USING INVESTIGATIONAL AIDS

Developing aids such as forms and procedures can facilitate this process and ensure that important information is not omitted.

The investigation report, when completed, should be reviewed with the individual, and, ensure that the individual's signature is obtained, documenting their concurrence with the investigation, and, the dose to be assigned. This is critical in the event of regulatory intervention, and/or litigation.

The above assessment is performed by the facility. The investigation should also include as assessment from the dosimetry processor. The root cause may be the dosimeter, or, the processing of that dosimeter:

1. If a TLD, annealing data prior to be shipped to the facility.
2. If a TLD, copies of the various elemental glow curves.
3. Reader calibration data.
4. Quality Control dosimeter verifications read during the processing of the dosimeter being investigated.
5. Control dosimeter results. This could identify that the dosimeter in question may have been irradiated in transit, or, in some area where there was a continual, or intermittent exposure situation.
6. Algorithm path used for determining the dosimeter dose as reported. This step identifies the type of radiation and energy the algorithm determined that the dosimeter was exposed to.

EXPECTED RESULTS

A thorough dose investigation should result in the following:

1. The individual will be satisfied that whatever dose he/she should have received, is what is maintained in their dose history file. A satisfied employee is less apt to file a litigation claim.
2. Potentially mitigates regulatory intervention and the assignment of a violation and potential civil penalty.
3. The investigation may very well conclude that there was an unknown source of radiation within the facility. The dosimeter may be the key quality outcome indicator.

In summary, the investigation should look at all areas to eliminate unknowns. Be thorough, be honest and document the investigation in as much detail as possible. Only then will the investigation be considered a closed item.**RECORDS QUALITY MANAGEMENT**

When radiation exposure is the issue, records documentation is a critical factor, and a significant amount of effort should be expended to implement a comprehensive records management system. Why? For a lot of reasons.

- Records are essential for any litigation disposition and mitigation;
- They provide legal documentation of the actions taken which contributed to the establishment of a dose record;
- Records identify positive or negative trends which determine if a change to the operating process has occurred;

- They facilitate re-creation of a dose record; and
- Records promote a "paying attention to details" attitude among radiation workers, radiation protection and dosimetry processing staff, and management.

The following are the types of records a facility should consider with respect to the worker, that identify the risks and quantify the hazards in the work environment upon which the litigation is based:

1. Job training, qualifications and re-qualification (any testing data is very helpful);
2. Work processes involving exposure to radiation and/or radioactive materials;
3. Previous and current dose history;
4. Medical history, including any known therapeutic or diagnostic radiation treatments; and
5. The same records from other workers who perform the same general tasks, and/or who work in the same areas.

If you process your own dosimetry, or, if you use a vendor to process your dosimetry and they provide you with the "official dose of record," then you should ensure that the following records will be made available to you in the event of litigation:

1. Dosimeter life-cycle history (for TLD this would include a chronological record of initial receipt, correction factor calculations, cumulative dose, etc.; for film this would be emulsion number) The films worn should be kept in an environmentally controlled storage area, for future reassessment, as needed;
2. Receipt acceptance testing of new TLDs;
3. Calibration records-irradiator, readers and densitometers;
4. Type testing data for the specific dosimeter type;
5. Response characteristics of the dosimeter;
6. All accreditation proficiency testing data (NVLAP or similar);
7. Environmental factors that can potentially affect the dosimeter response;
8. Linearity determinations;
9. Filter/material verifications;
10. Radiation protection and dosimetry staff qualifications and certifications;
11. Dosimeter-specific processing follower form (a checklist for the entire processing conducted for a specific dosimeter lot);
12. TLD reader, irradiator and computer log books;
13. Quality assurance processing followers (all QA and QC data);
14. Exception and discrepancy reports;
15. Glow curve analysis evaluations;
16. Error report evaluations;
17. TLD Element Correction Factors (ECF) generation reports (which normalises the element's response with a known dose from a specific radiation source);
18. Software Quality Assurance records (SQA)—development and change control (software development and revision information, user requirements, user acceptance testing, verification and validation);
19. Deviations from procedures;
20. Index and copy of all historical procedures (required to identify how a badge was processed at any point in time);
21. Documentation on all modifications to a "dose of record;" and

22. Emulsion Numbers for film, and all acceptance testing conducted.

QUALITY INSTRUCTIONS WHICH COVER:

1. Procedure change control;
2. Procedural deviation;
3. Records retention;
4. Records storage;
5. Approval and authorisation requirements (specifying who can sign for what, acceptable alternates); and
6. Access to records.

The last item I would like to recommend for consideration is records maintenance and records retention. If records can not be retrieved efficiently and accurately, then the facility will have a very difficult time convincing a jury that they are running a well-organized program. Haphazard records management more often than not deflects the focus of a jury away from the real issues and onto the fact that the facility can't even keep the necessary records to validate that they are in control of everything under their supervision. The following media should be considered for record retention:

1. Hard disk;
2. Back-up cartridges or tapes with off-site copies;
3. Viable index and retrieval system established and tested periodically;
4. Optical systems (original can NOT be modified); and
5. Microfiche.

The first three methods should be implemented as a minimum, but the more backup methods used the better prepared a facility will be to address a litigation issue or questions from a regulatory agency.

Records Quality Assurance will ensure that the facility can document what actions were involved that led to an exposure to radiation or radioactive materials. Such a program will also be very helpful in mitigating a potential litigation case, where a significant amount of dollars are at stake and, more importantly, the public's perception of your company in court