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Based on the documents provided for review and discussions with NIST staff I offer my comments and observations on the 9 June event. These are mine alone but also reflect discussion with the other persons participating in this review. All the staff who met with us were open and quite detailed about their involvement with this event.

Causes and contributing factors:

The following items are not in any specific order. Most of these represent missed opportunities towards preventing the occurrence of this event.

· While the principal investigator [redacted] had general radiation safety training this was not adequate for the source in question. There was a lack of appreciation for the difference between this source and the other sealed sources previously used in terms of exposure risk, of fragility, of handling procedures, and of emergency response procedures.

· The source user [redacted] at the time of the event had no radiation safety training, contrary to NIST program requirements. This had been recognized by his project leader [redacted] but specific steps had not been taken to get this training scheduled. Nevertheless [redacted] was directed to perform work with the Pu source. However it is speculative whether this training would have made any difference since the previous training did not address the issues related to the safe handling of this source and the proper response to its containment failure.

· The NRC license issued to NIST-Boulder is a limited use license with four authorized users. Persons not on that list, e.g., [redacted] can work under the supervision of one of those authorized persons. It is not clear that this requirement was clearly understood by the involved individuals even though [redacted] has explicitly accepted that responsibility in this instance.

· The actual handling of the source bordered on the cavalier. It is speculative to assume the age of the bottle or its exposure to radiation made it any more fragile than a new bottle. But even if the users were ignorant of the potential exposure risk based on the quantity of material the simple fact that it was plutonium should have produced some level of respect in the handling of the source.

· The procurement approval process within Health Physics has a built-in coordination that, based on questioning of the HP and of the principal researcher [redacted], was not

performed. Specifically [redacted]. did not sign the request form, his division chief did not see or sign the form, and [redacted]. did not receive the completed form (with the specified usage precautions) upon receipt of the source. It is speculative that this form would have precipitated an appropriate risk review by the supervisor but it should have.

· The procurement process under the NIST-Gaithersburg broad NRC license is fundamentally different from that of Boulder. At Gaithersburg routine source acquisitions are reviewed as needed by the IRSC and unusual requests require specific IRSC review. The specific NRC license held by Boulder does not require an IRSC review. Nevertheless at the instigation of the Boulder HP an IRSC review of the proposed license amendment was performed. This was a missed opportunity to impose administrative limits to the usage of the NRC license, albeit such a procedure would have been unusual.

· The procurement process required approval for the dispersement of funds for the acquisition from DoE. Hence senior management was aware of this source acquisition. Nevertheless an appropriate risk assessment was not performed.

· The usage precautions from Health Physics (Form 364) do not specify secondary containment (e.g., plastic bags or the original shipping tube). This was suggested in an email from DoE during the source procurement process based on their understanding of the planned usage but this did not become part of the source usage procedures. Email from Health Physics during the procurement process identified the need to better secure the bottle containing the Pu but there is no evidence that action was taken on this note.

· The usage precautions did specify the use of gloves when handling the source but this point is mute since the users did not receive these usage instructions.

· The principal researcher [redacted] did direct the use of secondary containment bagging but the mounting process using tape created holes in the bags. They were not replaced with fresh, hole-free bags. And in fact the bags with holes were left in place. I would conclude that this indicates a lack of comprehension of the purpose of this secondary bagging.

· Alternative, less fragile containment, does not appear to have been considered as part of the acquisition process. The note from DoE relating to leaving the extra packaging in place (plastic bag, cardboard tube) indicates that it was understood that extra enclosure was feasible. But there is no evidence or testimony that such was considered.

· The multi-use aspect of this shared lab added to the potential for usage problems related to the use of this source, or in fact any other radiation source or hazardous material. It does not appear to have been a factor in the source failure but was certainly a factor in the spread of the radioactive material.

· Based on testimony the operational surveillance by Health Physics [redacted] was spotty at best. The lab user awareness of Health Physics was primarily as someone who

exchanged dosimetry. There appeared to be a lack of user performance review, i.e., informal lab visits, periodic observation of source usage activities, or casual conversations with users about ongoing or planned activities. One aspect of such a program is the observation of startup/first usages of a new source or new experiment.

· The delayed, and prolonged, response following the initial suspicion of a failed containment represents a failure of every step of a proper response to such an event. While the response might have been marginally better if the HP had been readily at hand the primary issue in this regard is the lack of training and understanding of proper response procedures on the part of the users.

· From the viewpoint of overall safety management the organization, the supervisory chain from the director to the first level, and the safety support groups bear primary responsibility. But day-to-day responsibility for bench activities must rest with the users. They must be informed of this, reminded of this, and be provided the training and resources to safely perform their duties. These researchers are highly intelligent. Ignorance should not be an issue but certainly was in this incident.

The immediate cause of this source failure was inappropriate handling by the user. All of the points above, to varying degrees, were contributing factors.

NIST response to the source containment failure:

The initial response, both by [redacted]. and [redacted]., to the suspicion of a containment failure (cracked bottle) were inappropriate. The current evidence indicates that these actions probably did not worsen the situation within the lab.
· The handling of the source once a possible crack was noted was inappropriate.
· Leaving other persons in the lab while the report was made to [redacted] was inappropriate.
· Making the report to [redacted] in person rather than by phone was inappropriate. This was probably the major mechanism in the extensive spread of contamination to other areas of the building.
· Returning to further examine the suspected crack, regardless of how uncertain [redacted] was of its existence, was inappropriate.
· Uncontrolled release of personnel from the lab was inappropriate. This simply accentuated the spread of contamination to other areas.

Once the safety office was notified and involved persons were recalled for contamination checks the response procedures started to be acceptable.
· One could quibble on the shoe removal step taken early in the recall process since it increased the chance of personal contamination. The positive aspect is that this limited further spread of secondary contamination since the shoes were possibly contaminated from contact in the lab.
· Assembly of personnel in the area outside the lab rather than a known clean area was a minor error. The concern should have been further personnel contamination rather than contaminating a clean area.
· The early personnel decontamination effort was well organized.

· The early request for the involved persons to document their event recall was certainly an excellent step to aid in identifying other involved areas and release pathways.
· The dedicated, all night effort to clean the hallway was admirable, but probably reflected the initial assessment that this could be a limited impact event. In hindsight an earlier effort to define the extent of contamination and to involve upper management in near term planning would have been more beneficial. But I find it difficult to fault those first 10-12 hours of work.
· The minimal radiation instrumentation available during the early phases of the response, and the failure of some of those units, certainly encumbered the HP response activities. The apparently minor extension of the source program from beta-gamma sealed sources to an alpha encapsulated source represents a significant additional instrumentation requirement, both in types (which was recognized) and numbers (which was underestimated). This requirement was mostly unfunded.
· Even after the arrival of the Gaithersburg HP [redacted] on 12 June as site response commander much of the activity was in response mode as additional information was discovered. Admittedly this is not unusual in that additional information and conflicts in current information tends to continue to develop over an extended time period, even for a limited release such as this.
· The long term planning for cleanup and remediation appears appropriate. The plans for additional, near-term HP staffing are certainly appropriate. Oversight of cleanup contractors, additional HP surveillance, and documentation and reports of these efforts will be labor intensive activities needing this added support.

Miscellaneous notes:

In general I would not characterize this incident as an accident. It was the inevitable (or at least highly likely) and foreseeable end result of the conditions outlined above. The fact that the breakage occurred after only the fourth or fifth usage of the source reinforces this conclusion. Nevertheless, with properly trained and experienced users this particular source could have been safely used irrespective of the fact that use of the source in this form was not essential to the experiment.

Although there is no basis for the following in terms of direct testimony I find the description of the events by [redacted] somewhat suspect. The fraction of the source lost from its container and observed in the vicinity of the detector seems rather large for what [redacted] describes as simply a crack. The import of this is that if in fact he had a total breakage, and had reported it as such, the immediate response actions might have contained the situation in a more effective manner. However I must emphasize this is speculation that cannot be substantiated.

While lack of appropriate training was an important if not preeminent factor in this incident I would be negligent if this issue was not put in perspective. The list of topics for which radioactive material users must have training is very extensive, some very mundane regulatory requirements but in many instances complex topics. Regardless of the numbers of hours devoted to such training it remains a collateral nuisance to the persons who want access to sources for their research. Short of requiring a user

certification like licensed operators of nuclear reactors a careful balance must be made between the nature of the source, the education and experience of the user, and on-site source-specific radiation safety training.

Recommendations:

There is a consensus among the involved users and supervisors to get rid of this source and do the work elsewhere. This may be the only choice from an organizational policy point of view. Clearly, with proper higher integrity containment (not necessarily of the 'sealed source' type), this material could be safely handled and used at NIST-Boulder.

My primary recommendations relate generally to all hazardous material work. An appropriate and explicit risk assessment should be done for work with any hazardous material or device during project planning with a review and approval by at least a division manager.

All workers should have training specific to the hazardous material or equipment they use. I believe this in fact is currently a NIST administrative requirement. Management simply must find a mechanism to make it happen, and to continue making it happen.

A detailed review of shared use of labs where potentially hazardous operations are conducted should be considered. If the shared use of this lab is typical of the rest of the site there could be other workers with potential exposure to risks for which they have no knowledge or training.

While the NRC license for Boulder is a rather limited license for specific users it has characteristics of a broad license. In particular the uses for the sources has only broad descriptive limits within the license and usage procedures are for the organization to determine. Because of this flexibility these uses and procedures should be subject to IRSC review.