Report of Investigation of the Plutonium Spill at NIST-Boulder

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On June 17, 2008, I was asked by Pat Gallagher, Chair of the NIST Ionizing Radiation Safety Committee (IRSC), to serve as a member of an independent group of experts in radiation safety formed to review and provide comments on the rupture of a plutonium source that occurred at the NIST facility in Boulder, CO on June 9, 2008. The charge to the reviewers was to:

- identify the cause(s) of the incident and any contributing factors
- evaluate the NIST response to the incident
- evaluate the report on the incident that will be prepared by the NIST IRSC, and
- provide the NIST Deputy Director with individual recommendations on the following:
    - corrective actions
    - avoiding future incidents
    - improving safety performance and incident response

This report is based on my review of materials provided by NIST staff and on interviews with NIST employees conducted on June 24, 2008 in Boulder, and it addresses the first two tasks above, with some comments regarding the fourth. In addition, on June 18, 2008, the Radiation Emergency Assistance Center/Training Site (REAC/TS) was notified by the Department of Energy (DOE) that NIST had requested assistance from the Radiological Assistance Program (RAP) to deal with this incident, and was requested to provide medical guidance as needed. I serve as a Senior Scientific Advisor to REAC/TS, and became extensively involved in performing calculations of potential radiation doses to NIST employees resulting from possible intakes of the plutonium compound. Consequently, some of my knowledge of this incident may have been provided through my role with REAC/TS. However, I have not yet read any of the reports prepared by other members of the group, nor the draft report of the IRSC. Rather than reviewing the details of the incident here, I will enumerate a number of facts that contributed to the incident:

Immediate causes:

- The proximate cause of this incident is that the guest researcher using the source had not been trained on source handling and radiation safety.
- The principal investigator (PI), who is the source custodian, had informed the RSO that new employees needed training; the RSO had provided training to some, but not all, and the PI did not ensure that the training was provided to all before they began work with the source. The PI assumed the RSO would take care of it, and the RSO assumed the PI would inform him who needed to be trained by name.
- The PI had not been informed of his responsibilities as source custodian under the amended NRC license.
- The guest researcher had repeatedly taped the source to the face of the detector array, and upon removing the tape, tore the plastic bag in which the source was contained.

- On Friday, June 6 the guest researcher and another NIST employee (who had received radiation training) tapped the source bottle on a marble lab bench in an attempt to settle the “powder” inside the bottle into one location. This action may have caused damage to the bottle that was not immediately evident.
- On Monday, July 9 the guest researcher was holding the bottle in his right hand in front of the detector array, while using the data collection computer with his left hand and looking away from the source. In his interview, he said he may have hit the bottle against a lead brick used for shielding. (Note: this is not a quote; the researcher did not indicate any sense of how hard the contact between the source bottle and the brick was.)
- After placing the source in an aluminum can used to position it in front of the detectors, the guest researcher noticed what appeared to be a crack in the bottle, washed his hands in the lab sink, and went to his office, used the men’s room, and then informed the PI, thereby tracking contamination out of the laboratory into the hallway.
- Upon later inspection, the bottom of the source bottle was observed to be completely separated from the rest of the bottle; it is not clear when or how this occurred.

Contributing causes:

- The staff at Boulder, including the RSO, were not familiar with the form 364 used to request purchase of the source; we did not see a work instruction for completing the form.
- The form 364 has a signature block for approval by the Division Chief or an authorized representative. This line was blank on the form for the plutonium source, and neither the Division Chief nor the EEEL Director reported ever seeing, much less approving the form.
- The RSO used the same form for three different sources, with different safety instructions, which may have been confusing to users had they read it.
- NIST has no system to document, track and ensure that new employees complete required safety training before beginning hands-on work.
- NIST-Boulder has no radiation work permit (RWP) system to ensure workers are aware of radiation safety requirements for particular jobs.
- The source was used in a multi-purpose lab, with numerous workers who would not normally be considered radiation workers. There is no general employee radiation safety training.
- NIST does not appear to have any systematic process for reviewing the hazards involved in new work and implementing appropriate safety controls before the work begins. That is, NIST does not have an integrated safety management (ISM) program.
- The NIST Safety, Health, and Environment Division (SHED) is understaffed; the Boulder RSO spends most of his time on laser safety, which may well be appropriate, but this involvement precluded him from periodically monitoring activities, including source use, in the detector lab.
- The NIST-Boulder Director position is a rotating assignment among site Division Directors; the site Director has no line management authority for Divisions other

than his or her own. Consequently, no one on site has overall line management responsibility for safety operations at Boulder.

NIST response to the incident:

- Once the PI noted the condition of the source, he took immediate action by evacuating the laboratory and informing workers to remain in the hallway outside the lab.
- Subsequent advice (from the Group Leader?) that shoes should be removed was counter-productive, since that resulted in contamination of socks and in some cases bare skin.
- There was no spill response plan for radioactive materials.
- If the Boulder RSO had been unreachable (he was scheduled for vacation) rather than just delayed in arriving at the lab, one can only imagine how much worse this incident could have become in terms of contamination spread on and off site.
- The RSO responded appropriately and took charge of the situation, and controlled the hazards within the constraints of his available resources.
- There was only one alpha detector available, and it malfunctioned later that evening.
- There were no instructions posted in the laboratory for RSO notification (including an alternate), self-monitoring, self-decontamination, and other individual actions to be taken in case of a contamination incident. Nor is there a posting for radiological emergency response phone numbers, such as REAC/TS.
- The RSO is to be commended for both his immediate response, and for the realization that additional resources would be required from DOE to manage this incident.
- On-site occupational medical services are provided by NOAA; no expertise with radiation medicine is available.
- There is no arrangement with a local hospital for treatment of a contaminated accident victim. For example, if the guest researcher had sustained a contaminated wound when the source bottle broke, there would have been no appropriate medical management available.

Safety culture:

The safety culture at NIST reminds me of that at DOE research labs some twenty years ago. In general, the safety culture appears to be at stage 2, which is a high-risk condition. These stages, based on the DuPont model, are as follows, in order of decreasing risk:

1. Safety is an externally-imposed requirement by the NRC, OSHA, EPA, etc.
2. Safety is the responsibility of the internal safety and health staff.
3. Safety is a line management responsibility.
4. Safety is the responsibility of each individual.
5. Everyone is responsible not only for their own, but also for everyone else’s safety.

My assessment is that NIST is at stage 2; this is based on the following information gathered through the interview process:

- Managers expect safety staff to fix problems, rather than to advise them how they should fix the problems.
- Safety personnel have been told that safety must not interfere with creativity.
- Safety personnel have stop-work authority, but are reluctant to use it. Most believe they would receive management support, but would also receive significant "push-back" from the research staff and damage their working relationships.
- Safety personnel prefer to take the "back-door" approach by personally working with researchers to facilitate their work from a safety standpoint, rather than a formal program of review and oversight. Consequently, no line manager is required to make a decision on risk acceptance.
- Annual safety walk-throughs are conducted by upper-level managers, but perhaps from the point of view of demonstrating management support of the safety staff. Under stage 3 safety culture, the line managers clearly demonstrate their responsibility for safety by conducting walk-throughs as owners of the safety program, with technical input from the safety staff. One manager was noted as spending a portion of a safety walk-through on his cell phone, which clearly demonstrates to both employees and safety staff that safety is not a line management priority.
- Several mangers noted that they needed to do a better job of helping the safety staff fulfill their responsibilities; this is clearly a stage 2 attitude.
- Because of the lack of a hazards analysis system, no one considered the "what if" aspects of the use of this source, nor realized that the Boulder facility was not equipped to handle this source.
- The IRSC approved the license amendment, but without knowledge of the source configuration. Management decisions were based on assumptions rather than on documentation.

General comments:

When an incident such as this occurs at a facility with a poor safety culture, the safety and health personnel usually bear most of the blame, for "not doing their job." The result is typically a rather harsh imposition of safety requirements and endless reviews, which does not actually address the root causes, and further exacerbates the alienation between safety staff and researchers.

However, I do not expect that to be the case at NIST (or at least I hope not). Every line manager interviewed acknowledged personal responsibility: "we blew it"; "we did not have a handle on this"; "we failed at multiple levels." This incident, together with the laser exposure at Gaithersburg and the near-fatal injury of a contractor in July 2006, can serve to transform the safety culture to what it needs to be.

Instead of fixing blame for errors or failings by individuals, top management needs to look at the system that permitted these failures to occur. How do our organizational structure, goals, and priorities make it possible for an untrained user to handle such a potentially hazardous source? In a research setting, the researchers usually feel they know more about what they are doing than the safety and health staff, which is typically true in regards to the underlying science, but is certainly not true for hazards analysis and mitigation. Safety is not a required course for completion of a Ph.D. Safety is seen as a burdensome overhead function that detracts from the rapid development of new science. I believe this is because the relationship between safety and health personnel and researchers is seen as an economic contract: we pay you (through overhead) to do your job and keep us safe in spite of ourselves, so we do not need to worry about it. Unfortunately this is a sure route to disaster. A better model might be to establish a social contract, in which reciprocal altruism, rather than payment-for-service is the basis of the interaction. A start on this can be a statement from line management to research staff: "We want you to be innovative and creative, and we want you to do world-class research. We also want you to go home safely every night after work."

The implementation of the proper culture is usually achieved through an integrated safety management program, and in the DOE world, achievement of Voluntary Protection Program (VPP) "Star" status, in which management determines to meet not just the bare regulatory requirements, but to exceed them. At first glance, the cost of this effort seems prohibitive, but the costs of not doing it are far greater, as will no doubt be proven to be the case here. In fact, we were informed that NIST had explored VPP 4 to 5 years ago, but dropped the idea because of push-back from researchers. As a start, NIST should identify specific areas of safety excellence, such as laser safety in the EEEL, and build on them as models for the rest of the program.

Respectfully submitted,

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