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James Turner, Director
National Institute of Standards and Technology
100 Bureau Drive, Stop 1000
Gaithersburg, MD 20899-1000

Dear Dr. Turner:

On June 23 and June 24, 2008 at NIST Boulder I participated in a number of interviews with NIST Boulder staff as a member of a group of experts assembled to examine the events leading up to and following the Plutonium spill on June 9, 2008. The other members of the group were Dr. J. Michael Rowe, Dr. Paul S. Hoover, Dr. Richard E. Toohey, and Mr. Lester A. Slaback. In addition to the interviews, which were conducted by the group as a whole, we were provided with copies of e-mail communications and reports related to the research project involved with the spill. We were assured that any other materials we might want to examine would be available to us.

On the evening of June 23 Tom O'Brian (Director of the Boulder laboratory), [redacted] (Head of Health Physics, NIST Gaithersburg), [redacted] (Radiation Safety Officer, Boulder laboratory) and Patrick Gallagher (Chair, Ionizing Radiation Safety Committee, NIST) briefed the group on the spill and the current status of the laboratory's response to it, which was still in progress. [redacted]) was also present, but did not make a presentation.

The following day the group as a whole met with eleven NIST personnel. We talked to persons at all levels of management up to one level below the Director of NIST. The interviews lasted approximately fifty minutes each, and every member of the expert group had ample time to pose as many questions as he wished. The interviews were conducted in the following order:

[redacted] Chief Safety Officer for the incident
[redacted] Radiation Safety Officer (RSO), Boulder
[redacted] Principal Investigator (PI) of the research project
[redacted] foreign guest researcher (GR), user of the Plutonium source of interest
[redacted] NIST Boulder Safety Officer
[redacted]
supervisor of [redacted] and [redacted]

[redacted] supervisor of [redacted]
[redacted] Division Chief and supervisor of [redacted]
[redacted] Director of the EEEL and supervisor of [redacted]
[redacted], Chair, Ionizing Radiation Safety Committee

In general, I found the scientists and NIST staff members involved to be experienced, dedicated and competent professionals deeply concerned with the accident and with its implications for all those directly touched by it as well as for the possible seriously damaging long-term consequences. They were cooperative and forthright in their statements. In my view, the single exception was the visiting researcher most directly involved in the accident, GR. He appeared not to fully appreciate the implications of his activities and of the accident for himself and for others. His statements to the experts group and to [redacted] regarding his actions up to, during and after the spill lacked the details essential for precisely reconstructing what he did on the day of the accident.

My observations here will focus more on the circumstances leading up to and including the accident itself, rather than the immediate actions following it, for which my expertise is less relevant. I wish to emphasize that my comments are based on limited information gleaned from the interviews and my review of the copies of e-mails and other documents supplied to the group, They have not been independently checked for accuracy.

Observations Specifically Related to the Spill

On April 28, 2007, [redacted] the Boulder RSO, sent [redacted] the Principal Investigator (PI), an e-mail informing him that the NRC license amendment to possess U-235 and Thorium had arrived. Also the RSO stated to the PI that, before he ordered sources, training would have to take place, and that they should get together to set up some times. He also stated that he would be helping the PI to “set up your lab for the safe handling of the sources”. [redacted] the PI’s supervisor, was not copied on that memo.

On August 20, 2007, in an e-mail to the PI with a copy to [redacted] but not to [redacted] the RSO stated, “ The sources you are requesting are within our license limitations, therefore it is perfectly okay to purchase them”. Had [redacted] received that information he might have raised questions about the nature of the sources and precisely how they were to be used.

On September 21, 2007, the RSO expressed his concerns in a memo to the PI with a copy to [redacted] about a lack of training of the PI and his staff on handling of open source material once they acquire and begin using sources in screw top bottles. He suggested considering some sealant on the bottles to prevent their being opened. The PI’s Supervisor, [redacted] was not copied on that memo. Once again he was uninformed of a serious safety concern and therefore had no opportunity to intervene.

On October 11, 2007, in a memo to the PI and to [redacted], the RSO stated that he would go over some Pu packaging issues with him and included in the message,"I'll go over some of this when we do the training next week". However, the PI stated to the expert group that he had not received any special training related to his use of the Pu sources.

The Pu Sources were received at Boulder on October 11, according to a memo dated October 12, 2007 from the RSO to [redacted] of DOE with a copy to the PI, but not to his Supervisor, [redacted].

On October 16, 2007 the PI sent a memo to the RSO, to [redacted], and to [redacted] informing them that he had ordered a fire resistant set of shelves for the sources and expected the set to arrive in two weeks.

The RSO told the experts group that he had helped the PI with storing the sources in the fire resistant cabinet and had arranged a lead brick barrier on the shelf where they were to be stored. Therefore, he was in the lab with the PI sometime in late October or early November. We did not hear from the RSO about the extent to which he reviewed the experimental set up and the procedures that were going to be followed, or of any training he gave to the PI.

The PI did not formally inform the RSO who the new people were who would be joining the team, although the RSO apparently learned through a casual conversation with the PI that there would be new staff added to the project. The RSO did not find out who these people were and whether they needed training in Radiation Safety or when they would join the team. He stated in the interviews that the very first time he met GR was in the afternoon following the accident.

GR joined the PI's team in December. Ultimately, he was allowed to work with the Pu source with no radiation training from NIST. He was totally unaware of the policies at NIST Boulder that would have required him to be badged and trained. He said that he had mentioned to someone that he had no radiation badge even though those who were working with him were badged, and he claimed to have asked to have one, but that did not take place. It wasn't clear to whom he made that request.

The PI and his supervisor should have ascertained what GR actually knew about radiation safety and NIST policies respecting use of radioactive sources and how they might apply to the work he was about to begin. They didn't understand that while the RSO had the responsibility of delivering training, they had the responsibility for arranging for it to take place. They should not have permitted him to begin using the Pu sources without having had specific training.

GR was permitted by the PI to work alone in the laboratory with the Pu sources outside of normal working hours. The PI's Supervisor was unaware of this.

We saw no evidence that the experimental procedures to be followed in using the Pu source were carefully planned and documented.

The RSO stated that he had told the PI that the Pu source should be kept in the sealed plastic bags and in the labeled can in which it was stored. It is not clear whether that warning was actually conveyed to GR.

GR, while working alone in the lab on the weekend before the spill, removed the source from the can and bags and held it in his hand while adjusting its position relative to the detector so as to find the optimum position. He appears to have been unaware that he should have checked with the PI, before embarking on such an approach to conducting the laboratory studies. Consequently the PI had no opportunity to prevent it.

Precisely how the source glass container became damaged and the spill occurred on the following Monday were not described by GR to the expert group, although he did comment that he may have struck the encapsulated source in its unprotected glass container against a lead brick while moving it back and forth with one hand while he observed the readout on a computer screen. It is clear that he was unaware of the serious consequences of a release and spill of the Pu powder. He did not act in a prudent manner in handling the source. Moreover, because he was untrained in such matters, he was not aware of the course of action that should be taken in the event of a release to the environment of the Pu powder.

Following disclosure to the PI that there was a problem with the source and the subsequent discovery by the PI that contamination of the lab workspace had occurred, the RSO was notified. Based on his very limited training and knowledge, the PI initiated steps (some of which may have been questionable) to deal with the situation.

The RSO responded and initiated a check line and control process. However, the equipment and trained human resources available to him on site were extremely limited and inadequate to characterize and deal completely with what happened.

It became apparent after some time that additional help was needed. The NIST Boulder and Gaithersburg laboratory management responded very positively to meeting those needs. Nevertheless, there were serious delays in initiating the necessary controls and procedures to deal with the spill and its aftermath. Apparently no one at Boulder considered a spill of Pu powder as a possibility, and therefore they were unprepared to deal with it.

The plan for going forward was under intense development but not yet totally clear before I left the site on June 24.

Observations Relating to NIST Systems

In recent years the use of sources of radioactivity at NIST Boulder had been minimal and involved sealed non-dispersible sources. There was no resident staff health physicist at NIST Boulder until [redacted] was hired in October 2006. Detection equipment on site was minimal and budget lines for equipment acquisition and training materials were very difficult to obtain.

However, the decision to proceed with the detector research program, which ultimately involved the use of Plutonium sources on site at Boulder, was not taken lightly. Several layers of management were involved, as was the Ionizing Radiation Safety Committee (IRSC). A Costs/Benefits analysis performed at the Division level turned out to be very favorable. Some time after the Costs/Benefits analysis was done, a decision was made to acquire unsealed (but encapsulated) Plutonium sources, in particular encapsulated powdered sources. *Encapsulated* appears to be a loosely defined term easily misinterpreted as equivalent to sealed. The decision to use such sources should have triggered a new Costs/Benefits analysis, but it did not. The Division Director, based in Gaithersburg, was unaware of the decision to order encapsulated powdered Plutonium sources. The NIST Form 364 Proposal to Acquire a Radioactive Source was prepared by the RSO and processed without his knowledge or signature. One can only wonder why.

The IRSC Committee was cognizant of the Boulder plans for acquiring small amounts of Plutonium for testing the detector system being developed and discussed the matter at some length. The Boulder RSO is a member of the IRSC. However, the description of the sources as "encapsulated" appears to have misled the IRSC and others into a belief that the sources were robust and very difficult to break open. The IRSC apparently was not aware that the Plutonium sources would be in powder form in unsealed screw top glass containers. Perhaps because they believed it to be relatively safe, the IRSC did not aggressively follow the details of the evolving work on this project. However, that proved to be a serious mistake.

In 2006, Boulder Health Physics had no funding for the acquisition of equipment. The minutes of the June 27, 2006 IRSC Meeting noted without comment that the Boulder Health Physics Invested Equipment (IE) request list, which included a smear counter, would not be in the HP IE List for FY 07. This was not the Committee's decision but was a decision by the NIST Budget Office.

However, this took place before the hiring by the Boulder site of [redacted] in early October 2006. He became the Boulder RSO. His efforts led to a decision by the Boulder Office of Health Safety and Environment (OSHE) to sacrifice other equipment needs and to purchase two G-M detectors and to borrow from Gaithersburg two additional G-M detectors and an alpha/beta counter. He also developed a list of needed ionizing and non-ionizing equipment for the Boulder HP IE 2007 budget request. We did not learn about the outcome of that list.

It is clear that no one at NIST Boulder realized that embarking on a program that would use Pu in an encapsulated source (not a precisely defined technical term) entailed serious

potential hazards and new equipment and other resource requirements. The hiring of a health physicist indicates an awareness that something new was occurring, but assigning laboratory workspace to the project in a busy mixed-use laboratory suggests that no one considered the work to be radioactively hazardous. Senior managers confirmed that in their interviews with the experts group. It is not clear that the RSO understood that this decision did not conform to the NRC amended NIST license conditions.

While some of the weaknesses, which led to this accident, involved a lack of technical training, a lack of familiarity on the part of newly acquired staff with the administrative policies and procedures of the laboratory was also a significant contributor.

> The PI did not know that he was responsible for seeing that his assistants had the necessary training for handling radioactive materials.
>
> He was also unaware that as Custodian of the sources it was his responsibility to see that only qualified individuals had access to them.
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> The RSO did not know that he must have the approval of a Division Director before approving the purchase of a radioactive material.

There is no uniform system, supported at all levels of management, of nurturing and supporting a culture of safety awareness as a high priority in every NIST Boulder activity.

The Boulder Safety Organization has not been adequately supported and has had to function with inadequate human and technical resources, although there has been some improvement in the last year or so.

While the spill was probably the direct result of the actions of unsupervised and inadequately trained individuals who did not understand the hazards of the radioactive material they were working with and conducted their laboratory procedures in a manner that violated some specific instructions given to them, underlying weaknesses in the Laboratory fostered an environment which left open the possible occurrence of such an event.

These weaknesses stem partly from the failure of some key individuals at various levels of authority to personally embrace and consciously support an institutional culture which seriously considers the safety implications of every aspect of their work and makes decisions based on avoiding unsafe practices while also preparing for the possibility of unlikely yet possible safety challenges. While scientific and technical analyses at NIST generally receive the highest possible quality of thought, safety considerations do not enjoy that status. (There are or course exceptions.)

In fact there were indications that some researchers and their managers, when in hot pursuit of an important scientific objective, might set safety aside for consideration at a

later date, if at all. Some of the staff involved in the promotion and assurance of safety described the Safety Culture at NIST as dysfunctional.

Apparently, the NRC did not follow up (either by a formal communication or a site visit) its issuance of a license amendment to the lab to use Pu and other SNM in order to check on the capability of the individuals, the laboratory management and the equipment and facilities involved to handle these materials. It might have flagged training and equipment deficiencies relating to this project and might have prevented the accident. However, the responsibility for compliance with NRC requirements and safe practices rests with the licensee. NRC's failure to act in no way reduces the responsibility of NIST.

Preliminary Recommendations

- NIST must proceed apace with the decontamination and decommissioning (if advisable) of all laboratory areas affected by the spill by employing experienced well-regarded professionals. Credibility of the quality of the final results is extremely important.

  Consistent, open and clear lines of communication, providing up to date factual information about the incident, must be created and maintained to the NIST Boulder staff and to all interested government and concerned public interest entities.

  A process should be established immediately for assisting NIST Boulder staff in coping with any physical and psychological trauma occasioned by the accident and its aftermath. NIST's people are its most valuable resource.

- A comprehensive Root Causes and Lessons Learned analysis must begin immediately and involve experienced recognized experts in such analyses from outside of NIST. It must be penetrating and highly credible.

- A new Costs/Benefits analysis should be carried out that seriously considers alternative modes of conducting the research required for continuing the detector program. It should include performing any studies requiring Pu or other SNM at laboratories well qualified to work with such materials.

- The use of the Plutonium sources CRM 133, CRM 138-1 and CRM 138-2 should not resume in any research at NIST Boulder, and alternative safer sealed sources must be used in any further work at Boulder. The CRM 133, 138-1 and 138-2 sources should be properly disposed of off site.

- Resumption of the research project should only occur after all staff connected with it are thoroughly trained and qualified for the safe use of any radiological or non-radiological material or equipment to be used in their work.

- The RSO should be encouraged to routinely check on staff compliance with the SAFETY PROCEDURE/HAZARD ANALYSIS CONSIDERATIONS he lists in Form 364 as well as on the practices planned and occurring in the relevant laboratories.

- Use of radiological material at Boulder should only take place in laboratories specifically qualified for such purposes in accordance with well-established standards and requirements. Room 1-2124, in which the spill occurred, did not meet those standards.

- A systematic study of all potential and actual hazards at NIST should be carried out across the board as soon as possible. All potentially hazardous materials and equipment at any NIST site should be identified and analyzed. On the basis of that analysis a safe practices protocol should be developed for the guidance of all users of the materials or equipment. This may require the assistance of additional experts outside of NIST.

- The NIST staff training policies and practices should be thoroughly reviewed and modified to correct deficiencies. Safety training must be based on a clear understanding of the hazards and their potential consequences of every new activity as well as ongoing projects. Attention should be directed to familiarizing all staff with NIST administrative procedures as well as the safety requirements related to their work.

- There is no uniform system, supported at all levels of management, of nurturing and supporting a culture of safety awareness as a high priority in every NIST Boulder activity. All managers should be held accountable for promoting a safety culture within their purviews, and manager performance reviews should include a consideration of how effective they have been in that regard. The Boulder Safety Organization has not been adequately supported and has had to function with inadequate human and technical resources, although there has been some improvement in the last year or so. That improvement should continue.

- The functionality of the line management relationships at NIST Boulder to NIST Gaithersburg should be examined as a possible contributor to this unfortunate event. This study could take place in parallel with the Root Causes Analysis. Lines of communications and authority clearly broke down.

- Equally important is an examination of the functionality of the relationships between the Boulder Safety Organization and the other Groups, Divisions and Projects at Boulder and Gaithersburg. A clear understanding of how those relationships are envisioned by NIST top-level management has not been successfully communicated to staff at Boulder. This lack of clarity is a serious weakness and should be corrected.

Once again I wish to emphasize the preliminary nature of these comments and recommendations. With further information and more opportunity for reflection I might change some of them. I appreciate the opportunity to be of assistance to NIST and will be happy to continue to do in the future.

Sincerely Yours,

Kenneth C. Rogers