Los Alamos
NATIONAL LABORATORY
EST. 1943

Radiation Protection Division
P.O. Box 1663, MS G760
Los Alamos, New Mexico 87545
Phone: 505-665-7797/Fax: 505-664-0668

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Refer To: RP-DO-08:017

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

Dear Dr. Turner:

This letter documents my preliminary observations, findings, conclusions and recommendations regarding the June 9, 2008 NIST Boulder plutonium contamination event. I formed these conclusions based on the June 23-24, 2008 subject matter expert on-site review of the event, review of available documentation, and interviews with 10 persons of interest. All persons interviewed were accommodating, cooperative, forthcoming, and professional. They demonstrated serious concern over this event, intent to understand underlying causes, and commitment to prevent recurrence.

Following are my observations and findings, including supporting information where appropriate. Findings are organized in areas of *Management Systems, Hazard Analysis and Control, Work Execution,* and *Response to the Event.* Many of the findings are interrelated, and many are causal to subsequent findings (e.g., a less than adequate hazard analysis resulted in less than adequate controls). Please consider these in the context of the limited scope and duration of the SME review. This information is intended to be useful in conducting further investigation, causal analysis, development of corrective actions, and in helping prevent recurrence of this event.

Preliminary Observations

Both NIST Gaithersburg and Boulder personnel took deliberate actions to manage the evolving scope of this work in detector technology.

- Management consideration and decision to fund, support, and expand application of this technology
- Boulder Radiation Protection Program included in Ionizing Radiation Safety Committee (IRSC) charter
- Review of the Boulder Radiation Protection Program conducted by IRSC
- Hiring the Radiation Safety Officer (RSO) at Boulder
- Amending the radioactive material license at Boulder after consideration of license options
- Initiating radiological worker training at Boulder in 2005 and 2007
- Acquiring hand-held radiation monitoring equipment in support of this work
- Performing a hazard analysis for the new radioactive materials
- Propagating NIST Gaithersburg health physics instructions to Boulder

Involved personnel expanded the emergency response as the extent of concerns came to light.

- The breached source was physically isolated
- Personnel were evacuated from immediate hazard
- Personnel were surveyed and decontaminated

- Interviews with involved personnel led to further area surveys that revealed extent of contamination beyond the primary laboratory
- Access control was established for the building and specific rooms
- Localized contamination was managed, and areas of concern were isolated
- Contaminated waste materials were controlled
- Additional resources and expertise were acquired, leading to help with personnel dose assessment (including in vivo and in vitro bioassay), characterization of the remaining material, and stabilization of the contaminated areas.

The planned path forward to recover the laboratory appears appropriate.

- Establishing a recovery plan
- Further isolating the contaminated laboratory
- Acquiring additional radiation protection and safety staff
- Obtaining contractor assistance to fully recover the contaminated areas

Preliminary Findings

Management Systems

Management attention to safety issues was less than adequate.

- Safety and RP resources were not sufficiently funded (staff, administrative support, instruments, equipment, supplies)
- History of transferring safety responsibilities among other entities (e.g. NOAA)
- Competing priorities and over-stretched existing Safety and radiation protection (RP) resources (e.g. focus on laser safety at the expense of radiological safety)
- Insufficient priorities on safety to ensure training (funding, staff, attendance, management engagement); computer-based training solution not funded
- Demonstrated safety awareness (e.g. engagement through safety processes) varies by organization
- Senior management presence on the floor is sparse
- Expectations for management ownership of safety, responsibility for hazard control, integrated safety management not sufficiently communicated to managers
- Line management relies on Safety and RP to ensure safety without direct line management support, in an R&D environment of principal investigators, in the absence of line management presence
- No systematic approach for establishing safety requirements
- Implementation of safety requirements is highly dependent upon individual personalities rather than requirements and processes

Roles, responsibilities, authorities, and accountabilities (R2A2) and organization structure were either not sufficiently defined or contributed to this event.

- No formal connection or reporting requirements between Boulder and Gaithersburg RP functions
- Gaithersburg RP has no authority at Boulder (e.g. stop work)
- Line managers are license managers at Gaithersburg; RSO is license manager at Boulder
- Line safety representatives lacked focus on radiological safety – this was consigned to RSO
- PI is responsible for worker training under the radioactive material license as opposed to typical line manager function
- Workers look to PI for guidance and mentoring, without much line manager interaction or oversight
- Boulder Safety and RP rely on influence and negotiation to establish programs; unable to establish requirements due to weak line management engagement in safety

- Safety requirements at Gaithersburg not established by Safety or RP, rather require consensus among line organizations

IRSC oversight and follow-through for identified Boulder RP issues was less than adequate.
- No coordination or link of radioactive material licenses between Gaithersburg and Boulder
- Boulder license amendment not reviewed by IRSC prior to submittal
- Recognized new RP program and new work direction but did not engage to provide more direct oversight with respect to this new activity (e.g. newly selected RSO unfamiliar with NIST safety protocols, including Form 364)
- Relied on RSO Boulder to identify deficiencies, concerns, and significant changes without detailed verification

Interface and communication between line management, the PI, the worker (W1) and RSO was informal.
- Dispersible nature of radioactive material not discussed with line management
- No formal tracking of new radioactive material users or followup on informal discussions regarding new workers
- Neither the evolving work practices nor configuration of the radioactive material was communicated to RSO
- W1 and RSO had never interfaced

The line management decision to proceed with expanding this work did not adequately consider safety risks associated with the new radioactive materials to be used.
- Protocols for evaluating cost/risk/benefit of new work not sufficiently established or implemented
- Risks from dispersible material not understood or considered by management decision makers

The NRC radioactive material license amendment process did not assure adequate review of new hazards.
- Amendment request contained inaccurate information (e.g. spent fuel elements)
- NRC did not emphasize dispersible nature of material
- There was no NRC followup / inspection to verify amendment conditions

The NIST change control mechanism (Form 364 *Proposal to Acquire a Radiation Source*) was not formally applied.
- Lacked review and approval by PI and line management

Hazard Analysis and Control
The hazards associated with the new radioactive materials were not adequately identified or analyzed.
- No consistent understanding or risk analysis associated with "encapsulated" source vs. "sealed" source
- Lack of understanding the dispersible nature of the new radioactive material by line management, IRSC, and RP in Gaithersburg and Boulder

Controls for these hazards were not adequately established or communicated.
- Form 364 identified powder nature of material, but lacked emphasis on contamination control (containment, monitoring)
- Form 364 overemphasized external radiation hazards and prescribed conservative controls (shielding, remote handling) which could conflict with contamination control

- New Brunswick Laboratory recommended leaving the source in the cardboard tube (and opening the tube should be performed in a glovebox)
- RP directed PI to leave the source in sealed plastic bag (this was not communicated to worker)
- W1 was not issued external dosimetry

Conditions of the radioactive material license were not adequately implemented.
- Radioactive material user training was not conducted as required
- RSO did not "review all uses of radioactive material"
- Sources were not controlled as required
- Workplace monitoring and contamination control measures were not implemented

Training and qualification of radioactive material users was less than adequate.
- Inconsistent application of employee hazards Form 1197
- W1 had no previous experience with radiological materials
- W1 had no safety training
- W1 was not trained on radiological hazards, controls, or emergency response
- W1 was instructed on work, without mention of safety procedures
- W1 misunderstood effects of radiation on electronic equipment (driving placement of lead bricks at detector array)
- No clear definition or threshold of radiological workers and associated training and dosimetry requirements at Boulder
- Established training did not include a focus on response to radioactive material spill
- Source custodian responsibilities not clearly defined or communicated
- Safety training at Gaithersburg not necessarily linked to specific activities or hazards

RP program and infrastructure for routine work and upset conditions with this dispersible material was less than adequate, including insufficient:
- Facility systems (containment/confinement devices)
- Instrumentation (survey and analysis equipment, air sampling and monitoring)
- Contamination control (routine area and personnel surveys)
- Area designation and posting (access control, radiological activity separation, PPE requirements, monitoring)
- Respiratory protection program (equipment and qualified workers)

Work Execution

In-field oversight of the work by line management and the PI was less than adequate.
- Risks of dispersible material were not communicated to W1
- Containment requirement was not communicated to W1
- W1 modified configuration and containment without knowledge or oversight

In-field oversight by RSO was less than adequate.
- There was no startup review or observation of work with new materials
- Interaction was informal, focused on transactional duties (e.g. dosimetry exchange) rather than evaluation of frequently changing work and practices
- Confirmatory contamination surveys were not performed
- Assumptions were not confirmed regarding configuration of experiment and implementation of controls

Work control associated with using these materials was less than adequate.
- No procedure or work control document established prescribing hazard control
- Existing Form 364 was not used to guide control of hazards

No formal experimental plan was established or executed.
- Worker was left to modify approach and source configuration through trial-and-error approach
- Safety expectations or controls were not established in the experimental plan

Controls that were established were not adequately implemented.
- Secondary containment was removed
- PPE (gloves) were not worn
- Source was physically mishandled (e.g. tapping)
- Source was not controlled as required (left unattended during experimental run)

Human errors were committed during the experimental work.
- Worker did not keep eyes on work (potentially the direct cause of the source containment breach)
- Worker did not recognize or react appropriately to changes in work practices (evolving source geometry measures – multiple containment configurations, source support configurations (taping to detector array, to block in vise, within can) or controls (torn secondary containment bag(s))

Programmatic pressures contributed to mistakes.
- Experiment was delayed by equipment challenges, causing schedule slip
- PI was not onsite during restart by W1
- W1 felt schedule pressure to achieve results

Response to the Event

Emergency preparedness was less than adequate, including insufficient:
- Emergency planning, training and drills
- Instrumentation and equipment (contamination and air monitors, large area swipes, HEPA
- Decontamination capabilities (materials and supplies, collection systems)
- PPE (respiratory protection, PPE for contaminated persons)
- Planned emergency contacts (REAC/TS, RAP, expert consultants)

Immediate emergency response was less than adequate.
- Extent of initial rupture was not recognized, although W1 took mitigating actions (taped up source in can, washed hands)
- Workers not immediately evacuated
- Notification to safety personnel was delayed
- PI made multiple entries (investigating ruptured source, monitoring contamination, isolating ventilation) without safety support, without understanding hazard or implementing appropriate controls (e.g. respiratory protection)
- Workers were instructed to remove shoes
- Workers were allowed to roam

Evolving emergency response was less than adequate.
- RP / Safety were not provided adequate resources in early stages (lacking supplies, administrative support)

- Initial bioassay samples were small volume, not collected away from work site, not prioritized at analysis laboratory
- Nasal swabs were not taken until the next day
- RAP response required interaction with multiple regions, required recall and delays for expertise and equipment, and limited support services at relatively low hazard

Preliminary Conclusions

- Safety was not sufficiently integrated into NIST processes, systems, or organization.
- Mechanisms for cost/risk/benefit analysis lacked sufficient communication and full consideration of risks.
- Safety processes (including hazard analysis & control and work control) and requirements were either not established or consistently implemented in Boulder operations.
- The fundamental lack of understanding of the hazards associated with this material and missed opportunities to identify significant change led to the lack of readiness and capability to safely handle this dispersible material and respond to associated emergencies.
- Issues regarding this activity and event may be systemic and reach into other areas of safety.

Recommendations

- Conduct further investigation of this incident, identify causal factors, develop and implement corrective actions and evaluate effectiveness of these corrective actions.
- Evaluate the extent of the conditions found in this incident for other radiological operations as well as other hazardous operations.
- Continue with the established recovery plan for this laboratory, ensuring adequate resources, appropriate oversight & involvement of line management and RP, and analysis & control of other safety considerations including electrical and chemical hazards.
- Stand down this work pending analysis, development, and implementation of alternative approaches and commensurate radiation protection program to include appropriate resources, infrastructure, training, and emergency preparedness.
- Establish mechanisms - involving line management and experimenters as well as subject matter experts - to include comprehensive safety review of new or changed work; consistent, formal hazard analysis and control; and worker qualification (with emphasis on new or transfered workers and including associates).

It is important to consider these observations and findings as preliminary and subject to change based on further investigation and confirmation of factual accuracy. I am available for discussion and clarification as needed. I look forward to assisting further as requested in an SME capacity.

Regards,

6/27/08

Paul Hoover
Radiation Protection Senior Advisor

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cy: Patrick Gallagher, Stop 6100