



# OPERATING EXPERIENCE SUMMARY



## U.S. Department of Energy

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## Explosion at the Nonproliferation Test and Evaluation Complex

# 1

On June 13, 2014, a drum, believed to be empty, exploded and injured two workers at the Nonproliferation and Test Evaluation Complex (NPTEC) at the Nevada National Security Site (NNSS). As part of a Work for Others (WFO) project, the workers intended to obtain a drum of isopropyl alcohol (IPA) but had to move a second drum to access it. The drum that had to be moved previously held IPA. Personnel believed they had emptied the drum 2 days before the incident. However, movement, combined with accumulated organic peroxides in the drum, oxygen, and high ambient temperatures, resulted in the unplanned detonation. The contractor, National Security Technologies, LLC (NSTec) and National Nuclear Security Administration/Nevada Field Office (NNSA/NFO) senior management recognized the significance of the event and established a local Accident Investigation Board (Board). That Board determined that the accident could have been prevented by implementation of both a comprehensive Chemical Safety Lifecycle Management (CSLM) program and a robust facility-specific Chemical Hygiene Plan (CHP). (ORPS Report NA--NVSO-NST-NTS-2014-0009, Final Report October 28, 2014)

### Background: The Site and Its Management

NPTEC is the world's largest facility for open-air testing and evaluation of emerging sensor technologies. NPTEC performs tests, experiments, and training for any technology that requires the release of toxic chemicals or biological stimulants into the environment. The site is located in a natural geologi-

cal basin approximately 70 miles north of Las Vegas, Nevada, where the topography, wind predictability, and location provide a secure, controlled environment for such testing. NPTEC consists of four test areas and numerous support buildings, including the East and West "Motels." These open-sided concrete structures, approximately 186 feet long by 14 feet wide by 8 feet high, were created for above-ground testing and are currently used for storage of chemicals and materials that support WFO experiments. The size of the NNSS (1,375 square miles) and the thousands of acres of additional Federally-controlled lands surrounding the site provide a large safety zone for the protection of the public.

In 1982, Congress passed Public Law 97-377, authorizing construction of a Liquefied Gaseous Fuels Spill Test Facility, where tests with hazardous chemicals and liquefied gasses could be performed safely. The site was later given its current name, the NPTEC. NSTec was awarded the Management and Operations (M&O) contract in July 2006. NSTec is a joint venture among Northrup Grumman Corporation, AECOM, CH2MHill, and Babcock& Wilcox. Since the inception of the NSTec contract in July 2006, NPTEC has had a series of organizational changes.

Procurements for projects frequently involved greater quantities of chemicals than tests required to be prepared for contingencies, in case tests had to be redone or more tests were ordered. These excess chemicals were retained in anticipation of a WFO customer's return or possible use in another WFO customer's test program. The practice resulted in the accumulation in Bay 30 of the West Motel of approximately 250 gallons of IPA stored in a series of 55-gallon drums, some of which appeared to have been received a decade ago. Similarly, other chemicals of unknown origin or unknown acquisition dates had also accumulated in Bay 30, including a 55-gallon drum of hydrochloric acid.

Because IPA can form peroxide bonds as it evaporates, and formation is accelerated by heat and other conditions (see text box), there is an extremely high possibility that accumulated organic peroxide compounds in the drum caused it to explode when a worker moved the drum, see Figure 1-1.

## Work Location and Activity

On the morning of the event, a subcontractor and an NPTEC project representative entered Bay 30 to obtain IPA for a WFO project. To access the 55-gallon drum they needed, workers had to move another 55-gallon drum blocking access. The workers believed they had emptied the drum of IPA 2 days earlier and had left the lid off the drum after they pumped the material from it. As the subcontractor lifted the open and (thought to be) empty drum, it exploded, projecting him 8 feet out of the Bay. The heat flash singed his arms and hair, and shrapnel cut his right foot and lower leg. (Note: He was wearing tennis shoes instead of safety shoes). The project representative, who was standing 6–8 feet away from the drum, suffered ringing in his ears but was not cut by shrapnel. Some of the shrapnel also punctured the rear tire of a nearby utility truck.



**Figure 1-1. Views of exploded drum. The left image and the close-up image on the cover show the bottom of the exploded drum. The right image is a close-up view of the bottom seam of the drum.**

Peroxide formation is accelerated by heat, light, exposure to ionizing radiation, and any other environmental condition that increases the rate of free-radical formation in the solvent. This reaction is observed in the pure solvent. In concentrated form, organic peroxides are exceptionally prone to explosive decomposition and are very sensitive to mechanical shock, friction, or heat.

*AI Final Report, ES-2*

NPTEC personnel immediately evacuated the West Motel, and roadblocks were placed in the immediate area by security personnel to prevent unauthorized access. An ambulance transported the subcontractor to the University Medical Center, where he received stitches in his right calf and foot. He was released later that afternoon. The project representative, who complained of ringing in the ears, was examined by paramedics at the scene and released.

Mutual aid resources and NNSS Fire and Rescue deployed to NPTEC, and a robot was used by local police department representatives in Bay 30 to move some drums to determine which ones were empty and full. A plan was then developed to keep the area isolated and secure until recovery operations were determined.

## Discussion of Primary Issues Investigated by the Board

Based on the results of the investigation, the Board identified 56 Conclusions (CON) and 44 Judgments of Need (JON). CONs are derived from the analyses to determine what happened and why it happened; JONs are the recommended managerial controls and safety measures necessary to prevent or minimize the probability of recurrence. CONs and JONs were assigned in the areas of Safety Culture, Training and Qualification, Chemical Safety, Management, Work Control, Issues Management, Federal Oversight, Self-Assessment and Corporate Oversight,



Conduct of Operations, Emergency Management, Environmental Compliance, and Authorization Basis. Discussion of the highlighted six areas follows; more information is available in the Board's Final Report linked at the end of this article.

## Safety Culture

The Board reviewed two surveys addressing safety culture. Stressors and topics of concern in the overall safety and security culture that could impact organizational excellence included the following: (1) open communication; (2) fostering an environment free of retribution; (3) credibility, trust, and reporting of problems; (4) and effective resolution of reported problems. Other topics that needed to be addressed included risk-informed, conservative decision-making; management engagement and time spent in the field; clear expectations and accountability; participation in work planning; and a questioning attitude. Leadership is essential in addressing safety culture, but it was an area identified as not meeting expectations. Organizational changes, including the change to Nuclear Operations Directorate (NOD) for facility management, were made to instill a “nuclear operations” attitude for day-to-day activities, but there has been limited management or NOD presence to implement these values. NSTec Global Security (GS) senior management has visited NPTEC while escorting customers, but has not routinely met with NPTEC personnel. Also, due to a series of previous challenges, management focus has been on nuclear facilities, not the non-nuclear ones.

Of particular note in the culture surveys was the hesitancy to raise issues, fear of reprisal, and lack of accountability. Workers saw that maintenance requests were not acted on, that management appeared to place a higher value on mission than on facility infrastructure needs, and that previous issues were not resolved. Coupled with both the uncertainty of funding and job security, a “why bother?” sense of frustration developed that led to low morale. Even after the accident, the culture of

indifference and lack of situational awareness continued. For example, the Local Emergency Director advised personnel that the area was safe to enter immediately after the accident even though chemical odors and liquid were present. Despite evidence to the contrary, NPTEC personnel stated during a post-accident review meeting that the event was a “freak occurrence” that could not have been prevented. The Board also received comments from personnel that the accident stemmed from “just an SME [Subject Matter Expert] issue” rather than recognizing that it had resulted from a series of challenges at the system/program level and could have been prevented.

## Training and Qualification

As stated in the AI Board Report, one of the cornerstones of safe operations is trained and qualified personnel who perform day-to-day functions to accomplish the facility mission. To ensure that workers understand activities and processes, management is responsible for budgeting and scheduling time for both initial and continuing performance-based training, and for providing SMEs to review and participate in the training process.

Successful training programs are developed using a performance-based process that provides structure, yet is flexible, and can be applied with a graded approach as safety requirements and risk dictate. NPTEC has a qualified Facility Manager (FM) and alternate FM who authorize work. Several documents provide initial training and qualification requirements, and it is the FM's responsibility to arrange for worker training in order to keep their training current and ensure that requirements are listed on their Employee Qualification Requirement for any tasks they perform. Out of a total of 43 required training courses for the NPTEC subcontractor who was injured, 21 (49 percent) training courses were not current. In addition, the subcontractor had not been assigned self-contained breathing apparatus training as required by the work package, as well as

training courses addressing *Conduct of Operations for Nuclear and High-Risk Facility Workers*, and *Pressure Safety Requalification*.

## Chemical Safety and Management

An effective chemical management program consists of a “cradle to grave” methodology whereby the entire process is a cycle of interrelated elements, addressed in terms of the hazards posed by chemical storage, usage, and disposal. The process begins during work planning prior to chemical acquisition and continues through the final disposal of the chemical(s).

The hybrid term Chemical Safety and Lifecycle Management (CSLM) is meant to convey the concept to ensure that all aspects are coordinated and addressed. For example, acquisition management should consider hazards of chemicals involved in the task, justifiable quantities, use of available excess chemicals in lieu of new purchases, stability and shelf life, suitability of storage facilities, and means of final disposition. The Board observed that a large quantity of legacy chemicals (in excess of 2,000 gallons) had accumulated in the West Motel storage bays, endangering personnel and facilities. Interviews indicated

that ordering excess chemicals for Work for Others projects was routine and that they were subsequently left at the facility, resulting in years of accumulated inventory. There were no effective controls in place to ensure that only necessary amounts were ordered, or for using untapped material that was already in stock.

In accordance with company requirements, storage areas are required to be checked weekly, but there was no evidence to indicate that the required checks were being performed. And, although electrical grounding and bonding are required to be used to minimize fires and explosion hazards, corrosion was observed that prevented direct metal-to-metal contact. Required labeling was sometimes degraded or missing altogether. See Figure 1-2. Material Safety Data Sheets (MSDS) have requirements for separate storage of certain chemicals and for storage out of direct sunlight. In contrast, the Board observed incompatible collocated chemicals and outdoor storage facilities with minimal protection from direct sunlight in an area where temperatures can reach 120°F in summer and below freezing in winter. In the case of the IPA involved in this

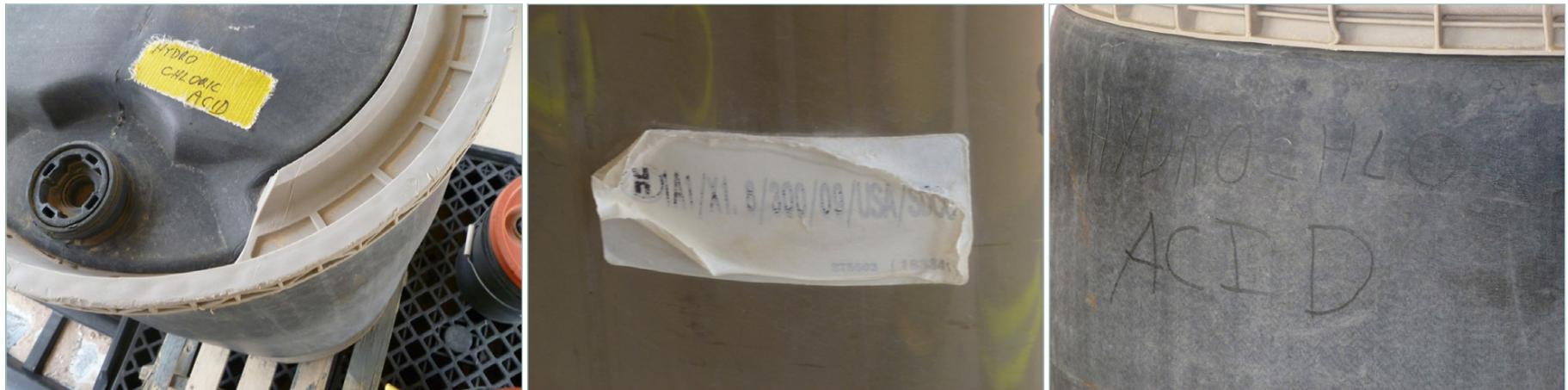


Figure 1-2. Three photos showing the following conditions: grounding system, improvised tape label, weathered label, and hand-etched HCl label



accident, high temperatures could have promoted peroxide formation, leading to higher concentrations than would have been expected under recommended storage conditions.

The Board determined that NSTec had not implemented the following basic elements of a CSLM Program:

- chemical tracking and inventory commencing upon chemical receipt;
- chemical ownership assignment;
- accountability for tracking and proper storage;
- routine inspections for condition, labeling, and inventory;
- maintenance of current MSDS;
- chemical purchase minimization; and
- clear disposition paths when chemicals are no longer needed or have exceeded shelf life.

## Work Control

Although the Board requested multiple work packages (WP) that would be applicable to NPTEC, only two were provided during the review. The WP for NPTEC activities associated with this accident addressed the installation and maintenance of equipment being used to support testing and operations, but it provided no instructions for opening drums or transferring or dispensing chemicals. The Board considered this a significant gap, since the MSDSs and site procedures require grounding of containers and using specific precautions when handling flammables. The work also included open chemical transfers and handling but none was analyzed in the Job Hazard Analysis (JHA). The project work required SME review, although no evidence of that being accomplished was available. The omissions seen in Rev. 0 of the WP were carried over to Rev. 1. In addition, site procedures require that WPs must be walked-

down in the field or given a tabletop review to involve as many parties as possible. Contrary to this requirement, Rev. 1 was routed to a series of individuals for review and sign off, thus preventing affected parties from meeting as a team to ask questions about the scope change, including “what if?” conditions. Finally, interviews with personnel indicated lack of adequate communication about the work and workers’ concerns.

Personnel had reported to supervision that the inside of the subject drum had been sloughing off (“looked weird”), but no photos were taken, no Stop Work was ordered, and no precautions were put in place. Also, personnel left the lid off the drum after they pumped material out. It is unknown what, if any, role this practice played in the buildup of organic peroxide concentrations that likely led to the incident 2 days later.

## Issues Management

The Board reviewed issues identified during an NSTec Facility Programs and Real Estate Services site assistance assessment and noted that, although the assessment identified significant programmatic weaknesses in the flow-down of requirements and their implementation, only 10 of the 15 identified issues were entered into caWeb (the tracking database).

The Board also stated its concerns regarding determination of appropriate priority level. It noted instances where issues dealing with programmatic failure or failure to address a primary mission of the facility within the Scope of Work/Safety Envelope (failing to mention Work for Others) were assigned a Priority Level (PL) 4 instead of a PL2. Because of their low significance, PL4s do not require formal causal analysis or the development of a Corrective Action Plan, nor do they require a review after the issue is closed in caWeb. Contrary to this practice, the finding should be addressed with actions that the Responsible Manager (RM) believes will minimize recurrence.



As stated in the AI Board Report: in April 2012, Management Assessment, “Nonproliferation Test and Evaluation Complex (NPTEC) Work Control” identified seven findings and two Opportunities for Improvement (OFI). One of the most serious findings was the use of Type III work packages for subcontractors and employees not in the NPTEC Skill of the Worker Program. Other findings addressed workers and supervisors performing/supporting activity-level work without completing required Integrated Work Control Process training courses. All seven findings were prioritized as PL4 and entered into caWeb in April 2012. Five of the findings and both OFIs were closed the following January, citing that no action was taken because “all work packages are closed.” There was no rationale or documentation to support the assertion. One was closed due to change in facility ownership. Supervisor training was completed, but not until March 2013, nearly a year after the assessment was performed. As stated in the AI Board Report: in these cases, managers did not provide rationale for taking no action and simply delayed until it became too late. By avoiding addressing the issues, management missed an opportunity to correct minor problems that may have encouraged workers to have a questioning attitude. Instead, the lack of management action further enhanced the workforce’s perception that there was no reason to raise concerns because they would not be addressed.

Issues may also be designated “On Hold,” a category intended to be used when funding constraints or resource limitations made the completion date indeterminate. However, it was not clear to the Board if all the designations were justified. In the Board’s opinion, some issues were placed “On Hold” to avoid taking immediate action and instead expedite other work. Workers saw this as another example that identified issues were not being addressed. Based on this investigation, it appears that RMs do not look beyond funding costs when placing issues “On Hold” or consider the risks involved with doing so, either for accidents or regulatory exposure. It also

appeared to the Board that non-conservative decisions were being made in the field based solely on time and resource constraints. Because of the authority given to RMs, and without routine review or discussion of issues with Senior Management, the opportunity to consider risks is lost. For example, two of the four issues placed “On Hold” for lack of funding for Engineering support directly affected the effort to manage legacy chemicals at NPTEC.

### Federal Oversight

Interviews conducted by the Board determined that the Federal Facility Representative (FR) is onsite for the Plan of the Day meetings and during operational activities. The FR is assigned multiple activities; however, with all the activities assigned, transactional oversight cannot be effectively performed at the appropriate level of rigor to ensure Integrated Safety Management is being maintained.

Functional Area Representatives (FAR) are assigned to oversee all aspects of worker protection, ensuring their assigned functions satisfy defined requirements and are performed adequately to control associated risks. A significant level of NPTEC oversight relies heavily on verbal discussion and contractor feedback with an understanding that the contractor is doing a good job most of the time. Field oversight was conditional and based on significant events or meetings, not routine observations of work in progress. Due to conflicting priorities and oversight of multiple facilities, the FAR did not spend any field time at NPTEC during the past seven months.

Several months had gone by since the FAR walked down NPTEC, which is designated as a Moderate Hazard Facility. Documentation reviews were sporadic and not current. For example, an MSDS spot check was last performed more than 4 years ago. An interview with the Industrial Hygiene FAR indicated that, although there were hazards with maintaining legacy chemicals, operations staff and facility management



did recognize that the chemicals should have been removed. Discussions about disposition were held periodically, with no subsequent action, according to the FAR, and it was unclear who was/is responsible for managing the chemical inventory.

## Findings and Recommendations

Based on the results of its investigation, the Board determined that the accident was preventable.

The Board identified the *direct cause* as the detonation of shock-sensitive peroxides caused by movement of the event drum.

The Board identified three *root causes*.

1. The safety culture at NPTEC did not facilitate the effective identification and resolution of problems.
2. NSTec failed to fully implement the formality and operational rigor necessary for managing and operating NPTEC.
3. NSTec did not effectively manage chemicals in a safe and compliant manner, including the disposition of legacy chemicals.

The Board identified three *contributing causes*.

1. The transition of NPTEC facility management from GS to the NO Directorate created a false sense of security with respect to the formality of facility operations.
2. NPTEC facility and program organizations did not effectively manage issues, resulting in corrective actions that addressed immediate issues without considering programmatic or systemic causes.
3. NSTec and NNSA/NFO processes did not enable risk-informed decision making regarding operation and maintenance of NPTEC, and NPTEC oversight did not fully recognize hazards associated with bulk/legacy chemical storage in the West Motel.

## Enterprise-wide Takeaways Related to Culture

Findings from this investigation are not unique to the NNSC. At the investigation exit briefing to Federal and Contract staff, the Board highlighted cultural issues that were observed during the investigation that are ongoing Complex-wide challenges. Some of these are noted below.

**Attitude toward non-nuclear operations.** Approaches to risks and formality of operations that exist in non-nuclear operations can lag significantly behind those in nuclear operations. NNSC management recognized there was a lax attitude at NPTEC and made the change to bring the operation under Nuclear Operations Directorate to bring more formality. However, this effort lacked the dedicated follow-up and diligence required to effectively implement this change.

**Diligence related to hazard identification.** One conclusion of the investigation was that there was no provision to ensure the most current chemical hazard information was available. The hazard of forming shock-sensitive peroxides in IPA under certain conditions was not noted in the older MSDSs the site had. However, the hazard was known and appears in newer MSDSs and research papers. The process of hazard identification is ongoing and requires constant vigilance and curiosity that even goes beyond MSDSs. As the Board noted at the exit briefing, the MSDS should be your first source, not your last.

**Attitude related to Work for Others.** Chemicals accumulated in this area partly because the projects were WFO and personnel had procured more than they needed in case additional work came which required these chemicals. When the work did not come, the chemicals accumulated. There was also a hesitancy to ask for assistance from customers because some staff felt it would upset them to be asked to pay for disposal, and the disposal costs were not always factored into the price. There are hazards associated with WFO that need to be considered at the onset of work and factored in at the beginning when developing safety controls.



***Accumulation of legacy chemicals.*** When an organization allows hazardous chemicals to accumulate in bulk over many years, it is often not a matter of *will* a problem occur, but *when*. One of the first principles of safety is to eliminate the hazard. If the material is not there, it will not cause a problem; if it is there and is not problem-managed, it can. As the board noted in the exit briefing, unlike wine, these chemicals did not improve with age.

***Considering only short-term costs in risk reduction.*** Staff previously estimated that it would cost approximately \$11,000 to eliminate the legacy chemicals from NPTEC. This issue was put into the tracking system 3 years before the incident, but put “On hold” due to lack of funding. At the time of the incident exit briefing, the cost of the incident was over \$300,000 and growing.

More information about the event, as well as the Board’s Findings and Recommendations, is available in the Board’s report, which can be accessed by clicking [here](#).

**KEYWORDS:** Isopropyl alcohol, IPA, explosion, Work for Others, WFO legacy, Chemical Safety Lifecycle Management program, CSLM, inventory, Motel

**ISM CORE FUNCTIONS:** Define the Scope of Work, Analyze the Hazards, Develop and Implement Hazard Controls, Perform Work within Controls, Provide Feedback and Improvement



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To issue the Summary in a timely manner, AU relies on preliminary information such as daily operations reports, notification reports, and conversations with cognizant facility or DOE field office staff. If you have additional pertinent information or identify inaccurate statements in the Summary, please bring this to the attention of Ms. Ashley Ruocco, (301) 903-7010, or e-mail address [ashley.ruocco@hq.doe.gov](mailto:ashley.ruocco@hq.doe.gov), so we may issue a correction. We would like to hear from you regarding how we can make our products better and more useful. Please forward any comments to Ms. Ruocco at the e-mail address above.