

OE-2: 2019-01

September 2019

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## Over-Pressurized Drum Event Involving Reactive Materials and Flammable Gases in Radioactive Waste

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### Purpose

This Operating Experience Level 2 (OE-2) document provides information on a safety concern related to site waste generation activities, waste generated and stored on-site or being repackaged, and retrieval and repackaging of legacy wastes received from other Department of Energy (DOE) sites. Although the events in this OE-2 are related to transuranic (TRU) waste, the scope of this OE-2 includes all types of radioactive waste.

### Background

On April 11, 2018, there was an incident in the Accelerated Retrieval Project (ARP) V facility at the Idaho National Laboratory (INL) Site: a thermal event led to subsequent energetic release of radioactive material from four 55-gal drums of suspect transuranic (TRU) waste located in the ARP V airlock drum storage area. No personnel were in the vicinity when the reactions occurred and the drums were in a high efficiency particulate air filtered area. There was no detected release to the environment.

During the initial response on April 11, 2018, INL firefighters entered the facility and observed one drum with a lid off; no flames were observed but smoke was emanating from the top of a drum. The firefighters attempted unsuccessfully to extinguish hot spots in the affected drum, moved the drum away from the array of staged drums, and exited the facility. Responders established a 24-hour facility surveillance, fire watch, radiological surveys and ventilation monitoring to assess conditions. On April 19, 2018, workers

reentered the facility and discovered a total of four vented drums had experienced exothermic chemical reactions, ejecting their lids and partially ejecting the drum contents. The breaches resulted in TRU waste being spread throughout the ARP V operations area (a filtered, uncontaminated area normally occupied by workers), resulting in a radioactive high contamination area and an airborne radioactivity area.

For further background information, the Formal Cause Analysis for the ARP V (building WMF-1617) Drum Event can be found at: [https://idahocleanupproject.com/Content/documents/Community/8283498\\_RPT-1659.pdf](https://idahocleanupproject.com/Content/documents/Community/8283498_RPT-1659.pdf).

A Safety Alert for this Over-Pressurized Drum event was developed by the Office of Environmental Management and distributed by Memorandum to Environmental Management Field Sites on May 28, 2019 (see *Attachment*). The Safety Alert should be reviewed for root cause and safety culture aspects of the occurrence. This OE-2 is an extension of that memorandum to further disseminate the lessons learned information to other organizations and entities as well as provide required actions of DOE waste generation and storage sites.

### Reason for Concern

Analysis of the incident indicates two mechanisms likely led to the event: (1) Oxidation of a pyrophoric non-roaster-oxide depleted uranium (DU) metal powder and fines (heat source that initiated secondary reactions) over a period of approximately eight hours, and (2) Generation of substantial amounts of methane

by hydrolysis of beryllium carbide. Technical information from process knowledge and historical records identified processes at the former Rocky Flats Site as the potential source of the DU and beryllium carbide. While the possible presence of these components was understood, decisions and controls did not adequately reflect their potential reactivity, the timeframe of reactions, and the initiation of secondary reactions.

The investigation identified the direct cause of this event as the breach of four suspect TRU waste drums in the ARP V building resulting from an oxidation reaction initiated during drum waste repackaging whereby waste containing reactive uranium was mixed with additional parent drum material and exposed to the ambient atmosphere. The initiating mechanism (heat source), based on sample results, was oxidation of the uranium metal, which then supported secondary chemical reactions (hydrolysis of beryllium carbide, which generated significant amounts of methane gas) that pressurized and breached the waste containers. Based on analysis of the event scene, the methane gas did not ignite; however, the potential generation of flammable gases in packaged waste drums is an identified hazard across the DOE complex.

An Office of Environmental Management review of DOE Standard (STD) 5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*, concluded that, although appropriate accident scenarios exist within the standard that reflect the event experienced at ARP V, the standard should be updated to reflect information and lessons learned from this event. That information will be included in the pending DOE-STD-5506 update, however this OE-2 serves to disseminate the above information throughout the DOE complex and ensure that all sites potentially affected take appropriate actions and report results to their respective Chief of Nuclear Safety.

### Action Required

Radioactive and mixed waste generation and storage sites are requested to complete a site-

specific extent of conditions review by October 31, 2019 to include the following items.

*For all waste generation and storage facilities:*

- Verify that site programmatic requirements, facility practices and procedures for testing waste drums for flammable gas concentrations include when and how often measurements are taken.
- Identify vented waste drums that were sampled and found to contain flammable or near-flammable conditions and, if so, identify what facility controls are in place to prevent or mitigate potential deflagration hazards.
- Identify the inventory of stored waste drums (including potential waste streams yet to be recovered or excavated) that contain or may contain metal carbides.
- Identify the source (generation location and process) and estimated inventory of stored waste drums (including potential waste streams yet to be recovered or excavated) with uncertain characteristics or inadequate process documentation to determine potential for flammable or other reactive conditions.
- Verify practices (and, if applicable, identify relevant policies or procedures) for monitoring of changing waste characteristics and uncertainties during waste management activities (excavation/relocation, storage, repackaging, etc.) and for adequately controlling project risks that consider lessons-learned from the ARP V over-pressurized drum event.
- Summarize results from your extent of conditions review and report results to your Program's Chief of Nuclear Safety.

*For waste generation and storage activities within a Hazard Category 1, 2, or 3 nuclear facility:*

- Verify how potential events and risks associated with flammable gas are

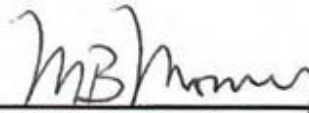
addressed in the applicable documented safety analysis for each facility and situation.

- For TRU waste assure conditions, if identified on site that could pose similar risks, are properly evaluated per appropriate DOE-STD-5506 scenarios in facility safety bases.
- Summarize results from your extent of conditions review and report results to your Program's Chief of Nuclear Safety.

**Information Contacts:**

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Matthew B. Moury  
Associate Under Secretary for  
Environment, Health, Safety and Security  
U.S. Department of Energy



**Department of Energy**  
Washington, DC 20585

May 28, 2019

MEMORANDUM FOR DISTRIBUTION

FROM: JEFF C. GRIFFIN, Ph.D. *J.C. Griffin*  
ASSOCIATE PRINCIPAL DEPUTY ASSISTANT  
SECRETARY FOR FIELD OPERATIONS

THRU: ELIZABETH A. CONNELL *Elizabeth A. Connell*  
ASSOCIATE PRINCIPAL DEPUTY ASSISTANT  
SECRETARY FOR REGULATORY AND POLICY AFFAIRS

TO: Field Managers for Office of Environmental Management Waste  
Generator Sites

SUBJECT: ACTION: Safety Alert on Over-Pressurized Radioactive Waste  
Drum Event

Please read and distribute the attached Safety Alert to responsible federal and contractor personnel within your organization, and take appropriate actions to address the recommendations identified in the Safety Alert. The Safety Alert contains information on the April 11, 2018, over-pressurized radioactive waste drum event at the Idaho Cleanup Project. It includes required and recommended actions to prevent occurrence of a similar event at Department of Energy Environmental Management sites and facilities. The Safety Alert incorporates comments from EM sites in response to a May 16, 2019, teleconference on a draft copy of the document.

I request that you complete the required actions identified in the Safety Alert related to radioactive and mixed waste at your site. (While the event at Idaho involved transuranic waste, the conditions and reactions could also arise with waste that meets other classification criteria.) This should include both waste generated at your site and any waste stored at your site that originated at other sites. Information collected will inform a complex-wide extent of condition review. The focus of the review is radioactive or mixed waste streams and waste drums with uncertain or unknown waste contents that could pose pyrophoric or reactive conditions. The review will document how sites currently assess and control potential risks from such waste in their documented safety analyses and work procedures for waste handling. No additional data generation, sampling or characterization is required or recommended to support reporting for the review. Sites should consider initiating site-specific program changes or sampling, if appropriate, based on the outcomes of the data review for required and recommended actions.

Please submit your responses to the required actions to Betsy Forinash, Director, Office of National TRU Program (EM-4.21), at [betsy.forinash@em.doe.gov](mailto:betsy.forinash@em.doe.gov) by September 30, 2019. The required actions are also anticipated to be included in a forthcoming Operational Experience Level 2 (OE-2) document.

Please contact me or Ms. Forinash at (202) 586-1467 if you have questions.

Attachment

Distribution for Action:

John P. Zimmerman, Deputy Manager for Idaho Cleanup Project  
Douglas E. Hintze, Manager for Environmental Management, Los Alamos Field Office  
John A. Mullis II, Manager, Oak Ridge Office of Environmental Management  
Brian T. Vance, Manager, Office of River Protection  
Robert E. Edwards III, Manager, Portsmouth/Paducah Project Office  
Brian T. Vance Acting Manager, Richland Operations Office  
Michael D. Budney, Manager, Savannah River Operations Office  
John Jones, Director, Energy Technology Engineering Center  
Russell J. McCallister, Director, Moab Federal Project Office  
Robert F. Boehlecke, Program Manager for Environmental Management, Nevada  
Steven Feinberg, Manager, Separations Process Research Unit  
Bryan Bower, Director, West Valley Demonstration Project Office

Distribution for Information:

Mark Gilbertson, Principal Deputy Assistant Secretary for Environmental Management  
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Gregory Sosson, Associate Deputy Assistant Secretary for Field Operations Oversight/  
Chief of Nuclear Safety  
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John Marra, Chief Engineer  
Mark Senderling, Deputy Assistant Secretary for Waste and Materials Management  
Betsy Forinash, Director, National TRU Program Office-HQ  
Todd A. Shrader, Manager, Carlsbad Field Office  
James McConnell, NA-50 (for information only)  
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William Bohne, NE-31 (for information only)  
David Michlewicz, SC-31 (for information only)  
Andrew Wallo, AU-20 (for information only)

# Safety Alert

## Over-Pressurized Drum Event



ARP V Drums

### Investigation

On April 16, 2018, DOE directed the contractor to conduct an investigation of the event (comprised of a Technical Team, Independent Causal Analysis Team, and Recovery Team) to identify root and contributing causes, and to develop corrective actions to prevent recurrence.

Investigation results are documented in two Fluor Idaho reports: RPT-1659, “Formal Cause Analysis for the ARP V (WMF-1617) Drum Event at the RWMC,” and RPT-1662, “Technical Analysis of Drum Lid Ejections—ARP V.” The event is also documented in the Occurrence Reporting and Processing System: EM-ID--FID-RWMC-2018-0001.

### Technical Analysis

Analysis of the incident indicates two mechanisms likely led to the event: (1) Oxidation of a pyrophoric non-roaster-oxide depleted uranium (DU) metal powder and fines over a period of approximately eight hours (heat source that initiated secondary

reactions);<sup>1</sup> and (2) Generation of substantial amounts of methane by hydrolysis of beryllium carbide. Technical information from process knowledge and historical records identified processes at Rocky Flats as the potential source of the DU and beryllium carbide. While the possible presence of these components was understood, decisions and controls did not adequately reflect their potential reactivity, the timeframe of reactions, and the initiation of secondary reactions.

### Root Cause Analysis

The investigation identified two root causes and eight contributing causes. The analysis covered a timespan up to the event on April 11, 2018, that included receipt and burial—at the Idaho site—of waste from Rocky Flats and retrieval, storage, and development of the process used to treat the waste.

The investigation identified the direct cause of this event as the breach of four suspect TRU waste drums in the ARP V building resulting from an oxidation reaction, initiated during drum waste repackaging during which waste containing reactive uranium was mixed with additional parent drum material and exposure to the ambient atmosphere. The initiating mechanism (heat source), based on sample results, was oxidation of the uranium metal, which then supported secondary chemical reactions (hydrolysis of beryllium carbide, which generated significant amounts of methane gas) that pressurized and breached the waste containers. [Based on analysis of the event

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<sup>1</sup> Roaster oxides refer to depleted uranium material (e.g., uranium chips, fines, and chunks oxidized in a furnace to uranium oxide) generated at the former Rocky Flats Plant near Denver, which were shipped to the Idaho Site for disposal. Prior to shipment to

ID, the uranium material was roasted to force the reactive metal to oxidize and render it safer for transport and disposal. Non-roaster oxides refers to uranium material that did not go through the roasting process.

# Safety Alert

## Over-Pressurized Drum Event

scene, the methane gas did not ignite; however, the potential generation of flammable gases in packaged waste drums should be evaluated as a potential hazard across the DOE complex.]

The investigation identified two root causes for this event:

- (1) Management failed to fully understand, characterize, establish and implement adequate process controls for treating waste that lacked documented origin or process information; and
- (2) Management failed to continue to develop the safety culture over a number of years.

The eight contributing causes include lack of a change management process to identify vulnerabilities over time; lack of a documented disposal plan; and ineffective application of lessons learned during a prior pyrophoric reaction.<sup>2</sup> A full description of contributing causes can be found in RPT-1659, *Formal Cause Analysis for the ARP V (WMF-1617)*.

### Review of DOE Standard 5506

An Office of Environmental Management review of DOE-STD-5506, *Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities*, concluded that, although appropriate accidents scenarios exist within the standard that reflect the event experienced at ARP V, the standard should be updated to reflect information and lessons learned from the event. That information will be included in the pending DOE-STD-5506 update. An Operational Experience Level 2 (OE-2) document is

under development to further disseminate the above information throughout the DOE complex and ensure that all sites potentially affected are informed and take appropriate actions.

### Waste Generator Site Actions

Required and Recommended Actions by waste generator sites to address concerns raised by the ARP incident are described below; information reported by sites will support a complex-wide extent of condition review.

The focus of the review is radioactive or mixed waste streams and waste drums with uncertain or unknown components that could pose pyrophoric or reactive conditions similar to those encountered at Idaho. These are expected to be primarily legacy waste streams, given that newly generated waste streams typically have more complete process documentation and characterization before packaging.

Information is requested on existing practices for testing and not testing flammable gas in drums, to provide a comprehensive understanding of sites' approaches to testing and the relative number of drums that may be of concern. Such descriptions may be at a general level (e.g., all mixed wastes with specific RCRA codes are tested at a given point, or stored under certain conditions), with estimated waste volumes or number of drums. More detailed information and inventories, as far as it is available, should be provided on waste with uncertain or unknown components.

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<sup>2</sup> A TRU waste drum was involved in a pyrophoric event in the AMWTP Treatment Facility (WMF-676) North Box Line during waste processing activities on

December 21, 2017. Although originally designated a fire, during the emergency response it was determined to be a pyrophoric reaction.



# Safety Alert

## Over-Pressurized Drum Event

Sites should use existing information in responding to the required actions. The issue of concern is the impact of chemical compatibility and waste reactivity in terms of safety and not compliance with hazardous waste requirements; testing to determine RCRA codes, for example, may be relevant if also applied for safety, and sampling not required by regulation may also be important and should be described. No additional data generation, sampling or characterization is required or recommended to support reporting for the extent of condition review. Sites should consider initiating site-specific program changes or sampling, if appropriate, based on the outcomes of required and recommended actions.

### Required Actions

Complete a site-specific extent of condition review by September 30, 2019, for radioactive waste or mixed waste drums in storage that have not been certified for shipment, which includes the following<sup>3</sup>:

1. Describe programmatic requirements, facility practices and procedures for testing waste drums for flammable gas concentrations (e.g., when and how often measurements are taken).
2. Describe situations (and rationale) and waste in which flammable gas concentrations are not measured for potentially reactive waste, and identify relevant waste streams and estimated volumes. Explain how potential events and risks associated with flammable gas are addressed in the applicable

documented safety analysis for such facilities and situations.

3. Identify vented waste drums that were sampled and found to contain flammable or near-flammable conditions and, if so, identify what facility controls are in place to prevent or mitigate potential deflagration hazards.
4. Identify the inventory of stored waste drums (including potential waste streams yet to be recovered or excavated) that contain or may contain metal carbides.
5. Identify the source (generation location and process) and estimated inventory of stored waste drums (including potential waste streams yet to be recovered or excavated) with uncertain characteristics or inadequate process documentation to determine potential for flammable or other reactive conditions.
6. Describe practices (and, if applicable, identify relevant policies or procedures) for monitoring of changing waste forms and uncertainties during waste management activities (excavation/relocation, storage, repackaging, etc.) and for adequately controlling project risks that consider lessons-learned from the ARP V over-pressurized drum event.
7. If conditions are identified on site that could pose similar risks, facilities should ensure that the condition is properly evaluated per appropriate DOE-STD-5506 scenarios.

Send results of the extent of condition review to: Betsy Forinash, Director, Office of National TRU Program (EM-4.21), at

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<sup>3</sup> The extent of condition review responds to March 12, 2019, Defense Nuclear Facilities Safety Board inquiry.

# Safety Alert

## Over-Pressurized Drum Event

[betsy.forinash@em.doe.gov](mailto:betsy.forinash@em.doe.gov) no later than September 30, 2019.

### Recommended Actions

Federal and contractor staff should take the following actions. Sites do not need to provide a written response to EM Headquarters on these actions but Field Managers should work to complete these actions as soon as practicable, so that results can be discussed with EM-Headquarters in FY 2020 as part of established communications (e.g., the quarterly site briefings).

1. Review the ARP V causal analysis report and incorporate lessons-learned into appropriate site procedures and processes.
2. Review DOE-STD-5506 accident scenarios for application to site waste retrieval and repackaging activities.
3. Assess training of personnel responsible for approving waste for processing and treatment to ensure they are sufficiently qualified to make decisions related to the safe execution of waste processes. Review waste operator training materials to ensure modules address the identification of changing waste conditions and include practical examples of pyrophoric materials, oxidizing metals, metal carbides, and other challenging waste profiles.
4. Evaluate existing processes for treating legacy waste with uncertain pedigree to ensure effective controls are in place to safely handle, process, treat, package, and store the waste pending transport and disposal.
5. In particular, review procedures for current and future drums with repackaged waste:
  - (i) to ensure effective controls are in place and followed to prevent or mitigate

deflagrations; (ii) to approve individual containers with potential reactive materials for waste handling and treatment processes; and (iii) to ensure conservatism on timeframe of potential reactions and initiation of secondary reactions.

6. Review radiological response procedures for first responders to ensure appropriate entry requirements for areas with potential airborne transuranic hazards.
7. Promote continuous improvement in site safety culture where workers can express an inquisitive attitude toward challenging assumptions regardless of potential impact to cost and schedule.

### Additional Information

The Formal Cause Analysis for the ARP V (WMF-1617) Drum Event can be found at: [https://idahocleanupproject.com/Content/documents/Community/8283498\\_RPT-1659.pdf](https://idahocleanupproject.com/Content/documents/Community/8283498_RPT-1659.pdf)

Questions concerning this Safety Alert should be directed to Betsy Forinash at (202) 586-1467, [betsy.forinash@em.doe.gov](mailto:betsy.forinash@em.doe.gov).



Betsy Forinash, Director,  
Office of National TRU Programs, EM-4.21