Remediated Nitrate Salt (RNS) Disposition

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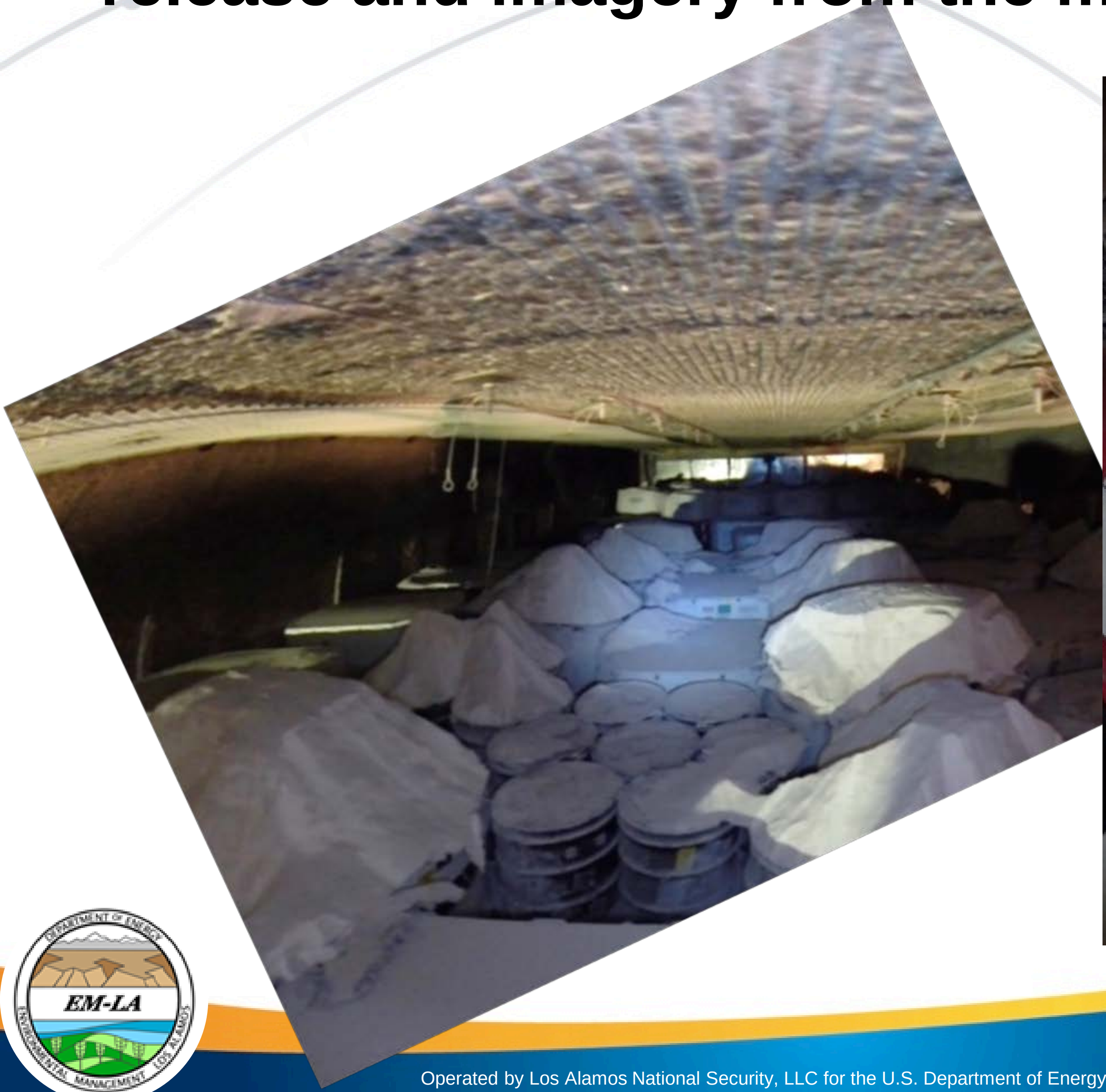
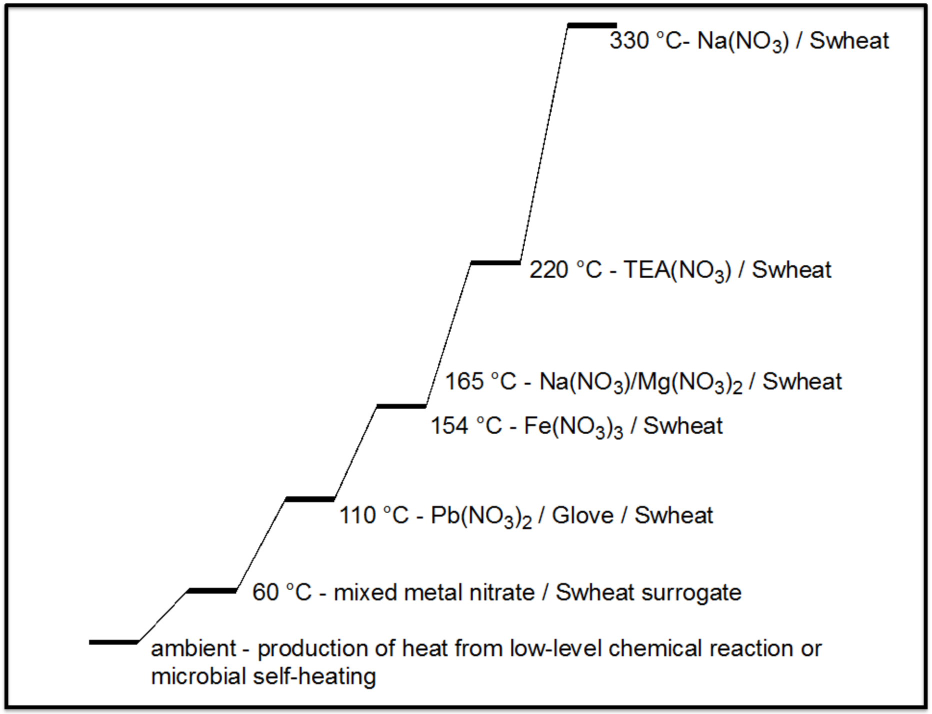
LA-UR-17-21622

Incident was identified by rad release and imagery from the mine



Summary Description of the LANL Nitrate Salt Incident

- The incompatibility of the nitrate salt (oxidizer) and sWheat Scoop® (fuel), created the potential for thermal runaway that was ultimately realized when Drum 68660 pressurized and breached

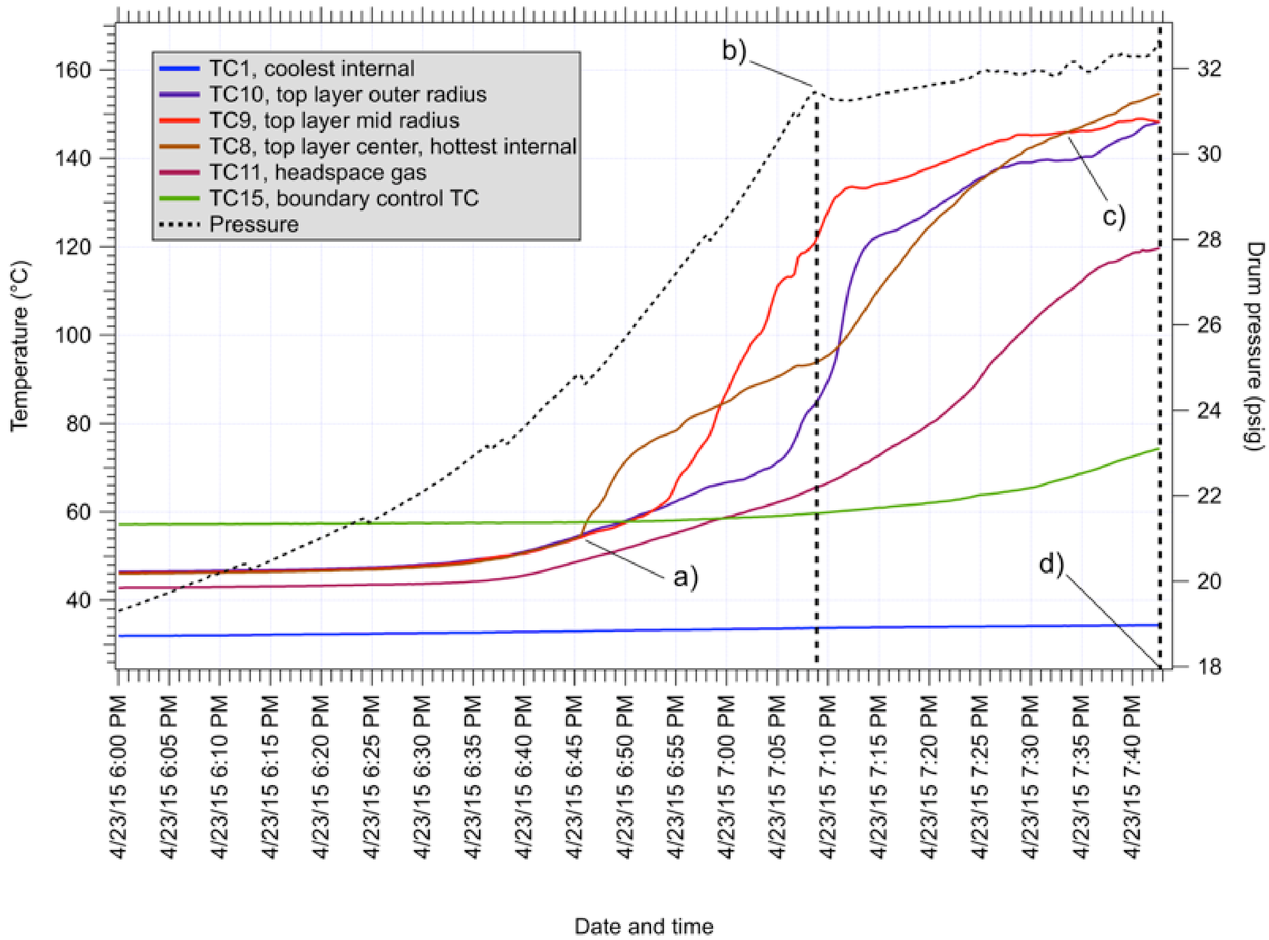


- Production of NO_x and heat from low-level chemical reactions, combined with inadequate pressure relief, generated a series of exothermic reactions that heated and pressurized the drum, resulting in the venting of high-temperature gases and radioactive material into the room.

The chemical incompatibility lead to thermal runaway through low temperature reaction and pressurization of the waste container

The Thermolytic Response of a Surrogate RNS Waste Mixture at the Drum Scale

- Requested by the AIB to support their investigation
- A goal was to demonstrate that we have an understanding of the mechanisms by which the 68660 breach may have occurred
- Provided valuable insight to guide the storage and processing of existing nitrate salt bearing drums processed with sWheat



The full scale drum tests were of significant technical value

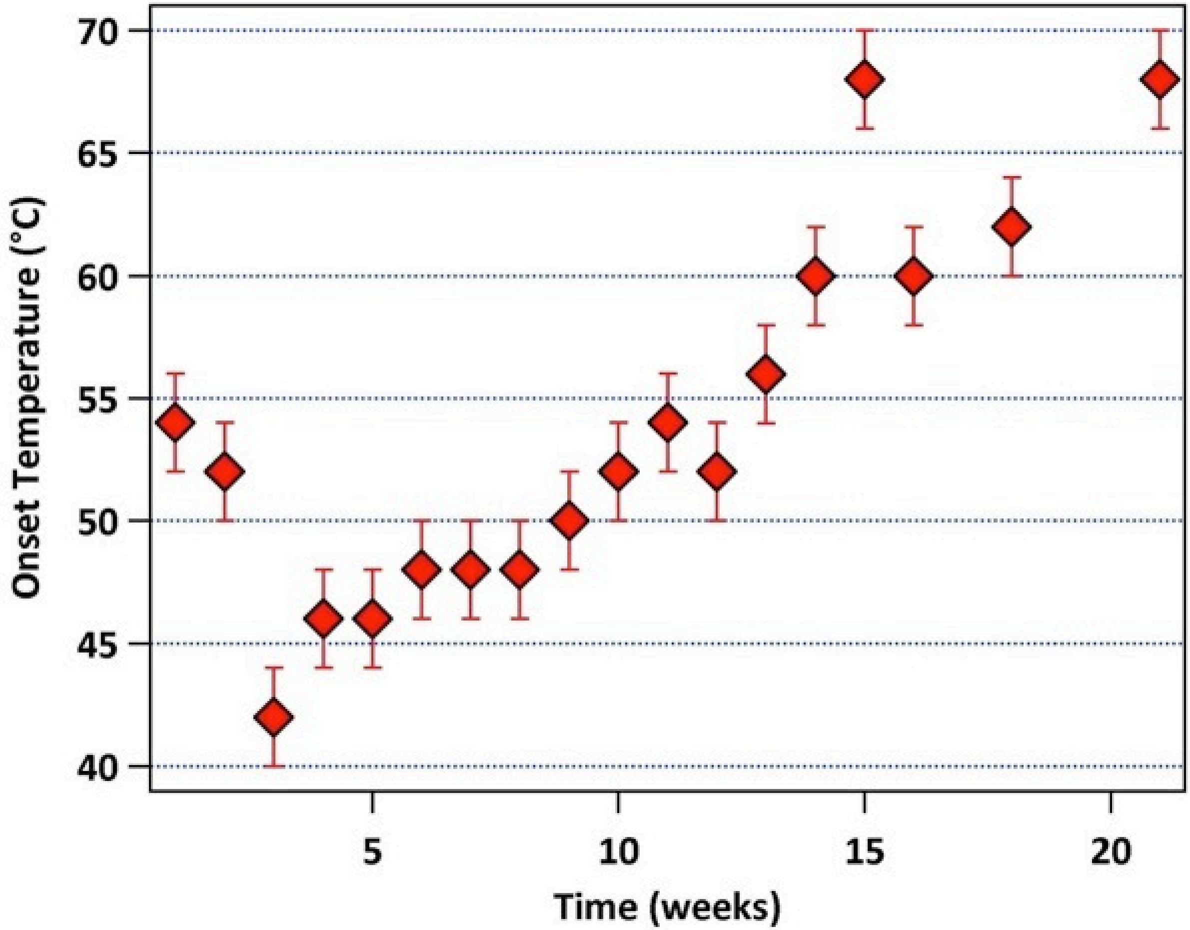
Conclusions from the full scale tests

- The tests demonstrated thermal runaway and drum rupture with a plausible surrogate nitrate salt/sWheat mixture
  - Evidence supports the hypothesis that NO_x product gases from hydrolysis of metal nitrate salts are responsible for exothermic oxidation of the organic pet litter
- Pressurization is required for thermal runaway
  - Very sensitive to gas concentration (correlated with pressure)
- Reactant concentrations for the low-temperature chemistry can be diminished with sufficient time at ambient temperature
  - Likelihood of activating higher-temperature chemistry goes down with time
  - Does not mean that higher-temperature reactions can't be activated if external heating is applied
- **Recurrence prevention strategies include:**
  - ***Elimination of the potential for pressurization***
  - ***Reduction in storage temperature:*** $Q_{eff}=Q_{rxn}/Q_{diss}$

Small Scale Follow-On Work

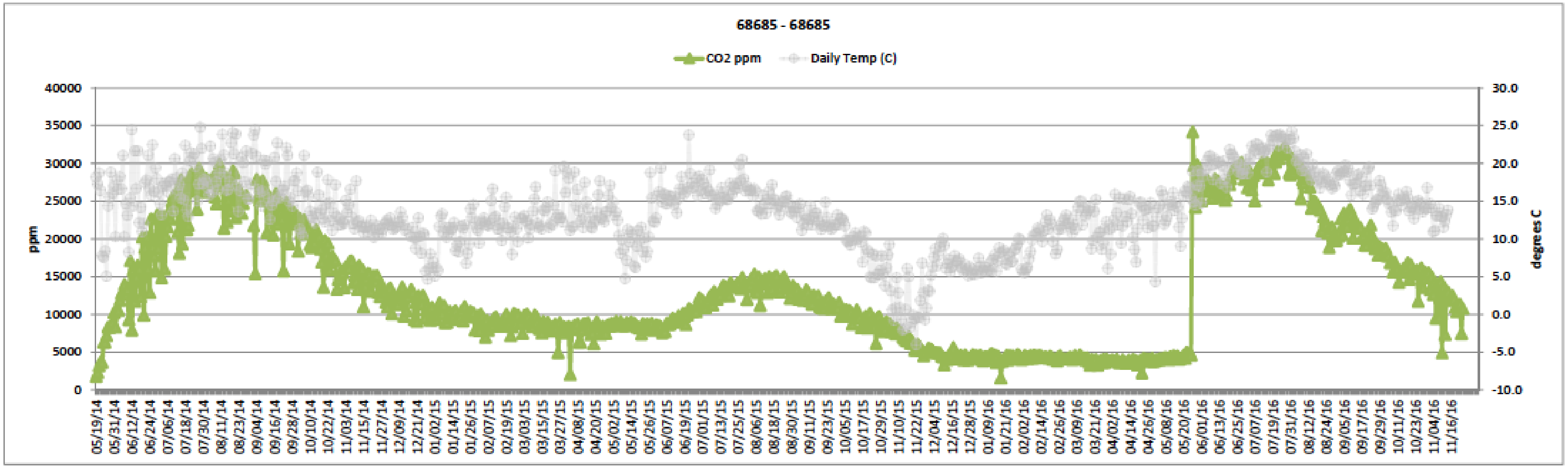
- Validated thermal sensitivity decreases with time
  - Simply put, the lower the onset temperature, the more reactive the the species and the greater their subsequent depletion at ambient temperatures
- Demonstrated that agitation cannot readily reset drum contents; significant concern about this
- Study
  - Prepare 15 salt/swheat mixtures in Nalgene bottles equipped with NFT filters
  - Once a week test with APTAC to evaluate whether we observe increasing/decreasing thermal/ignitability behavior
  - The samples were mixed for each run, prior to testing, to observe the effect of agitation

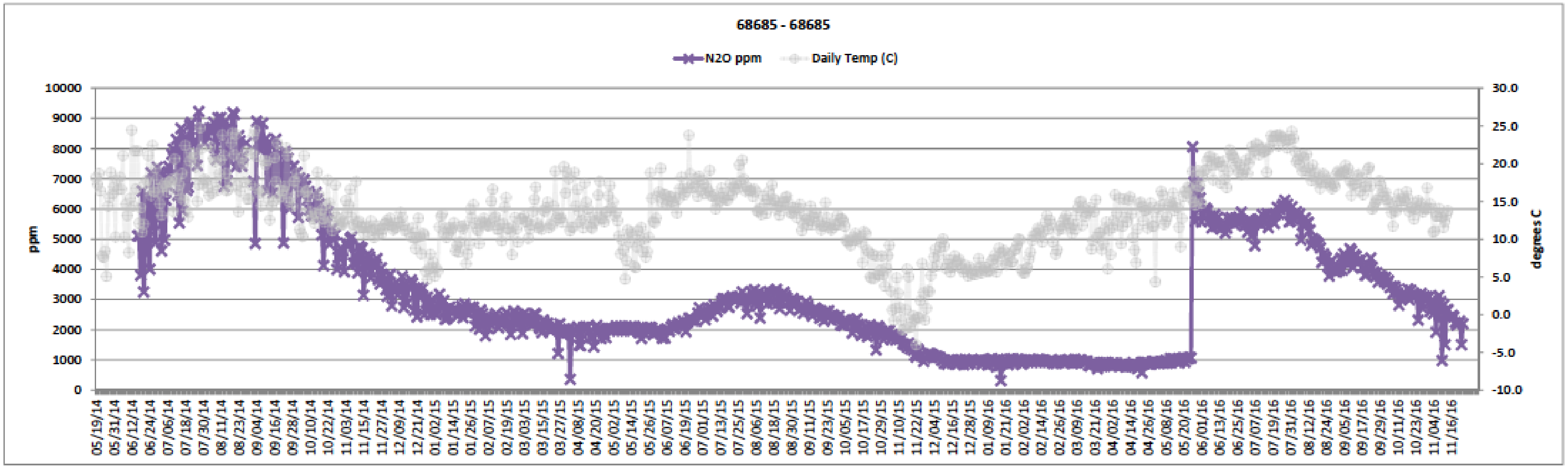
Plot of self-heating onset temperature as a function of time for RNS surrogates



Measured using Automatic Pressure Tracking Adiabatic Calorimetry (APTAC)

CO_2 and N_2O concentrations – Head Space Gas measurements vs. time





Remediated Nitrate Salts: Safety & Storage

❑ Safe Storage

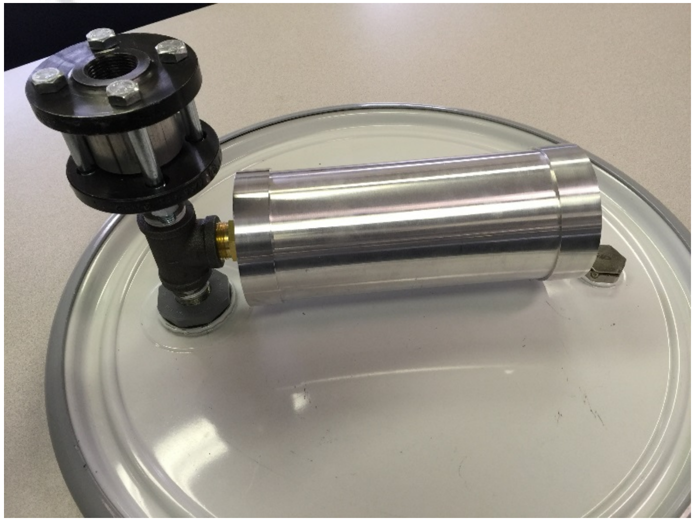
- RNS drums are nested in either steel standard waste boxes or 85-gallon drums and are stored in a contamination-control structure known as a PermaCon
- This structure is equipped with fire suppression, a high-efficiency particulate air system (HEPA), and a climate control system (maintain temperature < 75 °F).

❑ Wildfire Mitigation

- Extensive thinning operations conducted in the canyons that border Area G.
- A defensible perimeter has been created around the PermaCon – no vegetation taller than 6 inches grows within 75 feet of this structure.

❑ Pressure Relief Devices Installed

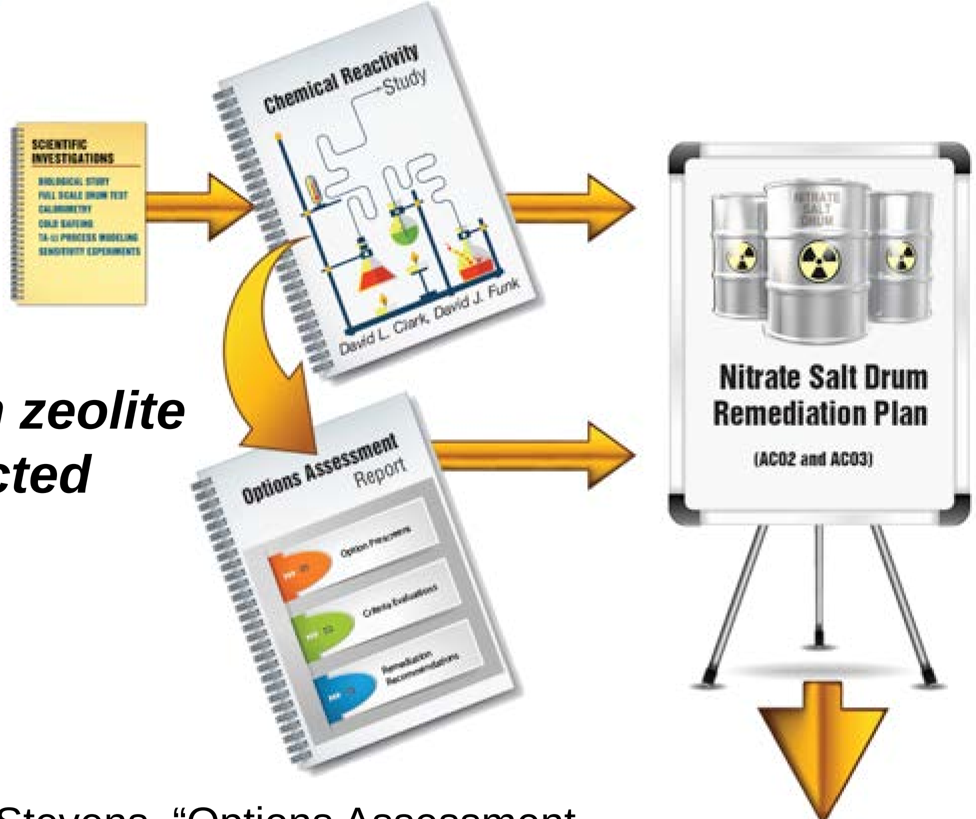
- In the spring of 2016 HEPA filtration vents and pressure relief devices were installed on the RNS drums. This prevents pressure from building up inside an RNS drum.



The HEPA filtration system prevents pressure from building up

Workers installed pressure relief devices onto the lids of the RNS drums

A Panel of Experts Assessed Treatment Options for the Nitrate Salt Waste



Stabilization through zeolite addition was elected

B. A. Robinson and P. A. Stevens, "Options Assessment Report: Treatment of Nitrate Salt Waste at Los Alamos National Laboratory," LA-UR-15-27180 (2015)

Multiple Peer Reviews: F. Pennebaker (SRNL) and L. Smith (Bechtel) leads

An Engineering Options Assessment was Conducted

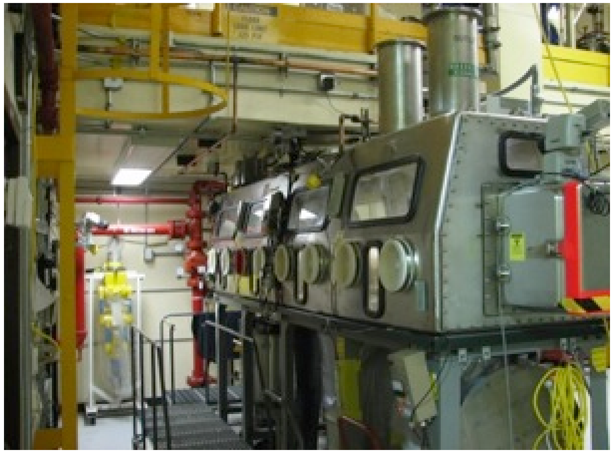
K. Anast, "Engineering Options Assessment Report: Nitrate Salt Waste Stream Processing," LA-UR-15-28900 (2015)

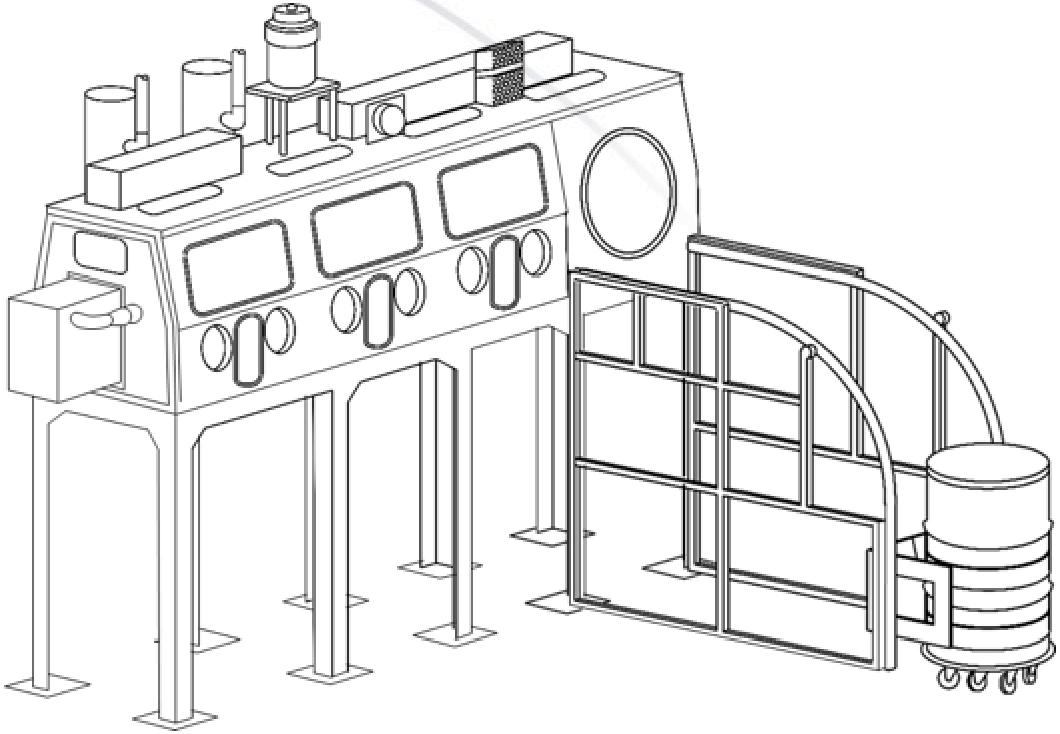
- Evaluation Approach
  - Characterize Waste Streams
    - RNS, UNS
  - Examine Treatment Approaches
    - Blending & Cementation
  - Evaluate Remediation/Repackaging Systems
    - WCRRF, Modulars, Gloveboxes at TA-54
    - RNS and UNS streams
    - Remaining Legacy Waste

An additional look at our options was taken using a broad, national team of experts; Technical Assessment Panel, S. Krahn (Vanderbilt), lead

Remediation/Repackaging Systems

WCRRF





Class 1* Permit Mod has been approved

Treatment methodologies were evaluated for efficacy (supported permit mod request)

- EPA testing methodologies were used to evaluate RCRA Characteristics of Ignitability (D001) and Corrosivity (D002)
  - Southwest Research Institute (SwRI, EPA Certified Lab)
    - Conducted SW-846 1030 (burn rate), 1050 (spontaneous combustion), UN DOT O.1 and O.2 (oxidizers), 9095B (liquids) tests
  - Testing complete
    - Tests include controls and treated surrogates
      - Nitrate salts mixed in various ratios with water and Swheat and then mixed with zeolite (0.5:1:3; water:waste:zeolite)
- Results confirmed that the remedy is effective

Evaluation of the impact of the Basis of Knowledge (BoK) for oxidizing chemicals is in process

Safety Basis Controls: provide a safety envelope that protects workers, public, and the environment

- Controls are designed to reduce the risk of initiating events and to reduce the probability of inducing thermal runaway of an RNS waste container
- The control set should be familiar to all, with the exception of two distinct controls designed to reduce the risk of thermal runaway and provide adequate protection to worker, public, and environment:
  - **PRESSURE**: Eliminate the ability of a drum to pressurize through addition of "Pressure Relief with Supplemental Filtration (PRDwSF)"
  - **TEMPERATURE:** Minimize chemical reactivity through the use of temperature control, while in storage (refrigeration at 375 and WCRRF) and during transport (cooling jackets)

Four safety basis documents incorporate the control sets for safe storage, shipping, and processing

- Evaluation of the Safety of the Situation (ESS)
  - controls for storage: is currently at Revision 6.1
- Documented Safety Analysis Attachment for Area G
  - controls for denesting and cooling prior to transport of the waste
- Transportation Safety Document Temporary Modification
  - controls for transport from Area G to WCRRF
- Documented Safety Analysis Attachment for WCRRF
  - controls for receipt, storage, and processing in the glovebox

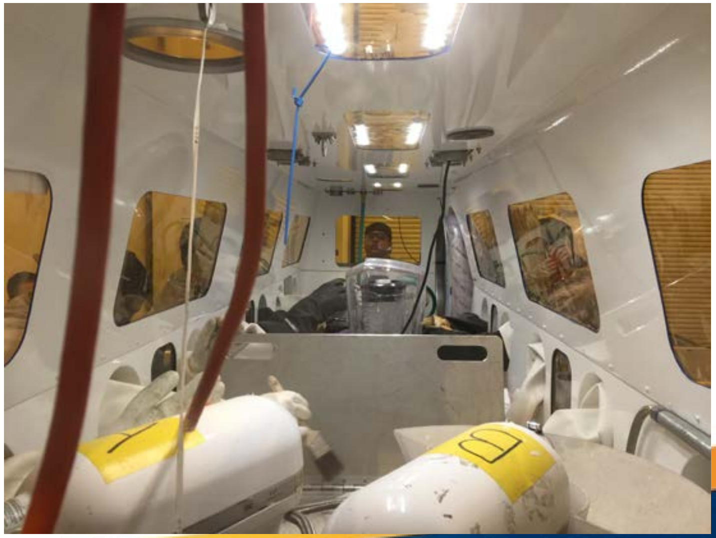
Strong partnering between DOE and LANS enabled the development of a technically sound, robust control set

Summary of the Overall Steps for Treatment of Nitrate Salt Wastes

- Temperature and Pressure Control – Safing
  - Open SWBs, add vent/pressure relief to drums to minimize likelihood of the accident (POCs remain)
  - Cool waste to lower chemical reactivity ($Q_{eff}=Q_{rxn}/Q_{diss}$)
  - Transport waste to the Waste Characterization, Reduction, and Repackaging Facility (WCRRF)
    - Cooling jackets during transport
- Treatment of Waste
  - Engineered implementation at WCRRF
  - Treat the nitrate salt wastes: stabilization through water and zeolite addition

Due to the nature of the waste and WCRRF status, we developed "cold" practice facilities

- Enabled early identification of equipment and process issues (e.g., bowl not readily dumped; added plug on bowl bottom that is easily removed/replaced)
- Allowed for refinement of the treatment procedure
- Practice ground helped develop proficiency in support nuclear operation readiness activities
- Allowed demonstration of process to stakeholders – important method of communication
- Facilities both in G and near WCRRF



Remediated Nitrate Salts Path Forward

- ❑ **Facility Upgrades Complete**

- ❑ **Readiness Activities**
  - Area G operations, transportation, and treatment at WCRR Facility
  - Contractor Management Self-Assessment of Area G & WCRR Facility Complete
  - Contractor Readiness Assessment of WCRR Facility Complete
  - Contractor Readiness Assessment for Area G completed
  - Federal Readiness Assessment for WCRR Facility underway

- ❑ **Treatment**
  - Treatment plan has been approved
  - Treatment of RNS scheduled for spring of 2017

A technician performs an RNS treatment walk-through at a mock-up glove box

A refrigerator will keep RNS drums cool prior to their treatment

AIB Corrective Actions have been completed*

Addressing Systemic Issues	JON 14: Process Engineering / Change Control (ADEM) JON 32: Procedure Development (ADEM) JON 39: Safety Culture (DEP DIR)
Improving Requirements Definition	JON 9,10: RCRA Requirements (ADESH) JON 13,18: RNS Tech Basis (ADEM) JON 19, 20, 21: Safety Basis (ADNHHO)
Implementing Improvements	JON 15,16,17: WCRRF GB Procedure (ADEM) JON 38: Training and Qualification (ADEM)
Ensuring Compliance	JON 22, 23: USQ (ADNHHO) JON 25: CAS/QA (ADBI, ADMASER)

*Need NTP concurrence and EM HQ approval of the treatment procedure

Key Lessons Learned and Corrective Actions

- Strong technical basis for treatment
- Implementation through process engineering principles (including change control)
- Appropriate procedures, training, and qualification
- Strong use of Contractor Assurance Systems (CAS – oversight)

Questions?

LANS' Corrective Action Status – Reviews Related to Nitrate Salt Incident

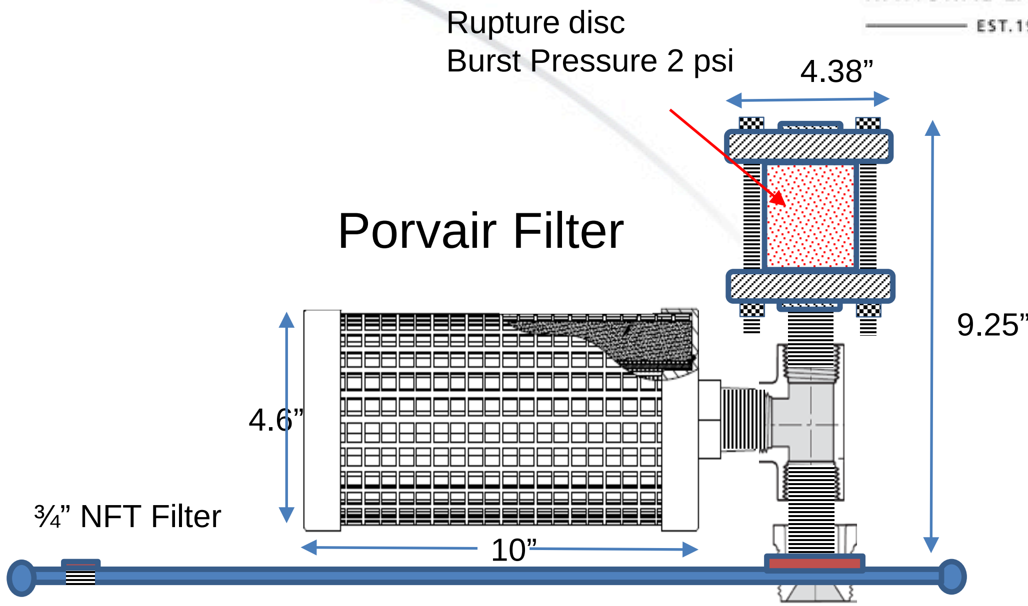
Reviewer	Number of Actions	Number Completed	Number Validated for Closure			Impact Actions Not Completed
			Owning MRB	IMRB	DOE	
DOE Office of Inspector General (DOE/IG-0922)	18	17	17	17	0 *	1 Post-Start
LANS' Root Cause Analysis (Longenecker & Assoc.)	8	8	8	8	NA**	NA
AIB Phase 2 Rad Release at WIPP Report (Integrated CAP for Office of Enforcement PNOV NEA-2016-01)	58	56	55	55	45	2 Pre-Start
DOE EHSS Operating Experience Level 2 Report (OE-2: 2015-1)	4	4	NA	NA	0*	NA
LANL Nitrate Salt Remediation Plan Review (Pennebaker 1, SRNL-RP-2015-00420,)	6	6	6	NA	NA	NA
Parent Organization Review, RCRA Nitrate Salt Treatability Plan (POFMR-2015-87)	15	15	15	NA	NA	NA
LANL Nitrate Salt Waste Remediation Peer Review Team Report (Pennebaker 2, SRNL-MS-2016-00035)	21	21	21	NA	NA	NA
Report of Technical Advisory Panel: Options for Processing RNS/UNS Waste at LANL (Krahn report)	16	16	16	NA	NA	NA
Area G and WCRRF Facility Evaluation	136	81	81	NA	NA	55 Post-Start
Area G Management Self Assessment	32	13	0	NA	NA	3 Pre-Start; 16 Post-Start
WCRRF Management Self Assessment	94	66	66	NA	NA	1 Pre-Start; 27 Post-Start

* DOE request for validation received January 4, 2017
** NA = Not Applicable

Strategy for enhanced safing has been implemented

Estimate Flow of Gas in Large Drum Tests

time	Temp	Pressure	Flow Rate	
hrs	oF	psig	l/m	cfm
24	73	0.7	0.003	0.000
48	84	2.0	0.012	0.000
60	82	3.7	0.020	0.001
62	89	4.8	0.055	0.002
64	96	5.2	0.063	0.002
66	101	6.5	0.104	0.004
68	104	8.7	0.214	0.008
70	106	13.3	0.430	0.015
72	110	21.7	1.16	0.041
72.6	146	30.9	2.75	0.1



Rupture Disc

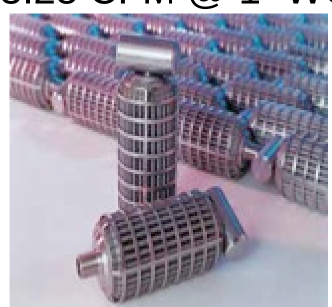
Holder

Disc

1.5 to 10 psi

Porvair Filter

91,000 ml/m @ 1 “ WC
3.25 CFM @ 1” WC



NFT Filters

¾” NFT = 200ml/m @ 1 “ WC