Independent Oversight Review of the Los Alamos National Laboratory Weapons Engineering Tritium Facility Tritium Gas Containment Vital Safety System

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Office of Safety and Emergency Management Evaluations
Office of Enforcement and Oversight
Office of Health, Safety and Security
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Table of Contents

Acronyms and Abbreviations

AM	Auxiliary Maintenance
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CSE	Cognizant System Engineer
DOE	U.S. Department of Energy
dp	Differential Pressure
DSA	Documented Safety Analysis
HSS	Office of Health, Safety and Security
HVAC	Heating, Ventilation, and Air Conditioning
LANL	Los Alamos National Laboratory
LASO	Los Alamos Site Office
SFD	Safety Function Definition
SM	System Maintenance
SSC	Structures, Systems, and Components
SST	System Surveillance and Testing
TGCS	Tritium Gas Containment System
TSR	Technical Safety Requirement
WETF	Weapons Engineering Tritium Facility

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1.0 PURPOSE

The Office of Enforcement and Oversight (Independent Oversight), within the Office of Health, Safety and Security (HSS), conducted an independent review of the Los Alamos National Laboratory (LANL) Weapons Engineering Tritium Facility (WETF) safety significant Tritium Gas Containment System (TGCS), concurrent with a scheduled Los Alamos Site Office (LASO) assessment.

The purpose of the LASO assessment was to evaluate the functionality and operability of the TGCS (a vital safety system) and to ensure that the system complied with U.S. Department of Energy (DOE) orders and standards and other applicable standards and requirements. The assessment was conducted February 20 through March 2, 2012. Issuance of this report was deferred until completion of the related LASO report, issued in October 2012.

An HSS subject matter expert independently assessed selected technical areas, as described in the scope section below, and also evaluated the LASO assessment process. The HSS independent review scope was selected based on current HSS priorities to focus oversight activities on nuclear facilities and, in particular, the adequacy and implementation of nuclear facility safety basis requirements.

2.0 BACKGROUND

The WETF is classified as a hazard category 2 nuclear facility. Its programmatic mission is to perform research and development and to process tritium to meet the requirements of the present and future stockpile stewardship program, while operating in a manner that provides adequate protection for LANL's workers, the public, and the environment. The tritium-processing activities performed by WETF support the nuclear weapons program and other programs at LANL. Typical activities include repackaging, purifying, mixing, analyzing mixtures, and loading gaseous tritium into getter materials. The TGCS consists primarily of the gloveboxes in which these activities take place, the glovebox bubbler pressure relief devices, and related components. Its safety functions are to provide secondary containment for events or conditions that could entail release of tritium gas from its various primary containment components into the gloveboxes, to provide the boundaries for an inert gas atmosphere inside the gloveboxes, and to prevent air in-leakage to limit the potential for a hydrogen gas explosion/deflagration.

3.0 SCOPE

The LASO assessment of the TGCS vital safety system was achieved primarily through a performance-based assessment, the methodology and process of which were based on LASO Procedure MP 06.02, Rev. 4, *Safety System Oversight*. The assessment focused on three broad safety areas – safety bases; system operation, maintenance, and performance; and effects of aging – with the following six safety objective topics: Safety Function Definition (SFD), Configuration Management (CM), System Maintenance (SM), System Surveillance and Testing (SST), Cognizant System Engineer (CSE), and Issues Resolution Effectiveness.

HSS focused on the last two of these objective topics (i.e., CSE and Issues Resolution) and conducted the following activities:

- Review of documentation supporting the design and safety basis requirements of the system, including supporting analyses, drawings, and technical procedures

- Walkdowns of the TGCS and supporting and interfacing structures, systems, and components (SSC)

- Interviews with facility engineering and safety basis staff, including the CSE for the TGCS.

The HSS independent review of the effectiveness of issue resolution placed priority attention on verifying that actual design capabilities of the TGCS meet the performance requirements of the safety basis and that the safety basis requirements reflect applicable Federal regulations, DOE orders and standards, industry codes and standards, and good engineering practice. The starting points for the technical review were issues that had remained open at the end of HSS's 2007 technical assessment of this same system. However, addressing these points led to some expansion of HSS's scope into the SFD area due to the discovery of several new technical issues, which remained open at the completion of this 2012 assessment.

4.0 RESULTS

Overall, the LASO assessment was competently performed by knowledgeable LASO personnel using appropriate and challenging criteria. The LASO team was technically well qualified and, based on prior preparation and knowledge, demonstrated a high degree of familiarity with the WETF facility. The LASO assessment team, in conjunction with HSS, identified nine findings and three observations, which are described in detail in the LASO assessment report. Of the nine findings identified in the LASO report, seven findings were in the SFD objective area; one finding was in the SM objective area; and one finding was in the SST objective area (resulting directly from one of the HSS SFD findings). The LASO report concluded that three of the six objectives were not met (SFD, SST, and Issues Resolution).

The nine LASO findings are listed below; in the bolded statements; additional Independent Oversight insights follow each bolded finding:

1. **Contrary to DOE-STD-3009-94, the TGCS interfacing and supporting SSC are not fully identified in the WETF documented safety analysis (DSA)**. DSA Section 4.4.4.2, [TGCS] *System Description,* subsection *Boundaries and Interfaces,* does not identify the TGCS bubbler exhaust connection to the fume hoods, the fume hoods themselves, and the direct supporting interface with the building's ventilation exhaust system exhausting the fume hoods to the stack and the environment.

2. **Contrary to DOE-STD-3009-94, the TGCS safety function is dependent on the non-safety ventilation system.** The primary safety function of the TGCS is to protect workers from exposure to tritium that may escape from primary containments into the gloveboxes. If overpressure occurs in the gloveboxes, pressure relief bubblers exhaust to fume hoods or heating, ventilation, and air conditioning (HVAC) ducts in the glovebox rooms. This arrangement is intended to inhibit tritium exhausted from the bubblers from entering the rooms, which may be occupied by workers. However, the current design relies on the non-safety exhaust ventilation system to evacuate the fume hoods. Such reliance on a non-safety system is inconsistent with the

standard, which requires such supporting SSC to be classified consistent with the safety SSC they support.

3. **Contrary to DOE-STD-3009-94, the TGCS contains unanalyzed interactions with ventilation systems and does not identify the ventilation system as a TGCS boundary or interface.** In addition to the above-described direct TGCS-to-exhaust ventilation system interface, the TGCS also has indirect interfaces with the TGCS room ventilation systems, both supply and exhaust, with respect to their effects on room pressures and hence on the glovebox-to-room differential pressures (dp). Although this interface, under normal operating conditions, poses little threat to the TGCS, the loss of either the exhaust or supply ventilation function, without attendant shutdown of the opposite function, could subject the room-to-glovebox dps to rapid and dramatic changes, potentially challenging the gloveboxes' integrity. Although the current design provides a supply fan trip interlock on loss of an exhaust fan, this interlock is not classified as safety significant and has not been analyzed, maintained, or tested as such. Additionally, there is no corresponding trip interlock for the exhaust fan for loss of HVAC supply.

4. **Contrary to DOE-STD-3009-94, the TGCS glovebox bubbler design uses non- conservative analytical bases that could result in inadequate overpressure protection.** In response to concerns during the 2007 HSS assessment with respect to the TGCS glovebox pressure relief bubblers, WETF performed a calculation, which concluded that, with the installed bubbler exhaust tubing, the bubblers were incapable of protecting the gloveboxes from overpressure due to excessive backpressure in the exhaust lines. WETF identified changes to make the relief protection viable, which included lowered bubbler relief setpoints and redesign of the exhaust tubing (also known as tailpipes), both of which were implemented. A second calculation explored the potential pressurization/vacuum sources associated with each glovebox. However, this 2012 assessment identified non-conservatisms in both calculations that could render the bubblers' exhaust tubing redesign unable to provide the required relief protection. Three specific concerns are listed below. The first two of these concerns, regarding the bubbler tailpipe designs, resulted from these calculations and are contrary to good engineering practice, as described in design guidelines in American National Standards Institute (ANSI) and American Society of Mechanical Engineers (ASME) standards for pressure relief device tailpipes:

   - **Inadequate pressure relief protection for dual bubbler gloveboxes.** The function tester glovebox (FTGB) is equipped with two 10 standard cubic feet per minute (scfm)-rated bubblers to provide the required 20 cubic feet per minute (cfm) relief flow, and the redesigned exhaust tubing was sized and arranged to satisfy this intent. However, the two bubbler exhaust lines join to form a single line before connecting to the room exhaust duct. Inherent in the calculations was an unrecognized assumption that both bubblers would actuate simultaneously. However, due to relief setpoint tolerances, the bubblers will not necessarily actuate simultaneously. If they do not, the first bubbler to actuate will cause exhaust line backpressure, which will raise the effective setpoint of the second bubbler and possibly prevent it from actuating. If the second bubbler does not actuate, the glovebox dp will continue to rise, increasing exhaust flow and backpressure and further suppressing actuation of the second bubbler. Eventually, this condition could allow overpressurization of the glovebox. Essentially the same concern exists for the auxiliary maintenance (AM) glovebox bubblers.

   - **Non-conservative assumption of single glovebox event.** The calculations were based on an unstated assumption that an event would result in only one glovebox experiencing a pressurization/vacuum challenge. However, a common event, such as a seismic event,

could cause simultaneous failures inside more than one glovebox. The DSA recognizes that the gloveboxes themselves are not seismically qualified, so the safety bases institute source term reduction compensatory controls inside the gloveboxes. Still, the gloveboxes' failure to meet seismic requirements does not negate the requirement that they be protected from failure due to high dps, regardless of the credible causes. Since all of the glovebox bubbler exhaust tubes combine into a single tube in each glovebox room that is connected to the respective room fume hoods, the initial actuation of any one bubbler would tend to inhibit actuation of the other connected bubblers due to the generated backpressure, as previously described. Further, unlike the AM glovebox, even if more than one glovebox bubbler would actuate, since the calculated exhaust flow backpressures were based on only a single bubbler actuation, the resultant backpressure would exceed the values calculated for individual relief flows. This condition would result in individual relief flows being less than calculated, possibly not providing the required glovebox overpressure protection for any of the affected gloveboxes.

- **Non-conservative assumption of only one pressure/vacuum source in each glovebox.** The second calculation examined all of the potential pressure/vacuum sources in each glovebox that could overpressurize it, assuming that the corrective measures resulting from the first calculation were implemented. This second calculation found that some potential sources could exceed the available relief protection capacity, and measures were subsequently implemented to limit such sources to acceptable values. One of the first calculation's assumptions was, "If a flow of gas into or out of a glovebox required multiple *independent* [emphasis added] failures…, then the scenario was not considered in this calculation." However, it did not consider that multiple failures inside any glovebox could result from a single event; such multiple failures would thus not be "independent." Examples would include seismic events, tool failures inside a glovebox, and compressor explosion. Such multiple source challenges could exceed bubbler relief capacities.

5. **Contrary to requirements of DOE-STD-3009-94, glovebox underpressure protection is not identified in the DSA or the technical safety requirements (TSRs) as a safety functional requirement, although this function is recognized in the supporting analyses and other documents.**

6. **Contrary to requirements of DOE-STD-3009-94, the TGCS is not credited as a Design Feature.** 10 CFR 830.3, Definitions, states, "Design features means the design features of a nuclear facility specified in the technical safety requirements that, if altered or modified, would have a significant effect on safe operation." Although Section 4.4.4.5 of the final safety analysis report mentions the TGCS with respect to design features, it refers to the Design Feature section of the TSRs where, contrary to the DOE standard, the TGCS had been deleted as a design feature by a previous revision. Shortly after this assessment's field work was completed, a new revision of the DSA removed all mention of TGCS as a design feature.

7. **Controls identified in DSA Section 4.4.4.5 are inconsistent with those in DSA Section 5.3.2.4.**

8. **Contrary to DOE-STD-3009-94, the safety management program for TGCS pressure safety does not demonstrate that flow rates are controlled adequately to ensure system operability.**

9. **Contrary to requirements listed in the TGCS glovebox vendor's technical manual, test procedure WETF-TGCS-TP-01, Glovebox Maintenance and Testing, does not specify those vendor requirements.**

LASO and HSS considered the first four findings listed above to be the most significant. These four findings, in the SFD and SST areas, have the potential to challenge the ability of the TGCS to perform its credited safety functions, as documented in the safety basis. The other five findings identified by the LASO assessment team and HSS are considered to be of lesser significance. Eight of the nine findings arose from the review of finding closure from the 2007 HSS assessment. The remaining finding (the last in the list above) was identified by LASO and HSS based on its review of other findings (i.e., not the 2007 HSS review).

With the two exceptions below, the specific technical concerns identified during the 2007 HSS inspection related to WETF Conduct of Engineering for TGCS were satisfactorily resolved (although the broader issues were not always fully addressed and the corrective actions were not always sufficiently comprehensive, resulting in a number of new findings for related deficiencies). For the first exception, the specific technical concern listed below was not fully resolved, and no apparent action had been taken on the second:

- **Inappropriate rerouting of bubbler tailpipes.** The bubbler tailpipe design at the time of the 2007 HSS assessment had the tailpipes connecting to the room ventilation exhaust ducts. These ducts are normally at negative pressure relative to the room, thereby inducing errors in the pressure relief setpoints (lowering the overpressure setpoints, raising the underpressure setpoints) that could allow challenges to most of the gloveboxes' maximum allowable working pressures for underpressure conditions.

  In response to this concern, modifications were made to reroute the tailpipes in Room 205 to two other locations – a fume hood and a ventilation exhaust duct inlet – both of which were improvements with respect to induced bubbler setpoint errors. For the exhaust duct inlet reroute, there was little pressure variance between the room and the tailpipe outlet. However, for the reroute to the fume hood, there was still an induced setpoint error; the error was less severe than before but would vary depending on the hood sash position, which was not controlled by procedure. This redesign also substantially increased the dependence of the TGCS on the non-safety ventilation system to perform its worker safety function. In the previous design, even with the ventilation system not in service, contamination of the room atmosphere would be somewhat delayed because any tritium would exit the tailpipe directly into the ductwork. In the new design, with the ventilation system not in operation, any tritium release from the tailpipe would essentially go directly into the room, as it would have in the original system design before any modifications were made. Although this modification resolved some of the concern about ventilation system-induced bubbler setpoint error, it increased the dependency on the non-safety ventilation system to provide worker protection.

- **Inadequate glovebox mass limit warning in procedure.** The pressurized gas control procedure addressed assurance that the pressurized gas mass contained in any single glovebox did not exceed two moles per cubic meter of glovebox volume. However, this procedure contained an insufficiently explicit warning to ensure that the two-mole limit would not be exceeded when individual gloveboxes that had been connected, so that materials could be moved from one to the other, were subsequently separated. This issue was not closed.

The Independent Oversight team did not consider these two residual specific technical concerns, taken together or separately, to rise to the level of a finding. Appendix B summarizes the results of findings followed-up from the 2007 HSS Inspection during this independent review.

5.0 CONCLUSIONS

Overall, the LASO assessment was competently performed by knowledgeable LASO personnel using appropriate and challenging criteria. The LASO team was technically well qualified and, based on prior preparation and knowledge, demonstrated a high degree of familiarity with the WETF facility. Independent Oversight concurs with the objectives and results of the LASO assessment and believes that LASO applied sufficient rigor before and during the TGCS review.

However, the HSS independent review in conjunction with the LASO assessment identified a number of significant issues that require LANL management attention. Some of the issues are of particular significance because they may challenge the ability of the TGCS to perform its credited safety functions as documented in the safety basis. Other identified issues relate to the adequacy of the safety basis itself; these issues also have implications for the ability of the TGCS to perform its necessary safety functions to protect workers, as required by 10 CFR 830 and DOE-STD-3009.

6.0 OPPORTUNITIES FOR IMPROVEMENT

This Independent Oversight review identified the following opportunities for improvement (OFIs). These potential enhancements are not intended to be prescriptive or mandatory. Rather, they are offered to the site to be reviewed and evaluated by the responsible line management organizations and accepted, rejected, or modified as appropriate, in accordance with site-specific program objectives and priorities.

1. Consider reanalyzing all potential pressure/vacuum source threats to the TGCS gloveboxes, including those related to common-event failures of multiple internal sources and common-mode failures in multiple gloveboxes and their effects on bubbler tailpipe relief capabilities, and threats related to systems interaction failure modes, such as those that may be associated with the facility's HVAC supply and exhaust systems.

2. Based on the results of reanalysis of the potential source threats, where necessary, redesign the glovebox bubbler pressure/vacuum relief system to ensure that it can provide the required protection, with particular attention to ensuring that the bubbler tailpipes reflect good engineering practice, as described in ASME and ANSI codes and standards.

3. Ensure that the final design of the TGCS does not make it dependent on non-safety SSC for the performance of its safety functions, as the current TGCS depends on the HVAC exhaust system. Also, ensure that it is protected from potential system interactions due to failure modes of non-safety systems (e.g., the HVAC systems) and that any existing or future features in such non-safety systems that provide such protection, such as supply/exhaust fan control interlocks, are upgraded to safety significant.

4. Ensure that the safety bases fully, completely, and consistently identify and describe all of the TGCS safety functions, its boundaries, and its supporting and interfacing systems, such as the HVAC exhaust system's supporting function and the HVAC supply and exhaust systems' indirect interfaces with respect to glovebox dp. Ensure that all such supporting or interfacing SSC are appropriately classified with respect to safety, with reference to both support and protection of the TGCS from threats. Also ensure that the TGCS is appropriately credited as a design feature and that the safety function of the bubblers to provide glovebox *underpressure* protection, as well as overpressure protection, is formally credited.

7.0 ITEMS FOR FOLLOW-UP

On October 10, 2012, the LASO report was formally issued to the contractor, identifying nine findings in the SFD and SST areas. LANL was asked to review the report and confirm that the identified issues were entered into the facility's corrective action program. Based on the report's conclusions and the high significance of some of the findings, Independent Oversight will monitor expected corrective actions related to the following findings listed in Section 4.0 of this report which HSS considers to be of the highest significance based on their potential to negatively affect the ability of the TGCS to perform its safety function:

- Item 2 - TGCS safety function is dependent on the non-safety ventilation system (LASO Finding TGCS-SFD-F-4).
- Item 3 - TGCS contains unanalyzed interactions with ventilation systems and does not identify the ventilation system as a TGCS boundary or interface (LASO Finding TC LASO TGCS- SFD-F-5).
- Item 4 - TGCS glovebox bubbler design uses non- conservative analytical bases that could result in inadequate overpressure protection (LASO Finding TGCS-SFD-6):
- Inadequate pressure relief protection for dual bubbler gloveboxes.
- Non-conservative assumption of single glovebox event.
- Non-conservative assumption of only one pressure/vacuum source in each glovebox.
- Item 8 - The safety management program for TGCS pressure safety does not demonstrate that flow rates are controlled adequately to ensure system operability (LASO Finding TGCS-SFD-9).

Independent Oversight will also monitor expected corrective actions related to the following two remaining unresolved findings from the 2008 HSS inspection, which also have the potential to negatively affect the ability of the TGCS to perform its safety function:

- Inappropriate rerouting of bubbler tailpipes.
- Inadequate glovebox mass limit warning in procedure.

Upon LASO's approval of the new updated DSA and TSRs, HSS will conduct a follow-up review of the revisions.

Appendix A
Supplemental Information

Dates of Review: February 6 – March 9, 2012

Onsite Review: February 20 – March 2, 2012

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Appendix B
Issues Followed-up
From 2007 HSS Inspection (report issued January, 2008) of
WETF Tritium Gas Containment System

Finding No.	Finding Description	HSS Comments/Observations
E-3	WETF safety systems designs do not always completely and/or correctly reflect the performance requirements of the safety bases and/or good engineering practices, calling into question the systems' abilities to fully perform their credited safety functions, as required by site processes, DOE Order 420.1B, DOE Standard 3009, and 10CFR830.	
	• **Incorrect glovebox pressure relief bubbler design.** Bubblers were connected to ventilation exhaust ducts, which are at negative pressure relative to room, inducing relief pressure setpoint errors up to 2.6 in. w.c., thus potentially challenging gloveboxes' maximum allowable working pressures.	Modifications rerouted the bubbler exhausts in Room 114 to two other locations – a fume hood and a ventilation exhaust duct inlet. Reroute to ventilation exhaust inlet was satisfactory; reroute to fume hood still induced setpoint errors, now variable, depending on hood sash position, which was not controlled. Therefore, issue not resolved. New issue created by redesign: Substantially increased dependence of the SS TGCS on non-safety ventilation system for worker safety function.
	• **Function Tester Glovebox pressure rating/relief setpoint not described in the FSAR.**	Resolved
	• **Incorrect bubbler sightglass design**	Resolved
	• **Incorrect bubbler nominal setpoints.**	Resolved
	• **Incorrectly applied setpoint tolerance.**	Resolved

	• **Tritium pressure safety program procedure weaknesses.**	Resolved
E-4	WETF safety bases or actual designs have not always been completely and/or correctly translated into TSRs, procedures, and practices, as required by site processes, DOE Order 420.1B, DOE Standard 3009, and 10 CFR830.	
	• **Inadequate control of pressure-limiting valve positions on glovebox connections to pressures and vacuum sources.**	Resolved
	• **No leakage testing requirements for glovebox doors**	Resolved
	• **No formal maintenance program requirements for WETF glovebox doors.**	Resolved
	• **Inadequate glovebox mass limiting warning in WETF-OP-TGC-S-01.**	The pressurized gas control procedure was intended to assure that the pressurized gas mass contained in each glovebox did not exceed two moles per cubic meter of glovebox volume. It contained no explicit warning to assure that the limit would not be exceeded when individual gloveboxes, that are connected such that materials could be moved from one to the other, are separated. The procedure was not corrected with regard to this concern
	E-4.5 **Unidentified check valves functions.**	Resolved
E-5	In several instances, conditions in the WETF tritium gas containment system were outside established limits, but these conditions had not been recognized by facility staff as required by site processes, DOE Order 420.1B, DOE Standard 3009, and 10 CFR 830.	Resolved
	E-5.1 **Seven of eight bubbler levels were outside limits**.	Resolved

E-6	Documentation and analyses that demonstrate the ability of WETF safety structures, systems, and components to perform their safety functions, or that provide the bases for administrative controls, often do not exist, are not reasonably accessible, and/or are not controlled in a manner to allow confident day-to-day use in facility operations, as required by site processes, DOE Order 420.1B, DOE Standard 3009, and 10 CFR 830.	Resolved
	E-6.1 **Unavailability of documents and analyses supporting TGCS.**	Resolved