**Criteria, Review, and Approach Document for the Assessment of Operational Readiness of Vital Safety Systems (VSS)**

**Site:** **LLNL**

**Facility:** **Plutonium Facility - Building 332**

**System:** **Glove Box Exhaust System**

**System Classification:** **Safety Class**

**System Safety Function:** **Increment 1 and 3 have completely separate glovebox exhaust systems. However, both increments' GBES performs the same safety function. The GBES is comprised of the following components: Fisher regulator, room ducting, loft ducting and fire dampers (Increment 1), ducting and fire dampers (Increment 3), HEPA and spray plenums, HEPA filters, GBES fans, and exhaust stacks.**

## Review Approach

### Question 1

**Using the DOE-approved facility safety analysis (i.e., SAR, BIO, etc.), identify: (a) the system safety function(s); (b) the normal, abnormal, and accident conditions under which the system is intended to perform its safety function(s); and (c) relevant system functional requirements and performance criteria.**

### Answer 1.a

The glovebox exhaust system (GBES) ensures worker safety and prevents radioactive release to the environment and the public. It also provides continuous/intermittent air or inert gas flow from potentially contaminated areas (occupied rooms) into contaminated areas (gloveboxes). This is the primary means of maintaining negative pressure inside the glovebox to protect workers from contaminated gases. The GBES confines contaminated gases within the ductwork and HEPA plenum and directs contaminated gases through the HEPA filters before releasing the filtered gases into the environment. The GBES is categorized as a Safety Class System in Chapter 4 of Building 332 SAR.

### Answer 1.b

The accidents under which the GBES must perform its safety function are: Hydrogen Explosion, Solvent explosion, Room fire, Uncontrolled oxidation of lathe turnings, Evaluation-basis Earthquake and Evaluation-basis Wind. These conditions are:

**Hydrogen Explosion.** A pressure shock wave from a hydrogen explosion moving through Increment 3 GBES to the filters involves high-explosive-equivalent energy of 5-lb TNT equivalent (Section 4.3.4 of Bldg. 332 SAR).

**Answer 1.b (cont)**

**Solvent Explosion.** In the event of a solvent explosion in an Increment 1 glovebox, the environment in the GBES will consist of a pressure and temperature pulse of moderate magnitude as described in Section 3.4.3.4 of Bldg. 332 SAR. The temperature in the GBES will be less than the initial temperature (91°C, 196°F) as well as that for a hydrogen explosion (see Appendix D of Bldg. 332 SAR).

**Room Fire Involving Two Gloveboxes.** The GBES safety-class components in Increments 1 and 3 must survive a 2-hr evaluation-basis fire in a room (Section 3.4.3.1, of Bldg. 332 SAR). This scenario assumes that room sprinklers are not available. The evaluation-basis fire described in Section 3.4.3.1of Bldg. 332 SAR involves two gloveboxes and results in a maximum hot gas temperature of 815°C (1500°F), tailing off to 652°C (1200°F) at 2 hr (i.e., $0.8 \times 815 = 652$°C) (SAR Chapter 3 of Bldg. 332 SAR; See also Ref. 10 in Bldg. 332 SAR).

**Rapid Oxidation of Lathe Turnings.** During the lathe turnings fire in a glovebox in Increment 1, the environment in the GBES experiences a temperature rise of a gas of moderate but unknown magnitude for 4.5 h as described in Section 3.4.3.3.3 of Bldg. 332 SAR. The temperature in the GBES ducting will be less than the 807°C (1485°F) initial oxidation temperature when diluted with air entering the glovebox through a gloveport at 125 linear feet per minute.

**Evaluation-Basis Earthquake (EBE).** In accordance with DOE-STD-1020, the GBES are to be designated Performance Category (PC)-3 equipment that must be able to withstand the EBE with a peak acceleration of 0.57g (see Section 4.5.1of Bldg. 332 SAR).

**Evaluation-Basis Wind/Tornado (EBW).** In accordance with DOE-STD-1020, the PC-3 GBES must be able to withstand an extreme wind of 96 mph and missile hazards (2-in. × 4-in. timber plank, weighing 15 lb) having a horizontal velocity of 50 mph at a maximum height of 30 ft (see Section 4.6.1 of Bldg. 332 SAR).

In addition, the GBES is critical in minimizing the impact to workers during accident conditions. Hazards 2, 4, and 5 in the Table 3-4 of Bldg. 332 SAR describe events that effect facility workers (e.g., small spills or minor containment breeches) and shows that the functionality of the GBES minimizes the severity of the event.

**Answer 1.c**

The functional requirements for Increment 1 GBES ducting and exhaust fans are to confine and maintain gas flow from Increment 1 gloveboxes through all subsystems and out the stack under normal and abnormal conditions. Under accident conditions, Increment 1 GBES loft ducting, fire dampers, and filter plenums upstream of the final two-stage HEPA filters shall maintain their

structural integrity so that contaminated gases are not released in the Increment 1 loft (Section 4.3.2.3 of Bldg. 332 SAR).

The functional requirements for Increment 3 GBES ducting and exhaust fans are to confine and maintain gas flow from the Increment 3 gloveboxes through all subsystems and out the stack under normal and abnormal conditions. Under accident conditions, Increment 3 filter

**Answer 1.c (cont)**

plenum, fan housing, and the ducting downstream of the fan shall maintain their structural integrity so that no contaminated gases are released into these areas (Section 4.3.2.3 of Bldg. 332 SAR).

The functional requirements of the GBES Fisher regulators are to confine and maintain gas flow from gloveboxes through all subsystems and out the stack under both normal and abnormal event conditions. Under accident conditions, the GBES Fisher regulators shall maintain their structural integrity so that no contaminated gases are released from the GBES.

The performance criterion for both the Increment 1 and Increment 3 GBES ducting and exhaust fans during normal and abnormal conditions is to maintain the pressure in the ducting upstream of the HEPA plenum between –3 and –7 in. WG (relative to atmospheric). This performance criterion does not need to be met during accident conditions (Bldg. 332 SAR, Section 4.3.2.3).

The performance criterion for the GBES Fisher regulators during normal and abnormal conditions is to maintain the pressure in gloveboxes below –0.5 WG (relative to the room). This performance criterion does not need to be met during accident conditions (Bldg. 332 SAR, Section 4.3.2.3).

**Question 2**

**Identify the acceptance criteria from the surveillance tests used to verify that the system is capable of accomplishing its safety function(s). Review the acceptance criteria against the function(s), conditions, requirements, and performance criteria identified in Question 1 above.**

**Answer 2**

Building 332 Administrative Control Procedure ACP-B332-007 requires that each GBES standby fan be tested periodically to ensure an exhaust pressure of –3 to –7 in. WG (relative to atmospheric) can be maintained in the event the lead fan fails or the negative exhaust pressure drops below –1.5 in. WG. The surveillance test described in ACP-B332-007 states that the low- and high-pressure differential alarms will annunciate when a setpoint of–3 in. and –7 in. WG, respectively, is reached.

The acceptance criterion for the surveillance test in ACP-B332-007 is the ability of the LAG fan to start and supply the required pressure for each set of redundant fan systems along with the triggering alarms at both the high- and low-pressure differential set points.

Building 332 Facility Safety Plan (FSP) and the Operational Safety Plan (OSP) for each glovebox require that Fisher regulators have $\leq$–0.6 WG (relative to the room) prior to entry into a glovebox.

**Question 3**

**At what frequency are the tests identified in Question 2 above performed? Determine whether these tests and inspections are required by Technical Safety Requirements, Operational Safety Requirements (OSRs), or other Authorization Basis or Authorization Agreement requirements.**

**Answer 3**

Table 5-7 in Chapter 5 of Bldg. 332 SAR requires that the surveillance test described in ACP-B332-007 be conducted quarterly on the glovebox exhaust system and redundant fan controls.

Building 332 FSP and OSP require that the GBES Fisher regulators be checked each day prior to entry into a glovebox to determine their performance.

**Question 4**

**For each of the past three years: a) identify the number of times that the system has failed to meet its test acceptance criteria; b) identify the number of times that the system has failed in response to facility operating conditions (i.e., failed on demand); and c) estimate the percentage of time that the system was not capable of accomplishing its safety function(s) when required to be operable.**

**Answer 4**

In the past three years, the GBES has not failed its test acceptance criteria; nor has it failed in response to facility operating conditions. Other than down time related to preventive maintenance, the GBES has been operable, with full redundancy, 100% of the time.

Furthermore, none of the Fisher regulators have failed in the past three years.

**Question 5**

**Identify formally scheduled activities, in addition to those addressed in item 2 above that are intended to help ensure reliable performance of the system. Include preventive maintenance, walkdowns, inspections, and assessments as appropriate.**

**Answer 5**

Prior to opening the RMA each day, a facility operator completes the Daily Facility Operation Checklist verifying and noting on it the duct pressure readings and the overall system configuration. The completed checklist is maintained in the Facility Operations Office. A Daily Maintenance Inspection, which is not required to be performed prior to opening the RMA, is also conducted by a facility operator or designated personnel.

Quarterly maintenance of the GBES fans are conducted by Plant Engineering's Maintenance/Operations (M/O) Department. This involves an inspection of the following parts:

**Answer 5 (cont)**

Belts and sheaves, to check for wear, cracks, and alignment. Parts are replaced as necessary.

Fans, to check for balance, alignment, and damage. The bearings are also checked for excessive heat or vibration and lubricated. A notation is made if replacement of any part is necessary. Flex connections. If applicable, conditions warranting attention are noted.

In addition, monthly vibration measurements of the GBES exhaust fan's bearings and motors are taken to help predict failures. Annual duct inspections are also conducted to insure continued integrity.

To ensure that the glovebox pressure is at least 0.5 in. WG lower that the room pressure, the performance of the Fisher regulator is checked each day prior to entering a glovebox.

**Question 6**

**Identify the current backlog for the system for items such as preventive maintenance, corrective maintenance, modifications, surveillance's, tests, inspections, and corrective actions.**

**Answer 6**

There is no backlog for the GBES with regard to preventive maintenance, corrective maintenance, surveillance, tests, and inspections nor are there any corrective actions. However, work is under way to modify some GBES ducting and HEPA filter plenums. The Increment 3 final two stages of GBES HEPA filters will be upgraded from wood construction to steel plenum construction. This work is part of the Work Smart Standards implementation plan.

GBES ducting replacement is under way to correct a concern documented in Building 332 SAR relating to cracked ducting. The cracks are circumferential and are in the heat-affected zone of welds. Temporary cuffs (a band fully surrounding the duct with circumferential clamps) were installed over each crack to maintain integrity of the ducts and will remain in place until the ducts are replaced. A fireproof sealant was used to maintain fire resistance. A structural analysis of the ducts with the cuffs in place indicated that the ducts are capable of performing their design function even if the cracks extend a full 360° around the duct.

**Question 7**

**Are drawings that document the system configuration available? If so, identify the types of drawings (e.g., piping and instrumentation diagrams, electrical one-line, wiring, or schematic diagrams, installation drawings).**

**Answer 7**

Mechanical, electrical schematic/controls, as-builts, and fire alarm drawings are available for the GBES and are located in the Facility Operations Office and in Facility Engineering. Schematic drawings of the GBES in Increments 1 and 3 can be found in Chapter 4 of Building 332 SAR.

**Question 8**

**Review the processes used to ensure that work on the system and changes to the system are properly controlled (i.e., formally reviewed, approved, implemented, tested, USQ review performed if required, documents updated, and work/change accepted).**

**Answer 8**

*Building 332 Work Control/Design Change Control Process Manual* (WC/DCCPM) describes processes for requesting, reviewing, approving, and conducting work activities in the Plutonium Facility (B332). In addition, ACP-B332-011, *Unreviewed Safety Questions (USQ) Procedure* provides guidance for evaluating proposed activities for potential Unreviewed Safety Questions. These processes and guidance are in place to assure that work activities conducted in Building 332 are properly requested, reviewed, and authorized before being performed and that such work activities are performed in a formal and deliberate manner with emphasis on safety.

Changes to the safety systems are covered in Category E activities in the WC/DCCPM, which also includes changes to facility and programmatic equipment, the installation of new equipment, and the introduction of new activities. The following steps are required for Category E activities:

- Complete a Design Change Request
- In the request, identify the hazards associated with the construction and operation of the new or modified activity
- In the request, identify the tasks that are necessary for completion of the installation or modification
- Submit the Design Change Request for Facility Staff review and Facility Manager approval
- Perform USQ prescreening or formal USQ documentation as defined in ACP-B332-011
- The Facility Design Review Committee will conduct a design review and will provide recommendations to the Facility Manager
- When the Facility Manager approves the Design Change, the work can be performed
- At the completion of work requested, a Facility Operation Readiness Review (FORR) reviews the implementation of the design change. Operation requires approval from Facility Manager upon satisfaction of FORR
- The FORR checks completion of documentation

**Question 9**

**Determine whether the procedures identified in items 2 and 5 above, and the drawings identified in item 7 above, are controlled under a formal document control process, and indicate whether the process requires that documents be updated as necessary to maintain their accuracy.**

**Answer 9**

All procedures within the Plutonium Facility are prepared using QOP-B332-001, *Preparation of Controlled Procedures,* and are reviewed, approved, and revised using QOP-B332-002, *Review, Approval and Revision of Unclassified Controlled Documents – Document Change Control Process*.

**Answer 9 (cont)**

ACP-B332-007 was prepared and is controlled by these two documents. All controlled procedures within the Building 332 are reviewed every three years.

For the past two years, the Work Control Process has been used to control changes to systems in Building 332. This process utilizes engineering design reviews to ensure "as-built" conditions are confirmed prior to beginning work, and also is the mechanism for triggering drawing updates. Prior to 1998, less vigorous configuration management existed in
Building 332. The facility is gathering drawings and documentation for an archiving initiative.

**Question 10**

**Identify any systems and equipment (e.g., electric power, instrument or control air, diesel fuel transfer, vacuum, heat tracing, etc.) that directly support the operation of the vital safety system being assessed (i.e., where the support systems/equipment are essential for the safety system to perform its safety functions) that are not included within the defined system boundary.**

**Answer 10**

Following are the systems and equipment that support the GBES safety function:

**Emergency Power System (Safety Class).** The GBES may require support from the Emergency Power System under accident conditions. This includes exhaust fans, power dampers, solenoid valves and other control equipment.

**Final HEPA Filtration Stages (Safety Class).** The function of the final two-stage HEPA filters is to remove radioactive particulates from the exhaust gas stream before the air is released to the atmosphere.

**Fire- Suppression System (Safety Class).** The GBES requires support from the fire-detection and suppression system under accident conditions. In an accident scenario, a fire in any glovebox could plug the glovebox housekeeping filters permitting venting into the lab. In this situation, or in a room fire, the room HEPA filters could also plug. To prevent room overpressure, the room exhaust duct has a fire bypass damper that is actuated by a fusible link. This allows the lab to vent room exhaust downstream of the plugged room HEPA filters. In the event of a cold, smoldering fire, smoke detectors will close room supply dampers, preventing overpressurization.

All glovebox ducts are equipped with fire dampers, which are actuated by a fusible link. These are located where the riser from the lab penetrates into the floor of the fan loft. The loft fire damper will survive a room fire in the partially open position (3/8 in.).

If the glovebox ducting in the loft were to develop a crack due to fire, then loft air will be drawn into this crack by the GBES exhaust fans. This prevents contaminated gases from entering the loft. If the ducting were to completely break open or the exhaust fans failed to perform, the room exhaust ventilation system would draw loft air and contaminated gases back

**Answer 10 (cont)**

into the open end of the duct and the partially open fire damper into the room, the room exhaust ducting and through the housekeeping HEPA filters.

The final HEPA filters in the loft are made of fire-resistant construction and are operable for at least 2 hr at 250°F. In addition, each HEPA filter plenum employs a fire protection design using a deluge valve, fog nozzles, and demister. These water sprays protect the filters from elevated temperatures in the event the glovebox duct sprays do not perform as intended. The fusible plug in the deluge valve will melt at nominally 212°F and allow water to flow to the fog nozzles. These nozzles generate a fine mist, which will cool the duct gases. Water droplets are collected on a demister, which is located between the nozzles and HEPA filters. Thus, during a fire, duct gases can continue to be filtered and exhausted out the stack.

**Fire Alarm and Detection System (Safety Significant).** In Increment 3, high-temperature heat detectors in the GBES ducting will signal for the glovebox exhaust fans to be turned off. This serves to isolate the GBES HEPA filters and to maintain confinement. Also, in specific applications, heat detectors in gloveboxes trigger an alarm at 212°F indicating a glovebox fire.

**Glovebox System (Safety Significant).** The GBES connects directly to all gloveboxes. The safety function of the gloveboxes is to protect workers by providing primary confinement of hazardous and radioactive materials.

**Inert gas system (Safety Significant).** The safety function of the Inert Gas System (Nitrogen and Argon) is to prevent the oxidation of Plutonium or the combustion of flammable solids and liquids and, in turn, protect workers.

**Continuous Air Monitoring System (CAMs) (Safety Significant).** This system shall enunciate (i.e., audible alarm signal) when airborne radioactivity is released into the ventilation exhaust.