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6. CHEMICAL PROCESS SAFETY

This chapter describes the chemical classification process, the hazards of chemicals of concern, process interactions with chemicals affecting licensed materials and/or hazardous chemicals produced from licensed material, the methodology for evaluating hazardous chemical consequences, and the chemical safety assurance features.

The GE-Hitachi Global Laser Enrichment LLC (GLE) Chemical Process Safety Program has been developed consistent with the guidance in Chapter 6 of NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility (Ref. 6-1)*, and complies with 10 CFR 70.61, *Performance Requirements (Ref. 6-2)*, 10 CFR 70.62, *Safety Program and Integrated Safety Analysis (Ref. 6-3)*, and 10 CFR 70.64, *Requirements for New Facilities or New Processes at Existing Facilities (Ref. 6-4).*

6.1 PROCESS CHEMICAL RISK AND ACCIDENT SEQUENCES

It is GLE Policy to provide a safe and healthy work place by minimizing the risk of chemical exposure from licensed material and other hazardous chemicals to employees, the public, and the environment. This is accomplished through the Integrated Safety Analysis (ISA), the controls resulting from the ISA, and through the implementation of the Chemical Safety Program. This chapter discusses chemical safety issues related to: radiation and chemical risks of licensed materials; hazardous chemicals produced from licensed material; and facility conditions that affect or may affect the safety of licensed material resulting in an increased radiation risk to personnel, the public, or the environment.

6.1.1 Process Descriptions

The GLE process descriptions are provided in the ISA Summary. The descriptions are intended to allow a basic understanding of the chemical process hazards including radiological hazards caused by or involving chemical accidents. Summaries of the process descriptions are also included in GLE license application (LA) Chapter 1, *General Information*.

6.1.2 Consequences and Likelihoods of Accident Sequences

An ISA has been performed as required by 10 CFR 70.62. The ISA provides a list of the accident sequences that have the potential to result in radiological and non-radiological releases of chemicals; provides reasonable estimates for the likelihood and consequence of each accident identified; and applies acceptable methods to estimate potential impacts of accidental releases. The ISA also identifies the engineering and/or administrative controls for each accident sequence of significance; satisfies principles of the baseline design criteria (BDC) and performance requirements in 10 CFR 70.61 by applying defense-in-depth to high-risk chemical release scenarios; and assures adequate levels of these controls are provided so Items Relied on for Safety (IROFS) will satisfactorily perform their safety function when needed.

Accident sequences involving licensed materials, and those chemicals that may impact licensed materials, have been analyzed in the ISA and summarized in the ISA Summary. The accident sequences identified by the ISA were categorized into one of three consequence categories (high, intermediate, or low) based on their radiological, chemical, and/or environmental impacts. The radiological and chemical consequence severity limits, defined by 10 CFR 70.61 for the high and intermediate categories, are presented in Table 6-1, *Chemical Consequence Severity Levels from 10 CFR 70.61*. The ISA considers the potential interactions of process chemicals with confinement vessels, and with process equipment in which initiating events include releases of uranium hexafluoride (UF_6) from equipment, including vessels, pipes, valves, and cylinders. Interactions between process chemicals and personnel are considered both in the ISA, and during the preparation of procedures to include industrial safety protective measures.

The measures to mitigate the consequences of accident sequences identified in the ISA Summary are consistent with protective actions described in the GLE Radiological Contingency and Emergency Plan (RC&EP) *(Ref. 6-5)*. The site emergency response team is prepared to respond to various emergency conditions, including a chemical accident.

6.1.3 Chemical Release Scenario Techniques and Assumptions

This section describes the techniques and assumptions used to estimate the concentrations or to predict the "toxic" footprint for potential releases of hazardous chemicals produced by licensed material or by abnormal facility conditions that could affect the safety of licensed materials.

6.1.3.1 Worker Exposure Assumptions

Any release from UF_6 systems and/or cylinders at the GLE Commercial Facility would predominately consist of hydrogen fluoride (HF), uranyl fluorde (UO_2F_2), and potentially some UF_6. The release would cause a visible cloud and a pungent odor. The odor threshold for HF is less than one parts per million (ppm). The irritating effects of HF are typically intolerable at concentrations well below those that cause permanent injury or which produce escape-impairing symptoms. Workers are trained to take immediate self-protective action to escape a release upon sensing HF effects. For the purpose of evaluating personnel exposure in cases where a worker would be expected to be in the immediate proximity of a release, the 10-minute Acute Exposure Guideline Levels (AEGL) values have been used for HF and UF_6. Table 6-2, *Chemical Consequence Values*, shows the numeric values used as chemical consequence thresholds. Once a release is detected, the worker is assumed to evacuate the area of concern. Sufficient time is available for the worker to reliably detect and evacuate the area of concern.

6.1.3.2 Public Exposure Assumptions

Potential exposures to the public were evaluated using conservative assumptions for both exposure concentrations and durations. Exposure was evaluated for consequence severity against chemotoxic, radiotoxic, and radiological dose. Public exposures were estimated to last for a duration of 30 minutes. This is consistent with self-protection criteria for UF_6/HF plumes listed in NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees (Ref. 6-6)*.

6.1.4 Source Term and Dispersion Models

The methodologies used to determine the source term are those prescribed in NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook (Ref. 6-7)*, and supporting documents. The specific modeling methods utilized follow consistent and conservative methods for source term determination, release fraction, dispersion factors, and meteorological conditions. For releases inside of buildings, conservative leak path fractions were assumed as recommended by NUREG/CR-6410.

6.1.5 Description of Chemical Dispersion Models

The computer codes used in chemical consequence analyses were RASCAL 3.0.5 (Radiological Assessment System for Consequence Analysis) *(Ref. 6-8)* and ARCON 96, both of which are widely-accepted by the nuclear industry as appropriate for chemical dispersion modeling.

6.1.6 Chemical Exposure Standards

To quantify criteria of 10 CFR 70.61 for chemical exposure, standards for each applicable hazardous chemical must be applied to determine exposure that could: endanger the life of a worker; lead to irreversible or other serious long-lasting health effects in an individual; and cause mild transient health effects to an individual. Per NUREG-1520, acceptable exposure standards include the AEGL established by the National Advisory Committee for Acute Guideline Levels for Hazardous Substances. Consistent with the NUREG-1520 guidance, GLE uses the AEGL standard to assess the consequences of postulated chemical releases The only accident sequences resulting in chemical consequences exceeding the criteria in 10 CFR 70.61 involve the release of UF_6 and its hydrolysis products HF and UO_2F_2. These accident sequences are presented in the ISA Summary.

Dermal exposures to HF have been evaluated in the ISA Summary. Although HF is not used directly in the enrichment process, limited quantities of dilute HF (< 4%) are generated in the Laboratory and Decontamination/Maintenance Areas. The criteria for assessing dermal exposures are listed in Table 6-3, *HF Dermal Exposure Consequence Severity Levels.*

6.2 ITEMS RELIED ON FOR SAFETY AND MANAGEMENT MEASURES

This section describes the identification and management measures associated with chemical process safety IROFS.

6.2.1 Chemical Safety Approach

Safety in normal operations is maintained through the implementation of the defense-in-depth engineering design philosophy. The ISA Summary describes the basis for providing successive levels of protection such that the health and safety of employees and the public are not wholly dependent upon any single element of the design, construction, maintenance, or operation of the facility. The schemes employed to ensure safe operation of the facility include management measures that provide for the reliability of IROFS. These measures include configuration management (CM), maintenance, procedures, training, audits/ assessments, emergency planning, incident investigation, human factors, records, and reporting. Management measures are fully described in GLE LA Chapter 11, *Management Measures*.

6.2.1.1 Chemical Safety Program

The Chemical Safety Program is applicable to the chemicals associated with the authorized activities described in GLE LA Chapter 1, and includes UF_6 and hydrofluoric acid as well as other hazardous chemicals associated with licensed material activities. The Chemical Safety Program provides oversight of the handling, use, and storage of chemicals at the GLE Commercial Facility. The Chemical Safety Program is documented in approved written procedures that ensure processes and operations comply with applicable Federal and State regulations pertaining to chemical safety.

The Chemical Safety Program falls within the Environmental, Health, and Safety (EHS) Organization and overlaps with several other disciplines including: Operations, Maintenance, Radiation Protection (RP), Emergency Preparedness, Environmental Protection, Industrial Safety, and Nuclear Criticality Safety (NCS). Prior to starting a new activity involving chemicals, a job hazards analysis (JHA) is performed to ensure that the work is conducted safely and the appropriate training, authorizations, and procedures are completed. This ensures that appropriate controls are in place for adequate protection of the general public and safe use by employees, and that the use of chemicals does not create potential conditions that adversely affect the handling of licensed materials. Employees and contractors using hazardous materials are trained to ensure safe handling, use, and disposal.

EHS management reviews and approves JHAs prior to initial issuance. The review and approval is to affirm that the criticality, radiation, chemical, process, fire, and explosion risks associated with the process or facility under evaluation is understood and proper safety measures are in place. GLE LA Chapter 2, *Organization and Administration*, contains a description of the GLE Organization, including the responsibilities of the EHS Manager.

6.2.1.1.1 Chemical Evaluation and Approval

Prior to new hazardous materials being brought onsite or being used in an activity, the materials are approved through a formal process initiated when a request for procurement of a new chemical is submitted. Before a new chemical is ordered, the requester must obtain approval from the Chemical Review Committee. The Chemical Review Committee is comprised of a representative of the EHS Organization, an area manager, and others as deemed appropriate by the EHS representative. The EHS representative leads the review and is a qualified chemical safety reviewer. The process for approval includes reviewing the health and safety risks of the chemical, as well as appropriate handling, storage, and disposal information. Every effort is made to limit the amount of hazardous chemicals used, including identifying feasible alternative chemicals or processes. The EHS representative coordinates with representatives from Environmental Protection, Industrial Safety, RP, and NCS. The formal approval process consists of evaluations for the physical, health, and fire/explosive hazards; as well as the potential impact on the handling of licensed material. The conclusions of this approval process may dictate some or all of the following for assurance of chemical process safety:

- New procedures or changes to existing procedures,
- Maintenance programs for equipment,
- CM controls,
- Addition of material safety data sheet(s) (MSDS) to database/CD,
- Emergency planning modifications, and/or
- Training requirements.

The process for approving new hazardous materials being brought onsite or used in a process is applicable to GLE employees and contractors. If a contractor is using a new chemical, the contractor must notify the GLE point-of-contact and the GLE approval process is initiated. If an existing hazardous chemical is used in a new process or an existing process that has not previously used the chemical, then the change would be evaluated through the 10 CFR 70.72, *Facility Changes and Change Process (Ref. 6-9)*, process described in GLE LA Chapter 11.

6.2.1.1.2 Labeling and Identification

Hazardous materials or conveyance systems are labeled or identified to meet applicable regulations. The proper identification of hazardous materials decreases the likelihood of improper use, handling, and disposal reducing potential negative consequences.

The hazards of chemicals are identified for personnel through the MSDSs. These documents are available on the GLE intranet.

6.2.1.1.3 Chemical Inventories

Chemical inventories at the GLE Commercial Facility are maintained below the threshold quantities set forth in 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals (Ref. 6-10),* and 40 CFR 68, *Chemical Accident Prevention Provisions (Ref. 6-11)* (also referred to as the Risk Management Program); therefore, these regulations are not applicable to GLE.

Inventories of chemicals are tracked through the procurement process. In addition, the GLE RC&EP contains an inventory, including amounts and locations, of bulk chemicals as required by EPA's Emergency Planning and Community Right-to-Know-Act (EPCRA), Section 312, Tier II *(Ref. 6-12)*. The GLE RC&EP, as well as GLE Commercial Facility MSDSs, are provided to applicable offsite responders. The GLE RC&EP is updated annually.

6.2.1.1.4 Hazardous Chemicals and Chemical Interactions

Chemicals utilized at the GLE Commercial Facility that have the potential to affect licensed material, either directly or indirectly, are evaluated to determine the consequence level for a particular accident sequence. The main process chemicals of concern at the GLE Commercial Facility are UF_6, and two hydrolysis products, HF and UO_2F_2. If UF_6 is released into the atmosphere, the uranium compounds and HF that are formed by reaction with moisture in the air are chemically toxic. Uranium is a heavy metal that, in addition to being radioactive, can have toxic chemical effects primarily on the kidneys if it enters the bloodstream by means of ingestion or inhalation. HF is an extremely corrosive gas that can damage the lungs and cause death if inhaled at sufficiently high concentrations.

The ISA process evaluates the potential for UF_6 releases, as well as the interaction of non-licensed chemicals impacting licensed materials. Details of this process and the results of this evaluation are presented in the ISA Summary. For new chemicals brought onsite, the process described in Section 6.2.1.1.1, *Chemical Evaluation and Approval*, includes an evaluation of the potential hazardous interactions between process chemicals.

6.2.1.2 Materials of Construction, Sizing of Equipment, System Fabrication, and Process Control Schemes

The design of the chemical process systems includes numerous controls for maintaining safe conditions during operations. These controls include, but are not limited to: managing the arrangement and size of material containers and processes; selection and use of materials compatible with process chemicals; providing inherently safe operating conditions (such as, UF_6 confinement); and providing process interlocks, controls, and alarming within the chemical processes. These facility and equipment features help prevent chemical releases. Process piping and components (such as, separators, traps, vents, etc.) are maintained safe by limits placed on their operating parameters.

6.2.1.2.1 Materials of Construction

Interactions between process equipment and process fluids/gasses were considered in the design of the GLE Commercial Facility. The GLE Commercial Facility will utilize approved materials of construction throughout the process and operations areas that are compatible with UF_6 and/or are corrosion resistant to UF_6. These materials of construction are also compatible with the process operational physical parameters of pressure and temperature accordingly. The materials of construction meet the applicable standard engineering specifications required by the International Building Code *(Ref. 6-13)* and/or other building codes, and their use is consistent with standard industry practice for processing UF_6.

The cylinders to be used at the GLE Commercial Facility for transport, processing, and storage of UF_6 are designed and maintained in accordance with ANSI N14.1, *Nuclear Materials: Uranium Hexafluoride – Packaging for Transport (Ref. 6-14)*. These containers are appropriate due to the resistance of the materials to corrosion by UF_6. These cylinders are painted to resist corrosion from atmospheric conditions. The cylinders are also inspected on a routine basis to assess corrosion and corrosion rates.

6.2.1.2.2 Sizing of Equipment

The sizing of process equipment is based on the amount of material to be used in the process. The design of preventive and/or mitigative features is based on conservative assumptions to allow for unusual conditions. For example, tanks that contain bulk chemicals are designed to provide for more than the maximum volume expected during normal operations. In addition, overflow alarms and mitigative devices (curbs, sumps, overflow tanks) are available for use during upset conditions.

6.2.1.2.3 System Fabrication

Within the GLE Commercial Facility, systems are fabricated with safety as a priority. Conservative assumptions are used for sizing and geometry, and materials of construction are chosen to avoid corrosion. Preventive maintenance is routinely scheduled for replaceable parts. The systems are designed to provide easy access for maintenance.

6.2.1.2.4 Process Control Schemes

Process control schemes are chosen with safety as a priority. The process control schemes that are associated with IROFS are described in the ISA Summary.

6.2.2 Chemical Process Safety Controls

Chemical process safety controls, including administrative controls, engineered controls, and management measures, are identified in the ISA Summary. The ISA Summary describes the controls to prevent or mitigate chemical process risks, the hazard being mitigated, and the risk category.

A defense-in-depth approach is followed during the design of chemical process systems. The ISA Summary has identified a number of generic and inherent safeguards protecting against or mitigating process material releases. Many of these reduce the likelihood or severity of hazardous releases from process equipment. Others help the operators respond more quickly and/or efficiently to limit the effect(s) of releases of hazardous materials. These safeguards include, in order of preference, passive controls (such as, curbs around chemical tanks), active engineered controls (such as, high temperature shutdown interlock), and administrative controls (such as, operator training and approved written procedures). Some safeguards, such as gas alarm systems, provide a mitigative function by alerting operators to evacuate the facility rapidly, thus limiting radiation and chemical exposure during an event.

6.2.3 Chemical Process Safety Management Measures

There are a number of safety features in place to help prevent, detect, and mitigate potential releases of UF_6. Some of these features are classified as IROFS as determined in the ISA. A listing of chemical process safety IROFS is presented in the ISA Summary. Management measures, as described in GLE LA Chapter 11, are implemented to assure the reliability and availability of chemical process safety IROFS.

6.2.3.1 Procedures to Ensure Reliable Operation of Engineered Controls

GLE maintains approved written procedures to ensure reliable operation of engineered controls (for example, inspection and testing procedures and frequencies, calibration programs, functional tests, corrective and preventive maintenance programs, criteria for acceptable test results).

6.2.3.2 Procedures to Ensure Proper Implementation of Administrative Controls

GLE maintains approved written procedures to ensure administrative controls are correctly implemented, when required (for example, employee training and qualification in procedures, refresher training, safe work practices, development of procedures, and training program evaluation).

6.3 REQUIREMENTS FOR NEW FACILITIES

GLE LA Chapter 3, *Integrated Safety Analysis*, and the ISA Summary describe the methodology for satisfying the principles of the baseline design criteria in 10 CFR 70.64.

The GLE Commercial Facility is designed using a defense-in-depth approach for protecting against chemical accidents. In accordance with 10 CFR 70.64(a)(5), the design provides for adequate protection against chemical risks produced from licensed material, facility conditions that affect the safety of licensed material, and hazardous chemicals produced from licensed material. For chemical process safety, the facility design considered the following:

- Preference for the selection of engineered controls over administrative controls to increase overall system reliability; and

- Features that enhance safety by reducing challenges to IROFS.

The main design feature to ensure chemical process safety is the robust equipment that contains UF_6 during the enrichment process. [Security-Related Information withheld from public disclosure per 10 CFR 2.390.]

Examples of mitigative features include temperature controls on process equipment, pressure sensors in process vessels, solenoid and control valves on the UF_6 Gas Handling System, auxiliary ventilation systems in UF_6 process areas, and gas detection/alarm systems.

GLE is not proposing any facility-specific or process-specific relaxations or additions to the baseline design criteria of 10 CFR 70.64.

6.4 REFERENCES

6-1 NUREG-1520, *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility*, U.S. Nuclear Regulatory Commission, March 2002.

6-2 10 CFR 70.61, *Performance Requirements*, U.S. Nuclear Regulatory Commission, 2008.

6-3 10 CFR 70.62, *Safety Program and Integrated Safety Analysis*, U.S. Nuclear Regulatory Commission, 2008.

6-4 10 CFR 70.64, *Requirements for New Facilities or New Processes at Existing Facilities*, U.S. Nuclear Regulatory Commission, 2008.

6-5 Radiological Contingency and Emergency Plan, GE-Hitachi Global Laser Enrichment LLC, April 2009.

6-6 NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*, U.S. Nuclear Regulatory Commission, January 1988.

6-7 NUREG/CR-6410, *Nuclear Fuel Cycle Facility Accident Analysis Handbook*, U.S. Nuclear Regulatory Commission, March 1998.

6-8 NUREG-1887, *RASCAL 3.0.5: Description of Model and Methods*, U.S. Nuclear Regulatory Commission, August 2007.

6-9 10 CFR 70.72, *Facility Changes and Change Process*, U.S. Nuclear Regulatory Commission, 2008.

6-10 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*, Occupational Safety and Health Standards, Hazardous Materials, 2008.

6-11 40 CFR 68, *Chemical Accident Prevention Provisions*, Environmental Protection Agency, 2008.

6-12 Emergency Planning and Community Right-to-Know-Act, Environmental Protection Agency, 2008.

6-13 2006 International Building Code (IBC), International Code Council, March 2006.

6-14 ANSI N14.1-2001, *Nuclear Materials: Uranium Hexafluoride – Packaging for Transport*, American National Standards Institute, January 2001.

Table 6-1. Chemical Consequence Severity Levels from 10 CFR 70.61.

	Workers	Offsite Public	Environment
High Consequence	• Radiological dose greater than 1 Sv (100 rem) • Chemical exposure greater than AEGL-3 (10 minute exposure) • A criticality accident occurs	• Radiological dose greater than 0.25 Sv (25 rem) • 30 mg soluble uranium intake • Chemical exposure greater than AEGL-2 (30 minute exposure) • A criticality accident occurs	A criticality accident occurs
Intermediate Consequence	• Radiological dose greater than 0.25 Sv (25 rem) but less than or equal to 1 Sv (100 rem) • Chemical exposure greater than AEGL-2 but less than or equal to AEGL-3 (10 minute exposure)	• Radiological dose greater than 0.05 Sv (5 rem) but less than or equal to 0.25 Sv (25 rem) • Chemical exposure greater than AEGL-1 but less than or equal to AEGL-2 (30 minute exposure)	Radioactive release greater than 5,000 times 10 CFR 20, Appendix B, Table 2

Table 6-2. Chemical Consequence Values.

	Workers	Offsite Public	Environment
Category 3 High Consequence	Soluble U intake > 75 mg HF > 139 mg/m^3 UF_6 > 216 mg/m^3	Soluble U intake > 30 mg HF >28 mg/m^3 UF_6 >19 mg/m^3	N/A
Category 2 Intermediate Consequence	HF > 78 but $\leq$ 139 mg/m^3 UF_6 > 28 but $\leq$ 216 mg/m^3	HF> 0.8 but $\leq$ 28 mg/m^3 UF_6 > 3.6 but $\leq$ 19 mg/m^3	Radioactive release>5000 times of 10 CFR 20, Appendix B, Table 2
Category 1 Low Consequence	Accidents of lower radiological and chemical exposures than those above in this column	Accidents of lower radiological and chemical exposures than those above in this column	Radioactive releases with lower effects than those referenced above in this column

Table 6-3. HF Dermal Exposure Consequence Severity Levels.

	Workers	Offsite Public
Category 3 High Consequence	Dermal exposure from an HF solution that endangers the life of the worker	Dermal exposure to HF solution resulting in irreversible or other serous long-lasting health effects Direct eye contact with HF solution that leads to irreversible or other serious long-lasting health effects
Category 2 Intermediate Consequence	Dermal exposure to HF solution resulting in irreversible or other serious long-lasting health effects Direct eye contact with HF solution that leads to irreversible or other serious long-lasting health effects	Dermal exposure from HF solution resulting in mild transient health effects

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