NEA International Workshop on Chemical Hazards in Fuel Cycle Facilities Nuclear Processing

Chemical Safety Requirements in the United States for Commercial Fuel Cycle Facilities

Marilyn Diaz
U.S. Nuclear Regulatory Commission

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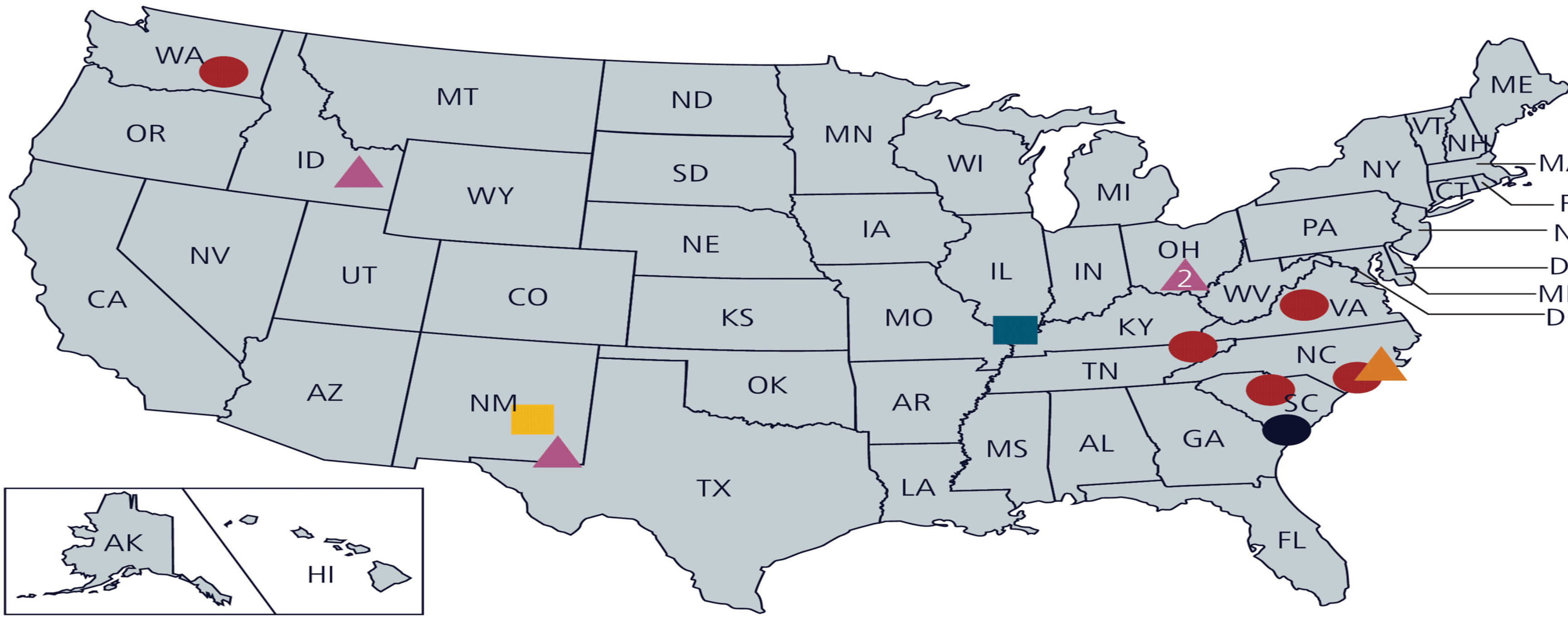
Topics

- Background:
  - Overview of Fuel Cycle Facilities
  - Memorandum of Understanding between U.S. agencies
  - Regulatory Framework
- Chemical Safety Requirements
- Guidance
- Conclusion

Overview of Fuel Cycle Facilities

Locations of Fuel Cycle Facilities



Uranium Hexafluoride Conversion Facility (1)
Uranium Fuel Fabrication Facility (5)
Mixed-Oxide Fuel Fabrication Facility (1)
Gas Centrifuge Uranium Enrichment Facility (4)*
Laser Separation Enrichment Facility (1)
Uranium Hexafluoride Deconversion Facility (1)

Note: There are no fuel cycle facilities in Alaska or Hawaii.
For the most recent information, go to the Dataset Index Web page at *https://www.nrc.gov/reading-rm/doc-collections/datasets/*

As of June 2017

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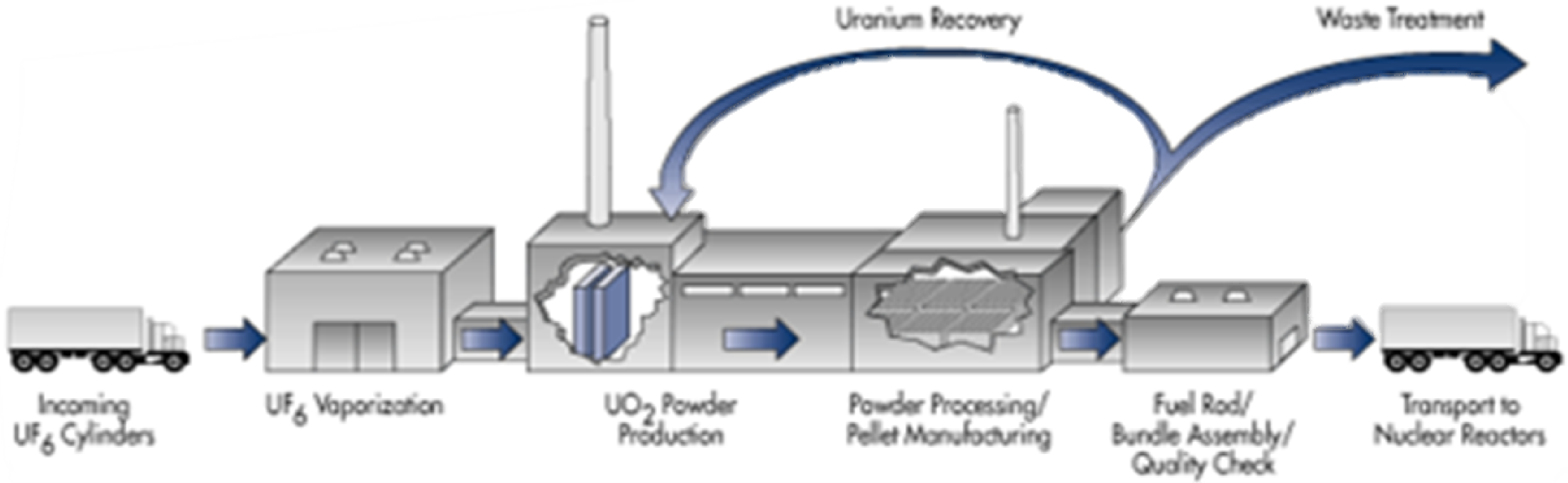
Overview of Fuel Cycle Facilities



Chemical Hazards

- Numerous chemicals used at fuel cycle facilities (FCF) for processing uranium and other heavy metals.
- These are chemicals commonly used at FCF that may be considered hazardous:
  - Uranium hexafluoride, hydrogen fluoride, ammonia, hydroxylamine nitrate, nitrogen oxides, nitric acid, other acids and solvents.

Shared Responsibilities for Chemical Hazards

- Memorandum of Understanding between U.S. Occupational Safety and Health Administration (OSHA) and U.S. Nuclear Regulatory Commission (NRC).
- NRC is responsible for:
  - Radiation risks of licensed materials
  - Chemical risks of licensed materials, and
  - Plant conditions that affect or may affect the safety of licensed materials and thus , present an increased risk to workers.

Regulatory Framework

- 10 CFR Part 70: Amended, in 2002, to incorporate Subpart H requirements which are risk informed, performance-based requirements.
    - Performance Requirements (70.61)
    - Conduct and maintain an Integrated Safety Analysis (ISA) (70.62)
    - Identification of items relied on for safety (IROFS)
    - ISA summary must include quantitative standards (70.65)

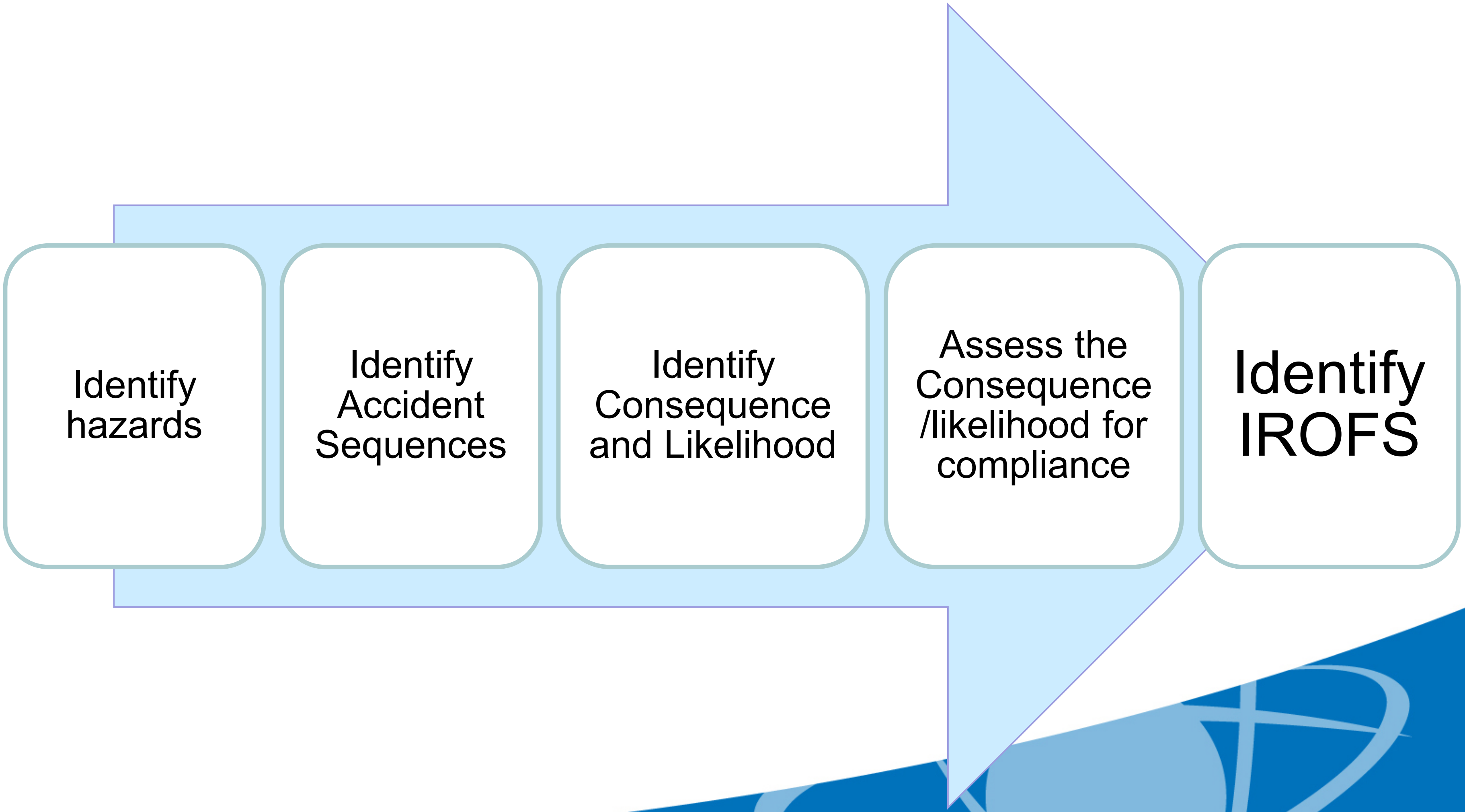
Chemical Safety Requirements

- 10 CFR 70.61 presents risk *performance requirements* which include requirements for acute chemical exposure resulting in high and intermediate consequences (70.61(b)(4) and 70.61(c)(4)).
  - High consequence: initiated events that result in:
    - Could endanger life of a worker, or
    - Could lead to irreversible or other serious, long-lasting health effects to any individual
  - Intermediate consequence: initiated events that result in:
    - Could lead to irreversible or other serious, long-lasting health effects to a worker,
    - Could cause mild transient health effects to any individual

Chemical Safety Requirements

- 10 CFR 70.65 requires submittal of ISA Summary to support demonstration of compliance with performance requirements.
  - 70.65(b)(7) requires a description of the proposed standards used to assess compliance with 70.61.

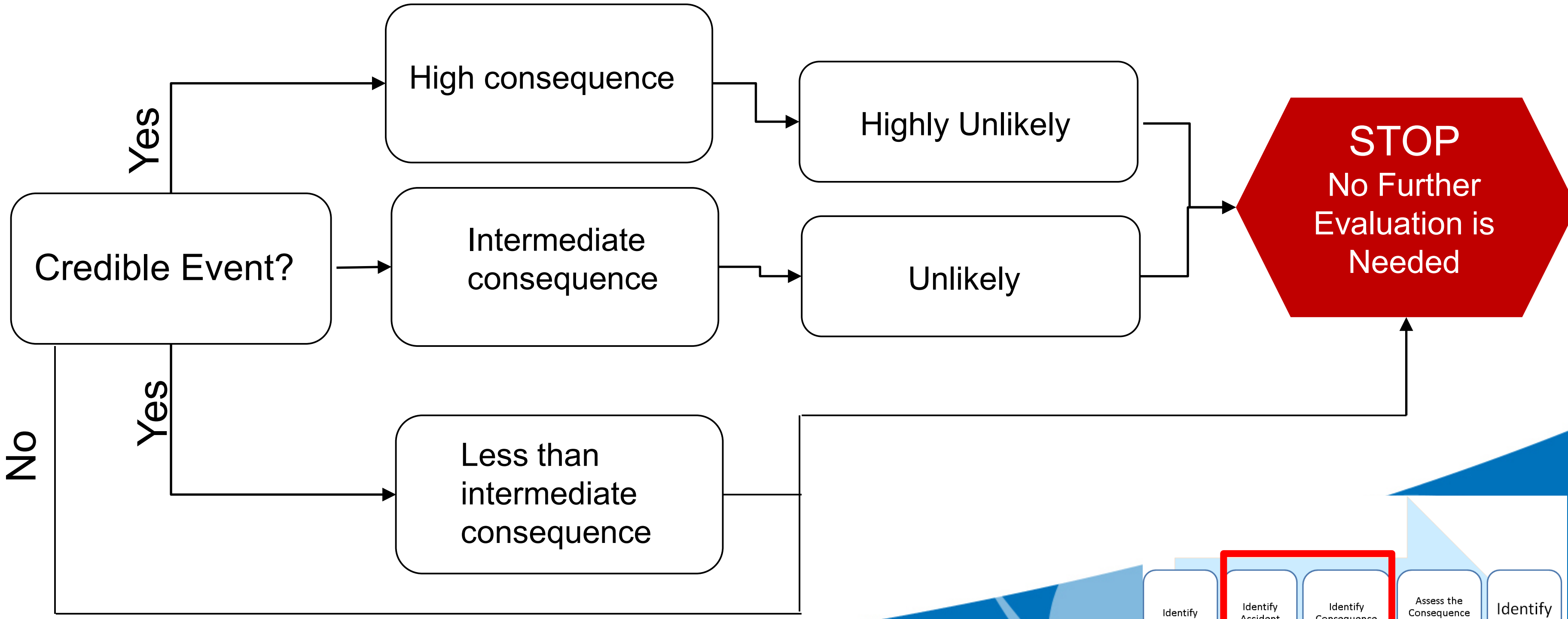
ISA Process

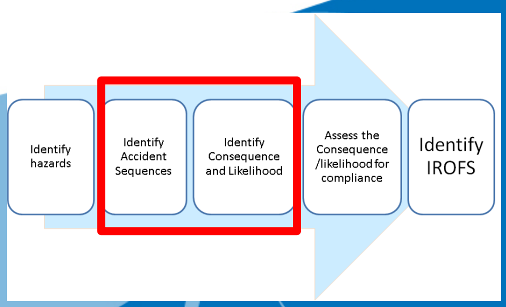


Identify hazards
Identify Accident Sequences
Identify Consequence and Likelihood
Assess the Consequence /likelihood for compliance
Identify IROFS

ISA Process

- 10 CFR 70.61 Performance Requirements





NRC Review of Chemical Safety

- Overview:
  - Review of Chemical Hazards and Accident Consequences
  - Review of Chemical Accident Likelihood
  - Review of Quantitative Standards for Acute Chemical Exposures

NRC Review of Chemical Safety

- Review of Chemical Hazards and Accident Consequences
  - Description and nature of chemical hazards
    - Concentration, release point, receptor location, processes involved.
    - Vessel size, pressure, ventilation, building characteristics, meteorology, duration.
  - Assessment of the consequences
  - Credible scenarios identified in the ISA
    - Normal and abnormal conditions.

NRC Review of Chemical Safety

- Review of Chemical Accident Likelihood
  - High consequence events must be highly unlikely.
  - Intermediate consequence events must be unlikely.
- Quantitative Standards for chemical consequences
  - When is a standard necessary?
  - Consideration of physical and chemical properties.
  - No toxicity or animal testing needed.

NRC Review of Quantitative Standards

- The quantitative standards serve to identify the event consequence categories for the ISA.
- When evaluating standards, NRC reviews the and expects a reasonable estimate of the consequences
- Publicly available, useful sources identified
  - AEGLs, ERPGs, TEELs and others.
  - Globally Harmonized System of Classification and Labelling of Chemicals (GHS): Hazard Statements.
  - NIOSH Skin Notations for dermal exposures.

Table 1 – Acute Exposure Hazard Information for Common Fuel Cycle Process Chemicals[6]

Chemical	GHS Hazard Statement in GHS database[7] (Inhalation, dermal, ocular, ingestion exposure)	NIOSH skin notation[8]	Noted by OSHA list for skin adsorption[9]	AEGL; ERPG[10]; TEEL (Inhalation exposure)
ammonium hydroxide (NH_4OH)	H314 1B (causes severe skin burns and eye damage) H335 (may cause respiratory irritation): C≥ 5 %	No	No	Yes
ammonium fluoride (NH_4F)	H301 (toxic if swallowed) H311 (toxic in contact with skin) H331 (toxic if inhaled)	No	No	No
hydrochloric acid (HCl)	H314 1B (causes severe skin burns and eye damage): C ≥ 25% for 1 hour exposure H335 (may cause respiratory irritation): C ≥ 10 %	No	No	Yes
hydrofluoric acid (HF)	**H300 (fatal if swallowed)** **H310 (fatal in contact with skin)** H314 (causes severe skin burns and eye damage): C ≥ 7% for 3 minute exposure; 1% ≤ C < 7% for 1 hour exposure **H330 (fatal if inhaled)**	SK: **SYS (FATAL)**-DIR (COR): **may be potentially lethal or life-threatening following exposure of the skin**; corrosive following exposure of the skin	Yes	Yes
hydrogen peroxide (H_2O_2)	H302 (harmful if swallowed) H314 (causes severe skin burns and eye damage): C ≥ 70% for 3 minute exposure; 50% ≤ C < 70% for 1 hour exposure H322 (harmful of inhaled) H335 (may cause respiratory irritation) C ≥ 35%	No	No	Yes
nitric acid (HNO_3)	H314 (causes severe skin burns and eye damage): C ≥ 20% for 3 minute exposure; 5% ≤ C < 20% for 1 hour exposure	No	No	Yes
perchloroethylene (C_2CL_4)	H315 (causes skin irritation)	No	No	Yes
sodium hydroxide (NaOH)	H314 (causes severe skin burns and eye damage): C ≥ 5% for 3 minute exposure; 2% ≤ C < 5% for 1 hour exp.	SK: DIR (COR), corrosive following exposure of the skin	No	Yes
sulfuric acid (H_2SO_4)	H314 (causes severe skin burns and eye damage): C ≥ 15% for 3 minute exposure	No	No	Yes
Tributyl phosphate ($(CH_3CH_2CH_2CH_2O)_3PO$)	H302 (harmful if swallowed) H315 (causes skin irritation)	No	No	Yes
uranyl nitrate ($UO_2(NO_3)_2$)	**H300 (fatal if swallowed)** **H330 (fatal if inhaled)**	No	No	Yes

Note: Exposure to chemicals with hazard or skin notation statements in bold would generally be considered a high consequence event in the context of an ISA. Exposure to chemicals with a hazard or skin notation statement that is underlined would generally be considered an intermediate consequence even in the context of an ISA. Skin Corr 1A is for exposure less than 3 minutes. Skin Corr 1B is for exposure less than 1 hour.

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6 The user should verify that current information is used because the sources identified in Table 1 are occasionally revised.

7 GHS information source: http://www.dguv.de/ifa/Gefahrstoffdatenbanken/GESTIS-Stoffdatenbank/index-2.jsp

8 NIOSH skin notation profiles: http://www.cdc.gov/niosh/topics/skin/skin-notation_profiles.html

9 Table A-1 of OSHA Technical Manual Section II, Chapter 2: https://www.osha.gov/dts/osta/otm/otm_ii/otm_ii_2.html

10 The AEGL and ERPG levels were established considering the more vulnerable receptors in the exposed public (elderly, children).

Table 2 – Inhalation Exposure description and statements related to the performance requirements in 70.61

	Description in 70.61	Description in AEGL[13]	Description in ERPG[14]	Description in GHS Hazard Statements
High Consequences	Could endanger the life of a worker	**AEGL-3** is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.	**ERPG-3** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.	H330 Fatal if inhaled
	Could lead to irreversible or other serious, long-lasting health effects to any individual located outside the controlled area	**AEGL-2** is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.	**ERPG-2** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.	H331 Toxic if inhaled
Intermediate Consequences	Could lead to irreversible or other serious, long-lasting health effects to a worker	**AEGL-2** is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.	**ERPG-2** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.	H331 Toxic if inhaled
	Could cause mild transient health effects to any individual located outside the controlled area	**AEGL-1** is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.	**ERPG-1** is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.	H332 Harmful if inhaled

Conclusion

- The NRC regulations use risk informed performance standards. Assessment of compliance with the performance standards requires a thorough identification of credible hazards.
- New hazards may be introduced as the result of the introduction of new technology and/or new processes.
- The NRC recognizes that new technology and processes may introduce new hazards and it is important that regulators and operators maintain the safety mindset and conduct thorough analysis and review of the new hazards.

Marilyn Diaz
U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of Fuel Cycle Safety and Safeguards, and Environmental Review
Marilyn.Diaz@nrc.gov
301-415-7110

Questions?

Key Terms

- CFR – *Code of Federal Regulations*
- ISA – integrated safety analysis
- IROFS – items relied on for safety
- UF6 – Uranium hexafluoride
- HF – Hydrogen Fluoride
- Subpart H - ISA requirements
- AEGL – Acute Exposure Guideline Levels
- ERPG – Emergency Response Planning Guidelines
- TEEL – Temporary Emergency Exposure Limits

Key Terms

- NIOSH – The National Institute for Occupational Safety and Health
- OSHA – Occupational Safety and Health Administration
- FCF – Fuel Cycle Facilities