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Credible Accident Sequences in NCS

NCSD Panel Session

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THE VALUE OF NUCLEAR
Minneapolis, MN, USA
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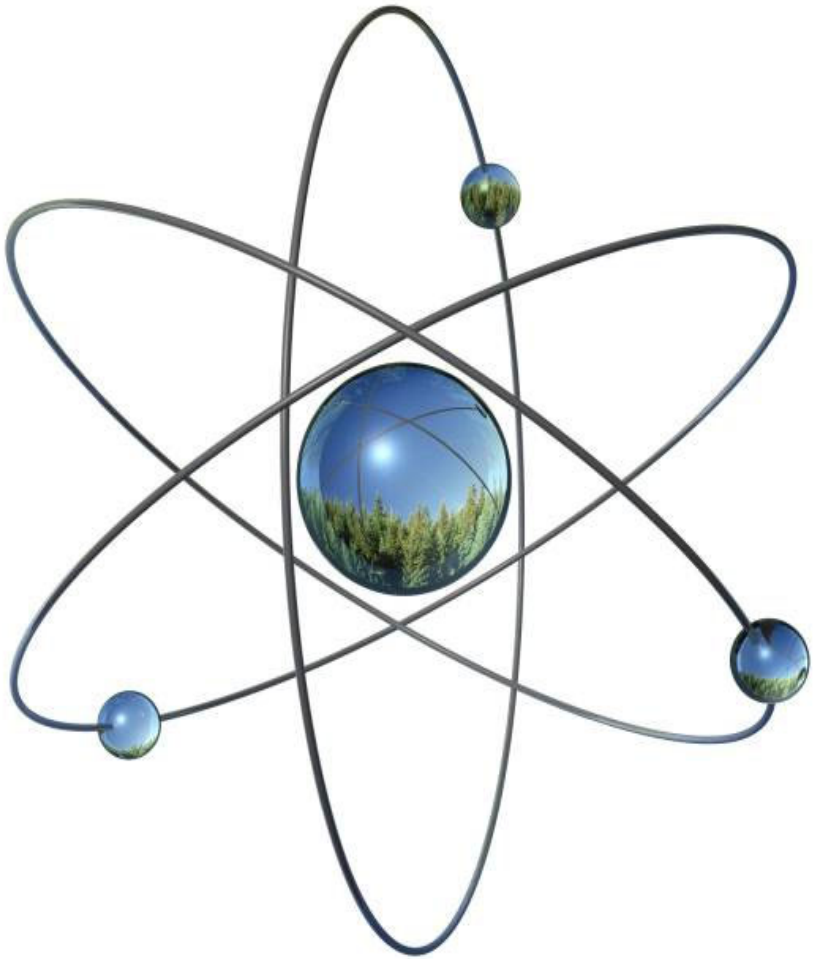

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Agenda

- Two classes of NCS hazards
- Regulations
- Standards
- Guidance
- GNFA ISA Process
- Practical Examples
- Summary

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NCS Accident Sequences

When evaluating nuclear criticality safety hazards in fissionable material operations outside reactors one may postulate there are two general classifications:

Credible **nuclear criticality safety accident sequence which pose a *real risk* of an inadvertent criticality in the absence of controls.**

Or

Not Credible **nuclear criticality safety accident sequence which in the absence of controls is judged to not pose a real risk or the accident sequence is determined to be *highly unlikely*.**

Risk: Measure of the likelihood of a consequence with a certain severity

- Risk = Consequence Severity × Likelihood

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Regulations

Underlying NRC Requirements

10 CFR 70 Subpart H: Additional Requirements for Certain Licensees Authorized to Possess a Critical Mass of Special Nuclear Material

§ 70.61: Performance Requirements

§ 70.62: Safety Program & Integrated Safety Analysis

§ 70.64: Requirements for New Facilities or New Processes at Existing Facilities

§ 70.65: Additional Content of Applications

§ 70.72: Facility Changes & Change Process

§ 70.74: Additional Reporting Requirements

Applicable NRC Guidance

NUREG-1520: Standard Review Plan for Fuel Cycle Facility License Applications

NUREG-1513: Integrated Safety Analysis Guidance Document

NUREG-6410: Nuclear Fuel Cycle Facility Accident Analysis Handbook

FCSS-ISG-12: 10CFR Part 70, Appendix A - Reportable Safety Events

FCSS-ISG-14: Acute Uranium Exposure Standards for Workers

FCSS-ISG-15: Natural Phenomena Hazards in Fuel Cycle Facilities

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Regulations

§ 70.61 Performance requirements.

(b) The risk of each **credible** high-consequence **event** must be limited. Engineered controls, administrative controls, or both, shall be applied to the extent needed to reduce the likelihood of occurrence of the event so that, upon implementation of such controls, the event is highly unlikely or its consequences are less severe than those in paragraphs (b)(1)-(4) of this section. High consequence events are those internally or externally initiated events . . .

(d) Preventive controls must be applied to **limit the risk of criticality** accident

But what is credible. . .?

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Standards

ANSI/ANS-8.1 (2014)

4.2 Technical Practices

Nuclear criticality safety is achieved by controlling one or more parameters of the system within subcritical limits and by allowances for process contingencies. Control may be exercised through…..reliance on a natural or **credible** course of events, such as a process whose nature is to keep the density of uranium oxide less than a specified fraction of theoretical…

4.1.2 Process analysis

Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and **credible** abnormal conditions.

Appendix B.2 The application of PA

The word "**credible**" is not defined in the standard but relies on the judgment of the key professionals involved (nuclear criticality safety staff, operations supervisors, etc.) to determine the credible abnormal conditions for a particular fissionable material operation. The abnormal conditions that are deemed credible can differ from process to process and from site to site. Elimination of all risk is not possible; the goal is to ensure an acceptably low level of risk to workers and the public.

B.2 is very insightful…but again, what is credible…?

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Guidance

NUREG-1520 (rev. 2, 2015)

3.4.3.2, Integrated Safety Analysis Summary and Documentation

(9) Definitions of “Unlikely,” “Highly Unlikely,” and “Credible.”

The regulation in 10 CFR 70.65 requires that the applicant’s ISA Summary must define the terms “unlikely,” “highly unlikely,” and **“credible**.” The applicant’s definitions of these terms are acceptable if, when used with the applicant’s method of assessing likelihoods, they provide reasonable assurance that the performance requirements of 10 CFR 70.61 can be met.

As stated in 10 CFR 70.61, **credible** high-consequence events must be “highly unlikely.”

The regulation in 10 CFR 70.65 requires that the applicant define the term **“credible.”** This term is used in 10 CFR 70.61, which requires that all credible accident sequences for which the consequences could exceed the performance requirements of 10 CFR 70.61 must be controlled to be unlikely or highly unlikely, as appropriate. If an event is not credible, IROFS are not required to prevent or mitigate the event.

Guidance *expectations* are put forth for each licensee to define “credible”…

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Guidance

NUREG-1520 (rev. 2, 2015) –cont'd.

In the safety program embodied in Subpart H to 10 CFR Part 70, the "not credible" nature of an event must not depend on any facility feature that could credibly fail to function or be rendered ineffective as a result of a change to the system. Each facility feature that is needed to ensure that accident events are sufficiently unlikely is an IROFS. Management measures must offer high assurance, that such features are not removed or rendered ineffective during system changes.

….although an accident sequence may not meet a definition of "not credible," it may meet the standards for "highly unlikely" or "unlikely" because of an infrequent external initiating event, without the use of IROFS. In such a case, IROFS are not necessary, but information is needed to show that the event does qualify as "highly unlikely" or "unlikely."

Confused yet on definition of credible? Fortunately, there is an out….

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Guidance

NUREG-1520 (rev. 2, 2015) –cont'd.

Any one of the following three independent acceptable sets of qualities could define an event as **not credible:**

1) An external event for which the frequency of occurrence can conservatively be estimated as less than once in a million years.
2) A process deviation that consists of a sequence of many unlikely events or errors for which there is no reason or motive. In determining that there is no reason for such errors, a wide range of possible motives, short of intent to cause harm, must be considered. Complete ignorance of safe procedures is possible for untrained personnel, which should be considered a credible possibility. Obviously, no sequence of events should be categorized as not credible if it has actually occurred in any fuel cycle facility.
3) A convincing argument exists that, given physical laws, process deviations are not possible, or are extremely unlikely. The validity of the argument must not depend on any feature of the design or materials controlled by the facility's system of IROFS or management measures.

Per SNM-1097 § 3.3.3: …..When conducting the process hazard analysis, the ISA team considers each accident sequence as credible, unless it can be determined to be not credible. Accident sequences that do not meet the definition of *not credible* are therefore considered *credible* and treated in accordance with 10 CFR 70.61.

If all else fails…. define "not credible"…

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GNFA ISA Process

Integrated Safety Analysis, or ISA, is a process used to evaluate hazards and accident sequence so the risk can be limited to an acceptable level

The ISA is focused on the hazards associated with NRC licensed material and *"hazardous chemicals produced from licensed material"* (i.e., Uranium and HF produced from UF_6)

Hazards of concern in ISA include:

- Criticality *(Radiological Hazard)*
- Uranium Inhalation *(Radiological Hazard)*
- Soluble Uranium Inhalation *(Chemical Hazard)*
- HF Inhalation *(Chemical Hazard)*
- Dermal/Ocular Exposure to HF *(Chemical Hazard)*

Fire or Explosion could also initiate these hazards of concern

GNFA ISA Process

At GNFA, the ISA has the following two distinct parts:

1) Process Hazard Analysis

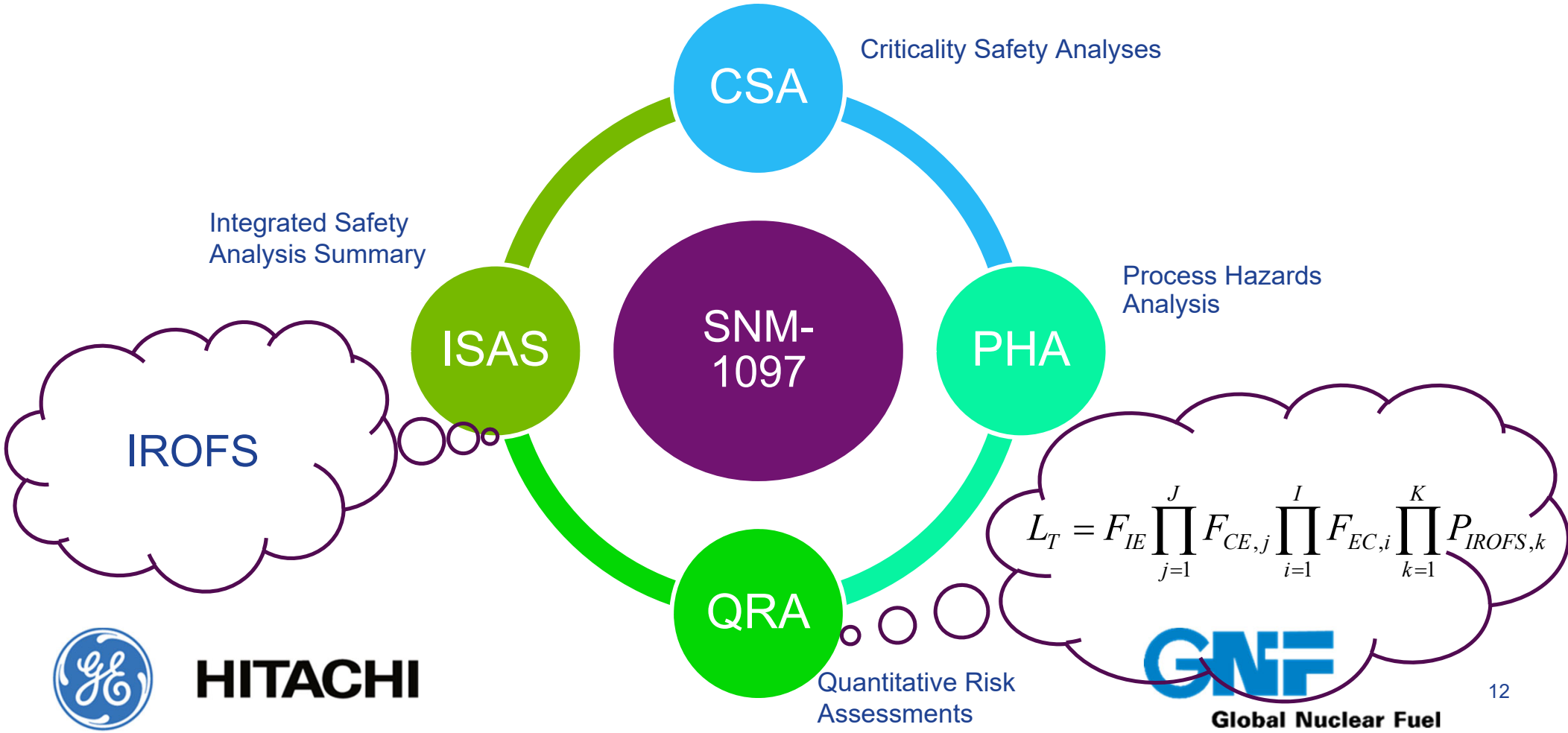
- Performed by an ISA Team for each process to identify potential accident sequences
- Does not credit safety controls that could prevent or mitigate an accident sequence
- Events are assigned a hazard consequence, severity, likelihood, and risk
- Used to identify unmitigated events that have an “unacceptable” risk

2) Quantitative Risk Assessment

- Evaluates the overall likelihood of “unacceptable” risk accident sequences from the PHA with controls applied to prevent or mitigate the accident consequence
- Credited controls are designated as Items Relied on For Safety (IROFS)
- Sufficient IROFS must be applied to make the mitigated risk “acceptable”
- Management Measures are selected for each IROFS to ensure the control(s) remain available and reliable to perform its intended safety function

GNFA ISA Process

- Commensurate with the SNM-1097 consolidated license application, an integrated safety analysis summary (ISAS) is required to demonstrate that each credible criticality accident sequence ("high consequence event") remains *highly unlikely* pursuant 10CFR70.



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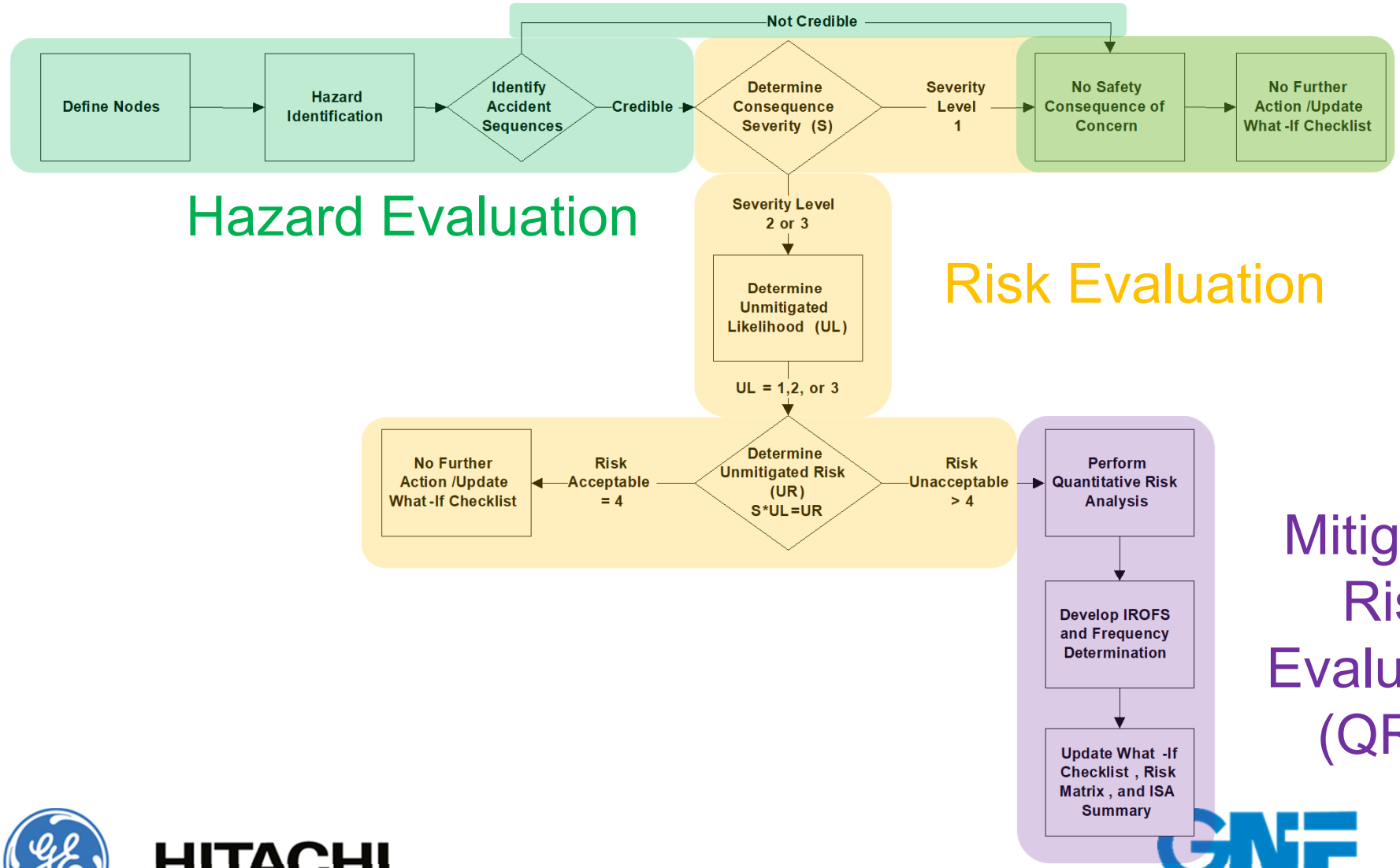
GNFA ISA Process (Cont'd.)

ISA Process Flow Diagram



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Practical Example(s)

PHA #2081.3 – Uranium Accumulates in Floor Scrubber / Sink

The initiating event is defined as accumulation of an unsafe mass of uranium (e.g., > 31.6 kg UO_2 at 5% enrichment corresponding to a 12-inch reflected sphere of homogeneous UO_2 and water mixture). ➔ Judged not credible per 3.3.3(2)

2081.3	**Accumulation of uranium in floor scrubber due to HU error.** 	**Potential criticality concern if sufficient uranium mass concurrently moderated.**	**No credible cause identified; no means to accumulate kg quantities from contamination removal from floor.**

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Practical Example(s)

PHA #2081.1 – High Moisture in N2 Utility Supply to MRA Processes

The initiating event is defined as high moderator content in gaseous N2 utility supplied to MRA process equipment ➔ Judged not credible per 3.3.3(2)

2081.1	**High moisture in N2 supply system; due to HU error.**	**Potential criticality concern high moisture content N2 fed to reactor-kiln, powder outlet, blender, homogenizer and sufficient uranium is concurrently moderated.**	**No credible cause identified to have high moisture in pressurized nitrogen header.**

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Practical Example(s)

PHA #2081.4 – Uranium Accumulates in HVAC Floor Trenches

The initiating event is defined as accumulation of an unsafe mass of uranium (e.g., > 31.6 kg UO2 at 5% enrichment) in an MRA HVAC floor trench and is concurrently moderated.

➔ Judged not credible per 3.3.3(2)

2081.4	**Accumulation of uranium in floor trenches due to equipment failure.**	**cause o means to kg quantities currently covered MRA.**

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Summary

- The word “credible” is not defined in ANSI/ANS-8.1 standard as “it relies on the judgment of the key professionals involved (nuclear criticality safety staff, operations supervisors, etc.) to determine the credible abnormal conditions for a particular fissionable material operation”.

- *Judgement* of key professionals is directly proportional to the process understanding and experience of qualified NCS staff.

- GNFA SNM-1097 permits either quantitative reasoning to define postulated criticality accident sequences as “highly unlikely” or qualitative arguments to justify an accident sequences is “not credible” using NUREG-1520 criteria.

- NCS practitioners are encouraged to revisit credible accident sequences. Careful review can result in elimination of unnecessary controls [IROFS]. This permits more focus on NCS accident sequences that matter.