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Subject: Industry Guidance Document on Preparation of an ISA Summary

Attached is a revision of the Industry Guidance Document on Preparation of an ISA Summary. This document has been revised to address improvements suggested by the NRC staff and by NEI's industry members.

The more significant changes include:

- (1) use of the terms "mitigation" and "mitigative" has been corrected to correspond to industry usage
- (2) Chapter 5 ('Risk Assessment Methodology') has been revised by transferring information specific to the "Index Method" to Appendix A. This reduces the prescriptiveness of the guidance.
- (3) additional explanatory footnotes, including definitions of terms, have been added
- (4) discussion of "failure limits" has been omitted. Failure limits do not give an indication of risk, safety or safety margin. The safety of operations in which reactivity is calculated is based on an understanding of "safety margins" provided by the controlled parameters (e.g. mass, moderation) or the sensitivity of K-eff to changes in controlled parameters. The NRC has previously recognized this and realizes that the approach appropriately shifts the focus from an arbitrary K-eff value as an indication of available safety margin to an understanding of what changes in controlled parameters do to the safety of the system. In addition, not all licensees are required to calculate failure limits.
- (4) NUREG-1520 citations in Table 1 have been adjusted to correspond with the proposed revisions to SRP Chapter 3 that industry is developing. Industry's proposed revision to NUREG-1520 Chapter 3 will be sent to you later this week.

Best Regards,
Clifton

<<ISA Guidance (Rev.Nov).doc>>

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DRAFT

**INDUSTRY GUIDANCE
DOCUMENT
ON PREPARATION OF AN
ISA SUMMARY**



NUCLEAR ENERGY INSTITUTE

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INDUSTRY GUIDANCE DOCUMENT ON PREPARATION OF AN ISA SUMMARY

1. INTRODUCTION

1.1 Purpose of the Industry Guidance

The *Industry Guidance Document on Preparation of an ISA Summary* will assist an applicant for a new license or for amendment or renewal of an existing license, in the preparation of an Integrated Safety Analysis Summary (ISA Summary). It will also assist existing licensees who are required to conduct an ISA and submit an ISA Summary for NRC approval by October 18, 2004. This industry guidance document addresses the format, structure and content of an ISA Summary that is consistent with the requirements of 10 CFR 70. Adoption of this guidance will provide consistency in the content, style and completeness of applications submitted to the NRC and should, therefore, facilitate and expedite NRC staff reviews.

1.2 Overview of an ISA Summary

The ISA Summary is a document that is prepared after the facility or process ISA is completed. The applicant may prepare and submit to the NRC either one single ISA Summary for the entire facility or multiple ISA Summaries, for example, for each process or groups of processes. Each ISA Summary must be approved by the NRC through issuance of a Safety Evaluation Report (SER). The ISA Summary is submitted with an applicant's license application for placement on the NRC public docket. Neither the ISA nor the ISA Summary are, however, incorporated as part of the license. Together with the ISA, process safety information and other ISA supporting documentation, the ISA Summary must be maintained accurate by the licensee to serve as an up-to-date reference source on the facility's safety bases. The ISA Summary provides information on how the ISA was conducted (methodology, approach, investigators), identifies high-and intermediate-consequence accident sequences whose outcomes could exceed the performance requirements of 10 CFR 70.61 and provides information on items relied on for safety (IROFS) and corresponding management measures proposed to prevent or mitigate such accident sequences.

1.3 Relation of Industry Guidance to NUREG-1520

A licensee (or license applicant) must prepare a summary of the facility ISA in accordance with the requirements of 10 CFR 70.65. Chapter 3 of NUREG-1520 (*Standard Review Plan for the Review of a License Application for a Fuel Cycle*

Facility) provides guidance on the content of an ISA Summary and acceptance criteria for the staff to evaluate its adequacy and acceptability.

The SRP Acceptance Criteria do not, however, represent the only means of satisfying the regulatory requirements and objectives. A license application may differ from the design approaches and acceptance criteria of NUREG-1520, but the applicant should, in such cases, explain how the applicant's submission will satisfy the 10 CFR 70 regulatory requirements.

1.4 Risk Assessment Methodology

NUREG-1520 permits an applicant to use any risk assessment method that provides a robust and comprehensive evaluation of facility risks and that demonstrates an adequate safety margin of the operation. The *Industry Guidance Document on Preparation of an ISA Summary* presents one method to perform a qualitative evaluation of the risk of credible accident sequences. Other methods that the applicant may select for qualitative or qualitative risk evaluation may also be acceptable. The effectiveness of designated IROFS is incorporated into this qualitative risk evaluation to decide if the designated IROFS and supporting management measures are adequate in number and type to meet the regulatory performance requirements of 10 CFR 70.61.

Part 70 regulations permit the applicant to apply 'safety grading' to the facility's safety program. Management measures may, for example, be applied to IROFS commensurate with the reduction in risk attributable to the IROFS (or system of IROFS). The decision whether or not to apply safety grading rests solely with the license applicant (or licensee).

1.5 Cross-Referencing of Information for the ISA Summary

An ISA Summary prepared in accordance with the methodology and guidance contained in this document should meet the requirements of 10 CFR 70.65 and be acceptable to the NRC. For clarity and simplicity, information required in the ISA Summary that has been included in the license application in fulfillment of other chapters of NUREG-1520 (e.g. facility description, safety program outlines, organization and management structure) may be cross-referenced in the ISA Summary.

Information at an appropriate level of detail from the facility ISA should be incorporated into the ISA Summary to enable the NRC to conduct its review without a need for multiple Requests for Additional Information (RAIs). Rather than reproducing voluminous detailed information in the ISA Summary, the applicant should refer the reviewer to sources of information maintained at the facility, such as the ISA and its supporting analyses and databases.

1.6 Approval of the ISA Summary

Staff review of the ISA Summary is undertaken to confirm that an ISA of appropriate complexity and detail has been conducted for the facility. The review will ensure that the applicant has addressed each topic listed in 10 CFR 70.65(b), including, for example, general facility information, descriptions of analyzed processes, ISA methodologies, individuals who performed the ISA and safety controls that are designated to be IROFS. Although the NRC does not review or approve the applicant's ISA, by reviewing the ISA Summary the staff will be indirectly assessing the adequacy of the ISA. Areas of technical review for the ISA Summary will include examination of hazard analyses, internal and external initiating events, accident sequences, accident risk assessment and ranking, and the designation and safety-grading (if applicable) of IROFS and their complementary management measures. The review will also confirm that commitments made by the applicant to keep the ISA and ISA Summary current and accurate are acceptable.

Review of the ISA Summary will likely require consultation of the ISA and ISA supporting documentation (e.g. piping and instrumentation diagrams, criticality safety analyses, dose modeling calculations, process safety information and ISA worksheets, etc.). Such information is not submitted to the NRC, but rather is maintained by the applicant or kept by the licensee at the facility. Reviews of this supporting information are needed to establish the completeness and acceptability of the ISA and, for example, to confirm that low-risk accident sequences not reported in the ISA Summary were correctly identified and analyzed in the ISA. Visits to operating facilities may prove useful to the staff to fully understand a process operation.

1.7 Summary Introductory Comments

This guidance document describes one approach to prepare an ISA Summary to adequately establish the safety bases of the facility and to provide reasonable assurance that the facility operations will meet the regulatory performance requirements of 10 CFR 70.61. It complements NUREG-1520 and the two documents should be used in concert to conduct the ISA and to prepare the ISA Summary. It does not, however, substitute for regulations and compliance with its contents is not required. Alternate methods and solutions different from those set out in this guidance should be acceptable, if they provide a robust and rigorous basis for compliance with the requisite regulations.

2. NRC USE OF THE ISA SUMMARY

The ISA Summary constitutes the primary source of information the NRC staff will use in evaluating a license application. It is a succinct synopsis of the results of the ISA and focuses on the higher risk, more safety-significant facility accidents that could pose a greater risk to workers, the public and the environment. The ISA Summary must provide sufficient information to the NRC staff to conduct their review and to answer the following questions:

- was the ISA conducted adequately (e.g. correct application of the selected ISA methodology, all facility processes identified, safety-significant hazards characterized for those processes, all credible accident sequences identified and evaluated, etc.)?
- did the process hazard analyses and risk assessments correctly identify high- and intermediate-consequence accident sequences as defined by 10 CFR 70.61? Were the accident consequences (e.g. doses, chemical exposures, nuclear criticalities) and likelihoods correctly determined?
- were adequate safety controls (IROFS) designated so that:
 - (i) credible high-consequence events are highly unlikely, and
 - (ii) credible intermediate-consequence events are unlikely?
- were management measures identified for each IROFS to provide reasonable assurance of its availability and reliability when needed?
- if safety grading was applied by the applicant (or licensee) to IROFS and management measures, is the grading method acceptable and was it applied correctly?

To answer these questions and establish a level of confidence in the ISA, the NRC staff will examine facility hazards, accident sequences, accident sequence risk assessments and comparative risks, designated IROFS and management measures. As the ISA Summary presents only a sub-set of the total number of facility hazards and accident sequences identified and analyzed in the ISA, staff review may extend to examination of low-consequence accidents and supporting documentation (e.g. nuclear criticality evaluations, radiation exposure dose modeling, etc.) to ensure that the identification and evaluation of accident sequence risks was correctly performed.

3. REGULATORY REQUIREMENTS FOR THE ISA SUMMARY

Regulatory requirements for the content of the ISA Summary are presented in 10 CFR 70.65(b). Information to be included in the ISA Summary can be divided into three categories: (i) information of a general nature, (ii) process-specific information, and (iii) IROFS and their supporting management measures. Information requirements for each category, the corresponding regulatory citation and the section of NUREG-1520 Chapter 3 in which the NRC expectations for such information (primarily for the ISA) are presented are all summarized in Table 1.

TABLE 1: INFORMATION REQUIREMENTS FOR THE ISA SUMMARY AND CORRESPONDING REGULATORY AND NUREG-1520 CITATIONS

<u>Information Category and Requirement</u>	<u>10 CFR 70 Regulatory Citation</u>	<u>NUREG-1520 Chapter 3 Reference</u>
<u>General Information:</u>		
• site description	70.65(b)(1)	§3.4.3.2(2)(ii)
• facility description	70.65(b)(2)	§3.4.3.2(2)(i)
• ISA methodology description	70.65(b)(5)	§3.4.3.2(2)(iii)
• ISA team description	70.65(b)(5)	§3.4.3.2(2)(iv)
• quantitative standards for acute chemical exposures	70.65(b)(7)	§3.4.3.2(2)(v)
• definition of terms	70.65(b)(9)	§3.4.3.2(2)(vi)
• compliance with baseline design criteria and criticality monitoring and alarms	70.64 (if applicable) & 70.65(b)(4)	§3.4.3.2(2)(viii) if applicable & §3.4.3.2(2)(ix)
<u>Process-Specific Information:</u>		
• description of processes analyzed	70.65(b)(3)	§3.4.3.2(3)(i)
• identification of hazards	70.65(b)(3)	§3.4.3.2(2)(vii)
• general types of accident sequences	70.65(b)(3)	§3.4.3.2(3)(ii)
• risk ranking (typically into three tiers)	70.65(b)(3)	§3.4.3.2(3)(iii)
• characterization of intermediate- and high-risk accident sequences	70.65(b)(3)	§3.4.3.2(3)(iii)
<u>Items Relied on For Safety:</u>		
• list and description of IROFS at the systems level	§70.65(b)(6)	§3.4.3.2(4)(i)
• IROFS management measures	§70.65(b)(4)	§3.4.3.2(4)(iii)
• sole IROFS	§70.65(b)(8)	§3.4.3.2(4)(ii)

4. FORMAT AND CONTENT OF THE ISA SUMMARY

4.1 Content Overview

The ISA Summary should address the information requirements listed in Table 1. Detailed operating procedures, program descriptions or information on facility operation management are not required in the ISA Summary. The ISA Summary may also contain licensee commitments, such as those to maintain the ISA Summary accurate and up-to-date, or to report changes to the ISA Summary to the NRC in accordance with the 10 CFR 70.72(d) reporting requirements. These and other commitments are best included in Section 1 of the ISA Summary.

4.2 ISA Summary Structure

The ISA Summary can logically be structured into three sections entitled: '*General Information*', '*Process-Specific Information*' and '*Items Relied on For Safety*'. The general types of information that should be discussed in each section are summarized below. The detailed information that should be included in each section is presented in Chapter 6.

4.2.1 ISA Summary Section 1: General Information

Information applicable to the facility and site and all processes analyzed in the ISA should be presented in this section. It should include the following:

- ✓ facility and site descriptions
- ✓ ISA methodology description
- ✓ ISA team composition and member qualifications
- ✓ quantitative standards selected for acute chemical exposure
- ✓ definitions of unlikely, highly unlikely, and credible
- ✓ typical hazards analyzed for the facility, including chemical hazards
- ✓ if applicable, statement that there are no IROFS solely relied on for safety
- ✓ compliance with criticality monitoring and alarms (10 CFR 70.24)
- ✓ compliance, if applicable, with baseline design criteria (10 CFR 70.64)
- ✓ applicant (or licensee) commitments

4.2.2 ISA Summary Section 2: Process-Specific Information

Information in this section will include a summary of risk and safety assessments performed for each process analyzed in the ISA. Information should include:

- ✓ processes analyzed

- ✓ process hazards identified
- ✓ general types of accident sequences
- ✓ identification and characterization of intermediate- and high-consequence accident sequences

4.2.3 ISA Summary Section 3: Items Relied on For Safety Information

Information in this section includes lists and descriptions of IROFS designated in the ISA:

- ✓ description of designated IROFS for high- and intermediate-consequence accident sequences
- ✓ risk assessment of accident sequences after application of IROFS and demonstration of compliance with 10 CFR 70.61 performance requirements
- ✓ IROFS for accident sequences that are the sole item preventing or mitigating a high- or intermediate-consequence accident sequence
- ✓ description of management measures supporting each IROFS

5. RISK ASSESSMENT METHODOLOGY

5.1 Risk Assessment

The heart of the ISA is the risk assessment that is performed on process and facility accident sequences. Results of the risk assessment are used to rank the comparative risks of different accident sequences (or initiating events for one accident sequence) and to establish the need for compensating safety controls, or IROFS, to prevent the accident or to mitigate its consequences to an acceptable level.

The ISA Summary must describe and justify the appropriateness of the risk assessment methodology used in performing the ISA. The ISA Summary must convey that the risk analysis provides reasonable assurance that high-consequence accident sequences will be highly unlikely and that intermediate-consequence accident sequences will be unlikely.

5.2 Methodology Overview

Selection of a risk assessment methodology remains the prerogative of the applicant (or licensee). Aspects of the selected methodology that the NRC staff will closely examine are:

- hazard identification method
- Process Hazard Analysis (PHA) method (including definition of accident sequences)
- analysis of accident consequences
- analysis of accident likelihoods
- risk assessment and designation of IROFS and management measures
- if applicable, safety grading of IROFS and their management measures

Any robust method that uses objective criteria to document and comprehensively assess the risks of the facility and its operations and to identify appropriate IROFS and supporting management measures should be acceptable. Appendix A presents one such method that uses an matrix index approach to perform a qualitative evaluation of the risks of credible accident sequences.

6. DETAILED CONTENT OF THE ISA SUMMARY

This chapter provides guidance on what detailed information should be included in each of the three sections of the ISA Summary. The ISA Summary should not contain detailed procedures or in-depth technical information; such detailed information is available for inspection at the facility either in the ISA or in the supporting ISA analyses and documentation.

6.1 ISA Summary Section 1: General Information

- ✓ Facility Description: information should be included on facility features that could affect potential accidents and the reliability and availability of IROFS. Examples include: facility location, facility design, the location and arrangement of buildings and the distance from the site boundary to the nearest residents. The facility description can reference and build upon information provided in Chapter 1 of the license application (NUREG-1520, Chapter 1, *General Information*).
- ✓ Site Description: information on factors that could affect facility safety, such as natural phenomena, transport corridors and nearby industrial operations, should be described. The geographical setting, regional demographic information and susceptibility to natural phenomena including meteorology (e.g. high winds, tornadoes), flood potential (e.g. 100 year flood potential based on U.S. Army Corps of Engineers flood plain maps) and seismology (e.g. maximum earthquake magnitude, peak ground acceleration and return period expected at the site) should be detailed. Characterization of natural phenomena should identify all design basis natural events, identify which events are considered 'incredible' and which could occur without adversely affecting safety. The site description can reference and build upon the general information provided in Chapter 1 of the license application (NUREG-1520, Chapter 1, *General Information*).
- ✓ ISA method(s): a summary of the method(s) and analytical techniques used to conduct the ISA for each facility process should be presented. For each ISA method the following information should be provided:

Hazard Identification: description of the criteria to identify hazards, including a list of hazardous materials^{1,2} (flammable, toxic, fissile,

¹ Hazardous materials that should be included in the inventory, if present on-site, are: ammonia, fines (UO₂ dust, beryllium), flammable liquids and gases, fluorine, hydrofluoric acid, hydrogen, nitric acid, organic solvents, propane, uranium hexafluoride and Zircalloy.

² Hazardous chemicals are of regulatory concern to the NRC only to the extent that they are incident to the processing of licensed nuclear material or have the potential for adversely affecting radiological safety (see the October 31, 1988 *Memorandum of Understanding between the NRC*

radioactive) and conditions that could result in hazardous situations (e.g. loss of containment) and potential interactions of such hazardous materials

Process Hazard Analysis Method: a description of the methods to evaluate all identified hazards (and their potential interactions), identify all safety-significant, credible accident sequences³, consider all modes of operation (startup, normal operation, shutdown, maintenance), examine hazards resulting from process deviations and credible initiating events external and internal to the facility (including human errors), and consider common mode failures and system interactions for systems protected by double contingency. If analysis methods described in NUREG-1513 (*ISA Integrated Safety Analysis Guidance Document*) were used, only reference need be made to those that were chosen. Detailed method descriptions are not required in this case.

Consequence Analysis Method: a description of the method used to assess and classify the consequences of an accident sequence with reference to the classification criteria of 10 CFR 70.61. The methods should be consistent with the approaches described in NUREG/CR-6410 (*Nuclear Fuel Cycle Facility Accident Analysis Handbook* (March 1998)).

Likelihood Analysis Method: a description of how the likelihood of an accident sequence is classified to be 'unlikely', 'highly unlikely' or neither of the above. The methodology should invoke objective criteria including assessment of the preventive or mitigative features of IROFS that take into account factors such as redundancy, independence and the type of safety control (engineered or administrative) designated for the sequence.

and Occupational Health and Safety Administration (OSHA) which delineates the respective jurisdictional responsibilities of each agency.)

³ The term 'accident sequence' is not defined in 10 CFR 70. For purposes of this Industry Guidance document the following definition has been adopted: "*Accident Sequence refers to an unintended sequence of events, process failures or process deviations caused by an event internal to the facility or by a credible external event (including natural phenomena) that would result in adverse consequences.*" An unintended sequence of events that results in environmental contamination, a radiation exposure, a release of licensed material, an inadvertent nuclear criticality or an exposure to hazardous materials incident to the processing of licensed material constitutes an 'accident sequence'.

If analysis methods described in NUREG-1513 (*ISA Integrated Safety Analysis Guidance Document*) were used, only reference need be made to those that were chosen. Detailed method descriptions are not required in this case.

- ✓ ISA Team: the composition and qualifications of the team(s) that conducted the ISA should be described. The areas of technical expertise of ISA team members (e.g. hazard analysis, process design, radiation safety, etc.) should be stated along with the team's experience and qualifications in conducting ISAs. The applicant should discuss the experience of each team member in process design and relevant safety experience in disciplines relevant to identified process hazards, including, for example, radiation safety, nuclear criticality safety, fire protection and chemical safety.
- ✓ Selection of Quantitative Standards: quantitative standards⁴ used in the ISA to assess consequences from acute chemical exposure to licensed material or hazardous chemicals incident to the processing of licensed material must be identified. The standards should be conservatively selected and be appropriate to the exposure conditions cited in 10 CFR 70.61(b)(4) and (c)(4). Actual values selected for each chemical should be tabulated and the source(s) for each standard should be cited. If an exposure standard is not available for a chemical, the applicant should explain the methodology used to develop a proposed standard and provide supporting scientific and dose modeling data.
- ✓ Definitions of Likelihood Terms: definitions of the following three terms as they are used in the ISA must be included in the ISA Summary: credible, unlikely and highly unlikely.
- ✓ Hazards Analyzed: descriptions of the types of hazards analyzed for each process (including any unique or specific hazards) should be provided. Hazards that could cause an accident whose consequences could exceed the performance requirements of 10 CFR 70.61 should be identified. If the on-site inventories or conditions of storage or use of a hazardous material could not credibly cause an accident exceeding the 10 CFR 70.61 performance requirements, then the hazard can be excluded. Note that the maximum

⁴ Quantitative acute exposure standards such as the *Acute Exposure Guideline Levels* (AEGLE) established by the National Advisory Committee for Acute Guideline Levels for Hazardous Substances and the *Emergency Response Planning Guidelines* (ERPG) established by the American Industrial Hygiene Association are acceptable to the NRC. Data from other organizations such as the Occupational Health and Safety Administration (OSHA), the National Institute for Occupational Safety (NIOSH) and the International Standards Organization (ISO) should also be acceptable.

inventory level used to disqualify the hazardous material from further analysis may itself constitute an IROFS.

- ✓ *IROFS Solely Relied on For Safety*: if there are no '*sole items relied on for safety*' in the ISA, this fact should be acknowledged in this Section 1 of the ISA Summary.
- ✓ *Criticality Monitoring and Alarms*: information and programmatic commitments must be provided, most likely through reference to Chapter 5 of the license application ('*Nuclear Criticality Safety*'), to demonstrate compliance with provisions of 10 CFR 70.24.
- ✓ *Baseline Design Criteria (BDC)*: if the license application is for a new facility or a new process at an existing facility (that requires a license amendment under 10 CFR 70.72), the ISA Summary must document how the BDC of 10 CFR 70.64 were incorporated into the process design. Methods, data and results of analyses showing compliance with the BDC should be given for individual processes and structures.
- ✓ *Applicant/Licensee Commitments*: binding commitments made by the applicant (or licensee) to fulfill the regulatory requirements should be stated.

6.2 ISA Summary Section 2: Process-Specific Information

- (i) *Processes Analyzed*: a tabulation of all processes⁵ analyzed in the ISA should be provided. Processes can be described at the systems level, but must be in sufficient detail to explain the theory of operation, to permit an understanding of hazards and risks of potential accidents and to document how any designated IROFS prevent the process conditions from exceeding the performance requirements of 10 CFR 70.61. Information on the following topics should be provided for each process:

- basic process function and theory of operation
- process design, equipment and instrumentation
- process operating ranges and limits for process variables (e.g. flow, temperature, compositions) that are controlled to ensure safe operation of the process
- function and operation of major process components

⁵ The term 'process' is defined in 10 CFR 70.65(b)(3) to be "*a single, integrated unit operation within an overall production line.*" A process may designate a workstation where a single unit process or processing step is conducted. A typical fuel cycle facility is divided into several major process lines (e.g. UF₆ conversion, UO₂ powder blending, pellet pressing, scrap reprocessing, etc.)

This tabulation can be presented using a 'top-down' approach:

- **Facility:** the top level of detailed analysis would cover the facility and apply, for example, to a facility with limited operations, such as rod loading and assembly completion
- **Building:** the next level of detail would be on the building level. This application would be for a facility that has multiple buildings that have a limited number of processes in each
- **Product Line:** the next level of detail would be by product line. This application would be for a facility that has several product lines, such as conversion of UF₆ to UO₂ powder, scrap recovery, or a powder-to-pellet operation
- **Sub-Process:** the lowest detailed level would be a specific sub-process in a product line or building. Examples would include pelleting, dissolving uranium-bearing scrap, or packaging for shipment
- **Combined Approach:** combining different levels of detail is acceptable. For example, one analysis could be adequate for capturing the hazards in a building that includes just a few processes. However, an adjacent building may require a product line analysis with a specific sub-process analysis.

For each process analyzed in the ISA a narrative process description accompanied by a simple block flow diagram should be provided. A logic diagram or fault tree incorporating the process and each designated IROFS could also be used. Information on the chemical and physical transformations that occur in the process should be stated.

The ISA Summary should also explain how the methodology described in Section 1 of the ISA Summary for classifying the comparative risks of accident sequences was used in the risk analysis of processes. Accident sequences that are classified as 'low-consequence' do not require application of IROFS and can be eliminated from any further consideration in the ISA Summary.

- ✓ Process Hazards: hazards that were identified in the ISA specific to each process should be listed and discussed.
- ✓ General Types of Accident Sequences: general types of accident sequences that were identified in the ISA for each process should be identified. Accident sequences can be grouped in one of several ways, such as having the same initiating event, experiencing failure of the same IROFS, resulting in the same type and severity of consequences, etc. For example, several processes

each having a set of functionally identical IROFS can be considered the same 'type' and need only to be listed and described once. For simplicity, the applicant may describe the general principles of use of a particular safety control (e.g. geometry control, concentration control), but supplement this description with additional detailed information for a specific application of the safety control, if required.

Thus, accidents having characteristics that all fall in the same categories can be grouped as a single type of accident if, for example:

- the initiating events have the same effect on the system
 - they all consist of failures of the same type of IROFS
 - they all result in violation of the safety limit on the same parameter, and
 - they all result in the same type and severity level of consequences
- ✓ Process Risk Assessment: the results of the risk assessment performed for each process should be presented. The following information should be provided:
- consequences for each general type of uncontrolled accident sequence
 - comparison of the accident consequences to the performance requirements of 10 CFR 70.61 and designation of each as a '*high consequence event*' (10 CFR 70.61(b)), an '*intermediate consequence event*' (10 CFR 70.61(c)) or neither (i.e. an event of no regulatory concern (low consequence event))
 - likelihood of occurrence of each general type of accident sequence, expressed in terms of the definitions of unlikely and highly unlikely
 - classification of the risk of each general type of uncontrolled accident sequence
 - classification of the likelihood of occurrence of each general type of mitigated (i.e. controlled) accident sequence (following application of IROFS))
 - classification of the risk of each general type of mitigated (i.e. controlled) accident sequence

6.3 ISA Summary Section 3: IROFS

Section 3 of the ISA Summary contains lists of IROFS designated for high- and intermediate-consequence accident sequences.

- ✓ *IROFS*: a description should be provided of all IROFS⁶ designated for each general type of accident sequence. The description should identify the essential features of the item, the safety parameter that it controls and, for administrative control IROFS, the nature of the action(s) to be performed (or prohibited). Because the likelihood of failure of IROFS often depends on safety margins, inclusion of information on the safety parameter controlled by the IROFS and its safety limits may be instructive. The characteristics of the IROFS' preventive, mitigative or other safety function should be described and the assumptions and conditions under which the IROFS is relied upon to support compliance with the performance requirements of 10 CFR 70.61 should be noted. Classification of each IROFS by type (passive engineered, active engineered, augmented administrative, administrative) should be provided and, if applicable, an explanation of methods used to grade IROFS according to their safety-importance.
- ✓ *IROFS List*: a tabulation of all IROFS identified for high-and intermediate-consequence accident sequences should be provided. Each IROFS should be identified and its function explained in sufficient narrative detail to enable the NRC staff reviewer to understand how it will allow the performance requirements of 10 CFR 70.61 to be satisfied. Safety grading of IROFS, if applicable, can conveniently be stated by means of a numerical index whose value corresponds to the safety importance attributed to the IROFS.
- ✓ *Sole IROFS List*: a tabulation of IROFS that are the sole item preventing or mitigating an accident sequence classified as a high-consequence event (10 CFR 70.61(b)) or an intermediate-consequence event (10 CFR 70.61(c)) should be prepared. The 'Sole IROFS List' will be a sub-set of the complete list of IROFS noted above.
- ✓ *Management Measures*: a description of those management measures to be applied to each IROFS should be provided. For simplicity, the applicant may wish to outline the general features and principal elements of a management measure (e.g. worker training) and provide additional information for specific applications, if required. Similarly, the applicant may wish to outline levels of management measure grading and discuss application to specific IROFS with supplement information. For example, application of the Preventive Maintenance management measure may be at a high (e.g. daily), intermediate (e.g. monthly) or low (e.g. annual) frequency depending on the

⁶ IROFS are safety controls designed to regulate a device or process so as to maintain a safe state. IROFS, which may be engineered or administrative in nature, may be selected to be a preventive control (i.e. to prevent an accident entirely) or a mitigative control (i.e. to reduce the consequences of an accident sequence, but not to prevent it entirely). When a mitigative control works as intended, the results of the accident sequence are referred to as the 'mitigated consequences'.

importance to safety of the IROFS. Safety grading of management measures, if applicable, can conveniently be stated by means of a numerical index whose value corresponds to the safety importance attributed to the IROFS to which the measure are being applied.

The description should identify the core elements of a management measure that will be applied to the IROFS and outline how parameters for each will be established. For example, application of the surveillance/monitoring element of the maintenance management measure should include a description of how the frequency of surveillance will be established (e.g. based upon known failure frequency, engineering judgement, type of IROFS and its importance to safety, incorporation of fail-safe mechanism, etc.). For most batch operations, the frequency of application (and consequently, the maximum outage duration for an IROFS) will be the duration of the batch process, reflecting the licensee's commitment to not knowingly operate a process for which an IROFS is out of service or non-operational.

APPENDIX A

INDEX METHOD FOR RISK ASSESSMENT

A.1 Introductory Comments

Appendix A outlines one method for conducting a risk assessment. This methodology is then applied in Appendix B to a hypothetical uranium oxide scrap recovery operation. There are numerous methods other than that presented in Appendix A to conduct a risk assessment.

A.2 Method Overview

This Appendix outlines a four-step '*Index Method for Risk Assessment*' to perform a qualitative risk assessment of a facility process. In the first step, an accident sequence is established to be '*credible*' or '*not credible*'. Any '*credible*' accident sequence may require application of IROFS depending on its likelihood or occurrence. Any accident sequence deemed to be '*incredible*' requires no further analysis and will not be included in the ISA Summary. The second step entails calculation of a Matrix Risk Factor based on qualitative estimates of the likelihood of occurrence and severity of consequences of the accident sequence. The uncontrolled accident's Matrix Risk Factor establishes the risk that must be protected against by the IROFS. In the third step the Matrix Risk Factor is compared to various 'risk zones' defined by the performance requirements of 10 CFR 70.61 to decide whether IROFS are needed and, if so, the values of 'likelihood' and/or 'consequence' that must be achieved so as to reduce the accident's risk to an acceptable level. In the final step, the Matrix Risk Factor is modified taking into account the effectiveness of any designated IROFS and compared again to the matrix 'risk zones'. This comparison is used to demonstrate that the IROFS are sufficient in number and effectiveness to provide reasonable assurance that the performance requirements of 10 CFR 70.61 will be met. This demonstration satisfies the regulatory requirements of 10 CFR 70.65(4).

For simplicity, a 3x3 matrix of '*accident likelihood*' and '*accident severity of consequences*' is used in this guidance document to determine if IROFS are required to protect against an accident sequence.

The *Index Method of Risk Assessment* methodology consists, therefore, of four steps:

- (1) **Establish Accident Credibility:** assess whether the accident sequence is credible. If the accident sequence is not credible, no risk assessment need be performed. If the accident is credible, IROFS may be required depending on its consequences and likelihood of occurrence.

- (2) **Compute Matrix Risk Factor:** compute a Matrix Risk Factor based upon the forecast likelihood of the initiating event and the severity of the consequences of the uncontrolled accident sequence
- (3) **Determine Risk of Unmitigated Accident Sequence:** establish the risk level that designated IROFS must protect against
- (4) **Assess Adequacy of Designated IROFS for the Mitigated Accident Sequence:** the likelihood of occurrence and consequences of the accident sequence is reduced by taking into account the effectiveness of the number and type of designated IROFS. Such reductions are compared to various risk zones to verify that the designated IROFS are adequate for reducing the accident's risk to an acceptable level.

A.3 Method Implementation

The *Index Method of Risk Assessment* is applied in the following manner:

Step 1: Establish Accident Credibility

Each accident sequence identified in the Process Hazards Analysis is first assessed and classified to be either '*credible*' or '*incredible*'. Only accidents that are deemed '*credible*' need to be evaluated in the ISA and evaluated for inclusion in the ISA Summary. A '*credible*' accident in this Index Method is one for which there exists some non-negligible likelihood that it will occur during the life cycle of the system. For example, if the accident could reasonably be expected to occur during the life of the facility (assumed to be 50 years) it is considered to be '*credible*'. An externally-initiated accident is considered '*credible*' if historical data or probability modeling indicate that an event of a sufficient minimum magnitude (e.g. earthquake, flood, hurricane) could occur during the life of the facility. Any accident that could be initiated by a human performance deficiency (e.g. failure to follow a procedure, collection of erroneous process data, failure to perform a human activity relied on for safety) should be classified as '*credible*'. Accidents that could be initiated by any mechanical failure, regardless of the number of redundant safety controls or quality assurance measures, are also deemed '*credible*'.

An accident sequence is *not* considered by the NRC to be '*credible*' if: (i) it requires an external initiating event that can be conservatively estimated to occur less than once in a million years, (ii) is a process deviation that consists of a sequence of many unlikely human actions or errors for which there is no reason or motive (and that has never actually happened at a fuel cycle facility), (iii) is a process deviation for which there is a

convincing argument, based upon physical laws, that it is not possible or is unquestionably extremely unlikely, or (iv) its likelihood is negligible or sufficiently low that, considering the consequences, the addition to total risk is small.

Step 2: Estimate Accident Likelihood and Consequences

The risk of each credible accident sequence is evaluated without consideration of any IROFS (i.e. uncontrolled accident).

The *likelihood of occurrence* of the accident is dependent upon the frequency of occurrence of an initiating event. A qualitative assessment is used to establish numerical scores for accident likelihood based upon the guidelines presented in Table A-1. Three levels of likelihood are used: highly unlikely, unlikely and likely (equivalent to 'not unlikely'). The term 'life cycle of the system' in Table A-1 is dependent upon the component, piece of equipment or process operation that is under consideration and must be specified by the applicant. For example, the life cycle of an ADU line may be 50 years, whereas that for a short-term maintenance system may be one year.

**TABLE A-1
QUALITATIVE NUMERICAL VALUES FOR THE LIKELIHOOD OF
OCCURRENCE OF UNCONTROLLED ACCIDENTS**

Numerical Value	Qualitative Description
3	Likely to occur sometime (or repeatedly) during the life cycle of the system
2	Unlikely to occur during the life cycle of the system
1	Highly unlikely to occur during the life cycle of the system

The *severity of consequences* of an uncontrolled accident sequence is measured in terms of resulting health effects (including fatalities) presented in 10 CFR 70.61. Table A-2 summarizes these standards. Based upon the accident's potential adverse effects a numerical score is assigned for the severity of consequences. Severity of consequences is assigned to one of three categories: '*high consequence*', '*intermediate consequence*', and '*low-consequence*'. Accident sequences determined to have low consequences need not be further analyzed.

TABLE A-2		
QUALITATIVE NUMERICAL VALUES FOR THE SEVERITY OF CONSEQUENCES OF UNCONTROLLED ACCIDENTS		
Numerical Value	Accident Consequence Category	Classification Criteria
3	High	<ul style="list-style-type: none"> • Acute occupational TEDE > 100 rem • Public acute exposure TEDE > 25 rem • Public uptake > 30 mg uranium • Acute chemical exposure endangers life of worker or irreversible long-lasting health effects to public
2	Intermediate	<ul style="list-style-type: none"> • Acute occupational TEDE > 25 rem • Public acute exposure TEDE > 5 rem • 24-hr average release of licensed material > 5,000 times 10 CFR 20 Appendix B Table 2 concentrations • acute chemical exposure causes irreversible long-lasting health effects to worker or transient health effects to member of the public
1	Low	<ul style="list-style-type: none"> • any effects less than those for intermediate consequence event

Step 3: Determine Risk of the Unmitigated Accident Sequence:

The three possible measures of '*likelihood of occurrence*' and '*severity of consequences*' may be represented as a 3x3 matrix (Table A-3). The performance requirements of 10 CFR 70.61 may be added to this matrix to illustrate what combinations of uncontrolled accident sequence likelihood and consequences are permissible and do not require IROFS. For example, a high-consequence accident that is highly unlikely or an intermediate-consequence accident that is unlikely will not need any IROFS. Whether an accident sequence requires IROFS can be ascertained visually on the 3x3 matrix or by computing the value of the Matrix Risk Factor (product of the numerical scores assigned to likelihood and consequence) and comparing it to the shaded risk zones shown on the Table A-3 matrix. In the present model, if the value of the Matrix Risk Factor is greater than or equal to 6, IROFS(s) will be needed.

TABLE A-3

RISK ASSESSMENT TABLE FOR UNMITIGATED ACCIDENT SEQUENCES ILLUSTRATING MATRIX RISK FACTORS

		LIKELIHOOD OF OCCURRENCE		
		Highly Unlikely (1)	Unlikely (2)	Likely (3)
SEVERITY OF CONSEQUENCE	High (3)	3	6	9
	Intermediate (2)	2	4	6
	Low (1)	1	2	3

 Accident sequences whose 'likelihood of occurrence' and 'severity of consequence' numerical scores necessitate designation of IROFS

Step 4: Assess Adequacy of Designated IROFS and Mitigated Accident Sequence:

The risk of an accident sequence is reduced through application of different numbers and types of IROFS. By either reducing the likelihood of occurrence of the accident or by mitigating its consequences, IROFS can reduce the overall risk of the accident sequence. Designation of IROFS should generally be made to reduce the likelihood of the accident occurring in the first place. But acknowledging that the accident could still occur – albeit with a reduced likelihood – IROFS can be designated to mitigate the accident’s consequences if it does, in fact, occur. The *Index Method of Risk Assessment* ‘credits’ (i.e. reduces) the likelihood of occurrence of the uncontrolled accident sequence to reflect both the number and robustness of different IROFS that are designated for an accident sequence. Reducing the numerical likelihood score will shift the Matrix Risk Factor Index in the direction of a lower risk zone. Alternatively, the IROFS may mitigate the consequences of the accident and lower the consequence severity to a lower numerical value.

Numerical values assigned to different types of IROFS (administrative, augmented administrative, active engineered, passive engineered) are listed in Table A-4.

TABLE A-4
QUALITATIVE NUMERICAL VALUES FOR THE EFFECTIVENESS OF IROFS PROTECTION

Numerical Value	Description of IROFS
1	Protection by a single, trained operator with adequate response time (administrative)
2	Protection by a single hardware system, functionally tested on a regular basis (active engineered)
3	Protection by a single passive-engineered safety device, functionally tested on a regular basis <u>or</u> a single, tested hardware system with trained operator back-up
4	Protection by two independent, redundant hardware systems, each functionally tested on a regular basis (e.g. geometry)

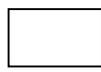
The likelihood index selected in Step 2 for the uncontrolled accident is adjusted by subtracting the appropriate IROFS score (from Table A-4) and then the appropriate risk zone is identified in Table A-5 by identifying the final adjusted likelihood index.

The likelihood-consequence matrix used in Step 4 has been modified from that illustrated in Table A-3 in three ways. First, the lowest category of 'severity of consequences' has been deleted as no accident sequence having low-consequences will exceed the 10 CFR 70.61 performance requirements and need not be considered in the ISA Summary. Second, the "intermediate-consequence" category has been subdivided into two categories: '*off-site intermediate-consequence*' and '*on-site intermediate-consequence*' events. In this model, the severity of consequence of an off-site intermediate-consequence event is assumed to be greater than an on-site intermediate-consequence event. While the risk of an off-site event will probably be minor due to the highly localized character of facility accidents, the adverse public perception could make such an accident into a serious public relations challenge. Third, the number of likelihood categories has been increased from three to six to accommodate the new range of values resulting from application of the IROFS scores in Table A-4 to the likelihood of occurrence scores.

TABLE A-5

**RISK ASSESSMENT TABLE FOR ASSESSING THE ADEQUACY OF IROFS
TO MEET THE PERFORMANCE REQUIREMENTS OF 10 CFR 70.61**

		LIKELIHOOD OF OCCURRENCE					
		Highly Unlikely		Unlikely		Not Unlikely (Likely)	
		-2	-1	0	1	2	3
SEVERITY OF CONSEQUENCE	High (3)						
	Intermediate (Off-site) (2)						
	Intermediate (On-site) (1)						

-  Risk Zone 1: (Does not meet performance requirements. Immediate corrective action required.)
-  Risk Zone 2: (Does not meet the performance requirements. However, a sufficient margin of safety is present to allow continued operation for a specified period to allow for correction.)⁷
-  Risk Zone 3: (Meets the performance requirements. No corrective action is required. Acceptable for start-up of a new operation)

When two concurrent events (contingencies) are identified that result in a condition whereby a criticality is possible, the two elements of the accident likelihood ((i) frequency of the initiating event, and (ii) the reliability or effectiveness of the IROFS that protect against the event progressing to the accident) are used to demonstrate compliance with the Double Contingency Principle (i.e., two unlikely, independent, and concurrent changes in process conditions must occur before criticality is

⁷ For existing licensees 10 CFR 70.62(c)(3)(ii) requires that any unacceptable performance deficiencies be corrected by October 18, 2004, unless the NRC authorizes an extension to this deadline. The deadline for submitting to the NRC the facility's ISA Summary – either as one document or as multiple ISA Summaries of separate facility processes -- is October 18, 2004.

possible). The first element (frequency of the initiating event) determines the qualitative probability that an event will occur despite prevention measures in place. The second element (effectiveness of IROFS) determines the qualitative probability that another event will not occur concurrently resulting in a condition whereby a criticality is possible. In each case, the quality of the measures in place designed to preclude these events is determined based upon the reliability and availability of the measures to function when required.

APPENDIX B

PROCESS RISK ASSESSMENT EXAMPLE

An example of a risk assessment for one hypothetical process -- a dissolver operation for uranium oxide scrap recovery -- is developed in this Appendix B. This working example is provided as an example for fulfillment of Section 2 ('*Process-Specific Information*') and Section 3 ('*IROFS*') of the ISA Summary. The risk assessment methodology used is that presented in Appendix A.

Appendix B is presented in two sections. Section 1 steps through an analysis of the uranium dissolver operation for each topic to be discussed in the ISA Summary (see chapters 4.2.2 and 4.2.3 of this document). Section 2 presents the information for the uranium dissolver analysis that should be included in the ISA Summary.

B.1 Section 1: Process Risk Analysis

(a) Process Analyzed:

- (i) **Process Identity:** Uranium Oxide Dissolver
- (ii) **Operational Configuration:** the uranium dissolver operation is designed to recover uranium oxide from filings produced in the grinding of sintered fuel pellets prior to their placement in fuel assemblies. This batch operation entails transfer of a measured quantity of uranium oxide filings (≈ 15 kgs) from a safe-geometry hopper into a vertical, cylindrical, steel-walled tank of safe geometry (8" in diameter, 50 liter capacity) containing heated, concentrated nitric acid ($\approx 60\%$). The uranium oxide solids are dissolved in an exothermic reaction and converted into soluble uranyl nitrate. At the end of a dissolution cycle, the uranyl nitrate solution is pumped from the dissolver, passed through several filters and transferred to a solvent extraction circuit for impurity removal. The uranyl nitrate solution is analyzed both for its uranium content and to ensure sufficient free acid ($\approx 5\%$) is present to maintain the uranium in the soluble form.
- (iii) **Safety Design Basis:** process safety is primarily assured by satisfying the Double Contingency/Defense in Depth Principle ('...*at least two unlikely, independent and concurrent changes in process conditions, or failures of multiple independent and reliable controls on a single*

process condition would be required before a nuclear criticality accident would be possible...')

(b) Process Hazards:

Three process hazards were identified:

- (1) **nuclear criticality hazard**
- (2) **chemical hazards:** toxic chemical hazards from two chemicals of concern:
 - Nitric Acid (70%): toxic by inhalation, ingestion or skin contact. HNO₃ is heated and added to dissolver
 - Uranium Compounds: (e.g. UO₂, UO₂(NO₃)₂·6H₂O, U₃O₈) chemically toxic. Primarily addressed as a radiation hazard
- (3) **radiological hazards:** the primary radiological hazard is a nuclear criticality. Additional exposure may result from inhalation of uranium oxide dust during solids transfer and from the uranyl nitrate solution and exposure to, or inhalation of, dissolver off-gases containing nitric acid and uranyl nitrate

(c) General Types of Accident Sequences:

Accident scenarios and their causes (initiating events) were developed by considering deviations from normal modes of operation. Credible upset conditions were developed for each identified hazard:

(1) **nuclear criticality hazards:**

Credible Upset Conditions:

(The loss of a barrier or controlled parameter was assumed to be the initiating event in every accident sequence.)

- (i) exceeding concentration limits
- (ii) violating favorable geometry parameters (dissolver volume)
- (iii) violating spacing limits

General Types of Accident Sequences:

- (i) addition of too many solids (exceed dissolver concentration limit)
- (ii) plugging of in-line filters on dissolver discharge line
- (iii) incorrect spacing between dissolver and other tanks and containers brought into the dissolver room containing uranium
- (iv) precipitation of uranyl nitrate due to insufficient free acid

(2) **chemical accident hazards:**

Credible Upset Conditions:

- (i) reagent or solids spillage
- (ii) dissolver off-gases (containing nitric acid and uranium)

General Types of Accident Sequences:

- (i) loss of containment (leaks, spills from corrosion)
- (ii) overfilling of dissolver vessel
- (iii) spillage of nitric acid during addition to dissolver
- (iv) inadvertent addition of excessive solids
- (v) inadvertent reversal of solids-to-acid addition sequence
- (vi) failure to use correct nitric acid strength
- (vii) worker exposure to acidic and radioactive off-gases

(3) **radiological hazards:**

Radiation hazards may arise from internal exposure (breathing contaminated air) and external exposure (radiation levels).

Credible Upset Conditions:

- (i) spillage of solids being transferred to dissolver
- (ii) loss of containment of dissolver contents (spillage)

General Types of Accident Sequences:

The only general type of accident sequence that could result in significant radiological exposure to a worker is an inadvertent nuclear criticality. These accident scenarios are discussed under the '*nuclear criticality hazard*' section above.

(d) Process Risk Assessment:

For each general type of accident sequence identified for the dissolver the integrated risk assessment process explained in Appendix A was used to assign numerical scores to 'likelihood of occurrence' and 'severity of consequences'. These data are presented in Table B-1.

In the risk analysis of chemical accident hazards, quantitative standards for acute exposure must be specified (e.g. Acute Exposure Guideline Level (AEGL) values). The AEGL values for acute exposure to nitric acid are:

Severity of Consequences	Quantitative Acute Exposure Standard	Numerical Values	
		mg/L	mg/m ³
High	AEGL-3	13	34
Intermediate (Off-Site)	<AEGL-2 & >AEGL-1	>0.5 & <4	>1.3 & <10
Intermediate (On-Site)	<AEGL-3 & >AEGL-2	>4 & <13	>10 & <34

The principal occupational risks posed by the dissolver operation are the effects of a nuclear criticality. Nuclear criticality safety is based upon controlling geometry and

uranium concentration. Use of geometry and uranium concentration as controlled parameters satisfies the Double Contingency/Defense-In-Depth Principle.

There are no potential off-site impacts from this process, and thus, no accident sequences having an '*Intermediate - Off-Site*' severity of consequence classification.

(e) IROFS:

Three types of IROFS are used in the uranium dissolver operation:

- (1) Passive Engineered Controls: consist primarily of containment systems (e.g. process liquid piping, chemical tanks, vessels, columns, spill dikes), dissolver vessel dimensions and fixed spacing between equipment. Containment systems are designed for chemical compatibility/resistance and anticipated service conditions (temperature and pressure).
- (2) Active Engineered Controls: used primarily to control the flow of solids and liquids into and out of the dissolver and to prevent releases of hazardous vapors, acid and uranyl nitrate solutions and radioactivity to the process work area. These controls consist of in-line monitors, valves that fail to the closed position, high level alarms, pump shut-offs/activations and automatic chemical addition.
- (3) Administrative Controls (including Enhanced Administrative): consist of operator actions such as opening valves, activating pumps and use of other equipment to maintain containment of chemical hazards, controlling feed stream flow rates, pH probes, sampling of the dissolver contents and performance of preventive maintenance. Personnel Protective Equipment (PPE) worn by operators (e.g. chemical resistant gloves, safety glasses) is considered a passive control.

The IROFS designated for each general type of accident sequence and controlled parameters for each, as well as the 'IROFS effectiveness' credit applied to the Matrix Risk Factor are presented in Table B-2.

(f) Management Measures:

IROFS must be maintained to ensure their reliability and availability. Active and passive engineered controls are maintained by means of the facility change control process and through testing and/or inspection programs. Administrative controls are specified in area operating procedures or plant-wide procedures (e.g. nuclear criticality safety procedure manual, industrial health and safety procedure manual). Training programs increase the reliability of administrative controls while

inspections and audits verify compliance with administrative controls. Administrative controls protecting against the mixing of incompatible chemicals are aided by proper identification of equipment and containers. Operators are periodically trained on existing procedures and postings and on all revised and new procedures and postings prior to implementation. In the case of nuclear criticality safety, NCS inspections and periodic area NCS audits verify compliance with administrative controls.

Management measures applied to each type of IROFS are summarized in Table B-2. Detailed information for each management measure -- for example on maintenance surveillance methods and frequencies, whether an IROFS is fail-safe, self-indicating or monitored, safety margins or detailed grading of a management measure -- is too detailed for inclusion in the ISA Summary, but is available in the license application or in the ISA and ISA supporting documentation. Values in Table B-2 for Controlled Parameter Limits have built-in safety margins, the values for which and supporting computations are available in the facility's ISA. Tables B-1 and B-2 include a column entitled "*Management Measure Grading*" that provides a general indication of what level of grading the applicant proposes to apply to management measures. Detailed information on each grading method (e.g. what constitutes a "high" grading of training versus an "intermediate" level of preventive maintenance) will be presented in the ISA.

TABLE B-1

LIST OF ACCIDENT SEQUENCES FOR URANIUM DISSOLVER AND COMPARISON OF MATRIX RISK FACTORS TO THE PERFORMANCE REQUIREMENTS OF 10 CFR 70.61

General Accident Type and Number	Unmitigated Accident Consequences	Consequence Score (Table A-2)	Likelihood Score (Table A-1)	Matrix Risk Factor	Management Measure Grading	Comparison to 70.61 Performance Requirements
UD-1: Addition of too many uranium oxide solids	Exceed dissolver concentration limits, endanger criticality event	3 (High)	3 (Likely)	9	High	Exceed 70.61(b)
UD-2: Occupational exposure to acidic off-gases from the dissolver	Acid burns to skin and lungs, radiation exposure exceeding 10 CFR 20 limits from uranyl nitrate solution	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-3: Placement of uranium-bearing containers too close to dissolver	Violate spacing limits, endanger criticality event	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-4: Incorrect sequence of acid and solid addition	Splattering of solids and liquid, occupational radiation exposure	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-5: Plugging of in-line filters on dissolver discharge	Impeded drainage, spillage potential, occupational exposure potential	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-6: Loss of nitric acid supply containment, overflow from dissolver	Spillage of acid, occupational radiation risk potential	2 (Intermediate)	2 (Unlikely)	4	Intermediate	Exceed 70.61(c)
UD-7: Malfunction of hopper feed mechanism	Spillage of uranium oxide solids, radiation exposure potential, interaction with spilled acid	3 (High)	3 (Likely)	9	High	Exceed 70.61(b)
UD-8: Addition of excessive quantities of acid	Spillage of acid (and entrained solids), occupational radiation risk potential	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-9: Loss of containment for dissolver	Spillage and release of uranyl nitrate solution and solids	3 (High)	2 (Unlikely)	6	High	Exceed 70.61(b)

TABLE B-2

LIST OF ACCIDENT SEQUENCES FOR URANIUM DISSOLVER, CONTROLLED PARAMETER, DESIGNATED IROFS (IDENTITY AND CATEGORY), AND MANAGEMENT MEASURES

General Accident Type and Number	Controlled Parameter	Controlled Parameter Limits	IROFS (Identity and Type ¹)	Likelihood Score ²		Management Measures
				Old	New	
UD-1: Addition of too many uranium oxide solids	Mass	15 kg max	<u>PE</u> : Weigh scale with interlock:2	3	-2	Procedures, operator training, weigh scale maintenance
	Geometry	8" diameter column	<u>PE</u> Fixed geometry: 3			
UD-2: Occupational exposure to acidic off-gases from the dissolver	Concentration of acid in air	<4 mg/l HNO ₃	<u>PE</u> Ventilation system/scrubber: 2	3	0	Procedures, operator training, weigh scale maintenance
			<u>A</u> : Operator PPE: 1			
UD-3: Placement of uranium-bearing containers too close to dissolver	Spacing	>50 inches separation	<u>A</u> : Operational procedures (administrative control): 1 <u>PE</u> : floor design: 2	3	0	Training, procedures
UD-4: Incorrect sequence of acid and solid addition	Liquid Level	Postings	<u>PE</u> Dissolver liquid level monitor: 2	3	0	Training, maintenance
			<u>A</u> : Operator : 1			
UD-5: Plugging of in-line filters on dissolver discharge	Discharge Flow Rate	5 gpm (minimum)	<u>PE</u> In-line flow monitor: 2	3	0	Maintenance, operator training
			<u>A</u> : Operator oversight: 1			
UD-6: Loss of nitric acid supply containment	Containment of HNO ₃ supply tank	N/A	<u>PE</u> : acid-compatible construction materials, 2 ^{ndary} containment pit: 2 <u>AE</u> : automatic closure valve on acid feed line to dissolver: 2	2	-2	Maintenance (valves, corrosion)
UD-7: Malfunction of hopper feed mechanism	Mass	<15 kg solids per dissolver loading	<u>A</u> : exposure control program and timely clean-up of spills: 1 <u>P</u> : containment for hopper: 2 <u>AE</u> : automatic level control for hopper contents: 2	3	-2	Maintenance (level controls, containment hardware), training
UD-8: Addition of excessive quantities of acid	Volume	<30 gallons	<u>A</u> : operator oversight: 1 <u>PE</u> : automatic shut-off valve: 2	3	0	Maintenance, procedures, training

TABLE B-2 (Continued)

**LIST OF ACCIDENT SEQUENCES FOR URANIUM DISSOLVER, CONTROLLED PARAMETER,
DESIGNATED IROFS (IDENTITY AND CATEGORY), AND MANAGEMENT MEASURES**

General Accident Type and Number	Controlled Parameter	Controlled Parameter Limits	IROFS (Identity and Type ¹)	Likelihood Score ²		Management Measures
UD-9: Loss of containment for dissolver	Vessel Integrity	N/A	<u>A</u> : operator oversight (including inspection for corrosion): 1 <u>PE</u> : secondary containment beneath dissolver: 3	2	-2	Maintenance, training

Note 1: Abbreviations for types of IROFS: AE = active engineered, PE = passive engineered, A = administrative, AUE = augmented administrative.

Note 2: 'Old Likelihood Score' is reproduced in this column from Table C-1. 'New Likelihood Score' is computed by subtracting from the Old Likelihood Score the total score assigned to all designated IROFS (listed in the IROFS column of this table). Scores for the effectiveness of an IROFS are listed in Table A-3.

B.2 Section 2: Reporting of Process Risk Analysis in ISA Summary

Information developed in Section 1 for the risk assessment of the Uranium Oxide Dissolver process should be condensed for inclusion in the ISA Summary. One example of how this information could be summarized and presented follows.

PROCESS RISK ASSESSMENT		
(a) <u>Process Analyzed:</u>		
Process Identity:	Uranium Oxide Dissolver	
Process Reference:	UD-05	
Operational Description:	process for the batch dissolution of uranium oxide scrap in nitric acid	
Safety Design Basis:	process safety is assured through adherence to the Double Contingency/Defense-in-Depth Principle	
(b) <u>Process Hazards:</u>		
Process Hazards Identified:	(i)	Nuclear criticality hazard
	(ii)	Chemical hazards: nitric acid (~70%): toxic by inhalation, ingestion, skin exposure; uranium oxide compounds (treated as a radiation hazard)
	(iii)	Radiological hazards: primarily associated with nuclear criticality; exposure from inhalation of uranium oxide dust and dissolver off-gases
(c) <u>General Types of Accident Sequences:</u>		
General types of accident sequences for each identified hazard and possible initiating events follow:		
<u>Process Hazard Type</u>	<u>Initiating Events</u>	<u>General Accident Sequences</u>
Nuclear Criticality	Exceed concentration limits Violate favorable geometry Violate spacing limits	Addition of too many solids Plugging of in-line filters Too close spacing of dissolver to containers containing dissolved uranyl nitrate Precipitation of uranyl nitrate due to lack of sufficient free acid
Chemical Hazards	Reagent or solids spills Inhalation of dissolver off-gases	Loss of containment (leaks, spills from tank and piping corrosion or failure) Overfilling of dissolver vessel Spillage of nitric acid Addition of too many solids Incorrect solids/acid mixing sequence Failure to use correct acid strength
Radiological Hazards	Spillage of uranium oxide solids during transfer to dissolver Loss of containment of dissolver contents	Nuclear criticality Occupational exposure from inhalation of dissolver off-gases or uranium dust

(d) Process Risk Assessment: Consult Table UD-1

(e) Items Relied on For Safety (IROFS): Consult Table UD-2

IROFS for each general type of accident sequence are identified in Table UD-2 by type and number. A list of each IROFS identified for this process and a brief description of the IROFS's function follow:

<u>IROFS</u>	<u>IROFS Description</u>
Weigh Scale with Interlock	Weigh scale to measure quantity of uranium oxide solids that are to be added to the dissolver for a batch dissolution. Interlock device prevents removal of weighing container from the scale if the solid quantity exceeds maximum permissible weight. Prevents nuclear criticality (Reference Accident Sequence UD0-1)
Fixed Geometry	Uranium dissolver is of a fixed cylindrical geometry to minimize occurrence of a nuclear criticality for complete filling with uranium scrap of the maximum permissible enrichment. Prevents nuclear criticality (Reference Accident Sequence UD-1)
Ventilation System	Exhaust fan and ventilation system (including a scrubber system) to capture any acidic off-gases from the dissolver that may contain uranyl nitrate and pose health and radiation risks to the worker. Protects against exceeding acute chemical exposure standards and Part 20 radiation exposures (Reference Accident Sequence UD-2)
Personal Protective Equipment (PPE)	PPE worn by the dissolver operator is designed to protect against splashes of uranyl nitrate-bearing acid solutions. Protects against exceeding acute chemical exposure standards and Part 20 radiation exposures (Reference Accident Sequence UD-2)
Vessel Spacing Procedures	Procedures to prevent the placement of any container brought into the dissolver room (or containing uranyl nitrate solution produced in a batch dissolution) from being placed too close to the dissolver so as to prevent a nuclear criticality. (Reference Accident Sequence UD-3).
Liquid Level Monitors	Automatic level monitors for use in the uranium dissolver and nitric acid bulk storage tank. These active engineered controls protect against overfilling of the dissolver or acid tank through sounding of alarms to prompt operator action. Protects against spillage of uranyl nitrate-bearing solution and/or nitric acid and concomitant worker exposures. (Reference Accident Sequence UD-4).
Operator Oversight	Operator procedures to ensure correct measurement of the quantities of solids and acid added to the dissolver, sampling and analysis of the dissolver discharge, prompt clean-up of spills, monitoring of filter media for plugging, etc. Protects against exceeding acute chemical exposure standards and Part 20 radiation exposures (Reference Accident Sequences UD-4, UD-5, UD-8, UD-9)
In-Line Flow Monitors	Flow monitors are installed on the dissolver discharge line to detect any blockage or reduced flow across filter media that could, if not corrected, result in back-up and spillage of the uranyl nitrate solution. Protects against exceeding acute chemical exposure standards and Part 20 radiation exposures (Reference Accident Sequence UD-5)

Materials of Construction	Dissolver vessel, piping, acid bulk storage tanks and associated measurement devices are manufactured of materials that provide suitable chemical resistance to corrosive dissolver conditions so as to prevent loss of solution containment. Protects against exceeding acute chemical exposure standards and Part 20 radiation exposures (Reference Accident Sequence UD-6)
Automatic Closure Valves	Automatic closure valves on the acid feed line are designed to allow only a measured quantity of acid to be placed into the dissolver. Protects against spillage of acid, violent chemical reaction and exceeding acute chemical exposure standards and Part 20 radiation exposures. Fail-safe design (Reference Accident Sequence UD-6)
Automatic Level Control	Automatic level control on the uranium oxide feed hopper serves to prevent the overfilling of the hopper and loss of containment. Protects against spillage of oxide solids, nuclear criticality and Part 20 radiation exposures. Self-indicating design (Reference Accident Sequence UD-7)
Secondary Containment	Secondary containment on the floor beneath the dissolver is designed to collect any solids, acid or uranyl nitrate that is spilled during the batch loading or emptying of the dissolver. Designed to as to protect against nuclear criticality, exceeding acute chemical exposure standards and Part 20 radiation exposures (Reference Accident Sequence UD-9)

(f) Sole Items Relied on For Safety (IROFS):

There are no sole items relied on for safety for the Uranium Dissolver.

TABLE UD-1

LIST OF ACCIDENT SEQUENCES FOR URANIUM DISSOLVER AND COMPARISON OF MATRIX RISK FACTORS TO THE PERFORMANCE REQUIREMENTS OF 70.61

General Accident Type and Number	Unmitigated Accident Consequences	Consequence Score (Table A-2)	Likelihood Score (Table A-1)	Matrix Risk Factor	Management Measure Grading	Comparison to 70.61 Performance Requirements
UD-1: Addition of too many uranium oxide solids	Exceed dissolver concentration limits, endanger criticality event	3 (High)	3 (Likely)	9	High	Exceed 70.61(b)
UD-2: Occupational exposure to acidic off-gases from the dissolver	Acid burns to skin and lungs, radiation exposure exceeding 10 CFR 20 limits from uranyl nitrate solution	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-3: Placement of uranium-bearing containers too close to dissolver	Violate spacing limits, endanger criticality event	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-4: Incorrect sequence of acid and solid addition	Splattering of solids and liquid, occupational radiation exposure	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-5: Plugging of in-line filters on dissolver discharge	Impeded drainage, spillage potential, occupational exposure potential	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-6: Loss of nitric acid supply containment, overflow from dissolver	Spillage of acid, occupational radiation risk potential	2 (Intermediate)	2 (Unlikely)	4	Intermediate	Exceed 70.61(c)
UD-7: Malfunction of hopper feed mechanism	Spillage of UO ₂ solids, radiation exposure potential, interaction with spilled acid	3 (High)	3 (Likely)	9	High	Exceed 70.61(b)
UD-8: Addition of excessive quantities of acid	Spillage of acid (and entrained solids), occupational radiation risk potential	2 (Intermediate)	3 (Likely)	6	Intermediate	Exceed 70.61(c)
UD-9: Loss of containment for dissolver	Spillage and release of uranyl nitrate solution and solids	3 (High)	2 (Unlikely)	6	High	Exceed 70.61(b)

TABLE UD-2

LIST OF ACCIDENT SEQUENCES FOR URANIUM DISSOLVER, CONTROLLED PARAMETER, DESIGNATED IROFS (IDENTITY AND CATEGORY), AND MANAGEMENT MEASURES

General Accident Type and Number	Controlled Parameter(s)	Controlled Parameter Limits	IROFS (Identity, Type and Effectiveness Score ¹)	Likelihood Score ²		Management Measures
				Old	New	
UD-1: Addition of too many uranium oxide solids	Mass	15 kg max	PE: Weigh scale with interlock: 2	3	-2	Procedures, operator training, weigh scale maintenance
	Geometry	8" diameter column	PE Fixed geometry: 3			
UD-2: Occupational exposure to acidic off-gases from the dissolver	Concentration of acid in air	<4 mg/l HNO ₃	PE Ventilation system/scrubber: 2	3	0	Procedures, operator training, weigh scale maintenance
			A: Operator PPE: 1			
UD-3: Placement of uranium-bearing containers too close to dissolver	Spacing	>50 inches separation	A: Operational procedures (administrative control): 1 PE: floor design: 2	3	0	Training, procedures
UD-4: Incorrect sequence of acid and solid addition	Liquid Level	Postings	PE Dissolver liquid level monitor: 2	3	0	Training, maintenance
			A: Operator : 1			
UD-5: Plugging of in-line filters on dissolver discharge	Discharge Flow Rate	5 gpm (minimum)	PE In-line flow monitor: 2	3	0	Maintenance, operator training
			A: Operator oversight: 1			
UD-6: Loss of nitric acid supply containment	Containment of HNO ₃ supply tank	N/A	PE: acid-compatible construction materials, 2 ^{ndary} containment pit: 2 AE: automatic closure valve on acid feed line to dissolver: 2	2	-2	Maintenance (valves, corrosion)
UD-7: Malfunction of hopper feed mechanism	Mass	<15 kg solids per dissolver loading	A: exposure control program and timely clean-up of spills: 1 P: containment for hopper: 2 AE: automatic level control for hopper contents: 2	3	-2	Maintenance (level controls, containment hardware), training
UD-8: Addition of excessive quantities of acid	Volume	<30 gallons	A: operator oversight: 1 PE: automatic shut-off valve: 2	3	0	Maintenance, procedures, training
UD-9: Loss of containment for dissolver	Vessel Integrity	N/A	A: operator oversight (including inspection for corrosion): 1 PE: secondary containment beneath dissolver: 3	2	-2	Maintenance, training

Note 1: Abbreviations for types of IROFS: AE = active engineered, PE = passive engineered, A = administrative, AUE = augmented administrative.

Note 2: 'Old Likelihood Score' is reproduced in this column from Table UD-1. 'New Likelihood Score' is computed by subtracting from the Old Likelihood Score the total score assigned to all designated IROFS (listed in the IROFS column of this table). Scores for the effectiveness of an IROFS are listed in Table A-3.