Criticality Safety at Zircatec – Past Present and Future – Part II

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Abstract

In response to the Power Uprate program at Bruce Power, Zircatec has committed to introduce, by Spring 2006 a new manufacturing line for the production of 43 element CANFLEX bundles containing Slightly Enriched Uranium (SEU) with a centre pin of blended dysprosia/urania (BDU). This is a new fuel design and is the first change in fuel design since the introduction of the current 37 element fuel over 20 years ago.

This move to LVRF fuel manufacture has prompted the change to a plant wide implementation of criticality safety methods. The major aspects of this change will be discussed from the viewpoint of the end user of the facility. Some of the methods used in the design of the unit processes and in the conducting of the criticality safety evaluations will be elaborated.

1. Introduction:

Ensuring Nuclear Criticality Safety (NCS) during the manufacture of enriched uranium fuel involves designing the process such that a nuclear reactor is NOT created. It is important to realize that LVRF production cannot be conducted in the same manner as natural uranium production. A robust yet manageable system has to be designed and set up via policies, program structure, process design and operational limits and controls and operator and supervisor training such that an inappropriate assembly of material and moderator cannot be created during the manufacture of the fuel. The fact that such concerns are new to CANDU fuel production, makes it imperative that issues of cultural mindset be addressed at the outset through rigorous involvement and training of all operational levels. The Zircatec NCS program is based on various Industry Standard guidelines (ANS) such as those for administrative practices, processes and operations, and training. Although Zircatec is licensed to manufacture enriched fuel bundles, to date such manufacture has been limited to laboratory scale. The introduction of the new SEU fuel line requires that the criticality safety principles currently in use be modified and extended to accommodate larger volumes of production.

2. Nuclear Criticality Safety (NCS) Program

Issues pertaining to criticality safety will be addressed via the establishment of a new Program, the Nuclear Criticality Safety Program based on a Criticality Safety Policy. This program will govern all practices surrounding new SEU / LVRF Production Line. The program is derived from existing applicable standards such as ANS 8.1 etc. which are currently being used for such matters.

The Criticality Safety Program:

- defines the criticality safety program for the site.
- It identifies the objective of the criticality safety program, the responsibilities of various levels of management and of employees,
- lists the elements required to comprise the criticality safety program.
- discusses when exemptions to the program elements are permitted.
- The program is the “mother document” under which all of the remaining elements of the criticality program fall.

The Program incorporates various Program Elements, most of which are too detailed to reiterate here. The following describes some of the issues that need to be addressed – the point of importance is that most of these structures are very new to natural uranium (NU) manufacture; for example:

- Validation Program:
  - Describes how the computer codes used in calculations that support criticality evaluations must be validated against experiments.
  - The procedure assures that the validation report will address all of these requirements .
- Nuclear Criticality Safety Evaluation Program:
  - Defines the fissile material operation, identifies the hazards that could lead to an inadvertent criticality, implements controls that prevent any of the identified hazards from occurring, and demonstrates double contingency for the operation.
  - The NCSE procedure provides guidance to the NCSE author to assure that the NCSE contains all required information, and to promote uniformity and consistency between different authors. It also serves as a guide for technical reviewers.
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- Nuclear Criticality Safety Training & Qualification Program:

- Implementation of Nuclear Criticality Safety Control Program:

    - Specifies how the criticality group verifies that the active and passive engineered controls, as well as the administrative limits that are identified in NCSEs as necessary for double contingency, are implemented in the field.

- Configuration Control / Change Control Program:

    - Specifies how active and passive engineered controls are identified and specifies procedures to prevent them from being changed without the proper review and analysis.
    - In general, the only change to an active or passive engineered control that can be made without criticality safety approval is an exact replacement.
    - This procedure is necessary to maintain the integrity of these controls. Change control is a general safety department procedure, as opposed to a specific criticality safety procedure.
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- General Criticality Safety Limits Program:

    - Lists generic criticality safety limits that must be observed throughout the facility.
    - Items covered include rules for handling fissile-contaminated waste, for moving containers of fissile material, for cleaning up both solid and liquid spills of fissile material, etc.

- Non-compliance arises when it is discovered that a requirement in an NCSE is not being followed. There are varying degrees of non-compliance, depending on how important the control is to the double contingency argument. The criticality staff uses this procedure to determine how to categorize the non-compliance. Also covered is how to track and trend non-compliances.

Criticality Detector and Alarm System Program:

- ANSI/ANS 8.3 details requirements for a Criticality Accident Alarm System (CAAS), including design criteria, testing requirements, and training requirements.
- Implements the requirements for the CAAS program to ensure the ANSI standard requirements are met.

The balance of this paper will focus on NCSEs, in particular the methodology that was adopted to ensure that process designs with passive criticality safety could be incorporated in a manner that was readily adopted by people who would have to operate the process.

3. Nuclear Criticality Safety Evaluations (NCSEs):

    a. Is a stand-alone safety report that contains a comprehensive process description, including description of equipment, materials, and activities.
    b. Identifies the hazards that are significant to criticality safety
    c. Is an evaluation of each criticality accident pathway, with a demonstration of double contingency and a demonstration that the accident sequence is highly unlikely.
    d. Is a description of any calculations relied on in the double contingency arguments.
    e. Is a listing of all passive engineered, active engineered, and administrative controls needed for double contingency.
    f. These comprehensive safety reports are typically 80 – 200 pages in length.

The requirement of the NCSE is that these be performed and documented for each of the fissile operations in the Zircatec facility. At a minimum preliminary design work must be completed and made available to the criticality safety engineers before NCSEs can be started. The benefit of starting NCSEs early is that, upon detailed examination of the process, the criticality safety engineer can identify desirable changes to enhance criticality safety before it is too late to implement them. Eight Nuclear Criticality Safety Evaluations were identified for the Zircatec Plant:

- Powder Receipt and Storage, Blending and Milling
- Pellet Pressing
- Furnace (including green pellet tray stacking)
- Pellet Grinding
- Pellet Storage and Tubing
- Bundle Handling
- Waste Operations
- Bundle storage

4. Implementation of NCSEs

Given that the majority of production personnel, including supervisors and shop floor personnel were unacquainted with the concepts of criticality safety, we recognized early on that a considerable culture change would be needed so that constructive conversations could be initiated to design and analyze unit processes. Recognizing this, we began personnel training on criticality issues early – several core personnel were trained using existing in-house developed modules. To support this discussion, issues pertaining to criticality were introduced into our Quality Methods as well as into daily conversations. In-house training was supplemented by training from experts in several week-long sessions. Shop floor personnel and supervisors were involved in this training.

We recognized that the primary response to a change stimulus of this order could result in fear and anxiety, and that without taking serious account of the dynamics of these often unstated fears and anxieties the enterprise would likely be doomed. Thus, we addressed anxiety issues first. We developed enabling conversations where such anxieties could be stated without fear and where constructive proposals would not be derailed. We built on the several years we had spent in developing mission and values with the involvement of all our co-workers. Following Zircatec's philosophy of using cross functional teams the people affected by the process were involved in all decision making regarding process set-up, the criticality controls to be established as well as the "what if" analyses.

We engaged criticality experts to help us through the process, our team leaders supplemented their expertise with their intimate knowledge of our people and our processes.

The success of our designs and our accomplishment of our internal targets is a direct result of this process.

5. Current Status

ZPI has completed definition of the Program Elements and most of the sub-elements have been completed in draft form. Details of NCSE methodology have been refined and the evaluations are proceeding apace. Licensing activities are on target.