Integration Of Criticality Alarm System At A Fuel Manufacturing Facility

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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.

As the primary fuel supplier to the reactor site that has chosen to utilize this new fuel design, Zircatec has agreed to manufacture and supply this new fuel at their facility in Port Hope, Ontario. Under this agreement, Zircatec is challenged with converting a fuel manufacturing facility to include the processing of enriched uranium. The challenge is to introduce the new concept of criticality control to a facility that traditionally does not have to deal with such a concept. One of the elements of the implementation is the criticality detection and alarm system – CIDAS.

Since a criticality could go undetected by human senses, one of the methods of ensuring safety from radiation exposure in the event of a criticality is the installation of a criticality incident detection and alarm system. This early warning device could be the difference between low dose exposure and lethal exposure.

This paper describes the challenges that Zircatec has faced with the installation of a criticality incident detection and alarm system. These challenges include determining the needs and requirements, determining appropriate specifications, selecting the right equipment, installing the equipment and training personnel in the operation of the new equipment.

Key Words: criticality, alarm, fuel fabrication, Zircatec.

1 INTRODUCTION

In response to the Power uprate program at Bruce Power, Zircatec committed itself in the spring of 2003, to introduce by the 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 is the first change since the introduction of the current 37 element fuel over 20 years ago.

As the primary fuel supplier to the reactor site that has chosen to utilize this new fuel design, Zircatec has agreed to manufacture and supply this new fuel at their facility in Port Hope, Ontario. Under this agreement, Zircatec is challenged with converting a fuel manufacturing facility to include the processing of enriched uranium. The challenge is to introduce the new concept of criticality control to a facility that traditionally does not have to deal with such a concept. One of the elements of the implementation is the criticality detection and alarm system – CIDAS.

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This paper is not a technical paper but rather an information paper. The objectives of this paper are to detail the following:

1. Give a brief background of Zircatec;
2. Describe the changes at Zircatec that gives rise to the need of a CIDAS;
3. Share some of the processes Zircatec wrestled during the CIDAS selection process; and,
4. Share the status of the new system with respect to impact on the culture at Zircatec.

2 BACKGROUND OF ZIRCATEC

Zircatec Precision Industries has operated a fuel fabrication facility in support of the Canadian CANDU fuel requirements since 1957. Primarily, Zircatec has manufactured CANDU fuel bundles from natural uranium dioxide (UO_2) powder, Zircaloy and other materials.

While Zircatec possesses the only enriched fuel fabrication license in Canada, the majority of the enriched work was to cater to the small research jobs such as booster reactor fuel for research cores.

Our criticality control program consists of small number of trained and knowledgeable people who work in heavily administrative control processes. The material handling process includes such controls as:

1. Dedicated areas – layout of Criticality Control Zones (CCZs);
2. Material accounting – into and out of CCZs;
3. Complete clean down after each project/enrichment; and

4. Nuclear Measurements Corp (NMC) GT-2T0 Gamma Alarm.

Currently, our new project requires tests of pressing and sintering of 1 wt% material. Quantities are << 0.1 SCM. Other recent projects include:

1. 1998: 2.26 wt% down blending and bundle manufacture ~ 0.3 SCM;
2. 1997: Slowpoke research reactor core ~ 19.89 wt% and 1.2 SCM;
3. 1994: 2.25 wt% test bundles ~ 50% SCM; and
4. 1993: 2.28 wt% test bundles ~ 75% SCM.

3 CHANGE

In response to our client's uprate program, Zircatec has committed itself to introduce by the spring of 2006 a manufacturing line for the production of a new fuel design – CANFLEX. The new fuel design incorporates 43 elements. The 42 outer elements will utilize 1 wt% enriched uranium dioxide with the centre element utilizing natural uranium with dysprosium (burnable poison).

The new fuel line will need to produce approximately 125 bundles per day (2750 kg UO_2). This will deviate greatly from our natural line and our small scale enriched processes. With the significantly larger enriched quantities on site, the current methods of criticality control are no longer economically feasible. The new production line will deviate from an administratively controlled process to a process with greater reliance on worker knowledge and engineering controls.

When administration must take a back seat, and the greater reliance on the worker and engineering controls is required, is criticality detection still warranted or more warranted?

4 CIDAS SELCTION PROCESS

4.1 Criticality Detection

In Canada, there are no regulations regarding the handling of enriched work. Since very little is performed in Canada, there has been little impetus for change. It is left to the licensee, under its due diligence, and radiation safety regulations, to ensure that the worker, environment and public are adequately protected.

Historically, Zircatec typically handled enriched uranium with enrichments of 2.2 wt% and greater. Even though in most cases the total quantity of material was less than one SCM, Zircatec had a "criticality detector". Many international standards don't require the use of a criticality monitor for enrichments at 1 wt% and below. When deciding on criticality detection, will these international standards be accepted by the regulator, or even the Zircatec work-force?

In May of 2003, Zircatec decided it would be easier to install a criticality detection system rather than put a case together to explain why it was not needed. Zircatec decided that following an internationally recognized standard would uphold the company's due diligence and to meet the scrutiny of the regulator. ANSI/ANS-8.3-1997: "Criticality Accident Alarm Systems" was the obvious choice.

It proved to be a correct choice as in April 2005 the regulator solidified its position on the requirements it will be using when evaluating criticality related safety issues, including the use of criticality detection, associated with Zircatec's proposed SEU fuel project. The regulator required ANSI/ANS-8.3-1997: "Criticality Accident Alarm Systems" be followed for Zircatec's new production line. The regulator also invoked two additional requirements to the standard, they are:

- A criticality alarm system shall be installed in each area where enriched uranium is handled, processed, or stored; and
- The criticality alarm system in each area shall include two radiation detectors.

4.2 System Selection

In spring of 2003, and after the decision that a criticality detection system is warranted, the selection process began. Two Requests for Quotation (RFQ) were issued to two manufacturers of criticality detection equipment.

Both companies bid on the project, both companies met the requirements of the ANSI/ANS standard. The positive and negative sides for each quotation are summarized in the Table I.

Based upon the features and price of the two quotations, System #2 was selected.

Table I. Criticality Detector Vendor
Description and System Pros & Cons

System	Description	System Pros	System Cons
#1	Each Criticality alarm system is an enclosure (detector unit / logic unit). Enclosures are connected together. Each enclosures is placed in areas where enriched material is handled	One unit (enclosure) must be purchased for each enriched work area.	Criticality detectors are not stock items, therefore must be ordered early in factory design. It may be unclear how many are needed until factory design is complete.
		Similar design to household smoke detection system (hardwired at time of home building)	Each unit is expensive. Approximately $100k per unit.

		of home building). When one enclosure detects and alarms, all enclosures alarm.	Installation could be labour intensive.
			12 work areas = $1.2M. Each additional work area = $100k
#2	Criticality system is console based with rings of detectors that are positioned where enriched material is handled	Main console is heart of system- rings of detectors are placed in work areas	Installation could be labour intensive.
		Detectors are in-expensive	Criticality detectors are not stock items, therefore must be ordered early in factory design. It may be unclear how many are needed until factory design is complete.
		System can be expanded at any time with minimal cost	
		12 work areas < $500k Each additional work area = ¢	
		Main console can be placed in area away from enriched work.	

4.3 System Commissioning

From initial purchase through to commissioning took the following chronology:

1. The system was purchased in May 2003.
2. Factory acceptance testing occurred in September 2003.
3. Equipment was shipped to Zircatec in November 2003.
4. Installation commenced March 2004.
5. Vendor commissioned the system August 2004.

From initial purchase order to commissioning of the system took 15 months. Of that, there was approximately 4 months of idle time between receipt of the system and the beginning of installation. The commissioning of the system could have been in the order of 11 months had the installation been expedited.

During the commissioning of the system, there were quite a bit of additional features offered by the system that integrated well with the needs of Zircatec. Some of the features are as follows:

1. Second wave generator – was offered by the vendor for use with an in-house "alpha-in-air" monitoring system. Zircatec is currently evaluating the use of this second generator for its Hydrogen detection system as a plant wide alarm.
2. 24 hour emergency battery back-up – the system was designed to have a bank of batteries located with the console to ensure that criticality is monitored even during a power failure.
3. Emergency paging system – the system can its loudspeaker system as a public address system for emergency use. In the event of a power failure, the system has 24 hour emergency back up.
4. KOWL – Keep Out Warning Light system can be used in lieu or in addition to loudspeakers in potentially noisy areas.
5. "Confidence Click" – the system incorporates an audible "click" to inform the workforce that the system is operational and monitoring as required.

4.4 Training

With any new system, the workforce needs to be made aware and have understanding of the new safety equipment. The training of the workforce and the operators who will have to work with the system was accomplished with little effort.

During the commissioning of the system, the vendor trained all maintenance personnel, Zircatec's Criticality Control Committee, and the Health Physics Department. The largest and most difficult part of training was informing the workforce about the new "Confidence Click".

4.5 Safety Culture

Zircatec's new criticality detector has become our "poster child" for critical safety systems. In particular, the "confidence click" is used as a model to develop other safety systems. This proactive approach to monitor the system's status will be applied to other safety systems. Rightly or wrongly, our criticality detection system is considered by many as our most important safety devices. It is nice to "know" and not presume that it is working all the time.

Faults have occurred with the system. The system operated as designed. The "confidence clicks" stop when a fault is detected. Even though the clicking has blended into our background noise, many operators alerted when the clicking stopped to raise a flag to the fault that had occurred.

5 CONCLUSIONS AND SYSTEM STATUS

Since commissioning, the system has operated as it has been designed. Several faults have occurred that have been attributed to routine operations. Fortunately the system has not been tested for which it has been designed. The “confidence click” has been embraced by the workforce.

One interesting side-note, Zircatec’s workforce has suggested that the “confidence click” may be also used as a subliminal working beat. The workforce would uncontrollably work to the beat of the clicking. Over time, it is suggested, that management would slowly increase the frequency of the clicking, thus speeding up production. This information has been passed onto the vendor for future designs.