Zircatec
Precision Industries Inc.
A Cameco Company

Cameco

# Integration of Criticality Alarm System in a Fuel Fabrication Plant

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AEN NEA Agence pour l'énergie nucléaire
Nuclear Energy Agency

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# Introduction

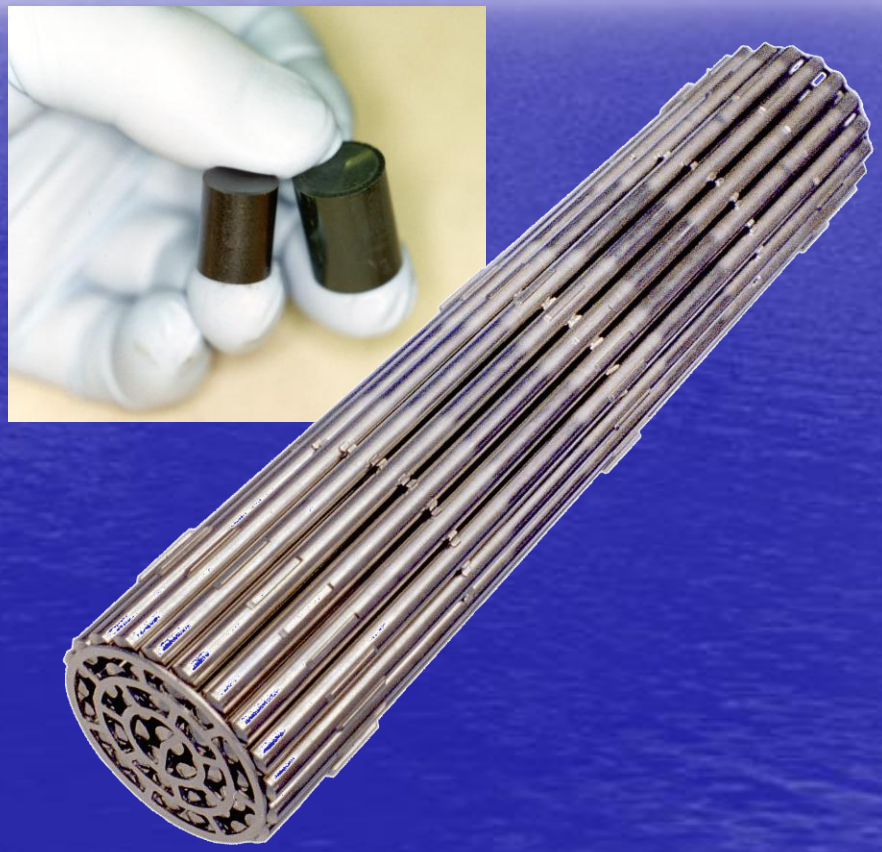
- This presentation is not a technical presentation but rather an information presentation.
- Zircatec Precision Industries has recently purchased a Criticality Incident Detection Alarm System (CIDAS).
- The purpose of this presentation is to:
  - Introduce to you what Zircatec has historically manufactured.
  - Describe to you what has changed to give rise to the purchase of the CIDAS.
  - Share with you some of the process Zircatec went through when selecting a new criticality detection system.
  - Share with you the status of the new system at Zircatec and how it has impacted the culture at Zircatec.

# The ZPI Plant

- Zircatec Precision Industries operates a Nuclear Fuel Fabrication Facility.
- The facility is located in Port Hope, Ontario, 45 minute drive east of Toronto on the north side of Lake Ontario.

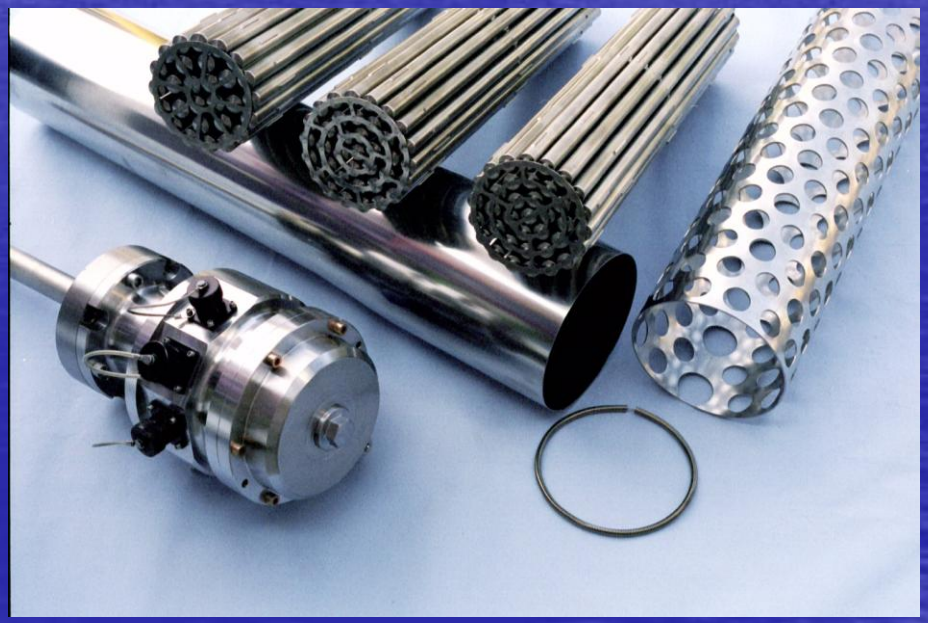
# Background

- Primarily Zircatec manufactures CANDU nuclear fuel bundles from natural uranium dioxide ($UO_2$) powder, zircaloy tubing and other materials.
- Primarily supplies to the Canadian CANDU market.



# Background

- We are the only supplier of reactivity control mechanisms (primarily zirconium based).
- Shut-Off and Adjuster Rods
- Flux Detectors
- Injection Nozzles
- Guide Tubes
- Liquid Zone Controls
- Calandria Tubes
- Garter Spring Spacers



# Our Past

- Zircatec has the only enriched fuel fabrication license in Canada.
- We cater to small jobs – booster reactor fuel to research reactor cores.
- Strong administrative structure exists at Zircatec for the handling of limited amounts of enriched material
- Existing license allows:
  - Up to 5% EU
  - Up to 5 Smallest/Spherical Critical Mass (SCM) on site, 0.9 SCM in-process.
  - No solutions
  - Special License for > 5% or > 5 SCM

# Our Past

- Small number of trained and knowledgeable people.
- Heavily reliant on Administrative controls.
- Dedicated areas - Layout Criticality Control Zones (CCZ).
- Material Accounting in/out of CCZ.
- Material Log in/out of CCZ.
- Complete clean down after project.
- Old gamma detectors act as a criticality alarm system.

# Our Past

- Currently – SEU tests conducted on pressing and sintering 1% pellets <<0.1 SCM
- 1998 – 2.26% EU down blend and bundle manufacture in test bundles ~ 0.3 SCM
- 1997 – Slowpoke research reactor – 19.89% EU under Special License ~ 1.2 SCM
- 1994 – 2.26% EU test bundles ~ 0.5 SCM
- 1993 – 2.28% EU test bundles ~ 0.75 SCM

# Change

- New project.
- Significantly larger SEU inventory in plant will be required.
- Will require larger SCM limits than current.
- Greater reliance on worker to work safely – need to engineer a critically safe work environment.

# Change

- Response to power up-rate program at Bruce Power.
- ZPI committed to introduce a manufacturing line for the production of a new fuel design.
- New fuel design is called CANFLEX.
- Utilizes 43 element design.
- Outer 42 elements use 1.0 wt% (possibility of 1.2 wt%).
- Centre element use natural uranium and dysprosium.

37 Element

43 Element

# Change

- Zircatec is the primary fuel supplier to Bruce Power.
- Zircatec agreed to manufacture the new fuel design.
- New plan will require production of 125 bundles per day (2750 kg $UO_2$ per day).
- This production capacity cannot rely on heavy managerial oversight.
- Many challenges with changing a manufacturing facility from natural uranium to a facility that includes enriched uranium.
- New criticality detection system must be reviewed.

# Criticality Detection Requirements

- Who are our stakeholders with respect to criticality safety?
- Regulators
  - What are the regulations?
  - What will the regulator want?
- Workforce
  - What is the Political Climate?
  - What are the expectations of the workforce?

# Regulator

- At the beginning of the project, there were no regulations, standards or guides in Canada regarding criticality detection requirements (the requirements would come later).
- Don't know how regulator would respond to the use of system that does not meet a reliable standard.
- Current work performed with use of criticality detection system.

# Workforce

- Current workforce is familiar with a criticality warning system.
- Even though processing at 1 wt%, past work "relied" on detection system.
- Knowing that current equipment is dated, the question could be asked: "If you invest in new production equipment, shouldn't you invest in new safety equipment?"

# CIDAS or Not

- May be seen by both regulator and workforce as greater enriched material in a full production system will mandate a more robust criticality detection system.
- It was suggested that it would be far to expensive in time to try to convince the regulator and workforce why we don't need a CIDAS.
- Corporate decision was made to install new criticality detection system to quell potential concerns from regulator and workforce.

# Selection

- Due Diligence
  - Since no regulation or standard exists in Canada – must look for suitable standard.
  - ANSI/ANS-8.3-1997 "Criticality Accident Alarm System" was the logical choice.
  - Internationally recognized standard.
  - Any system that meets this standard *should* meet any concern or future legal requirements of the regulator.

# Selection

- Quotes received from two manufacturers.
- Both meet ANS standards.
- Basic Designs
  - System 1: criticality alarm system are paired enclosures (detector unit / logic unit) detector units that are connected together – each paired enclosures are placed in an area where enriched material is handled.
  - System 2: criticality system is console based with rings of detectors that are positioned where material is handled.

# Selection

- System 1 pros and cons:
  - Pro – a unit must be purchased for each enriched work area.
  - Pro – similar design to household smoke detector system (hard wired into homes). When one instrument alarms – they all alarm.
  - Con – need to purchase equipment early in factory design. Unclear how many units are required for coverage. Need final factory layout to perform shielding calculations.
  - Con - each unit is expensive, so final cost is not easy to determine until final plant layout. Initial estimate was approximately $1M plus $100k for each additional work area.
  - Con – Installation could be seen as labour intensive.

# Selection

- System 2 pros and cons:
  - Pro – main console is heart of system – rings of detectors are placed in areas of enriched work. A master/slave set up.
  - Pro – detectors are inexpensive – system can be expanded at any time with minimal cost.
  - Pro – whole system is not as expensive as system 1 – approx $350k.
  - Pro – main console can be placed in area away from enriched work for easy maintenance.
  - Con – initial installation could be seen as labour intensive.

# Selection

- System 2 was purchased by Zircatec in May 2003.
- Factory acceptance testing September 2003
- Ship date November 2003
- Installation started March 2004
- Commissioned August 2004
- 15 months from purchase to commissioning.

# Selection

- Bonuses:
  - Second wave generator – will be used for either alpha in air monitoring system or hydrogen leak detection system or any other critical safety system the end user may have.
  - 24 hour battery backup.
  - Emergency Paging system via loud speaker system.
  - Keep Out Warning Light system.
  - Confidence Click (audible pipping sounds) informs the workforce that the system is functioning correctly. Pipping stops to alert of a detected fault.
  - Easy to 'trip' wave generator for weekly announcements to workforce.
  - System logic auto-testing.

# Training

- Training was easy.
- Maintenance and Criticality Control Committee were trained on operation and maintenance of equipment.
- Done at the time of commissioning.
- Biggest part of training was informing the workforce about the new Confidence Click that was broadcasting over the loudspeaker system.
- Workforce had to train themselves to allow the Confidence Click to blend into background.

# Operation

- Since commissioning, the criticality monitoring system has worked as described.
- Fortunately we have not had to test it under intended conditions.
- Workforce has embraced the Confidence Click.

# Safety Culture

- The CIDAS system 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 indicate the system's status is applied to other safety systems.
- Recently, an critical safety system was tested only to find out that a fuse had blown. It was unknown how long we were without the safety system.

# Safety Culture

- Faults have occurred that caused the CIDAS to turn off the Confidence Click. This was immediately evident to many of the workforce.
- The faults were diagnosed and corrected – the Confidence Click was returned.
- No preventative maintenance order was relied upon to find the fault an unknown number of days after the fault.

# Safety Culture

- The supplier has "reassured us that the Confidence Click will easily blend into our safety culture as it has done with all of the other facilities that are currently using it. The CIDAS system is considered one of the most important safety devices we have – it is nice to ***know*** and not ***assume*** that it is working all of the time".
- The workforce has embraced this system.

# Safety Culture

- Interesting side note.
- Our workforce suggested that the Confidence Click is a subliminal working beat.
- Over time they have suggested that management would slowly speed up the beat.
- This would increase productivity.

# Photos – Main Consoles

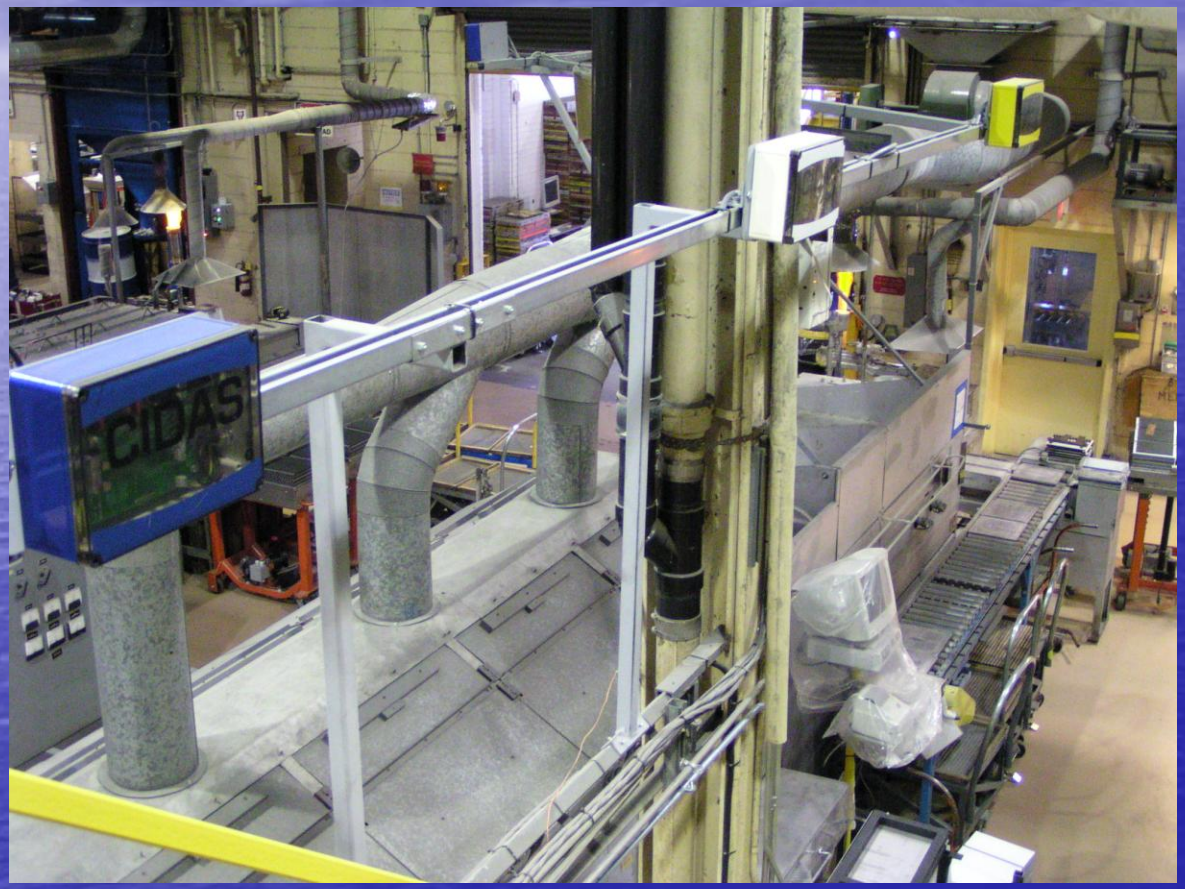
# Photos – Main Consoles


# Photos – Loud Speakers


# Photos – Paging System

# Photos - KOWLs


# Photos - Detectors



# For More Information

- If anyone is seriously considering the purchase of a Criticality Alarm system – please feel free to contact me regarding Zircatec's experience.
- A on site display of our system can be arranged if required.
- The purpose of this presentation is to share my experience in the purchase of this system with anyone who wants it.
- Contact:
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