Technical Reports

Safety Report - Public Summary

Blind River Refinery

Safety Report

Cameco Corporation's (Cameco) Blind River Refinery (BRR or site) is located about 5 km west of the Town of Blind River, Ontario and adjacent to the Mississauga First Nation. While the secured, CNSC-licensed site, has a relatively small footprint, the property owned by Cameco Corporation is significantly larger, bounded to the north by the railway line, to the west by the Mississagi River and to the south by Lake Huron. Cameco has also leased from the Town of Blind River additional lands to the east of the existing property boundary as a buffer. The nearest residence is located approximately 1 km NE of the refinery.

The protection of the environment and health and safety of persons is a fundamental principle of the *Nuclear Safety and Control Act*, its regulations and the regulatory approval process. The BRR operates under a fuel facility operating licence from the Canadian Nuclear Safety Commission (CNSC) to process uranium that is used in the fuel for nuclear power generating stations. A requirement of that licence is that Cameco must regularly review and update a safety analysis report, which identifies potential hazards at the operation and outlines how the facility will prevent and mitigate their potential impact on people and the environment.

The detailed descriptions of process equipment and controls and other information contained within the Safety Report for the BRR (Safety Report) is prescribed information, controlled nuclear information pursuant to the *Nuclear Non-proliferation Import and Export Control Regulations* or information that is exempted from disclosure under the *Access to Information Act*, and therefore cannot be made publicly available. This summary provides an overview of the methodology and results of the assessments described in the Safety Report, which was reviewed and accepted by CNSC Staff in 2016.

Methodology

Hazard risk assessments and safety analyses are now the cornerstone of process safety management throughout the world. This is a widely accepted method and practice used by industry and regulators to assess the risk and potential impact from plant operations.

A safety analyses of the BRR was done prior to commissioning the UO3 plant in 1983. Since then, Cameco has continually strived to improve the safety of operations as new technology and information has become available. In 1999 Cameco elected to review the BRR design using the Hazards and Operability (HAZOP) study technique as their method of process hazard assessment (PHA). The HAZOP methodology was determined to be the most appropriate and comprehensive technique for the BRR, given the nature of the operation.

The HAZOP study did not bring to light any previously unidentified safety concerns of significance. A structured design control system has since been established to review and assess current and future operational changes.

Design reviews are done prior to making any plant modifications that may affect the safety case for the refinery. The site safety report is periodically updated to include the findings from design reviews completed since the last revision to the report.

Defence in Depth

Cameco's safety systems are built on the Defence-in-Depth concept. Defence in Depth is a multiple barrier approach, which was applied throughout the design and construction of production buildings and continues to be applied during the operation of the BRR. It is intended to eliminate or minimize the potential of radiological, chemical or other physical hazard to facility personnel, the environment and the general public. This is accomplished through implementation of safety features and systems which can prevent hazards and/or ensure appropriate protection in the event that the prevention measure fails. The systems also allow the failure to be detected and compensated for or corrected, and consider organizational and human performance. Many of these features and systems are independent and redundant.

The defence-in depth model depicts how the emergency planning process begins long before activation of the site and community emergency plans. Safety systems comprise many barriers from design through to containment systems that are implemented before emergency response as illustrated in Figure 1.

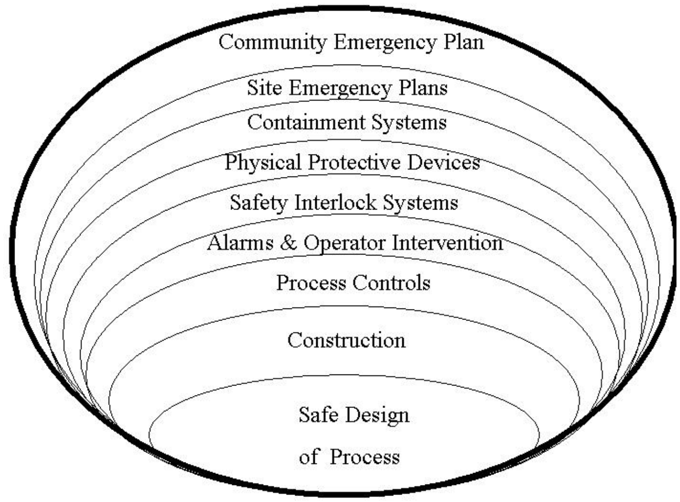

Figure 1

Overview of the Safety Analysis for Cameco's Blind River Refinery

Safety Analysis – Operations

In the refining process, nitric acid is added to uranium concentrate to produce a uranyl nitrate solution. Impurities are removed from the uranyl nitrate solution using a solvent extraction process. The purified uranyl nitrate is then heated and concentrated, producing a nuclear-grade uranyl nitrate hexahydrate (UNH) liquid. This UNH is thermally decomposed to form uranium trioxide (UO_3) powder. The UO_3 is stored and shipped in specially designed bulk containers called tote bins, containing approximately 9.5 tonnes of uranium each, to Cameco's Port Hope Conversion Facility (PHCF) for further processing. The UO_3 can also be stored in steel drums for shipment to other customers.

Two recyclable products of the refining process are regeneration product – formed in the solvent treatment circuit; and calcined product – produced in the DRaff circuit. Both of these products contain recoverable uranium and are shipped off-site to other licensed facilities for uranium recovery.

UO3 Plant Safety Systems

The following safety systems are used in the design and operation of the UO_3 plant to ensure that workers, the public and the environment are protected.

Engineered Barriers:

- Back up (spare) equipment
- Emergency shutdown systems
- Leak detection systems
  - Smoke detectors
  - Freon detection
  - Uranium in air monitors
- Instrumentation systems
  - Level, pressure, temperature, flow and other indicators and alarms throughout the process – significant parameters are also appropriately interlocked to maintain a safe state
  - Redundant instrumentation
  - Fail safe valves
- Emissions control
  - Dust and fume collection lines
  - Bag houses
  - Fume scrubbers and demisters
  - HVAC systems in place
  - Continuous emission control systems
- Design controls
  - Liquid containment and management
  - Pipe specifications
  - Overpressure prevention/safety relief devices
  - Explosion-proof wiring
  - Dust collection systems
  - Pressure boundary program for vessels and piping
- Emergency power for safety significant equipment and systems
- Fire protection systems (including 3rd party reviews as required)

Administrative Barriers:

- Quality Management System
  - Change management
  - Interlock management
- Operator training and qualification
- Operating procedures
  - Defined operating parameters
- Process monitoring
  - Operator care rounds
  - Facility fire inspections
- Additional operating controls
  - Housekeeping procedures
  - Dust and fume collection line cleaning procedures
  - Product approval process
  - Use of compatible materials in processing areas
- Preventative maintenance and NDE programs for safety significant systems
- Monitoring Programs
  - Environmental monitoring program
  - Radiation protection program
  - Fire Safety Program and Fire Hazard Analysis
- Emergency Response Plan and on-site emergency response capability 24/7
  - Testing and drills
  - Spill kits available

Safety Analysis – Support Services

Bulk Chemical Storage and Handling

Bulk chemical storage and handling operations deal with the unloading, transportation and/or storage of various substances used by the BRR. Many of the potential hazards associated with bulk chemical storage and handling operations involve leaks, spills or releases of materials that could occur in outside areas.

There is one main chemical storage tank farm located adjacent to the south side of the powerhouse. The tank farm was constructed for containment.

Bulk Chemical Storage and Handling – Safety Systems

The following safety systems are used for bulk chemical storage and handling activities to ensure that workers, the public and the environment are protected.

Engineering Barriers:

- Fire protection program (including 3rd party reviews as required)
- A designated truck unloading station, draining into the stormwater collection system.
- Bulk chemical storage facilities, including fill lines, are located within secondary containment structures
- Nitric and phosphoric acid tanks equipped with pressure relief valves, rupture discs and a pressure regulator on the air supply line
- Product transfer hoses are designed to withstand pressures substantially greater than the rupture pressure of tanker's safety relief valves and redundant valves are installed on tanks to prevent leakage from fill lines when not in use.

Administrative Barriers:

- Quality Management System
    - Change management
- Operator training and qualification
- Material Handling procedures
- Additional administrative controls
    - Chemical unloading is an attended operation
    - Designated truck route
    - Tankers are escorted on site
- Preventative maintenance and NDE programs
- Fire Safety Program and Fire Hazard Analysis
- Environmental Monitoring Program
- Emergency Response Plan and onsite emergency response capability 24/7
    - Spill kits available
    - Testing and drills

Powerhouse

The powerhouse produces steam and compressed air for various uses throughout the BRR. Powerhouse engineers also look after most of the plants water systems including the sewage treatment plant.

Natural gas is used as the primary fuel for the steam boilers. No. 2 fuel oil is used as a backup fuel for the boilers and for the powerhouse emergency electrical power generator.

Sanitary wastes from the BRR are treated in an on-site biological treatment plant with chlorination of treated effluent.

Powerhouse – Safety Systems

The following safety systems are used for the powerhouse to ensure that workers, the public and the environment are protected.

Engineering Barriers:

- Fire protection systems (including 3rd party review as required)
- Design controls
    - Extensive safety relief valve protection in place
    - Overpressure prevention devices
    - Pipe specifications
    - Pressure boundary program for vessels and piping
- Instrumentation systems
    - Interlocks are in place to minimize potential for error
    - back-up air compressor will start automatically if main compressor fails

Powerhouse – Safety Systems (continued)

- Leak detection systems
    - Secondary containment for fuel oil and glycol tanks
    - Conductivity alarms on condensate returns from heat exchangers
    - pH and high level alarm and neutralization sump

Administrative Barriers:

- Quality Management System
    - Change management
    - Interlock management
    - TSSA registered steam and compressed air systems
- Powerhouse engineer training and qualification
- Powerhouse operating procedures
    - Defined operating parameters
- Preventative maintenance and NDE programs
- Monitoring Programs for water quality and STP performance
- Condensate quality monitoring
- Emergency Response Plan and onsite emergency response capability 24/7
    - Testing and drills
    - Spill kits available

Incinerator

The Blind River Refinery, Port Hope Conversion Facility and Cameco Fuel Manufacturing operations generate a small volume of solid low-level radioactive waste. This material is incinerated at the BRR in an industrial, natural gas-fired incinerator. The incinerator ash produced is drummed and stored on site. The waste materials received from the two Port Hope sites are shipped and received in flexible intermediate bulk containers (FIBC) that meet all transport regulations.

The incinerator and associated air pollution control circuit are located in an area adjacent to and south of the powerhouse.

Incinerator – Safety Systems

The following safety systems are used for activities related to the operation of the incinerator, to ensure that workers, the public and the environment are protected.

Engineered Barriers:

- Back up (spare) equipment
- Emergency shutdown systems
- Leak detection systems
    - Smoke detectors
- Instrumentation systems
    - Level, pressure, temperature, flow and other indicators and alarms throughout the process – significant parameters are also appropriately interlocked to maintain a safe state
    - Redundant instrumentation
    - Fail safe valves
- Emissions control
    - Bag houses
    - Fume scrubbers and demisters
    - HVAC systems in place
    - Continuous emission control systems
- Design controls
    - Liquid containment and management
    - Pipe specifications
    - Overpressure prevention/safety relief devices
    - Dust collection systems
    - Pressure boundary program for vessels and piping
- Emergency power for safety significant equipment and systems
- Fire protection systems

Administrative Barriers:

- Quality Assurance program
    - Change management
    - Interlock management
- Operator training and qualification
- Material handling procedures
- Additional administrative controls
    - Area operating manual
- Preventative maintenance
- NDE program
- Environmental Monitoring Program
- Emergency Response Plan and onsite emergency response capability 24/7
    - Testing and drills
    - Spill kits available

Liquid Effluent

Condensed vapors (distillates) from the nitric acid concentrators, jet educator steam and cooling water is recycled through a treatment circuit where it is separated into pure distillate and soft water. Pure distillate is recycled back to the process. Soft water is oxidized to decompose entrained organics and nitrite, mixed with lab sink wastes and treated by ultraviolet (UV) photo-oxidation reactors to destroy any traces of cyanide and mixed with chloride circuit scrubber water prior to pH adjustment. This treated effluent is combined with backwash settling pond decant, powerhouse neutralization sump discharge and sewage treatment plant liquid effluent and pumped to one of three process effluent lagoons. Filled lagoons are sampled, analyzed, and if acceptable, discharged on a batch basis to the North Channel of Lake Huron via an outfall pipe diffuser.

Precipitation from refinery roof areas, tank farm dykes and the paved yard areas are collected as potentially contaminated effluent and directed to a storm water lagoon, where it is retained and monitored prior to discharge. If suitable for discharge to Lake Huron, lagoon contents are transferred to one of the process effluent lagoons and from there, discharged.

Liquid Effluent – Safety Systems

The following safety systems are used for the liquid effluent circuit to ensure that workers, the public and the environment are protected.

Engineering Barriers:

- Fire protection systems (including 3rd party review as required)
- Design controls
  - Lagoons are adequately sized and designed to overflow into the adjacent lagoon, limiting the risk of overflow of a lagoon to the environment.
  - Lagoons have PVC liner to minimize risk of leakage to the ground.
  - The storm water transfer system has three pumps to provide redundancy
  - Precipitation or run-off from paved areas is collected in the storm water lagoon
  - Permanent and portable containment dykes and absorbent materials are provided for chemical totes and containers in storage.
- Instrumentation systems
  - UV reactor doors and fan covers are equipped with interlocks, which shut down UV lamps upon opening, and UV filters are installed on reactor inspection ports to protect workers.
  - On-line pH and turbidity meters in effluent pump house to monitor effluent quality.
  - At various points in the process, the equipment utilizes redundant instrumentation with alarms and interlocks (e.g. temperature, flow, level) to ensure that a process upset or equipment failure is immediately identified.

Administrative Barriers:

- Quality Assurance program
  - Change management
  - Interlock management
- Operator training and qualification
  - Area routinely monitored by operations personnel
  - Routine sampling and analysis of effluent going into the lagoons and prior to discharge
- Groundwater monitoring program, including monitoring stations in the vicinity of the lagoons to detect changes on groundwater quality.
- Lagoon isolated prior to and during discharge so no effluent discharged prior to analysis. Effluent analysis completed on-site by qualified lab technicians.
- Pressure drop across coalescers used to remove entrained solvent in effluent treatment circuit are checked and solvent is bled regularly to ensure their continued operation and to maintain good effluent quality.
- Preventative maintenance for safety significant systems
- Emergency Response Plan and on-site emergency response capability 24/7
  - Testing and drills
  - Spill kits available

Safety Analysis and Planning for Emergencies

Assessment of Potential Releases for Emergency Planning

The Safety Report evaluated all of the major processes at the BRR to identify potential process upsets and credible accident scenarios that could result in releases to the environment. Since liquid effluent is discharged on a batch basis after analysis, releases to air were considered to be more credible. The two contaminants considered are uranium and oxides of nitrogen (NOx). The release scenarios were established through a review of the upsets considered in the initial site application and 30+ years of refinery operating experience to date. The analysis uses generally accepted air dispersion models to assess combinations of upsets and meteorological conditions potentially resulting in unacceptably elevated off site concentration.

Criteria for Off-Site Concentrations

For consideration of process upsets which are very infrequent and of short duration, it was determined that in addition to ambient air quality criteria, occupational exposure criteria would also be appropriate for comparison to predicted off-site concentrations, along with . Criteria utilized therefore, included not only values from the Ontario Ministry of the Environment and Climate Change, but also from the US National Institute of Occupational Health and Safety (NIOSH) and the US Occupational Health and Safety Association.

Accidental Release Scenario for Oxides of Nitrogen and Results

For a release of oxides of nitrogen, the most realistic scenario involved the failure of the absorber fume blower, resulting in an in-plant release that disperses within the main refinery building and exits via plant ventilation exhausts. Operator or automated response systems were assumed to be operational, including the stand-by blower, which will come on-line automatically within one minute of the failure of the main fume flower. It was further assumed that the release would occur for a full hour, though most of the release would likely occur in the first minute.

The results of the modelling exercise are summarized below:

- The maximum one-hour concentration predicted by the modeling would occur within the Cameco fence line and the concentration would not be immediately dangerous to the life and health of individuals.
- If the one-hour event were to occur during the least favorable meteorological conditions (i.e. the release would occur during the worst single hour from a five-year meteorological data set.), there is not anticipated to be any adverse effect on public health. The likelihood of an unplanned release occurring during the worst-case meteorological condition is very small (i.e.; 1 hour in 44,000 hours, or <0.01%). This means that should such a release scenario occur, 99.99% of the time it would **not** occur during the worst single hour from a five-year meteorological data set, therefore the resultant concentration and potential exposure to a member of the public would be further reduced.

Accidental Release Scenario for Uranium and Results

For a release of uranium, the most realistic scenario involves a release of 10 kg of uranium from the dust collection exhaust vent (DCEV), one of the two refinery process stacks, over a 24-hour period. It should be noted that it has been more than 25 years since a 24-hour release of this magnitude has actually occurred.

The results of the modelling exercise are summarized below:

- The maximum one-hour concentration predicted by the modeling would occur just beyond the north and NW fence line, but still on Cameco property and the concentration would be well below that immediately dangerous to life and health.
- If the event were to occur during the least favorable meteorological conditions (i.e. the release would occur during the worst single hour from a five-year meteorological data set.), there would be no adverse effect on public health. Again, the likelihood of an unplanned release occurring during the worst-case meteorological condition is very small (i.e.; 1 hour in 44,000 hours, or <0.01%). This means that should such a release scenario occur, 99.99% of the time it would **not** occur during the worst single hour from a five-year meteorological data set, therefore the resultant concentration and potential exposure to a member of the public would be further reduced.
- A 24-hour release of this magnitude would not be sufficient to impact the refinery's ability to meet the MOECC annual ambient air quality criteria for uranium.

Results from air dispersion modelling exercises such as this are used to assist Cameco in prioritizing its efforts to further reduce the potential for and potential impact of a release. Emergency response planning and continual improvement projects may include the improved detection of and/or response time to a release or engineered controls to prevent or mitigate a release.

Emergency Planning

Emergency planning is required for responding to hazards, actual or potential, that are identified in the Safety Report. Depending on type and magnitude of an incident, the site may activate any or all of the following response organizations for the protection of human health, the environment and property:

- Emergency Response Team;
- Emergency Response Organization;
- Local Crisis Management Team;
- Corporate Crisis Management Team; and,
- Crisis Assistance Team (Transportation events).

These organizations include personnel from all levels of the operations and support departments. In the event of an emergency, personnel will leave their normal assigned duties and assume their role in the appropriate response organization.

Emergency preparedness and response is broken down into two components: a planning function and a response function. Planning is responsible for the development and maintenance of the emergency planning and control program. This includes the preparation and periodic review of documentation, ensuring that the program meets regulatory and internal Cameco requirements, periodic testing of the procedures, personnel and equipment to ensure that the facility is in a state of readiness. The response function is initiated only in the event of an actual or potential emergency.

One aspect of emergency planning is a component that ensures that members of the public are kept informed of developments in the event of an emergency at the BRR with the potential for off-site impacts. The designated public information officer is responsible for liaising with the media and providing necessary information to the public to ensure that the impact of the emergency on the public is minimized.

In the event that urgent information needs to be communicated to the public, Cameco will request that the Municipality activate the Rapid Notify system, which automatically delivers a pre-recorded message to residents in the Town of Blind River and the Mississauga First Nation community.

Conclusion

Based on this report, Cameco believes that the risk to the public and the environment arising from the unplanned release of hazardous materials stored, processed and transported to and from the BRR has been mitigated. The current safety systems, procedural controls and abatement equipment in place mitigate risk effectively. Cameco is committed to ongoing improvement to minimize the risk to the public and to the environment in keeping with the As Low As Reasonably Achievable (ALARA) principal.