Journey to Reliability Excellence
The Story of Cameco's Port Hope Conversion Facility 2010-2016

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Introduction

Cameco is one of the world's largest uranium producers providing about 18% of the world's production from mines in Canada, the US and Kazakhstan. It is also a leading supplier of uranium refining, conversion and fuel manufacturing services required to generate fuel for electricity-generating nuclear reactors. Globalisation, soaring costs, and a number of other industry specific factors are forcing companies of all types to improve business processes and results, and ultimately, the bottom line. Cameco is not immune to this. For its Port Hope conversion facility, increasing reliability is deemed a key component to delivering value (if not survival) and therefore the site has invested heavily in reliability improvement.

The Port Hope conversion facility is located in the small community of Port Hope, Ontario approximately 70 miles east of the metropolitan of Toronto. It consists of two separate plants that each convert uranium trioxide (UO3) into one of two products. The first produces uranium hexafluoride (UF6) while the other produces uranium dioxide (UO2).

Faced with the question of whether its ageing assets would be able to meet future expected production demands, in 2008 an external consulting firm was brought to the facility to perform a 'reliability excellence' assessment. The assessment looked for various elements in place or the degree to which various elements were in place and working. On a scale of 0-100%, the facility scored a mere 31%. Two years later, Cameco's executives demonstrated their commitment to improving reliability by endorsing the necessary investment, and in November 2010 a journey was started that continues to this day. The journey was aptly named the Operational Reliability program.

Operational Reliability Program

Operational Reliability was chosen as the name of the improvement program because it was, and still is, believed that reliability is not merely one department's mandate, but an objective for the entire operation and therefore each of its constituent departments' responsibility. To this end, the program was structured around four focus areas determined to be the main pillars for improvement:

a) Materials Management,

b) Work Management,

c) Reliability Engineering, and

d) Operations Improvement

Improving reliability was not simply going to be the introduction or re-deployment of a new EAM system or CMMS, or depend on the purchase of any other software or devices. In fact it was clear early on that tools alone were not going to be sufficient to achieve desired sustainable results. Instead *processes, people, procedures and culture* were always stated as the path to success.

In terms of business processes, a main objective was to identify key processes in each area that affect reliability, whether existing or not. Those that existed were put through a 'brown paper' review processes to capture the 'as-is' state. The 'as-is' processes were then critiqued by focus teams and new 'to-be' processed were developed through a 'white paper' process. Non-existent processes went straight to the 'to-be' stage.

In order to accomplish this, employees were taken from all aspects of the business, from virtually all departments, and assembled in one of four 'Focus Teams', mirroring the four areas of improvement. It was felt that in order to develop the necessary culture, it would take ownership from employees. The business processes had to become 'theirs' so that they could truly be disciples of change amongst their peers. While mainly employee- owned, the initiative did receive coaching from the consulting firm specialising in reliability improvement initiatives in terms of suggesting a number of best practices.

While defining business processes and metrics was the ultimate goal, teams actually had to accomplish the following:

- Develop team charters with defined scope
- Perform 'as-is' process definition, review and critique (aka 'brown paper' exercise)
- Perform 'to-be' process definition and approval (aka 'white paper' exercise)
- Organised and host white paper fairs
- Develop RASCIs tables
- Define and implement performance metrics
- Develop training materials and implement (deliver training)
- Design and execute communication and engagement activities
- Where required, develop rudimentary tools & templates (e.g. production loss tracking system, care round sheets, scheduling template, etc.)

Materials Management

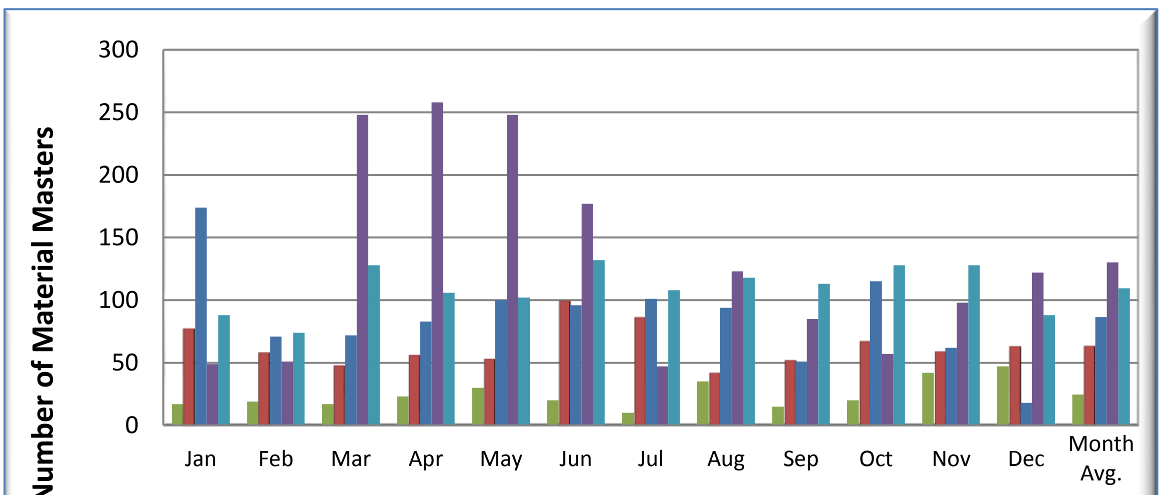
Materials Management, which includes direct buy and inventoried MRO materials and spare parts, was deemed a focus area because of the numerous ways in which improper materials management can compromise reliability. This includes poor performance of such materials and parts, as well as insufficient quantities. This focus team looked at the following areas:

- Material/Part master data processes and controls (creating or modifying)
- Purchasing of parts, materials, and services

- Receiving of parts and materials, include QA inspection
- Issuing parts and materials, including kitting and delivery
- Management repair and replace activities
- Returning parts and materials to inventory and/or vendor
- Inventory management, including entry criteria, min/max, and obsolescence management

One of the desired outcomes, and incidentally the area of most marked improvement and contribution for the Materials Management team, was on increasing use of the material reservation function in the EAM system. By communicating and training out this functionality, use of this process increased 400% over four years (see figure 2). This reduced traffic to the Stores wicket by operators and tradespeople and freed them up for better things. Improved use of the reservation system also enabled the kitting process (see figure 1) to take flight and allow the work scheduling process to stipulate that work was only scheduled once parts and materials were received, kitted, and delivered.

Figure 1 - New kitting process



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Month Avg.
2011	17	19	17	23	30	20	10	35	15	20	42	47	25
2012	77	58	48	56	53	99	86	42	52	67	59	63	63
2013	174	71	72	83	100	96	101	94	51	115	62	18	86
2014	49	51	248	258	248	177	47	123	85	57	98	122	130
2015	88	74	128	106	102	132	108	118	113	128	128	88	109

Figure 2- Improvement of the Material Reservation process

Work Management

Work Management, which for the most part is related to 'maintenance' work, was deemed a focus area because of the need to improve the efficiency of the maintenance work force so that additional work (such as missing preventive and predictive maintenance required to ensure reliability) could be performed with existing resources. This focus team looked at the following areas:

- Work identification, including backlog management
- Planning of work operations and tasks
- Acquisitioning (ordering, reserving) of parts, materials, and services
- Scheduling of work (weekly, daily)
- Permitting and job clearances
- Execution of work
- Feedback and close-out

The area of most marked improvement was in planning & scheduling. Prior to the program, this function was not officially recognised and therefore not standardised, not consistent, not measured, and not respected. Eight staff employees had the title of 'supervisor/planner' and all got involved in day-to-day issues.

Today, the site has three dedicated planner/schedulers, a dedicated shutdown planner/scheduler, a lead planner/scheduler overseeing the aforementioned, and four crew supervisors. Although they have a dual title, planner/schedulers and all within the organisation understand that planning is distinct from scheduling. Planner/schedulers follow identical processes which are measured, host weekly scheduling meetings, and do not deal with weekly break-in work.

Another area of improvement was in the creation of new work order status codes (see figure 3). In order to get a better understanding of the backlog, in terms of what work was still in need of planning, or waiting parts, or even ready to be scheduled, new codes were required. This allowed all involved in the management of maintenance work, in particular planners and Stores personnel, to have better visibility of their tasks. These improvements and many more have had a dramatic increase in work management efficiency. Schedule loading has gone from less than 80% of available trade hours to consistently 95%. Schedule compliance has risen from approximately 75% to consistently around 90%. The net result is approximately a 40% increase in scheduled work accomplished every week, from approximately 60% prior to 2010, to 85% today. (See figure 4)

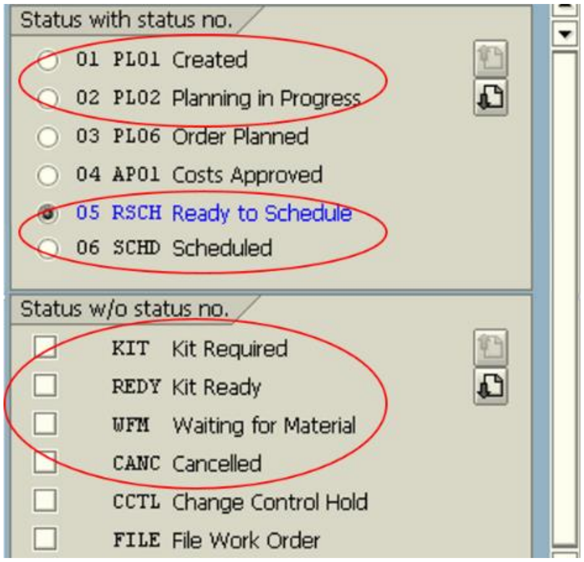


Figure 3 - New work order status codes

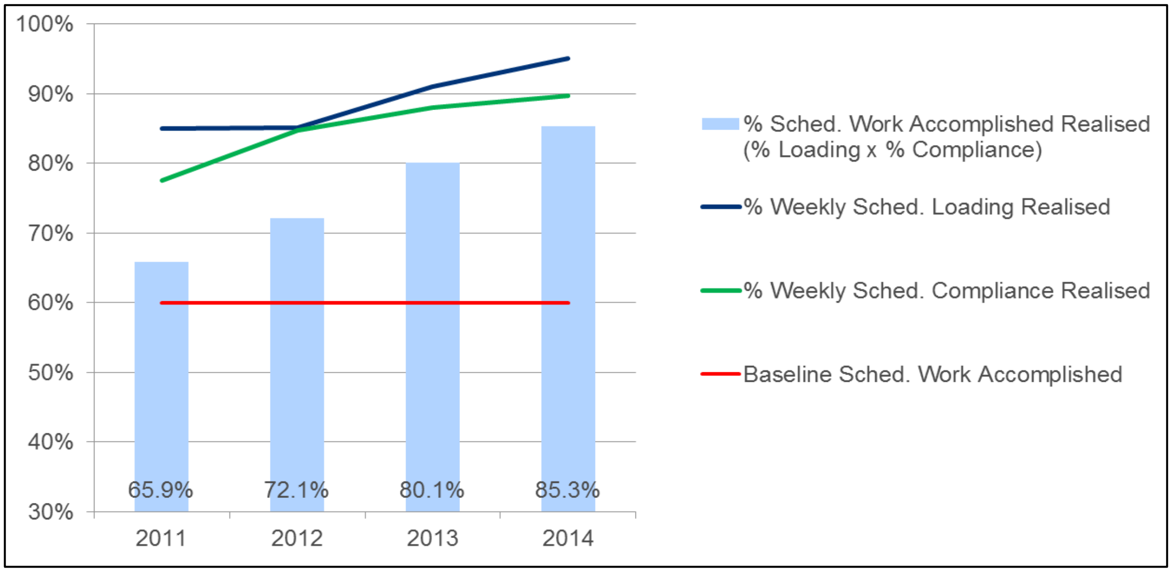


Figure 4 - Improvements in scheduled work accomplished

Reliability Engineering

Whereas Work Management focused on work *efficiency*, Reliability Engineering is about work *effectiveness* in terms of reaching reliability goals. To that end, this focus team looked at the following areas:

- Asset/equipment identification, including master data functions and hierarchy improvement
- Asset importance (criticality) ranking
- Development of operating and maintenance strategies, including use of RCM/FMEA techniques
- PM (Preventive Maintenance) Optimisation
- Loss elimination including root-cause analysis (RCA) of equipment failures

Figure 5 - Gathering master data

Soon after processes were identified, it was clear that a subject matter expert needed to be part of the organisation in order to own and properly execute several of the processes. In 2011 the site hired its first reliability specialist, a trained RCM practitioner and certified reliability professional.

Today the majority of assets have been ranked and efforts to perform, implement, and optimise analyses continues. Recommendations from analyses are reviewed with operations and actions with due dates assigned in the site's corrective action tracking database. But it was not always this way. In the beginning many people questioned the usefulness of the RCM process and struggled with devoting the necessary time to participate and/or review outcomes, and even complete their actions. Now when reliability issues manifest themselves, everybody is quick to reach out to the site specialist to ask whether a strategy was in place and if not whether an RCM session could be held. They fully engage in the process from start to finish and truly understand to potential for uncovering threats to reliability.

Finally, despite all the good work to prevent failures and other types of losses, RCA has been established as a fundamental tool to identify and eliminate failure modes.

Operations Improvement

The fourth and final area of focus, and arguably the area of most drastic change in terms of immediate impact on improving reliability, was led by operation teams in both production plants. These group (one for each plant) tackled the following:

- Development of Operator Care Rounds
- Development of a production loss tracking (accounting) system and subsequent reporting
- 5S support

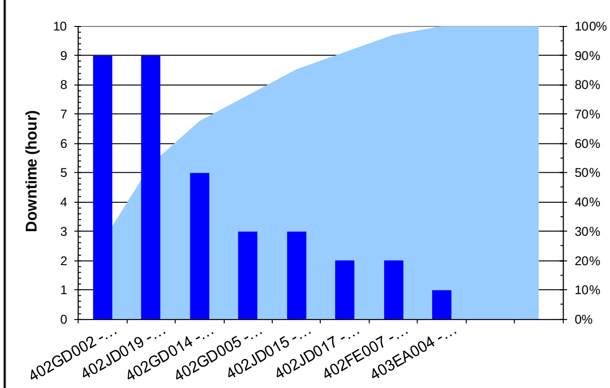
Prior to the program, downtime and production losses were inconsistently kept in a hand-written log book and only major issues and loss events would be captured. This tracking method made it difficult to understand and analyse the frequency and impact of 'unreliability' occurrences and therefore nearly impossible to prioritise or even determine required improvement. For operations that run 24/7, there is a lot of time maintenance and reliability personnel are not around to make notes of their own. It was clear that a downtime tracking system and protocol was required and that it had to be electronic so that decision could be data driven.

Faced with the challenge of an absence of capital funds to purchase any purpose-built software for tracking downtime and losses, once again site employees demonstrated their savvy. After establishing design criteria with the maintenance and reliability manager and the RE specialist, the process control group went to work on a solution. They managed to program their SCADA system to accept production target set-points in each area and setup alarms to prompt operators when a particular production value was out of range from the set point for a given hour. This would require an entry into a pre-configured electronic logbook (spreadsheet) and would be validated for procedural compliance periodically. The data collected is then reviewed and corrected as required by process engineers and Pareto-style charts developed to identify bad actors. Although focused on downtime only and not true production

Production Area

UF_6 — From: 11 10 01 — To: 11 10 31

Pareto Chart



Results Table

Rank	Equipment Number & Description		Primary Cause	Production Loss Hour	Production Loss %
1	402GD002 - Disperser			9.0	26%
2	402JD019 - Feed Screw Conveyor			9.0	26%
3	402GD014 - Disperser			5.0	15%
4	402GD005 - Disperser			3.0	9%
5	402JD015 - Feed Screw Conveyor			3.0	9%
6	402JD017 - Disperser			2.0	6%
7	402FE007 - Feed Hopper & Dust Line			2.0	6%
8	403EA004 - Cold Trap			1.0	3%
9				0.0	0%
10				0.0	0%
		Others		0.0	
			Total (all events)	***34.0***	

Figure 6 - 1st Generation Production Loss Report

loss, this first generation solution yielded tremendous benefit to both operation and maintenance teams. (See figure 6)

In 2014, a new and improved production loss tracking system was developed and now production losses through the plants are not only measured in terms of time, but in terms of production units (in this case 'kilograms') and within 15 minutes of a detected slowdown or stoppage. The system alarms will not disappear unless operators enter required minimum data to record the production loss event. This includes reasons codes and system or equipment responsible.

The level of automation is so sophisticated that OEE and MTBF for the UF6 plant is tracked continuously and key personnel receive daily updates and the end of each 24 hours shift on their smartphones, including a 'bad actor' Pareto (see figure 7).

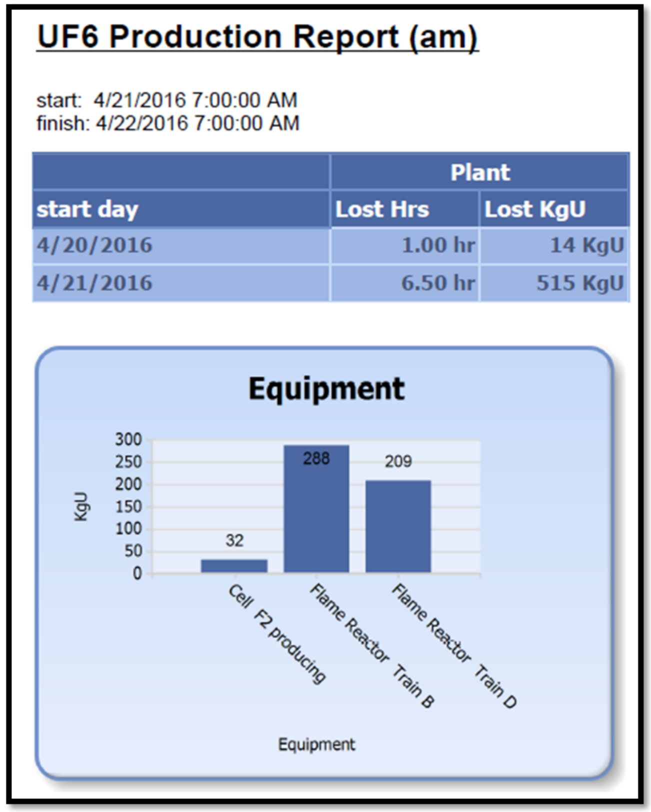


Figure 7 - Sample smartphone information

Change Management

While a very important and necessary activity, re-engineering business processes was a technical activity that needed to be supplemented by a shift in culture through an immense change management effort. To this end, an entire section of the project plan was dedicated to various change management activities focusing on education, engagement and communication. Communication efforts happened through a number of mediums, including 'town hall' type forums, open houses, crew meetings, and supervisory bulletins to name a few. The most consistent means of communicating however was thorough dedicated 'communication boards' put up in a number of high traffic areas. These boards kept people engaged with what the focus teams were working on and the progress they were making. While the teams have now disbanded, these boards are still used today to provide updates from subject matter experts for each area. See figure 8.

Instrumental to the change management effort was also branding. The company's communications group was tasked with developing a 'logo' that was and continues to be used on all publications and media types in order to continuously visually link all the improvements that have been made over the years including their outputs.

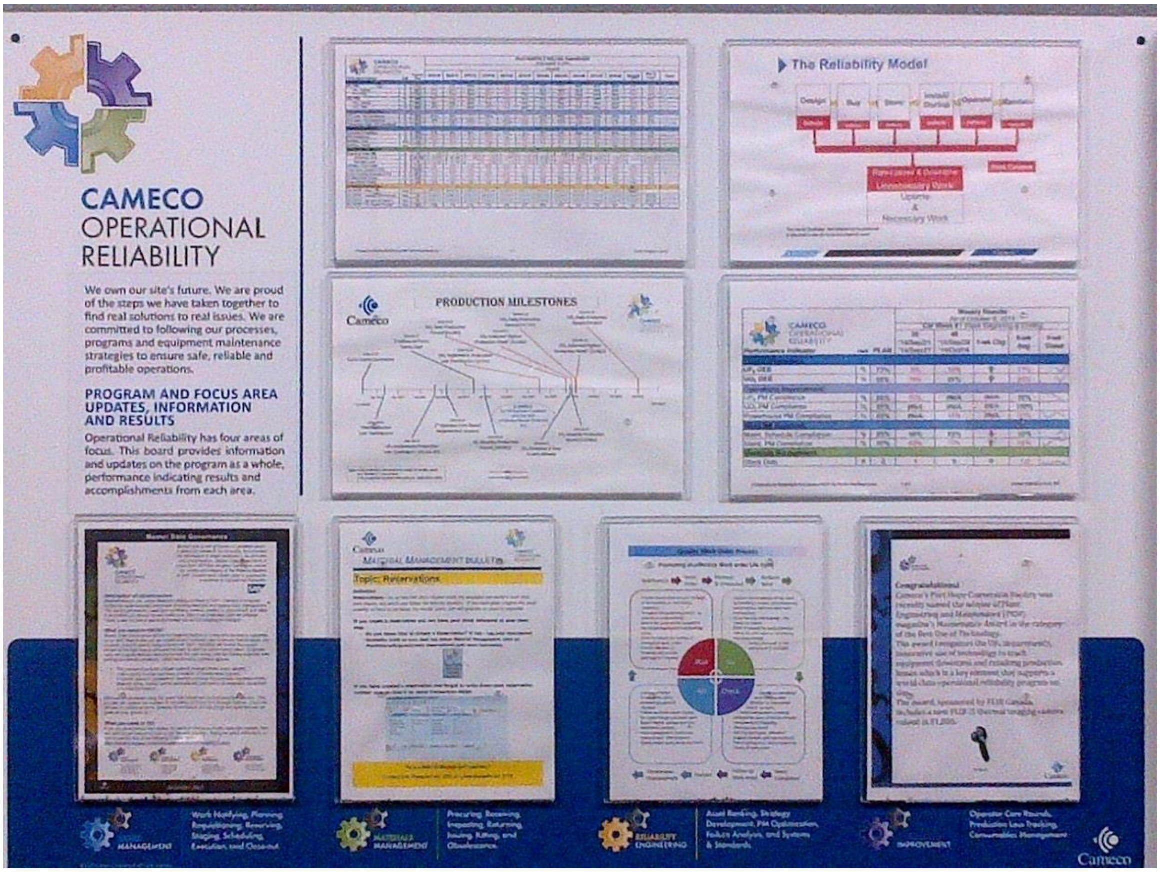


Figure 8 - Program Communication Board

Figure 9 - Program branding logos

Management Support

The final element to ensuring success and continuous improvement throughout this journey was the establishment of two key support teams. First and foremost, a site steering team comprising of key managers and leaders from all relevant site departments was established. This team devised and owns a master plan of activities and milestones that, in the earlier years was reviewed bi-weekly and today is reviewed every other month now that the program has reached maturity and sustainability. The second team that was in existence in the early years was a corporate support team, again consisting of high-profile leaders from various functional areas of the business. Their role was to remove roadblocks, set certain expectations, and also to monitor the development of this pilot program for future consideration at other Cameco operations.

Conclusion

It has been said that journeys toward reliability excellence never end. Considering how long the Port Hope conversion facility has been keeping its Operational Reliability program alive, employees would surely attest to this. And to attempt to capture all that has been accomplished in one essay would not do justice to the program or the efforts of employees.

However, it is evident that through employee participation, management support, and a well-executed change management strategy, the facility has not only improved its business processes but has developed sustainable culture of reliability and continuous improvement. The result are demonstrable, sustainable, and exportable.

Reference:

- Pascoli, J. (2016). Operational Reliability: 2010-2016 Maintenance & Reliability Improvement journey at the Port Hope Conversion Facility. Port Hope, Ontario, Canada

Appendix

1. Company Vision, Mission, and Values Statement
2. Key Reliability Team Member Certifications
3. ISO Certifications
4. Reliability and Asset Management Software utilized
5. Condition Monitoring systems used
6. Previous awards earned

Appendix 1 – Company Vision, Mission, and Values Statement

Vision: Cameco will energize the world as the global leader of fuel supply for clean-air nuclear power

Mission: Our mission is to bring the multiple benefits of nuclear energy to the world

Values: Our values guide our decisions and actions. They are:

- Safety & Environment
  - The safety of people and protection of the environment are the foundations of our work. All of us share in the responsibility of continually improving the safety of our workplace and the quality of our environment.
  - We are committed to keeping people safe and conducting our business with respect and care for both the local and global environment.
- People
  - We value the contribution of every employee and we treat people fairly by demonstrating our respect for individual dignity, creativity and cultural diversity. By being open and honest we achieve the strong relationships we seek.
  - We are committed to developing and supporting a flexible, skilled, stable and diverse workforce, in an environment that:
  - •attracts and retains talented people and inspires them to be fully productive and engaged
  - •encourages relationships that build the trust, credibility and support we need to grow our business.
- Integrity
  - Through personal and professional integrity, we lead by example, earn trust, honour our commitments and conduct our business ethically.
  - We are committed to acting with integrity in every area of our business, wherever we operate.
- Excellence
  - We pursue excellence in all that we do. Through leadership, collaboration and innovation, we strive to achieve our full potential and inspire others to reach theirs.
  - We are committed to achieving excellence in all aspects of our business.

Source: www.cameco.com

Appendix 2 – Key Reliability Team Member Certifications

- Jean-Pierre (J.P.) Pascoli, P.Eng, CMRP, CAMA
  - Engineering & Maintenance Manager, Port Hope Conversion Facility (formerly)
  - Director, Asset Management & Reliability, Corporate Office (currently)

- Dale Clark, P.Eng
  - General Manager, Port Hope Conversion Facility (formerly)
  - Vice President, Fuel Services Division (currently)

- Dave Ingalls, P.Eng
  - Director, Compliance & Licensing, Fuel Services Division (formerly)
  - General Manager, Port Hope Conversion Facility (currently)

- Chris Herron
  - Superintendent, Maintenance, Port Hope Conversion Facility

- Ron Moreau
  - Co-ordinator, Operational Reliability, Port Hope Conversion Facility (formerly)
  - Sr. co-ordinator, UF_6 Production, Port Hope Conversion Facility (currently)

- Randy Grant, CMRP
  - Reliability Specialist (former), Port Hope Conversion Facility

- Bob Routly, CET
  - Reliability Technologist (former), Port Hope Conversion Facility

- Brett Stevens, P.Eng
  - Sr. Engineer, Process Control, Port Hope Conversion Facility

- David Landry, P.Eng
  - Chief Engineer - UF_6 , Port Hope Conversion Facility

- Vanni Iemma, P.Eng
  - Process Engineer - UO_2, Port Hope Conversion Facility

Appendix 3 - ISO Certifications

- ISO 14001 - Environmental Management

Appendix 4 - Reliability and Asset Management Software utilized

- **SAP**
  - Assets/Equipment (SAP-PM)
  - Work Management (SAP-PM)
  - Materials Management (SAP-MM)
  - Human Resource Management (SAP-HR)
- **Prometheus (2015)**
  - Weekly regular work scheduling
- **Primavera (2012)**
  - Shutdown scheduling (Gantt chart)
- **MS-Excel**
  - Assets/Equipment criticality ranking
  - RCM analyses (FMEAs)
  - Root-Cause Analyses
  - KPI reporting
- **MS-Word**
  - Detailed work procedures
  - Root-Cause Analyses
- **CIRS (Cameco Incident Reporting System)**
  - Major incident, investigation, and corrective actions tracking
  - Used for significant equipment failures (RCAs) but also RCM tracking
- **Adroit SCADA system**
  - UF_6 Production Loss Tracking System
- **iFIX + Excel**
  - UO_2 Production Loss Tracking System

Appendix 5 - Condition monitoring systems used

- **Laser Alignment**
    - Shaft alignment
    - Belt alignment
    - Pulley alignment
- **Vibration Analysis (contractor)**
- **Thermography**
    - Switchgear and MCCs
- **Oil Analysis**
    - Transformers, other
- **Radiographic Testing**
    - Welded joints
- **Eddy current Testing**
    - Heat exchanger tubes
- **Ultrasonics**
    - Thickness measurements
    - Steam trap leaks (since 2014)
    - Acoustic greasing (since 2014)

Appendix 6 - Previous awards earned

- **2012 PEM Magazine Maintenance Award**
    - Plant Engineering & Maintenance magazine
    - Best use of Technology/Maintenance Innovation category
    - Production Loss Tracing system
    - Published March/April 2013 edition of PEM magazine