Canadian Light Source Vacuum

A shift from reactive to preventative maintenance

Dana Warriner | Dana.Kary@lightsource.ca
Mechanical Engineering, Canadian Light Source Inc., Saskatoon, Canada

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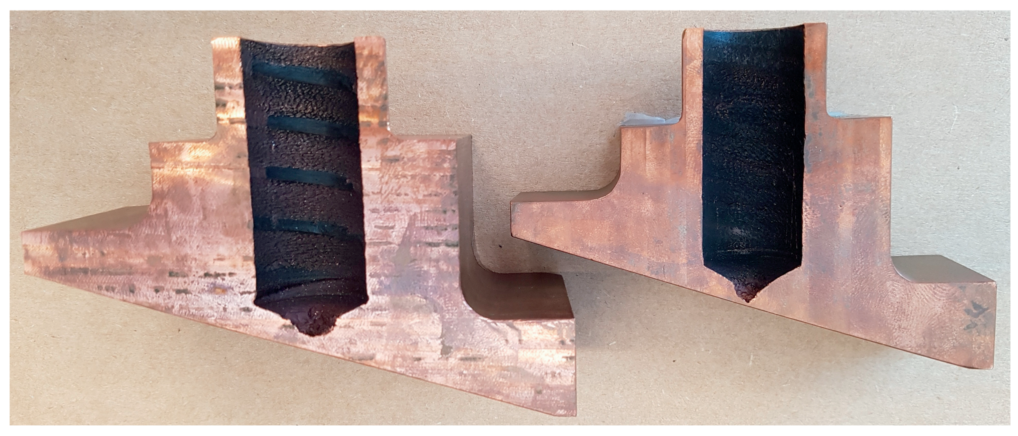
Introduction

Maintenance of the Canadian Light Source (CLS) vacuum system has shifted from a reactive approach to a preventative maintenance approach. The catalyst of this shift is the aging facility and infrastructure. A comprehensive analysis of vacuum system components guides preventative maintenance activities. Components that pose the greatest risk of failure are determined using the CLS enterprise risk management (ERM) framework. Components in need of spares or replacement are identified and the health of the vacuum system is now better understood. Design, fabrication, and procurement of spares and replacements has increased the ability to respond quickly to failures, thereby reducing potential downtime. The reliability of the machine is increased as components posing the greatest risk to the vacuum system are replaced.

History

Historically, components in vacuum were run until failure. One example of a component replaced upon failure was a dipole photon shutter that leaked water into the storage ring vacuum space in 2016. This failure brought to attention the need for critical spares and pre-emptive replacements. There were some spare components, but a comprehensive review of components containing and maintaining vacuum had never been completed. There are some critical components for which there are no spares on hand.



Cutaway of dipole photon shutter run until failure. Low conductivity water that cooled the absorber slowly eroded copper until a pinhole leak developed and water leaked into the vacuum space.

Method

A comprehensive review of all components containing and maintaining vacuum will be conducted starting with components that are most likely to fail. In CLS experience, this includes water-cooled components and actuated bellows. Each phase of the review consists of analyzing each component, determining a risk score, and acting on the risk.

PHASE 1 - MACHINE
Actuated bellows | Water cooled components | Chambers and unique components | Alignment bellows

PHASE 2 – STOCK LEVELS
Purchased parts Ex. IOPs, valves, gauges | Raw materials Ex. Flanges, tube, OFHC

PHASE 3 - BEAMLINES
Beamline components that pose a risk to vacuum integrity

The risk score is determined using enterprise risk management (ERM) framework established by the CLS. An event or risk scenario that could happen to a component is given a likelihood and categorized in terms of impact the event would have on the organization. For example, a failure that causes a disruption of 1 week - 4 months is considered major. A failure is considered likely if the component is expected to occur in the next 2 years. This example then gives a risk score of *High*.

Some criteria that are used to determine likelihood and impact of failure are:

- **Age**
- **Frequency of past failures**
- **Criticality to operations**
- **Robustness of design**
- **Known lifespan**

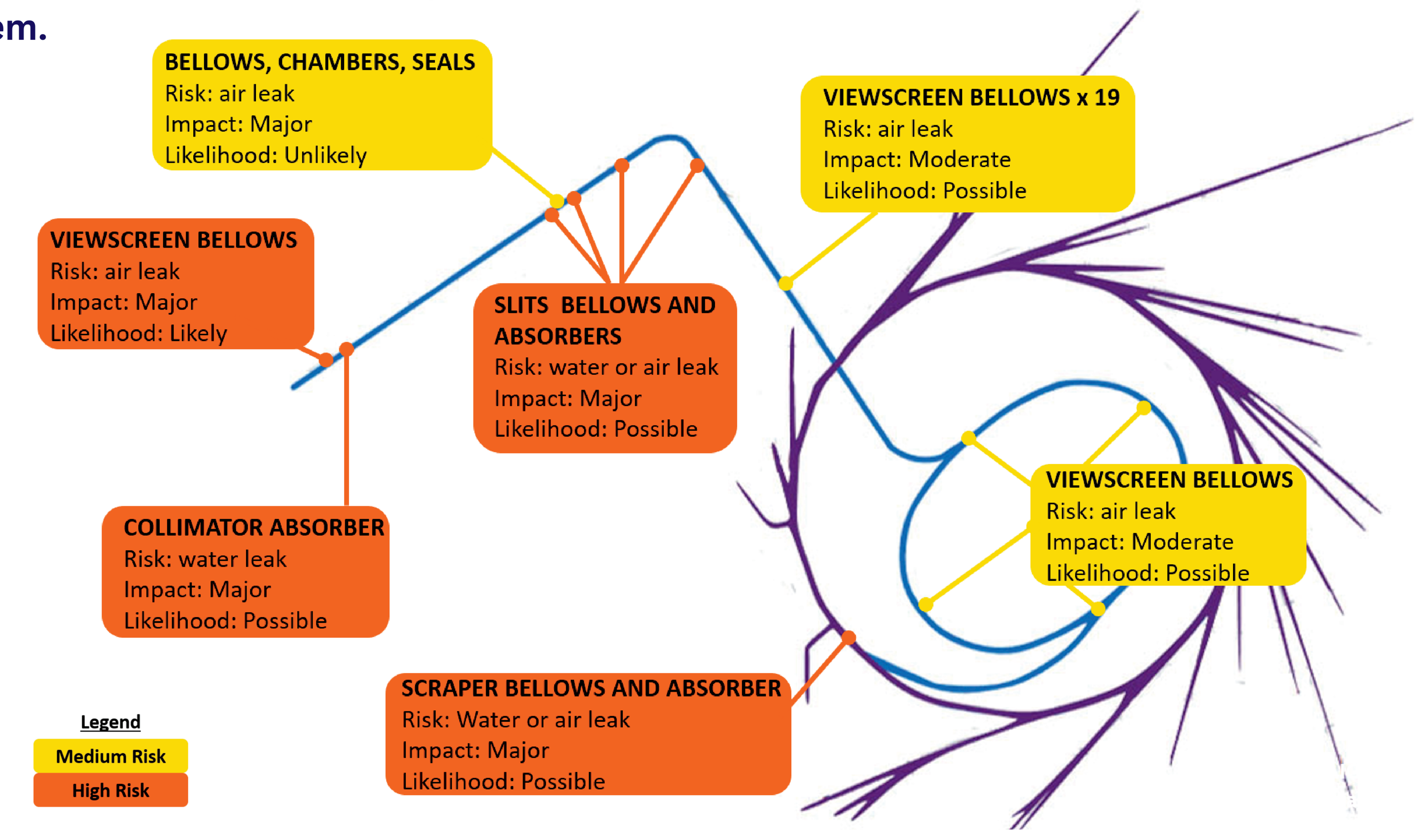
		LIKELIHOOD				
IMPACT		Rare 1	Unlikely 2	Possible 3	Likely 4	Almost Certain 5
Extreme	5	Medium	High	High	Very High	Very High
Major	4	Medium	Medium	High	High	Very High
Moderate	3	Low	Medium	Medium	High	High
Minor	2	Low	Low	Medium	Medium	High
Insignificant	1	Low	Low	Low	Medium	Medium

Components that score *High* or *Very High* are evaluated for solutions to lower the risk. Some examples of actions taken to lower the identified risks are:

- Design work to plan for failure scenario
- Procurement of long lead time spares
- Replace component
- Request for replacement when resources become available

Results

Highlights from Phase 1 of the ERM analysis are show below. **ERM analysis allowed for data-driven decisions on what components to focus on in order to address risks to the vacuum system.**

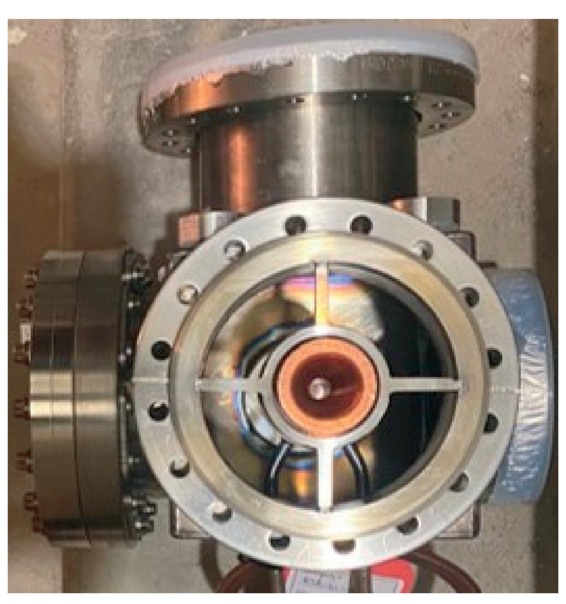


As a result of the Phase 1 analysis, many components were replaced, spares made available, and many in the queue for replacement as summarized in the table below.

	BELLOWS	WATER-COOLED COMPONENTS	CHAMBERS AND UNIQUE COMPONENTS
Replaced	2	1	–
Spares	21	1	–
Submitted for Approval	10	6	9

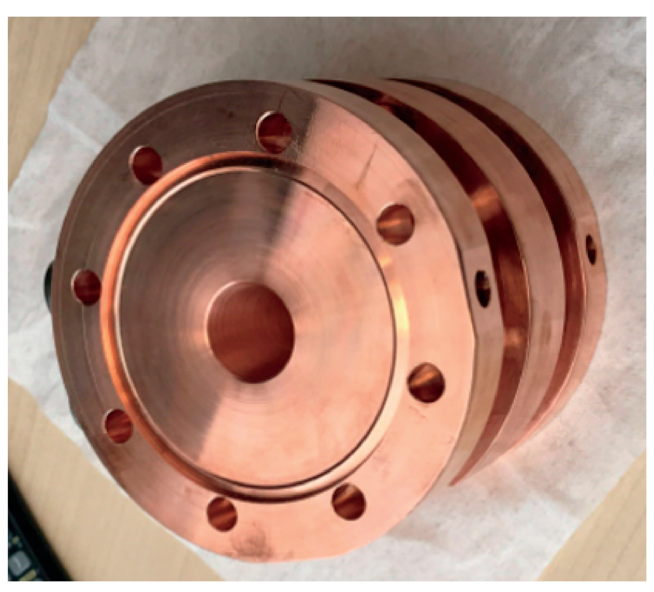
Some examples of components that were replaced as a result of the ERM analysis are a LINAC collimator (CL) and LINAC viewscreen (VSC). Some of the determining factors that categorized these components as high risk to the vacuum system are listed below.

OLD LINAC CL



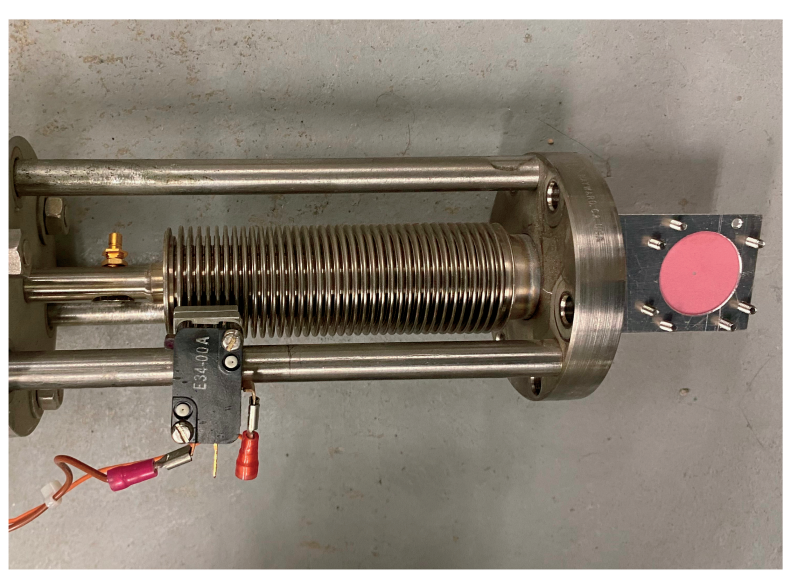
- **Installed in 1984**
- History of water-cooled copper absorbers leaking into vacuum
- Experience with low conductivity water corroding copper over time
- In-vacuum water connections - copper brazed to stainless steel - not allowed
- Critical for machine operation

NEW LINAC CL



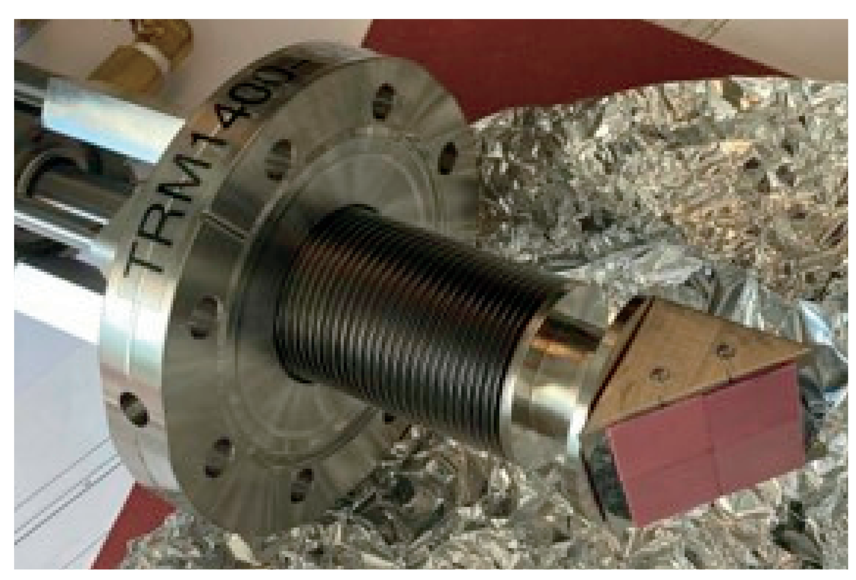
- **Replaced with in-flange CuCrZr design October 2022**
- Old CL kept as spare

OLD LINAC VSC



- **Estimated install date 1980**
- No drawings or information
- Used often
- Critical for machine operation

NEW LINAC VSC



- **Replaced with new VSC assembly Oct 2022**
- New VSC assembly occurs in 18 other locations at the CLS
- One extra bellows ordered to provide spares for 19 components

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