Steam generators have a historical role in electricity production but their potential to make or break cost curves remains as strong today as ever.

With advances in maintenance procedures and manufacturing materials, a well cared for steam generator can offer predictability and cost effectiveness. But aging boilers require special care or else they can be one of the greatest threats to reliability and productivity resulting in derating and lost revenue.

Best practices in boiler maintenance remains a critical focus area for operators looking to improve reliability and safety. In turn, these improvements can help operators attain the desired outcomes ascribed to the “nuclear promise” of safe, reliable operation that remains competitive with other generation technologies.

**A COG primary side cleaning joint project**

Primary Side Cleaning of boilers has been performed about a dozen times in CANDU reactors over the last two decades with uneven results. In December 2016, COG held a workshop to kick off the planning for a joint project (JP 4556 Boiler PSC) on primary side cleaning (PSC), which includes an effectiveness study to be completed in 2017-18.

Workshop participants created a list of 27 issues and agreed to 15 actions as a basis for an integrated industry plan to improve performance of the boilers through improved PSC. The workshop covered all aspects of PSC including reactor inlet header temperature (RIHT) gain, other PSC impacts as well as PSC process, technology, methodology, planning and execution in such areas as waste management, dose control and outage management. Participants also shared lessons learned and explored improvements in PSC technology.

“We have an ongoing need to monitor, analyze and mitigate the impacts of heat transport system aging,” says COG’s Paul Lafreniere, co-facilitator of the workshop with COG’s Bill Anderson.

This isn’t a new issue but there is a new emphasis on addressing reactor derating, says Lafreniere, recalling efforts to address issues such as RIHT going as far back as the early 1990s.

“RIHT rise due to oxide deposits in steam generators generates considerable interest among COG members,” he says. “This issue impacts all CANDU stations because it causes loss of safety margin and creates deratings. It remains one of the top threats to new and/or increased derating events for both C6 and Ontario stations despite these long-standing efforts.”

Workshop executive sponsors and co-chairs were Bruce Power’s Gary Newman and Peter Purdy. Bruce Power will need to keep its 1980s vintage B-plant steam generators at the top of their game until they are replaced as part of their major component replacement execution that runs for about a decade across the four units beginning in 2020. Some of the seminal 1990s research on boiler maintenance occurred at the Bruce site (see Reference List: Basu, Bruggeman, 1997).
Lafreniere says bringing together operating experience and knowledge from across the industry on this initiative will be important to pulling together the empirical data and trends that will “allow us to better understand the heat transport system’s key aging parameters.” As well he says, it is important to “monitor the operating and safety margins, as well as effectiveness of any actions taken to mitigate aging impacts.”

At the workshop’s conclusion, specific goals for the project were identified:

- Measurable benefits from cleaning;
- Predictable RIHT gains from cleaning;
- Boiler tube ID fouling characterization;
- Effective cleaning application;
- Standard CANDU cleaning database to inform understanding; and
- Technology innovation.

A medium-term plan will be presented to members by March 31, 2017 with the effectiveness study to be concluded in the spring-summer period.

### Why is effective primary side cleaning essential?

As they age, steam generators experience “corrosion, fouling degradation, and fretting of the upper bundle… leading to thermal and hydraulic inefficiencies as well as tube integrity concerns,” (Marsuka, Nickerson, Spekkens, Tapping, 2000). As well, an increase in reactor inlet header temperature can impact fuel integrity, resulting in a reduction of safety that triggers unit derating. Effective primary side cleaning can mitigate the effects of aging, thus maintaining safety and reliability thereby preventing deratings.

### What is reactor inlet header temperature (RIHT) and why does it matter?

CANDU reactors operate within a small RIHT range during normal operation to ensure optimal safety and reliability. When the temperature rises above that window, it impacts critical heat flux in the reactor channel thus impacting fuel integrity. When this safety requirement is exceeded, it forces the unit to be derated. As they age, boilers and feedwater pre-heaters become less efficient at removing heat. Proper maintenance for older reactors as well as new materials in newer steam generators can significantly improve performance outcomes.

### References


Boiler PSC Enhancement
Fishbone Diagram

1. Effective PSC
2. Timely Decision Making
3. Long term problem management strategy

Shot blast process optimized (technology)

How to prepare lead-in

Cleaning Procedure

Nature of Magnetite (Site qualification)

When to clean

Operational considerations to maximize benefits

Defining conditions

[Diagram with various nodes and arrows indicating relationships]

14th COG/IAEA Technical Meeting on
Exchange of Operational Safety Experience of Pressurized Heavy Water Reactors

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