PLGS Steam Generator Decontamination
Using Ice Blast

Stephen Smith
Senior Technical Specialist
Health Physics Department

Point Lepreau Generating Station
New Brunswick Power
P.O. Box 10
Lepreau, New Brunswick
Canada, E0G 2H0

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Background

At Point Lepreau NGS the Health Physics Department looked for alternative decontamination methods that could be applied to reduce the dose expenditure as a result of maintenance on the primary side of our steam generators. Due to the characteristics of the CANDU design (i.e., primary circuit being high purity D_2O) introduction of foreign contaminants was also a concern. Other technologies available such as, blasting with CO_2, use of solid blast media, and high pressure water were explored, but for various factors, were not ideally suited for this particular application.

CO_2 being a dry process requiring large quantities of CO_2 and process air, would increase the probability of airborne contamination and generate an oxygen deficient atmosphere. Blasting with other types of solid media generates an excessive amount of solid wastes and dusts requiring prolonged exposures for cleanup and disposal. High pressure water, although more attractive, requires large volumes, in this case D_2O, resulting in a substantial cost and limited availability.

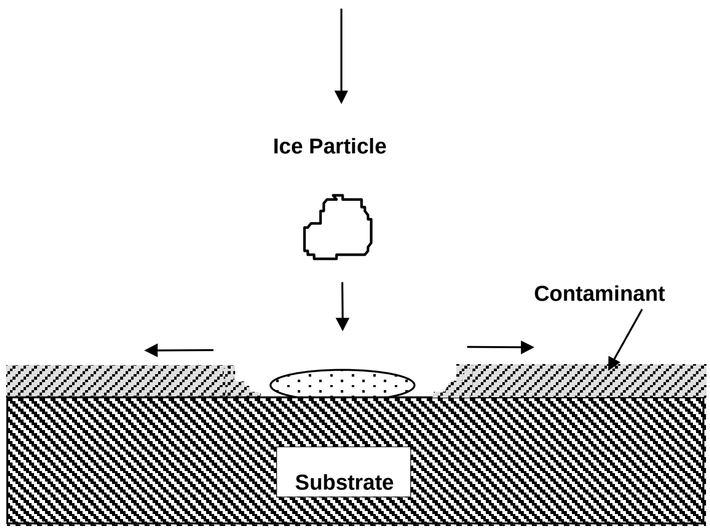
The IceBlast process provides an economical, dust free alternative to conventional methods, and permits “in situ” cleaning or decontamination of system components. Ice being the blast medium, starts as a solid and ends as a liquid. Although ice particles fracture rather than abrade, they provide physical agitation on impact creating a mechanical rubbing action that removes most non-bonded foreign material. When the ice melts (following impact) it flushes the surface free of debris leaving no substrate damage.

The source of ice, for this particular application, is a minimal volume of high quality (reactor grade) virgin D_2O. Virgin D_2O is used to prevent an increase in airborne tritium during operation, down-grading the purity of the main circuit inventory, and contaminating the IceBlast machine internals. These considerations allowed the process to be used for other non-radiological applications as well.

Blast Media

Ice as a blast media performs three types of impact work. Water in its liquid state is not an ideal blast media because it lacks the frictional scrub capability, even though it can be made to generate a very high momentum for displacement work.

Small ice particles are ideal for precision cleaning because they impact the target surface as solids, deform to the surface structure in a frictional scrubbing action, and finally melt to water providing a rinsing action as illustrated below.



Displacement work is performed before phase change, frictional work is performed during phase change, and rinsing work is performed after phase change. The ability to perform frictional scrub is the reason ice blast provides a high level of decontamination or cleanliness with a minimum amount of media.

Optimum performance dictates the ice blast stream be directed at an angle favoring high frictional scrub pressure (90^0 to the target surface) while maintaining sufficient forward blast force (8 cm. from target) for displacement cleaning. The rinse water should also have sufficient forward momentum to minimize any chance of spray contamination, although the water spray produced does help to encapsulate blast debris that is often hazardous. In practice, it is not always possible to have a large approach angle because of spatial constraints and equipment configuration. In these cases, higher air pressure to provide higher ice velocities and longer dwell time must be considered.

Finally, it is important to remember the cleanliness of the finished product is no better than the quality of the air and water used in ice blast. Oil free compressed air and high purity water (whether heavy water or light) must be considered to obtain high levels of cleanliness.

Requirements

For optimum operation the IceBlast machine and auxiliary equipment should be located on the same elevation or above the target work area. The machine and auxiliary equipment should be located on a level surface and in a moderate temperature, low humidity environment. The following block diagram lists the requirements and operational parameters that must be satisfied prior to starting the blasting operation.

Aggressive

Specific task requirements are dependent on the application desired and corresponding blast wand pressure requirement. For all situations initial air volume must be 8 m^3/min for optimum results. Air volume below this value causes inadequate operation/cleaning and operational faults of the IceBlast process.

Based on the type of wand being used the following cleaning/decontamination applications can be realized.

- Light (550 - 830 kPa) used for delicate applications such as deburring, surface finishing, cleaning, and degreasing of delicate components.
- General (830 - 1100 kPa) for light surface decontamination of instrumentation, tooling or equipment, and paint removal from rubber or plastic surfaces.
- Aggressive (1100 - 1450 kPa) for de-coating, paint stripping, gasket removal, chrome removal, radioactive decontamination of tooling and or equipment where high impact velocities are not a concern.

Field Application

Equipment location, operational parameters and wand selection impact on the performance of the process, but consideration must also include some form of controlled exhaust ventilation, with a flow rating exceeding that of the Ice blast machine, for removal of airborne contaminants generated during the process.

For non-nuclear applications use of a portable extraction fan equipped with a filter medium would suffice. For nuclear applications, equipment components, dependent on size, are either decontaminated in shielded flasks constructed for that purpose, or within the confines of a temporary containment structure. Exhaust ventilation equipped with filter medium (HEPA) is then directed to an approved ventilation path (monitored release) and rinse effluent is filtered prior to disposal or collection.

To date we have used and provided IceBlast decontamination for the following:

- Decontamination of PLGS primary heat transport pump rotating element.
- Decontamination of a primary heat transport pump rotating element for Ontario Hydro Bruce B NGS.
- Decontamination of shielded work stations (cells) Chalk River Laboratories.

In general terms a decontamination factor of 4 to 4.5 for gamma and in excess of 100 for beta have been realized.

An example of the potential dose savings using this technique was decontamination of the PLGS four steam generators primary side, prior to maintenance activities carried out during the 1995 outage. Further decontamination of longer duration in the same locations (and familiarity with the equipment) produced higher decontamination factors ranging from 5 to 6.5.

The following table lists the average dose rates before and after decontamination of the four steam generators (10 minutes of IceBlast/leg) at the start of PLGS 1995 annual outage.

Location	Dose Rate mGy/h	
Hotleg	**Before**	**After**
Tubesheet contact beta	5.2	0.3
Tubesheet contact gamma	2.8	0.8
General beta	2.4	0.6
General gamma	2.1	0.5
Coldleg		
Tubesheet contact beta	9.1	0.9
Tubesheet contact gamma	6.8	2.2
General beta	2.6	0.6
General gamma	4.6	0.8

The table below lists the maintenance activities and corresponding dose expenditure (after decontamination) for the four steam generators during the 1995 outage.

Activity	man-mSv
boiler modifications	11.88
primary side tubesheet inspection	81.30
boiler tube plugging	9.10
divider plate inspection	22.18
divider plate repair (replace)	204.37
total	328.83

Comparing both of the above tables, an average decontamination factor of 4.5 for both hot and cold legs was attained. The dose savings alone (*gamma only*) for steam generator maintenance was approximately 1152 mSv.