# ONTARIO HYDRO DECONTAMINATION EXPERIENCE

BY

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ONTARIO HYDRO - CANADA

# Ontario Hydro Decontamination Experience

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Ontario Hydro currently operates 18 nuclear electric generating units of the CANDU design with a net capacity of 12402 MW(e). An additional 1762 MW(e) is under construction. The operation of these facilities has underlined the need to have decontamination capability both to reduce radiation fields, as well as to control and reduce contamination during component maintenance. This paper presents Ontario Hydro decontamination experience in two key areas - full heat transport decontamination to reduce system radiation fields, and component decontamination to reduce loose contamination particularly as practised in maintenance and decontamination centres.

## Part 1: HEAT TRANSPORT DECONTAMINATION

### INTRODUCTION

With Ontario Hydro's large commitment to nuclear power, the need to control radiation dose became obvious in 1970 during early operating experience with the CANDU prototype reactor - Douglas Point NGS. There, high cobalt-60 radiation fields seriously threatened the ability to operate and maintain the unit. The radiation fields were principally due to the deposited activity on the large surface area of the carbon steel feeders. Clearly, similar radiation fields would be unacceptable for planned commercial reactors. Concerted efforts were therefore undertaken both to eliminate cobalt bearing alloys as well as to develop a decontamination process specifically to remove activity from the carbon steel feeders. The result of this program was the CANDECON process. Although this initial development was successful, operating experience demonstrated the need for further development. This part of the paper traces the development of the CANDECON process together with experience with it's application.

### INITIAL PROCESS DEVELOPMENT

The CANDECON process was developed jointly by Atomic Energy of Canada Limited (AECL) and Ontario Hydro. Development began in 1970. Extensive loop tests were carried out at AECL's Chalk River Nuclear Laboratories to demonstrate the ability of the process to decontaminate, its corrosion behaviour to materials in the CANDU HT system, and its effect on mechanical components of the HT system such as valves and pump seals. The loop tests led to three successful tests of the process at the Nuclear Power Demonstration (NPD). The decontamination chemicals could be added, removed, regenerated and used to decontaminate.

The essence of the process involves the addition of organic acid reagents to the HT coolant to form a 0.1 % solution. These reagents dissolve and complex the corrosion product layer and activity deposited on the HT system internal surfaces. The resultant solution is circulated through cation ion exchange resins in the purification circuit to remove the complexed metals and regenerate the reagents. Mixed bed resins are subsequently used when the cation beds are exhausted to remove both the reagents and the remaining corrosion products from solution. Filtration in the form of submicron filters installed in the purification circuit (and later directly to the HT system) is used to remove fine particulate crud produced during the decontamination.

The development program culminated in 1975 with a full scale decontamination of Douglas Point NGS(1). The decontamination factors (DF's) achieved on the heavily contaminated HT system ranged from 3 to 6 on the reactor face. This reduction resulted in a station dose saving of 162 rem in the ensuing maintenance outage with additional savings over the next few years as fields slowly increased.

## EARLY OPERATIONAL EXPERIENCE

Due to much lower radiation fields at Pickering NGS compared to Douglas Point NGS, decontaminations were not anticipated to be required except for major maintenance efforts such as Large Scale Fuel Channel Replacement (LSFCR) Programs. Any maintenance on fuel channels has to be carried out in the vicinity of the reactor face where a dominant source of radiation fields is the large surface area of contaminated feeders as shown in figure 1. Hence, as a contingency, a large (12 $m^3$) purification skid was procured.

Early attempts to apply the CANDECON process to Pickering were not successful and prompted a renewed development program to understand why a process, so successful at Douglas Point, was unsuccessful at Pickering. The failure of a Pickering NGS unit 2 pressure tube in August 1983 intensified development efforts to provide a process that could be successfully applied at any station. The immediate need at Pickering NGS was to reduce the dose required for pressure tube inspection. However, before proceeding to Pickering, although the required improvements were intuitively thought to be at hand, it was considered prudent to better characterize the oxide on the carbon steel surfaces to be decontaminated and to test a modified process in a full scale HT system decontamination.

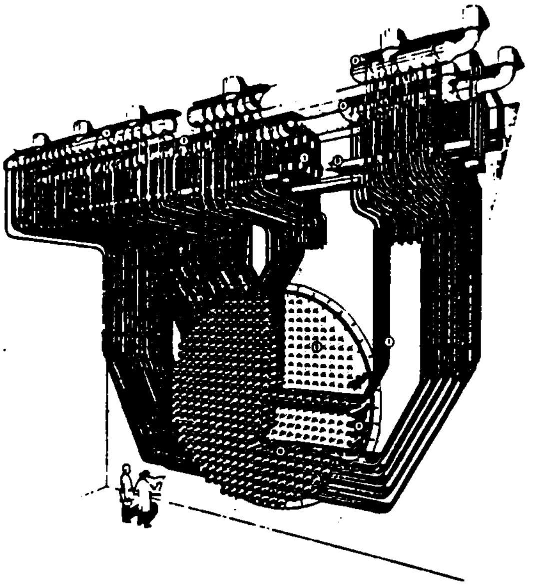

**Figure 1: Pickering Reactor Face**

Both of these activities were carried out at NPD in December 1983. A sample of carbon steel feeder was removed and a demonstration of the modified process completed. Several chemical strategies were tested during the NPD decontamination. Analysis of the results suggested that the critical parameters were the use of 100 mg/kg $D_2O$ of a corrosion inhibitor and the maintenance of EDTA concentrations in the range of 400 to 500 mg/kg $D_2O$.

The wisdom of removing a feeder from the HT system was clearly demonstrated. At NPD the oxide on the feeders was much greater than anticipated. Because of limited ion exchange capacity, predictions for a decontamination factor were reduced. Even so, the decontamination showed that improved results could be achieved. At this point, a process applicable to Pickering was available.

## PICKERING DECONTAMINATIONS

The usefulness of obtaining a sample from the system being decontaminated was clearly shown at NPD. A feeder section from Pickering unit 2 was therefore removed. The oxide on this feeder was twice as thick as that at NPD. Calculations of iron to be transported during the decontamination indicated that there was limited ion exchange capacity. This limited capacity would in turn limit the decontamination effectiveness. A decontamination factor of 2 was predicted for the first decontamination. The actual results (January 1984) were close to those predicted. This suggested that with additional ion exchange resin, higher decontamination factors could be achieved. With the decision made to replace the pressure tubes of unit 2, a repeat decontamination of unit 2 in April 1984 confirmed the confidence in the process(2). Decontamination factors at the reactor face of up to 10 were achieved as shown in figure 2.

The pressure tube problem was not confined to Pickering unit 2 but also affected the identical unit

1. Replacement of all the pressure tubes was therefore undertaken on both units. Unit 1 was decontaminated with similar results to unit 2. These Pickering units 1 and 2 decontaminations were highly successful. They were a major factor contributing to the viability of the pressure tube replacement program on these units. In excess of 2400 rem of dose was avoided by the reduction in reactor face radiation fields.

In 1985, P3 was also decontaminated in support of a single fuel channel replacement(3). P3 reactor face radiation fields were reduced from 1700 mR/h to 350 mR/h.

A major lesson learned during these early decontaminations was that the success of a decontamination was due in a large part in the ability to commission and operate the large purification system. This system consisted of the original 12 $m^3$ Pickering ion exchange skid supplemented by a new 24 $m^3$ skid. Experience has shown that such a large purification system must be rigorously commissioned to ensure flawless operation and to avoid costly outage extensions.

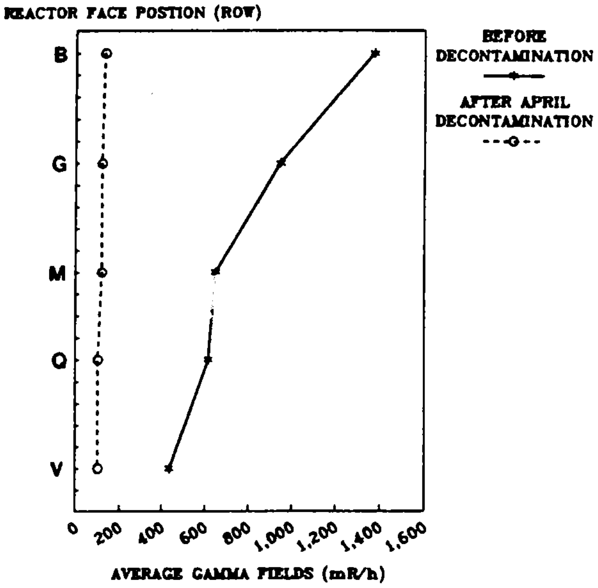

**Figure 2: PNGS Unit 2 Decontamination**

Again, to support reactor retubing, PNGS unit 3 required decontamination in 1989. The LSFCR program in 1989 had changed from 1984. More restrictive dose limits placed on workers and the need for accelerated maintenance work determined the criteria for the success of a P3 decontamination. Reactor face radiation fields would have to be reduced from 440 mR/h to 70 mR/h. Greater fields would result in removing workers from the job due to dose limits. These fields would in turn result in an extended outage time due to the loss of worker experience and the need to start over again on the learning curve.

Four sources were recognized as contributing to reactor face radiation fields. These were feeder contamination, end fitting contamination, crud, and antimony-124. An effective decontamination strategy had to include procedures for quantifying and dealing with these sources.

## P3 DECONTAMINATION STRATEGY

The general strategy for reducing P3 reactor face radiation fields was first to carry out a traditional CANDECON decontamination. Should this action achieve the goal of reducing fields to 70 mR/h, the decontamination would be declared complete. Should radiation fields plateau substantially above target levels, the initial decontamination would be terminated. On the basis of on-line survey equipment and gamma spectroscopy data, strategies developed for a subsequent decontamination would be applied.

Because it was recognized that the decontamination may have to be extended past the initial CANDECON, a prototype on-line electrochemical corrosion monitor was installed directly to the coolant circuit. This would allow measurement of materials corrosion rates in real time rather than after the fact using traditional corrosion coupons.

Within this general strategy, were the strategies for monitoring and controlling each of the four major sources contributing to reactor face radiation fields.

**Feeders**

Although decontamination factors of up to 20 have been achieved on carbon steel surfaces during a CANDECON step, samples of feeder piping removed after the decontaminations indicate that contamination remains on the surface. After the initial CANDECON decontamination, residual cobalt-60 activity of about 1 $mCi/m^2$ on the feeders was expected to contribute about 20 mR/h to radiation fields one meter from the reactor face.

The strategy for the feeders was therefore to monitor their field reduction using shielded survey probes connected directly to the feeder external surfaces. The feeder activity would also be measured in-situ before and after the decontamination using a "calibrated" gamma spectrometer(4).

Additional feeder decontamination factors were recognized as possible by using the Alkaline Permanganate (AP) process or by simply completing a second CANDECON (even though these possibilities could not be demonstrated in laboratory tests).

**End Fittings**

End fitting sources were expected to be the main contributors to reactor face radiation fields following the initial CANDECON. For the P3 decontamination the total contribution was assumed to be simply the difference between the total reactor face fields and the feeder contribution. These fields were known to be from contaminated stainless surfaces and deposited crud in end fitting dead spaces. Experience has shown that leakage from the reactor core is negligible.

Due to its relatively high chromium content, the oxide on the stainless steel end fitting surfaces was not expected to be effectively removed during the CANDECON process. If the end fitting activity were to remain high, an AP step could condition the oxide for subsequent removal by a second CANDECON decontamination.

The strategy for the end fittings was to monitor activity removal using shielded survey probes installed on the end fitting external surfaces. Data obtained from these probes, together with historic end fitting contamination analysis and P1/P2 post decontamination radiation field surveys, would be used to estimate the relative strength of the end fitting contaminated oxide source. Should contamination remain high, the AP/CANDECON step would be undertaken.

**Crud**

Crud is transported to the dead space between the end fitting closure plug and shield plug (see figure 3) during a decontamination. Previous experience at Pickering indicated that active crud could account for up to 50% of post CANDECON reactor face radiation fields. In addition crud would contaminate tooling thereby slowing retubing operations. There was, therefore, a great incentive to control this source.

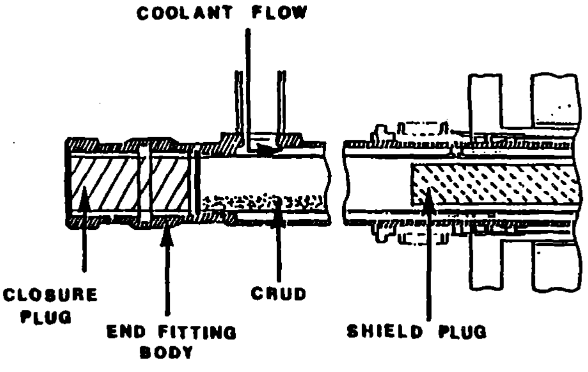

Figure 3: End Fitting Dead Space

The strategy for crud control was to add additional filtration capability. Calculations indicated that any increased filtration package would have to be capable of removing up to 100 kg crud at a total flow rate of about 100 kg/sec. Two filters and associated valves, shielding and piping were installed directly on to the coolant circuit. These filters would remain in service during the two CANDECON decontaminations.

### Antimony-124

This short lived isotope (half life ~60 days) is a relatively minor contributor (~2%) to reactor face radiation fields before a decontamination. However it is transported from in-core and boiler surfaces and deposits on feeder surfaces during a decontamination. Because the antimony-124 resides predominantly in-core it was not possible to accurately estimate the potential effects of its transport during a CANDECON decontamination.

The strategy for antimony-124 was therefore to use a combination of radiation survey and gamma spectroscopy data to determine the relative contribution of the radionuclides responsible for reactor face radiation fields following the initial CANDECON decontamination.

Should the antimony-124 be a major contributor to these fields, two possible techniques were available to us. Either use the AP step could be used to oxidize the deposited antimony-124 to soluble, ion exchangeable species or a process based on the addition of hydrogen peroxide could be used to oxidize the deposited antimony-124. Peroxide has been used to remove antimony-124 from PWR reactor systems.

## DECONTAMINATION RESULTS

### Initial CANDECON Step

Radiation fields one meter from the reactor face were reduced from 440 mR/h to 200 mR/h by the initial CANDECON decontamination - well above the target level of 70 mR/h. Figure 4 shows the dramatic decline of feeder activity as measured by on-line gamma survey probes attached to selected feeders. This trend was confirmed by cobalt-60 count rate measured by a collimated gamma spectrometer pointed at the reactor face (see figure 5). The net result was that the reactor face cobalt-60 radiation fields had been reduced from 395 mR/h to 140 mR/h. The balance of the fields was principally from antimony-124 deposition. Antimony-124 fields increased at the reactor face by a factor of about 4 (from 10 mR/h to 40 mR/h) as shown in figure 5.

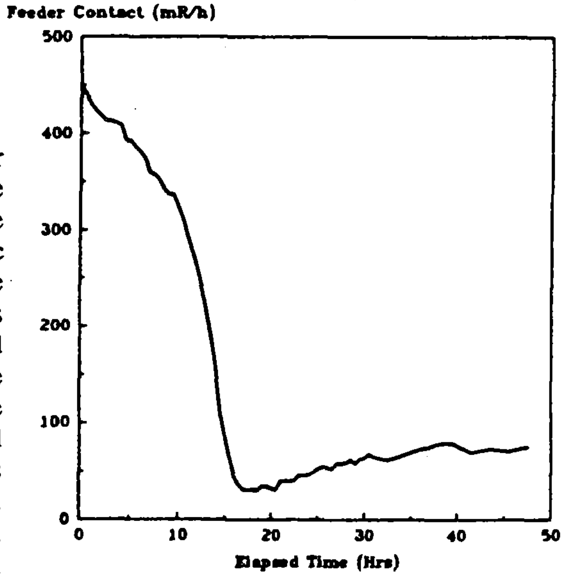

**Figure 4: Feeder Activity**

On-line survey probes attached to the end fittings indicated little activity removal from the stainless steel surfaces but some deposition of crud in the end fitting dead space between the closure plug and shield plug.

The major conclusions from this data was that most of the activity had been removed from the feeders. However an AP oxidizing step would be required to "condition" the stainless steel end fitting oxides for subsequent removal by a second CANDECON decontamination. Antimony-124 fields had risen but not to the point where the hydrogen peroxide decontamination step would be required.

## AP/CANDECON Step

The plan for the AP step was to inject potassium permanganate ($KMnO_4$) to a concentration of 1000 mg/kg with the reactor coolant system operating at a temperature of 85°C and a pH of 11 (using sodium hydroxide). On addition of the AP chemicals, $KMnO_4$ concentrations were found to be much lower than the target value of 1000 mg/kg. Although additional quantities of $KMnO_4$ were added, concentrations never increased above 540 mg/kg. As the $KMnO_4$ decomposed, considerable quantities of particulate manganese dioxide were produced which "plugged" a large capacity filter located upstream of the ion exchange columns. This filter was subsequently by-passed for the second CANDECON decontamination. Because $KMnO_4$ concentrations had dropped and further quantities could not be added without jeopardizing the ability to remove chemicals at the end of the step, the AP process was terminated prematurely.

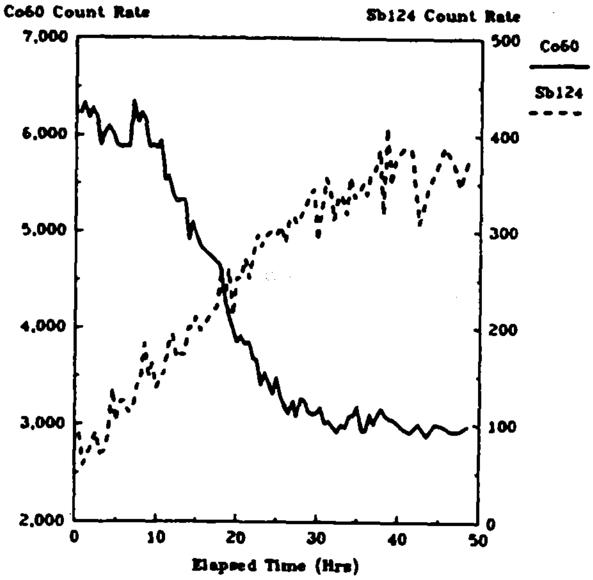

**Figure 5: Gamma Spectrometry Results**

Cobalt-60 radiation fields were not significantly affected by the AP process. Surprisingly, antimony-124 radiation fields were not significantly changed either. This was somewhat disappointing since it was expected that $KMnO_4$ would oxidize the deposited antimony-124 to soluble, ion exchangeable species. In addition, chromium dissolution was lower than expected with a maximum concentration of 2.5 mg/kg.

The second CANDECON decontamination was carried out immediately following the AP step to remove the "conditioned" stainless steel end fitting and residual feeder oxides. As with the initial CANDECON decontamination, comprehensive radiation field surveys were taken before, during and after the decontamination.

As shown in figure 6, cobalt-60 fields on the feeders dropped at a steady rate for the first 15 hours before plateauing out. This appears to indicate that the AP step affected the residual feeder oxide enabling subsequent removal by the CANDECON step.

Gamma spectroscopy count rate data indicated that antimony-124 was removed from the end fitting and feeder surfaces. This was contrary to experience during the initial CANDECON decontamination where antimony-124 was seen to deposit on the feeder and end fitting surfaces.

Subsequent inspections following the decontamination indicated that some crud was deposited in the end fittings. However the quantities were much less than expected based on previous Pickering decontamination experience.

Results of the corrosion monitor indicated that for the initial CANDECON decontamination, carbon

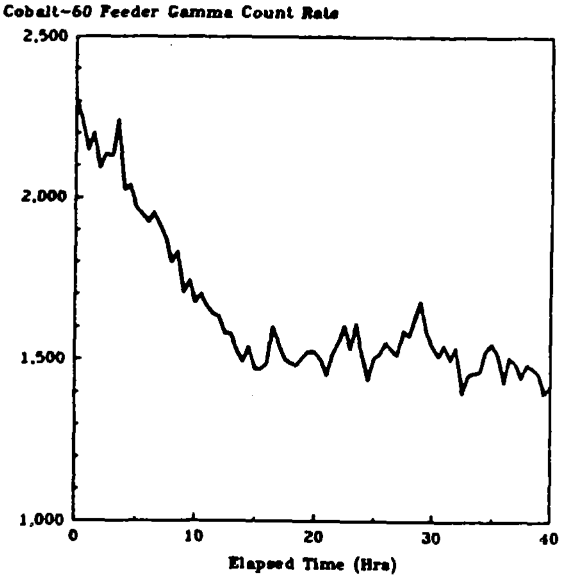

**Figure 6: Reactor Face Activity**

steel and 410 stainless steel corrosion rates were minimal. For the second CANDECON decontamination, carbon steel and 410 stainless steel corrosion rates were low at 0.13 and 0.012 µm/h respectively. Although some indications of pitting were observed on the 410 stainless steel, it was sporadic in nature and not considered to be significant.

The net result of the AP/CANDECON step was that radiation fields one meter from the reactor face had been reduced from 200 mR/h to 75 mR/h. The target had essentially been met! More than 1700 Rem of dose has been saved during the P3 LSFCR operations as a result of the decontamination. Further dose savings will continue during future operation from the now low radiation fields.

While an extensive understanding of the CANDECON process has been developed and while it's application to commercial reactors has been demonstrated, the knowledge remains empirical in some areas. The development program is therefore continuing. The program now focuses on four key areas:

- Decontamination factors are difficult to predict due to uncertainties about the relative contribution of contaminated feeders and end fittings to radiation fields at the reactor face. Comprehensive radiation field surveys are currently in progress on PNGS unit 3 during the LSFCR program to obtain a better understanding of the relative contribution of feeders and end fittings to reactor face radiation fields.

- Thought to be required, but not available, is a corrosion inhibitor suitable for use on later stations where the steam generators are tubed with Inconel-600 (as distinct from Pickering NGS where the steam generators are tubed with Monel-400). Programs are in place at AECL and Ontario Hydro Research to develop such an inhibitor.

- Antimony-124 has become a major contributor to reactor face radiation fields particularly at the later Bruce stations. It presents problems both with "normal" radiation fields and with radiation field enhancement following a CANDECON HT decontamination. An additional decontamination process needs to be developed specifically for antimony-124.

- With the present CANDECON process, reactor face radiation field reductions are limited due to residual oxides on both carbon steel and end fitting surfaces. To achieve further reductions:

  - why oxides remain on carbon steel surfaces following a decontamination must be determined.
  - a process to decontaminate the remaining oxides on (stainless steel) end fittings must be developed.

## Part 2: COMPONENT DECONTAMINATION

### INTRODUCTION

Decontamination of nuclear power plant components is required to reduce man-rem exposure, to reduce the potential for internal or external contamination of workers, and to minimize the potential for contamination spread.

Typically decontamination of components is carried out in a designated decontamination facility using processes which are not unlike conventional cleaning techniques. Within Ontario Hydro, decontamination facilities are now being upgraded by modifying layouts, reviewing operations and evaluating and using new decontamination techniques.

Proper decontamination facility layout is essential to minimize the spread of contamination. The decontamination facility should be laid out such that the components to be cleaned flow in one direction only, from the 'dirty' areas to the 'clean' area. Maintaining a similar flow path of personnel is equally important and therefore the facility must have separate entrance and exit doors. Current upgrading programs are addressing deficiencies in this area.

The operation of the decontamination facility is also being changed by assigning a dedicated crew to work solely within the facility. This 'ownership' of the facility is expected to result in more effective decontamination, better housekeeping, improved maintenance of decontamination equipment and development of decontamination expertise.

The third area being addressed is the development and evaluation of a variety of decontamination techniques and equipment. The balance of this paper discusses recent experience with the evaluation and use of numerous component decontamination techniques including high pressure water jetting, vibratory finishing, parts washers and liquid abrasive blasting.

## HIGH PRESSURE WATER JETTING

High pressure water jetting has been successfully applied for removal of loose and semi-adherent contamination from a wide variety of components. Portable high pressure pumps operating at discharge pressures between 21 and 69 MPa (3,000 - 10,000 psi) with flows of 20 to 40 L/min (5.2 to 10.4 USgpm) have been used with various types of nozzles for component decontamination.

The following sections describe some typical applications and results.

### Fuelling Machine Ram Assembly Decontamination

The fuelling machine ram assembly consists of a cylindrical housing which contains three telescopic rams. Two of the rams are moved by hydraulic power while the third ram is driven by four ball screws. The rams, ram ball screws, and other internal components are removed from the housing for maintenance. Each component must be decontaminated to remove the loose contamination prior to maintenance.

Ram assembly decontamination is carried out in two stages. The first step is to remove the internal components and then clean the inside of the ram housing. After the ram housing is cleaned, each of the internal components is decontaminated individually.

### Ram Housing Decontamination

Prior to the use of high pressure water lancing the interior surface of the 3.5 m long ram housing was decontaminated manually with long handled brushes. The manual method is labour intensive, dose intensive and did not always achieve the desired results. Loose contamination on the internal surface up to 5,000 cpm/100 cm$^2$ often remained after the manual brushing.

High pressure water lancing with a rotary cleaning head was used to overcome the deficiencies of manually cleaning the inside of the ram housing. The rotary cleaning head used is shown in figure 7. The head is a stainless steel high pressure swivel that is self-rotated by jet force. The rotational speed is controlled by an internal viscous fluid governor. Two sapphire pencil jet nozzles angled slightly forward are contained on the head.

High pressure water lancing

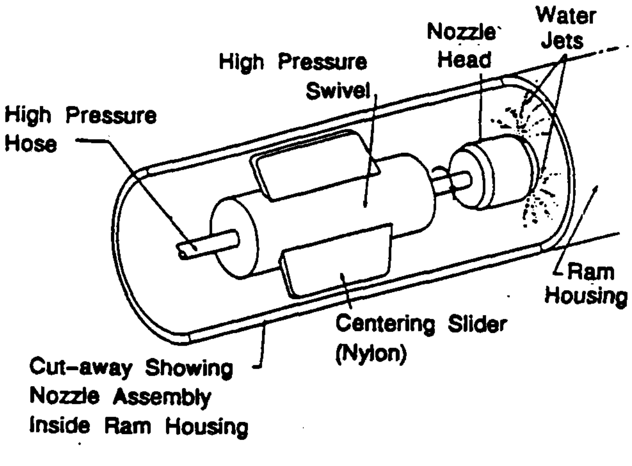

Figure 7: Rotary Cleaning Head

decontamination has been found to be much more effective than manual cleaning. One pass of the nozzle head through the ram housing reduces the loose contamination level to less than 1000 cpm/100 $cm^2$. In addition, water lancing reduces the time required to decontaminate a housing and lowers worker radiation exposure(5).

**Decontamination of External Surfaces of Ram Components**

The external surface of the ram housing, rams, and ram ball screws have previously been decontaminated by manually wiping with rags. The disadvantages of this method are similar to those experienced with manual decontamination of the ram housing internal surface. High pressure water lancing was identified as a better technique.

Initial attempts at water lancing decontamination of the component surfaces was conducted by hand held shotgunning. The results obtained were varied. Generally the surfaces were cleaned to loose contamination levels less than the required limit, however, areas of high contamination remained. The varied results were attributed to the difficulty in controlling the high pressure lance to ensure constant attack angle and 100% coverage.

A remotely operated lancing machine was designed and fabricated to improve the consistency of results attained. In addition the use of this machine would also be beneficial in improving worker safety by eliminating fatigue and reducing radiation exposure. The remotely operated lancing machine is shown in figure 8. The lancing machine is positioned over the component to be cleaned and the stand-off distance is set by hand wheels. A nozzle head is traversed, at variable rates, along the cross beam by a chain drive powered by an air motor. A hose carrier is provided to prevent the high pressure hose from becoming entangled in the chain. The nozzle head consists of a high pressure swivel joint with two pencil nozzles. An air motor is used to rotate the nozzle head. A control panel is included which can be positioned up to eight meters from the machine. The operator controls the horizontal traverse rate of the nozzle head and the rotational speed of the nozzles from this panel.

One of the first trials with the lancing machine was to determine the difference in decontamination

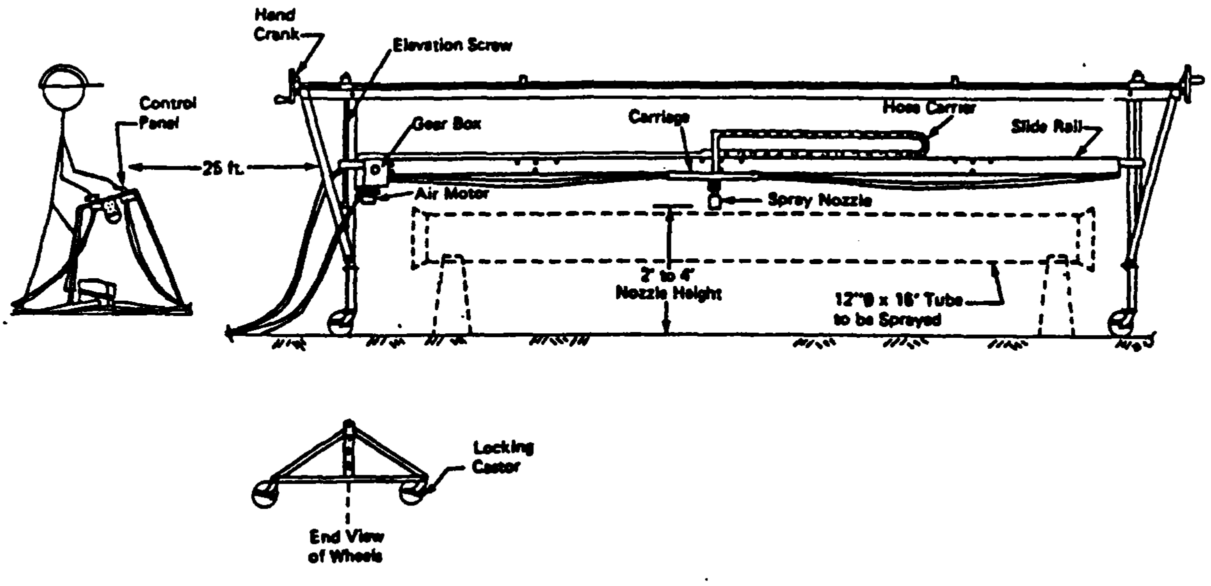

Figure 8: Lancing Machine

effectiveness between the machine and shot gunning. A ram ball screw was decontaminated by each method and the contamination remaining was determined. The effectiveness for the surface of the screw was similar for the two methods however the lancing machine was more effective for decontamination of the threads. The post lancing contamination levels with shot gunning were ten times those for the lancing machine.

The high pressure water lancing machine is now being used for decontamination of exterior surfaces of the ram assembly components. Decontamination results far surpass those obtained with manual wiping. With three passes along the length of the screw loose contamination was reduced from 20,000 cpm/smear to <10 cpm/smear in most cases. The time required to decontaminate the screw was reduced by a factor of 2 to 3 as compared to hand wiping.

### Fuelling Machine Head Decontamination

Decontamination of the interior surfaces of fuelling machine heads have been carried out at Pickering NGS using various manual methods such as hand scrubbing, wire brushing and even with a hammer and chisel. These methods were dose and labour intensive and led to a spread of contamination throughout the decontamination facility.

High pressure water jetting was suggested as an alternative technique to eliminate the problems associated with manual cleaning. A Unit 2 fuelling machine head was successfully decontaminated by manual shot-gunning.

The initial step in the decontamination of the head was to split the head at the Grayloc seal and attach a splash guard to each half. The splash guard is an aluminum end cap which is clamped onto the FM to contain the deflected spray. The high pressure lance is then inserted through access ports in the plexiglass front face of the splash guard.

The initial dose rates on the exterior surface of the head were 50 R/h. High pressure water jetting reduced the fields to 5 mR/h. Average loose contamination levels were reduced to <1,000 cpm/smear.

### Kelly Decontamination Machine

A Kelly Decontamination Machine was purchased for the decontamination of structural surfaces. The Kelly system involves the use of high pressure water (1.7 MPa) and water heated to 150°C to overcome the adhesion of the contamination to surfaces. Along with the hot high pressure water, a high efficiency vacuum is used to remove the contaminated water through the cleaning head.

The Kelly system was used successfully to decontaminate a section of the concrete floor of the Pickering NGS fuel transfer tunnel prior to repair of a leaking bulkhead. Radiation surveys of the area showed gamma fields to be 1-2 R/h and beta fields to be 300 mRad/h at the floor. Loose contamination on a smear was 15 mR/h. Approximately 24 square feet of concrete floor and wall were decontaminated in 60 minutes. The initial and final radiation results are impressive. Beta radiation was reduced from 300 mRad/h to undetectable levels, and loose contamination was reduced from 15 mR/h per smear to 100,000 cpm per smear. Further reductions in loose contamination levels were expected but time limitations did not allow the decontamination beyond 60 minutes.

The Kelly decontamination system is considered to be an effective tool for the very specific task of decontaminating structural surfaces.

## VIBRATORY FINISHING MACHINE

Vibratory finishing is a method used in the metal finishing industry to deburr, clean, and polish parts.

Application as a decontamination technique had been evaluated in about 1980 with decontamination factors of 100 being obtained. Advantages of vibratory finishing include; low manpower requirements, no hands-on requirement during operation, low waste volumes, and the ability to remove slightly adherent material.

A five cubic foot vibratory finishing machine was purchased for evaluation purposes. Stainless steel 'ballcones', football shaped with one round end, were chosen as the initial media to be used as they provide good surface coverage with a moderate aggressiveness. A commercially prepared proprietary solution was used to carry away the loosened contamination. A cartridge filter was used to remove contamination from the solution. A schematic of the PNGS vibratory finishing system is shown in figure 9.

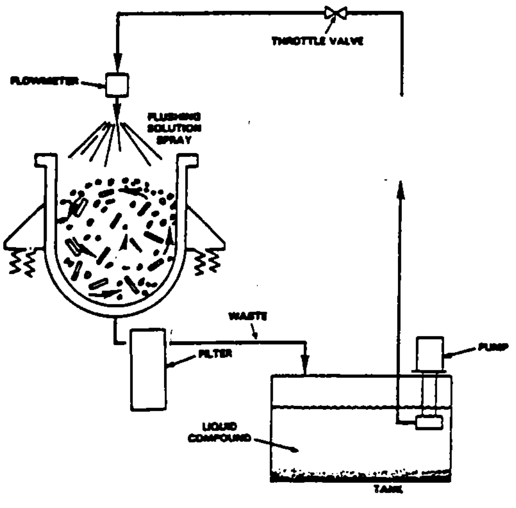

Figure 9: Vibratory Finisher

Initial evaluation has shown the vibratory finisher to be effective on various components including hand tools, bolts, and small machined components. Pressure tube closure plugs were decontaminated from 30,000 to 2500 cpm/ smear in approximately 2 hours. Currently evaluation of a more aggressive media, pins, and alternative flushing solutions are under way.

## PARTS WASHERS

Automated parts washing has been used on two size scales for decontamination purposes. A residential dishwasher was purchased for use in the PNGS fuel handling equipment decontamination facility to clean small components like valves, flowmeter, bearings and tools. This machine has been used almost continuously since it was purchased in 1989. Components are cleaned to <1,000 cpm/smear. In addition tests have been conducted with highly contaminated closure plugs. Typically it was found that the exterior of closure plugs can be cleaned from 30,000 cpm/smear to < 1000 cpm/smear in two to three wash cycles. The dishwasher has recently been replaced with a commercial laboratory equipment washer. This machine has the advantage that the inside is stainless steel and therefore will resist contamination better than the dishwasher. Water pressure and temperature are also somewhat higher.

An industrial parts washer with a 500 kg load capacity has recently been purchased and is undergoing commissioning tests in the PNGS decontamination facility. This machine is somewhat different from those previously purchased by Ontario Hydro in that it has 21 MPa rinse cycle sprays. Preliminary results indicate good decontamination effectiveness. Decontamination trials on valve bodies, heat transport pump seals and other mechanical components have reduced loose contamination to less than 1,000 cpm/smear. Further information on the effectiveness will be obtained as commissioning continues.

## LIQUID ABRASIVE BLASTING DECONTAMINATION SYSTEM

A liquid abrasive blasting (LAB) decontamination system, shown in figure 10, was purchased for use at PNGS for removing adherent loose and fixed contamination from reactor retube tooling. The LAB system purchased has the capability to decontaminate with liquid abrasive blasting or high pressure water jetting (21 MPa). The LAB system combines abrasive media to provide the cleaning action and air and water to provide cushioning and flushing.

The LAB booth has been in service since 1989 and has been used extensively for decontamination of retube tooling. Decontamination results have been very good. Loose contamination on tooling is routinely reduced to below required limits.

Specialized tooling has been fabricated for this booth to allow decontamination of various equipment geometries. In one case a tool to clean the bore of a cylindrical sleeve was designed and fabricated. During the previous retubing programs these sleeves could not be decontaminated with manual methods and as a result had to be capped and stored. Using the bore cleaning tool the sleeves were cleaned to acceptable units and reused.

The LAB booth has operated relatively problem free since being commissioned. Minor problems are usually traceable to improper operation and maintenance as a result of lack of expertise for this equipment. Purchase of a second booth to be used for decontamination during Bruce NGS Retubing is being recommended.

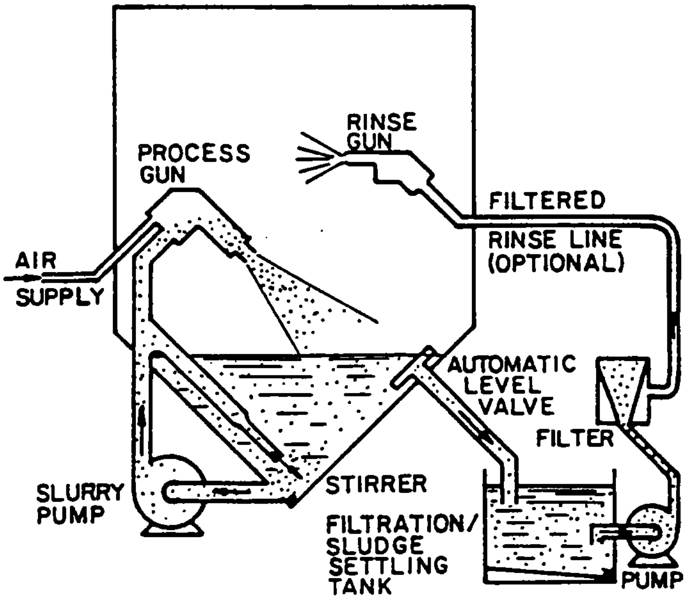

**Figure 10**: Liquid Abrasive Decontamination

## CONCLUSIONS

For HT decontamination, development of the CANDECON process and extensive experience with it's application, has enabled Ontario Hydro to apply tailor made decontaminations, with excellent radiation field reductions. Development to enhance these essential capabilities is ongoing.

For component decontamination, layout of the decontamination centre, ownership of the centre by dedicated manpower, and the availability of a variety of decontamination tooling, are all essential for effective decontaminations. High pressure water jetting, vibratory finishing, partswashers, and liquid abrasive blasting have all been demonstrated to be effective component decontamination techniques.

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