

Decommissioning of Active Ventilation Systems in a Nuclear R&D Facility to Prepare for Building Demolition (Whiteshell Laboratories Decommissioning Project, Canada) – 13073

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ABSTRACT

Whiteshell Laboratories (WL) is a nuclear research establishment owned by the Canadian government and operated by Atomic Energy of Canada Limited (AECL) since the early 1960s. WL is currently under a decommissioning license and the mandate is to remediate the nuclear legacy liabilities in a safe and cost effective manner. The WL Project is the first major nuclear decommissioning project in Canada. A major initiative underway is to decommission and demolish the main R&D Laboratory complex. The Building 300 R&D complex was constructed to accommodate laboratories and offices which were mainly used for research and development associated with organic-cooled reactors, nuclear fuel waste management, reactor safety, advanced fuel cycles and other applications of nuclear energy. Building 300 is a three storey structure of approximately 16,000 m². In order to proceed with building demolition, the contaminated systems inside the building have to be characterized, removed, and the waste managed. There is a significant focus on volume reduction of radioactive waste for the WL project. The active ventilation system is one of the significant contaminated systems in Building 300 that requires decommissioning and removal.

The active ventilation system was designed to manage hazardous fumes and radioactivity from ventilation devices (e.g., fume hoods, snorkels and glove boxes) and to prevent the escape of airborne hazardous material outside of the laboratory boundary in the event of an upset condition. The system includes over 200 ventilation devices and 32 active exhaust fan units and high efficiency particulate air (HEPA) filters. The strategy to remove the ventilation system was to work from the laboratory end back to the fan/filter system. Each ventilation duct was radiologically characterized. Fogging was used to minimize loose contamination. Sections of the duct were removed by various cutting methods and bagged for temporary storage prior to disposition. Maintenance of building heating, ventilation and air conditioning (HVAC) balancing was critical to ensure proper airflow and worker safety. Approximately 103 m³ of equipment and materials were recovered or generated by the project. Low level waste accounted for approximately 37.4 m³. Where possible, ducting was free released for metal recycling. Contaminated ducts were compacted into B-1000 containers and stored in a Shielded Modular Above-Ground Storage Facility (SMAGS) on the WL site awaiting final disposition. The project is divided into three significant phases, with Phases 1 and 2 completed. Lessons learned during the execution of Phases 1 and 2 have been incorporated into the current ventilation removal.

INTRODUCTION

In 1997, Atomic Energy of Canada Limited (AECL) made a business decision to discontinue research programs and operations at Whiteshell Laboratories (WL) due to the federal

government's program review process. As a result, AECL has a business requirement to operationally shutdown and to decommission WL buildings and facilities.

Building 300 (B300) was constructed in various stages from 1966 to 1985 to accommodate laboratories and offices for research and development associated with organic-cooled reactors, nuclear waste management, reactor safety, advanced fuel cycles and other applications of nuclear energy.

In preparation for eventual demolition of B300, the active ventilation first had to be removed. This included disconnecting and removing active ventilation ductwork, filters, fans, stacks and all associated redundant components. The project was divided into three major phases: Phase 1 consisting of the removal of five ventilation systems in B300 High Bay (Stage 3) completed in 2011, and Phase 2 consisting of the removal of ten ventilation systems in B300 Core Area (Stage 1) completed in 2012. Lessons learned during the execution of Phases 1 and 2 have been incorporated into the current ventilation removal.

The active ventilation ductwork was handled according to job specific hazard/risk assessment and work instructions. Where practical and economically reasonable, contaminated materials were decontaminated to unrestricted-release criteria and released as clean material. Cleared material was dispositioned for either reuse, recycling or disposed of as non-recyclable waste in the WL inactive landfill. Contaminated polyvinyl chloride (PVC) ducts cannot be easily decontaminated and were volume-reduced and transferred to the WL Waste Management Area (WMA) for storage.

Materials that are impossible/impractical or economically unreasonable to decontaminate, or cannot be verified to satisfy unconditional release criteria, may be recycled through an off-site contaminated metal-melt recycler via a contract established at Chalk River Laboratories (CRL) or transferred to the WL WMA for storage. WL is considering the former option for future disposition of Active Ventilation or a specific WL contract.

SYSTEM DESCRIPTION

The active ventilation system was designed to prevent the escape of hazardous fumes and radioactivity from confinement systems used in B300 laboratories (e.g., fume hoods and glove boxes) and to prevent the escape of airborne hazardous material outside of the laboratory boundary in the event of an upset condition. This was accomplished by directing the fresh air supply through areas of low potential contamination to areas of high potential contamination and finally through removable and replaceable HEPA filters to capture and contain airborne contaminants prior to exhausting the building. HEPA filters are rated to contain or trap particles down to 0.3 micron in size with 99.97% efficiency.

A typical layout of a ventilation fan and its related components is shown in Figure 1; stack on top of the roof, ventilation fan, damper, filter exhaust plenum, HEPA filter bank, filter intake plenum, main duct passing through different levels or floors of the building, branches of ducts connected to the ducts at various floors and rooms, device damper, and roughing filter located above each ventilation device.

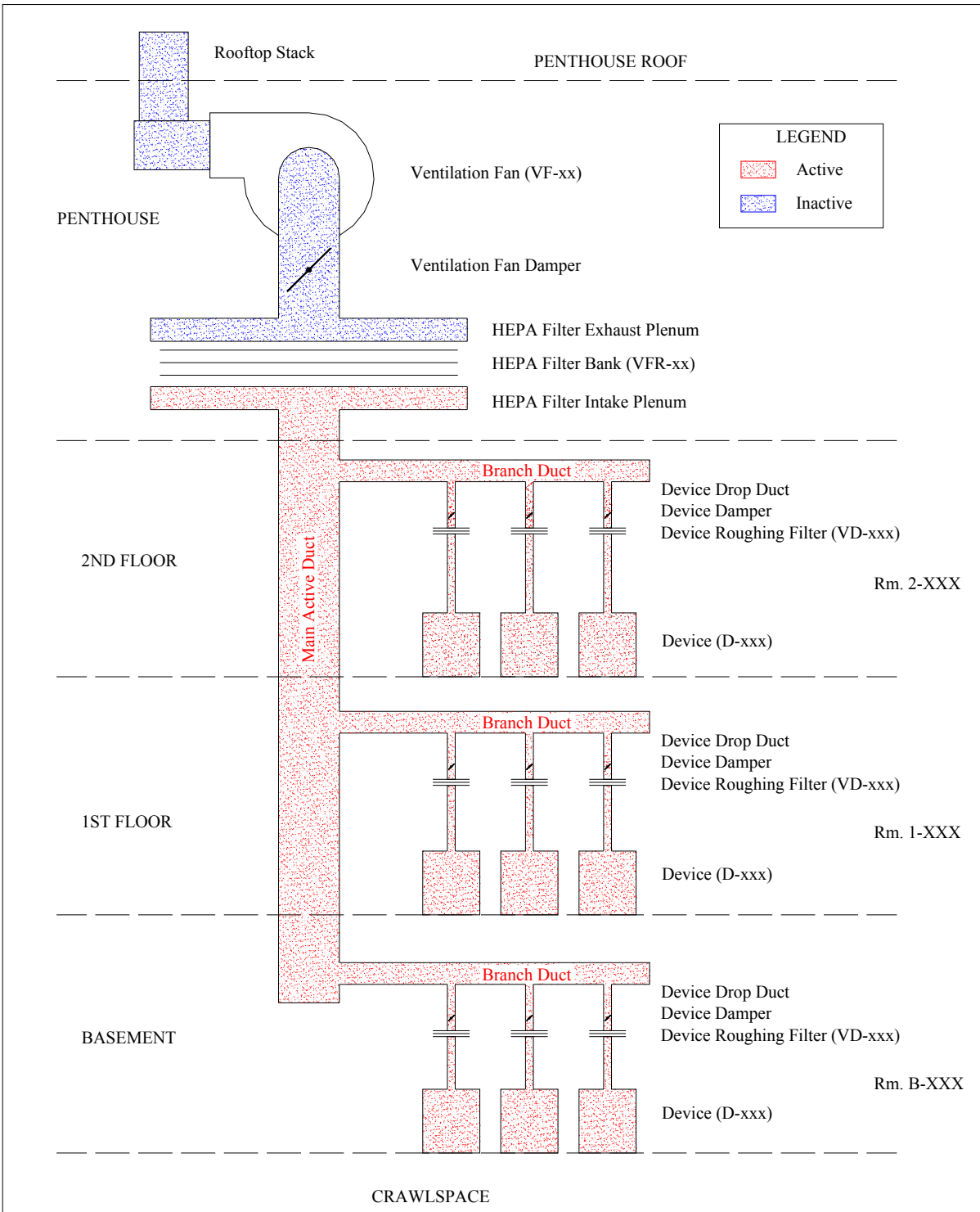


Figure 1 Typical Layout of a Ventilation Fan and its Components

The High Bay active ventilation system consists of five fan systems (V-F45, V-F64, and V-F67 are exclusive to the High Bays and V-F60 and V-F66 cross from the North High Bay into the southern portion of the B300 “Core Area”).

Duct material consisted of either Type 304 ASTM A240 Stainless Steel or PVC, with the exception of a few small diameter copper, plastic, or galvanized pipes used in ventilation of bench top experiments.

RADIOLOGICAL HAZARDS

The primary radiological hazard for the removal of the active ventilation was the risk of encountering loose contamination within the ducts and dispersal of airborne contamination during the removal of ventilation ducts, plenums, dampers, and roughing and HEPA filter housings.

Rooms exhausted by the five ventilation fan systems included the Van de Graaff Accelerator room, inactive laboratories, radioisotope laboratories and a workshop for tradesmen. The ventilation devices exhausted within these rooms included fume hoods and exhaust canopies. The primary radionuclides handled were natural uranium and thorium, with some rooms handling materials containing mixed fission products and reactor component activation products.

A hazard assessment of the South High Bay ventilation was completed to assess the potential for contamination within the ventilation systems and to confirm the types of radionuclides that might be expected. This assessment consisted of conducting contamination surveys of fume hoods prior to and during disconnection from the ventilation systems, conducting contamination surveys of fume hood roughing filter housings, conducting contamination surveys of fan system HEPA filter housings, performing over 80 ventilation duct coupons¹ that measured for alpha and beta/gamma contamination, and internal swipes inside ducts at the coupon openings.

Contamination was found in more than half of the fume hoods. Where contamination was found, the levels within these fume hoods were typically low level fixed contamination with mixed alpha and beta contamination ranging from 25 cpm to 100 cpm alpha and 400 cpm to 1500 cpm beta/gamma. Higher contamination levels were detected in two fume hoods in which natural thorium was handled.

Contamination was found in the filter housings in a basement lab and ventilation system, where 200 to 500 cpm beta/gamma fixed activity was measured.

During characterization, the only contamination detected at the 80 duct sampling locations was removable surface contamination in a section of ducting in the second floor High Bay. Swipes taken from inside the duct at 4 coupon locations on this fan system had detectable alpha contamination above background ranging from ~ 10 to 20 cpm alpha (0.015 to 0.025 Bq/cm² removable alpha per 100 cm²). Gamma spectroscopy of the swipes identified Th-232 decay progeny. These levels are below AECL's maximum removable contamination levels for unrestricted release.

Contamination surveys of the HEPA filter plenums, located in the penthouse, did not detect evidence of contamination, with the exception of one HEPA filter intake plenum with approximately 300 cpm beta/gamma above background², measured with a GM pancake detector. Radiation dose rates in laboratories were at background ambient levels (10 to < 18 microrem/h).

¹ The ductwork was characterized on fans V-F45, V-F64, V-F66, and V-F67 by cutting approximately 80 holes in the side of the duct using a hole saw to produce a cut-out coupon at approximately 2 m intervals. The outer surface of the duct was surveyed on the outside, the hole was cut, the coupon (hole saw cut-out) was surveyed, and a swipe was taken inside the duct adjacent the hole.

² Background in the penthouse was < 200 cpm beta/gamma.

No airborne contamination potential was anticipated during the removal of the ventilation system ducts and components. Based on the hazard assessment, the ventilation system ducts and components were expected to be clean or have only very low levels of contamination. In addition, all internal duct surfaces were coated with InstaCote™ CC WET³, a stabilising agent which mitigates or significantly suppresses the friability of surface contamination when cuts are performed. Overhead cuts were performed under the negative pressure of the operating fan.

Radiological characterization surveys of the ventilation system ducts and components indicated there was no or only low potential for residual radioactive contamination within the ductwork. The potential release of airborne contamination was further minimized when cutting ductwork coated with InstaCote™ CC WET stabilizing agent and with the duct maintained under negative pressure. The following radiological precautions were adhered to, to ensure acceptable radiological conditions were maintained and to protect workers from unforeseen abnormal conditions:

- Perform pre-cutting radiological surveys of ductwork to confirm no evidence of internal contamination or to identify locations of known or suspect internal contamination. This should consist, as a minimum, of an external survey of duct surfaces using a measurement instrument equipped with an NaI detector as specified by a Group 1 Health Physicist. If necessary, obtain additional duct coupons and internal duct swipes for assessing the presence of contamination within ducts to be cut or sectioned.
- Establish, as a minimum, a temporary contamination zone work area where ductwork will be removed or sectioned. If evidence of contamination is detected during pre-cut radiological surveys, consult with a Group 1 Health Physicist to determine whether an alarming continuous air monitor (CAM) is required in the work area.
- If deemed required and feasible, enclose the immediate work area surrounding the duct with fire retardant sheeting suspended from above the ducting to the floor in order to contain any cutting debris generated during the cutting of ducts.
- Implement the following contamination controls and precautions during the cutting, removing or handling of ductwork:
 - Wear as minimum appropriate personal protective work clothing including cut and puncture resistant gloves as recommended by site Occupational Safety and Health (OSH) staff, during the cutting, sectioning or handling of ductwork. Wear additional anti-contamination clothing (e.g., Tyvek® suit, double gloving, rubber shoe covers) when working on contaminated ductwork.
 - Use the following graded approach when selecting face and respiratory protection.
 - Wear as minimum a face shield during any duct cutting.
 - Wear a half-face air-purifying respirator and face shield or a full-face air-purifying respirator if the ductwork has not been confirmed to have low contamination or is suspected of being contaminated.

³ CC Wet is a water soluble solution used widely in industry to stabilize surfaces highly contaminated with radiological, beryllium, asbestos and other hazardous surface contamination and reduce airborne contamination. It is applied as either a fog or fine mist to internal surfaces of ductwork and filter housings. Wetting agents have been successfully used in the US nuclear industry to prevent re-suspension of radiological, beryllium, asbestos, or other harmful particulates, to reduce exposure to the worker and the level of respiratory protection required during decontamination and demolition activities.

- Wear a full-face air-purifying respirator if the duct is known to be contaminated.
- Treat all used cutting blades and surfaces of cutting tools as potentially contaminated until confirmed otherwise by Radiation Protection (RP) staff.
- Monitor hands, feet, tools and equipment for contamination following the completion of cutting operations.
- Perform work place air sampling in the vicinity of workers during any cutting and removal of exhaust ductwork. Collect at least daily, or at the completion of cutting a section of duct, and send for total alpha and beta counting and gamma spectroscopy, to confirm no evidence of airborne contamination or the adequacy of respirator protection.

Perform regular vacuuming using a vacuum cleaner equipped with a HEPA filter. Perform regular contamination checks. Mop and wipe down of the work area and surfaces at risk for contamination as directed by the Radiation Surveyor during and after cutting operations.

INDUSTRIAL HAZARDS

AECL's OSH programs, the Work Permit system, the Job Scope and Safety Analysis process, along with all applicable federal and provincial standards, were used to minimize the impact of hazards on worker health and safety.

A review of the historical use or presence of hazardous materials in B300 was conducted to identify rooms where the potential for residual hazardous material remained in B300 laboratories. InstaCote™ CC WET was also used to mitigate hazards associated with the potential for residual traces of asbestos, mercury, carcinogens and beryllium during the removal of the active ventilation ductwork.

The cutting, sectioning and handling of the ductwork involved several potential industrial safety hazards including slips, trips and falls; working at elevated heights; handling ducts, tools/objects while working at heights; cuts, scrapes and pinch points from handling cut ducts and metals; kick-back from cutting tools; flying debris from hand-held rotating cutting tools; and potential back strain from repetitive lifting/twisting during cutting and handling of duct sections. The following precautions were adhered to when preparing the Job Scope Safety Analysis:

- Maintain good housekeeping.
- Use work platforms when performing work at elevated heights. Ensure fall protection measures are in place for any work at heights above eight feet.
- Where feasible use mechanical lifting devices to help support and lower cut duct sections.
- Establish the work area as a hardhat area during any overhead work.
- Wear face and eye protection when using power tools.
- Wear cut and puncture resistant gloves when handling potentially sharp surfaces or surfaces with risk of slivers.

WASTE MANAGEMENT

Approximately 103 m³ of equipment and materials were expected to be recovered or generated from the B300 High Bay Active Ventilation decommissioning activities. Wastes were segregated and managed in accordance with AECL Procedures.

“Likely clean” material includes all non-ventilation system components and ventilation exhaust systems ducts and components located after the HEPA filters (e.g., stainless steel ductwork, fan

motors/fan housings), redundant air supply systems and any non-ventilation system materials that require removal to facilitate access to the ventilation system. “Likely Clean” material was estimated to be ~41.3 m³ (Table I).

The total Low Level Radioactive Waste (LLRW) requiring storage was estimated to be ~37.4 m³ (Table I) after volume reduction tactics were implemented. The LLRW was packaged, characterized and transferred for either storage in the WL WMA or sent off-site for processing by a licensed contaminated metal-melt recycler via a contract established at CRL. No intermediate-level waste was generated during execution of this ventilation removal work.

Table I. Total Compacted Waste Volume Estimate

Material Type	LLRW^a (m³)	Clean Recyclable to Materials Logistics (m³)	Clean Non-Recyclable to WL Landfill (m³)	Clean to Miller Environmental (m³)	TOTAL (m³)
Active Ventilation Stacks	0	1.3	1.9	0	3.2
Active Ventilation Ducting	23.8	4.3	10	0	38.1
Active Ventilation Fans/Fan-Motors ^b	0	29.2	0	0	29.2
HEPA Filter Plenums	5.4	0.3	0.2	0	5.9
HEPA Filters	3.2	0	0	0	3.2
Demolition Materials	1	2.2	2	0	5.2
Redundant Equipment	0	4	0	0	4
Bagged Waste	4	0	10	0	14
Hazardous Materials	0	0	0.2 ^c	0	0.2
Total (m³)	37.4	41.3	24.3	0	103
B-1000's Required	~ 15^d B-1000 Containers				
Recyclable Active Metal	24 m³ (~ 10 B-1000 containers)				

a Transferred for storage in the WL WMA and/or sent off-site for processing by a licensed contaminated metal-melt recycler.

b For the purpose of calculating estimated volumes, active ventilation fans are considered to be on average ~1 m³ (compacted) each. The total combined volume of all other redundant fans is estimated to be ~1 m³.

c The non-recyclable hazardous material shown in this table, refers to any appropriately packaged clean asbestos containing materials produced by this ventilation removal to be disposed of in the WL asbestos landfill.

d Assuming that a B-1000 container can hold ~ 2.5 m³ of compacted material, the ~ 29.4 m³ of LLW active waste produced by executing this ventilation removal work would fit into twelve B-1000 containers for storage in the WMA.

Approximately two standard garbage bags (un-compacted) of decommissioning operations active waste (e.g., disposable protective clothing, surface coverings, wipes, mops, etc.) were produced each day. The total volume of bagged active waste for completing the removal of the active ventilation was < 2 m³ for storage in the WL WMA.

PROCEDURE

The decommissioning technique described in this section uses a bottom-up method⁴ of systematically shutting down each fan system while maintaining the minimum requirements of building airflow volume and differential pressure.

The general order of decommissioning an active ventilation fan system using the “Bottom-Up” technique is as follows:

1. Remove all active ventilation devices. Systematically reduce airflow, by reducing the fan speed or shunting^{5, 6} exhaust flow while removing roughing filters and active ventilation ductwork. All ductwork will be removed under negative ventilation pressure using the “Bottom-Up” technique.
2. Remove all branch ductwork.
3. Remove HEPA filter system.
4. Remove the fan, the fan housing and the stack.
5. Restore building integrity for occupancy.

The following procedure was used to remove active ventilation in the High Bay area.

- Fog or spray the internal surfaces of all potentially contaminated ventilation ductwork with InstaCote™ CC WET stabilizing agent prior to cutting or removal.
- Begin the removal of ducting at the furthest branch from the fan and proceed toward the fan to ensure that there is always exhaust flow in the ducting being removed. As cutting proceeds, measure and adjust ventilation exhaust flow rates as directed by WL Engineering in order to maintain appropriate exhaust and differential pressures.
- If work is to cease for any length of time (e.g., overnight), a roughing filter will be temporarily installed over the open duct to protect against airborne release in an unlikely flow reversal caused by an upset condition.
- Perform overhead cuts under the negative pressure of the operating fan. If ground level sectioning of a duct is required, cutting is not required to be performed under ventilation as long as internal surfaces have been coated with InstaCote™ CC WET stabilizing agent. Otherwise, use a portable HEPA filter exhaust unit to exhaust and maintain the duct under negative pressure during any cutting or sectioning unless the surfaces have been confirmed to be free of contamination.
- Cover work surfaces directly under the cutting location in order to collect any cutting debris. When using work platforms, erect a fire retardant skirt around the platform railing to contain any cutting debris and prevent the risk of material falling off the platform.
- Plan duct cutting so that the number of necessary cuts and sectioning of duct work is kept to a minimum in order to satisfy handling, packaging and storage requirements for the

⁴ “Bottom-Up” refers to starting decommissioning of active ductwork starting at the furthest component away from the fan and systematically removing all active branch lines up to and including the HEPA filters, fan and stack.

⁵ Shunting airflow is the practice of bypassing air flow between the HEPA bank and the fan to manage the static pressure in the ductwork.

⁶ As long as the fan is running, the open duct shall never be restricted or blocked from airflow. If work is to cease for any length of time (e.g., overnight), a roughing filter will be temporarily installed over the open duct to protect against airborne release in an unlikely flow reversal caused by an upset condition.

disposition of the duct for clearance monitoring (likely clean material) or management as radioactive waste material.

- Avoid cutting curves and bends in the ducting which have an inherently higher potential for the accumulation of contaminated particles.
- Avoid cutting surfaces with known surface contamination.

CUTTING METHODS

Cutting methods and tools were selected to: a) optimise the efficient and safe removal of ventilation ductwork and components; b) minimize the generation of airborne particulates and dispersion of cutting debris; c) reduce the risk of kickback; and d) reduce the creation of sharp or jagged surfaces.

The preferred cutting tools, in order of preference were: mechanical nibbler, portable band saw, dual saw, chipper saw, reciprocating saw (with trigger locks disabled) and hot wire cutter.

The use of an angle grinder for cutting known or potentially contaminated metal surfaces was avoided. Other cutting tools and methods such as welding or plasma torch cutting were not used.

Wear cut resistant protective guards over personal protective equipment and clothing for protection of arms during any duct cutting or other handling that requires reaching into open or cut duct with sharp/jagged edges. Tape all sharp/jagged edges to avoid the direct handling of open ends or cut ducts.

CURRENT AND FUTURE ACTIVE VENTILATION REMOVAL

Lessons learned from the above work were reviewed and utilized to begin removal of a third group of active ventilation systems. Nine fans in this group serviced the Core Area Extension (Stage 4) and a further eight fans serviced the North Extension (Stage 7) of B300. All of these ventilation systems are scheduled to be removed by 2013 July with two systems already completed through 2012 October.

The lessons learned include:

- A separate set of tools for each team so people don't have to go get tools in another area would increase productivity.
- Better communication (possibly walkie-talkies) between floors would improve productivity.
- Need to apply InstaCote™ CC WET carefully so that it does not pool in low areas of the ducting.
- A scissor lift (instead of scaffold) would improve safety and productivity. A scaffold is tiring, increases the time a job takes and increases the potential for injury.
- Need to oil nibblers more often to keep them cutting well.

CONCLUSION

AECL has developed expertise in removing active ventilation systems from its nuclear buildings at the WL site. Seventeen ventilation systems in B300 have been removed as of 2012 October with another fifteen systems scheduled to be removed by 2013 July. Lessons learned from Phases 1 and 2 are being employed to more safely and efficiently remove the current ventilation systems.