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A tale of hazards: Ingenium's industrial collections move

Uma história dos perigos: o movimento das coleções industriais na Ingenium

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Abstract

In 2018, Ingenium began a large-scale collections move, consolidating artefacts from four rental warehouses into a new purpose built storage facility. Collection hazards were assessed, prioritised and treated according to Ingenium's comprehensive Collection Risk Management Program (CRMP), placing health and safety at the forefront of collections care. This paper will present hazard assessment and mitigation in one warehouse, the *Building 2421 Reserve Collection*, showing the challenges overcome to move a large industrial collection on a tight schedule and with limited staffing and resources. A selection of case studies will provide examples of hazard mitigation in artefacts containing asbestos, radioactivity, polychlorinated biphenyls (PCBs) and mercury. The case studies demonstrate how simple solutions and triage treatments were implemented by conservators and specialised contractors in order to mitigate collection hazards during the move project. The Building 2421 Reserve Collection move was completed in December 2021 and the full collections move was completed in August 2022.

KEYWORDS
Collections move
Asbestos
Polychlorinated biphenyls (PCBs)
Mercury
Radioactive
Hazardous collections

Resumo

Em 2018, a Ingenium iniciou uma mudança em grande escala de coleções, consolidando artefactos de quatro armazéns de aluguer para uma nova instalação de armazenamento construída para o efeito. Os perigos das coleções foram avaliados, priorizados e tratados de acordo com o abrangente Programa de Gestão de Riscos de Coleção (CRMP) da Ingenium, colocando a saúde e a segurança na vanguarda dos cuidados com as coleções. Este artigo apresentará a avaliação e mitigação dos riscos num armazém - *Building 2421 Reserve Collection* - mostrando os desafios superados para mover uma grande coleção industrial com tempo, pessoal e recursos limitados. Uma seleção de casos de estudo fornecerá exemplos de atenuação dos perigos em artefactos contendo amianto, radioatividade, bifenilos policlorados (PCBs) e mercúrio. Os casos de estudo demonstram como soluções simples e tratamentos de triagem foram implementados por conservadores e empreiteiros especializados, de modo a atenuar os riscos de recolha durante o projeto de mudança. A mudança para o *Building 2421 Reserve Collection* foi concluída em Dezembro de 2021 e a mudança completa das coleções foi concluída em Agosto de 2022.

PALAVRAS-CHAVE
Movimentação de coleções
Amianto
Policlorobifenilos (PCB)
Mercúrio
Radioatividade
Coleções perigosas

Introduction

We begin as all good tales begin: once upon a time… in land far, far away, where winters are cold and summers are hot, there was a museum corporation by the name of Ingenium. Nestled in the capital of Canada, the city of Ottawa, Ingenium runs three national museums located on three separate campuses: the Canada Aviation and Space Museum (CASM), Canada Science and Technology Museum (CSTM), and Canada Agriculture and Food Museum (CAFM). The three museums contain a variety of artefacts from scientific and technological history with special focus on Canada.

Previously, Ingenium's collections were stored in four rental warehouses. The Ingenium Centre, a new purpose-built storage facility, was recently constructed to house the 165,000 large and small artefacts. From 2018 to August 2022 the characters in our tale worked to prepare and move the artefacts into their new home, finding and fixing collections care issues along the way.

Amongst the four old and outdated rental buildings was the *Building 2421 Reserve Collection* comprising 5500 industrial artefacts. This industrial collections space included thousands of artefacts accessioned after the closure of the Ontario Hydro Museum of Electrical Progress in 1992 as well as two radioactive storage rooms. However, the collections storage space was overcrowded, leading to a host of issues due to lack of access. The collections move presented an opportunity to correct some collections care deficiencies and meet modern collections standards. Literature research and consultations on-site with other museums nationally and internationally assisted with the planning stages prior to moving the collection.

Three conservators worked full-time assessing and mitigating hazards in the *2421 Reserve Collection*. Conservation staff led the move project and led hazard assessment and mitigation, physical stabilisation and packing or palletising of each artefact. A team of artefact handlers, mount-makers, cataloguers and curators split their time between this collection and the other three buildings and contractors were called upon to complete specialised work. The 5500 artefacts were moved over 12 months between October 2020 and December 2021, with several COVID-19 lockdowns causing stoppage of work.

Project background: hazards in collections

Many of Ingenium's artefacts could not legally be moved without first mitigating their inherent hazards. Laws and regulations that govern labelling, storage, movement, and disposal of hazardous materials on an industrial scale often also apply in museum settings. Ingenium conservators are not certified health and safety professionals, but served as the defacto collections hazard management experts during the move.

Hazard management has always been part of Ingenium's collections practices. Assessments previously occurred as needed, but systematic hazard assessment was not possible in the overcrowded old collections spaces. In 2018, a comprehensive Collections Risk Management Program (CRMP) plan was implemented. The new CRMP put staff and visitor safety at the forefront of our conservation and collections practices, prioritising hazard management with the ultimate goal of making our collections spaces more physically accessible to the Canadian public. The beginning of the CRMP aligned with the beginning of the move, providing an opportunity to systematically assess each artefact in the collection.

As part of the CRMP, we underwent training in relevant areas, for example becoming certified Asbestos Type 1 and 2 workers (Ontario). However, external training courses were not available for most hazards we encountered. We also consulted external experts at the Canadian Nuclear Safety Commission during the project. We attempted to consult relevant experts at federal PCB Program, but these consultations showed a gap of awareness of the museum context. This led us to develop internal training protocols for each hazard. We produced written documents called *Artefact Hazard Risk Assessments and Safe Work Practices* (or RASPs) for each hazard type, which are mandatory reading material for all people working in the collections spaces. RASPs serve as a starting point to inform staff and volunteers of risks and safe work practices for each hazard, allowing them to develop safe move protocols. Labelling follows the Standard Global Harmonised System (GHS) for artefacts that contain a known chemical product. We also have labels for non-GHS hazards, for example: split rim tires, or stored mechanical energy. Labels are printed on cardstock paper and tied to an artefact when the hazard is identified. Hazards are flagged digitally in our museum management database with an icon appearing in the database file to indicate the presence of hazardous materials.

A tale of asbestos

Asbestos in museum collections

Asbestos containing materials (ACMs) are widely found in industrially-manufactured artefacts due to their resistance to heat and chemicals. A naturally occurring group of fibrous minerals, asbestos has been used by humans since prehistoric times. It was commercialised and became common in a variety of products in the late 1800s following the Industrial Revolution [1]. Canadian industrial history is deeply connected to the mining and manufacturing of asbestos, having once been a leading supplier of asbestos worldwide. Asbestos mining in Canada ceased in 2011, decades after being declared a human carcinogen by the World Health Organization's International Agency for Research on Cancer in 1987 [2]. The long term health effects of asbestos exposure are well known, including mesotheliomas, lung disease, and cancers [3].

ACMs are prevalent in museum collections worldwide. Asbestos can be found in artefacts with a heating element such as toasters, ovens and lamps, historic textiles, insulation, gaskets, fire hoses, natural history and mineralogical specimens, and many other artefacts common to scientific collections. Although asbestos is commonly listed on museum hazard websites, conservation literature has a relative dearth of papers that cover possible treatments for ACM artefacts [4].

Asbestos mitigation at Ingenium

At Ingenium, asbestos mitigation generally falls into three categories: disposal, isolation or encapsulation. Provincial laws dictate which treatment is appropriate for which type and quantity of asbestos, and whether the treatment can be conducted by Ingenium conservators, or by an external specialised asbestos contractor [5]. When appropriate, the ACM part may be removed from the artefact and disposed of as hazardous waste in consultation with the curator. Alternatively, small artefacts or parts of large artefacts may be isolated by sealing them in double-layered enclosures of 6 mil polyethylene sheeting. When removal or disposal of the part is not possible, or the historical significance of the ACM part outweighs its hazardous nature, encapsulation can be an appropriate hazard mitigation strategy.

There are various methods for encapsulation of asbestos. A detailed discussion of these processes is outside the scope of this paper. However, a method using two asbestos remediation products is commonly used at Ingenium: Childers CP-240 CHIL-LOCK (Clear), to wet the asbestos fibres and consolidate them for further treatment, and Childers CP-211 CHIL-BRIDGE, a white paste-like encapsulant [6-7]. These are products that can be safely and legally used in Canada for asbestos remediation.

Case study: two steam engines

This section's tale begins with two steam engines, both containing friable asbestos. These steam engines were selected from 436 asbestos treatments conducted during the move of the *Building 2421 collection*. The first steam engine in our story is a Corliss engine manufactured by

E. Leonard & Sons in London, Ontario in 1903 (Figure 1). This type of engine was mainly used in the textile and metallurgy industries.

When assessing the artefact prior to moving it to the new storage facility, we discovered a thick layer of asbestos insulation beneath the metal cladding. The asbestos was open to the air on the bottom (Figure 2a). Ingenium conservators have Ontario Type 1 and 2 asbestos certification, which allows us to remediate up to 1 m^2 of friable asbestos in our artefacts [8]. However, since we estimated that about 3 m^2 of asbestos was present, we were required by law to contract Type 3 asbestos specialists to work on this artefact.

The specialist contractors built an enclosure around the engine housing from a wooden frame and plastic tarp material (Figure 2c). The asbestos abatement was performed inside this enclosure, and only the specialised contractors could enter the enclosure during work. We discussed in detail the scope of work and the exact steps to be followed with the contractors, checking in at regular intervals during the two days of work. The contractors removed as much of the friable asbestos as possible, filling the void with Rockwool insulation and applying a canvas patch with encapsulant (Figure 2b). The materials used in their treatment have not been tested for long-term archival stability, but meet the legal requirements for asbestos mitigation. Treatments such as these increase the overall accessibility of our collections, as our new storage areas are safer for staff, visitors, and others who handle the collection.

The second steam engine in our tale is a uniflow steam engine dated circa 1920, manufactured by Fitchburg Steam Engine Co. and used in a University of Toronto engineering laboratory. During our pre-move condition assessment, we discovered some friable asbestos in the insulated housing (Figure 3a). In this case it was under 1 m^2, so it could be treated in-house. The asbestos insulation was located under a layer of painted green canvas, and was relatively well encapsulated by design. However, friable asbestos was present at the seams and at two damaged areas.

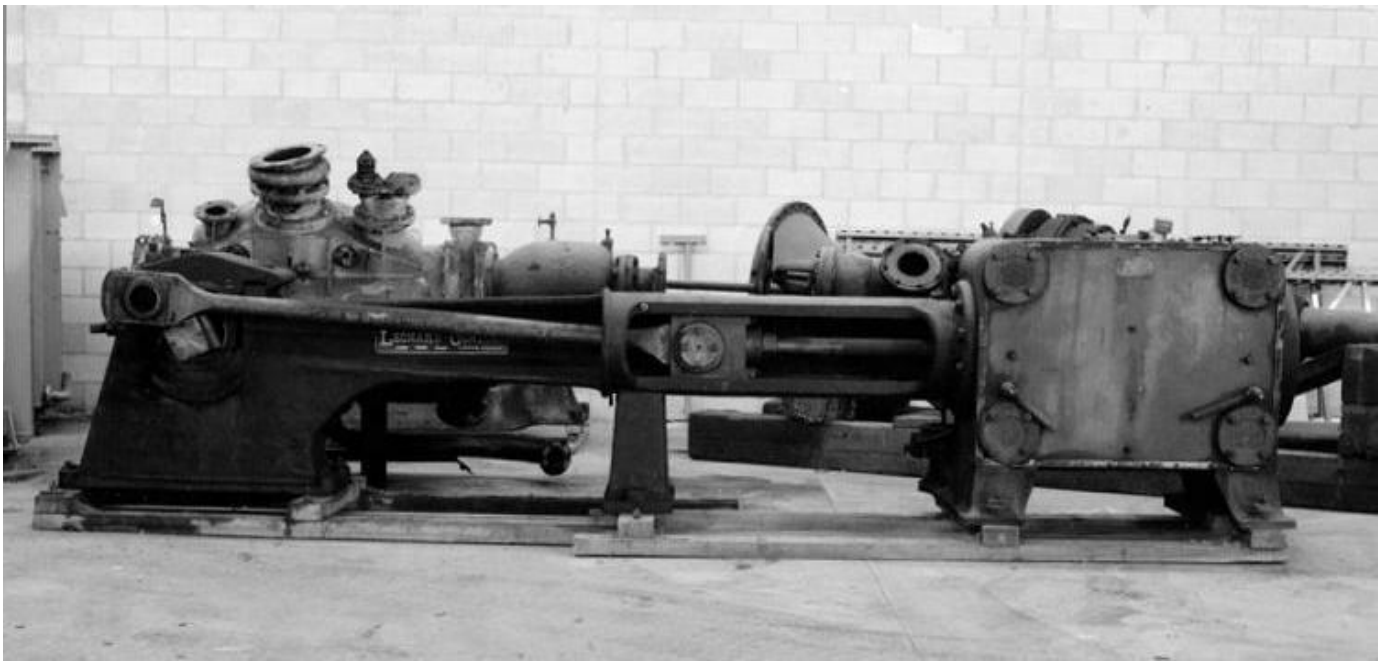

Figure 1. Corliss steam engine, ca. 1903, manufactured by E. Leonard and Sons in London, Ontario, Canada (Artefact number 1980.0526).

Figure 2. Treatment of asbestos in the Corliss steam engine (Artefact number 1980.0526) by specialised contractors: *a)* detailed view before treatment; *b)* detailed view after treatment; *c)* during treatment showing the custom-built enclosure.

Due to the size of the tears and extreme friability of the asbestos, we could not apply consolidants directly, as it was causing the asbestos to further detach from the artefact. Removal of the asbestos was also not practical, as it would both compromise the visual integrity of the artefact and expose more asbestos, worsening the hazard. We decided that a patch method would be best to encapsulate the torn areas. We worked on this artefact wearing a particulate P100 respirator, eye protection, a hooded Tyvek suit and nitrile gloves (Figure 3c). The surfaces were HEPA vacuumed before and after treatment. We soaked the area with an asbestos removal agent (CP-240) to wet the asbestos fibres and prepare them for encapsulation, as required by the asbestos regulations [5]. We then applied a canvas patch and a thick, white paste-like encapsulant (CP-211) to fully contain the damaged areas. This treatment protocol follows common industry practices and was implemented in consultation with asbestos specialist contractors according to applicable regulations.

The final triage treatment is visually discordant with the surrounding artefact, but does effectively mitigate the hazard (Figure 3b). Given the extremely tight timeline of the collections move project, our team was assessing, treating and moving dozens of artefacts per day and only 1.5 hours was dedicated to documentation, treatment and report writing of this large artefact. As conservation professionals, it is important to share a variety of treatments (not just the pretty ones), and we take comfort in the fact that the triage treatment made these artefacts safe to move and interact with. In the future, it would be possible to re-treat the encapsulated areas to make it more visually appealing, for example by in-painting to match the green colour of the surrounding steam engine housing.

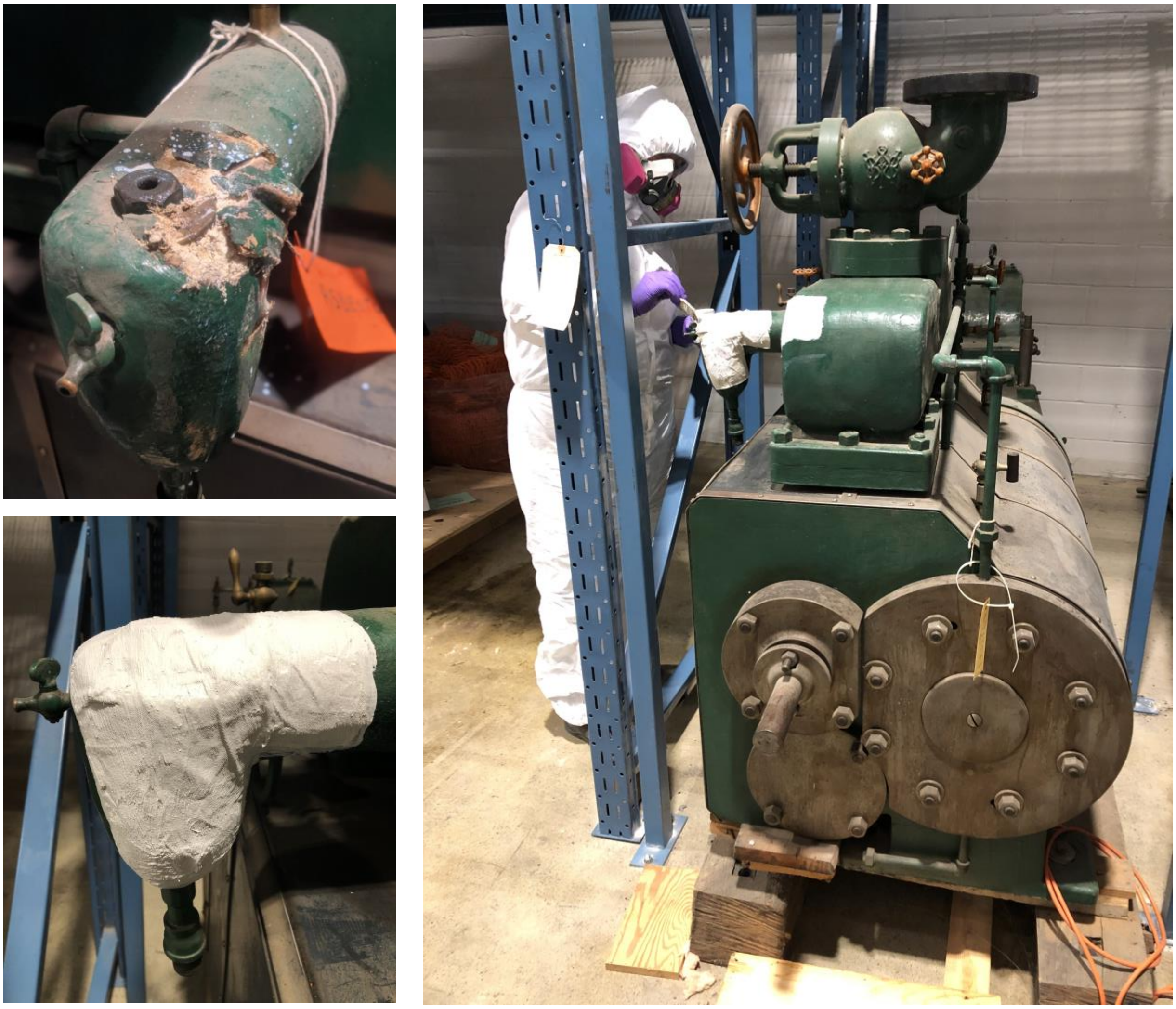

Figure 3. Encapsulation of friable asbestos by Ingenium conservators (Artefact number 1969.1317): *a)* detail of a friable area before treatment; *b)* detail of an area after treatment; *c)* during treatment showing a conservator wearing PPE.

Once the asbestos hazard was mitigated, the two steam engines were ready to be moved to the new purpose-built Ingenium Centre. However, both steam engines were too heavy to be moved by our in-house forklifts. As a result, we contracted specialist heavy machinery movers to move these and other overweight artefacts in the *2421 Reserve Collection*.

A tale of radioactivity

Radioactive hazards in museum collections

The radioactive collection at Ingenium includes a variety of artefacts and includes aircraft dials, ore samples, and historic wellness products (erroneously) thought to have positive health effects. The health effects of radiation are well known, including DNA changes, cancer, acute radiation syndrome (ARS), and cutaneous radiation injuries (CRI) [9]. High frequency or ionising radiation includes alpha (α), beta (β), and gamma (γ) rays. Alpha particles are unable to penetrate the skin but cause damage when inhaled or ingested into the body. Beta particles are able to penetrate the skin, but can be blocked by clothing or other thin barriers. The effects of β radiation are less harmful than that of αradiation, though once again the most harm is caused by ingestion or inhalation [10]. Gamma radiation causes the largest concern for health effects. Gamma radiation is able to penetrate and cause damage as it passes through the human body, and requires thick and dense shielding [10]. These three types of radiation make up the radiation hazards faced in a museum collection. While αand β are most concerning in the form of radioactive dust and flaking paints, γ radiation is a concern in all forms. A luminescent dial for example, would pose a risk of exposure to γ radiation based on proximity to the dial, but flaking paint or fine radium dust coming off the dial poses a risk of αand βdamage if ingested, inhaled, or if it were to enter the body through a cut.

Personal protective equipment can help to protect from α and β radiation. Tyvek suits, along with nitrile gloves and full face respirators can ensure that radioactive dust does not enter the body. Gamma radiation must be managed differently, by reducing the proximity to a radioactive source, and reducing the length of exposure [11]. In the case of Ingenium's large-scale collections move, the decision was to limit time of exposure to radiation by working as quickly and efficiently as possible with these artefacts. Radiation doses from each artefact were measured using a RadEye G-10 metre (Geiger counter) for γ radiation. A dosimeter 3700 survey meter was used to measure α and β radiation, and conservators wore whole-body and ring-format dosimeters to measure individual exposures.

Transport, disposal and storage of radioactive material is federally regulated in Canada under the *Nuclear Safety and Control Act* (S.C. 1997, c. 9) [12]. In order to ensure our processes followed the applicable legislation, we consulted with the Canadian Nuclear Safety Commission. Ingenium has been managing radioactive materials in collections for decades. Sue Warren, former Manager, Conservation Services, at Ingenium, has published on this topic and the luminous dial project which took place in the early 2000s [13].

Case study: a radium balance

Our next tale involves a radium balance with particular significance to Canadian industrial and radioactive history. This analytical balance and associated weights, bowls and tools were used in Port Hope, Ontario at the Eldorado Mining and Refining Company (Figure 4). They were used to weigh some of the first radium produced in Canada. As a result, the balance was covered in a layer of radioactive dust. Radium dust is hazardous when ingested, inhaled, or in contact with skin, due to the presence of γ, α, and βrays. Our first step was to take radiation readings at the surface of different areas of the balance, which read between 2 and 12 microSieverts per hour (μSv/hr) of γ radiation. For context, a person would have to work with this artefact for 83 hours to reach the annual public dose limit (APDL) of 1 milliSievert per year, a number that is set by the Canadian Nuclear Safety Commission [14].

Figure 4. Analytical balance (Artefact number 1969.1002).

So, direct exposure to radiation was a relatively low risk for this artefact. However, radium dust still posed an inhalation hazard. As a result, we wore personal protective equipment including Tyvek suits, nitrile gloves and particulate respirators while working with this and other radioactive artefacts. Our solution to the issue of radioactive dust was quite simple. We draped and sealed the balance in plastic sheeting during the move, to ensure the dust would be contained, and placed it in a Coroplast box for ease of handling (Figure 5). Once the balance had been moved to the new collections storage, the plastic was removed and disposed of with our PPE and other radioactive waste. This very simple approach allowed us to complete the move while maintaining the historic radium left on the balance.

The radioactive artefacts are now in their new home in the Ingenium Centre, stored in a purpose built radioactive artefact storage room. Artefacts were placed so that the radiation levels at the walls of the hallways and adjacent rooms measured below 2.5 μSv/hr, as recommended by the Canadian Nuclear Safety Commission. We also installed a radon gas sensor with a visual light alarm outside the room. The sensor will automatically vent to the outdoors should radon gas levels become too high, and the building operator will be notified.

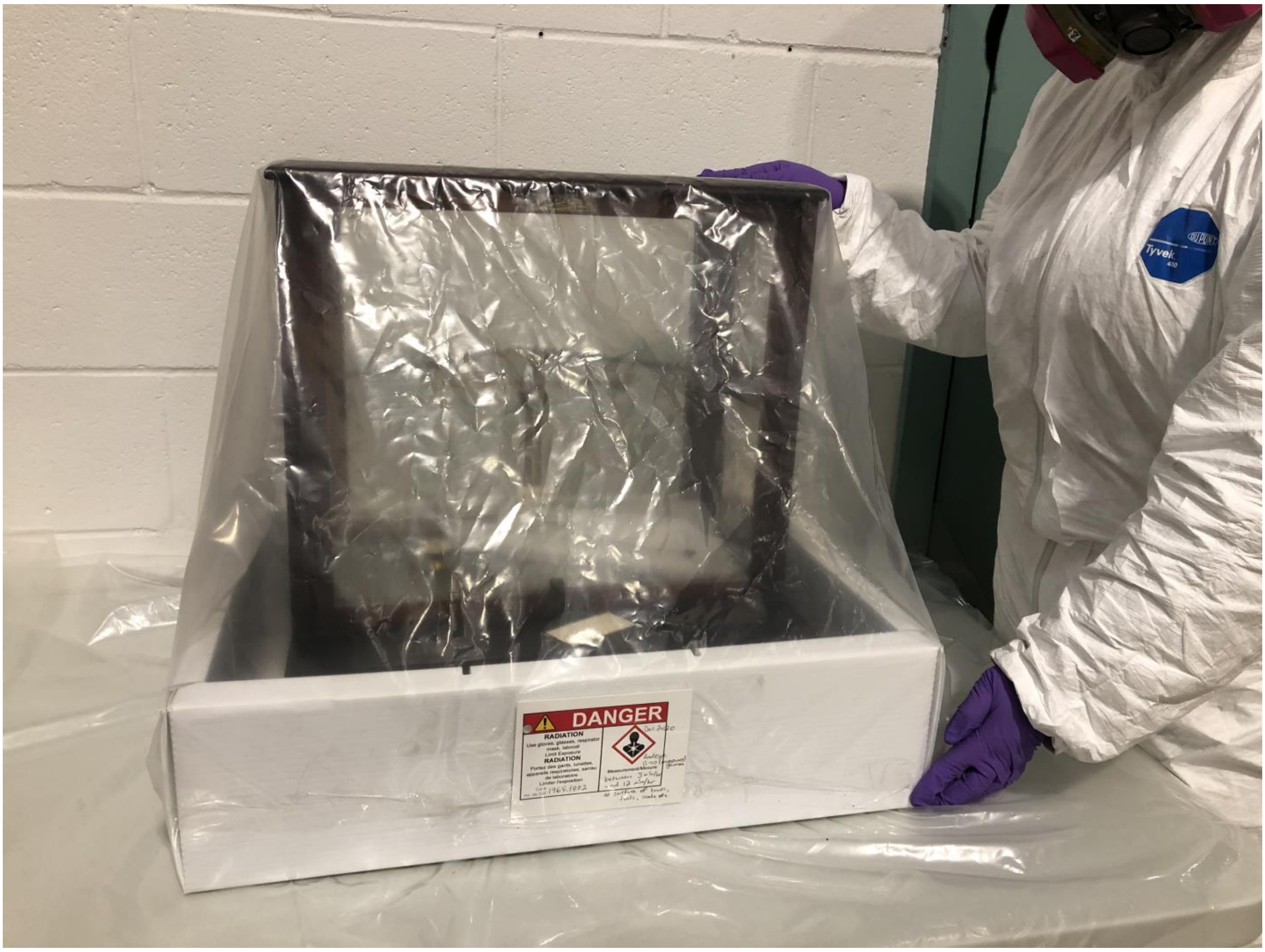

Figure 5. The radioactive analytical balance (Artefact number 1969.1002) contained in plastic during the collections move.

A tale of polychlorinated biphenyls (PCBs)

PCBs hazards in museum collections

Polychlorinated biphenyls, or PCBs, are a highly regulated class of compounds in Canada and internationally. They cause a wide variety of environmental and health concerns, including bioaccumulation, skin conditions, neurological damage, hormonal disruption, fertility damage, and cancer [15]. The first PCB was synthesised in the late nineteenth century but industrial production did not begin until 1929. Health concerns were first raised by the medical community as early as the 1930s, and in 1979 PCB manufacturing began to be regulated. In 2001, PCBs were included as Persistent Organic Pollutants in the United Nations Stockholm Convention [16].

PCBs are typically found in manufactured artefacts that need to withstand heat and provide fire resistance. They are most commonly found in capacitors, transformers, and electrical equipment. However, PCBs were also frequently used in hydraulic systems, brake fluids, plasticizers, paints, printing inks, fluorescent light ballasts, and carbonless copy paper. PCBs have also been used as pesticides and have been found applied to wooden artefacts in fine art museum collections [17]. Our research to date has focused on oils containing PCBs [18], and we have recently begun research into solid PCB materials.

In Canada, PCB legislation falls under the Environmental Protection Act (1999), *PCB Regulations* (SOR/2008-273) [19]. Museum collections are not currently considered an exception under the regulations, as a result, museums are not legally permitted to store any artefacts that contain materials with more than 50 ppm (or 50 μg/100 cm^2 surface contamination) of PCBs. Museums are also obligated to file an annual report detailing PCB-containing artefacts in their collection. Under current legislation, Canadian museums have until 2025 to be in full compliance and may be subject to inspections and fines for noncompliance.

Environmental contamination by PCBs, along with other persistent bioaccumulative toxic substances, have been shown to continually and disproportionately affect Indigenous peoples around the world [20]. As museums with colonial pasts, it is important to recognize that our collections hazards continue to contribute to this disproportionate impact, and that choosing to address PCBs and their history involves recognizing this impact and acknowledging our responsibility to dispose of PCBs safely going forward.

While Ingenium has long known that PCBs were present in our collection, testing and consequent documentation had been sporadic. In 2014, a major push was made to begin testing the large oil-filled transformers in the collection, and to conduct air quality testing. Since 2019, more comprehensive testing has been conducted as part of the collection move completed in August 2022. A significant portion of the testing and treatment of PCB materials in this period was conducted in the *2421 Reserve Collection*.

Case study: a tape-recorder player

This tape-recorder player was used between 1963 and 1996 as part of the Canadian Broadcasting Corporation (CBC) regional broadcast system inside the regional emergency headquarters in Nanaimo, British Columbia (Figure 6). The Nanaimo headquarters was one of seven underground bunkers across Canada designed to house military and government officials in case of a nuclear attack. Upon assessment of the artefact during the collections move, we found six black cylindrical capacitors in the interior which were stamped with Pyranol, a PCB trade name.

Figure 6. Tape-Recorder player (Artefact number 1996.0284).

This type of Pyranol capacitor is filled with a black potting material which has deteriorated, slowly melting onto lower surfaces (Figure 7a). We took a sample and sent it to an external environmental analytical laboratory for analysis via gas chromatography electron capture detection (GC-ECD) according to Environmental Protection Agency Method 8082A to determine its PCB levels [21-22]. The test result was 32100 μg/100 cm^2, indicating extremely high levels of PCB surface contamination, beyond the legal limit for museums in Canada.

The test results and the historical significance of the artefact created a dilemma. The capacitors could not be legally kept, but the artefact itself should remain in the national collection. Upon consultation with the curator, we determined that removal of the capacitors was the best option, allowing us to legally retain the rest of the unit. Due to the high level of PCBs, this work was done by specialised PCB mitigation contractors, who were brought in to work on a number of high level PCB artefacts. The contractors removed the capacitors, and decontaminated any surfaces that the potting material was in contact with using Varsol on cotton rags. We directly supervised the contractors, and assisted with disassembly of the artefact where needed. We also documented the work using digital photography and written treatment reports. Figure 7b shows an area after removal of a black cylindrical capacitor, and cleaning of PCB residues. Six capacitors were removed and documented photographically with written descriptions, and were disposed of as PCB waste.

This case study provides an example of one of our protocols for PCB mitigation in historic artefacts. For other artefact types, other methods of PCB mitigation such as draining PCB oil, or complete deaccession of the artefact were more appropriate [18]. Collectively, our PCB mitigation protocols ensure continued safe access to our collections.

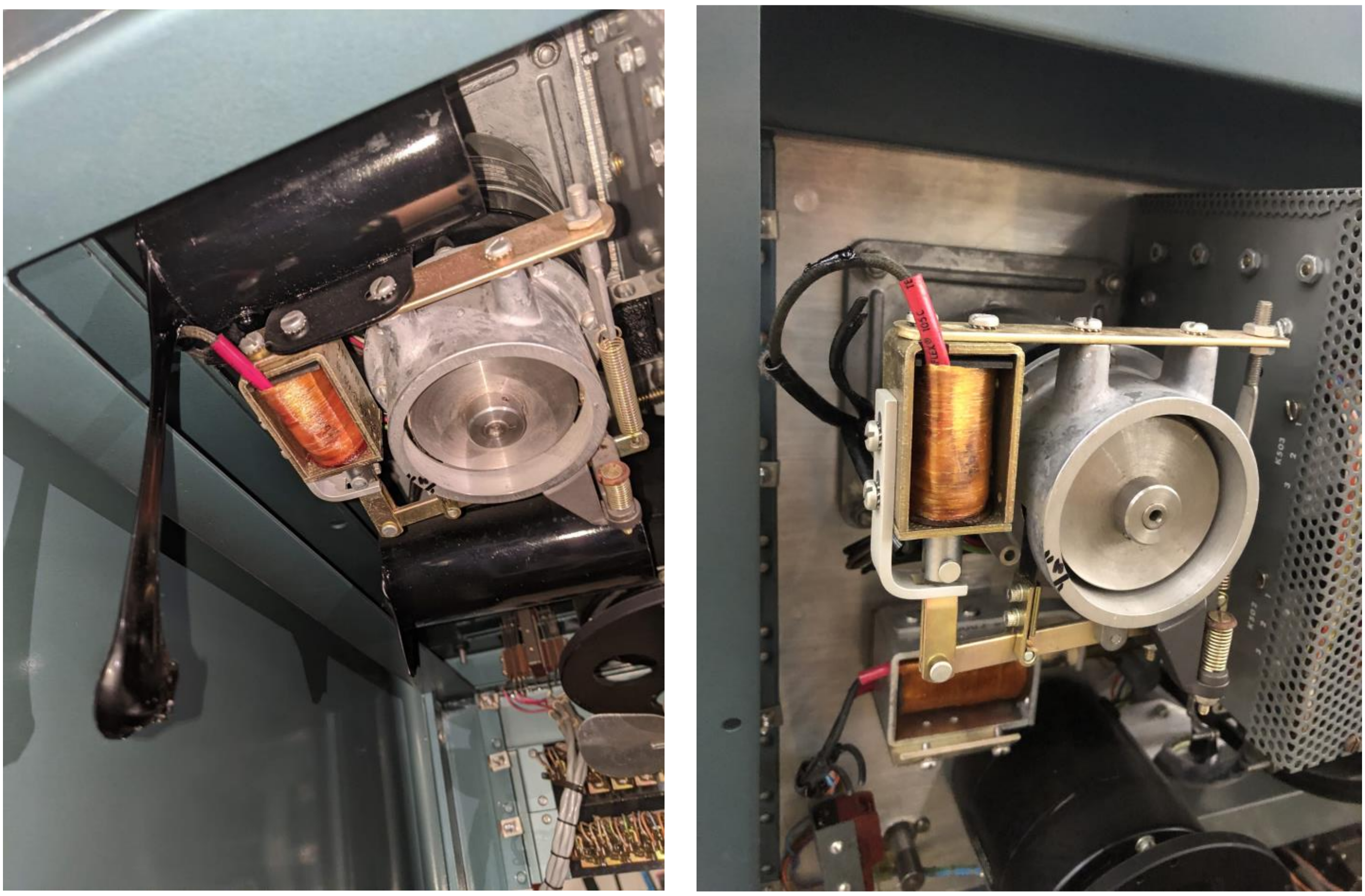

Figure 7. Remediation of PCB hazards in the tape recorder-player: *a)* before removal of PCB (Pyranol-branded) capacitor, showing black melting potting material; *b)* after removal of PCB capacitor.

A tale of mercury

Mercury hazards in museum collections

Mercury is an elemental metallic substance which is known for its liquid state at ambient temperature and its low viscosity. It causes a variety of neurological and other adverse health effects and is especially hazardous in its vaporous state [23]. The effects of mercury include neuromuscular changes, kidney damage, mood instability, and even death at high levels of exposure [24]. As mercury readily evaporates, any mercury spill is a cause for concern within a museum collection. A spill will quickly scatter into a dust-like coating on all surrounding surfaces, making it very difficult to clean, and increasing surface area from which to evaporate. In museum collections, mercury is found in a variety of artefacts, and several papers have been written regarding mercury pesticides and pigments in collections [25-26]. In Ingenium's collections, mercury is commonly found in thermometers, barometers, medications, rain gauges, pesticides on textiles, mineral collections and taxidermy, and electricity meters. This mercury is present in elemental forms, organic compounds such as methylmercury, and in inorganic compounds such as dental amalgamations.

Case study: crates of electrical meters

One of the challenges we faced during the collection move was large crates filled with unknown and uncatalogued artefacts from early electrical history. Many of these crates had not been opened since their arrival in 1992, following the closure of the Ontario Hydro Museum of Electrical Progress. Newspapers and magazines used as packing material indicated that the crates were likely last packed in the 1960s and 1970s. Upon arrival at Ingenium, each crate had been given an overall accession number for tracking purposes, but only a few crates had been assessed or repacked by Ingenium staff. There were approximately 30 crates, each with an average of 100 meters and other small electrical components. It became immediately apparent that unlabelled and unstable mercury-containing artefacts in these crates was of high concern.

During inspection of one of the first crates, we found a small mercury spill in the crate packing material. This incident prompted a thorough assessment of each crate to ensure we were not overlooking the risk of an additional mercury spill. Through this assessment we determined that the risk was highest in two situations. Firstly, some meters had a mercury switch present. These were sometimes in an additional wiring box on the meter, but other times were found only by opening the unit. Figure 8 shows two examples of mercury switches located inside two meters.

The second mercury risk in this collection was much easier to identify. Mercury type meters, such as those manufactured by Ferranti or Sangamo, contain a reservoir component (Figure 9). Many of the mercury meters in our collection had failed seals, which allowed mercury to leak into the meter case. Due to the expectation that all seals will eventually fail, causing future spills, we separated all mercury containing meters from the crates and stored them in plastic bins in our chemical artefact storage room. Any spills we encountered were cleaned using a Mercon mercury spill kit and a respirator with mercury vapour cartridges was worn in the presence of open mercury.

All mercury containing artefacts, including the meters, are now stored together in our chemical artefact storage room, including those found in the *2421 Reserve collection*. As an outcome of this project we acquired a mercury vapour monitor system for use in the chemical artefacts storage room. The VM 3000 Mercury Vapour Monitor sends notifications through audible and visual alarms, and email alerts when mercury vapour levels rise beyond a pre-set threshold, indicating the potential presence of a mercury spill and ensuring effective cleanup.

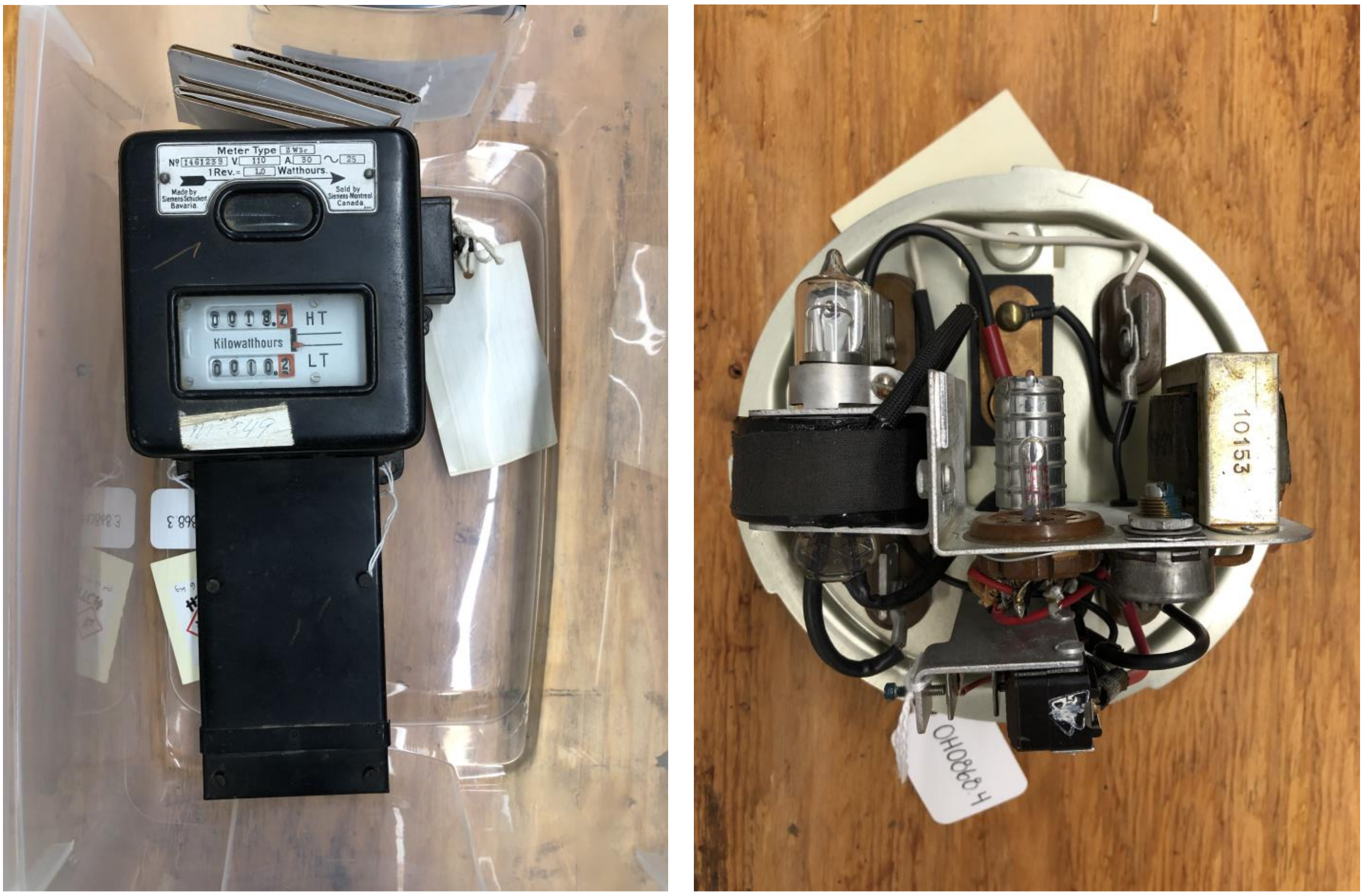

Figure 8. Examples of mercury switches in electrical meters: *a)* Siemens meter; *b)* Lumatrol meter.

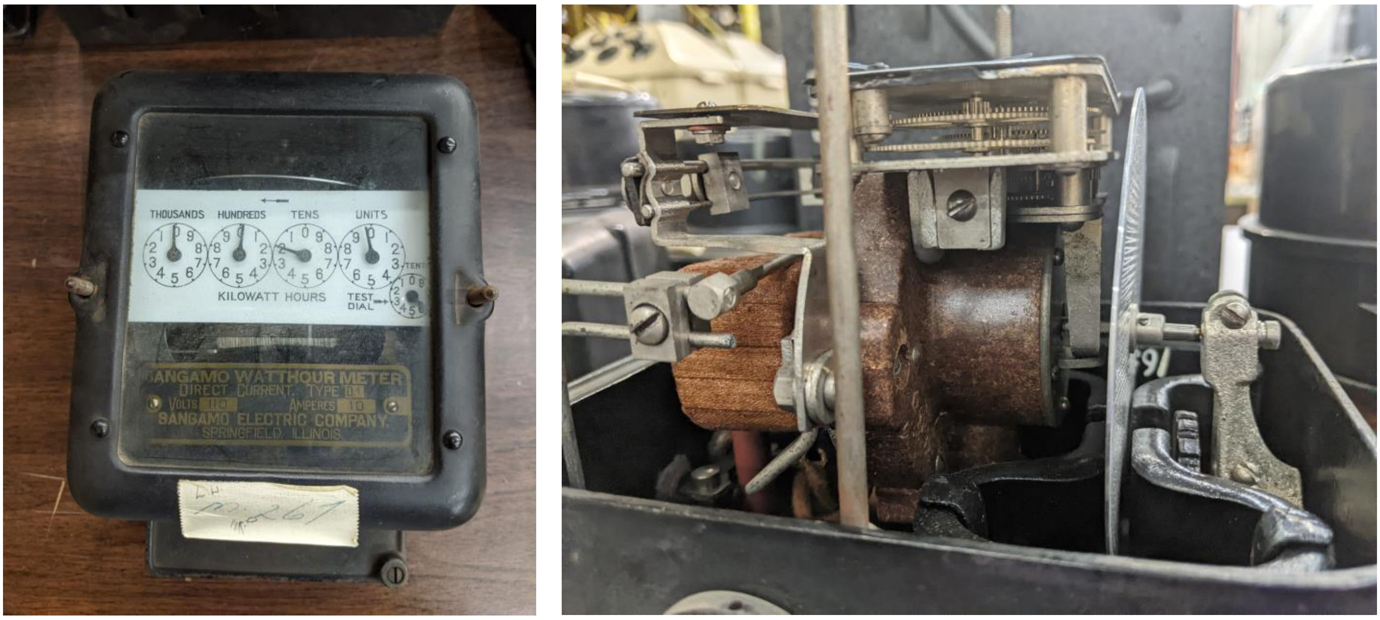

Figure 9. Example of a meter with a mercury reservoir, a Sangamo Type D meter: *a)* overall view; *b)* a mercury reservoir (brown component) in the interior of the meter.

Conclusions

The collections move provided an opportunity to assess and mitigate a variety of hazards in the collection. The move of the 5500 artefacts from *Building 2421* is a microcosm revealing that industrial collections such as these can be extremely hazard-rich, and showing the ability of Ingenium's CRMP process to effectively screen for hazards. Out of 5500 artefacts, we identified 1133 hazards, over 20 % of the total collection stored in *Building 2421*.

The case studies demonstrate how we dealt with typical hazards in the collection. Triage-type conservation treatments can be considered successful despite being visually incongruous, and are an essential tool in a large-scale collections move. Identifying hazards and understanding the regulations that allow a safe work environment are the first steps in ensuring that an industrial collection can be moved safely and legally. Laws dictate how certain hazardous artefacts can be treated, transported, labelled and stored. Knowing these laws lays out a framework, which gives us the knowledge and confidence to work with these materials, and sets limits which ensure the safety of all conservation staff. In these situations, outside contractors can provide the necessary knowledge, skills, and accreditations to effectively mitigate hazards. From simple solutions as demonstrated in the radioactive and mercury case studies, to mitigation treatments as with the asbestos and PCB case studies, we prioritise safety above all.

The new Ingenium Centre storage building has increased collection access and safety, with advanced hazard detection equipment like the radon sensor and the mercury vapour sensor. Better shelving, visual hazard tagging and updated hazard fields in the database mean the collection is not only in a much better environment, but that the researchers and public accessing the collection can take the appropriate precautions to do so. The move was completed on schedule, despite several COVID lockdowns. All of Ingenium's collections from our rental warehouses are now fully moved and incorporated into the new Ingenium Centre.

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