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1. INTRODUCTION

Morrison Hershfield Limited (MH) is retained by Hudson’s Bay Company (HBC) to provide an alternate life safety systems solution for the interstitial space within the HBC store, Freeman Mall section, located at 73 Rideau Street in Ottawa, Ontario. The building is five storeys in building height, with one below-grade basement level, and is constructed of combustible materials. Each store floor is approximately 3000 m$^2$ (32,300 sq. ft.) in building area. The building is a Group E Mercantile major occupancy.

1.1 Background

The Freeman Mall section of the HBC store was constructed in 1960. Following renovations a few years later, the interstitial space between the ceiling and the underside of the floor assembly was provided with a wet automatic sprinkler system. At that time, the existing floor and ceiling assemblies were not considered to significantly contribute to a fire resistance rating for the floor assemblies. The public areas below the interstitial ceilings are provided with a fully operational wet automatic sprinkler system. Sections of the interstitial space are plenum ceilings. (Refer To Appendix A: Floor Plans and Mark Ups.)

1.2 Interstitial Automatic Sprinkler System

Sections of the automatic sprinkler system within the interstitial ceiling space has not been maintained or tested in accordance with the Ontario Fire Code (OFC) or National Fire Protection Agency (NFPA) 13, “Installation of Sprinkler Systems” for the last 20 years. The reason for the lack of maintenance and testing are due to:

- HBC staff and fire alarm and suppression service providers were not aware of the interstitial sprinkler system until it was recently discovered.
- No documentation regarding the interstitial sprinkler system including test inspection valve locations and flow switch monitoring exists.
- Poor or no accessibility to test inspection valves.
- Assumptions made by maintenance staff that considered the public area wet sprinkler system (that is fully maintained and tested) supersedes the requirements for an interstitial sprinkler system.
- Concern regarding water damage due to potential leaks.
- Potential risk associated with raceway installations knocking off a sprinkler head and causing significant water damage including the false ceiling to collapses.
• Areas where the steel beams are supporting the wood floor assemblies contribute to a fire resistance rating for the floor assemblies and therefore the interstitial sprinkler are not required.

Replacement has been proposed to the interstitial automatic sprinkler system due to poor condition, age, and corrosion.

Currently HBC’s Insurance Company is aware of the situation and agrees with HBC’s approach to researching an alternative solution.

However, the installation of a new automatic wet sprinkler system in the interstitial ceiling space has raised the following comments and issues:

• The height difference between the ceiling and the underside of the floor varies from 457 mm (18 in.) to 1.2 m (4 ft.). Effective sprinkler suppression during the “heat” stage of a fire due to the inconsistency of the floor assemblies is suspect.

• Some portions of the floor assembly are provided with plaster and/or 15.9 mm (5/8 in.) gypsum board that contribute to the fire resistance rating. The ceiling membrane area, below the floor assemblies, is either 15.9 mm gypsum board or T-bar tile. Operation of an active interstitial ceiling space wet sprinkler system, either from a heat-activated sprinkler head or inadvertently if a head is dislodged (i.e., during electrical cable and raceway installations), may cause significant damage and harm. This could include the ceiling collapsing on either store occupants or fire fighters.

Typical Interstitial Space and Sprinklers
1.3 Alternate Solution

MH proposes an alternate life safety systems solution based on good fire protection engineering practice. The alternate solution proposed would facilitate the HBC facility life safety needs.

The alternate solution is a combined approach that includes early warning detection with strategic response procedures, improved control panel annunciation, and a revised fire safety plan with updated staff training.

An appropriate level of life safety for the HBC facility would be provided based on the following criteria:

- Install a very early warning incipient active smoke detection system (VESDA = Very Early Smoke Detection Apparatus) within the interstitial ceiling space.

- Combine the very early warning incipient active smoke detection system with the existing automatic wet sprinkler system serving the retail floors area.

- Install a detailed active graphic annunciator based on the existing floor plan. Active graphic annunciation will provide rapid response to any off-normal events within the earliest stages of a fire condition (i.e., before visible smoke is present).

- The environmental logging and assessment algorithms of the detection system will mitigate potential nuisance alarms caused by dust, dirt or other friable material in the interstitial space. The system “learns” the environment and references its own historical data to confirm detection of the products of combustion.

- It is important to note that the best detection technology is worthless unless the staff understand the response procedures outlined in the fire safety plan. HBC staff must be capable of responding properly to incidents. The responsibilities of the trained HBC staff begin with competent system application engineering, maintenance and response training.

1.4 Application Research

The objective of this design brief is to provide supporting information for the proposed alternate solution. Our recommendations are based on good fire protection engineering practice, recent National Research Council (NRC), National Institute Science and Technology (NIST) and NFPA research including white papers.
Very early detection, (i.e. detect in the incipient stage of the fire), initiates:

- Early investigation;
- Early notification to the fire service;
- A lesser amount of area involved in fire;
- Not as much smoke, thereby better visibility; and
- An earlier application of manual fire water.

MH offers the following comments for your consideration:

1. Conventional detection response, including heat detectors or sprinkler heads triggering flow switches, is too late when applied to an interstitial space application.

2. Accurate nuisance alarm immunity is critical. Very early warning detection provides time to investigate the event in the interstitial space and to evacuate the building earlier, thus decreasing the risks (including ceiling collapse) and increasing the potential to save lives.

3. Where access to the interstitial space detection area is difficult (i.e. 18 in. sections), air aspiration detection is a viable solution since it provides responsive active monitoring of the space.

4. Aggressive and dirty environments with high levels of pollution are the most difficult to protect with smoke detectors. The VESDA system discriminates between dust and products of combustion. An internal air filter is provided to block out large particles, thus mitigating potential nuisance alarms and providing a high level of early warning detection. Depending on how dirty the area is, the detector’s internal filter may require replacement more often in cleaner environments (typically the filters are changed once a year). The filter is monitored (internal manometer) and reports its status for quick replacement by qualified maintenance personnel.

1.5 Summary

Wet sprinkler heads in the interstitial space could cause the ceiling to collapse when operated. The following combined measures are recommended as an alternate solution:

- Install an active incipient early warning detection system (VESDA) in the interstitial space;
- Provide detailed active graphic annunciation detailing the interstitial space detection system including levels of pre-alarm and alarm conditions;
- Update the fire safety plan procedures and have them approved by Ottawa Fire and Building Departments;
- Update staff training regarding response techniques for interstitial space alarm events and other fire safety plan measures; and
- Provide access hatches for response procedures, including access for fire fighters with Self Contained Breathing Apparatus (SCBA) gear.
2. AIR ASPIRATION DETECTION

2.1 Aspirating Smoke Detection System

The early warning aspirating smoke detection system collects air samples through sampling holes on a network of pipes. The airflow within a protected area carries the air samples to the sampling holes. Conventional smoke detectors wait for the smoke to migrate through the detector. The system actively draws air samples into the sampling pipes. These samples are transported through the pipe network to the aspirating smoke detector.

The environmental logging and assessment algorithms of the detection system will mitigate potential nuisance alarms caused by dust, dirt or other friable material raised in the interstitial space. The system “learns” the environment and references its own historical data to confirm detection of the products of combustion.

Air aspiration smoke detection is considered to be an “Active” system, while conventional smoke detectors are considered to be “Passive”. The difference is simple; an “Active System” such as air aspiration smoke detection will always be drawing a sample of air through a sampling tube network. This air will pass through the device’s detection chamber, and exhaust back into the area of protection.

A “Passive System” such as standard or intelligent smoke or beam type detection essentially waits for the particles to come to it, depending on air movement to propel the particles through the device-sampling chamber or beam.

Air aspiration smoke detection systems provide early, constant real-time monitoring of many open areas, interstitial spaces or individual rooms.
An added feature of the air aspiration smoke detection system that MH recommends for this application is the ability to finely tune its sensitivity to the precise circumstances prevailing in the interstitial space. This approach allows some of the newer air aspiration smoke detection systems to be used in a wide variety of both clean and dirty applications. Adjustable sensitivity, networking and other technological advancements have expanded the application of these systems. These advancements have allowed air aspiration smoke detection systems to become a far more cost competitive solution, with far better early warning detection capability.

2.2 Fire Signature Analysis: Smoke Density/Time

Air aspiration detection provides significantly faster and more reliable detection than conventional systems, as well as improved sensitivity in some of the larger areas where heat stratification can occur (ceiling interstitial space).

Reliable very early warning detection capabilities help to avoid the need for suppression release.

According to Mr. Lawrence Ross, Stationary Engineer for Hearst Castle in the USA, “We have documented events where VESDA detected electrical faults and excessive carbon ignition that our conventional system never picked up.” An air aspiration detection system will detect smoke density in the earliest stage of a fire signature. The image below identifies multiple levels of pre-alarm annunciation well in advance of conventional detection:

VESDA Alert and VESDA Action
The selection of detection device is based on the environment, fire signature; risk assessment criteria based on response time and degree of loss, and device specific application requirements. For example:

- Conventional photoelectric detectors operate in the Stage 2 “Visible Smoke” stage.
- Optical flame detectors, typically used in areas where fast flaming fires could result, operate in Stage 3, “Flaming Fire”.
- Heat detectors and sprinkler heads operate in Stage 4 “Intense Heat”. This is typically the stage where fire suppression is used.
- Air aspiration detection system will detect smoke density in the earliest stage of a fire signature Stage 1 “Incipient.”

Combine this early detection solution with an accurate active graphic annunciator, a well trained staff for evacuation procedures, and fire service with detailed site information to get them to the source of the event, and an appropriate level of life safety for the HBC facility would be provided.

2.3 **Active Graphic Annunciator Interstitial Space** *(Reliable Systems Require Reliable Human Response)*

The active graphic display will be designed to detail a graphic representation of the complex including the early warning smoke detection system in the interstitial spaces. The graphic outline typically is either photo etched or screened on acrylic material in a tile format to permit changes without removing the entire graphic. The sampling tubes are typically displayed on the active graphic display using separate coloured lights arranged on a floor-by-floor, interstitial space, quadrant by quadrant basis.
2.4 **Human Response Component and Application Engineering**

It is important to note that the best detection technology is worthless unless the human response dimension of the life safety system is also capable of responding properly to incidents. The responsibilities of the trained HBC staff begin with competent system application engineering, maintenance and response training. MH proposes a design structure that methodically ties together all of the participants in the system’s creation and operation. This design structure assures that there are no ‘blind spots’ related to successful system application, operation and maintenance.

This structure also supports a strong training strategy, which is most effective when treated as a team endeavour involving the system’s designer, manufacturer, installer, Ottawa Fire Service Emergency Response staff, and the Ottawa Building Department.

2.5 **Interstitial Space Airflow Modelling**

Sections of the interstitial space are plenum ceilings. Airflow modelling technology has proven to be an important tool for the precise location of sample tubing for air aspiration detection systems. Models can accurately depict the airstreams in a specific room or interstitial space and anticipate smoke migration patterns in the event of a fire. Models are also invaluable for assessing the new airflow influences that result from the introduction of even minor new features in a ceiling space. The traditional lack of effective field-testing methods, (which often heavily relied upon exhaustive trial and error experimentation), reinforce the necessity for airflow modeling in life safety system planning. Airflow models often reveal some of the mysterious, counter-intuitive traits that airstreams can exhibit.

In one case, for example, a factory storage interstitial space was protected by passive photo electronic smoke detectors mounted at the ceiling level on the waffle slab.

An adjacent control room was equipped with an air aspiration smoke detection system. When apiece of equipment overheated and produced smoke in the area, air movement currents carried the resulting smoke away from the interstitial space ceiling mounted smoke detectors. However, air movement within the interstitial space pushed enough of the smoke particles through the adjacent control door to activate the control room’s air aspiration smoke detection system.

The paradox in this case was that it took a single active detector in a room next door to sense a fire that was missed by a network of passive detectors. There is a strong likelihood that an airflow model of the building would have revealed this inherent flaw in the smoke detection approach selected for the space.

As such, MH proposes that limited airflow testing of the interstitial space followed by a review of recent air flow modelling data from NIST and NRC be performed prior to the installation of the air aspiration system.
2.6 Risk Analysis and the Detection Application

Early warning air aspiration smoke detection systems have redefined the cost versus risk analysis when applied to conventional fire alarm system design applications.

Traditionally air aspiration smoke detection systems were used in only microelectronics manufacturing facilities and computer server LAN room. Air aspiration smoke detection systems were regarded as a relatively standard approach to loss mitigation for high vault rooms.

Early warning air aspiration smoke detection systems were considered a necessity largely to avert catastrophic events, provide means of protection and notification to human life, prevent damage to structures and satisfy regulatory requirements.

Protection of life always has been the paramount consideration in choosing an appropriate life safety system for mercantile/retail areas. Loss of life due to fire, smoke or other product releases has been very rare. However, HBC’s approach to life safety systems is treated as investments in owner’s ability to remain viable despite multiple threats to business continuity.

Considering the value of today’s store inventory, the impact of store downtime carries much greater stakes than ever before. The value of today’s store marketing and product delivery, including store accessibility, could create serious capital losses as the result of even relatively minor life safety incidents that do not always involve fire or smoke.

Recent store losses due to smoke, other contamination, fire, water, and damage have demonstrated this new reality, sometimes vividly.

Some portions of the floor assembly of stores interstitial space are provided with plaster and/or 15.9 mm (5/8 in.) gypsum board that contribute to the fire resistance rating. The ceiling membrane area, below the floor assemblies, is either 15.9 mm gypsum board or T-bar tile.
Operation of a new active interstitial ceiling space wet sprinkler system, either from a heat activated sprinkler head or if inadvertently a head is dislodged (i.e., during electrical cable and raceway installations) may cause significant damage and harm to the public. This type of failure could include the ceiling collapsing on either store occupants or fire fighters.

MH proposes that the right kind of solution, i.e., air aspiration and strategic response procedures, can maximize the protection of property that may incur significant damage before life is ever endangered.

Life safety air aspiration smoke detection systems and response procedures that show greater performance in protecting equipment and store inventory typically will also enhance the protection of life.

Air aspiration smoke detection superior performance is evidenced in the lower insurance premiums that can be earned through a comprehensive installation, and the acceptance that air aspiration smoke detection systems have earned in the industry’s safety codes and standards.

The benefits of early warning air aspirating smoke detection system are as follows:

- Very early detection, (i.e. detect in the incipient stage of the fire), initiates early investigation, early notification to the fire service, a lesser amount of area involved in fire, not as much smoke thereby better visibility, and an earlier application of manual fire water.
- Enhanced detection of smoke signatures like over heated wires or combustibles that emit low smoke mobility
- Freedom from nuisance alarms through microprocessor based (history buffer) learning of the environment and determining the difference between air handling unit start up and a real fire.
- Additional time to investigate the source of the fire to prevent a catastrophic loss.
3. IMPLEMENTATION & METHODOLOGY

3.1 Site Review and Observations

Sample Third Floor Section

Each store floor is approximately 3000 m² (32,300 sq. ft.) in building area. The hatched sections are suspended drywall ceilings. At location #4 steel beams are provided below the wood joist.

Location #4 Image
The remaining areas are typically suspended T-bar ceilings. Some areas have two layers of drywall above the T-Bar ceiling.

**Sample Second Floor Section**

Location #6, at approximately 30 inches above the T-bar two layers of drywall are fastened to the joists.
Sample Second Floor Section

Location #20, at approximately 30 inches above the T-bar open wood framing is provided.

Location #20 Image
Sample Third Floor Section

Location #3, at approximately 18 inches above the T-bar a Tin Ceiling is provided.
### 3.2 Interstitial Ceiling Zoning

The sampling tube zones will be delineated to provide the highest level of detection and response accuracy based on the interstitial space layout and volume.

![Sampling Tube Zone Delineation in Interstitial Space](image)

Based on our current understanding of the project, approximately four air aspiration (VESDA Laser Plus) units will be provided for each level (ground to 5).

Each unit will provide four discrete sampling zones. A minimum of two access hatches will be provided for each sampling zone. The hatches will allow for one fire fighter with self-contained breathing apparatus (SCBA) to access the space.

Zoning indications will be provided via an active graphic annunciator. The active graphic will indicate the piping zone layout, access hatch locations and where the closest standpipe fire hose cabinets are located.

This approach to zoning and annunciation provides a design structure that methodically ties together all of the participants in the system’s creation and operation.
Sixteen sampling zones will be provided on each level. Each store floor is approximately 3000 m$^2$ (32,300 sq. ft.) in building area. The maximum size of a sampling zone will be approximately 2,000 sq. ft. based on a 32,300 sq. ft. interstitial area.
3.3 System Description and Scope of Work

The following system description and scope of work information is provided as follows:

- Air aspiration sampling (VESDA) units and sampling tubes will be installed on each store level (levels of interstitial space).
- The Electrical Contractor will be responsible for the installation of the sampling tubes and the mounting and connection to the air aspiration sampling units, emergency power supply and the connections to the store fire alarm system.
- The fire alarm service provider will provide the final air aspiration sampling engineered design, materials (VESDA units and sampling tubes), unit programming, interconnection relays to the store’s fire alarm system, and commissioning services.
- The fire alarm system will monitor the air aspiration sampling unit’s power supply, unit trouble conditions, three levels of pre-alarm indication, and alarm indications.
- A new active graphic annunciator will be installed adjacent to the main fire alarm system annunciator. The active graphic will detail the location of each sampling tube in the interstitial space. The active graphic will also indicate three levels of pre-alarm and alarm indications for each sampling tube zone.
- The sampling tube zones will be delineated to provide the highest level of detection and response accuracy based on the interstitial space layout and volume.
- MH will provide detailed performance based design drawings and specifications. MH layout drawings of the interstitial space will outline the proposed sample piping layouts, VESDA unit locations, and fire alarm system interconnection points.
- The MH layout drawings will show the general arrangement of the piping network for the VESDA detector system. The fire alarm manufacturer will be responsible for providing detailed layout drawings showing applications engineering and product details for installation.
- The Electrical Contractor will perform the initial environmental learning stage VESDA start up tests with the assistance of the fire alarm manufacturer. A testing end cap (sample hole for annual testing) for each pipe will be installed at accessible locations below the interstitial ceilings.

The commissioning phase of the system is a key component for the success of the project. Following the installation, testing of each sampling zone will be performed to confirm, correct annunciation and operation.

Following the commissioning of the air aspiration system, a training session will be provided to the authorized store staff. A fire evacuation drill will be conducted to ascertain the effectiveness of the fire evacuation.
4. BUDGETS

A preliminary budget has been prepared based on the alternative solution. The budget includes the following components:

**Fire Protection Engineering and Code Consulting Budget**
- Design, Engineering, Project Administration and Commissioning Services
  - $20,000

**Fire Alarm Service and Equipment Budget**
- Air aspiration unit equipment, sampling piping, manufacturer engineered design drawings, system programming, testing, interface programming for the fire alarm system components and active graphic annunciation and commissioning tests
  - $70,000

**Electrical Contractor Budget**
- The Electrical Contractor will be responsible for the project coordination and management, installation of the sampling tubes and the mounting and connection to the air aspiration sampling units, emergency power supply raceway and conductors and the connections to the store fire alarm system.
  - $70,000

**Estimated Cost**
- $160,000
5. CONCLUSIONS

MH has proposed an alternate life safety systems solution based on good fire protection engineering practice. The alternate solution is a combined approach that includes early warning detection with strategic response procedures, improved control panel annunciation, and a revised fire safety plan with updated staff training. The objective of this design brief was to provide supporting information for the proposed alternate solution.

Very early detection, (i.e. detect in the incipient stage of the fire), initiates early investigation, early notification to the fire service, a lesser amount of area involved in fire, not as much smoke thereby better visibility, and an earlier application of manual fire water.

Sections of the automatic sprinkler system within the interstitial ceiling space have not been maintained or tested in accordance with the Ontario Fire Code (OFC) or National Fire Protection Agency (NFPA) 13, “Installation of Sprinkler Systems.” Replacement has been proposed to the automatic sprinkler system due to poor condition, age, and corrosion.

Operation of an active interstitial ceiling space wet sprinkler system, either from a heat-activated sprinkler head or inadvertently if a head is dislodged (i.e., during electrical cable and raceway installations) may cause significant damage and harm. This could include the ceiling collapsing on either store occupants or fire fighters.

An appropriate level of life safety for the HBC facility can be provided based on the following criteria:

- Install a very early warning incipient active smoke detection system (VESDA = Very Early Smoke Detection Apparatus) within the interstitial ceiling space.
- Combine the very early warning incipient active smoke detection system with the existing automatic wet sprinkler system serving the retail floors area.
- Install a detailed active graphic annunciator based on the existing floor plan. Active graphic annunciation will provide rapid response to any off-normal events within the earliest stages of a fire condition (i.e., before visible smoke is present).
- The environmental logging and assessment algorithms of the detection system will mitigate potential nuisance alarms caused by dust, dirt or other friable material in the interstitial space. The system “learns” the environment and references its own historical data to confirm detection of the products of combustion.

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Floor Plans
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PowerPoint Handout