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Making Buildings Better™

TO **Ms. Jennifer Cho**
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Engineers and Geoscientists of British Columbia
200 - 4010 Regent Street
Burnaby BC V5C 6N2

12384.000
Airtightness Testing Guidance and Training Guide Development
DATE February 15, 2018

REGARDING **Engineers and Geoscientist of British Columbia Office Building Whole-Building Airtightness Test Report**

Dear Ms. Cho,

RDH Building Science Inc. (RDH) is pleased to provide you with this report documenting the results of the whole-building airtightness testing conducted on the Engineers and Geoscientists of British Columbia office building, located at 4010 Regent St, Burnaby, BC.

Figure 1: Photo (Northeast corner) of the Engineers and Geoscientists of BC office building.

RDH performed airtightness testing of the building on Tuesday October 3, 2017 in general conformance with *ASTM E 779-10 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization*. The purpose of the test was to measure and to report the airtightness of the building enclosure. Knowledge of the airtightness level of an existing building can help identify and prioritize building energy retrofit measures. In addition to the quantitative airtightness testing, a thermographic survey of the building was conducted to identify potential air leakage path locations.

The following list of documents were made available to RDH prior to conducting the air leakage test:

→ Architectural Renovation November 1, 2008 (26 pages)

→ Architectural Renovation April 5, 2012 (30 pages)

→ Architectural Renovation December 9, 2015 (20 pages)

→ Mechanical As-Built July 10, 1994 (12 pages)

→ Mechanical Renovation February 2, 2012 (6 pages)

RDH performed an area takeoff of the building enclosure using the architectural renovation drawings dated December 9, 2015 and the as-built mechanical drawings dated July 10, 1994.

1 Building Description

The Engineers and Geoscientists of BC office building is a two-storey office with a concrete floor and a low-slop roof. A combination of curtain wall and framed walls compose the vertical enclosure. Curtain wall dominates the North, East and South elevations, while a framed wall assembly runs along the shaded West side of the building. Glazed swing doors are incorporated into the East facing curtain wall at ground level. There are no operable windows. Two sets of metal swing doors were located on the North and South facing walls towards the rear (West side) of the building. A total of four louvers for the mechanical system were located at the rear of the building.

Access to the second floor is via an open staircase or elevator located near reception or via two exterior staircases at the Northwest and Southwest corners of the building. The reception area at ground level is completely open to the floor above and the elevator is entirely located within the enclosure. There are no below-grade areas of the building.

2 Summary of Key Building Parameters

TABLE 2.1 - KEY BUILDING PARAMETERS	
Building Address	4010 Regent Street, Burnaby, BC V5C 6N2
Building Elevation Above Sea Level	24.5 m
Roof Height Above Ground	7.4 m
Conditioned Floor Area *Excl. Server Room*	1,824 m^2 1,812 m^2
Gross Enclosure Area[1]	2,802 m^2
Gross Enclosure Volume *Excl. Server Room*	6,749 m^3 6,704 m^3
Year Built	1995; Last renovated in 2016

[1] Including wall, roof, and floor areas using exterior dimensions

3 Airtightness Results

TABLE 3.1 - TEST INFORMATION	
Start Time	October 3, 2017 20:09
Indoor Temperature	23°C
Outdoor Temperature	11°C
Wind Speed and Direction	N/A
Height x Temperature Difference	84 m °C

TABLE 3.2 - SUMMARY OF RESULTS			
Test Condition	**Depressurize**	**Pressurize**	**Average**
Air Leakage Coefficient, C [L/s/Pa^n]	95.8 ±8.9%	96.6 ±6.7%	96.2 ±11.2%
Pressure Exponent, n	0.545 ±4.0%	0.607 ±2.6%	0.576 ±4.8%
Correlation Coefficient	0.999	0.999	0.999
ACH_{50} [h^{-1} @ 50 Pa]	0.44 ±0.5%	0.56 ±0.4%	0.49 ±0.6%
ACH_{75} [h^{-1} @ 75 Pa]	0.54 ±0.5%	0.71 ±0.4%	0.62 ±0.6%
Encl. Air Leakage Rate [L/s·m^2 @ 75 Pa]	0.36 ±0.5%	0.47 ±0.4%	**0.41 ±0.7%**
Effective Leakage Area [cm^2 at 4 Pa]	833 ±5.8%	869 ±4.4%	850 ±7.3%

TABLE 3.3 - DEVIATION STATEMENT	
Tested in both directions	Yes
Height x Temperature difference less than 200 m °C	Yes
Outdoor temperature between 7 °C and 35 °C	Yes
Five or more building pressure test points used	Yes
Bias taken for 10 seconds or more	Yes
Building Pressures taken for 10 seconds or more	Yes
Flow exponent (n) is ≥ 0.20 and ≤ 1.0	Yes
Correlation coefficient is ≥ 0.98	Yes
Test zone is interconnected with at least door sized openings	Yes[1]

[1] *Exception of server room, closed during test and excluded from results*

The average enclosure normalized air leakage rate was measured to be 0.41 L/(s·m^2) at 75 Pa. This result indicates a very airtight building enclosure. For comparison, current airtightness targets in codes and standards across BC range from 0.4 L/(s·m^2), for Passive House Institute US certification to 2.0 L/(s·m^2) for ASHRAE 90.1-2016, IECC 2012, and City of Vancouver Low Emission Green Buildings.

The air leakage rate was greater during the pressurization test. This is commonly attributable to poor gasket engagement on outward opening fenestration products such as doors and windows. During the pressurization test, the elevated building pressure acts to push these products outwards and can create greater air leakage area.

The following appendices are included at the end of this report to provide supplementary information regarding the test.

- → Appendix A: Air Leakage Test Procedure
- → Appendix B: Full Air Leakage Test Results
- → Appendix C: Thermographic Survey

The thermographic scan identified several potential air leakage locations that may be addressed including around doors and service penetrations. An example is shown in the following series of figures:

Figure 2 L1 exterior mounting bracket located on the Southwest corner

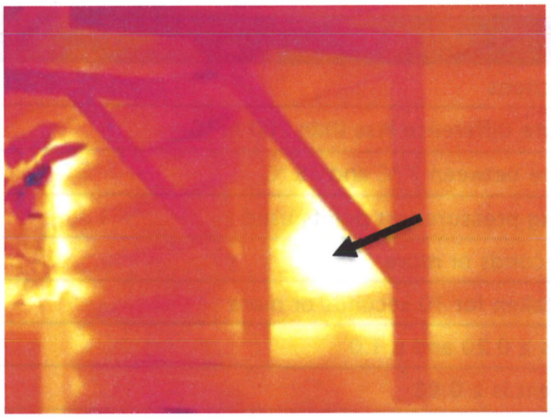

Figure 3 Positive pressure thermal scan showing potential air leakage behind the corrugated metal cladding.

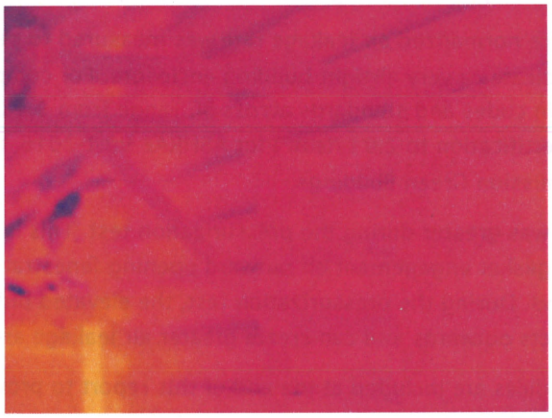

Figure 4 Negative pressure thermal scan

Please refer to Appendix C for the complete thermographic survey report.

We trust that this report meets your needs at this time. Please contact the undersigned with any questions regarding this testing.

Yours truly,

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Reviewed by:

2018-02-19

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encl. *Appendix A: Airtightness testing Procedure*
Appendix B: Airtightness Test Data
Appendix C: Thermographic Scan

Appendix A

Air Leakage Test Procedure

A.1 Air Leakage Test Procedures Overview

The building, in general, was prepared as specified in Section 8 of the ASTM E 779-10 test method. Mechanical penetrations through the building envelope were sealed off; exterior doors are closed. Interior doors were secured in the open position. Greater than 1% (4 ft^2 in 500 ft^2 of drop ceiling area) of the ceiling tiles were removed.

A computer-controlled fan-door system was used to pressurize the building as well as to measure and collect air flow and pressure data.

A.2 Blower door and Exterior Pressure Tap Locations

A single blower door with two fan openings was installed in the entrance door located on the East wall of Level 1, as shown in Figure 1. Two fans were installed in the blower door and controlled in tandem to create the desired test pressures.

Figure 1 Blower door installed and sealed to the front door frame during pressurization testing.

The exterior pressure differential was averaged from three locations at ground level on the North, East, and South of the building.

A.3 Preparation of the Interior/Exterior

All exterior doors were closed during testing. The building's mechanical system was shut off during the test. Four exterior vents located on the West elevation were sealed off using tape as shown in Figure 4. No other openings were closed or sealed during testing.

Figure 2 Exterior vents located on the West elevation were sealed using tape.

Interior spaces were interconnected with at least door-sized openings to create a single pressure boundary for the whole building. Ceiling tiles were removed to include the volume of the drop ceiling within the pressure boundary. Differential pressure measurements were taken throughout Levels 1 & 2 to confirm the uniform pressure boundary condition.

Figure 3 Ceiling tiles were removed during testing to create a single pressure boundary including the volume of the drop ceiling.

A.4 Area and Volume Calculations

The gross building volume was measured to be 6,749 m^3 based on external dimensions including all spaces within the thermal envelope. The gross floor area was measured to be 1,824 m^2 based on external dimensions. The building enclosure area was measured to be 2,802 m^2 including the wall, roof, and floor areas.

Building measurements were obtained from the Architectural Renovation drawings dated December 9, 2015, with the exception of building height, which was taken from the Mechanical As-Built drawings and confirmed on site.

A.5 Equipment List

The following equipment was used during the test. Calibration certificates are available upon request.

TABLE A.1 EQUIPMENT LIST

Equipment	**Model**	**Serial Number(s)**
Digital Manometer	Retrotec DM32	401735 (Primary Gauge) 407085
Blower Door Fan	Retrotec 6000	3PH600542 3PH600543
Digital temperature/RH meter	Kestrel 3500	

FanTestic (version 5.9.40) software was used to analyse and collect the data.

A.6 Modifications to the Test Procedure

At the request of Engineers and Geoscientists BC, the server room was excluded from the test boundary for security reasons. This area is shown in the figure below.

Figure 4 Level 1 floor plan. Server room (blue) was excluded from the calculated results.

The walls and ceiling of the server room do not connect to the exterior enclosure and the room represents less than 1% of the conditioned space. The floor area and volume of the server room are excluded from the results of the air leakage test, although the impact of this adjustment on the results is negligible.

Appendix B

Air Leakage Rate Test Results

October 3rd, 2017 Airtightness Test

The following tables summarize the measured and calculated results for the depressurization and pressurization tests. The results are shown graphically on the follow page.

TABLE B.1 - DEPRESSURIZATION TEST		
Measured Data		
Initial Baseline (Pa)	-1.3	
Induced Pressure	**Total**	**Corrected**
ΔP [Pa]	**Q [L/s]**	
-41.4	740.0	714.9
-44.5	772.6	746.6
-52.0	845.8	816.9
-55.9	879.3	849.5
-58.5	897.2	866.5
-63.0	932.6	901.0
-66.6	958.1	925.6
-69.4	978.4	945.4
-72.9	998.3	964.3
-74.5	1010.1	975.6
-76.4	1071.0	1034.6
Final baseline (Pa)	-1.4	
Calculated Data		
Flow coefficient, C_r	103.7	L /(s·Pa^n)
Flow exponent, n	0.526	-
ELA at 4 Pa	832.9	cm^2
Encl. Norm. Leakage Rate at 75 Pa	0.358	$L/(s·m^2)$
ACH_{75}	0.539	h^{-1}
Error	0.5	+/- %

TABLE B.2 - PRESSURIZATION TEST		
Measured Data:		
Initial Baseline (Pa)	-1.2	
Induced Pressure	**Total**	**Corrected**
ΔP [Pa]	**Q [L/s]**	
40.0	881.2	904.3
45.5	964.3	990.3
47.8	986.0	1012.4
51.8	1037.0	1064.4
55.0	1078.6	1107.4
59.0	1126.7	1156.9
62.8	1169.7	1200.9
67.0	1223.1	1255.6
70.3	1256.1	1289.6
73.5	1283.0	1317.0
76.7	1313.3	1348.2
81.8	1357.6	1394.0
Final baseline (Pa)	-0.8	
Calculated Data		
Flow coefficient, C_r	96.6	L /(s·Pa^n)
Flow exponent, n	0.607	-
ELA at 4 Pa	869.0	cm^2
Encl. Norm. Leakage Rate at 75 Pa	0.474	$L/(s·m^2)$
ACH_{75}	0.713	h^{-1}
Error	0.4	+/- %

The interior temperature throughout the test was approximately 23 °C. The exterior temperature was approximately 11 °C at the start of the test and decreased to 10 °C at the end of the test.

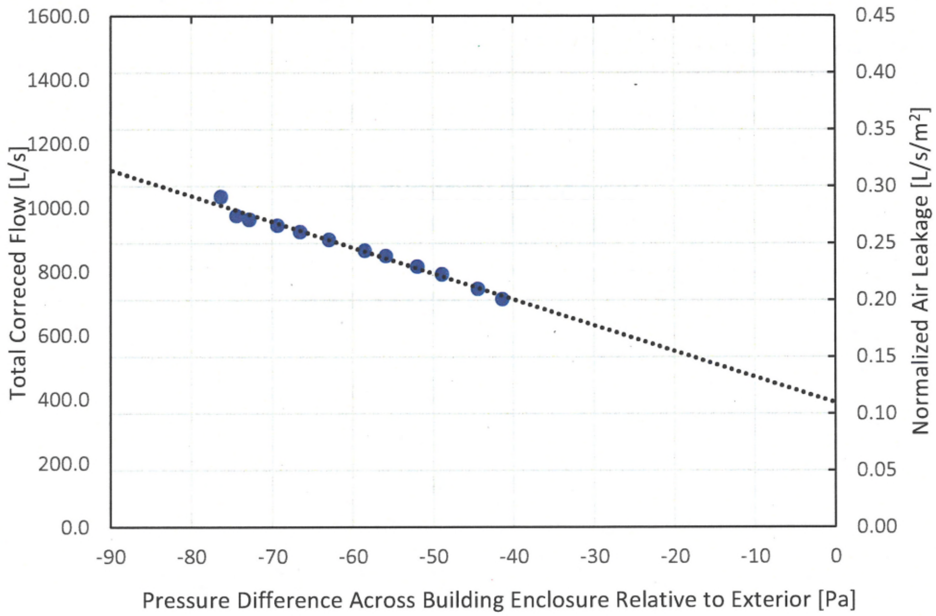

Figure 5 Chart of airtightness test depressurization results.

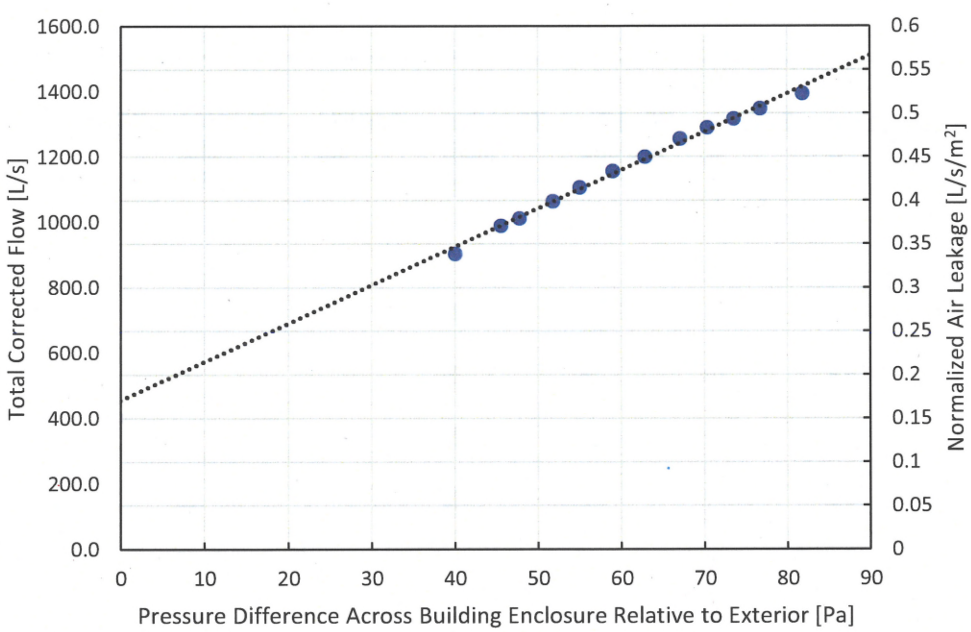

Figure 6 Chart of airtightness test pressurization results.

Government of Canada Gouvernement du Canada

Hourly Data Report for October 03, 2017

All times are specified in Local Standard Time (LST). Add 1 hour to adjust for Daylight Saving Time where and when it is observed.

VANCOUVER HARBOUR CS
BRITISH COLUMBIA

Latitude:	49°17'43.270" N
Longitude:	123°07'18.730" W
Elevation:	2.50 m
Climate ID:	1108446
WMO ID:	71201
TC ID:	WHC

TIME	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
00:00	10.8	5.7	71	M	M		M			NA
01:00	11.8	6.4	70	M	M		M			NA
02:00	9.4	4.9	74	M	M		M			NA
03:00	9.1	4.2	71	M	M		M			NA
04:00	8.9	4.8	76	M	M		M			NA
05:00	8.2	4.7	78	M	M		M			NA
06:00	8.2	5.4	82	M	M		M			NA
07:00	8.9	5.5	79	M	M		M			NA
08:00	12.8	6.4	65	M	M		M			NA
09:00	14.5	5.5	55	M	M		M			NA

	Temp °C	Dew Point Temp °C	Rel Hum %	Wind Dir 10's deg	Wind Spd km/h	Visibility km	Stn Press kPa	Hmdx	Wind Chill	Weather
10:00	14.8	5.6	54	M	M		M			NA
11:00	18.1	3.3	37	M	M		M			NA
12:00	16.5	5.0	46	M	M		M			NA
13:00	15.9	5.8	51	M	M		M			NA
14:00	16.1	5.2	48	M	M		M			NA
15:00	16.3	4.7	46	M	M		M			NA
16:00	16.3	4.3	45	M	M		M			NA
17:00	15.1	4.5	49	M	M		M			NA
18:00	13.0	8.7	75							NA
19:00	12.1	6.8	70							NA
20:00	11.0	7.1	77	M	M		M			NA
21:00	10.4	7.1	80	M	M		M			NA
22:00	10.0	7.9	87	M	M		M			NA
23:00	10.7	7.7	82	M	M		M			NA

Exterior weather conditions during air leakage testing

Legend

- E = Estimated
- M = Missing
- NA = Not Available
- ‡ = Partner data that is not subject to review by the National Climate Archives

Date modified:
2016-08-09

Appendix C

Thermographic Scan

1 Background

1.1 Introduction

RDH Building Science was retained by Engineers and Geoscientists of British Columbia to perform an infrared thermal scan their office building located at 4010 Regent Street, Burnaby.

Testing was performed on October 3, 2017, from 20:15 through 23:15. Lorne Ricketts and Daniel Haaland of RDH performed the thermographic scanning. Harshan Radhakrishnan of the Association of Engineers and Geoscientists of British Columbia was also present.

At the time of testing the building had been operational for 22 years.

1.2 Procedure

1.2.1 Infrared Scan with Pressurization

The infrared scan was performed in general conformance with *ASTM E1186 Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems* test using the infrared scanning with pressurization techniques. Prior to scanning, the building's mechanical system was used to heat the building. The ASTM standard states that "Normally, a pressure differential of 10 to 50 Pa is adequate in most cases..." An average positive and negative pressure differential of ± 25 Pa was achieved during the test.

The positive pressure differential was applied at 8:15 pm on the day of testing, and maintained for 30 minutes prior to commencing the scan.

the exterior walls and roof were scanned to identify potential air leakage locations. The scan was performed with a Fluke TiR32 infrared camera.

The positive pressure infrared scan was conducted from 8:45 pm to 10:00 pm at an ambient exterior temperature of 11°C. The negative pressure infrared scan was conducted between 10:00 pm and 11:15 pm at similar conditions of 10°C exterior temperature. The internal temperature at the start of the test was 23°C.

1.2.2 Background

An infrared camera is capable of detecting the surface temperature of materials based on the heat radiated from them. An infrared scan identifies locations on the building that are significantly warmer or colder than the surrounding building surface temperatures. Some known hot spots such as louvers, vents, and mechanical equipment will be much warmer or colder than the surrounding surface temperatures. When the cause of hot or cold spots is unknown they are referred to as thermal anomalies.

Thermal anomalies are generally a result of a thermal bridge, such as structural steel passing though the insulation, or air leakage. It is possible to isolate thermal bridge anomalies from air leakage anomalies by performing a thermographic scan under both positive and negative pressure.

When a building is pressurized, warm air is forced out through holes in the air barrier. This results in a warming of the wall components adjacent to the exfiltrating air, which can be detected by the thermographic camera.

When a building is depressurized; warm exterior surfaces are no longer exposed to exfiltrating air and will begin to cool. Under negative pressure the thermal bridge anomalies will be unaffected by the change in pressurization and will remain a similar temperature on both the positive and negative scan.

To determine the locations of probable air leakage, the results of both the positive and negative pressure infrared scans are compared. Areas with warm thermal anomalies during the pressurized scan that were subsequently reduced during the depressurized scan are identified as likely air leakage anomalies. An example of this can be seen in the two sample images, figures 1.2.2.1 and 1.2.2.2, (not from this building) which show thermal anomalies created by air leakage.

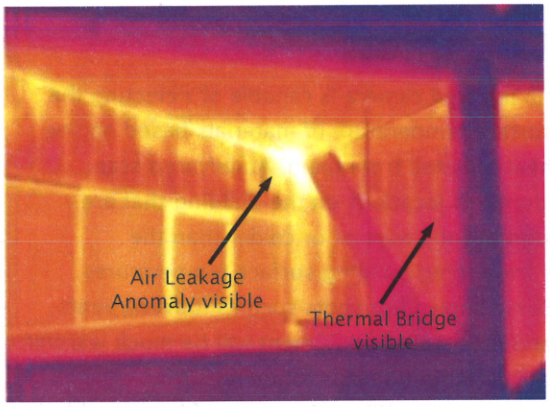

Fig 1.2.2.1 Sample Image – Thermal anomalies under positive pressurization (air exfiltration)

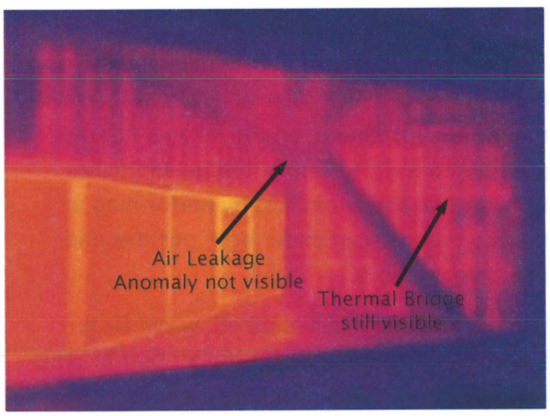

Fig 1.2.2.2 Sample Image – Thermal anomalies under negative pressurization (air infiltration)

2 Results and Observations

The image sets (photograph, positive pressure scan, and negative pressure scan) on the following pages were taken during the infrared scans. Commentary is provided with each photo discussing areas of potential air leakage.

The combination of infrared scans found numerous locations of suspected air leakage typically around doors and penetrations.

Figure 2.1 North door

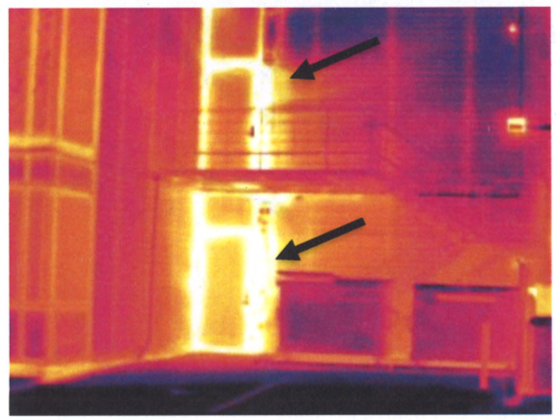

Figure 2.2 Positive pressure thermal scan showing potential air leakage around the perimeter of the L1 and L2 doors

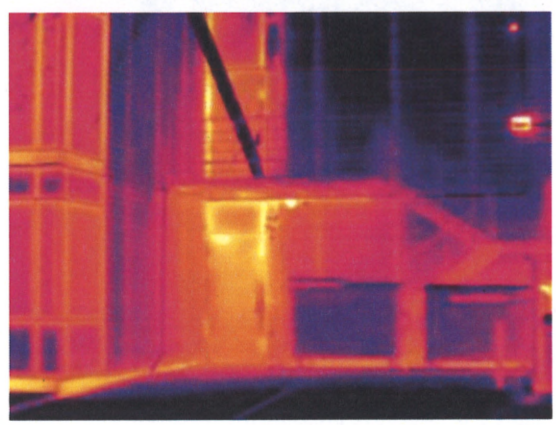

Figure 2.3 Negative pressure thermal scan

Figure 2.4 L2 northwest roof/wall corner

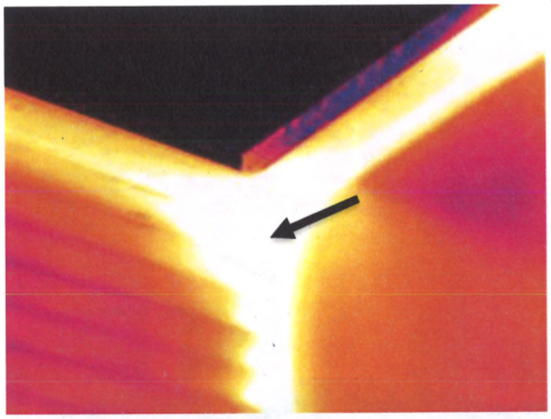

Figure 2.5 Positive pressure thermal scan showing potential air leakage at the corner above the L2 door

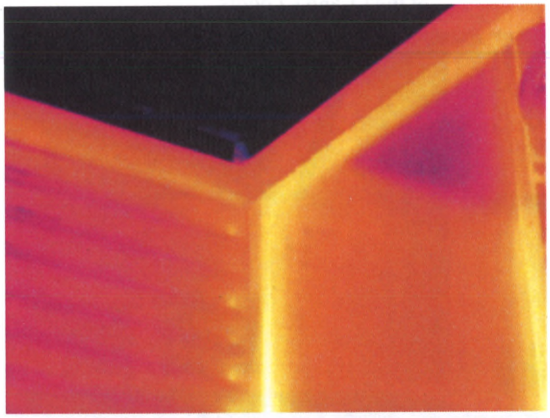

Figure 2.6 Negative pressure thermal scan

Figure 2.7 L1 louvre at the northwest corner

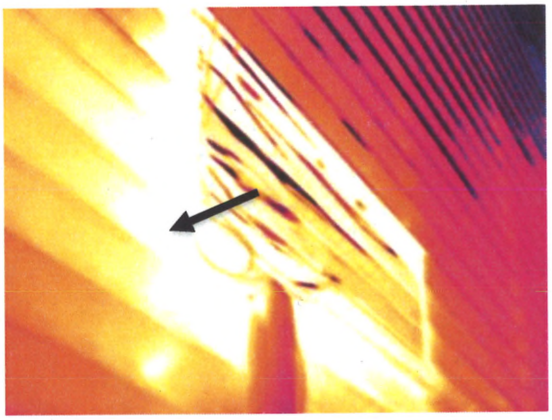

Figure 2.8 Positive pressure thermal scan showing potential air leakage around an exterior vent on the West elevation

Figure 2.9 Negative pressure thermal scan

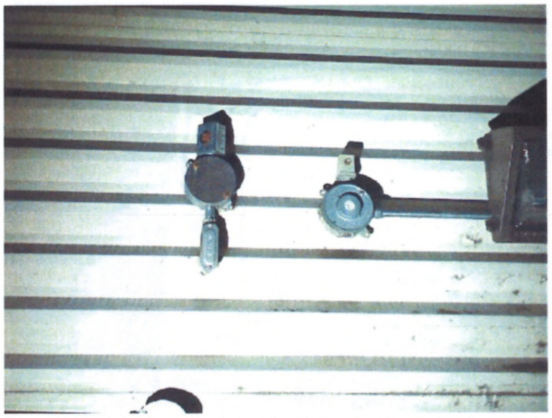

Figure 2.10 Electrical service penetrations on the west wall

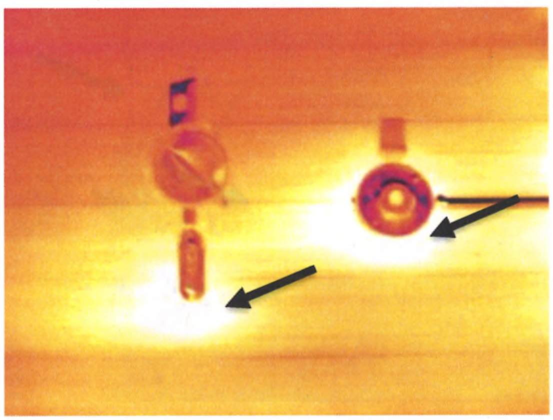

Figure 2.11 Positive pressure thermal scan showing potential air leakage around the penetrations

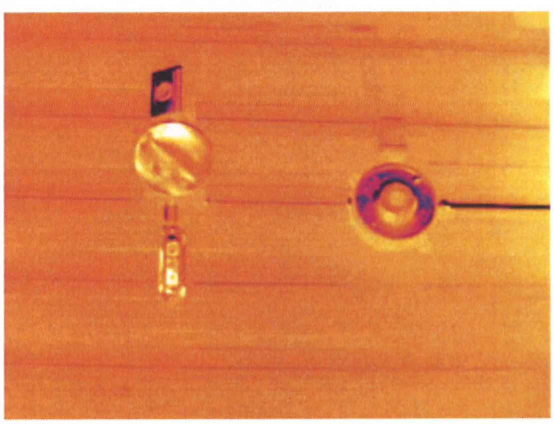

Figure 2.12 Negative pressure thermal scan

Figure 2.13 L1 exterior mounting bracket located on the Southwest corner

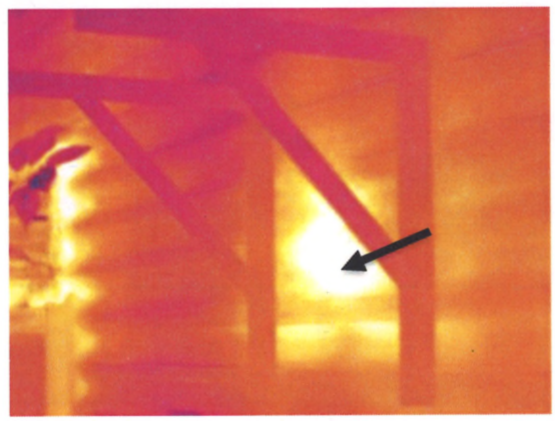

Figure 2.14 Positive pressure thermal scan showing potential air leakage behind the corrugated metal cladding.

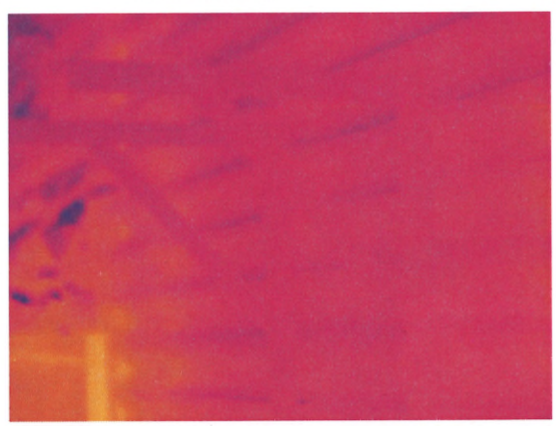

Figure 2.15 Negative pressure thermal scan

Figure 2.16 L1 southwest door

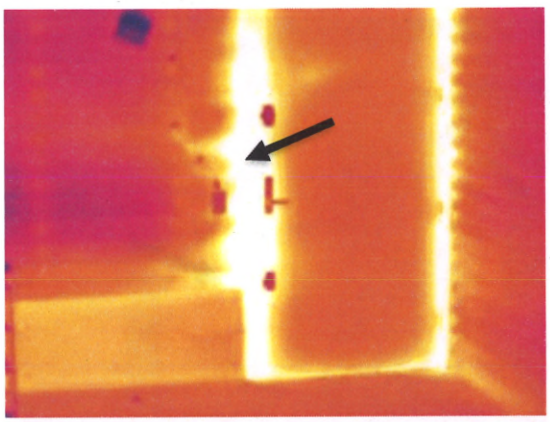

Figure 2.17 Positive pressure thermal scan showing potential air leakage around the L1 Southwest door

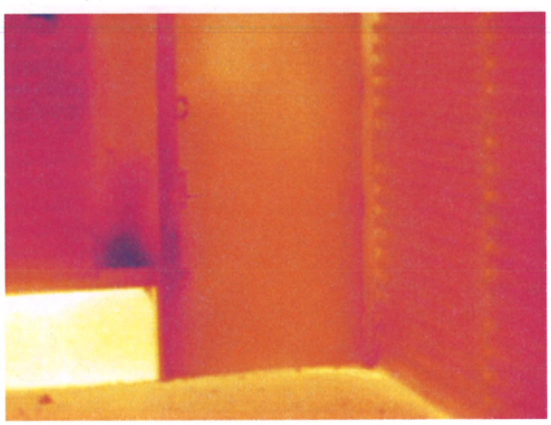

Figure 2.18 Negative pressure thermal scan

Figure 2.19 Hanging wire penetrations at the southwest corner

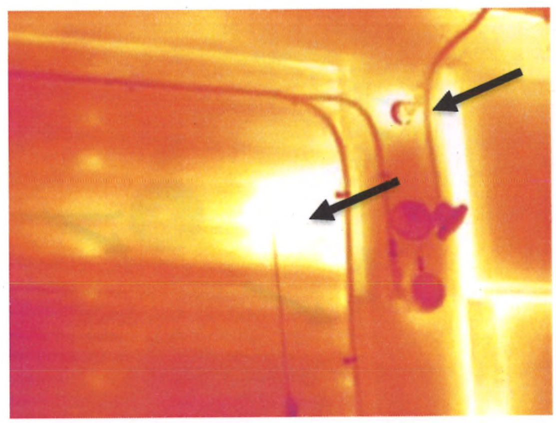

Figure 2.20 Positive pressure thermal scan showing potential air leakage around penetrations at the Southwest L1 door

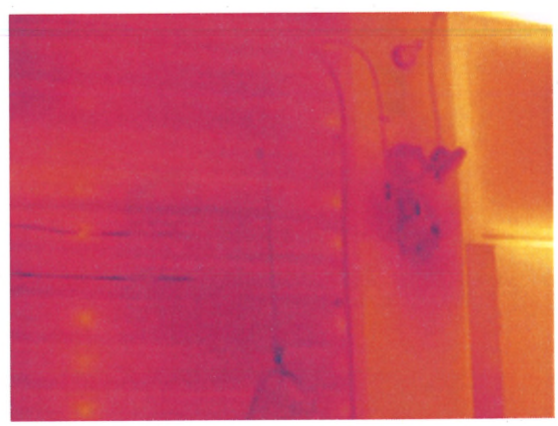

Figure 2.21 Negative pressure thermal scan

Figure 2.22 L2 southwest roof/wall corner

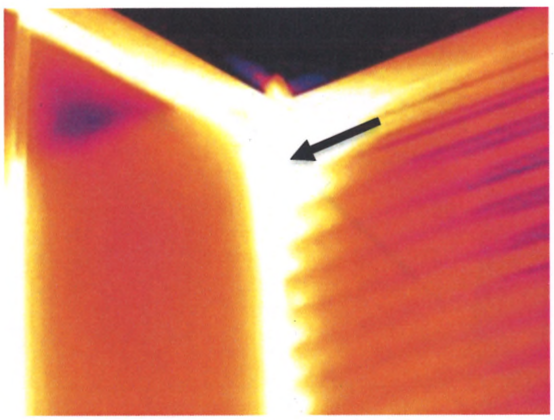

Figure 2.23 Positive pressure thermal scan showing potential air leakage at the top corner of the L2 Southwest door

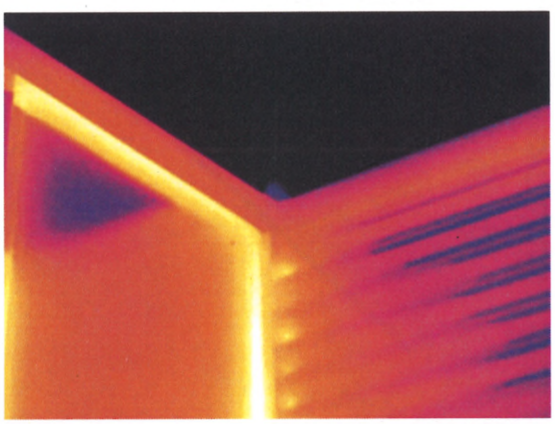

Figure 2.24 Negative pressure thermal scan

Figure 2.25 L2 southwest base of door

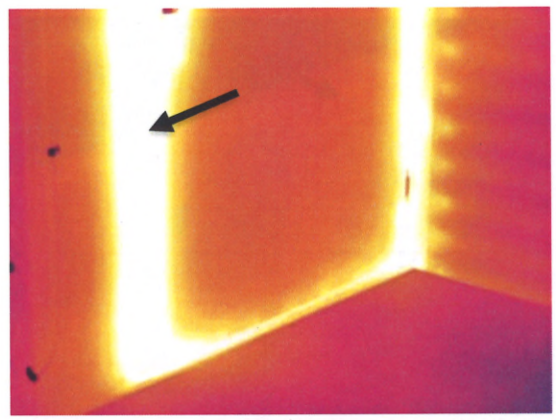

Figure 2.26 Positive pressure thermal scan showing potential air leakage around the L2 Southwest door

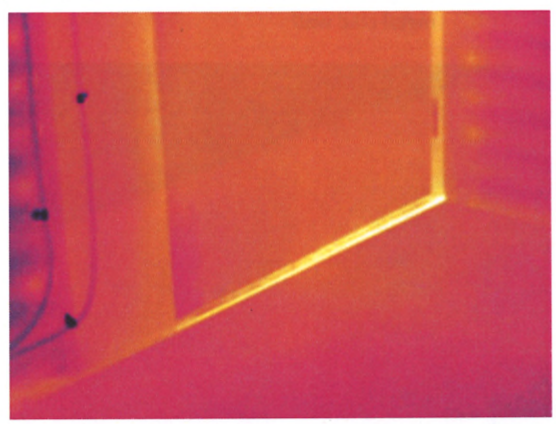

Figure 2.27 Negative pressure thermal scan


Figure 2.28 L2 southwest corner

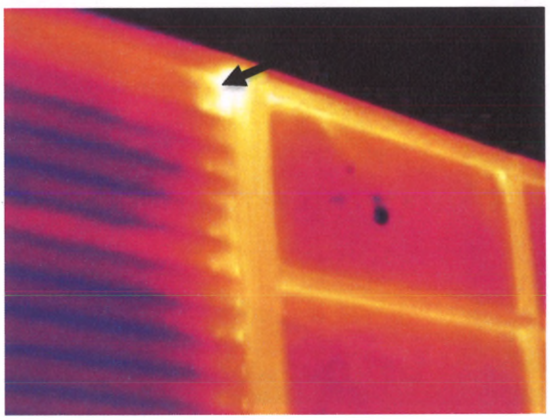
Figure 2.29 Positive pressure thermal scan showing potential air leakage where the curtain wall turns the Southwest corner and joints the metal clad wall

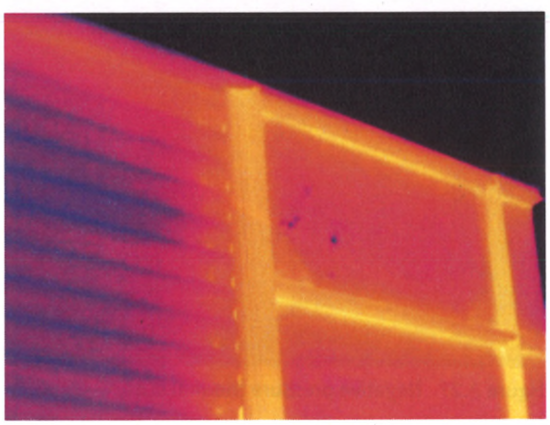
Figure 2.30 Negative pressure thermal scan


Figure 2.31 L1 southeast base of door

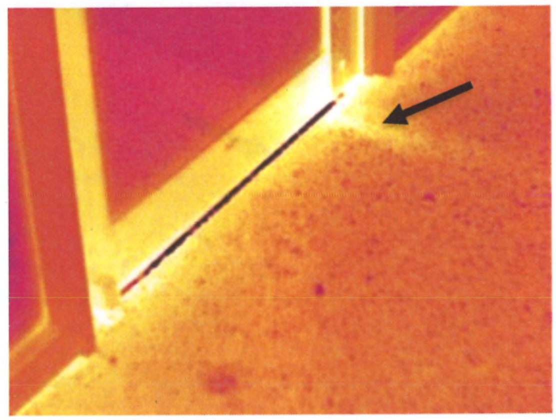
Figure 2.32 Positive pressure thermal scan showing potential air leakage at the base of the L1 Southeast door

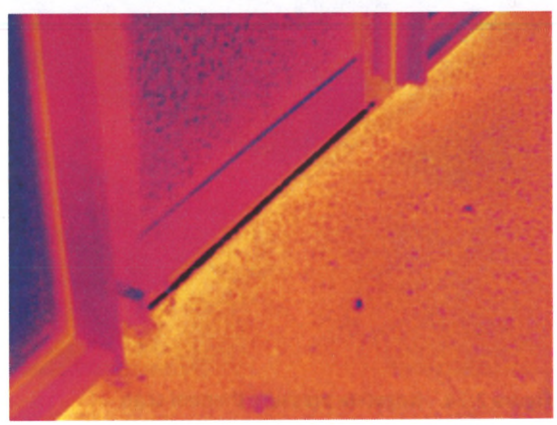
Figure 2.33 Negative pressure thermal scan

Figure 2.34 L1 base of south door

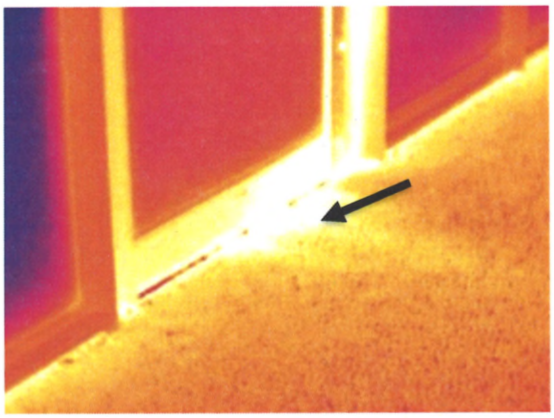

Figure 2.35 Positive pressure thermal scan showing potential air leakage at the base of the L1 South door

Figure 2.36 Negative pressure thermal scan

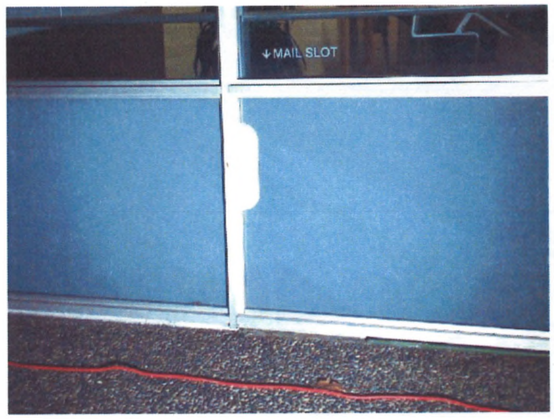

Figure 2.37 Mail slot near atrium

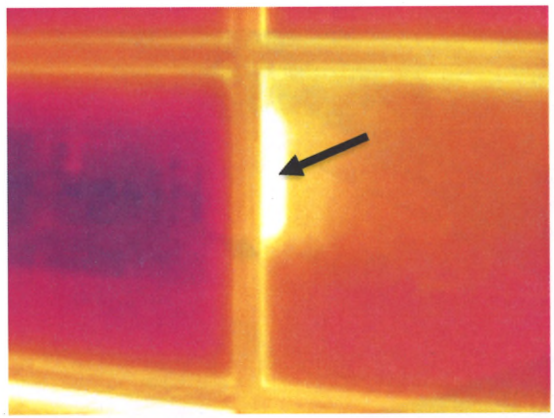

Figure 2.38 Positive pressure thermal scan showing potential air leakage at a mail slot on the East wall

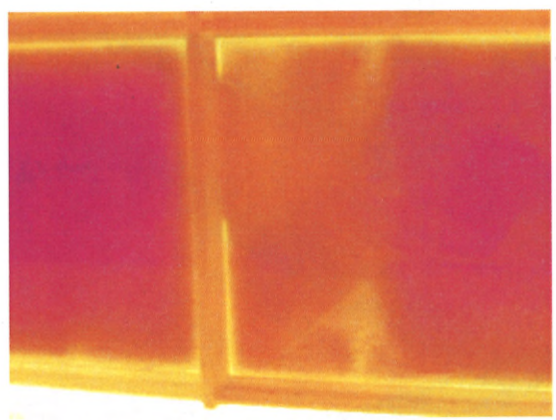

Figure 2.39 Negative pressure thermal scan

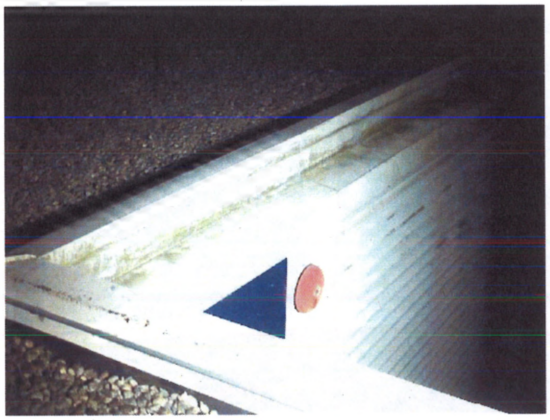

Figure 2.40 Top right corner of L2 north door

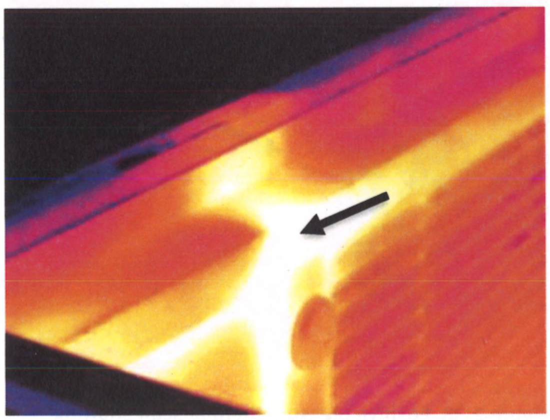

Figure 2.41 Positive pressure thermal scan showing potential air leakage around the fire alarm bell

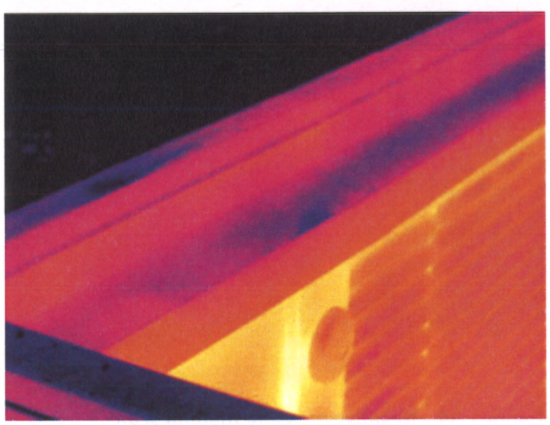

Figure 2.42 Negative pressure thermal scan

3 Recommendations

Based on the thermographic scan, some general recommendations can be made including:

- → Weather-strip all exterior doors and improve lock securement to ensure gaskets are engaged
- → Seal abandoned mail slot
- → At other likely locations of air leakage, smoke testing and exploratory openings could be performed to confirm air leakage paths and to facilitate design of potential repairs

We trust that this report meets your needs at this time. Please do not hesitate to contact the undersigned with questions regarding this report.