Structural and Nonstructural Building System Performance During Earthquake and Post-Earthquake Fire

Fire Test Program – Full Report

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NOTICE

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ABSTRACT

Earthquakes have the potential to cause significant damage to building structural and nonstructural systems. Once damaged, buildings become highly susceptible to post-earthquake fire. Although considerable research has been undertaken with respect to the performance of structural systems, research aimed at understanding and quantifying the performance of nonstructural systems and post-earthquake fire performance of buildings has been severely lacking. To begin addressing this crucial gap in knowledge, an academe-industry collaborative was formed to conduct the project *Full-Scale Structural and Nonstructural Building System Performance during Earthquakes & Post-Earthquake Fire*, a $5 Million effort referred to as the building nonstructural components and systems (BNCS) project (http://bncs.ucsd.edu/index.html). This report details those aspects of the BNCS project related to the fire performance testing, including details of the third floor fire test compartments, post-motion test state of the third floor systems, outcomes of the blower door fan tests, fire test plan and fire test data. Preliminary observations, planned analyses, and future research recommendations are presented. Details on the seismic design of the test specimen, overall building layout, installed systems and contents, the seismic test program, including earthquake motions, sensors and instrumentation, and data from the motion tests, including on fire protection systems, are available in Chen et al. (2013) and Pantoli et al. (2013).

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EXECUTIVE SUMMARY

In April and May 2012, a series of landmark full-scale experiments were conducted on and within a 5-story reinforced concrete frame test specimen, with floor plates measuring 6.6 meters by 11 meters (21.5 feet by 36 feet), which was erected on the nation's largest outdoor shake table at the Englekirk Structural Engineering Center at the University of California, San Diego. Referred to as the building nonstructural components and systems (BNCS) project (http://bncs.ucsd.edu/index.html), the goal of this $5 Million academe-industry-government collaborative was to investigate earthquake performance of nonstructural building systems and post-earthquake fire performance.

During the period 16 April - 15 May 2012, the test specimen was subjected to a total of 13 motion tests, seven with base isolation (BI) and six with a fixed base (FB) configuration. Seismic motions were selected from earthquake events occurring off the coast of California, in the central area of Alaska and the subduction zone of South America. These motions provided excitations with different frequency content distributions as well as varied strong motion durations and amplitudes. Seismic motions were designed and applied to the building to progressively increase the seismic demand on the structure and NCSs in both the BI and FB conditions. In addition, to compare the response and behavior of the structure and NCSs, the early (target) motions in the sequence of the BI and FB testing phases were similar. One maximum considered earthquake (MCE) motion and two serviceability level motions were obtained by spectrally matching to the ASCE 7-05 design spectrum achieved for a high seismic zone in Southern California (site class D). In addition a long duration motion from the 2007 Peru earthquake was selected and amplitude scaled (50, 100, and 140%, the later applied only during the BI testing phase). It was desirable to minimize the peak inter-story drift ratio (PIDR) to less than approximately 0.5% while the test specimen was isolated at its base, to preserve the structure for the FB testing phase. The design event imposed during the FB testing phase was intended to achieve approximately 2-2.5% PIDR and 0.8g peak floor acceleration in the test structure. The achieved peak input acceleration range for the FB earthquake motions ranged from about 0.2 to 0.8g, while the pseudo-spectral acceleration at a period of 1 sec ranged from about 0.3 to 1.3g. To collect data on the earthquake performance of the structure, nonstructural components and systems, sensors were installed to collect drift and acceleration data. Cameras were used to record visual data relative to movement, cracking and related effects. Following each motion test, damage to structural and nonstructural components and systems were photographed and documented. Details on the seismic design of the test specimen, overall building layout, installed systems and contents, the seismic test program, including earthquake motions, sensors and instrumentation, and data from the motion tests, including for fire protection systems, are available in Ebrahimian et al., (2013), Chen et al. (2013) and Pantoli et al. (2013).

Following the motion tests, blower door fan tests were conducted in compartments on the third floor, specifically to measure the effective leakage area which developed as a result of the various ground motion tests. The aim was to collect data on compartment integrity and motion-induced ventilation openings: factors which can have significant impacts on building fire conditions. Then, following the last motion test, six live fire tests were conducted within the earthquake-damaged specimen to evaluate various aspects of the fire performance of earthquake-damaged buildings. This report details the fire-related tests, including the blower door fan tests, live fire tests, instrumentation plan, test plan, data collected and preliminary findings.

The primary focus of fire-related tests was the third floor, on which four compartments were configured for testing: the Large Burn Room (LBR), the Small Burn Room (SBR), the area around the Elevator Shaft (ES), and the Elevator Lobby (EL). The LBR and SBR construction was Type-X gypsum board on steel studs with doors and frames indicative of nominal 20-minute fire rated construction. Door closers and magnetic door holders were installed. The ceiling consisted of Type-X gypsum board on an Armstrong ceiling system, which could be configured for a nominal 60-minute fire resistance rating. Floor/ceiling slabs were of unprotected reinforced concrete construction. A balloon framing system was used for the exterior walls. The third floor was served by an elevator and a full-size steel stair system, and was equipped with various nonstructural components, including heating, ventilation and air-conditioning (HVAC) system ductwork with fire dampers, a charged wet sprinkler system and smoke detectors. Various firestops were installed within vertical and horizontal partitions, including around pipe penetration openings, floor, wall and ceiling joints. In addition, a roll-down steel fire door was installed within the partition wall between the LBR and SBR.

During the period 23-25 May 2012, two fire tests per day were conducted on the third floor: two in LBR, two in EL, and one each in SBR and ES. To control the fire size and duration, the liquid Heptane was burned in steel pans. The fire tests ranged in size from approximately 500kw to 2000kW, dependent on the compartment and ventilation characteristics, number of pans and amount of Heptane used. A primary consideration was to limit the potential for fire-induced structural failure. To collect temperature data inside and outside of the fire test compartments, thermocouples were placed in various locations depending on the objectives of each fire test. The primary focus areas were to obtain data on the thermal environment within the fire compartment and adjacent spaces, to assess fire and smoke spread between compartments as a result of seismic-induced compartmentation failure, and to assess the performance of the fire protection systems (firestop, dampers, sprinklers). Multiple video cameras were also installed throughout the building to collect visual data on smoke or fire spread and activation of the fire protection systems.

Although most of the data on the fire performance of the test specimen was limited to systems and configurations on the third floor, and the live fire tests were limited in number and scope, important data were collected and the following initial observations are made.

General observations regarding earthquake performance of the specimen, which could have an impact on fire performance of a building, include:

- Ceiling systems on Floor 1 showed progressive damage with increased ground motion intensity. The potential fire performance concern is loss of compartment integrity and spread of fire and smoke. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Contents indicative of residential and laboratory spaces on Floor 2, ranging from small items such as books, vases and a television set, to larger items such as bookshelves, storage shelves, and refrigeration units were displaced if not anchored. The potential fire performance concern is that most of the unanchored items were distributed on the floor, which would represent a distributed fuel load that is different

that might be anticipated for a non-earthquake-damaged building. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)

- Some of the magnetic door holders installed on Floor 3 experienced damage during the motion tests. In one case, the magnetic bond was stronger than the fasteners used to connect the strike plate to the door, ripping the strike plate off the door. The potential fire performance concern here is that improperly operating doors might impede occupant egress and firefighter access.
- Some of the doors installed on Floor 3 were not functioning properly after the motion tests. In some cases doors were not able to close completely because door frames were distorted and locks were damaged. The potential fire performance concern here is that smoke and fire could spread through a door, which was designed to be closed during fire, hindering occupant egress and safety. In another instance, a door on Floor 3 was jammed closed during a ground motion tests, requiring tools to be used to pry the door open. The potential fire performance concerns here are that occupants can be hindered when trying to escape, placing them at risk, and the fire service can be hindered when undertaking rescue and firefighting operations.
- In various locations within the test specimen, including around the elevator shaft on Floor 3 and within the stairwell on various levels, gypsum wallboard sections became detached during motion tests. The potential fire concerns are loss of compartment integrity and spread of fire and smoke, hindering occupants when trying to escape and placing them at risk, and hindering the fire service when undertaking rescue and firefighting operations. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Following the largest ground motions, the stair became detached from the stair landing and handrails were broken at locations between Floors 2 and 4. The potential fire performance concerns here are that occupants can be hindered when trying to escape, placing them at risk, and the fire service can be hindered when undertaking rescue and firefighting operations. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Following the largest ground motions, significant spalling occurred on various concrete beam-column connections on the lower floor, resulting in exposed steel

rebars, degrading the structural load-bearing capacity and fire performance of the connection and structural system. The potential fire performance concerns here are that occupants can be hindered when trying to escape, placing them at risk, the fire service can be hindered when undertaking rescue and firefighting operations, and the building could be at risk of localized collapse or worse. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)

- Following the largest ground motions, one intensive care unit breakout door was detached from the door frame on Floor 4. Since the door provides a smoke barrier, the potential fire performance concern here is that smoke could spread through the opening, and occupants, who may be required to be protected in place, might be put at risk. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Following the largest ground motions, a rigid steel pipe, representative of a fuel gas supply line, failed at a connection. Such a failure could lead to release of fuel gas in a building, if other protective measures are not in place (e.g., shutoff valves). Corrugated stainless steel tubing (CSST), also representative of a fuel gas supply line, did not experience such a failure. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)

General observations regarding fire performance of the specimen, following the live fire tests, which could have an impact on fire performance of a building, include:

- The automatic sprinkler system functioned well during ground motion tests and activated as expected during the fire tests on Floor 3.
- All dynamic and truly static firestop systems installed on Floor 3 performed generally well during the motion tests and to the fire tests except, in earthquake conditions, some joints that would be static in normal operation were not static anymore and joint seals applied on such joints became separated by the ground motion. The potential fire performance concern is loss of compartment integrity and spread of fire and smoke.
- The roll-down steel fire door was intentionally not subjected to significant in-plane drifts during the motion tests and resisted shaking perpendicular to the plane of the door effectively (no damage, see Chen et al., 2013 and Pantoli et al., 2013 for more details) and activated as expected during the fire tests.

- Smoke detectors activated as expected during the fire tests.
- The fire dampers on Floor 3 performed generally well during the motion tests and fire tests. Two fire dampers closed completely following each motion test. The third damper's blade rotation was prevented by a screw used for damper installation which, once adjusted, allowed the damper to close completely following the motion tests. The potential fire performance concern is lack of smoke control, allowing smoke to spread from one compartment to another.
- The non-rated flexible duct melted and ruptured during some of the fire tests. The potential fire performance concern is lack of smoke control, allowing smoke to spread from one compartment to another.
- Significant gaps opened in several joint areas on Floor 3, as well as between steel brackets and the balloon framing. The gap between the balloon framing and slab was up to 10 cm (4 inches) in places (see Chen et al., 2013 and Pantoli et al., 2013 for more details). The potential fire performance concern is loss of compartment integrity and spread of fire and smoke. Smoke leakage was observed during the fire tests in several locations.
- The elevator was non-operable following the largest ground motion because the elevator doors and frames became distorted on several floors, with openings as large as 24 cm (9.4 inches) on the third floor. One potential fire performance concern is loss of compartment integrity and spread of fire and smoke, in this case allowing for vertical smoke (and fire) spread. The elevator shaft interior temperatures were greatly increased as smoke and hot gases from the EL1 and EL 2 fires were entrained into the shaft through the opening on Floor 3. An additional potential fire performance concern is the loss of elevators for occupant egress and for fire department rescue and suppression support operations.
- A long vertical steel pipe went through thermal expansion under elevated temperatures during one fire test and the pipe shifted the firestop material that was applied on the vertical pipe penetration opening. The potential fire performance concern is lack of intended smoke control, allowing smoke to spread from one compartment to another.

- Depending on the test, flashover conditions were observed, even with relatively small fuel loads. In some cases the ventilation conditions played a significant role.
- Fuel gas distribution systems, if damaged due to seismic motion, could result in additional fuel for post-earthquake fire, if not provided with additional safeguards (e.g., shutoff valves).
- Although it was not possible to test actual windows during these tests, window openings were provided and tested in various conditions, including completely closed, partially closed and fully open. In tests where the windows were fully opened, flame extension was observed, smoke venting was observed, and the test fires were exposed to wind-driven conditions, which affected the combustion rate, smoke spread and flame angle direction during the fire tests. The potential fire performance concerns here are that loss of windows could facilitate floor-to-floor fire spread, and that wind-driven conditions resulting from loss of windows could result in much different fire conditions that the building fire protection systems are designed for or the fire department might expect. This would place occupants and the fire service at risk.

Again, although most of the data on the fire performance of the test specimen was limited to systems and configurations on the third floor, and the live fire tests were limited in number and scope, important data were collected and the following initial observations are made. Since very few full-scale post-earthquake fire tests have been conducted to date, more testing is warranted to investigate in more depth the above situations, to assess the performance of other building constructions, contents and configurations, and to fill the gap of knowledge on post-earthquake building fire conditions. Some additional observations for future testing include the following:

- To better assess the potential for vertical fire spread and potential for and the effects of wind-driven fires, a variety of exterior glazing systems and window configurations should be tested.
- Post-earthquake fire experiments should be performed on a myriad of construction types as the code requirements, construction material and style vary across different regions. Test specimens utilizing lightweight steel construction, lightweight engineered wood construction, steel framed construction and combinations of construction (framing, interior and façade) systems should be

tested. Multiple ceiling systems and components should be tested. Multiple door/frame systems, closers and hold-open devices should be tested.

- To best mimic real life conditions, it is important to have fully operating building and fire protection systems, including a fully functioning HVAC system.
- Measurements of the heat flux, flow velocity, temperature, pressure and visual records of smoke and fire spread should be collected directly during the fire tests. This will provide more data on building performance and can be helpful in simulation or performance.
- Instead of a fuel pan, a gas burner system should be used which allows for controlling the fire size and for measuring the HRR. This will allow more flexible test schemes, and larger and longer fires, which can be stopped as needed if the potential for structural damage exists.
- Any data acquisition, instrumentation and sensors should be powered separately from that of the test building as building electrical wires are prone to melting during the fire tests.
- Two sets of tests should be conducted on the same building conditions at the pre- and post-earthquake damaged state. Where possible, laboratory pre- and post-damage testing of representative configurations will help to yield additional data.
- Tests should be repeated under the same testing environment for a more reliable set of test data.
- Tests should be repeated under a range of test environments (e.g., relative humidity, temperature and wind speeds) for a broader data set.

Details on the fire test program and data collected, including component data sheets, sensor and data acquisition details, and thermocouple data from each of the fire tests are provided in the report.

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1 INTRODUCTION

Earthquakes have the potential to cause significant damage to building structural and nonstructural systems. Once damaged, buildings become highly susceptible to post-earthquake fire. Although considerable research has been undertaken with respect to the performance of structural systems, research aimed at understanding and quantifying the performance of nonstructural systems and post-earthquake fire performance of buildings has been severely lacking. To begin addressing this crucial gap in knowledge, an academe-industry collaborative was formed to conduct the project *Full-Scale Structural and Nonstructural Building System Performance during Earthquakes & Post-Earthquake Fire*, a $5 Million effort referred to as the building nonstructural components and systems (BNCS) project (http://bncs.ucsd.edu/index.html). The project is overviewed in Hutchinson et al. (2013).

To facilitate the BNCS project, a 6.6m by 11m (21.5' by 36'), 5-story, reinforced concrete frame test specimen, representative of a full-scale building, was erected on the nation's largest outdoor shake table at the Englekirk Structural Engineering Center at the University of California, San Diego. The test specimen was equipped with various nonstructural components such as a fully functioning elevator, various ceiling systems, interior partition walls with doors, heating, ventilation and air-conditioning (HVAC) system components, and active and passive fire protection systems. The test specimen was also outfitted with various occupancy-specific contents, including two floors of medical facility components (Floors 4 and 5), computer servers (Floor 3), and residential and commercial storage components (Floor 2). The building design, construction, contents and layouts are detailed in Chen et al. (2013). To collect data on the earthquake performance of the structure, nonstructural components and systems, sensors were installed to collect drift and acceleration data. Cameras were used to record visual data relative to movement, cracking and related effects.

The test specimen was subjected to a total of 13 motion tests, seven with base isolation and six with a fixed base configuration. Seismic motions were selected from earthquake events occurring off the coast of California, in the central area of Alaska and the subduction zone of South America. These motions provided excitations with different frequency content distributions as well as varied strong motion durations and amplitudes. Seismic motions were designed and applied to the building to progressively increase the seismic demand on the structure and NCSs in both the BI and FB conditions. In addition, to compare the response and behavior of the structure and NCSs, the early (target) motions in the sequence of the BI and FB testing phases were similar. One maximum considered earthquake (MCE) motion and two serviceability level motions were obtained by spectrally matching to the ASCE 7-05 design spectrum achieved for a high seismic zone in Southern California (site class D). In addition a long duration motion from the 2007 Peru earthquake was selected and amplitude scaled (50, 100, and 140%, the later applied only during the BI testing phase). It was desirable to minimize the peak inter-story drift ratio (PIDR) to less than approximately 0.5% while the test specimen was isolated at its base, to preserve the structure for the FB testing phase. The design event imposed during the FB testing phase was intended to achieve approximately 2-2.5% PIDR and 0.8g peak floor acceleration in the test structure. The achieved peak input acceleration range for the FB earthquake motions ranged from about 0.2 to 0.8g, while the pseudo-spectral acceleration at a period of 1 sec ranged from about 0.3 to 1.3g. Details regarding the shake table, earthquake histories, test motions, and motion-related data collection, observations and preliminary outcomes are provided in Chen et al. (2013), Pantoli et al. (2013) and (Ebrahimian et al., 2013).

After the final ground motion test, six *in-situ* heptane pan fire tests were conducted in four different compartments of the third floor. Heptane was used as the fuel source and limited in amount to maintain the burning duration to less than 15 minutes. Fires ranged in in size from approximately 500kw to 2000kW, dependent on compartment configuration, ventilation and test objectives. The fire size and duration of each test was limited as a precautionary measure to prevent structural damage under elevated temperatures. To collect fire performance data, thermocouples were placed in various locations depending on the objectives of each fire test, with the main focus areas being thermal environment in fire compartment, and fire and smoke spread between compartments as a result of seismic-induced compartmentation failure or diminished functionality of the fire protection systems. Multiple video cameras were installed throughout the building to collect visual data on smoke or fire spread and activation of the fire protection systems. Smoke detectors were also installed to help track smoke spread throughout the building.

This report details those aspects of the BNCS project related to the fire performance testing, including details of the third floor fire test compartments, post-motion test state of the third floor systems, including outcomes of the blower door fan tests, fire test plan and fire test data. Preliminary observations, planned analyses, and future research recommendations are presented. Details on the seismic design of the test specimen, overall building layout, installed systems and contents, the seismic test program, including earthquake motions, sensors and instrumentation, and data from the motion tests, including on fire protection systems, are available in Chen et al. (2013), Ebrahimian et al., (2013) and Pantoli et al. (2013; 2013a).

2 BACKGROUND

2.1 MOTIVATION FOR POST-EARTHQUAKE FIRE PERFORMANCE TESTS

Earthquakes have the potential to damage structural and non-structural elements, including fire protection systems, and to induce multiple ignitions. The fact that the two largest peace-time urban conflagrations in history have been fires following earthquakes – 1906 San Francisco and 1923 Tokyo, the latter resulting in the great majority of the 140,000 fatalities only substantiates how destructive post-earthquake fires can be (Usami, 2006). More recently, investigation from the 1995 Kobe earthquake, which lasted 20-seconds and measured 6.8 on the Richter Scale, induced 148 separate fires destroying 6,513 buildings over a total land area of 624,671 m2 (0.24 sq mi) (NFPA, 1996), shown in Figure 2.1, revealed less than desirable fire protection systems performance (Sekizawa et al, 2003).

Figure 2.1. Post-earthquake fire from 1995 Kobe earthquake

Risk of fire in a building is greater than normal following an earthquake (Collier, 2005). Ignitions have occurred during and after earthquakes due to motion-induced damage to a wide range of systems and equipment, including utilities (e.g., gas and electrical systems), building equipment (e.g., boilers or furnaces) and contents (e.g., electrical appliances and chemicals and other hazardous materials) (Zolfaghari, 2009). In addition to increasing the risk of ignition, earthquake motions can lead to increased and/or redistributed fuel load, including release of flammable gasses and liquids if not adequately anchored to stored, or uncontained or broadly distributed combustible materials as a result of items shifting and falling. Such changes to fuel load and distribution can result in potentially unanticipated burning characteristics and larger fires due to increased fuel loading over a larger floor area.

It is also known that earthquakes can leave a building less air-tight than normal due to a wide range of damage conditions, such as windows breakage, façade failures and door failures, resulting in potentially unanticipated ventilation conditions (i.e., ample oxygen supply for the fire) which can have a bearing on fire growth and spread (e.g., fuel-controlled fire, openings in compartment barriers resulting in smoke and flame spread beyond the room of origin, etc.). For example, investigation following the 1995 Kobe earthquake found that damage to passive and active fire protection systems can adversely affect the fire spread rate beyond the room of origin and evacuation of the occupants (Sekizawa et al, 2003). Similarly, experimental results have shown that earthquakes can severely damage the integrity of fire resistant walls, significantly downgrading the expected fire resistance rating (Collier, 2005).

In summary, while fire protection standards for buildings in earthquake prone areas have advanced in recent times, building and fire safety performance has not been well-studied and post-earthquake fires remains a serious threat to life safety, property protection and mission continuity. Given the lack of systematic testing of post-earthquake fire performance, and considering the increased chances of ignition and fire spread following earthquakes, this experimental study was designed to better understand the building fire conditions following damage caused by earthquakes.

2.2 EXPERIMENTAL FACILITIES

Full scale experiments on post-earthquake fires have rarely been executed to date, and in that, the BNCS project was truly unique. To exhibit real life conditions, a 22.9m (75') 5-story cast-in-place concrete building, designed assuming it was located in a high seismic zone in Southern California, was erected on the nation's largest outdoor shake table at the Englekirk Structural Engineering Center at the University of California, San Diego. The large high performance outdoor shake table (LHPOST), shown in Figure 2.2, is 7.6m by 12.2m, with the unloaded shake table able to reach peak acceleration of 4.2g and a peak velocity of 1.8m/s. The LHPOST is capable of accurately reproducing near-fault ground motion effects controlled by the peak table velocity parameter.

Figure 2.2. UCSD NEES shake table

2.3 BUILDING DESIGN

Each floor of the BNCS building, shown in Figure 2.3, had a plan dimension of 6.6m by 11m (21.5' by 36'), 0.2m (8") cast-in-place slabs, floor to floor height of 4.3m (14'), deck to deck height of 4m (13') and a ceiling height of 2.8m (9.2'). The building was designed to withstand up to 2.5% lateral inter-story drift ratio at a maximum peak floor acceleration of around 0.7g to 0.8g. See Chen et al. (2013) for details.

Figure 2.3. BNCS building

Equipped with moment resisting frames on the longitudinal sides of the building, the moment resisting beams had the same design capacities although each floor varied in detail. High strength steel frame beams with design strength of 120 ksi was used for both floors 2 and 3. Upturned hybrid frame beam with four post-tensioned tendons and ductile rod connectors, ductile connector frame beam with rod connectors, and concrete frame beam was used for floors 4, 5 and the roof respectively. 18" $\times$ 26" prefabricated hoop and transverse reinforced concrete columns with compressing strength of 5000 psi was used.

Walls of the first three floors were constructed by a balloon framing with vertical metal studs, gypsum boards and exterior insulation finishing system (EIFS). Except for locations hindered by openings such as doors and windows, the metal studs extended 12.6 m (41.3’) high until the bottom of the fourth floor slab. Structural track was used to connect the stud framing to the structure with the bottom of the track being attached to the foundation using two shot pins. For the second and third floors, slabs contained outrigger clips with slotted holes to connect between each stud with the clips being connected to the concrete with embed power driven fasteners. For the fourth floor, metal studs were connected by slide clips on steel angle that was welded to the bottom of the slab with steel embeds. The gypsum boards were connected to the metal stud framing with #10 screws spaced 8” o.c.. Internal gypsum boards were fire-rated gypsum X panels 5/8” thick. The EIFS made of a continuous waterproof barrier was applied on the gypsum boards.

Two precast concrete cladding panels were installed on each side of the building for floors 4 and 5. Embeds were installed in the concrete slabs, beams and columns to connect the cladding panels. Figure 2.4 shows a concrete panel being installed on the 4th floor during the construction phase.

Figure 2.4. Installation of concrete panel on the 4th floor

A prefabricated stair assembly, shown in Figure 2.5 was installed at each floor of the building. Each floor consisted of lower and upper flights and an intermediate landing. The tread was 7” rise and 11” run with 12 treads completing one flight. The tread plates were fillet welded to the ASTM A36 plate stringers. Checker plate was supported by steel joists in the landings that were supported by ASTM A36 HSS landing posts. Fillet welds and T.C. bolts were used to connect the stair flight to the concrete slab and stair flight to landing respectively.

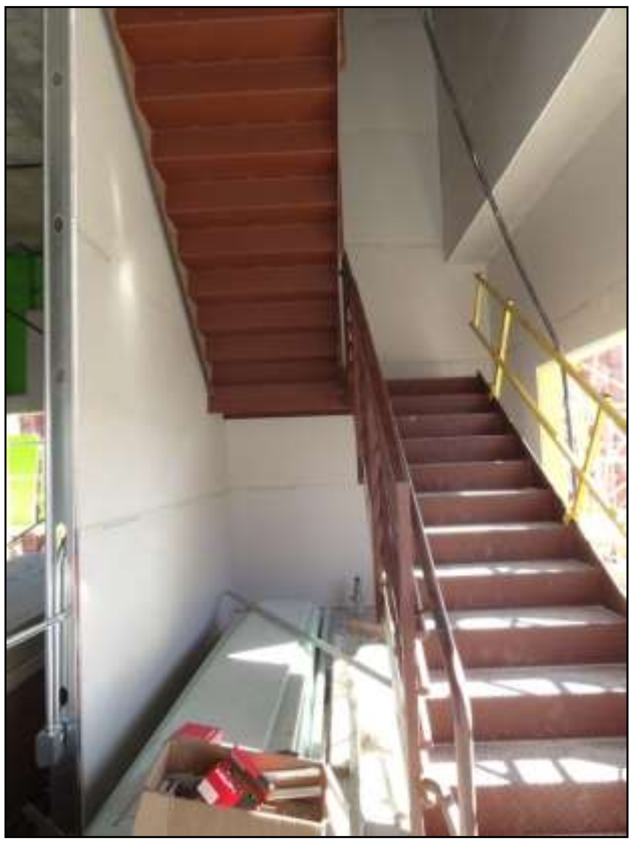

Figure 2.5. Stair assembly

A fully functioning elevator with 17.1m (56’) travel height at all floors was installed in the 2.64m by 2.1m (8.7’ by 6.9’) elevator hoistway as shown in Figure 2.6. The elevator components consisted of the cab, counterweight, guide rails and brackets, pit equipment and machine drive. In the cab, with dimensions of 1.92m by 1.7m by 2.36m (6’-9 3/8” by 5’-6 7/8” by 7’-9”), extra weight equivalent to 40% of the full cab capacity of 160kg (3500lbs) was placed throughout the entire seismic tests. The opening of the cab door was 2.1m by 1.1m (7' by 3.5').

Figure 2.6. Elevator shaft and door

To test a range of ceiling systems, multiple ceiling systems were installed per floor. The first floor ceiling systems were designed with Seismic design Category A (no seismic provisions, representative of the "typical East Coast" ceiling design system) and Seismic design Category C in the southwest and northeast room areas respectively. Design Category A ceiling was attached to the wall molding while design Category C ceiling was a free-floating system.

The second floor ceiling systems were designed with Seismic design Category D, E and F systems. The southwest system was an attached system, fully code compliant, with lateral bracing whereas the northeast system was a floating ceiling system designed per the Seismic Rx recommendations, with lateral bracing.

Drywall grid systems were tested on Floor 3, with the plan shown in Figure 2.7. The northeast ceiling suspension was allowed to move with clearances on the wide wall moldings above the drywall and lateral bracing with splay wires and compression posts. The southwest grid system and drywall of the ceiling system was tied of the structural walls or partitions being installed as a diaphragm. This allows for the seismic forces to move through the suspension system and ceiling membrane to dissipate through the wall systems. A finished ceiling system of the northeast room space is shown in Figure 2.8.

Floors 4 and 5 ceiling systems were designed to support large loads with a lot of interact with some of the medical equipment, loaded in the room areas, suspended from the ceiling. A drywall ceiling system was installed on Floor 5, only on the southwest room area. The penthouse over the top of the stairwell in the roof was utilized to install and test a hospital corridor ceiling system.

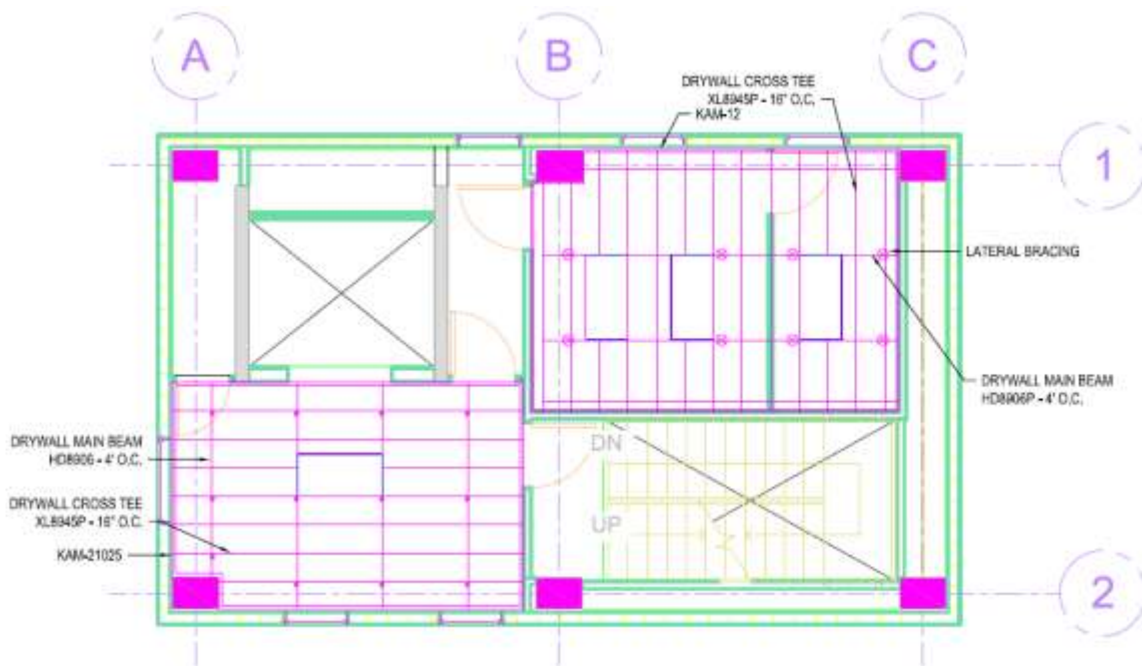

Figure 2.7. Floor 3 ceiling system

Figure 2.8. Floor 3 finished ceiling system with vents and access panel

A partial HVAC system was installed in Floor 3, with the design of the ductwork shown in Figure 2.9. The HVAC ducts are connected vertically to the ducts installed on the fourth floor slab in front of the elevator door. The supply and return runs were located above the plenum space in the elevator lobby. Although there was no fan, different parts were assembled together to form a comprehensive HVAC subsystem. The connections between the parts of the ducts were firestopped with fire caulk. The HVAC ducts running through the elevator shaft corridor and stairway landing were exposed as those spaces did not consist of any ceiling systems. A portion of the actual HVAC system is shown in Figure 2.10.

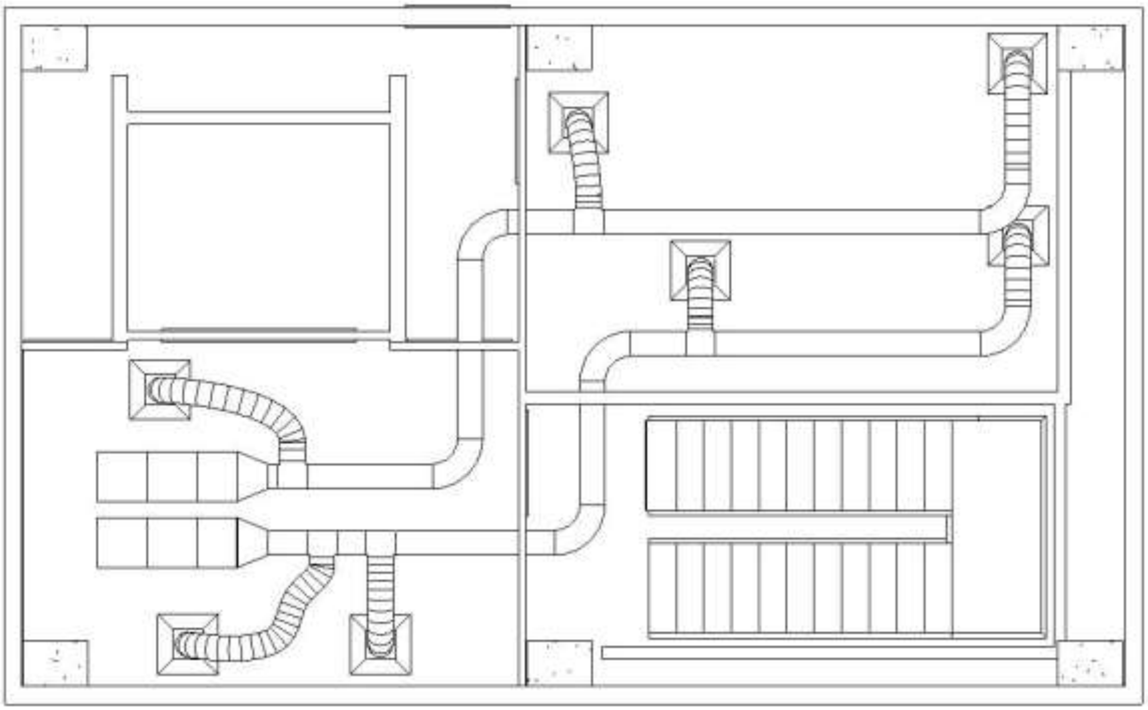

Figure 2.9. HVAC layout

Figure 2.10. Part of the actual HVAC system

2.4 BUILDING CONTENTS

The first floor of the building had electrical conduit and some medical equipment. Access inside the building was allowed through this floor by going up the ladder on either the north or south sides of the building as shown in Figure 2.11.

Figure 2.11. Building entrance on the 1st floor

The second floor consisted of spaces which mimicked a living room and a chemical laboratory space. The living room space included TV sets, kitchen table with glasses and plates, computers and shelves, and the laboratory space included equipment, shelving and storage units. Figure 2.12 shows the living room space setup on the 2nd floor.

Figure 2.12. Floor 2 living room setup

The third floor included computer servers and empty room spaces. All fire tests were conducted on the third floor, and more detail about the floor is provided in Section 3. Figure 2.13 shows the server setup.

Figure 2.13. Floor 3 server room

The fourth floor was set up as a hospital intensive-care unit (ICU) with patient beds, breakout doors and medical equipment. Figure 2.14 shows the intensive-care unit.

Figure 2.14. Floor 4 ICU patient beds

The fifth floor was set up as a hospital operating room with patient beds, breakout doors and medical equipment. Figure 2.15 shows the surgical suite setup.

Figure 2.15. Floor 5 surgical suite

A cooling tower was installed on the roof and various pipe systems ran vertically through the building. Figure 2.16 shows the cooling tower.

Figure 2.16. Cooling tower in the roof

2.5 TESTING OVERVIEW

A total of 13 seismic tests were conducted from April 16, 2012 to May 15, 2012. The tests were run in two configurations; 7 motions for the base isolation configuration and 6 motions in the fixed base configuration. The base isolators, shown in Figure 2.17, were removed to set up the fixed base configuration.

Figure 2.17. Base isolators

The seismic demand on the building was increased with each test motion. The seismic test motions were based on 6 actual earthquake ground motions, ranging in intensity from 6.7 on the Richer Scale, representative of motions from the 1994 Northridge earthquake, to 7.9 on the Richter Scale, representative of motions from the 2002 Denali earthquake. The seismic motions for the base isolation configuration and fixed based configuration are shown in Table 2.1 and Table 2.2 respectively.

Table 2.1. Base isolation configuration seismic test motions

Date	Name	Seismic Motion	Richter Scale
April 16, 2012	BI-1: CNP 100%	Canoga Park 1994 Northridge Earthquake (@100%)	6.7
	BI-2: LAC 100%	LA City Terrace 1994 Northridge Earthquake (@100%)	6.7
April 17, 2012	BI-3: LAC 100%	LA City Terrace 1994 Northridge Earthquake (@100%)	6.7
	BI-4: SP 100%	San Pedro 2010 Maule (Chile) Earthquake (@100%)	8.8
April 26, 2012	BI-5: ICA 50%	2007 Pisco (Peru) Earthquake (@50%)	8.0
April 27, 2012	BI-6: ICA 100%	2007 Pisco (Peru) Earthquake (@100%)	8.0
	BI-6 ICA 140%	2007 Pisco (Peru) Earthquake (@140%)	8.0

Table 2.2. Fixed base configuration seismic test motions

Date	Name	Seismic Motion	Richter Scale
May 7, 2012	FB-1: CNP 100%	Canoga Park 1994 Northridge Earthquake (@100%)	6.7
May 9, 2012	FB-2: LAC 100%	LA City Terrace 1994 Northridge Earthquake (@100%)	6.7
	FB-3: ICA 50%	2007 Pisco (Peru) Earthquake (@50%)	8.0
May 11, 2012	FB-4: ICA 100%	2007 Pisco (Peru) Earthquake (@100%)	8.0
May 15, 2012	FB-5: DEN 67%	TAPS Pump Station #9 2002 Denali Earthquake (@67%)	7.9
	FB-6: DEN 100%	TAPS Pump Station #9 2002 Denali Earthquake (@100%)	7.9

The conditions of both structural and nonstructural components were documented prior to and following all earthquake motion tests so that any visible changes, such as cracking, displacement of any components, etc. could be recognized following the earthquake motion tests. In particular, visual checkups were primarily focused on components that could affect building fire conditions such as displacement of combustible items or fuels, damage to doors, stairs and elevator that could hinder egress, formation of openings or leaks that could affect the compartment integrity. Besides the visual inspection of compartmentation, a blower dower fan test was conducted in the room spaces of the third floor to quantify the leakage area.

After the completion of all earthquake motion tests, a series of six fire tests were conducted on the third floor (servers were taken out of the building for the fire tests) with the building in the damage state. These fire tests consisted of heptane pan fires ranging in size (heat release rate, HRR) from approximately 500kW to 2000kW. Since the HRR of the pool fire could not be directly measured at the BNCS test site, the HRR of a representative fire was pre-measured in the fire laboratory at WPI. While re-radiation from the flame, walls and gas layer influence the mass burning rate, approximate amounts of initial fuel were calculated for specific test HRR and burning durations. Thermocouples were installed to obtain gas and surface temperatures at various locations to check for compartment integrity and functionality of fire systems, as well as to provide data for future simulations. Cameras were installed at multiple locations to capture the live fire tests, activation of fire systems and smoke spread.

The following chapters provide details regarding the compartments on Floor 3 (floor of fire testing), data which were collected, and preliminary analysis and findings of the performance of active and passive fire protection systems. Issues related to the building fire conditions and performance will be discussed and preliminary recommendations for fire protection engineers tasked with the job of performing fire protection analysis for earthquake-prone buildings will be outlined.

3 DETAILS OF FIRE TEST FLOOR (THIRD FLOOR)

3.1 OVERVIEW OF FLOOR 3

All six live fire tests were conducted on the third floor. Tests were conducted in four different locations, designated as the Large Burn Room (LBR), Small Burn Room (SBR), area behind the Elevator Shaft (ES) and the Elevator Lobby (EL). Figure 3.1 shows these spaces.

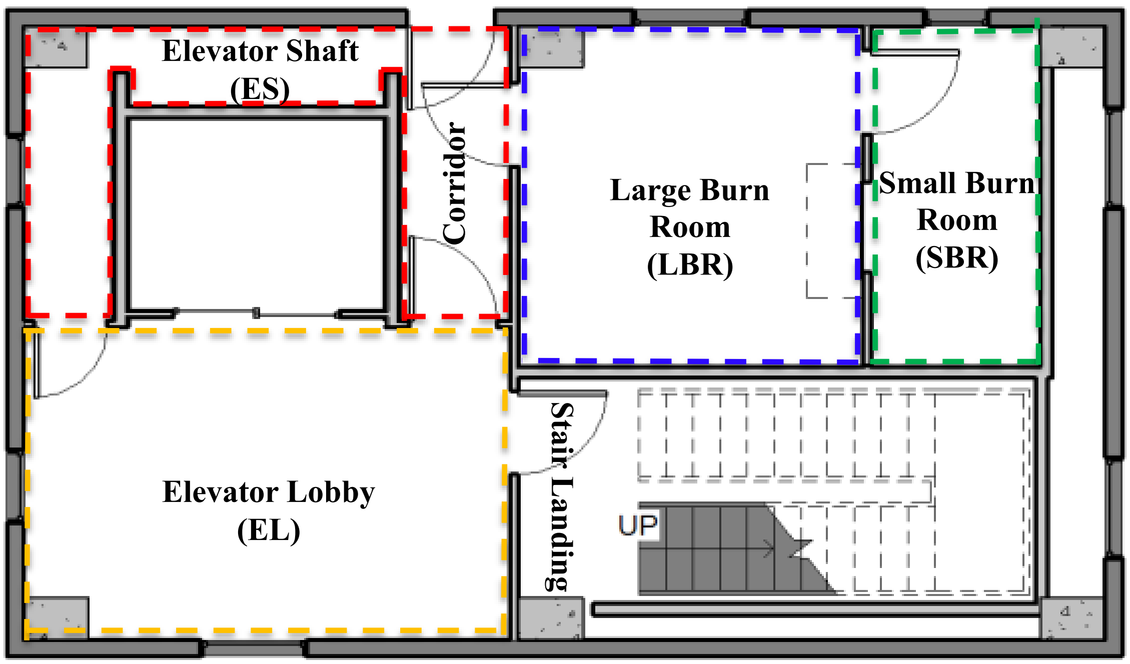

Figure 3.1. Top view of 3rd floor

The third floor was also outfit with a partial HVAC system, an elevator and a stairway. Figure 3.2 shows the location of the HVAC ductwork and vents.

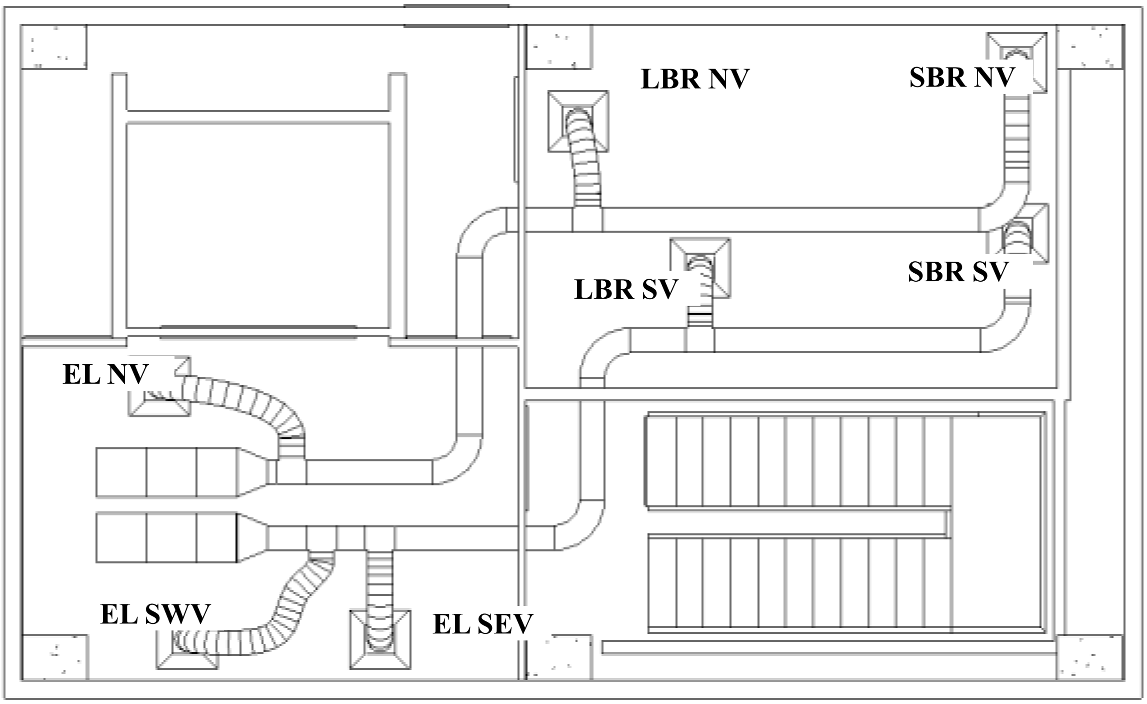

Figure 3.2. Floor 3 vent locations

Photographs of the elevator door in the lobby, Floor 3 stair landing, LBR and SBR areas separated by the partition wall, and EL corridor area are shown in Figure 3.3, Figure 3.4, Figure 3.5 and Figure 3.6 respectively.

Figure 3.3. Elevator door and lobby of Floor 3

Figure 3.4. Stair and stair landing of Floor 3

Figure 3.5. LBR and SBR area

Figure 3.6. EL corridor area

3.2 FIRE PROTECTION SYSTEMS

3.2.1 Automatic Fire Sprinkler System

All five floors of the BNCS building were protected with a wet-type automatic fire sprinkler system (sprinkler system) which was designed by Ken Wagoner of *Parsley Consulting*. The intent was to provide, within the limitations of the test specimen, a fully operational sprinkler system designed in accordance with recognized codes and standards (e.g., California Building Code (CBC), National Fire Protection Association (NFPA) Standards, etc.) and utilizing appropriately listed and approved product (e.g., Underwriters Laboratories, Inc. or FMGlobal listings or approvals). The intent was also to have a 'charged' system (water in the pipes) to have realistic loading. The aim was to obtain seismic performance and fire performance data.

Because of the nature of the tests and test facility (LHPOST), steps were taken to limit the total amount of water in the system during testing so as to minimize any potential damage to the shake table, instrumentation and data acquisition systems and to limit water run off on the site should any system component rupture or become damaged during the seismic tests. During testing, each floor was charged with 57 liters (15 gallons) of water, for a system total of 284 liters (75 gallons). The hose valve of the sprinkler system was disconnected from the water supply after the system was charged.

Risers and control valves were installed on the west wall of the elevator shaft for each floor. All sprinkler pipes were installed 30cm (12") below the deck of the floor above and exposed in areas with no ceiling. There were variances in the sprinkler pipe design layout and sprinkler system components per floor to test performance of the various systems under seismic loads and to comply with different occupancies mimicked in the experimental building. The variances in components included different types of pipe materials, drops, bracings and sprinkler heads. Also, after the sprinkler system was installed, additional sand weights were attached on pipes in various locations of the building to test how pipes with larger diameters, and thus increased loads, would have performed under seismic motions. Details are provided below.

3.2.1.1 Floor 1 Sprinkler System

For the first floor, steel Schedule 10, 3.8cm (1 ½”) pipe was used as the main line pipe material with grooved fittings while steel Schedule 40, 2.5cm (1”) pipe was used as the branch line material with threaded cast iron fittings. A total of seven sprinkler heads were installed throughout the floor with four of them being quick response pendent sprinklers and three of them being quick response upright sprinkler head. Both sprinkler head types had a 1.3cm (½”) orifice and a K-factor of 5.6. The activation temperatures were 68C (155F) and 79C (175F) for quick response pendent and quick response upright respectively. The sprinkler head specifications and sprinkler system layout plan for Floor 1 is shown in Figure 3.7.

SYMBOLS	SPRINKLERS						
	MAKE & MODEL	ORIFICE	K-FACTOR	TEMP	FINISH	CANOPY	QTY.
Quick Response Pendent	Tyco TY3231	1/2"	5.6	155°	WHITE	WHITE	4
Quick Response Upright	Tyco TY3131	1/2"	5.6	175°	BRASS	NONE	3
						TOTAL HEADS THIS SHEET	7

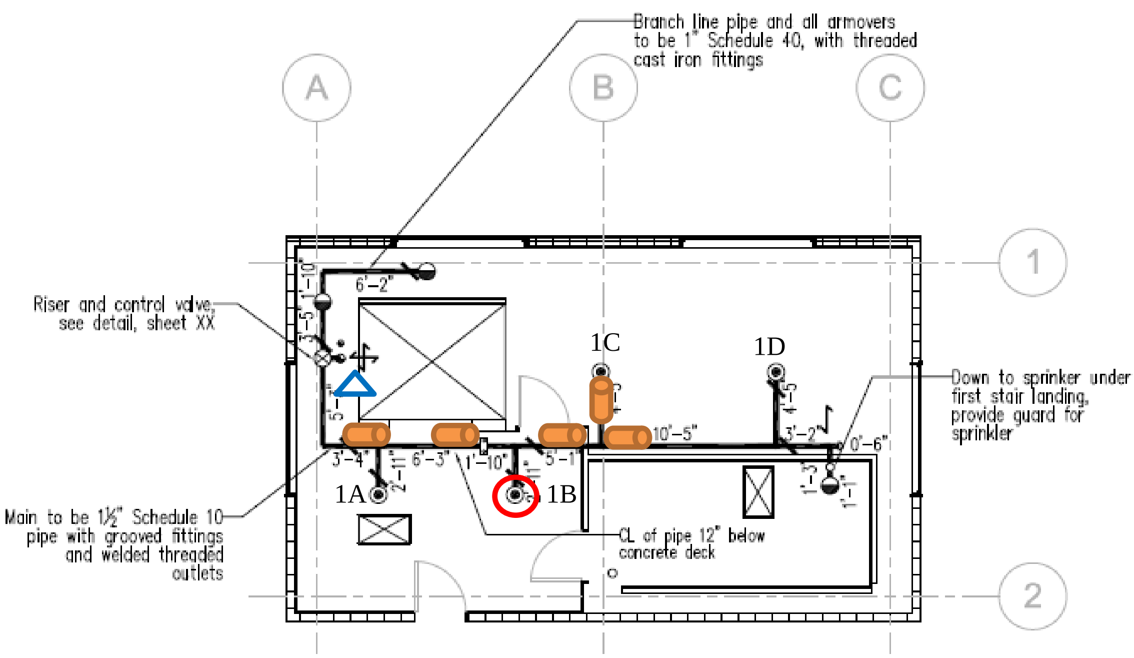

Figure 3.7. Floor 1 sprinkler system design layout and specifications

As noted above, since realistic pipe loading was desired, additional sand weights were added in some locations. The orange cylinders in Figure 3.7 indicate the locations where additional sand weight was attached on the sprinkler pipe. The red circle indicates the specific sprinkler head where a seismic drop was installed. For the rest of the sprinkler heads, rigid drops were installed. The blue triangles in Figure 3.7 indicate locations where seismic bracing was applied on the sprinkler pipes on the first floor. Seismic bracing consisted of Mason Industries' Seismic Solid Brace Strut Anchor (SSBS) 12 with 1.3cm (1/2") Hilti KB-TZ anchor bolts with an assembly rating of 5.6 kN (1250 lbs) in capacity, as is described in detail in Chen et al. (2013).

Figure 3.8 shows the riser, drain pipe and control assembly of the first floor, which was located on the west side of the elevator shaft as indicated in Figure 3.7. The control assembly consisted of test and drain valves, a pressure gauge and a waterflow switch. The riser and drain pipes both had seismic bracing installed on the west wall of the shaft. The sprinkler system was charged with about 221kPa (32 psi) of pressure as shown on the pressure gauge. The detailed specifications of the control assembly are shown in Figure 3.9.

Figure 3.8. Floor 1 control assembly

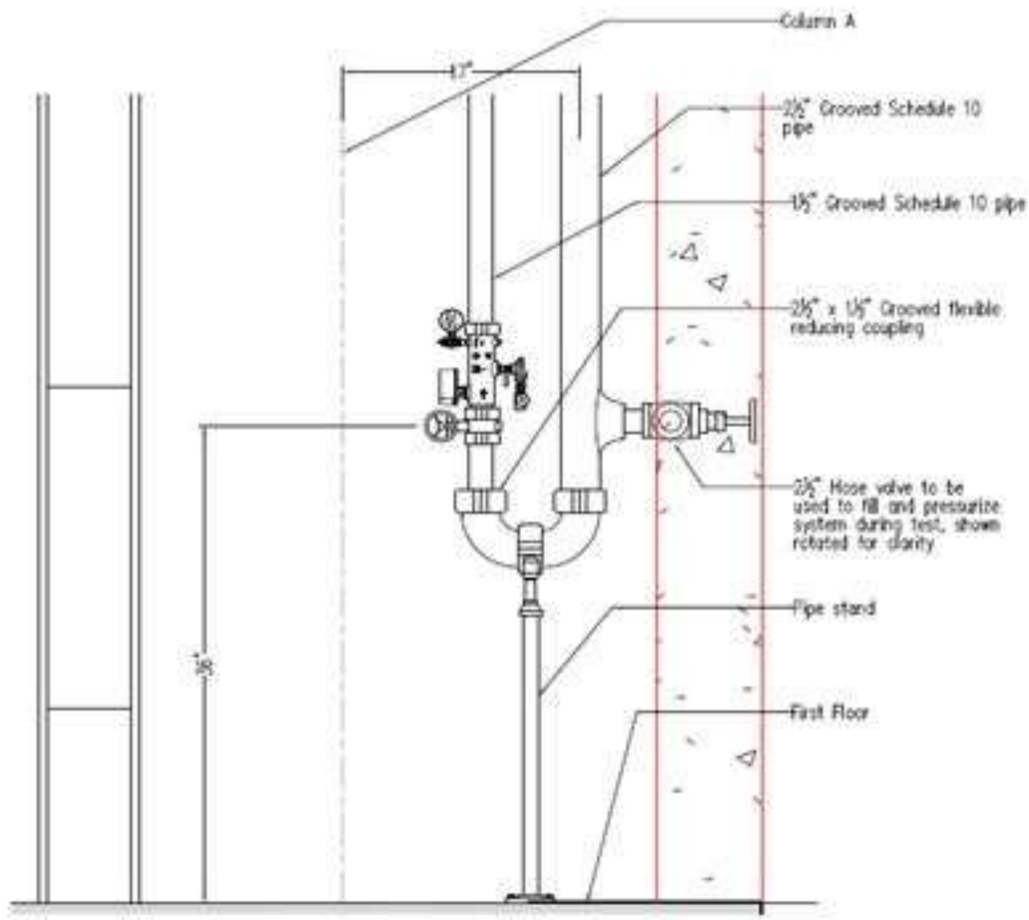

Figure 3.9. Floor 1 control assembly detailed drawing (looking north)

Two Mason Industries' SSBS-12's were applied on the first floor main feed pipe as shown in Figure 3.10. The braces were installed against the west wall of the elevator shaft. This was the only place a seismic brace was used on the first floor.

Figure 3.10. Seismic bracing on Floor 1 main feed

Three sand weights were attached to the first floor branch line pipe that ran through the elevator lobby area as shown in Figure 3.11. All weights were attached on the same east-west direction in this area. The location of these sand weights can be seen on Figure 3.7.

Figure 3.11. Sand weight on Floor 1 sprinkler pipe in the EL area

Two sand weights were also applied on the first floor sprinkler pipe in the room area as shown in Figure 3.12. One weight was applied on the east-west direction while the other was applied on the north-south direction. The location of these sand weight locations can be seen on Figure 3.7.

Figure 3.12. Sand weight on Floor 1 sprinkler pipe in the room area

A flexible drop was installed on 1A sprinkler head in the EL area as shown in Figure 3.13. The location of this sprinkler head can be seen on Figure 3.7. All other sprinkler heads were non-flexible drops.

Figure 3.13. Flexible drop on Floor 1 EL sprinkler head

3.2.1.2 Floor 2 Sprinkler System

For the second floor, CPVC piping was used throughout. Pipes of 3.8cm (1 ½”) and 2.5cm (1”) diameter were used for the main line and branch lines respectively, with solvent weld fittings. Two quick response pendent sprinkler heads, two quick response upright sprinkler heads and two residential concealed pendent sprinkler heads were installed. Both the quick response pendent and upright sprinkler heads had a 1.3cm (½”) orifice and a K-factor of 5.6. The residential concealed pendent sprinkler heads had a 1.1cm (7/16”) orifice and a K-factor of 4.9. The activation temperatures were 68C (155F) for quick response pendent, 79C (175F) for quick response upright and 71C (160F) for residential concealed pendent. The sprinkler head specifications and sprinkler system layout plan for Floor 1 is shown in Figure 3.14.

SYMBOLS	SPRINKLERS						
	MAKE & MODEL	ORIFICE	K-FACTOR	TEMP	FINISH	CANOPY	QTY.
Quick Response Pendent	Tyco TY3231	1/2"	5.6	155°	WHITE	WHITE	2
Quick Response Upright	Tyco TY3131	1/2"	5.6	175°	BRASS	NONE	2
Residential Concealed Pendent	Tyco TY2524	7/16"	4.9	160°	BRASS	WHITE	2
				TOTAL HEADS THIS SHEET			6

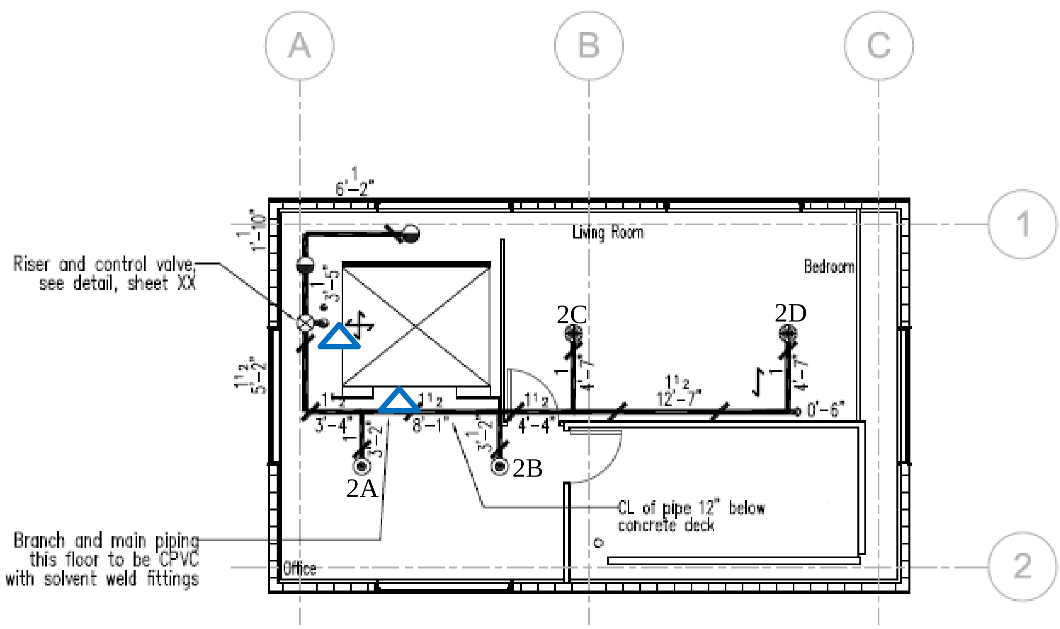

Figure 3.14. Floor 2 sprinkler system design layout and specifications

The blue triangles in Figure 3.14 indicate locations where Mason Industries' SSBS-12's with 1.3cm (1/2") Hilti KB-TZ anchor bolts with an assembly rating of 5.6 kN (1250 lbs) in capacity, were applied on the sprinkler pipes on the second floor. There were no added sand weights on the pipe or any flexible drops on Floor 2.

Figure 3.15 shows the riser, drain pipe and control assembly of the second floor, located on the west side of the elevator shaft as indicated in Figure 3.14. The control assembly components consisted of test and drain valves and a pressure gauge. The sprinkler system was charged with about 221kPa (32 psi) of pressure as shown on the pressure gauge. The detailed specifications of the control assembly are shown below in Figure 3.16.

Figure 3.15. Floor 2 control assembly

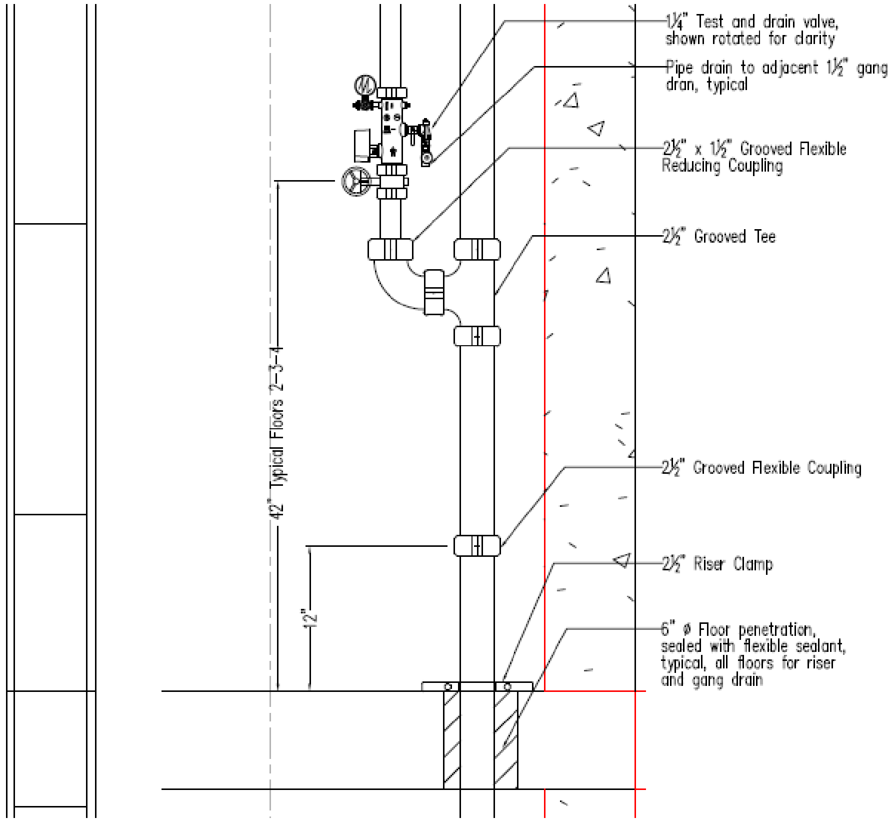

Figure 3.16. Floors 2, 3 and 4 control assembly detailed drawing (looking north)

The drain pipe and riser on the fourth floor had clamps near the slab penetrations as shown in Figure 3.17. The clamps were installed above the penetration of the second floor slab.

Figure 3.17. Clamps on bottom of Floor 2 drain pipe and riser

Two Mason Industries' SSBS-12's were applied on top of the second floor main feed pipe as shown in Figure 3.18. The braces were installed against the west wall of the elevator shaft.

Figure 3.18. Seismic bracing on Floor 2 main feed

A seismic brace was also installed on the second floor sprinkler branch line in the EL area as shown in Figure 3.19. The brace was installed against the third floor slab. The location of the bracing can be seen on Figure 3.14.

Figure 3.19. Seismic bracing on Floor 2 EL area sprinkler pipe

3.2.1.3 Floor 3 Sprinkler System

On the third floor, steel Schedule 10, 3.8cm (1 ½”) pipe with grooved fittings was used for the main line while steel Schedule 40, 2.5cm (1”) pipe with threaded cast iron fittings was used for the branch lines. A total of seven sprinkler heads were installed throughout the floor with four quick response pendent sprinkler heads and three quick response upright sprinkler heads. Both sprinkler head types had a 1.3cm (½”) orifice and a K-factor of 5.6. The activation temperatures were 68C (155F) and 79C (175F) for quick response pendent and quick response upright respectively. The sprinkler head specifications and sprinkler system layout plan for Floor 1 is shown below in Figure 3.20.

SYMBOLS	SPRINKLERS						
	MAKE & MODEL	ORIFICE	K-FACTOR	TEMP	FINISH	CANOPY	QTY.
Quick Response Pendent	Tyco TY3231	1/2"	5.6	155°	WHITE	WHITE	4
Quick Response Upright	Tyco TY3131	1/2"	5.6	175°	BRASS	NONE	3
						TOTAL HEADS THIS SHEET	7

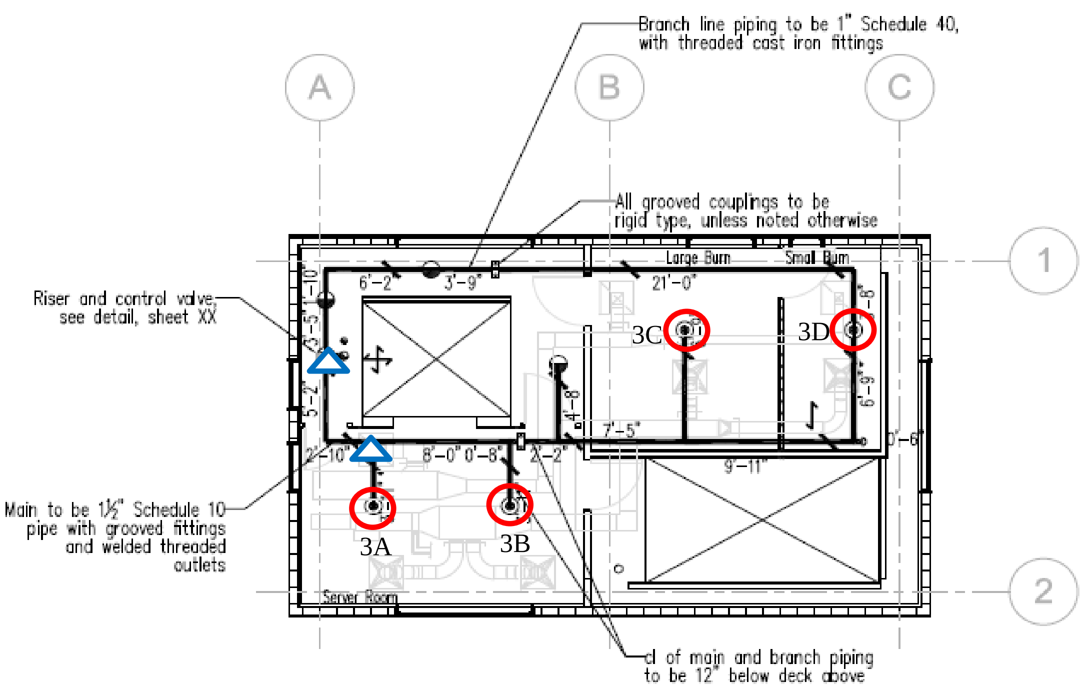

Figure 3.20. Floor 3 sprinkler system design layout and specifications

The red circles in Figure 3.20 indicate the specific sprinkler head where a flexible drop was installed for the third floor. For the rest of the sprinkler heads, rigid drops were installed. The blue triangles in Figure 3.20 indicate locations where Mason Industries' SSBS-12's with 1.3cm (1/2") Hilti KB-TZ anchor bolts with an assembly rating of 5.6 kN (1250 lbs) in capacity, were applied on the sprinkler pipes on Floor 3.

Figure 3.21 shows the riser, drain pipe and control assembly for the third floor, located on the west side of the elevator shaft as indicated in Figure 3.20. The control assembly components consisted of test and drain valves and a pressure gauge. The sprinkler system was charged with about 172kPa (25psi) of pressure as shown on the pressure gauge in Figure 3.21. The detailed specifications of the control assembly can be seen in Figure 3.16.

Figure 3.21. Floor 3 control assembly

The drain pipe and riser on the fourth floor had clamps near the slab penetrations as shown in Figure 3.22. The clamps were installed above the penetration firestop.

Figure 3.22. Clamps on bottom of Floor 3 drain pipe and riser

Two Mason Industries' SSBS-12's were applied on top of the third floor main feed pipe as shown in Figure 3.23. The braces were installed against the west wall of the elevator shaft.

Figure 3.23. Seismic bracing on Floor 3 main feed

A seismic brace was also installed on the third floor sprinkler branch line in the EL area as shown in Figure 3.24. The brace was installed against the third floor slab. The location of the bracing can be seen on Figure 3.20.

Figure 3.24. Seismic bracing on Floor 3 EL area sprinkler pipe

A flexible drop was installed on the 3A sprinkler head in the EL area as shown in Figure 3.25. The location of this sprinkler head can be seen on Figure 3.20. The eastern sprinkler head in the EL also had a flexible drop.

Figure 3.25. Flexible drop on Floor 3 EL 3A sprinkler head

A flexible drop was installed on the 3C sprinkler head in the LBR area as shown in Figure 3.26. The location of this sprinkler head can be seen on Figure 3.20. The sprinkler head 3D in the SBR area also had a flexible drop. All other sprinkler heads had rigid drops.

Figure 3.26. Flexible drop on Floor 3 3C LBR sprinkler head

3.2.1.4 Floor 4 Sprinkler System

For the fourth floor, steel Schedule 10, 3.8cm (1 ½”) pipe with grooved fittings was used for the main line while steel Schedule 40, 2.5cm (1”) pipe with threaded cast iron fittings was used for the branch lines. A total of six sprinkler heads were installed throughout the floor, with three quick response pendent sprinkler heads and three quick response upright sprinkler heads. Both sprinkler head types had a 1.3cm (½”) orifice and a K-factor of 5.6. The activation temperatures were 68C (155F) and 79C (175F) for quick response pendent and quick response upright respectively. The sprinkler head specifications and sprinkler system layout plan for Floor 4 is shown in Figure 3.27.

SYMBOLS	SPRINKLERS						
	MAKE & MODEL	ORIFICE	K-FACTOR	TEMP	FINISH	CANOPY	QTY.
Quick Response Pendent	Tyco TY3231	1/2"	5.6	155°	WHITE	WHITE	3
Quick Response Upright	Tyco TY3131	1/2"	5.6	175°	BRASS	NONE	3
						TOTAL HEADS THIS SHEET	6

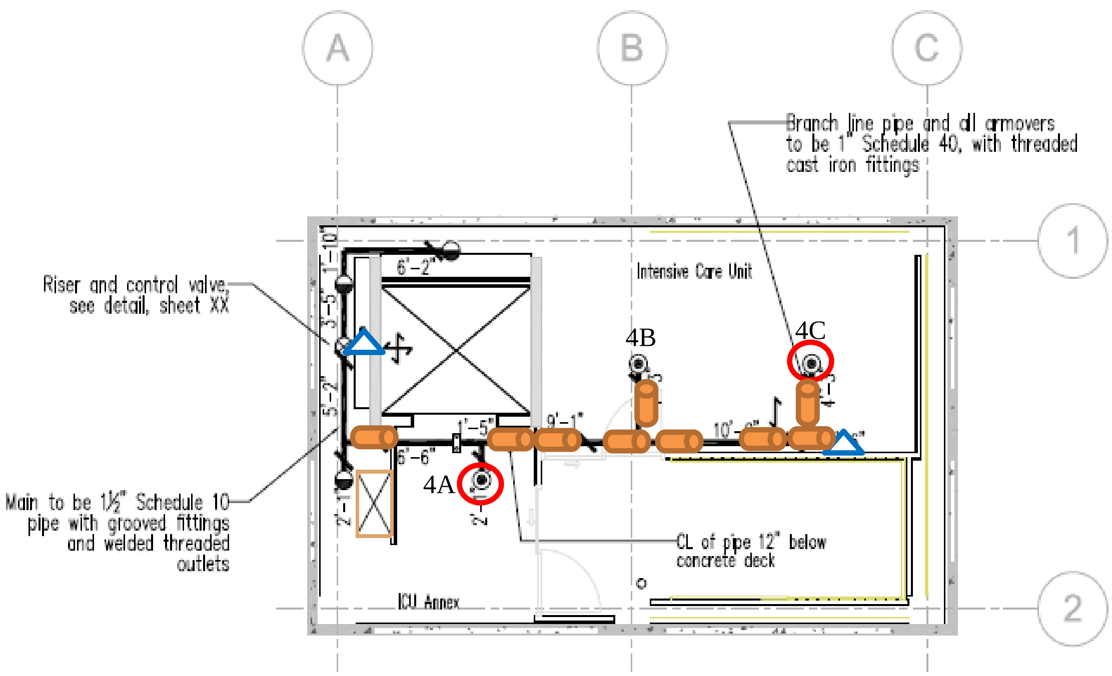

Figure 3.27. Floor 4 sprinkler system design layout and specifications

The orange cylinders in Figure 3.27 indicate the locations where additional sand weight was attached on the fourth floor sprinkler pipe. The red circles indicate the specific sprinkler head where a flexible drop was installed. The blue triangles indicate locations where Mason Industries' SSBS-12 with 1.3cm (1/2") Hilti KB-TZ anchor bolts with an assembly rating of 5.6 kN (1250 lbs) in capacity, was applied on the sprinkler pipes on Floor 4.

Figure 3.28 shows the riser, drain pipe and control assembly of the fourth floor, located on the west side of the elevator shaft as indicated in Figure 3.27. The control assembly components consisted of test and drain valves and a pressure gauge. The sprinkler system was charged with about 110kPa (16 psi) of pressure as shown on the pressure gauge. The detailed specifications of the control assembly can be seen in Figure 3.16.

Figure 3.28. Floor 4 control assembly

The drain pipe and riser on the fourth floor had clamps near the slab penetrations as shown in Figure 3.29. The clamps were installed above the penetration firestop.

Figure 3.29. Clamps on bottom of Floor 4 drain pipe and riser

Two Mason Industries' SSBS-12's were applied on top of the fourth floor main feed pipe as shown in Figure 3.30. The braces were installed against the west wall of the elevator shaft.

Figure 3.30. Seismic bracing on Floor 4 main feed

A Mason Industries' SSBS-12 was also installed on the fourth floor sprinkler branch line pipe in the EL area as shown in Figure 3.31. The brace was installed against the fifth floor slab. The location of the bracing can be seen on Figure 3.27.

Figure 3.31. Seismic bracing and sand weight on Floor 4 sprinkler pipe in the eastern room area

Two sand weights were attached on the eastern portion of the branch line running through the room area towards sprinkler head 4C and an additional weight on the arm-over sprinkler pipe as shown in Figure 3.31. The branch line pipe weights were attached on the same east-west direction and the sand weight on the arm-over sprinkler pipe was attached on the north-south direction. The location of these sand weights can be seen on Figure 3.27.

Two sand weights were attached on the western portion of the branch line pipe running through the room area towards sprinkler head 3C and an additional weight on the arm-over sprinkler pipe as shown in Figure 3.32. The sand weights on the branch line pipe were attached on the same east-west direction and the sand weight on the arm-over sprinkler pipe was attached on the north-south direction. The location of these sand weights can be seen on Figure 3.27.

Figure 3.32. Sand weight on Floor 4 sprinkler pipe in the western room area

Three sand weights were attached to the branch line pipe running through the elevator lobby area as shown in Figure 3.33. The sand weights on the branch line pipe were attached on the same east-west direction. The location of these sand weights can be seen on Figure 3.27.

Figure 3.33. Sand weight on Floor 4 sprinkler pipe in the EL area

A flexible drop was installed on the 4A sprinkler head in the EL area as shown in Figure 3.34. The location of this sprinkler head can be seen on Figure 3.27.

Figure 3.34. Flexible drop on Floor 4 4A sprinkler head

A flexible drop was installed on the sprinkler head 4C in the room area as shown in Figure 3.35. The location of this sprinkler head can be seen on Figure 3.27. Rigid drops were installed on all other sprinkler heads.

Figure 3.35. Flexible drop on Floor 4 4C sprinkler head

3.2.1.5 Floor 5 Sprinkler System

For the fifth floor, steel Schedule 10, 3.8cm (1 ½”) pipe with grooved fittings was used for the main line while steel Schedule 40, 2.5cm (1”) pipe with threaded cast iron fittings was used for the branch lines. A total of 7 sprinkler heads were installed throughout the floor, with 4 quick response pendent sprinkler heads and 3 quick response upright sprinkler heads. Both sprinkler head types had a 1.3cm (½”) orifice and a K-factor of 5.6. The activation temperatures were 68C (155F) and 79C (175F) for quick response pendent and quick response upright respectively. The sprinkler head specifications and sprinkler system layout plan for Floor 5 is shown in Figure 3.36.

SYMBOLS	SPRINKLERS						
	MAKE & MODEL	ORIFICE	K-FACTOR	TEMP	FINISH	CANOPY	QTY.
Quick Response Pendent	Tyco TY3231	1/2"	5.6	155°	WHITE	WHITE	4
Quick Response Upright	Tyco TY3131	1/2"	5.6	175°	BRASS	NONE	3
						TOTAL HEADS THIS SHEET	7

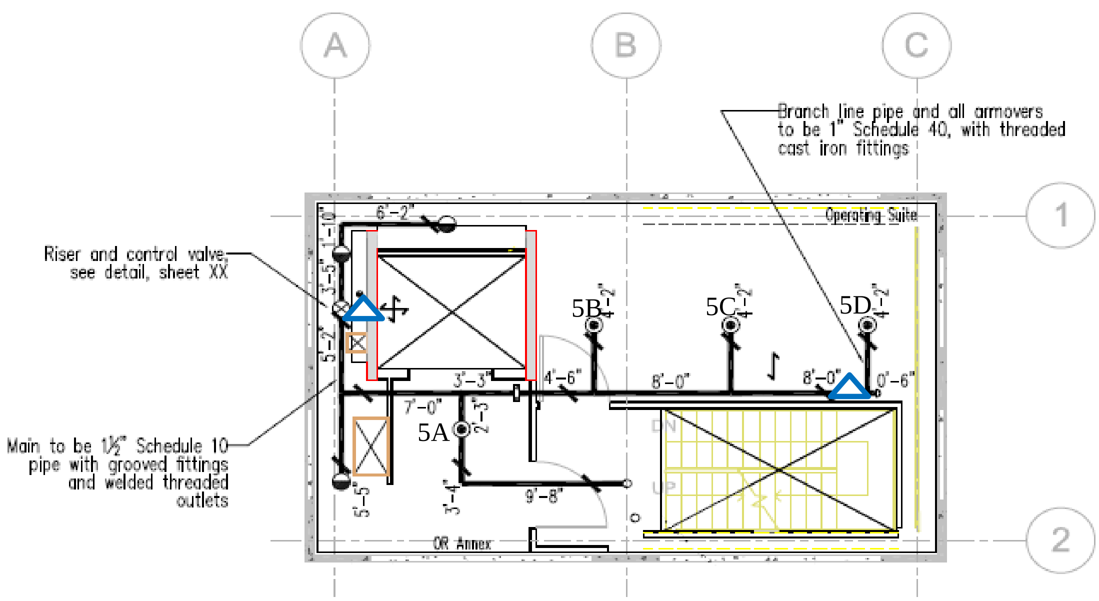

Figure 3.36. Floor 5 sprinkler system design layout and specifications

The blue triangles in Figure 3.36 indicate locations where Mason Industries' SSBS-12 with 1.3cm (1/2") Hilti KB-TZ anchor bolts with an assembly rating of 5.6 kN (1250 lbs) in capacity, was applied on the sprinkler pipes on Floor 5. There were no added sand weights on the pipe or any flexible drops on the 5th floor.

Figure 3.37 shows the riser, drain pipe and control assembly of the first floor, which was located on the west side of the elevator shaft as indicated in Figure 3.36. The control assembly consisted of test and drain valves, a pressure gauge and a waterflow switch. The riser and drain pipes both had seismic bracing installed on the west wall of the shaft. The sprinkler system was charged with about 138kPa (20psi) of pressure as shown on the pressure gauge. The detailed specifications of the control assembly are shown below in Figure 3.38.

Figure 3.37. Floor 5 control assembly

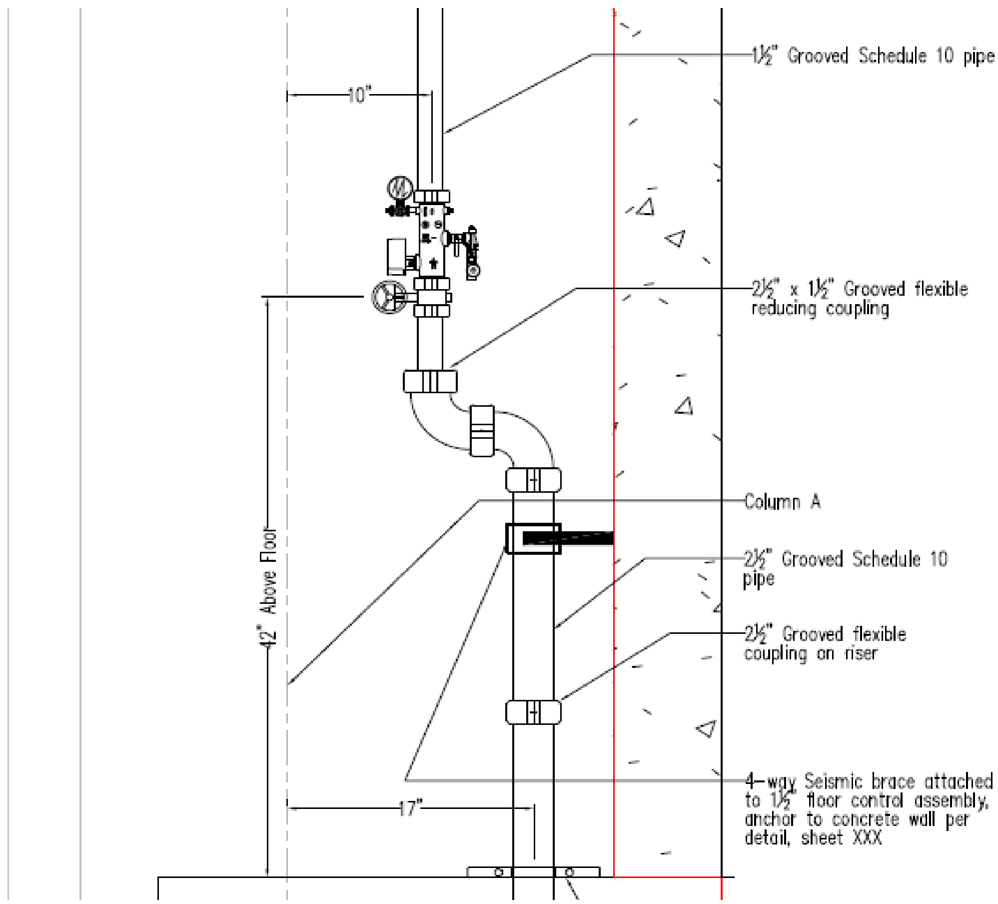

Figure 3.38. Floors 5 control assembly detailed drawing (looking north)

The drain pipe and riser on the fourth floor had clamps near the slab penetrations as shown in Figure 3.39. The clamps were installed above the fifth floor slab penetration.

Figure 3.39. Clamps on bottom of Floor 5 riser and drain pipe

Two Mason Industries' SSBS-12's were applied on top of the fifth floor main feed pipe as shown in Figure 3.40. The braces were installed against the west wall of the elevator shaft.

Figure 3.40. Seismic bracing on Floor 5 main feed pipe

A Mason Industries' SSBS-12 was also installed on the fifth floor sprinkler branch line pipe in the EL area as shown in Figure 3.41. The brace was installed against the roof. The location of the bracing can be seen on Figure 3.36.

Figure 3.41. Seismic bracing on Floor 5 branchline pipe running across the room area

3.2.2 Firestops

Firestop sealants and devices were installed in all vertical and horizontal pipe, cable, wire and HVAC penetration openings on the third floor. Additionally, firestop sealants were used to seal wall and floor assembly joints throughout the building. Some of the joint seals were installed in accordance with tested and listed designs, such as for top-of-wall joints that are stuffed with compressed mineral wool and then sealed. Some other joints, such as some wall to wall joints, were simply caulked using the firestop sealants in a manner for which tested and listed designs do not exist. As such, there would be no expectation of maintaining the fire or smoke resistance of the caulked joint, as this would not be a normally used application in any building where joint movement would be expected. For the penetrations that were firestopped using sealants (as opposed to using pre-formed devices), various firestop components of intumescent, non-intumescent and mineral fiber wool were applied, as dictated by previously fire-tested and listed firestop designs from the Underwriters Laboratories (UL) Fire Resistance Directory. Most of the vertical penetration firestops were installed on the north and west wall of the elevator shaft. Most horizontal penetration firestops were installed in the corridor areas where pipe, cable, wire and HVAC penetrated through the large burn room and elevator lobby area. Figure 3.42 shows the penetration firestop locations across the 3rd floor and Table 3.1 lists the details of each penetration opening. Data sheets on the firestop materials and systems can be found in Appendix A.2.

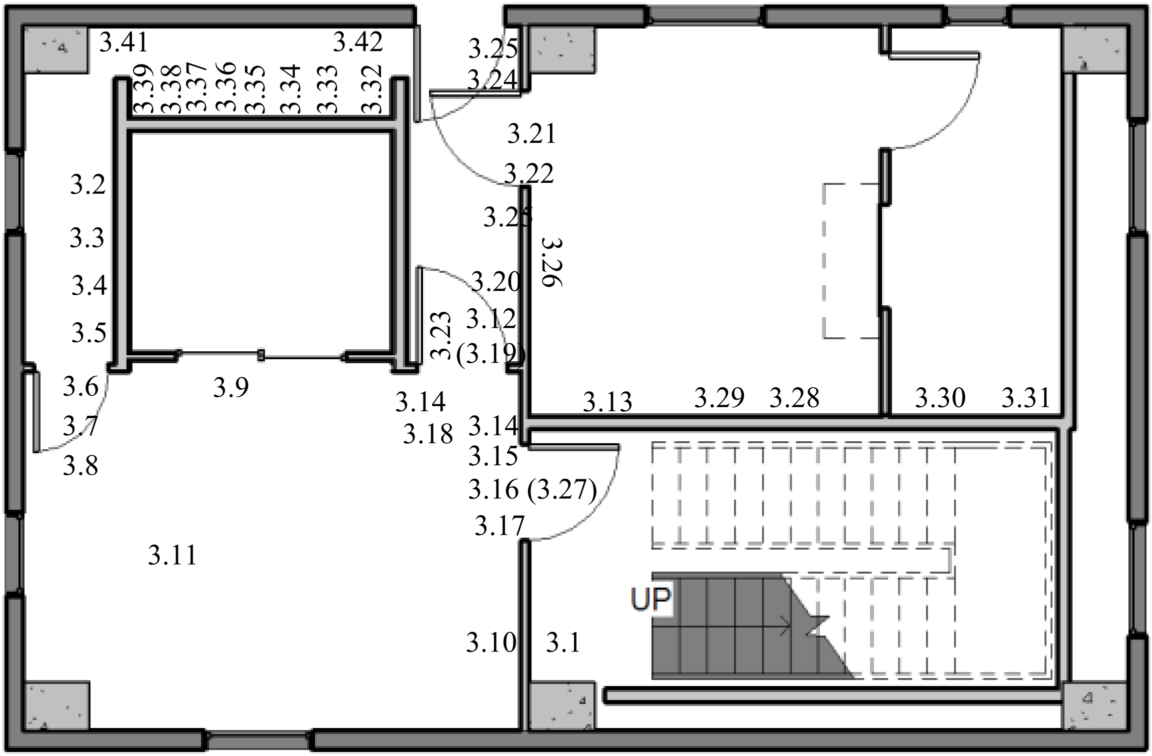

Figure 3.42. Floor 3 firestop locations

Table 3.1. Floor 3 firestop information

Number	Location	Opening Size	Penetration/Gap	Penetration Size	Firestop Product
3.1	Ceiling	Gap	HOW-Joint		CFS-SP WB
3.2	Floor	8"	Steel pipe insulated	4.5" + 2"	CP 604
3.3	Floor	8"	Copper pipe insulated	2" + 2"	FS-ONE
3.4	Floor	4"	Steel pipe	2"	CP 660
3.5	Floor	6"	Steel pipe	3"	CP 660
3.6	Wall	0.5"	Gap	0.5"	CP 606
3.7	Wall	10" x 4"	Steel pipe insulated	1" + 2"	CP 660 both
3.8	Wall	2"	Steel pipe	2"	CP 653
3.9	Ceiling	Gap	HOW-Joint	0.5"	CP 606
3.10	Ceiling	Gap	HOW-Joint	0.5"	CP 606
3.11	Ceiling	42 x 24"	Duct		CFS-BL
3.12	Wall	11 x 11"	Duct 3.19	10 x 10"	CP 660
3.13	Wall	2"	Steel pipe 3.20	2"	CP 653
3.14	Wall	1"	Cable	0.5"	CP 606
3.15	Wall	2"	Steel pipe	1"	CP 660
3.16	Wall	2"	Steel pipe	2"	CP 653
3.17	Wall	1"	Cable	0.5"	CP 606
3.18	Wall	2"	Steel pipe	1"	CP 660
3.19	Wall	11 x 11"	Duct 3.12	10 x 10"	CP 660
3.20	Wall	25 x 8	Cable tray	20 x 6	CFS-BL
3.21	Wall	25 x 8	Cable tray	20 x 6	CP 660
3.22	Wall	11 x 11"	Duct 3.12	10 x 10"	FS-ONE
3.23	Wall	0.5"	Joint	0.5"	CP 606
3.24	Wall	4"	Steel pipe	3"	CP 653
3.25	Ceiling	0.5"	HOW-Joint	0.5"	CFS-SP WB
3.26	Ceiling	0.5"	HOW-Joint	0.5"	CFS-SP WB
3.27	Wall	2"	Steel pipe	2"	CP 653
3.28	Wall	1"	Cable	0.5"	CP 606
3.29	Ceiling	Gap	HOW-Joint	0.5"	CFS-SP WB
3.30	Wall	3" + 2"	Steel pipe	0.5"	FS-ONE
3.31	Wall	3"	Steel pipe	1"	FS-ONE
3.32	Floor	3"		2"	CFS-DID
3.33	Floor	6"		4.5"	CFS-DID
3.34	Floor	5"		4"	CFS-DID
3.35	Floor	5"	Steel pipe	4"	FS-ONE
3.36	Floor	3"	Steel pipe	1.5"	FS-ONE
3.37	Floor	3"	Cable	1.5"	CP 680
3.38	Floor	4"		4"	CFS-DID
3.39	Floor	5"		4"	CFS-DID
3.40	Floor	2"		2"	CP 680
3.41	Wall	1.5"	Wall joint	1.5"	CFS-SP WB

3.42	Ceiling	Steel Beam	Steel beam		CFP-S WB

Figure 3.43 shows firestop 3.1 was applied on the gap between the wall and 4th floor slab joint in the stair landing area.

Figure 3.43. Floor 3 landing wall-slab gap firestop

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.1	CFS-SP WB Firestop Joint Spray 	N/A	Concrete, Masonry, Gypsum, Steel, Aluminum, Glass	Gap	HOW-Joint	

Figure 3.44 shows firestops 3.2, 3.3, 3.4 and 3.5 which were applied on the Floor 3 slab vertical pipe penetrations on the west of the elevator shaft.

Figure 3.44. Floor 3 west side of shaft penetration firestops

<table>
<tr><th rowspan="2">#</th><th rowspan="2">Firestop</th><th rowspan="2">Intumescent</th><th rowspan="2">Base Materials</th><th rowspan="2">Opening Size</th><th colspan="2">Penetration</th></tr>
<tr><th>Gap</th><th>Size</th></tr>
<tr><td>3.2</td><td>CP 604 Self-Leveling Firestop Sealant </td><td>No</td><td>Concrete, Masonry</td><td>8"</td><td>Steel pipe insulated</td><td>4.5" + 2"</td></tr>
<tr><td>3.3</td><td>FS-One Intumescent Firestop Sealant </td><td>Expansion at 121C (250F)</td><td>Concrete, Brick, Metal, Wood</td><td>8"</td><td>Copper pipe insulated</td><td>2" + 2"</td></tr>
<tr><td>3.4</td><td rowspan="2">CP660 Expanding Fire Seal </td><td rowspan="2">Yes</td><td rowspan="2">Concrete, Masonry, Drywall, Brick</td><td>4"</td><td>Steel pipe</td><td>2"</td></tr>
<tr><td>3.5</td><td>6"</td><td>Steel pipe</td><td>3"</td></tr>
</table>

Figure 3.45 shows firestops 3.6, 3.7 and 3.8 that were installed on the wall penetration openings between the west side of shaft and elevator lobby.

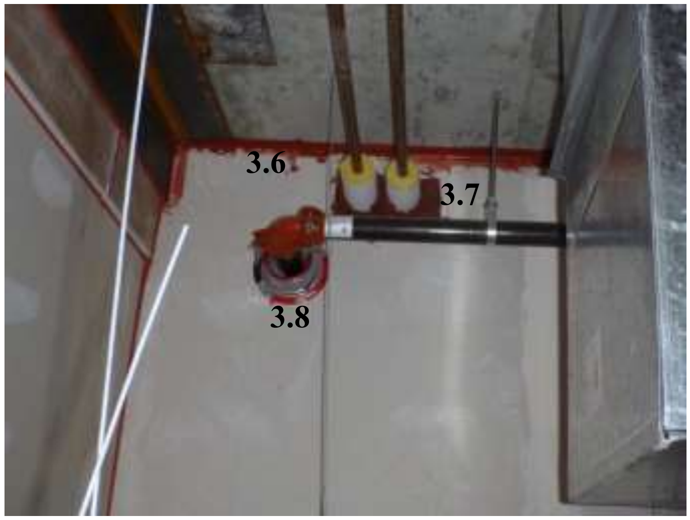

Figure 3.45. Floor 3 firestops between west side of shaft and EL (EL view)

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.6	CP 606 Flexible Firestop Sealant 	N/A	Concrete, Masonry, Drywall, Steel	0.5"	Gap	0.5"
3.7	CP 660 Expanding Fire Seal 	Yes	Concrete, Masonry, Drywall, Brick	10" x 4"	Steel pipe insulated	1" + 2"
3.8	CP 653 Speed Sleeve 	Expansion at 160C (320F)	N/A	2"	Steel pipe	2"

Figure 3.46 shows firestop 3.9 was applied between the EL north wall and the 4th floor slab joint.

Figure 3.46. Floor 3 above shaft door above the EL ceiling

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.9	CFS-SP WB Firestop Joint Spray 	N/A	Concrete, Masonry, Gypsum, Steel, Aluminum, Glass	Gap	HOW-Joint	0.5"

Figure 3.47 shows firestop 3.10 was applied between the EL east wall and the 4th floor slab joint.

Figure 3.47. Above ceiling, east wall of EL

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.10	CP 606 Flexible Firestop Sealant 	N/A	Concrete, Masonry, Drywall, Steel	Gap	HOW-Joint	0.5"

Figure 3.48 shows firestop 3.11 was applied on the 4th floor slab above the ceiling of the elevator lobby for vertical vent penetrations.

Figure 3.48. Floor 3 vertical firestop for vent penetration above ceiling of EL (EL view)

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.11	CFS-BL Firestop Block 	Expansion at 200C (392F)	Concrete, Concrete (porous), Masonry, Drywall	42 x 24"	Duct	N/A

` Figure 3.49 shows firestops 3.13 and 3.18 were applied on the horizontal pipe penetrations on above the EL ceiling on the east wall of the EL.

Figure 3.49. Pipe penetrations above the EL ceiling east wall

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.13	CP 653 Speed Sleeve 	Expansion at 160C (320F)	Masonry, Concrete	2"	Steel pipe	2"
3.18	CP 660 Expanding Fire Seal 	Yes	Concrete, Masonry, Drywall, Brick	2"	Steel pipe	1"

Figure 3.50 shows firestops 3.14, 3.15, 3.16 (3.27) and 3.17 were applied in various penetrations around the northeast corner of the EL above the ceiling.

Figure 3.50. Floor 3 north east corner of EL above ceiling

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.14	CP 606 Flexible Firestop Sealant 	N/A	Concrete, Masonry, Drywall, Steel	1"	Cable	0.5"
3.15	CP 660 Expanding Fire Seal 	Yes	Concrete, Masonry, Drywall, Brick	2"	Steel pipe	1"
3.16 (3.27)	CP 653 Speed Sleeve 	Expansion at 160C (320F)	Masonry, Concrete	2"	Steel pipe	2"
3.17	CP 606 Flexible Firestop Sealant 	N/A	Concrete, Masonry, Drywall, Steel	1"	Cable	0.5"

Figure 3.51 shows firestops 3.20, 3.21 and 3.22 were applied on the penetrations between the LBR and the corridor. Firestop 3.12 (3.19) was applied on the duct penetration between the corridor and the EL. Firestop 3.23 was applied on the wall-to-wall joint.

Figure 3.51. Floor 3 corridor firestop

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.12 (3.19)	CP 660 Expanding Fire Seal 	Yes	Concrete, Masonry, Drywall, Brick	11 x 11"	Duct	10 x 10"
3.11	CFS-BL Firestop Block 	Expansion at 200C (392F)	Concrete, Concrete (porous), Masonry, Drywall	25 x 8	Cable tray	20 x 6
3.21	CP 660 Expanding Fire Seal 	Yes	Concrete, Masonry, Drywall, Brick	25 x 8	Cable tray	20 x 6
3.22	FS-One Intumescent Firestop Sealant 	Expansion at 121C (250F)	Concrete, Brick, Metal, Wood	11 x 11"	Duct 3.12	10 x 10"
3.23	CP 606 Flexible Firestop Sealant 	N/A	Concrete, Masonry, Drywall, Steel	0.5"	Joint	0.5"

Figure 3.52 shows firestop 3.24 was installed on the pipe penetration between the corridor and the LBR. Firestop 3.25 was installed on the east corridor wall and 4th floor slab joint.

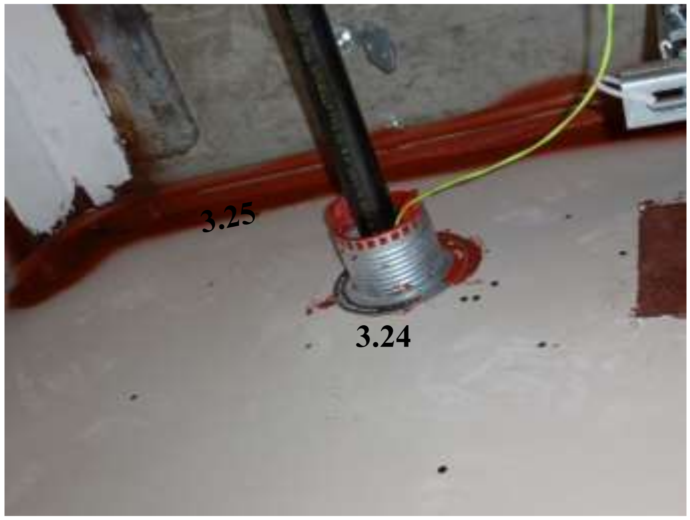

Figure 3.52. Floor 3 corridor and LBR pipe penetration

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	**Size**
3.24	CP 653 Speed Sleeve 	Expansion at 160C (320F)	Masonry, Concrete	4"	Steel pipe	3"
3.25	CFS-SP WB Firestop Joint Spray 	N/A	Concrete, Masonry, Gypsum, Steel, Aluminum, Glass	0.5"	HOW-Joint	0.5"

Figure 3.53 shows firestop 3.26 was applied on the LBR west wall and 4th floor slab joint.

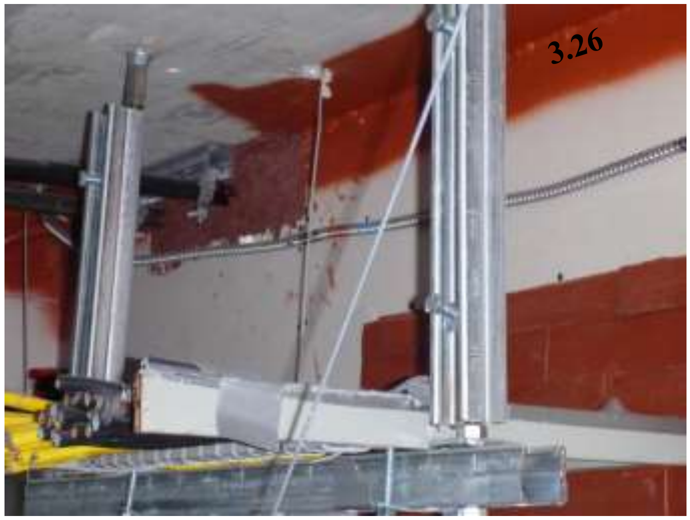

Figure 3.53. LBR west wall and 4th floor slab joint

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.26	CFS-SP WB Firestop Joint Spray 	N/A	Concrete, Masonry, Gypsum, Steel, Aluminum, Glass	0.5"	HOW-Joint	0.5"

Figure 3.54 shows firestop 3.28 was applied in on the cable penetration between the LBR and the staircase.

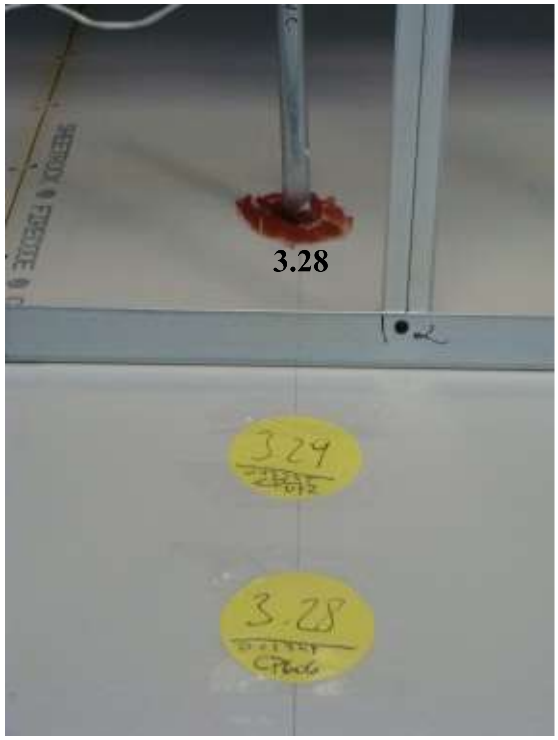

Figure 3.54. LBR above ceiling on the W wall

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.28	CP 606 Flexible Firestop Sealant 	N/A	Concrete, Masonry, Drywall, Steel	1"	Cable	0.5"

Figure 3.55 shows firestop 3.29 was applied on the LBR south wall and the 4th floor joint.

Figure 3.55. LBR S wall and 4th floor joint

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.29	CFS-SP WB Firestop Joint Spray 	N/A	Concrete, Masonry, Gypsum, Steel, Aluminum, Glass	Gap	HOW-Joint	0.5"

Figure 3.56 shows firestop 3.30 was applied on both pipe penetrations on the south wall of the SBR.

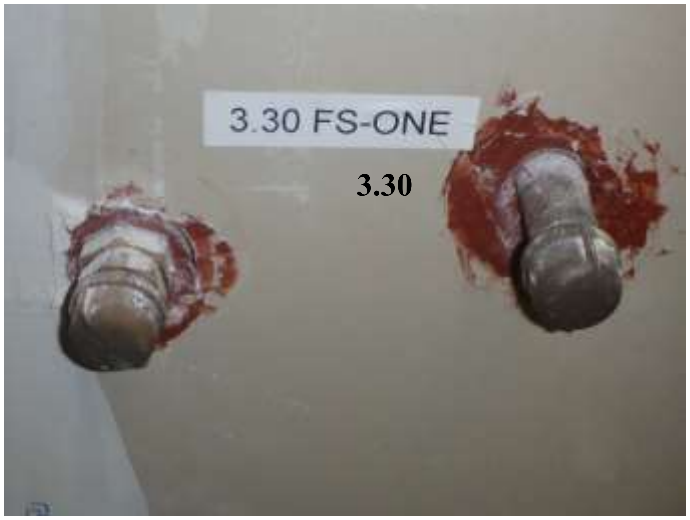

Figure 3.56. Floor 3 south wall of SBR

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.30	FS-One Intumescent Firestop Sealant 	Expansion at 121C (250F)	Concrete, Brick, Metal, Wood	3" + 2"	Steel pipe	0.5"

Figure 3.57 shows firestop 3.31 was applied on the pipe penetration on the south wall of the SBR.

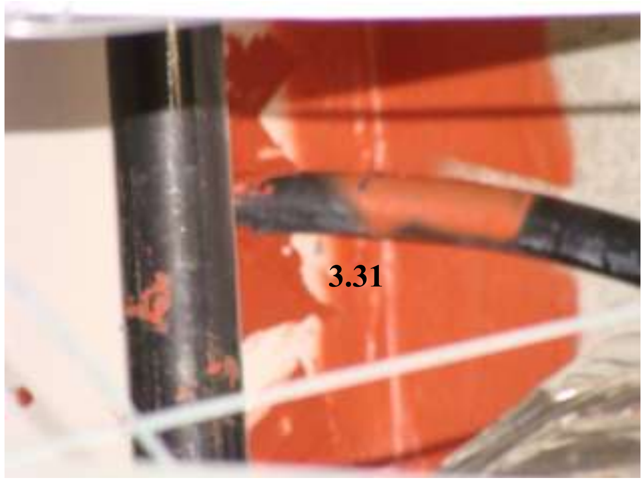

Figure 3.57. South wall of SBR above ceiling

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	**Size**
3.31	FS-One Intumescent Firestop Sealant 	Expansion at 121C (250F)	Concrete, Brick, Metal, Wood	3"	Steel pipe	1"

Figure shows firestops 3.32 through 3.39 were installed on the vertical pipe penetrations on the north side of the elevator shaft.

Figure 3.58. Floor 3 north wall of elevator shaft area

<table>
<tr><th rowspan="2">#</th><th rowspan="2">Firestop</th><th rowspan="2">Intumescent</th><th rowspan="2">Base Materials</th><th rowspan="2">Opening Size</th><th colspan="2">Penetration</th></tr>
<tr><th>Gap</th><th>Size</th></tr>
<tr><td>3.32</td><td rowspan="3">CFS-DID Firestop Drop-In Device </td><td rowspan="3">Expansion at 180C (356F)</td><td rowspan="3">Flat Pour Concrete, Concrete over metal deck, pre-cast</td><td>3"</td><td></td><td>2"</td></tr>
<tr><td>3.33</td><td>6"</td><td></td><td>4.5"</td></tr>
<tr><td>3.34</td><td>5"</td><td></td><td>4"</td></tr>
<tr><td>3.35</td><td rowspan="2">FS-One Intumescent Firestop Sealant </td><td rowspan="2">Expansion at 121C (250F)</td><td rowspan="2">Concrete, Brick, Metal, Wood</td><td>5"</td><td>Steel Pipe</td><td>4"</td></tr>
<tr><td>3.36</td><td>3"</td><td>Steel pipe</td><td>1.5"</td></tr>
<tr><td>3.37</td><td>CP 680 Cast in Firestop Device </td><td>Expansion at 200C (392F)</td><td>Concrete</td><td>3"</td><td>Cable</td><td>1.5"</td></tr>
<tr><td>3.38</td><td rowspan="2">CFS-DID Firestop Drop-In Device </td><td rowspan="2">Expansion at 180C (356F)</td><td rowspan="2">Flat Pour Concrete, Concrete over metal deck, pre-cast</td><td>4"</td><td></td><td>4"</td></tr>
<tr><td>3.39</td><td>5"</td><td></td><td>4"</td></tr>
</table>

Figure 3.59 shows firestop 3.41 was applied between the north wall of the building and the column joint. Firestop 3.42 was applied on the steel right below the 4th floor slab.

Figure 3.59. Floor 3 column in the north wall of ES area

#	Firestop	Intumescent	Base Materials	Opening Size	Penetration	
					Gap	Size
3.41	CFS-SP WB Firestop Joint Spray 	N/A	Concrete, Masonry, Gypsum, Steel, Aluminum, Glass	1.5"	Wall joint	1.5"
3.42	CFP-S WB Steel Spray 	N/A	N/A	steel beam	steel beam	

3.2.3 Fire Door

A Lawrence rolling steel fire door was installed in the partition wall between the LBR and SBR. The front of the door was installed facing the LBR space. The fire door was 0.9m (3’) wide and 2.1m (7’) high. The brackets on either sides of the hood were 0.3m by 0.3m (12” by 12”). The fire door was a chain operated door with the chain shown on the left side of the door in Figure 3.60. The fusible link, with an activation temperature of 74C (165F), was located above the hood between the cable attached to the partition wall and the hood. The fusible link was 2.56m (8.4’) above the 3rd floor slab and 0.24m (0.79ft) below the ceiling that was 2.8m (9.2’) high. At the activation temperature, the fusible link will melt and initiate the door’s automatic closing system. Hence, once the fire door is thermally activated via the fusible link, the curtain will automatically close at a governed speed of approximately 0.3m (12”) per second. Figure 3.60 and Figure 3.61 show the door at open and closed positions respectively.

Figure 3.60. Front side of fire door (LBR view)

Figure 3.61. Front and back of fire door when rolled down

Figure 3.61 shows the fire door at a closed state from both the front and back sides. Crush plates were used on the back side of the wall to support the door weight due to the lighter than normal steel stud framing at each jamb.

3.2.4 Fire Damper

Three Ruskin FSD60LP dampers, shown in Figure 3.62, were installed in each of the two HVAC ducts on the third floor. The dampers were 25cm (10”) high and 25 cm (10”) wide. The system was a 1-½ hour rated, Leakage Class I fire smoke damper with an airfoil blade. The damper can operate at a temperature of 177C (350F), against heated air flow velocities of at least 610MPM (2000 FPM) and 10cm (4”) of water. The dampers had electric fuse links that would automatically heat-actuate at a temperature of 74C (165F). Figure 3.63 shows the location of the dampers.

Figure 3.62. FSD60LP Fire smoke damper

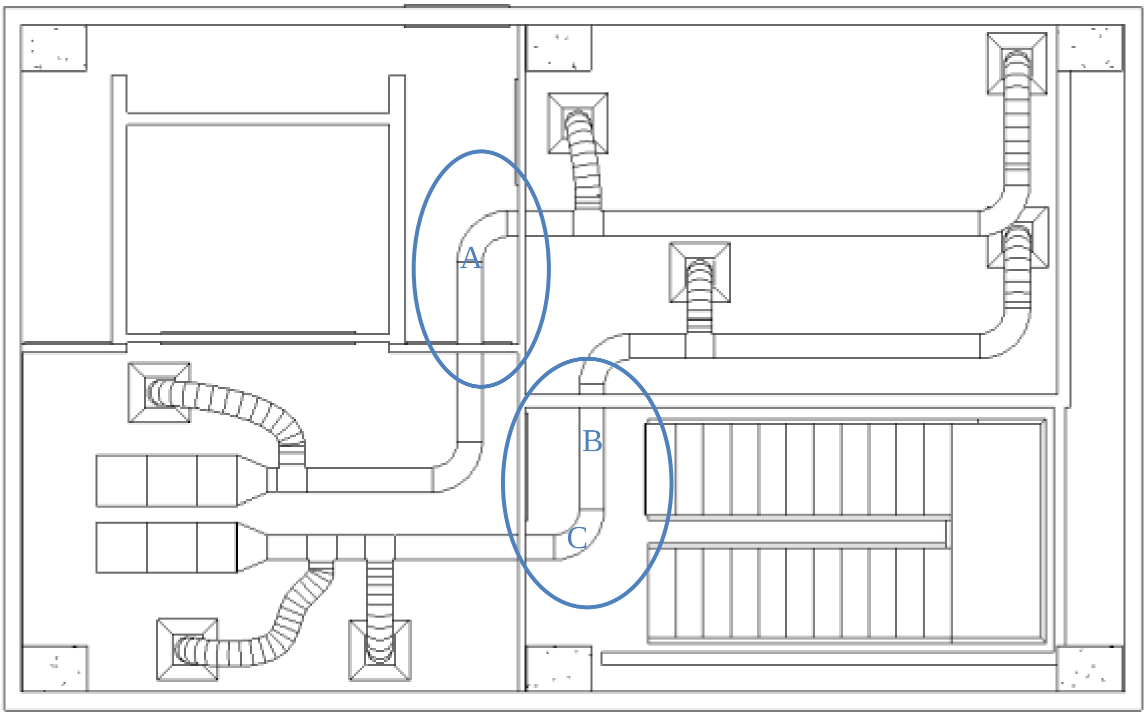

Figure 3.63. HVAC design layout and damper location

Points A, B and C in Figure 3.63 indicate the damper locations. These portions of the ducts, circled in blue, were where the fire dampers were located. One was in the corridor and two were in the stair landing areas. The ducts were exposed as there was no ceiling in both the areas. Figure 3.64 and Figure 3.65 show the exposed portions A and B respectively, where the fire smoke damper systems were located. An electrical switch outlet was installed on the east wall of the elevator lobby for the purpose of powering the system.

Figure 3.64. Floor 3 HVAC duct in corridor (portion A)

Figure 3.65. Floor 3 HVAC duct in stair landing (portion B and C)

3.2.5 Door and Door Frames

Doors were installed to establish several compartments in the Floor 3. Three different types of doors were used. Figure 3.66 shows the door numbers and their respective materials in parenthesis. Door 7 was a roll down fire door, discussed in detail in Section 3.2.3. Door 3 was a honeycomb core metal door. Doors 1, 2, 4, 5 and 6 were flush particleboard core doors. Specifications are provided in Appendix A.5.

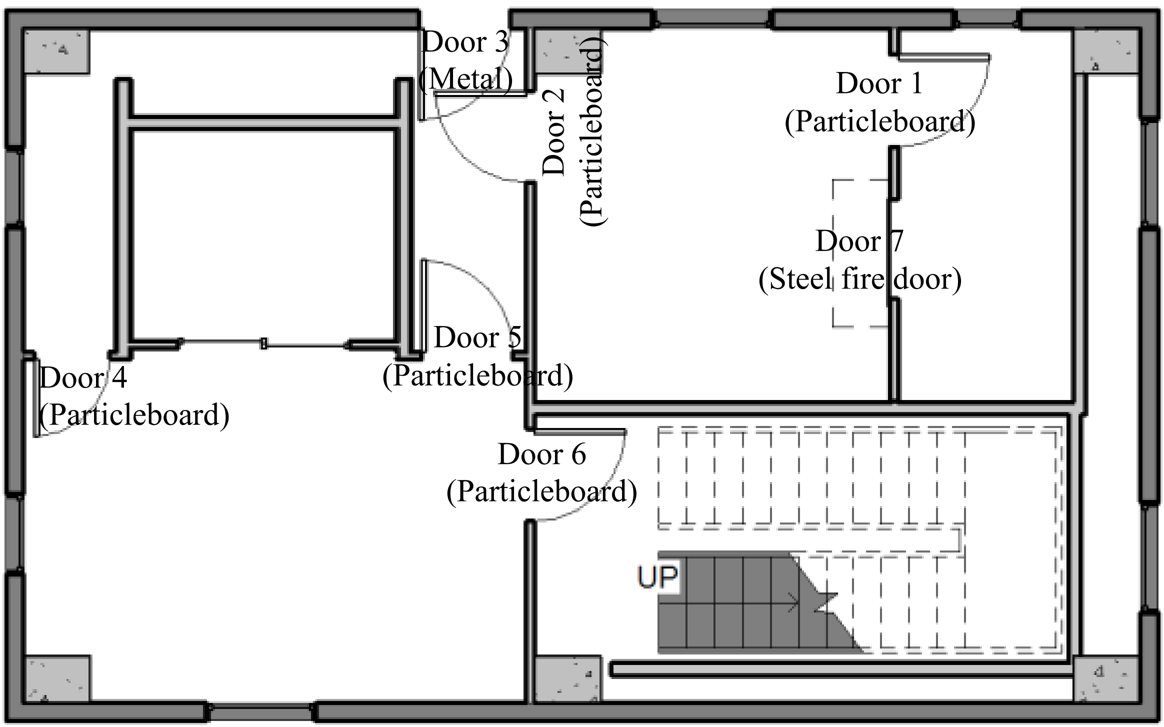

Figure 3.66. Floor 3 layout showing doors

The flush particleboard core doors, which would provide 20 minute fire rating if installed per specifications, were used for Doors 1, 2, 4, 5 and 6. A typical door installation is shown in Figure 3.67, The doors were 0.91m (3') wide, 2.1m (7') high and 3.5cm (1-3/8") thick. The doors were composed of a 13.6kg (30lbs) particleboard core with hardboard cover. The door hardware consisted of standard duty commercial cylindrical lever locks-grade 2. The door latch was made of 3-hour fire rated stainless steel.

Figure 3.67. Door 1, particleboard core door

Door 3 was a single honeycomb core, metal door, with a steel door frame. The frame was made of 16-gauge A60 galvannealed steel, with a 3 hour fire rating. The 18-guage steel standard door was 1.2m (4') wide, 2.7m (9') tall and 4.4cm (1-¾") thick and installed as an exterior door in the north wall of the building in the corridor area. The door was 1-½ hour fire rated. The door consisted of standard duty commercial cylindrical lever locks-grade 2. The door latch was made of 3-hour fire rated stainless steel.

3.2.6 Door Closers and Holders

To test door closing performance, light commercial/residential door closers and commercial grade magnetic door holders were installed in all interior doors in the 3rd floor. The Universal Hardware Light-Duty Aluminum Residential Hold-Open Door Closer 4013 White, were simple mechanical manual door closers that included a bracket, a forearm and a main arm. These closers were force and angle adjustable and adjusted so that all doors could be opened fully in a smooth manner. Figure 3.68 shows one of the interior doors on the third floor with the door closer installed on the top left corner of the door and door frame.

The magnetic door holder, Edwards Signaling Door Holder 1508-AQN5, assembly consisted of a wall mount electromagnet unit that was powered by 120VAC and a door mounted adjustable steel strike plate. The electromagnets were mounted on the walls and the adjustable pivot was mounted either on the top or bottom of the door according to the electromagnet locations. These door holders have the capacity to withstand up to 50 lbs (22.7 kg) of force. A magnetic door holder can be seen on Figure 3.68.

Figure 3.68. Door closer and magnetic door holder

4 COMPARTMENT INTEGRITY TESTS

Compartment integrity tests were performed on Floor 3 SBR and LBR areas. The initial building integrity conditions were measured prior to caulking and the start of both of the base isolation and fixed base test series. Integrity tests were then performed subsequently after BI-1, BI-2, BI-3, BI-6, FB-1, FB-3, FB-4, FB-5 and FB-6 seismic tests.

4.1 OVERVIEW

Compartment (room) integrity tests measure gross leakage area in compartment boundaries. This is done by measuring pressure differentials between the outside and inside pressures of the compartment under investigation. Tests such as these are part of requirements for smoke barrier and stair pressurization system testing and qualification.

It is important to perform room integrity tests because the air tightness of compartments as it not only relates to energy conservation but can also affect building fire conditions. The ventilation characteristics (air supply) of a compartment can change many aspects of fire, including heat release rate (HRR), the total heat released, flame shape, development of hot spots, flame/smoke spread direction, etc.

Since fire/smoke spread occurs through openings in compartment barriers (usually openings in the upper level, but not exclusively), fire compartmentation could be the most effective means of suppressing and limiting fire damage. As such, to determine the testing conditions for compartment fire tests the amount of available air (or oxygen), the direction of airflow, and the velocity of airflow were measured. Room integrity tests and air velocity measurements were performed to provide data to support fire/smoke spread simulation.

4.2 AIR VELOCITY MEASUREMENT

The aim of velocity measurement was to identify specific locations for leakage from a compartment, since the door fan test only provided for an indication of the total leakage area. Velocity measurements allowed for gauging of air flow rates, and identifying the specific locations of leaks.

4.3 COMPARTMENTATION TEST PROTOCOL

The focus of the compartment integrity tests was the third floor. Prior to the start of the first fixed-base test, and after each subsequent motion tests, two compartment integrity tests were conducted, followed by air velocity measurement tests. Figure 4.1 and Figure 4.2 show the compartments that were tested. The characteristics of the compartments are listed in

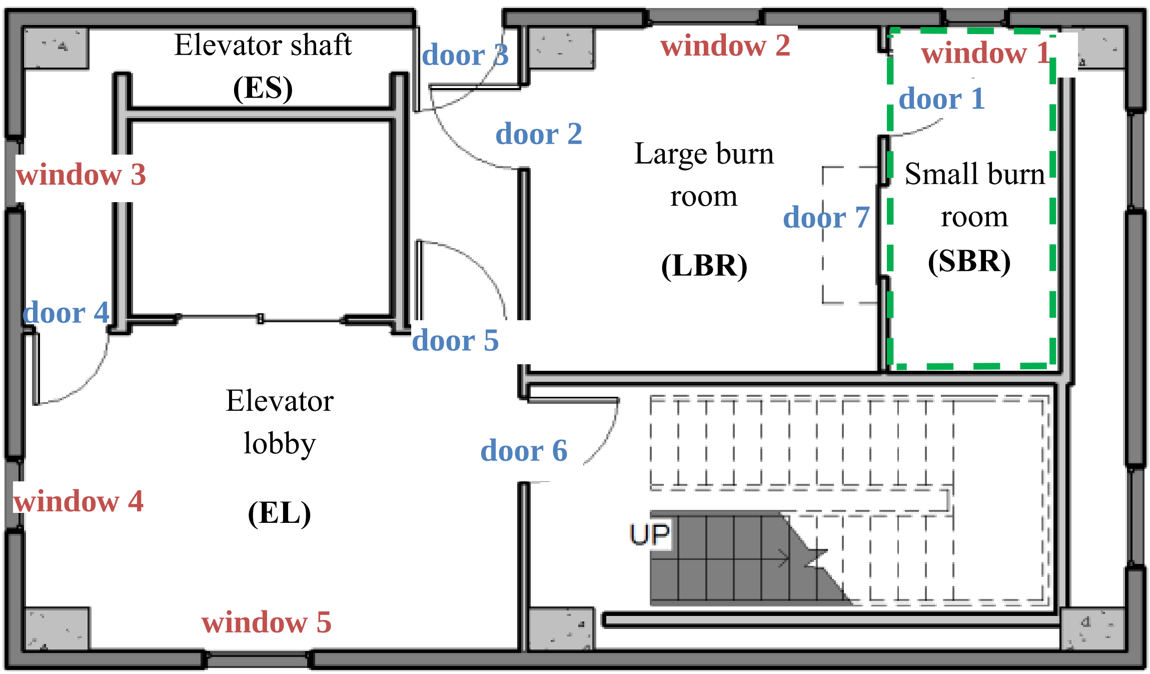

Figure 4.1. Floor 3 compartmentation test Area 1

The SBR space highlighted in green-dashed lines in Figure 4.1 was the focus of the first set of compartment integrity tests. For test Area 1, Door 7 and Window 1 were completely closed. Vents in the SBR ceiling were covered with plastic and sealed with duct tape on all edges to accurately measure the leakage area. The blower fan was installed in Door 1 for test Area 1. Doors 3 and 5 were closed completely

The combined space of LBR and SBR areas, highlighted in red-dashed lines in Figure 4.2, was the focus of the second set of compartment integrity tests. For test Area 2, Windows 1 and 2 were completely closed while vents in the SBR ceiling were covered with plastic and sealed with duct tape on all edges to accurately measure the leakage area. Doors 1 and 7 were opened fully. The fan was installed in door 2. Doors 3 and 5 were closed completely.

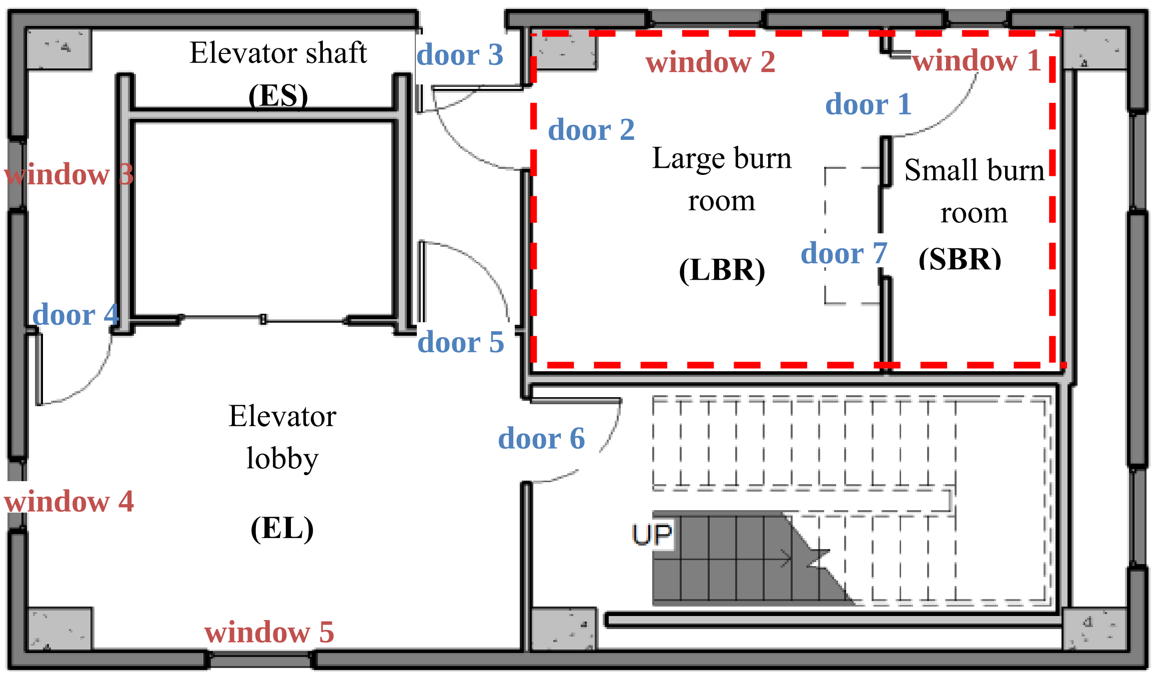

Figure 4.2. Floor 3 compartmentation test Area 2

The compartment integrity tests were conducted following the motion tests. For all the room integrity tests conducted after 50% FB-3, two settings different settings were examined with the ceiling access panel being open and closed in the LBR. After the integrity tests were completed, a leakage test was performed in the same space to find areas of leak and to validate the integrity test results.

The dimensions of each testing space were measured prior to testing. These measurements were used to determine the volume, surface area and floor area of both spaces as shown in Table 4.1.

Table 4.1. Testing space features

	Test 1 Space	**Test 2 Space**
Volume	642.1 ft^3	1879.1 ft^3
Surface area	470.3 ft^2	939.7 ft^2
Floor area	69.4 ft^2	203 ft^2

4.3.1 Room Integrity Test Instrumentation and Procedures

An *Infiltec* E3 fan was used to conduct the room integrity tests. Figure 4.3 shows the fan installed in the Door 1 frame. The adjustable frame was covered with a green-cloth temporary covering. The adjustable frame was put up against a door frame and adjusted to fit in as tight as possible within the door frame. The fan was inserted into the bottom opening on the temporary covering and the manometer was set up on the right of the adjustable frame. Green and red rubber tubes were connected to ports in the manometer and the fan. The fan and the manometer were powered by electricity. Both pressurizing and depressurizing of the room were performed by setting the front of the fan to blow air inwards and reversing the front of the fan to blow air outwards respectively as well as changing the setup of the rubber tubes. This was done to create either a positive or negative pressure differential between the testing compartment and its outside space.

Figure 4.3. Blower door test equipment set up in door 1

The low-flow plate was installed on the back of the fan for all tests as shown in Figure 4.4. To get the required airflow rate, some of the seven holes on the low-flow plate were covered. The number of holes changed depending on the leakage area of the compartments. Table 4.2Table lists the number of holes that were open on the low-flow plate per each integrity tests.

Figure 4.4. Low-flow plate attached on back of fan

Table 4.2. Number of open holes on the low-flow plate

Motion Test	**Number of Open Holes**					
	Area 1		**Area 2**			
			Panel Closed		**Panel Open**	
	Pressure	*Depressure*	*Pressure*	*Depressure*	*Pressure*	*Depressure*
Before caulking	3	3	4	4	N/A	N/A
Before BI-1	2	2	2	2	N/A	N/A
After BI-2	2	2	2	2	N/A	N/A
After BI-3	2	2	2	2	N/A	N/A
After BI-6	2	2	2	2	N/A	N/A
After FB-1	2	2	2	2	N/A	N/A
After FB-3	2	2	2	2	4	4
After FB-4	2	2	2	2	4	4
After FB-5	4	4	4	4	4	4
After FB-6	7	7	7	7	7	7

The number of open holes was adjusted in the manometer settings. The manometer, shown in Figure 4.5, was set to provide readings of pressure and airflow rate at an interval of every 4 seconds. All readings were taken in a patient manner to collect stable and accurate numbers.

Figure 4.5. Digital Manometer

The values presented in Table 4.1 were set as input values on the startup to the integrity test software, *BDWin*. All the readings were recorded into the *BDWin* software as shown on Figure 4.6. The software allows for recordings up to nine readings. As a result, for each fan test, a minimum of 7 readings were recorded.

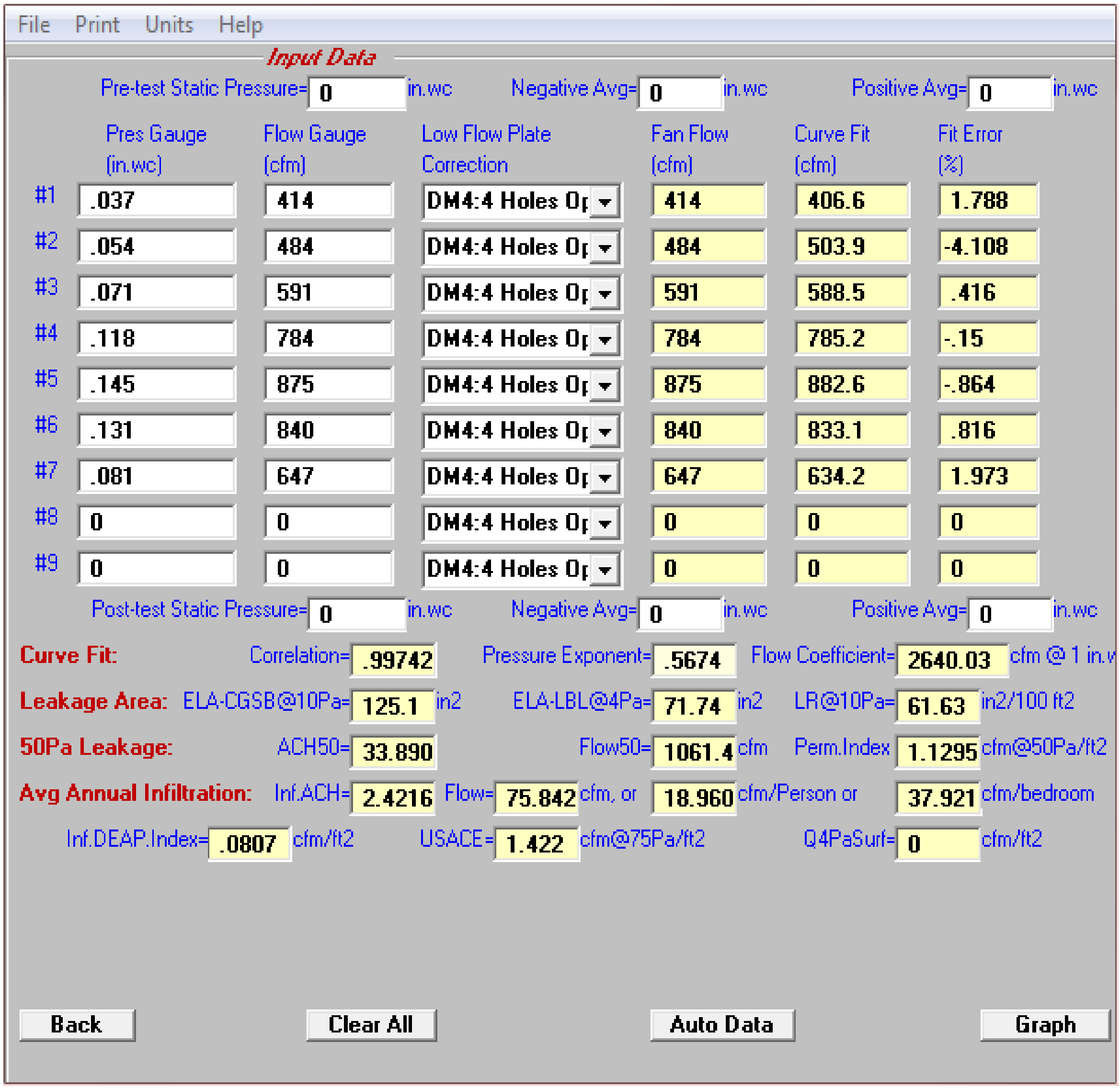

Figure 4.6. Screenshot of BDWin software

The fan flow and compartment pressure readings provided by the manometer, were used to determine the effective leakage area and the air change rate. The relationship of the flow and pressure can be expressed empirically as.

$$Q_f = \kappa P_f^n \qquad \text{Eq. 4.1}$$

where

f = fan induced flow or pressure

Q = airflow rate

P = Pressure

κ = leakage coefficient

Eq. 4.1 can be simplified to show the effective leakage area of an orifice as.

$$Q_f = ELA\sqrt{\frac{2P_f}{\rho}} \qquad \text{Eq. 4.2}$$

where

ELA = effective leakage area

ρ = density of air

With Eq. 4.1 and Eq. 4.2 describing flow at a reference pressure, P_r, of 4 Pa, the equations can be simplified as below.

$$Q_f = ELA\sqrt{\frac{2P_r}{\rho}}\left(\frac{P_f}{P_r}\right)^n \qquad \text{Eq. 4.3}$$

To achieve accurate test results of ELA, a statistical approach is used. The flow rate is related to the pressure difference expressed in a logarithmic function.

$$\log(Q_f) = \text{n}\log\left(\frac{P_f}{P_r}\right) + \log\left(ELA\sqrt{\frac{2P_r}{\rho}}\right) \qquad \text{Eq. 4.4}$$

Linear regression analysis is performed on the numerous readings taken during the test and the linear relationship of the fan flow rate and the pressure difference can be seen through the *BDWin* graph function in Figure 4.7.

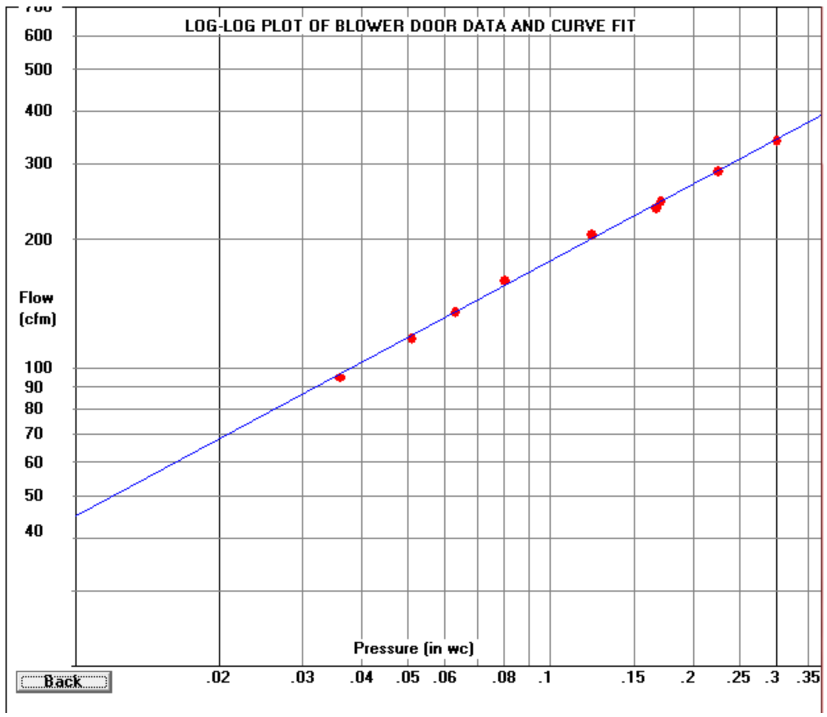

Figure 4.7. Fan flow rate and pressure difference plotted in logarithmic scale

The red dots in Figure 4.7 are plots of pressure differences (x-axis) and their respective fan flow rates (y-axis). The blue line shown is the best fit line running through the plots. The ELA value is taken from the best fit line when the pressure difference is at 4Pa (0.0006psi).

BDWin also provides the air change rate at a specified pressure of 50Pa (0.007psi). This measurement indicates how quickly the interior air gets replaced by outside air through either ventilation or infiltration. Eq. 4.5 below is used to determine the air change rate which is usually expressed in air changes per hour at a specified building pressure.

$$ACH_{50} = \frac{Q_{50}}{Space\ Volume} \qquad \text{Eq. 4.5}$$

where

ACH_{50} = air change per hour at 50 Pascal

Q_{50} = airflow at 50 Pascal

4.3.2 Leakage Check Using Anemometer

After all readings were recorded for the integrity tests, the fan was kept on at a relative slow speed to maintain the pressure differential between inside and outside of the testing compartment. The pressure differential initiates air flow in all openings of the compartments. To identify areas of leak a leakage test was performed right after the integrity tests using an anemometer as shown in Figure 4.8.

Figure 4.8. Air leak check using an anemometer

The anemometer was used to check for leakages around all joints, corners and areas of any visible cracks. While one carried the anemometer around the testing area, another carried around a camcorder and recorded all movements. As shown in Figure 4.8, steel rod with a sensor at the tip of the rod, plugged into the anemometer, detects any air movement. The air velocity is picked up by the sensor on the rod and displayed on the anemometer.

5 BLOWER DOOR FAN TEST RESULTS

5.1 EFFECTIVE LEAKAGE AREA

Table 5.1 shows the effective leakage area (ELA) data recorded per test. The data shown are the average values of the pressurization and depressurization tests. Figure 5.1 shows a graph of the ELA vs. motion test.

Table 5.1. Fan test leakage area results

	ELA-Average	
	SBR (Area 1)	**LBR + SBR (Area 2)**
Before caulking	193cm^2 (30in^2)	219cm^2 (34in^2)
Before BI-1	110cm^2 (17in^2)	84cm^2 (13in^2)
After BI-2	123cm^2 (19in^2)	90cm^2 (14in^2)
After BI-3	116cm^2 (18in^2)	84cm^2 (13in^2)
After BI-6	123cm^2 (19in^2)	97cm^2 (15in^2)
After FB-1	116cm^2 (18in^2)	97cm^2 (15in^2)
After FB-3	129cm^2 (20in^2)	110cm^2 (17in^2)
After FB-4	148cm^2 (23in^2)	148cm^2 (23in^2)
After FB-5	284cm^2 (44in^2)	310cm^2 (48in^2)
After FB-6	587cm^2 (91in^2)	819cm^2 (127in^2)

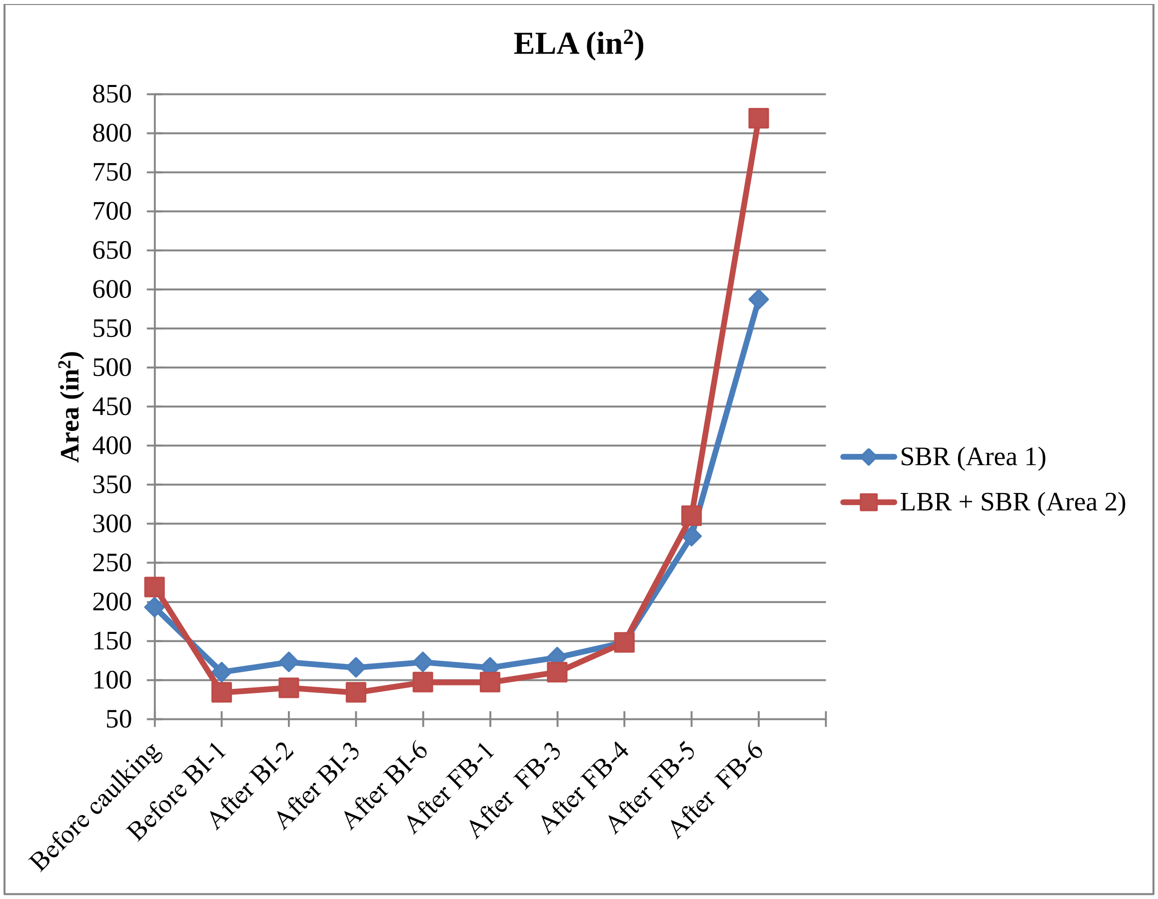

Figure 5.1. Graph of ELA results of both compartments

Figure 5.1 shows a drop in the leakage area for both testing areas after joints were caulked in the testing areas. This showed that caulking helped make the compartment more airtight and reduced significant leakage areas. During the sequence of the BI tests, not much change occurred in the leakage area except for slight variations. During all of the BI tests, the leakage area of Area 1 superseded the leakage area of Area 2.

Figure 5.1 shows the leakage areas of both testing areas increased after all of the FB tests. For all tests prior to FB-5, Area 1 had the larger leakage area compared to Area 2, which was attributed to the leakage areas formed in the partition wall at the edges where the fire door frame was. After FB-4, the leakage area of Area 1 and Area 2 became about the same. Significant leakage area increases were observed after FB-4, FB-5 and FB-6, and Area 2 leakage area became greater than the Area 1 leakage area after FB-4 as more leakage areas were formed in the LBR joint areas and the lighting fixture. The greatest leakage area increase occurred after FB-6. Figure 5.1 shows the steepest slope from FB-5 to FB-6. While the leakage areas of both areas were relatively similar throughout the entire testing series, Area 2 ended up with a leakage area of about 226cm^2 (34in^2) greater than the leakage area of Area 1 after FB-6.

5.2 AIR CHANGE RATE AT 50$_{PA}$

The American Society of Heating, Refrigerating and Air-Conditioning Engineers Incorporation (ASHRAE) Standard 119 categorizes building leakage level based on Air Changes per Hour at 50 Pa (ACH_{50}) values, which measures the total number of complete air changes that will occur in one hour in which pressure of 50 Pascal is being applied uniformly to the compartment. Table 5.2 below shows the ASHRAE Standard 119 values for ACH_{50}.

Table 5.2. Draft ASHRAE Standard 119

Category	Leakage Level (approximate)
1. Very Tight	$ACH_{50} < 1$
2. Tight	$1 < ACH_{50} < 4$
3. Moderate	$4 < ACH_{50} < 6$
4. Fair	$6 < ACH_{50} < 8$
5. Leaky	$8 < ACH_{50} < 18$
6. Very Leaky	$18 < ACH_{50}$

Table 5.3 shows the air change rate data collected from all tests. The data shown are the average values of the pressurization and depressurization tests. These data were plotted into a graph as shown in Figure 5.2.

Table 5.3. ACH50 test results

	ACH_{50} (*1/hr*)	
	SBR (Area 1)	**LBR + SBR (Area 2)**
Before caulking	30	16
Before BI-1	26	7
After BI-2	24	7
After BI-3	27	7
After BI-6	28	7
After FB-1	28	7
After FB-3	30	9
After FB-4	36	12
After FB-5	60	28
After FB-6	125	59

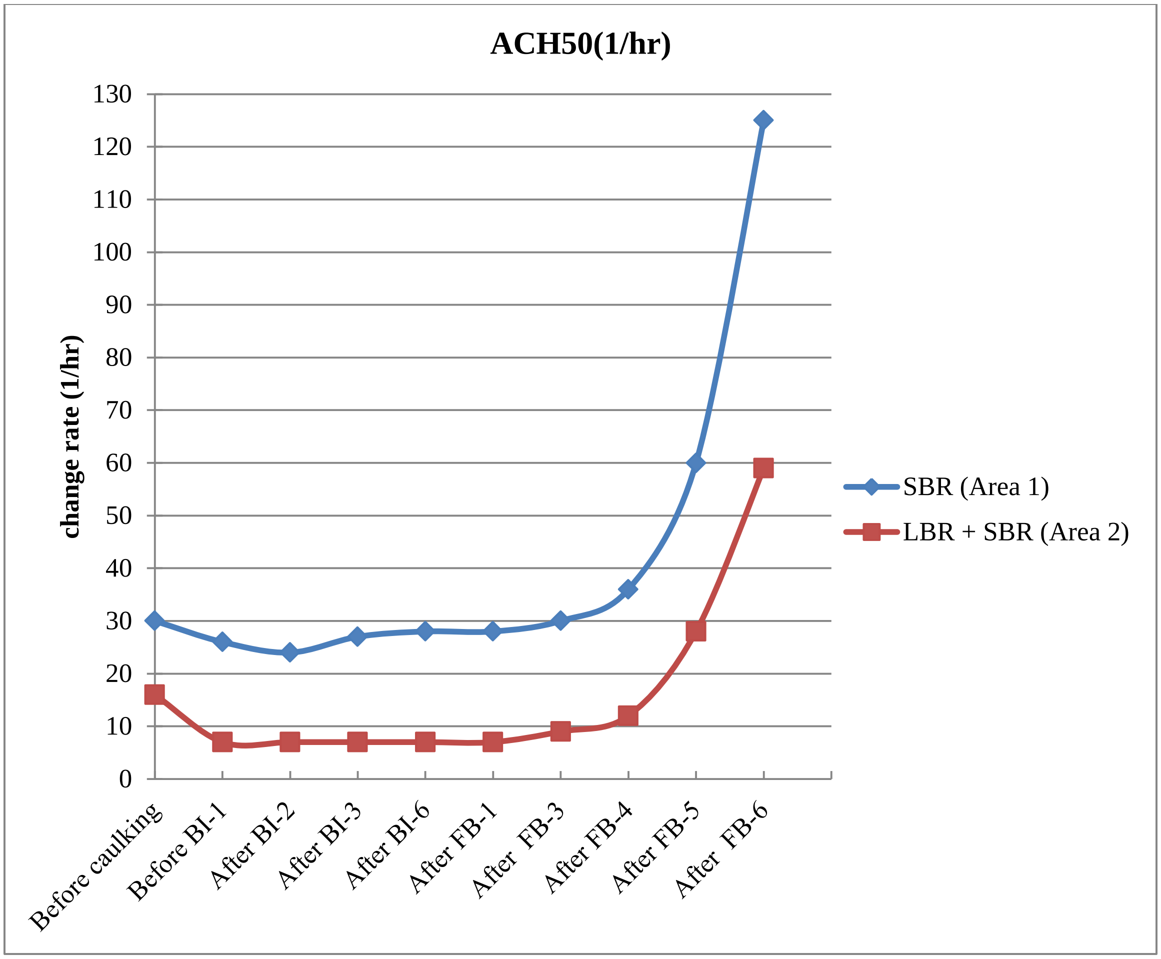

Figure 5.2. Graph of ACH_{50} test results of both compartments

Figure 5.2 showed similar results to that of the ELA results. The number of air change reduced slightly after the joint areas in both testing areas were caulked. That number stayed relatively similar for both compartments until after FB-1 took place. For all the tests that took place after FB-3, an increase in the number of air change was the trend in both Area 1 and Area 2. The increases were minimal during the FB tests but significant increases were visible from all tests after FB-4. The biggest increase in the number of air change occurred after FB-6. Even though Area 1 started with a very leaky category at 26 air changes per hour after caulking, that number increased almost five times the initial number at 125 air changes per hour after FB-6. Area 2 started off as a fair category at 7 air changes per hour after caulking but increased almost 8 times the initial number at 59 air changes per hour and put into the very leaky category after FB-6. The Area 1 air change rates are significantly higher than the air change rates of Area 2 since the air change rate calculations take into consideration the overall volume of the space. With Figure 5.1 showing similar ELAs between the two areas, since Area 1 has a smaller volume than the volume of Area 2, the air change rate of Area 1 is significantly higher than the air change rate of Area 2.

5.3 OBSERVATION OF COMPARTMENTATION ISSUES

The great increase of the leakage area was induced as seismic motions caused openings to form in various areas. Figure 5.3 shows the gap that was formed between the partition wall and the north wall of the building, increasing the leakage area of the SBR and LBR. This as well as the leaky installation of the fire door on the partition wall caused a greater leakage area only in the SBR compared to the both areas of SBR and LBR combined.

Figure 5.3. Gap formed on the partition wall between LBR and SBR

Gaps developed in the joint areas as the building was subject to seismic motions. Figure 5.4 shows the gap in the joint area above the LBR ceiling, allowing for leaks through the balloon framing. Figure 5.5 shows gaps that were formed in the joint areas increasing the overall leakage area.

Figure 5.4. Gap formed in the north wall balloon framing in the joint area above the LBR ceiling

Figure 5.5. Gaps in the joint area of Floor 3

The magnetic door holder of the SBR was found to have been completely ripped off the back of the door, failing to meet the demands of the seismic motions as shown in Figure 5.6.

Figure 5.6. Magnetic door closer failure

There were other noticeable issues in Floor 3 that were observed to add to the compartmentation issues outside of the room areas. It was found that the door in the corridor area was jammed not allowing for the door to close completely as shown in Figure 5.7.

Figure 5.7. Corridor door jam

The elevator door was also severely damaged with a large opening was created as the doors were wrecked and failed to close as shown in Figure 5.8.

Figure 5.8. Damage to the elevator door in Floor 3

6 ADDITIONAL OBSERVATIONS

Although fire tests were only conducted in Floor 3, there were noticeable damages to multiple structural and non-structural components at multiple floors which could pose threats to be fire risks to the building.

6.1 STRUCTURAL COMPONENT DAMAGE

After FB-6, the steel rebars of beam-column connections were completely exposed in several places of the building. Figure 6.1 shows the Floor 2 beam-column connection on the north wall that was damaged. This could severely limit the structural performance and the fire rating of the structural components when exposed to elevated temperatures.

Figure 6.1. Floor 2 north column in the middle

6.2 NONSTRUCTURAL COMPONENT DAMAGE

The living room contents of the elevator lobby and the chemical lab equipment in the room area of Floor 2 were greatly displaced and spread throughout the floor following FB-5 and FB-6. Small items such as cups and books as well as large items such as a book shelf, table and an anchored TV were displaced. The items on the floor in Figure 6.2 could be a fuel source for fires.

Figure 6.2. Floor 2 elevator lobby after FB-6

Following the largest ground motion (FB-6), a rigid steel pipe, representative of a fuel gas line, was damaged at a connection on Floor 1. The broken connection is shown in Figure 6.3. In the absence of other protective measures, such as shutoff valves, such a failure could lead to release of fuel gas in a building.

Figure 6.3. Floor 1 rigid gas pipe disconnection

The stair connection failed and detached off of the stair landing on Floor 3 following FB-6 as shown in Figure 6.4. Handrails had been disconnected following FB-5 as shown in Figure 6.5. Gypsum wallboards detached and fell off around the staircase and landing areas as shown in Figure 6.6 and at multiple locations throughout the building. Such issues as well as the displacement of building contents could hinder the evacuation of occupants during building fires.

Figure 6.4. Floor 3 stair landing following FB-6

Figure 6.5. Floor 4 stair handrail following FB-5

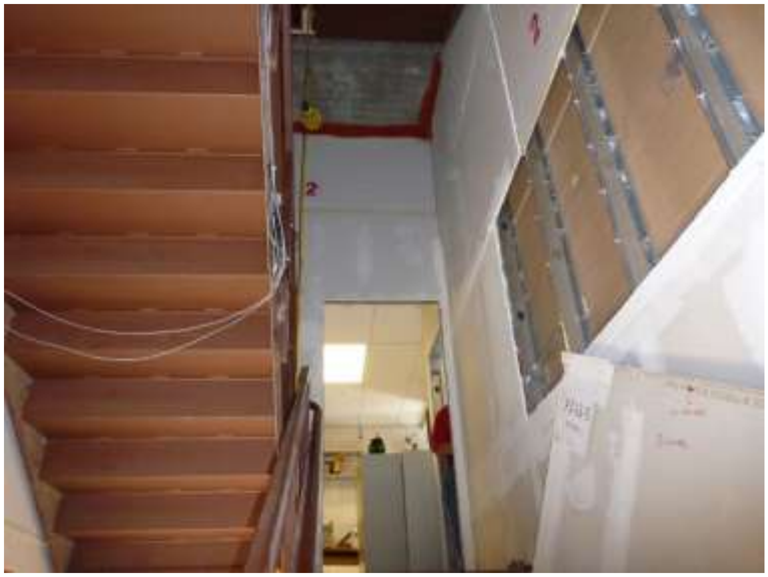

Figure 6.6. Wallboard detachment following FB-6 around intermediate landing of Floor 1 and 2

Two ICU breakout doors were installed in the Floor 4 landing area leading to the elevator lobby and ICU room. Both doors performed well and remained intact during the entire seismic test series except for the ICU door from the landing to the elevator lobby was damaged during FB-5. The ICU breakout doorframe performed well but a portion of the door was detached from the doorframe as shown in Figure 6.7.

Figure 6.7. ICU breakout door on Floor 4 following FB-5

7 INSTRUMENTATION AND FIRE TESTS PLAN

7.1 OVERVIEW

The fire tests were conducted to examine how the building fire protection measures would react to fires subjected to seismic motions. The fire tests were conducted in three different compartments to allow for testing of the various fire systems present throughout Floor 3. Thermocouples were used to measure record temperatures of the compartments, fire systems, while video cameras were used to record and obtain visual data of the fire tests. See Appendix B for additional details on thermocouple locations.

7.2 INSTRUMENTATION

7.2.1 DAQ

A National Instruments cDAQ-9178, data acquisition (DAQ) system was used to record thermocouple data during the fire tests. The DAQ system was located in the 2nd floor room area during all fire tests. The DAQ system components included a chassis connected to a laptop with USB 2.0 extension cable and 6 16-channel C series module placed in the chassis allowing for connection of a total of 96 thermocouples, as shown in Figure 7.1.

Figure 7.1. DAQ (left) and DVR (right) setup on Floor 2 for the fire tests

7.2.2 Thermocouples

For these tests, Type K, AWG (American Wire Gauge) 24, glass braided thermocouples were used to measure gas or surface temperatures at various locations and of fire systems during the fire tests. Because thermocouples were connected to the DAQ which allowed up to 96 thermocouples per test, each thermocouple was numbered and labeled in a format of ‘X-Y’. Both X and Y were numbers with X ranging from 1 to 12 and Y ranging from 1 to 8. For example, in the LBR-1 fire test when 96 thermocouples were used, the first thermocouple was labeled 1-1 and the 96th thermocouple was labeled 12-8. Thermocouple trees were made by placing thermocouples vertically in 30cm (1’) increments on a long metal rod. Thermocouple trees were fabricated and used in fire tests to measure general compartment gas temperatures at various height levels. The thermocouples were connected to the same channels during LBR-1 and SBR fire tests and in EL-1 and EL-2 fire tests. Due to high temperatures in the testing compartments, some thermocouple wire and connectors were protected by ceramic fiber board or blanket as shown in Figure 7.2. Table 7.6 summarizes the thermocouple locations per test.

Figure 7.2. TC tree protected with ceramic fiber blanket

Table 7.1. Summary of thermocouples per fire test

Date	Test	Number of Thermocouples	Locations
23/05/2012	LBR-1 and SBR	96	- 2 thermocouple trees in room areas - 2 thermocouple trees above ceiling - gaps formed on walls of room areas - fire systems - gaps above the ceiling - exterior balloon framing
24/05/2012	LBR-2	96	- 2 thermocouple trees in room areas - 2 thermocouple trees above ceiling - 2 thermocouple trees hanging out of LBR window - gaps formed on walls of room areas - fire systems - gaps above the ceiling - exterior balloon framing - HVAC duct - 4th floor vents
24/05/2012	ES	62	- thermocouple tree in corridor - thermocouple tree space above LBR ceiling - thermocouple tree inside elevator shaft - horizontal firestops on 3rd floor - vertical firestops on 4th floor - 4th floor concrete slab - exterior balloon framing
25/05/2012	EL-1 and EL-2	43	- 2 thermocouple trees in lobby - 2 thermocouple trees above lobby ceiling - thermocouple tree inside elevator shaft - exterior balloon framing

7.2.3 LBR-1 and SBR Fire Tests TC Locations

For the LBR-1 and SBR fire test configuration, a thermocouple tree was placed in each of the SBR and LBR to obtain the general compartment gas temperature. A thermocouple tree was placed above the SBR ceiling and above the LBR ceiling to measure temperature increases above the ceiling. At various noticeable gaps that were formed in the walls and joint areas of the rooms and the space above the ceiling from the motion tests, thermocouples were placed to measure the gas temperatures to check for smoke spread. Thermocouples were placed on thermal activation links of sprinkler heads and fire door to check for activation temperatures. Thermocouples were placed on the north balloon framing to check for increased temperatures indicative of smoke and hot gas leakage to the exterior of the building.

7.2.4 LBR-2 Fire Test TC Locations

Most of the thermocouple locations for the LBR-2 fire test remained intact from the LBR-1 and SBR fire tests, as the testing compartments were the same. For the LBR-2, due to greater fuel load and expectations of increase in temperatures, thermocouples were placed in the HVAC ducts in front of the fire damper and in Floor 4 vents to check if hot gases would travel through the HVAC duct. Also, 2 thermocouple trees were installed to hang out of the LBR window to measure the gas temperature exiting through the window.

7.2.5 ES Fire Test TC Locations

A thermocouple tree was placed in the corridor space for the ES fire test to measure general gas temperatures of the testing compartment. A thermocouple tree was located in the space above the LBR ceiling and inside the elevator shaft (only for Floors 3 through 5) to check for smoke spread. Thermocouples were placed on the surfaces of the horizontal firestops on the east and south walls of the corridor and on vertical firestops of the 4th floor slab to obtain activation temperatures. Also thermocouples were located on the 4th floor concrete slab to check for any temperature increase on the slab. Thermocouples were located on the north and west balloon framing to check for increased temperatures indicative of smoke and hot gas leakage to the exterior of the building.

7.2.6 EL-1 and EL-2 Fire Tests TC Locations

Two thermocouple trees were located in the lobby area, on the southwest corner and in front of the elevator door, for the EL-1 and EL-2 fire tests to measure general testing compartment gas temperatures. Two thermocouple trees were located in the space above the EL ceiling, on the northwest and southeast corners to measure temperature changes in the ceiling space. A special thermocouple tree with thermocouple spacing of 0.66m (2.2ft), was installed to hang from the top of the elevator shaft down to the floor slab of the 3rd floor to check how much temperature increase would occur inside the shaft. Thermocouples were placed on the west and south balloon framing to check for increased temperatures indicative of smoke and hot gas leakage to the exterior of the building.

7.2.7 Cameras

Two different sets of cameras were installed in various locations in the building to capture the fire, smoke spread, flame extension and fire systems activation. A digital video recorder (DVR) with 8 channels and 500GB of internal storage capacity was placed in the 2nd floor room area during the fire tests as shown in Figure 7.1. With 150 feet BNC cable extensions, the cameras were located in various locations on the 3rd floor. Figure 7.3 shows the components of the DVR camera system.

Power supply for camera

Camera

Zip (BNC) cable connecting camera to DVR

DVR with 8 BNC outlets

Figure 7.3. DVR-camera system components

Due to the limitation of the DVR only allowing for a maximum of 8 camera connections at once, UCSD IP cameras were also implemented throughout all fire tests to allow for more views. The UCSD IP cameras had one cable from the camera to a switch located on each floor with a maximum of 7 camera cables allowed per switch. The switch had a power cable connected to a closest power source and another cable exiting the building towards the control tower to a server system. A UCSD IP camera is shown in Figure 7.4. Due to high temperatures in the testing compartments, some cameras and portions of the BNC cable were protected by ceramic fiber blanket.

Figure 7.4. UCSD IP camera

7.2.7.1 DVR Camera Locations

Figure 7.5 shows the locations where DVR cameras were mounted on the 3rd floor. The DVR cameras were only mounted in locations on the 3rd floor. Table 7.2 lists the views and location level of all the cameras.

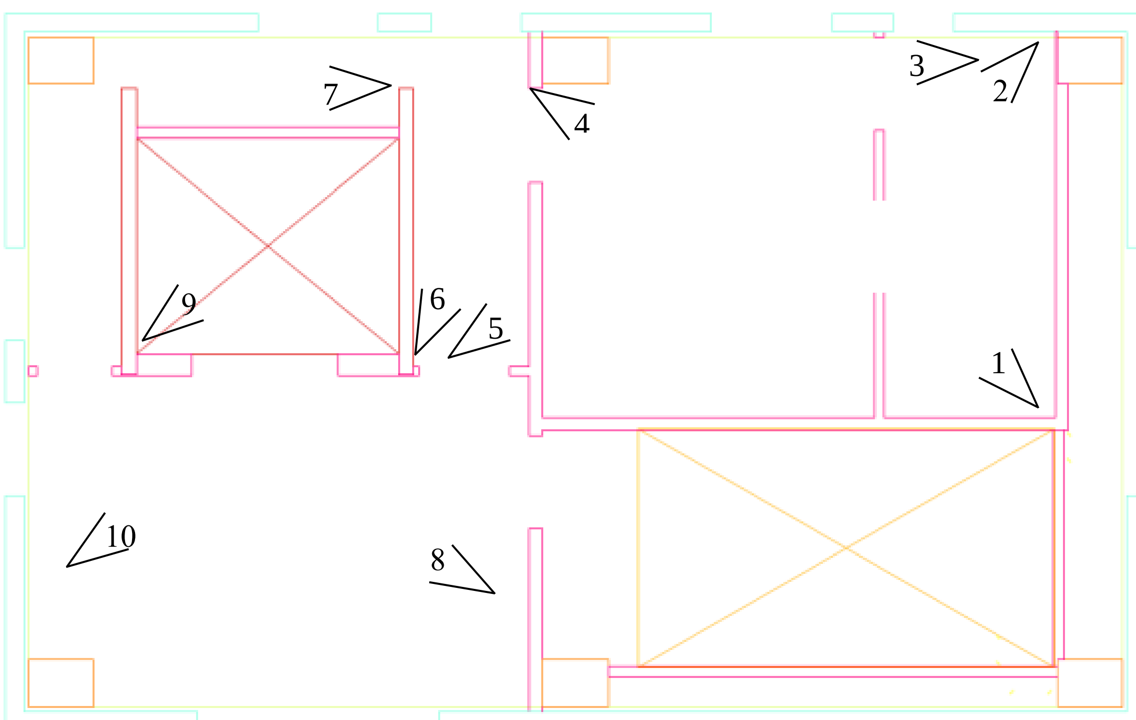

Figure 7.5. DVR camera locations on Floor 3

Table 7.2. Floor 3 DVR camera details

Camera #	Name	Level	View
1	SBR_SE_corner	3	Fire door
2	SBR_NE_corner	3	Partition wall and N wall of building gap
3	SBR_above_ceilin g	3 (above ceiling)	Overall ceiling view towards the LBR column
4	LBR_NW_corner	3	Center of LBR
5	corridor_firestop	3	Corridor wall firestop
6	Corridor	3	Corridor and LBR door
7	N_shaftwall_firest op	3	Vertical firestop and overall view of area behind N wall of shaft
8	EL_SE_corner	3	EL area and shaft door
9	Inside_shaft	3	Inside shaft looking NE and upwards
10	EL_above_ceiling _firestop	3(above ceiling)	HVAC duct and vertical firestop

Table 7.3 shows the status of the DVR camera during the fire tests. White indicates that the camera was not connected or mounted during the test. Dark gray indicates the camera was installed and recording during the test. Light gray indicates the camera was installed and recording but got destroyed during the test.

Table 7.3. DVR camera status during fire tests

Camera #	LBR-1	SBR	LBR-2	ES	EL-1	EL-2
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Figure 7.6 shows camera 4 that was installed in the northwest corner of the LBR adjacent to the column to capture the whole LBR area during the fire tests.

Figure 7.6. Camera 4 was installed adjacent to the column in the LBR

7.2.7.2 UCSD Camera Locations

UCSD cameras were located in various locations throughout floors 3, 4 and 5. The cameras were located in both interior and exterior locations of the building. Figure 7.7, Figure 7.8, and Figure 7.9 show the UCSD camera locations for floors 3, 4 and 5 respectively. Table 7.4 lists the views of each of the camera while Table 7.5 shows which cameras were recorded during the fire tests.

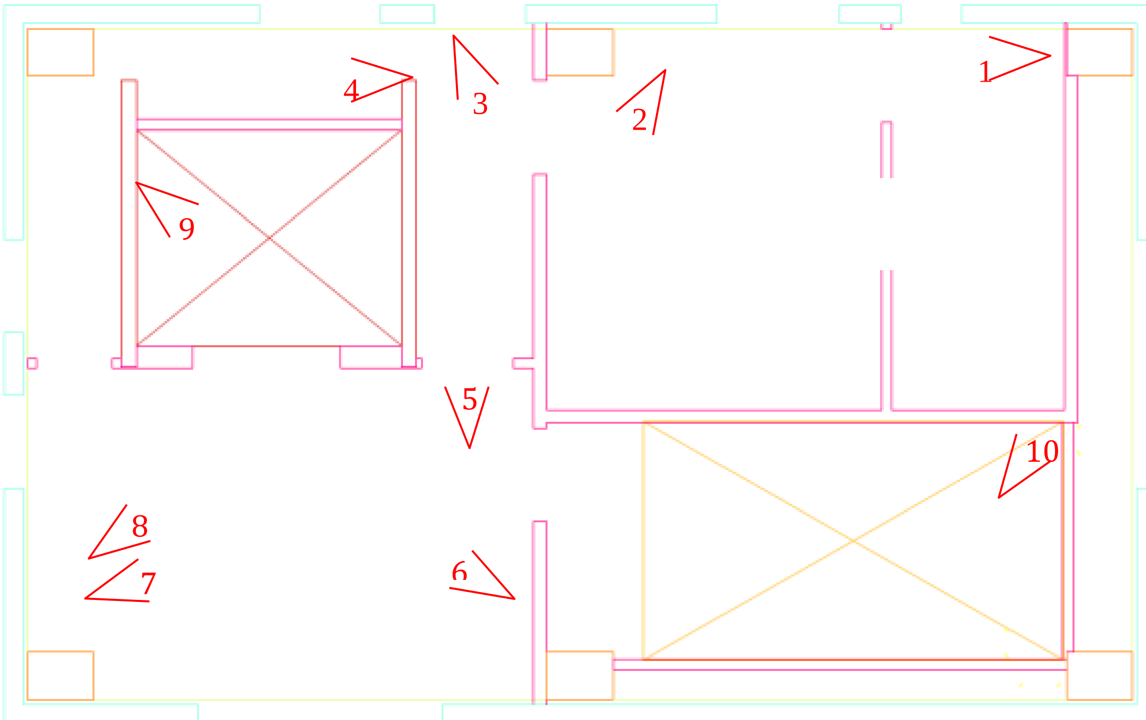

Figure 7.7. UCSD camera locations on Floor 3

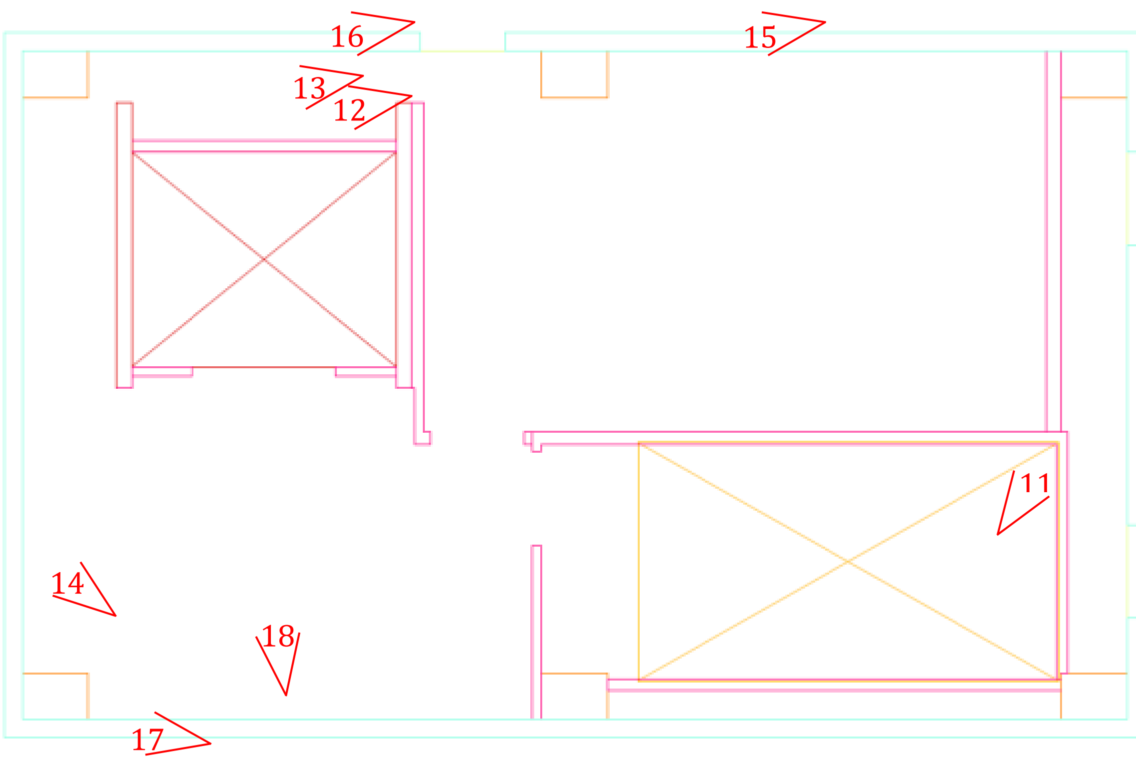

Figure 7.8. UCSD camera locations on Floor 4

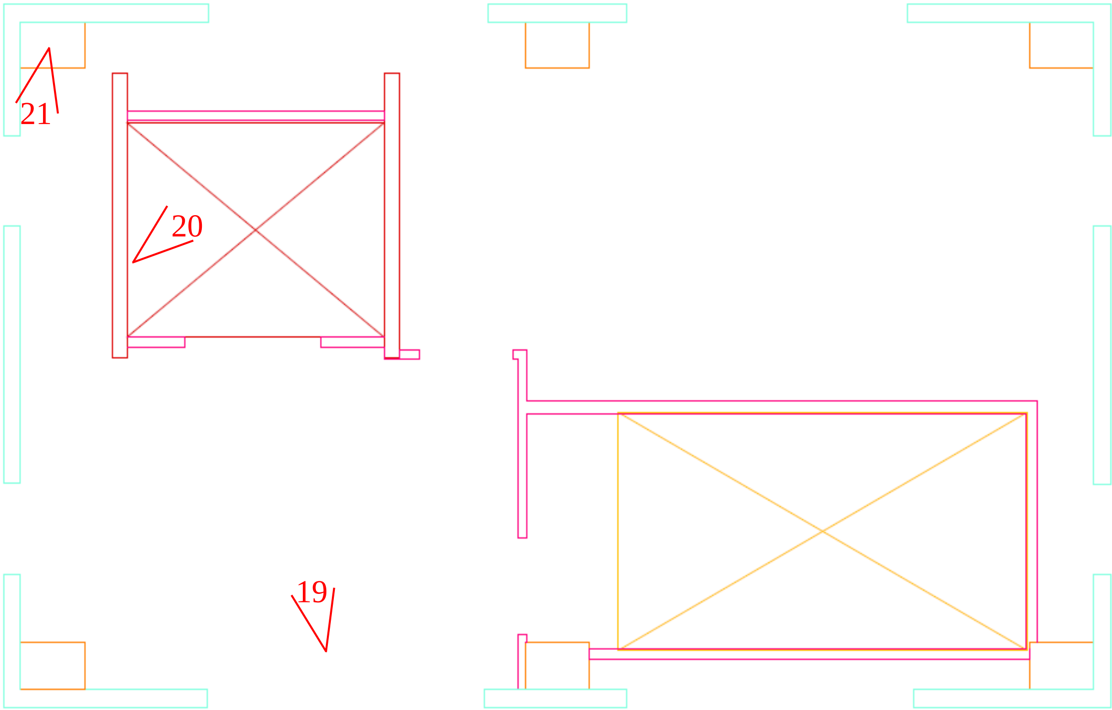

Figure 7.9. UCSD camera locations on Floor 5

Table 7.4. UCSD Camera details

Camera #	Name	Level	View
1	FL3_SBR_above_ceiling	3 (above ceiling)	Overall ceiling view towards the LBR column
2	FL3_LBR_firestop	3 (above ceiling)	Firestop on W wall of LBR
3	FL3_corridor_firestop	3	Firestop on E wall of corridor
4	FL3_N_shaftwall	3	Vertical firestop and overall view of area behind N wall of shaft
5	FL3_EL_damper	3 (above ceiling)	HVAC duct and firestop on S wall of corridor
6	FL3_EL_door	3	EL area and shaft door
7	FL3_EL_SW_ceiling	3 (above ceiling)	Above EL ceiling space looking NE
8	FL3_EL_vertical_FS	3 (above ceiling)	Vertical firestop and overall view of area behind N wall of shaft
9	FL3_inside_shaft	3	Inside shaft towards Floor 2 shaft door
10	FL2_3_landing_NE_corner	2 and 3	NE corner of intermediate landing
11	FL3_4_landing_NE_corner	3 and 4	NE corner of intermediate landing
12	FL4_N_shaftwall_firestop	4	Vertical firestop and overall view of area behind N wall of shaft
13	FL4_4NW_column	4	4NW column and overall view of area behind N wall of shaft
14	FL4_vent	4	Vent openings
15	FL4_N_balloon	4	Middle of balloon framing of N wall
16	FL4_NW_balloon	4	NW portion of balloon framing of N wall
17	FL4_SW_balloon	4	SW portion of balloon framing of S wall
18	FL4_EL_door	4	EL lobby and shaft door
19	FL5_EL_door	5	EL lobby and shaft door
20	FL5_inside_shaft	5	Elevator roller inside shaft
21	FL5_W_balloon	5	Exterior of W wall of building

Table 7.5 shows the status of the UCSD camera during the fire tests. White indicates that the camera was not connected or mounted during the test. Dark gray indicates the camera was installed and recording during the test. Light gray indicates the camera was installed and recording but got destroyed during the test.

Table 7.5. UCSD camera status during fire tests

Camera #	LBR-1	SBR	LBR-2	ES	EL-1	EL-2
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
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21						

Figure 7.10 shows UCSD IP Camera 1 that was installed on the northeast corner above the SBR ceiling to capture the smoke leak to the ceiling through the gaps formed between the north wall of the building and the ceiling system.

Figure 7.10. UCSD Camera 1 installed in the northeast corner above the SBR ceiling

7.2.8 Smoke Detectors

GE TX-6010-01-1 commercial-grade, photoelectric wireless smoke detectors, shown in Figure 7.11, were located in various locations on multiple floors to see smoke spread. The smoke detectors were powered by batteries and programmed into the Simon XT control panel as a sensor. A touchscreen keypad was also installed in which logs of events were recorded.

Wireless Smoke Detector

Control Panel

Touchscreen Keypad

Figure 7.11. Smoke detector components

Figure 7.11 shows the smoke detector components. Figure 7.12, Figure 7.13 and Figure 7.14 show the location of the smoke detectors in floors 3, 4 and 5 respectively.

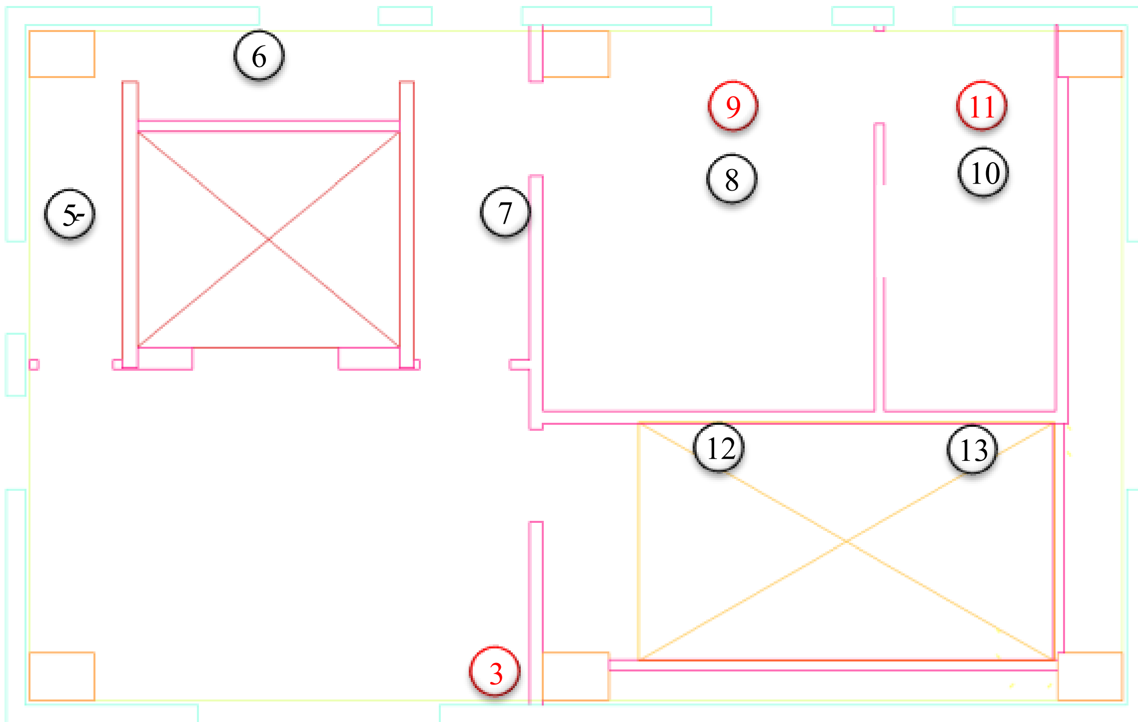

Figure 7.12. Floor 3 smoke detector locations

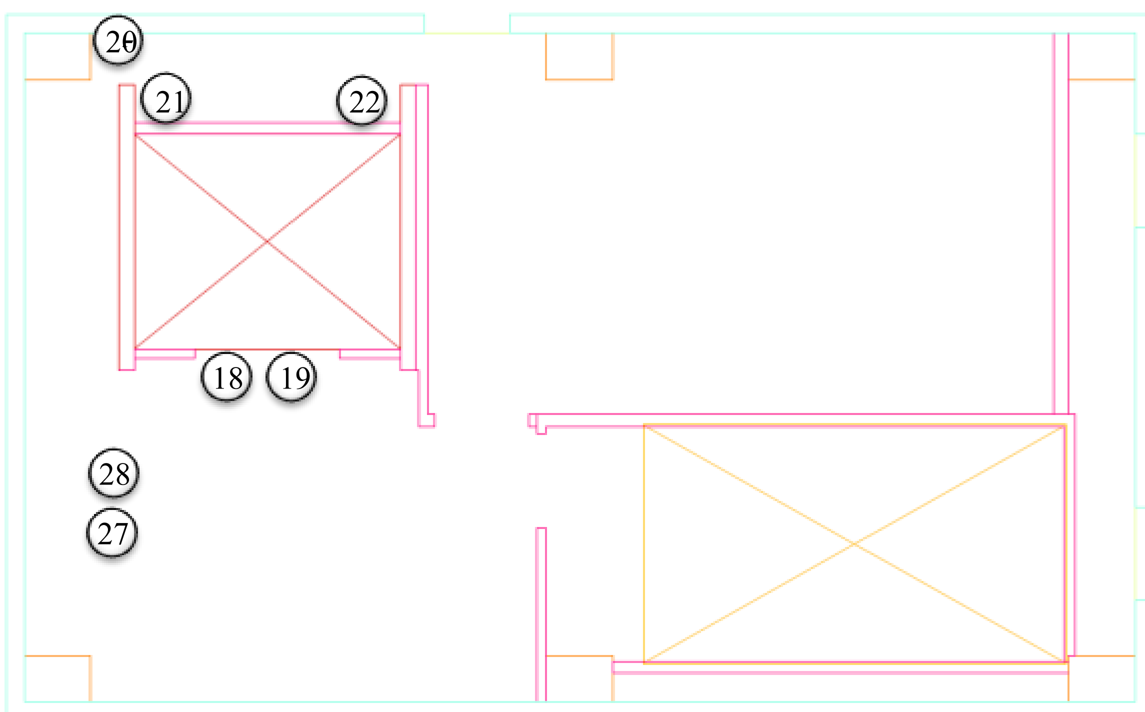

Figure 7.13. Floor 4 smoke detector locations

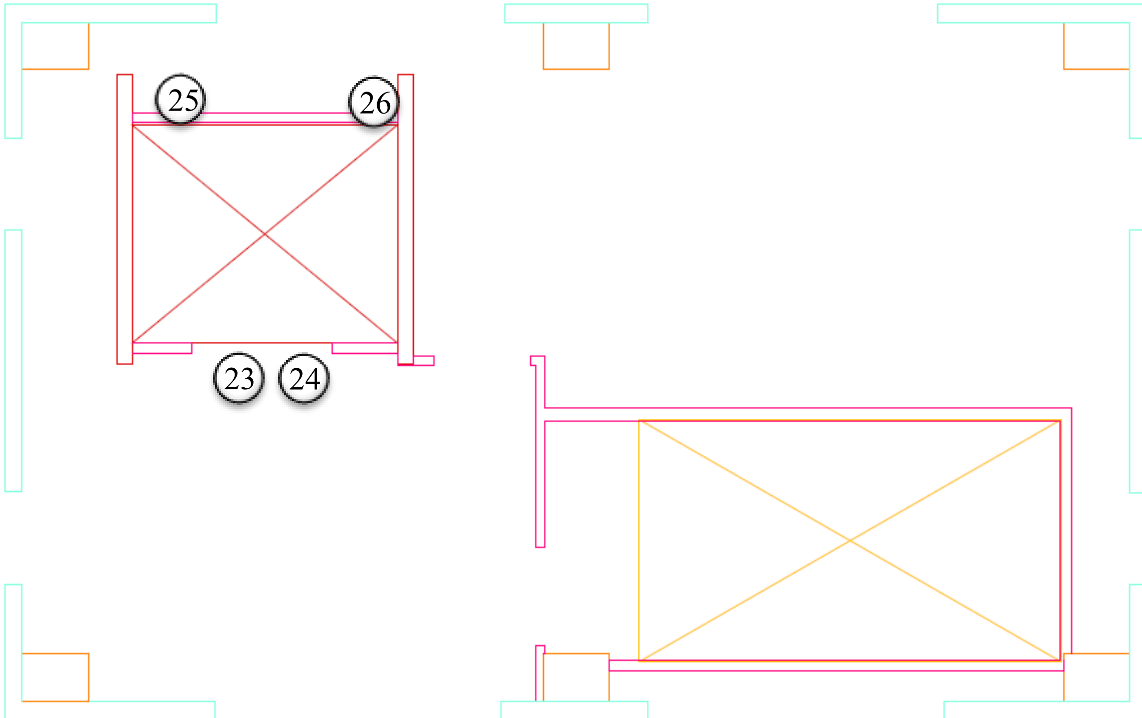

Figure 7.14. Floor 5 smoke detector locations

Figure 7.15 shows Smoke Detector 10 that was installed on the SBR ceiling adjacent to the sprinkler head.

Figure 7.15. Smoke Detector 10 installed on the SBR ceiling

7.3 TEST SCHEDULE

The fire tests were conducted on three consecutive days from May 23, 2012 to May 25, 2012. Fire test set up and instrumentation occurred during the previous week of the fire tests. Table 7.6 lists the fire test name, location and dates.

Table 7.6. Fire test schedule

Date	Fire Test Location	Test Name	Weather condition
May 23, 2012	LBR	LBR-1	Temp: 61~68^{o}F Wind: ~5 mph
	SBR	SBR	
May 24, 2012	LBR	LBR-2	Temp: 65~68^{o}F Wind: 5~10 mph
	ES	ES	
May 25, 2012	EL	EL-1	Temp: 57~62^{o}F Wind: 10~15 mph
	EL	EL-2	

7.4 FIRE TEST PLAN

The objectives of the fire tests were twofold: (1) to assess the potential for spread of fire and smoke in an earthquake damaged building, given the damage caused by the motion tests, and (2) collect sufficient compartment fire data to assist in simulation of the fires and prediction of post-earthquake fire performance of buildings.

While the initial intent was to collect fire performance data on multiple floors in multiple configurations, project resource constraints limited fire testing to the third floor. Also, while it would have been helpful to collect data on actual burning characteristics of representative contents, for purposes of environment protection and control of fire size and duration, it was determined that a controlled fuel source should be used. Initially, the intent was to use a propane gas burner with adjustable gas flow to control fire size (heat release rate) and duration, but financial constraints made this option impractical. In the end, it was decided to burn heptane in steel pans, as this allowed for a relatively inexpensive fire source, for which heat release rate and burning time could be controlled, relative to the experimental conditions.

This section of the report overviews the design of the fire source, size and duration based on the fuel, pan size and ventilation conditions, and describes the fire test plan for each of the six live fire tests.

7.4.1 Factors Affecting Fire Size

7.4.1.1 Heat Release Rate

A principal driver in describing the size of a fire is heat release rate (HRR). HRR, measured and expressed in kW, represents the rate at which thermal energy is produced during a fire, which in turn determines thermal conditions in compartment fire tests. If fire size is too small, it will not increase the room temperature high enough to assess key building performance features, such as activation of firestops, forcing flame or smoke outside of the compartment of fire origin, activate sprinkler heads or fusible link on fire doors, etc. For these tests, for example, the upper gas temperature needed to be higher than 250C (482F) to activate the firestops. However, if the fire size is too large, or burns for too long, failure of compartmentation, structural members or other building features could result. This facilitated the need to design the HRR from the pan fires to achieve minimum required compartment temperatures without bringing essential building elements to failure.

7.4.1.2 Quantity of Fuel

A major driver in the HRR of a fire is the amount and type of fuel. Cellulosic materials, such as paper, wood and cotton, typically burn more slowly and at lower temperatures than hydrocarbon fuels. However, it can be easier to control fire size and duration with hydrocarbon fuels, such as propane gas or liquid heptane, as opposed to cellulosic materials. For these tests, heptane was selected as a fuel, as the HRR could be controlled based on the surface area of the burning fuel, and the duration of burning could be controlled by the depth of the fuel, both of which could be controlled by using a pan configuration.

7.4.1.3 Ventilation Opening Factor

Another factor which affects HRR is the ventilation opening size in a fire compartment. If ventilation openings are too small, the fire size is limited by oxygen and self-extinguishment can occur (ventilation controlled). If the openings are too large relative to the fuel quantity, target compartment temperatures may not be achieved as the hot gas produced by the fire will be released through the opening.

7.4.1.4 Compartment Lining Factor

The boundary material of compartments also plays a role, as heat can be transferred through wall, ceiling and floor surfaces. If the material absorbs heat, the design fire size should be increased to account for this and still achieve target compartment temperatures.

7.4.2 Sizing the Heptane Pan Fire

Considering the focus of these tests being the post-earthquake condition of a building, in which one could reasonably expect fuel items are well spread over the floor area (e.g., papers, books, files, etc.), it was deemed reasonable to use multiple smaller pans to achieve the target fire size rather than one large pan. As noted above, the fire size and duration of a hydrocarbon liquid pool fire can be estimated (and controlled) based on the surface area of the pool (size) and the depth of fuel (duration). For these tests, heptane was selected as it was readily available and provided enough soot to visibly track smoke movement. Heptane pan fires are often used in control fire tests (e.g., see Effect of Fire Size on Suppression Characteristics of Halon Replacement Total-Flooding Systems, *Halon Options Technical Working Conference*, 2001). The design of the pans for this test series is described below.

7.4.2.1 Design Calculations

The HRR of a pool fire can be estimated from Eq. 7.1,

$$\text{Heat Release Rate: } \dot{Q} = \dot{m}''A\Delta h_c \qquad \text{Eq. 7.1}$$

with,

$$mass\ flux: \dot{m}'' = y\rho \qquad \text{Eq. 7.2}$$

where,

Δh_c = heat of combustion

$\mathrm{A} = \dfrac{volume\ of\ fuel}{fuel\ depth}$

ρ = density

y = velocity

From Figure 7.16 and Figure 7.17, about 540 kW (3.1×10^4BTU/min) fire can be achieved from each pan of 0.6m by 0.4m (2’ by 1.3’) pan. Expected flame height, which is the 50 % intermittency of flame tip, is about 2.3m (7.5’). This calculation is based on an open environment condition, which means that in a compartment condition, radiation from the hot gas layer will feed heat energy back to the fuel surface and increase the HRR accordingly.

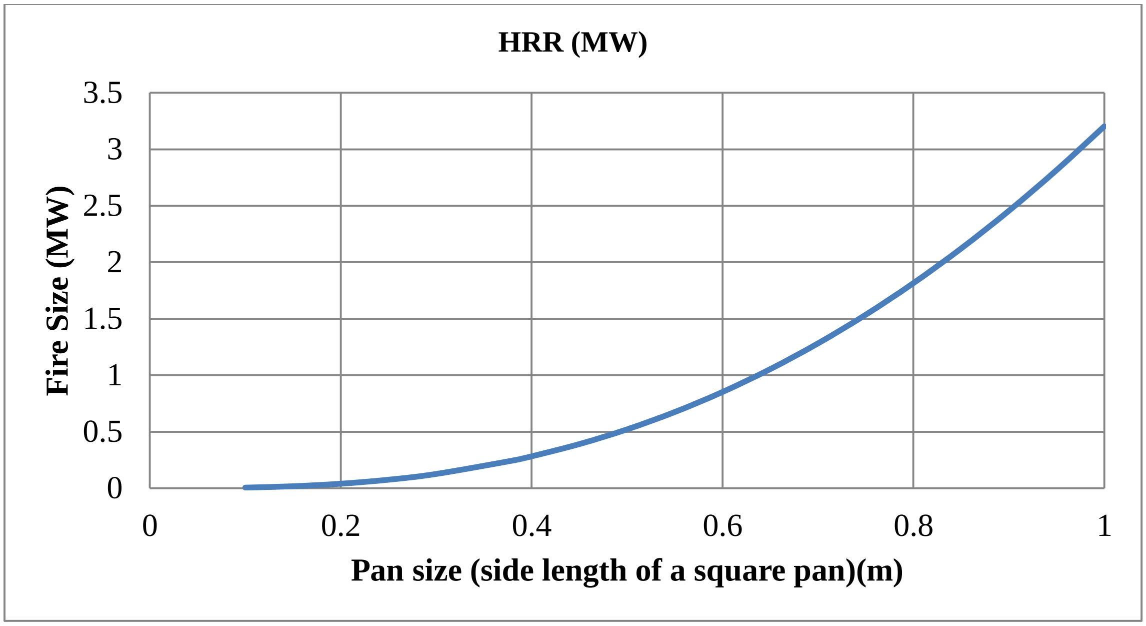

Figure 7.16. Fire size vs. pan size

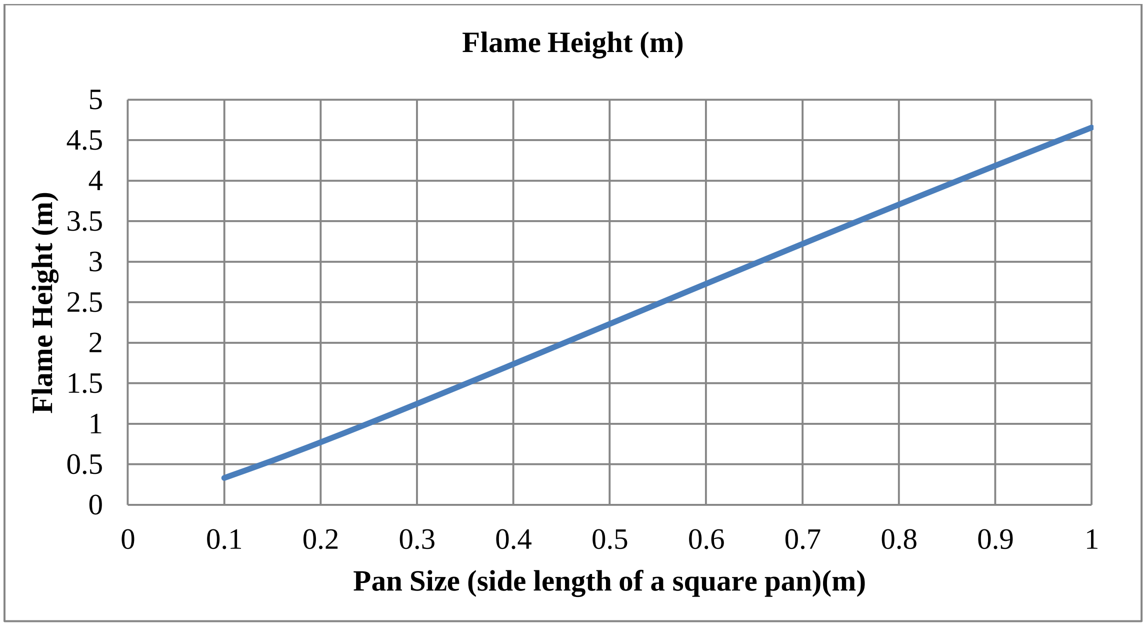

Figure 7.17. Flame height vs. pan size

The initial amount of heptane in the pan can be determined based on the test duration and regression rate of heptane shown in Figure 7.18. The burning time of heptane is shown in Figure 7.19. With a 0.6m by 0.4m (2' by 1.3') pool, and the regression rate of heptane is about 0.42cm/min (0.17"/min). Since the test duration is planned about 10 minutes, heptane of about 4.2cm (1.7") in height needs to be placed initially in a pool, which is about 11 liters (2.9gal). If one pan is used, the fire size will be about 540kW (3.1×10^4BTU/min). Two pans can be used to for about 1.1MW (6.3×10^4BTU/min).

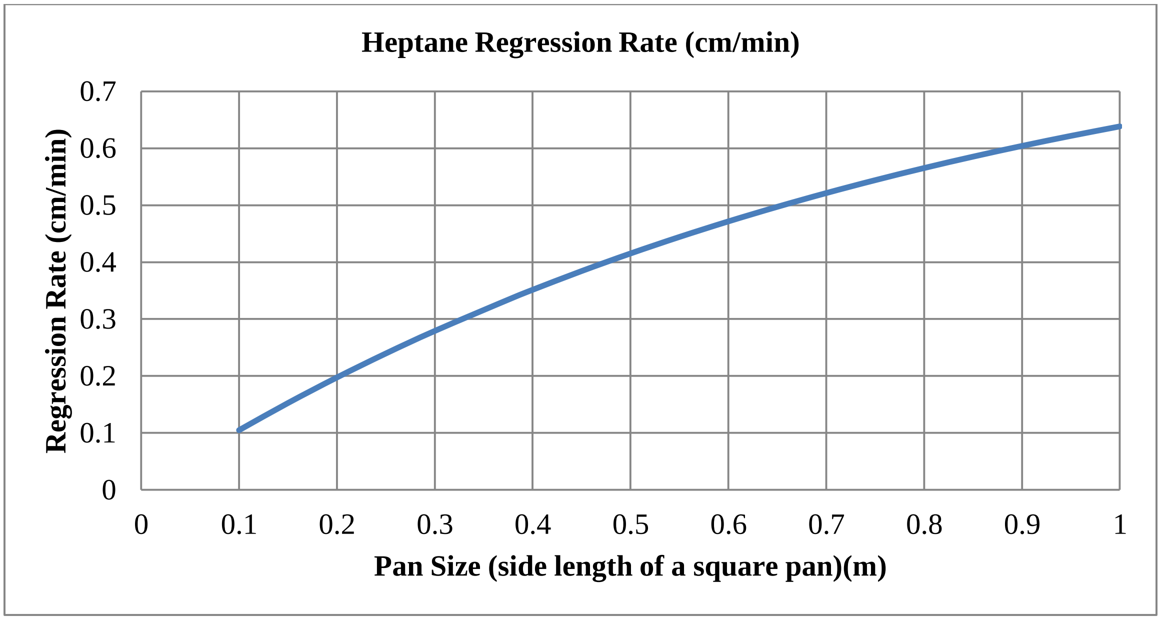

Figure 7.18. Heptane regression rate vs. pan size

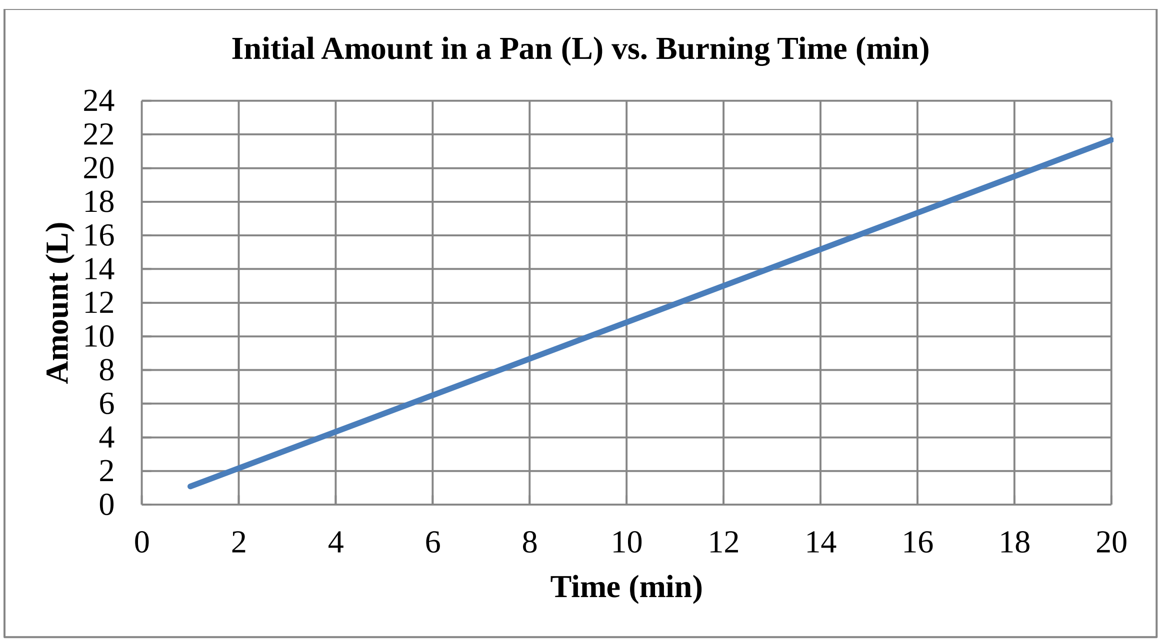

Figure 7.19. Initial amount of heptane vs. burning time

7.4.2.2 Confirmation by Experimental Results

As shown in Figure 7.20, with 9L (2.4gal) of heptane and 8L (2.1gal) of water in the retention pan, peak HRR was slightly less than 800 kW (4.6×10^4BTU/min), but average HRR was about 510kW (2.9×10^4BTU/min) with effective burning time of 9.5 minutes, which agrees well with the results of the design calculation. It is possible to burn the paper of gypsum wall board surface during fire tests, which provide additional heat release rate, especially for the tests with high HRR.

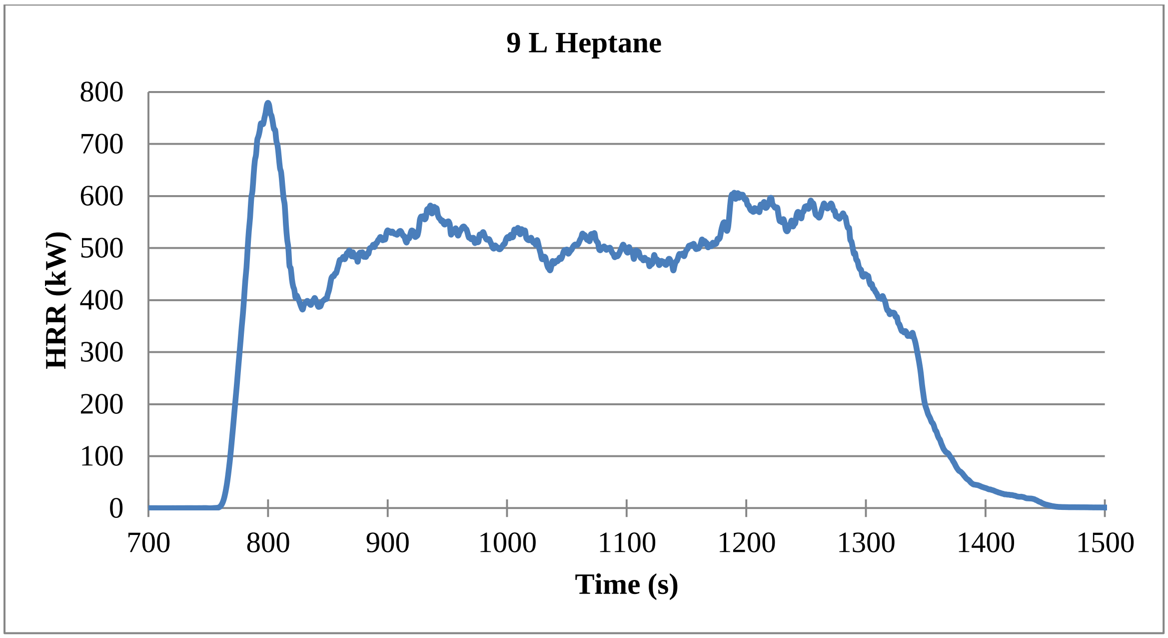

Figure 7.20. HRR of 9L heptane fires

7.4.2.3 Final Pan Configuration

The final design of a heptane pan and associated retention pan is shown in Figure 7.21. A retention pan is used to prevent further heptane fuel spread in case the heptane pan is physically damaged during fire tests. In addition, the retention pan contains water as a heat sink to prevent warp of the pan, which can cause uneven surface area of the heptane and possibly heptane spill over the pan due to warp. Ceramic fiber board is located between the heptane pan and retention pan to decrease any heat transfer between the pans.

By doing this, the retention pan does not cause any heat damage on the concrete floor. The actual design pan with the retention pan is shown in Figure 7.22.

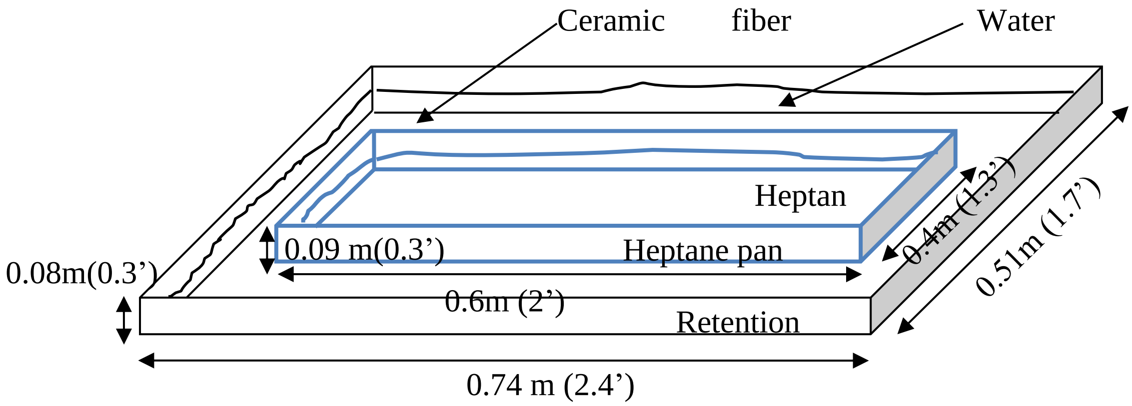

Figure 7.21. Heptane pan design

Figure 7.22. Actual heptane pans used for the fire tests

Given this pan configuration, with experimentally obtained HRR for the surface area, and burning time controlled by the depth of the heptane, source fires were designed for each burn area given the volume of the space, ventilation configuration and temperature and burning times that were targeted.

7.4.3 LBR-1 Fire Test

7.4.3.1 Purpose of Fire Test

The LBR-1 Fire Test was conducted to examine smoke spread between the LBR and SBR compartments and space above the ceiling and to check the functionality of fire systems after seismic motions. It was expected that with 8L (2.1gal) of heptane, the fire size would be sufficient enough to activate the fire door (Door 7) and sprinkler in the LBR. Since Door 1 will be open the entire test, sprinkler in the SBR will activate as well. The temperature data of the SBR area and space above the ceiling were collected to test compartmentation and use for modeling smoke leakage and its effect on fire development. With Windows 1 and 2 closed, it was expected that smoke would leak through the balloon frame of the building if gaps were created on the balloon frame through seismic tests. The testing conditions are shown in Figure 7.23.

7.4.3.2 Test Conditions

- Fuel. one pan with 8L (2.1gal) (2.25L was left after flame extinguished)
- Windows 1 and 2 were closed.
- Windows 3, 4, and 5 were left open.
- Doors 1, 7, 3, 5, 4 and 6 were left open
- Door 2 was closed.
- All the vents in the LBR and SBR were closed. All the vents in EL were open.
- Expected peak HRR: 300kW

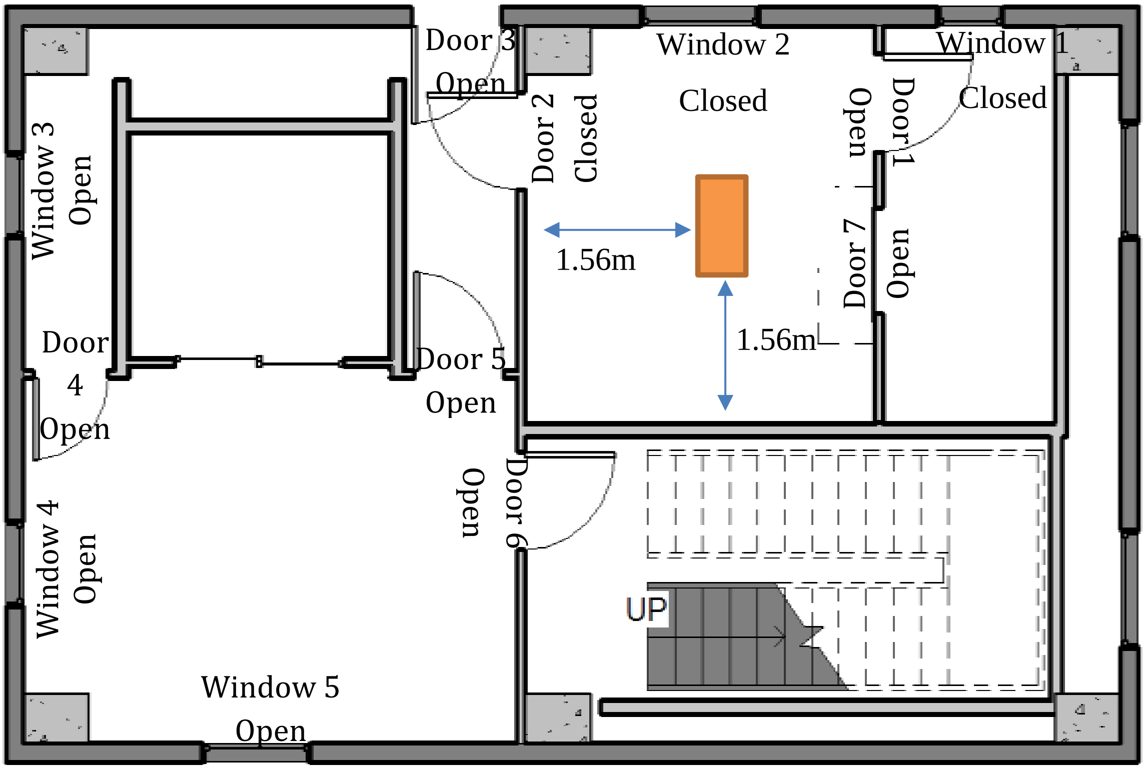

Figure 7.23. LBR-1 fire testing conditions

Figure 7.24 shows the actual setup of the pan and the thermocouple tree in the LBR area for the LBR-1 fire test. Figure 7.25 shows the window that was blocked off with wood panels. Figure 7.26 shows the vents in the ceiling that were blocked with ceramic fiber board. The edges of the window and the vents were sealed with fire caulking material.

Figure 7.24. Fuel pan and thermocouple tree setup for LBR-1 fire test

Figure 7.25. LBR window blocked with wood panel

Figure 7.26. LBR ceiling vents blocked with ceramic fiber board

7.4.4 SBR Fire Test

7.4.4.1 Purpose of Fire Test

The SBR Fire Test was conducted to examine smoke spread between the LBR and SBR compartments and space above the ceiling and to check the functionality of fire systems after seismic motions. It was expected that during the LBR-1 fire test, the fire door (Door 7) and sprinklers in the LBR and SBR would activate. The sprinkler system will be recharged after the LBR-1 but if the fire door is activated during the LBR-1 fire test, it will remain closed during the SBR fire test. The temperature data of the SBR area and space above the ceiling were collected to test compartmentation and use for modeling smoke leakage and its effect on fire development. It was expected that if gaps were formed during the seismic tests, smoke leak would be visible via the gaps formed between the partition wall and the north wall of the building since Door 1 and 7 will remain closed. With Windows 1 and 2 closed, it was expected that smoke would leak through the balloon frame of the building if gaps were created on the balloon frame through seismic tests. The testing conditions are shown in Figure 7.27.

7.4.4.2 Test Conditions

- Fuel. one pan with 3 L (0.8 gal) (0.25 L left after flame is out)
- Windows 1 and 2 were closed.
- Windows 2, 3, 4, and 5 were open.
- Door 1 was naturally closed by the door closure after ignition with some gaps formed by seismic motion tests. Door 7 was closed after LBR-1 fire test.
- Doors 2, 3, 4, 5 and 6 were open.
- All the vents in the LBR and SBR were closed. All the vents in EL were open.
- Expected peak HRR.: 150kW

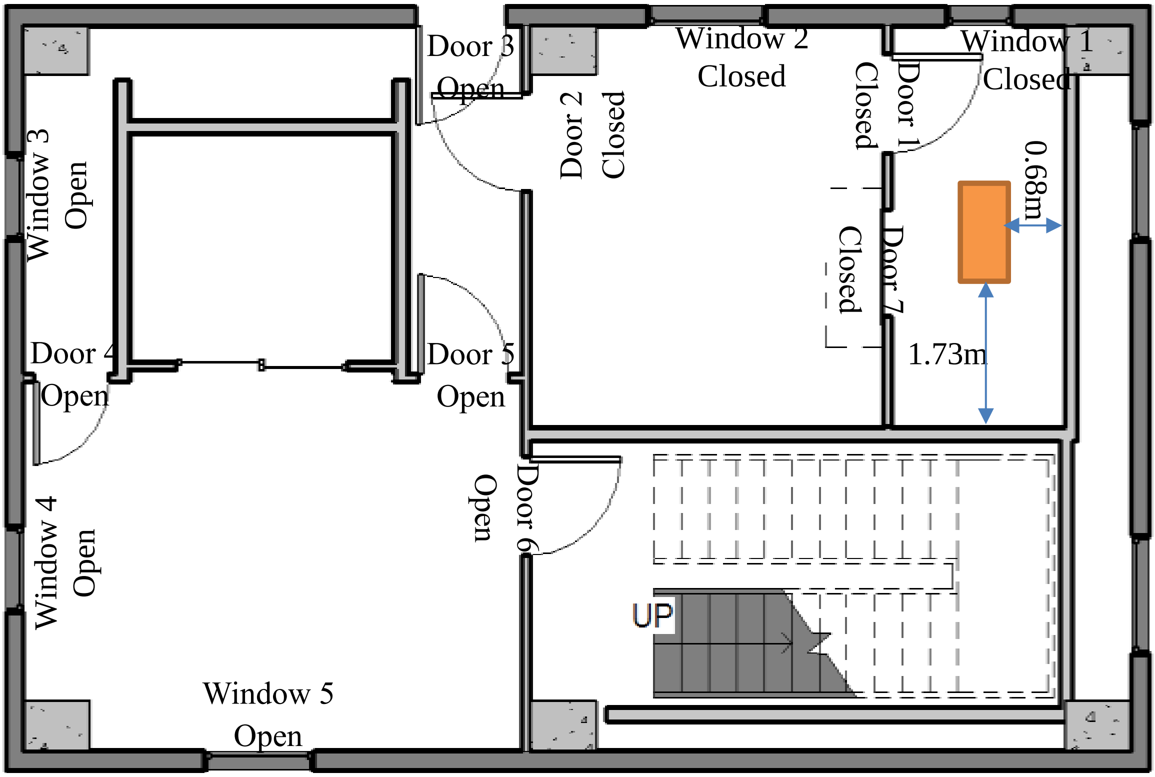

Figure 7.27. SBR fire testing conditions

Figure 7.28 shows the fuel pan and thermocouple tree setup in the SBR are for the SBR fire test. Figure 7.29 shows the SBR window that was blocked with wood panel. Figure 7.30 shows the ceiling vents blocked with ceramic fiber board. The edges of the window and the vents were sealed with fire caulking material.

Figure 7.28. Fuel pan and thermocouple tree setup in the SBR

Figure 7.29. SBR window blocked with wood panel

Figure 7.30. SBR ceiling vent blocked with ceramic fiber board

7.4.5 LBR-2 Fire Test

7.4.5.1 Purpose of Fire Test

The LBR-2 Fire Test was conducted to examine smoke spread between the LBR and SBR compartments and space above the ceiling and to check the functionality of fire systems after seismic motions. It was expected that with two pans with 8 L (2.1 gal.) of heptane each, the fire size would be sufficient enough to activate the fire door (Door 7) and sprinkler in the LBR and the SBR. The temperature data of the SBR area and space above the ceiling were collected to test compartmentation and use for modeling smoke leakage and its effect on fire development. Also, temperature data in both HVAC ducts was measured to determine if dampers were activated. It was expected that with 16 L (4.2 gal.) of heptane and Windows 1 and 2 open to provide ventilation, flashover phenomena could occur during the test. The testing conditions are shown in Figure 7.31

7.4.5.2 Test Conditions

- Fuel: two pans with 8 L (2.1 gal.) of heptane each
- Windows 1, 2, 3, 4, and 5 were open.
- Door 1 was naturally closed by the door closure and Door 2 was closed.
- Doors 3, 4, 5 and 6 and 7 were open.
- All the vents in the LBR, SBR and EL were open.
- Expected peak HRR.: 800kW

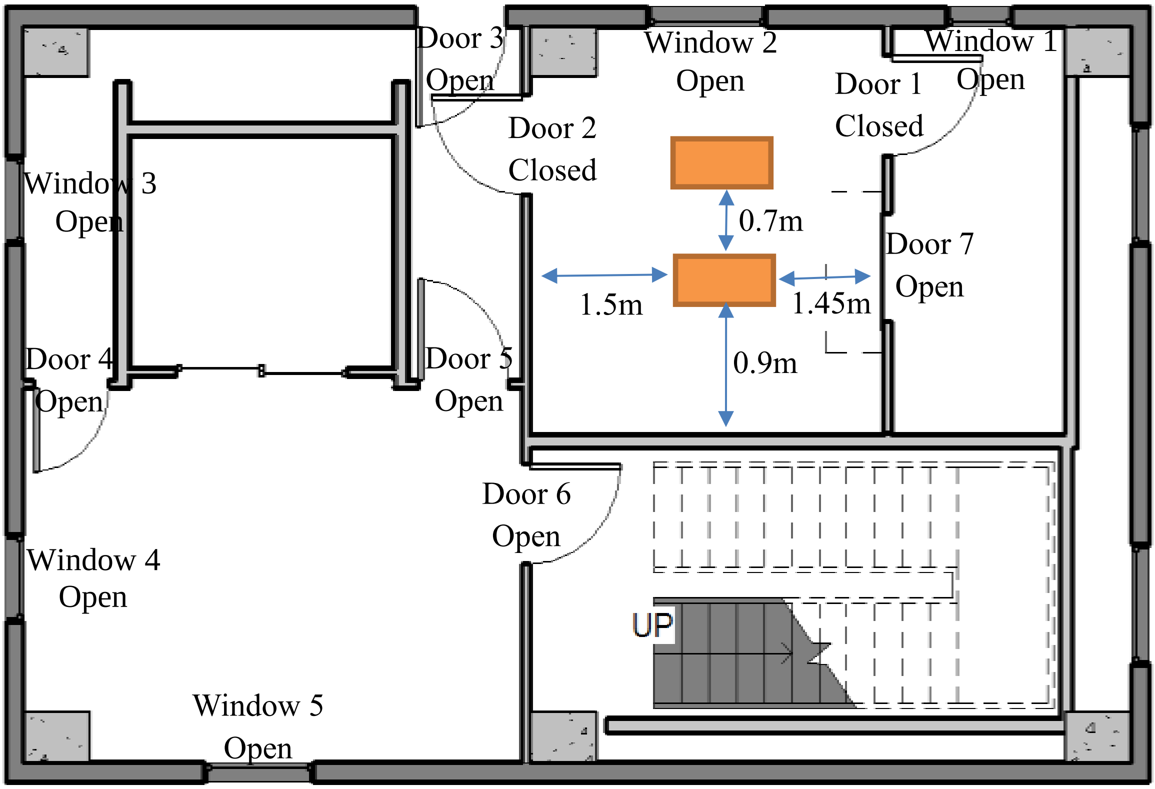

Figure 7.31. LBR-2 fire testing conditions

Figure 7.32 shows the fuel pans and thermocouple tree setup in the LBR for the LBR-2 fire test. The LBR window was opened up and thermocouple trees were placed through the window as shown in Figure 7.33

Figure 7.32. Fuel pans and thermocouple tree setup in the LBR

Figure 7.33. Thermocouple trees installed on the LBR window

7.4.6 ES Fire Test

7.4.6.1 Purpose of Fire Test

The ES Fire Test was conducted to examine smoke spread between the vertical and horizontal penetrations around the ES area. Temperature data and video recordings were collected to see if smoke leaked through the vertical firestops or the firestops activated on the north and west side of the ES. The concrete surface temperature was measured to see how much increase in temperature occurred. 4th floor vent temperature data and video footage data were recorded to see if any smoke comes out from any possible duct damage. Temperature data and video recordings were collected to see if the firestops activated or smoke leaked through the horizontal firestops on the wall between the corridor and the LBR and between the corridor and the EL. The testing conditions are shown in Figure 7.34.

7.4.6.2 Test Conditions

- Fuel: two pans with 8 L (2.1 gal.) each.
- Windows 1, 2, 3, 4 and 5 were open.
- ES side of Door 5 and Door 2 were protected with ceramic fiber blanket.
- Door 3 was partially open with a brick used as a holder. Door 6 was open.
- Door 1, 4 and 5 were closed. Door 7 was closed during the LBR-2 test.
- All the vents in the LBR and SBR were open. All the vents in EL were open.
- Expected peak HRR: 700kW.

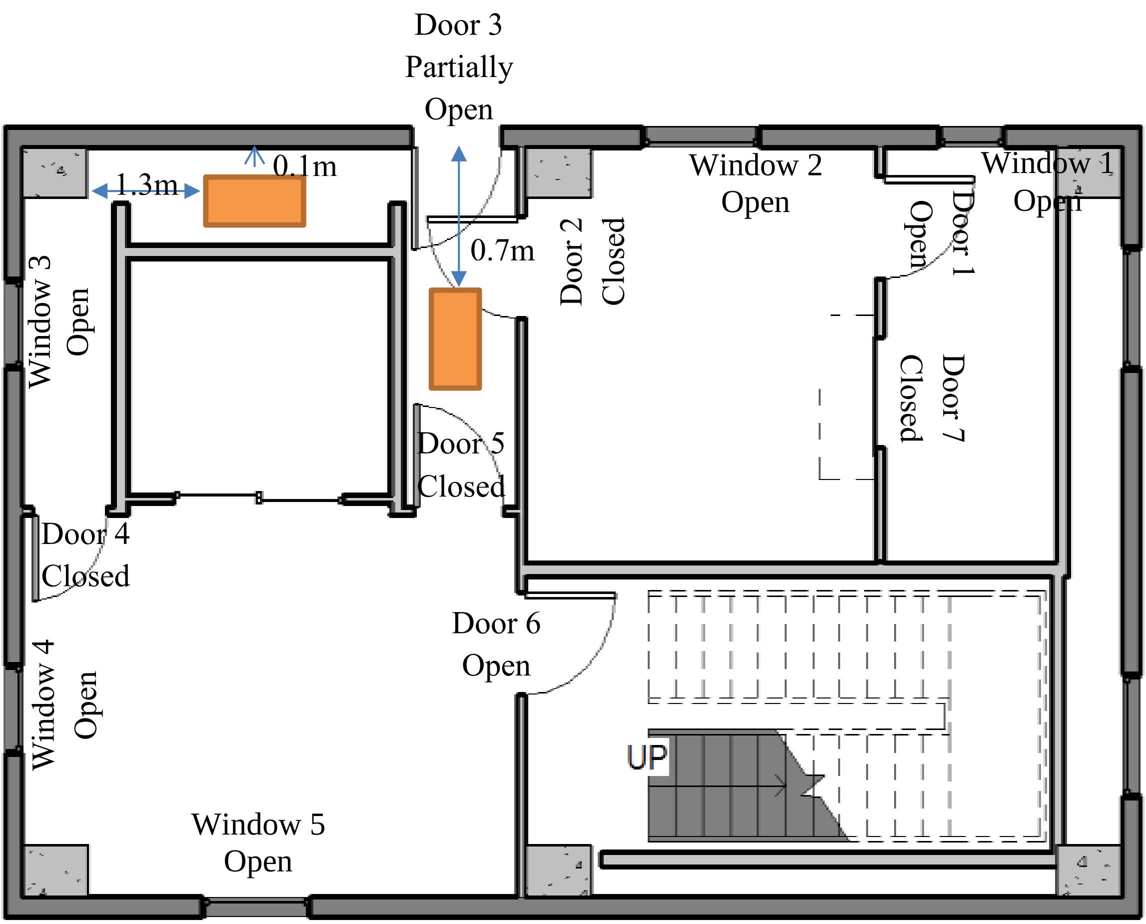

Figure 7.34. ES fire testing conditions

Figure 7.35 shows the fuel pan setup on the north side of the elevator shaft for the ES fire test. Figure 7.36 shows the fuel pan and thermocouple tree set up in the corridor area.

Figure 7.35. Fuel pan setup in the space north of the elevator shaft

Figure 7.36. Fuel pan and thermocouple tree setup in the corridor area

7.4.7 EL-1 Fire Test

7.4.7.1 Purpose of Fire Test

The EL-1 fire test was conducted to see the effect of fire on the elevator shaft with the elevator shaft door being damaged. TC tree was installed inside the elevator shaft to record temperature data inside the shaft. Also video camera was installed inside the shaft to see smoke spread and flame extensions. The temperature above the ceiling space was measured with two TC trees to see for any temperature increase in the space. The testing conditions are shown in Figure 7.37.

7.4.7.2 Testing Conditions

- Fuel: three pans with 8 L (2.1gal.) each
- Window 4 and 5 were partially open
- Window 1, 2, and 3 were open.
- Door 4, 5 and 6 were closed with ceramic blanket protection.
- Door 1 and door 2 were closed.
- Door 3 was open.
- All the vents in the LBR and SBR were open. All the vents in EL were closed.
- Expected peak HRR: 1400kW.

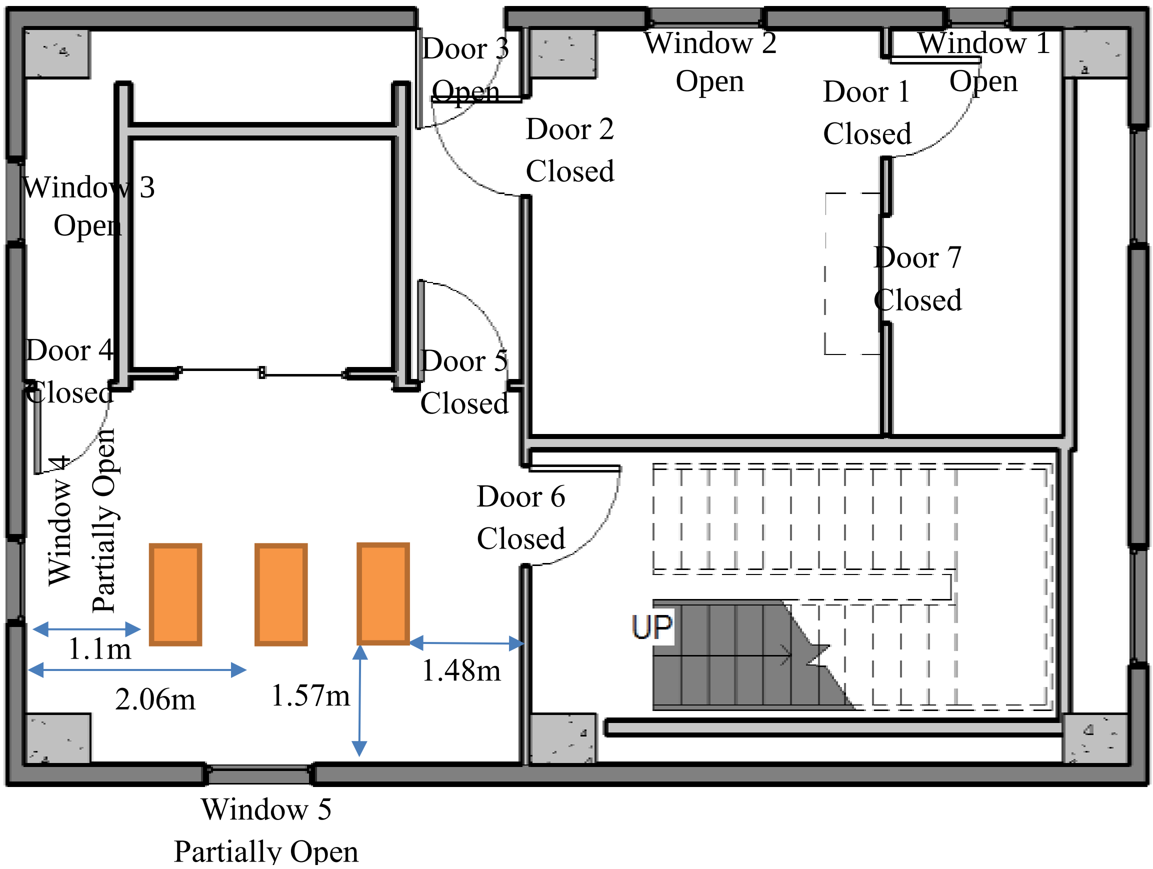

Figure 7.37. EL-1 fire testing conditions

Figure 7.38 shows the setup of the fuel pans and thermocouple trees in the EL for the EL-1 fire test. Figure 7.39 shows both the EL windows that were partially blocked with wood panels.

Figure 7.38. Setup of fuel pans and thermocouple trees in the EL

Figure 7.39. EL windows blocked with wood panels

7.4.8 EL-2 Fire Test

7.4.8.1 Purpose of Fire Test

The EL-2 fire test was conducted to see the effect of fire on the elevator shaft with the elevator shaft door being damaged. TC tree was installed inside the elevator shaft to record temperature data inside the shaft. Also video camera was installed inside the shaft to see smoke spread and flame extensions. The temperature above the ceiling space was measured with two TC trees to see for any temperature increase in the space. A portion of the ceiling near the vertical firestops above the ceiling was cut out to expose the firestops to the fire directly in attempts to activate the vertical firestops. The testing conditions are shown in Figure 7.40.

7.4.8.2 Test Conditions

- Fuel: three pans with 8 L (2.1 gal.) each
- Window 1, 2, 3, 4 and 5 were open
- Door 4, 5 and 6 were closed with ceramic blanket protection.
- Door 1 and door 2 were closed.
- Door 3 was open.
- All the vents in the LBR and SBR were open. All the vents in EL were open, and a small portion of the ceiling was cut open around the SW corner of the EL
- Expected peak HRR: 1800kW

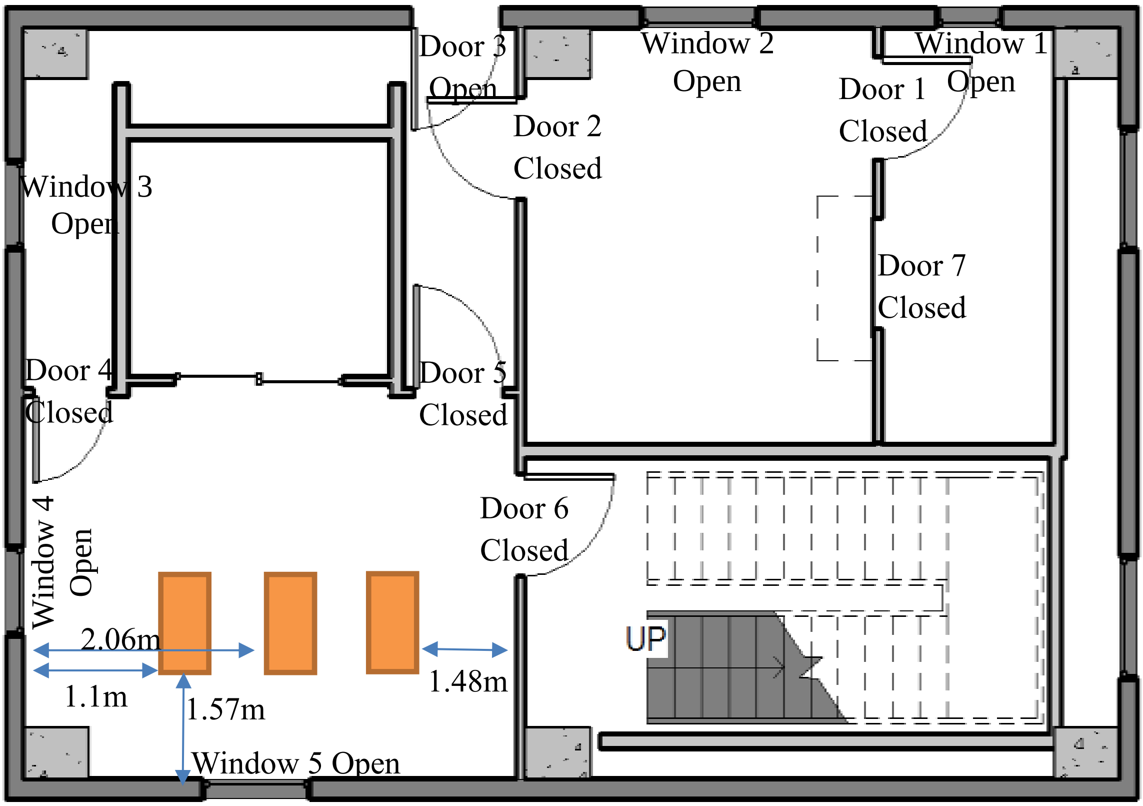

Figure 7.40. EL-2 fire testing conditions

Figure 7.41 shows the setup of the fuel pans and the thermocouple trees in the EL are for the EL-2 fire test. Figure 7.42 shows the portion of the ceiling that was cut out on the southwest corner adjacent to the access panel.

Figure 7.41. Setup of the fuel pans and thermocouple trees in the EL

Figure 7.42. Portion of the ceiling cut off adjacent to the access panel

8 FIRE TEST DATA

This chapter summarizes data collected during the fire tests. See Appendix C for more details.

8.1 LBR-1 FIRE TEST TEMPERATURES

8.1.1 Thermocouple Trees

Figure 8.1 shows the TC trees that were placed in the LBR and the SBR. Figure 8.2 shows the TC trees that were placed above the ceiling of the LBR and SBR.

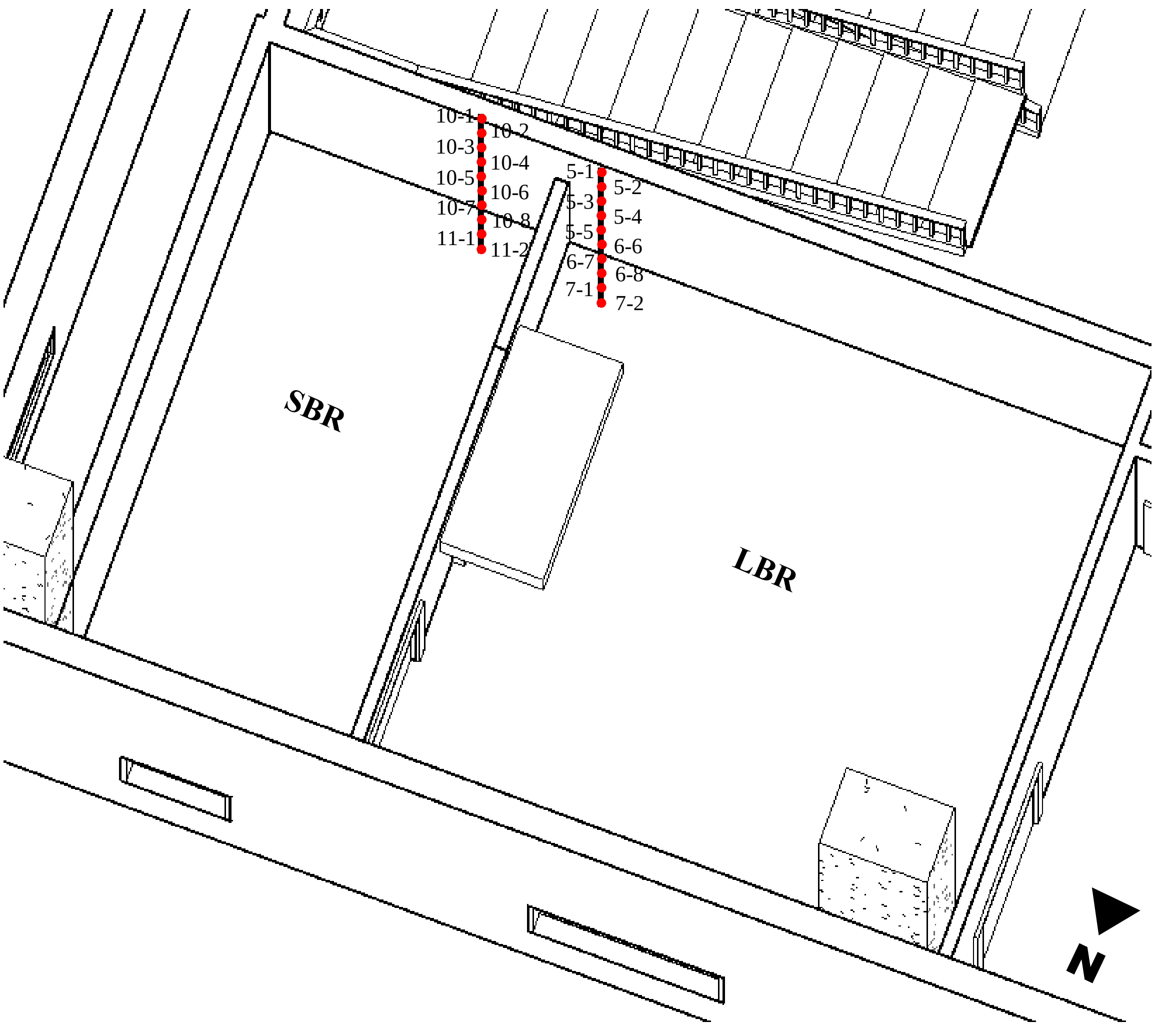

Figure 8.1. TC Trees in the SBR and LBR

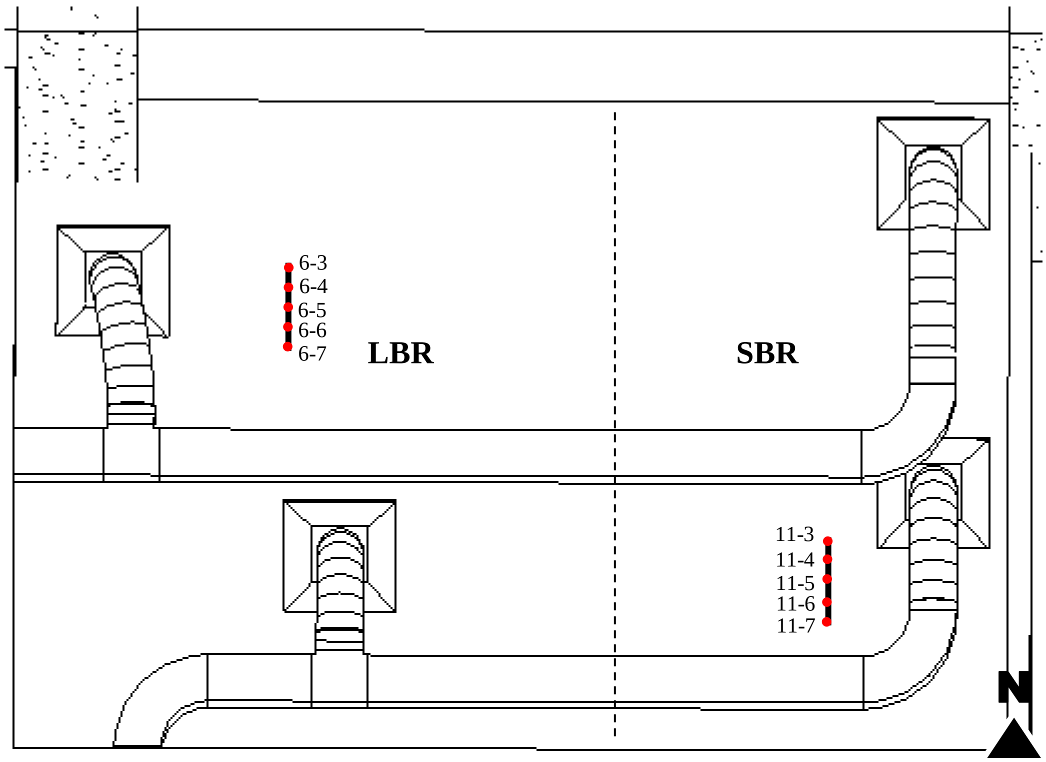

Figure 8.2. TC trees above ceiling of LBR and SBR

Figure 8.3 shows the temperatures recorded by the thermocouple trees in the LBR and space above the LBR ceiling. The thermocouple location details are listed in Table 8.1. The condition of the LBR after the LBR-1 fire test is shown in Figure 8.4.

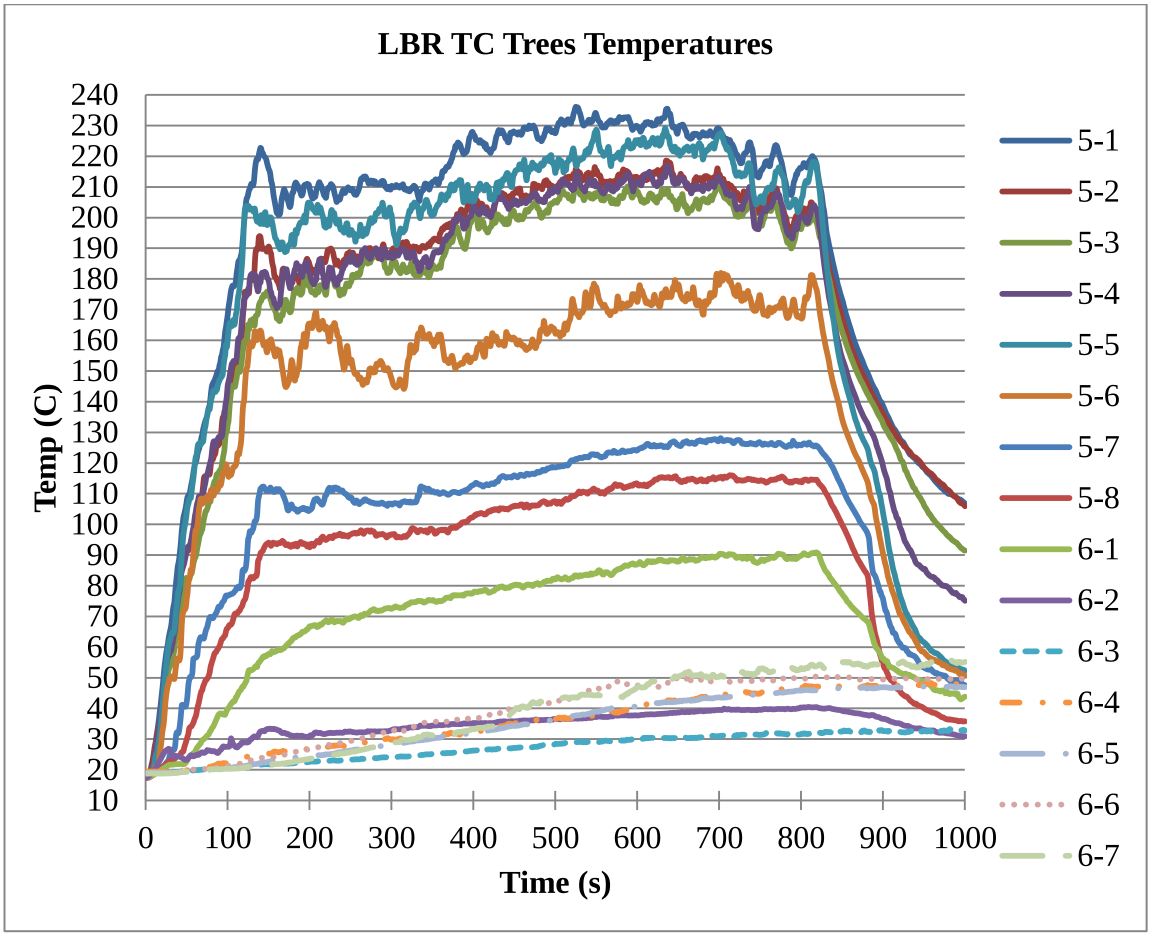

Figure 8.3. LBR and space above LBR ceiling temperatures

Table 8.1. LBR TC trees list

<table>
<tr><td>5-1</td><td rowspan="10">TC tree below ceiling of LBR starting with 6-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 5-1 on top at 2.7m (8.9ft)</td></tr>
<tr><td>5-2</td></tr>
<tr><td>5-3</td></tr>
<tr><td>5-4</td></tr>
<tr><td>5-5</td></tr>
<tr><td>5-6</td></tr>
<tr><td>5-7</td></tr>
<tr><td>5-8</td></tr>
<tr><td>6-1</td></tr>
<tr><td>6-2</td></tr>
<tr><td>6-3</td><td rowspan="5">TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top</td></tr>
<tr><td>6-4</td></tr>
<tr><td>6-5</td></tr>
<tr><td>6-6</td></tr>
<tr><td>6-7</td></tr>
</table>

Figure 8.4. LBR after LBR-1 fire test

Figure 8.5 shows the temperatures recorded by the thermocouple trees in the SBR and space above the SBR ceiling. The thermocouple location details are listed in Table 8.2.

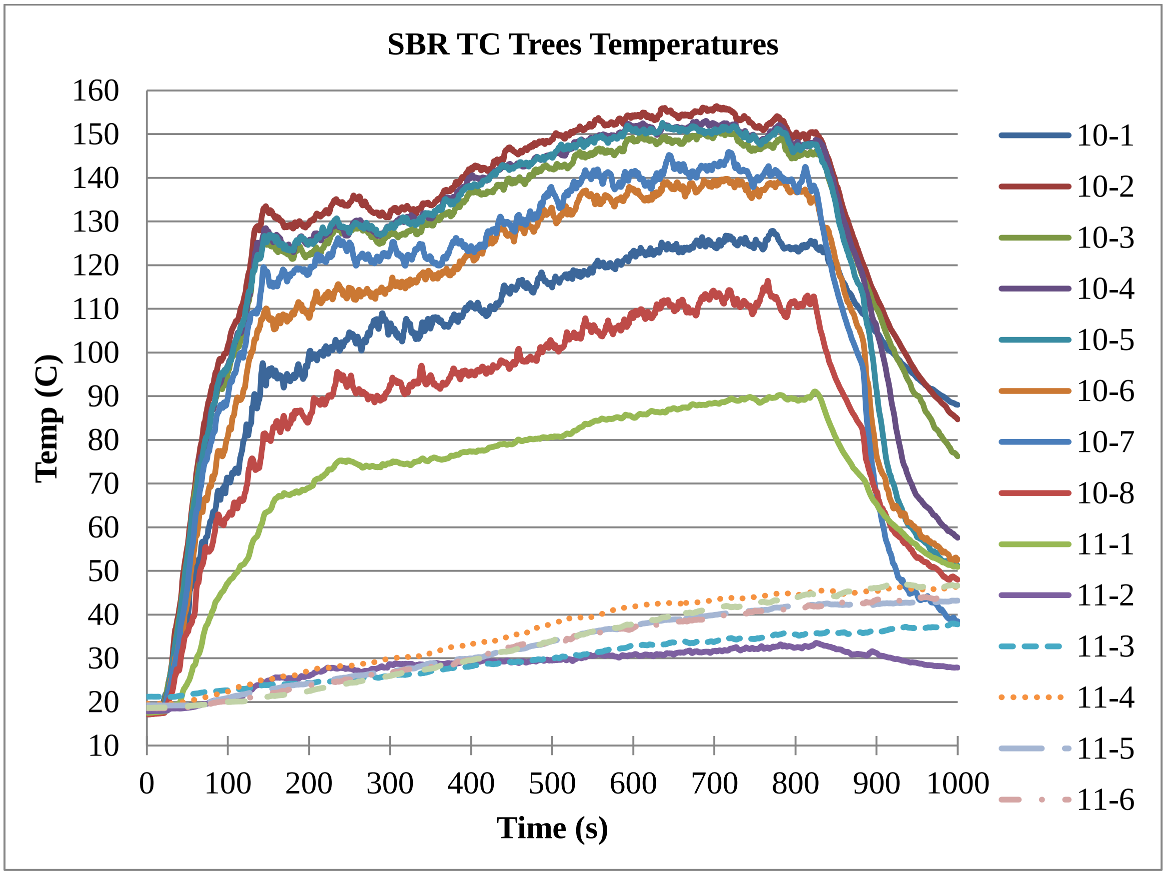

Figure 8.5. SBR and space above SBR ceiling temperatures

Table 8.2. SBR TC trees list

<table>
<tr><td>10-1</td><td rowspan="10">TC tree below ceiling of LBR starting with 11-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 10-1 on top at 2.7m (8.9ft)</td></tr>
<tr><td>10-2</td></tr>
<tr><td>10-3</td></tr>
<tr><td>10-4</td></tr>
<tr><td>10-5</td></tr>
<tr><td>10-6</td></tr>
<tr><td>10-7</td></tr>
<tr><td>10-8</td></tr>
<tr><td>11-1</td></tr>
<tr><td>11-2</td></tr>
<tr><td>11-3</td><td rowspan="5">TC tree hanging from 4th floor slab above ceiling of LBR starting with 11-7 right above ceiling and increasing in 0.3m (1ft) increments to 11-3 being on top</td></tr>
<tr><td>11-4</td></tr>
<tr><td>11-5</td></tr>
<tr><td>11-6</td></tr>
<tr><td>11-7</td></tr>
</table>

The SBR temperature increased via smoke spread through openings and the temperature was high enough to melt smoke detector 10 and the plastic cover of the SBR lighting fixture as shown in Figure 8.6. Figure 8.7 shows soot that was produced on the LBR northwest column as a result of the LBR-1 fire test. Figure 8.8 shows the north wall in the space above the ceiling with soot at locations where smoke leaked. Figure 8.9 substantiates for smoke spread to the SBR compartment through these openings.

Figure 8.6. SBR after LBR-1 fire test

Figure 8.7. LBR northwest column after LBR-1 fire test

Figure 8.8. Space above LBR ceiling after LBR-1 fire test

Figure 8.9. Partition wall gap after LBR-1 fire test

Figure 8.10. South wall of the SBR after the LBR-1 fire test

8.1.2 Active Fire Systems Activation Analysis

Figure 8.11 shows the temperatures of the fire door and the SBR sprinkler. The SBR sprinkler activated at 66 seconds at 109 ^oC (228 ^oF), as Figure 8.13 shows the activated sprinkler head. The fire door activated at 79 seconds at 108 ^oC (226 ^oF), as Figure 8.12 shows the fusible link melted and the fire door rolled down automatically. The thermocouple locations are listed in details in Table 8.3. There was no data available on the LBR sprinkler as the thermocouple malfunctioned during the test, but post-test visual inspection confirmed that the LBR sprinkler head activated during the LBR-1 fire test as shown in Figure 8.14.

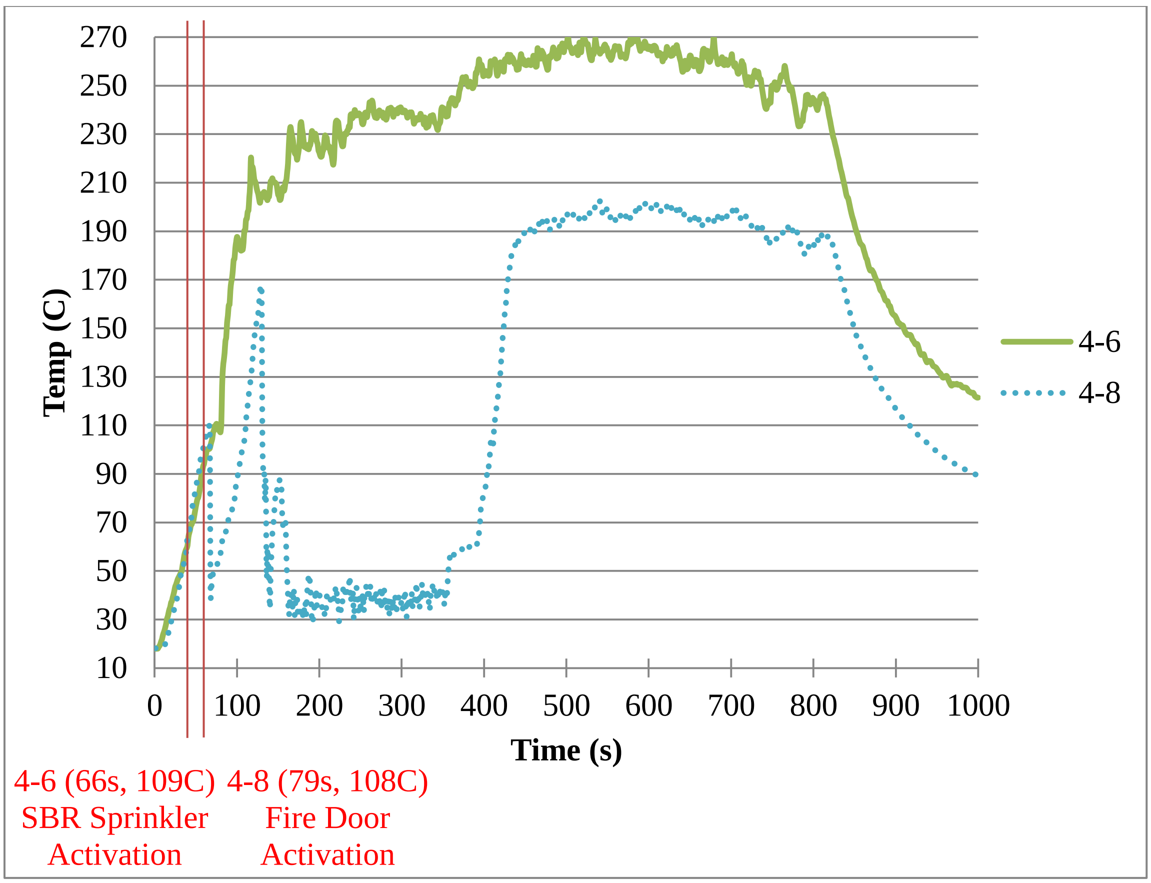

Figure 8.11. Temperatures of fire door and SBR sprinkler

Table 8.3. Fire door and SBR sprinkler TC list

4-6	(s) Fusible link of fire door, 1.5m (4.9') from N wall, 0.24m (0.8') below ceiling
4-7	(s) sprinkler head fusible link in the LBR, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor ***(NO DATA, TC Malfunctioned)***
4-8	(s) sprinkler head fusible link in the SBR, 1.3m (4.3') from N wall 1.4m (4.6') from W wall, 2.8m (9.2') above floor

Figure 8.12. Fire door activation during LBR-1 fire test

Figure 8.13. SBR sprinkler activation during LBR-1 fire test

Figure 8.14. LBR sprinkler activation during LBR-1 fire test

8.2 SBR FIRE TEST TEMPERATURES

8.2.1 Thermocouple Trees

Figure 8.15 shows the TC trees that were placed in the LBR and the SBR. Figure 8.16 shows the TC trees that were placed above the ceiling of the LBR and SBR.

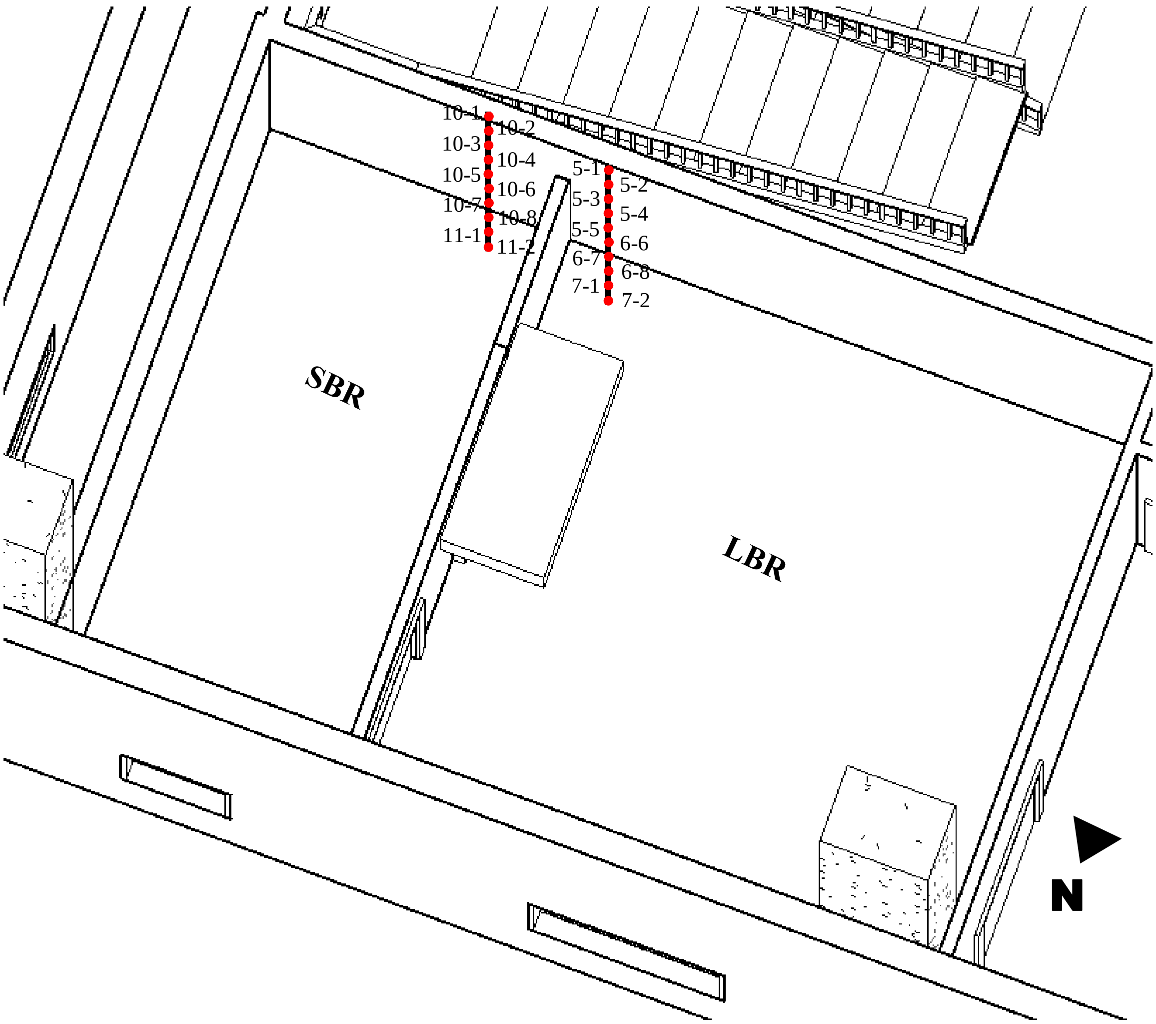

Figure 8.15. TC Trees in the SBR and LBR

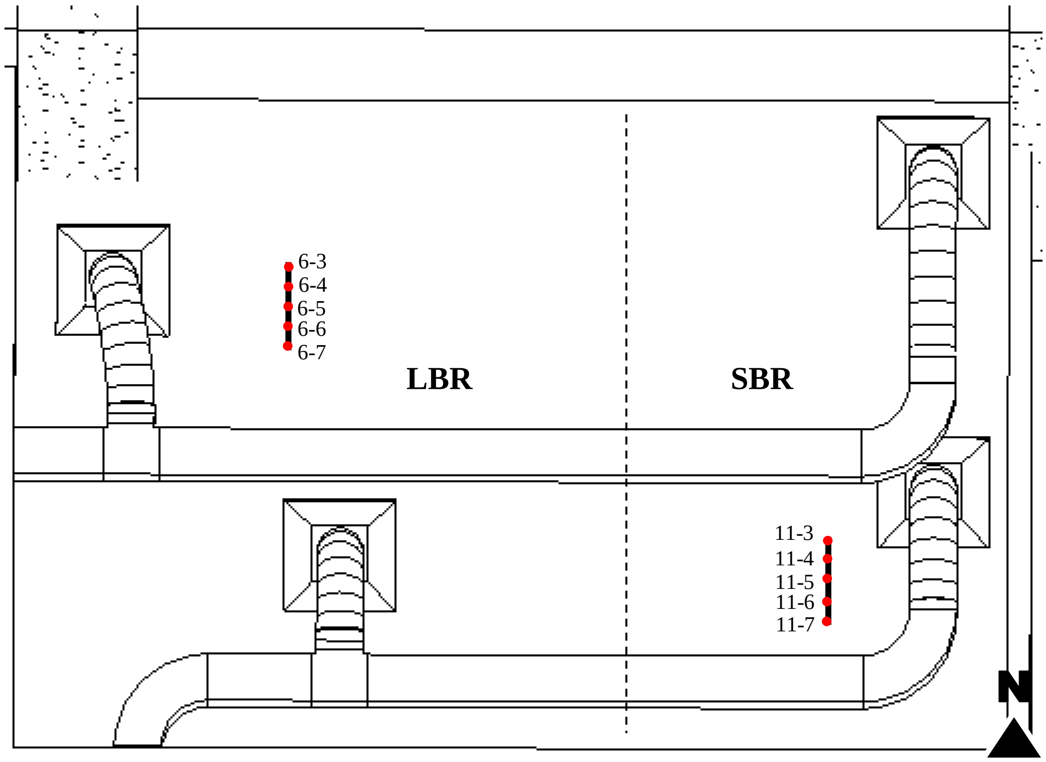

Figure 8.16. TC trees above ceiling of LBR and SBR

Figure 8.17 shows the temperatures recorded by the thermocouple trees in the SBR and space above the SBR ceiling. The thermocouple location details are listed in Table 8.4. It is seen from the overall view of the SBR in Figure 8.18, that due to limited ventilation, the fire extinguished before all the heptane fuel was used up with a portion of the heptane fuel remaining in the pan.

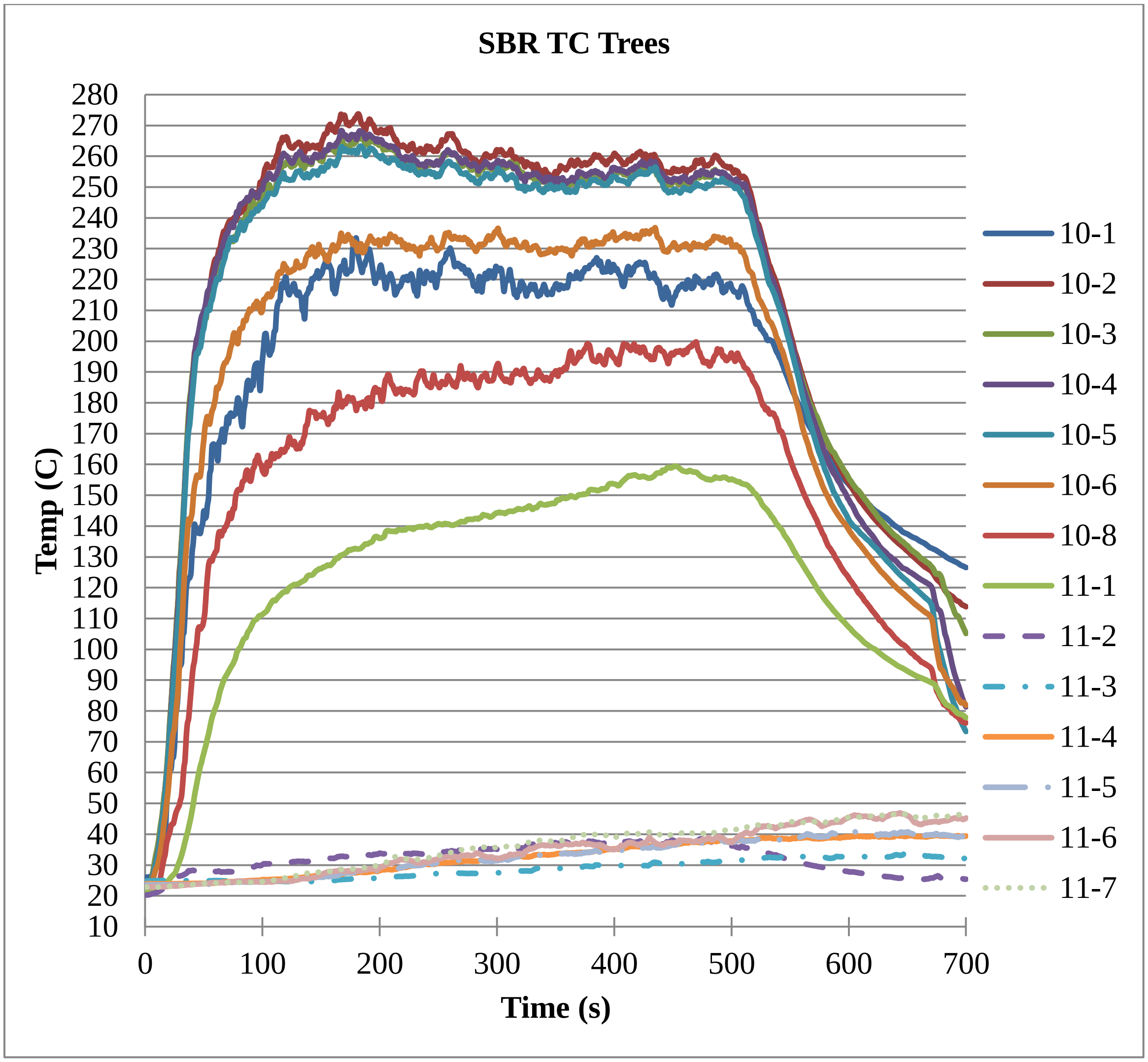

Figure 8.17. SBR and space above SBR ceiling temperatures

Table 8.4. SBR TC trees list

10-1	TC tree below ceiling of LBR starting with 11-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 10-1 on top at 2.7m (8.9ft)
10-2	
10-3	
10-4	
10-5	
10-6	
10-7	
10-8	
11-1	
11-2	
11-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 11-7 right above ceiling and increasing in 0.3m (1ft) increments to 11-3 being on top
11-4	
11-5	
11-6	
11-7	

Figure 8.18. SBR after SBR fire test

Figure 8.19 shows the temperatures recorded by the thermocouple trees in the LBR and space above the LBR ceiling. The thermocouple location details are listed in Table 8.5.

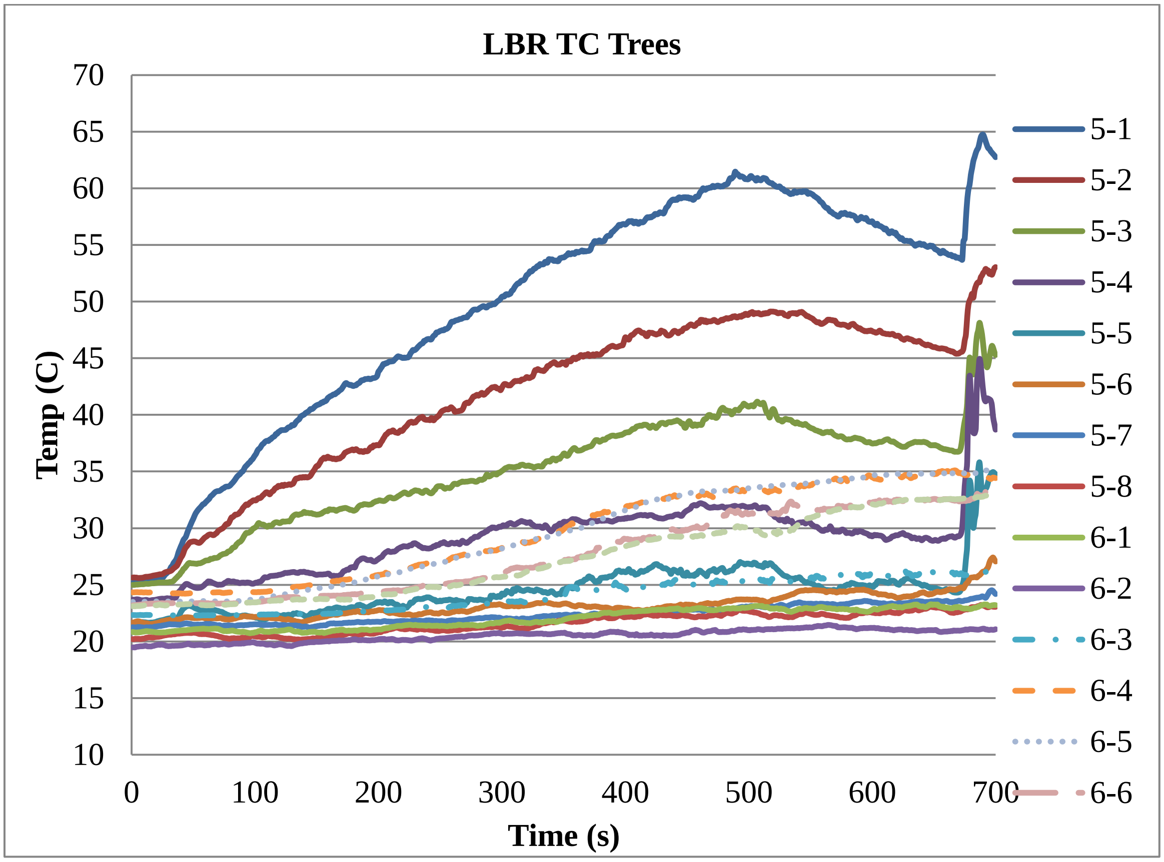

Figure 8.19. LBR and space above LBR ceiling temperatures

Table 8.5. LBR TC trees list

<table>
<tr><td>5-1</td><td rowspan="10">TC tree below ceiling of LBR starting with 6-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 5-1 on top at 2.7m (8.9ft)</td></tr>
<tr><td>5-2</td></tr>
<tr><td>5-3</td></tr>
<tr><td>5-4</td></tr>
<tr><td>5-5</td></tr>
<tr><td>5-6</td></tr>
<tr><td>5-7</td></tr>
<tr><td>5-8</td></tr>
<tr><td>6-1</td></tr>
<tr><td>6-2</td></tr>
<tr><td>6-3</td><td rowspan="5">TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top</td></tr>
<tr><td>6-4</td></tr>
<tr><td>6-5</td></tr>
<tr><td>6-6</td></tr>
<tr><td>6-7</td></tr>
</table>

Figure 8.20 shows soot on the northeast corner above the ceiling of the SBR as openings allowed for smoke leak. A ‘V’ shape soot pattern was produced as shown in Figure 8.21, on the northeast corner of the LBR as the smoke leaked through the partition wall to the LBR.

Figure 8.20. Northeast corner in space above SBR ceiling after SBR fire test

Figure 8.21. Partition wall gap after SBR fire test

8.2.2 Active Fire Systems Activation

Figure 8.22 shows the temperature of the SBR sprinkler. The graph indicates the SBR sprinkler activated at 21 seconds at 100C (212F). Although thermocouple 4-7 malfunctioned, post fire test visual inspection revealed the LBR sprinkler did not activate as shown in Figure 8.23. The thermocouple locations can be seen on Figure 6.32. The thermocouple location is listed in detail in Table 8.6.

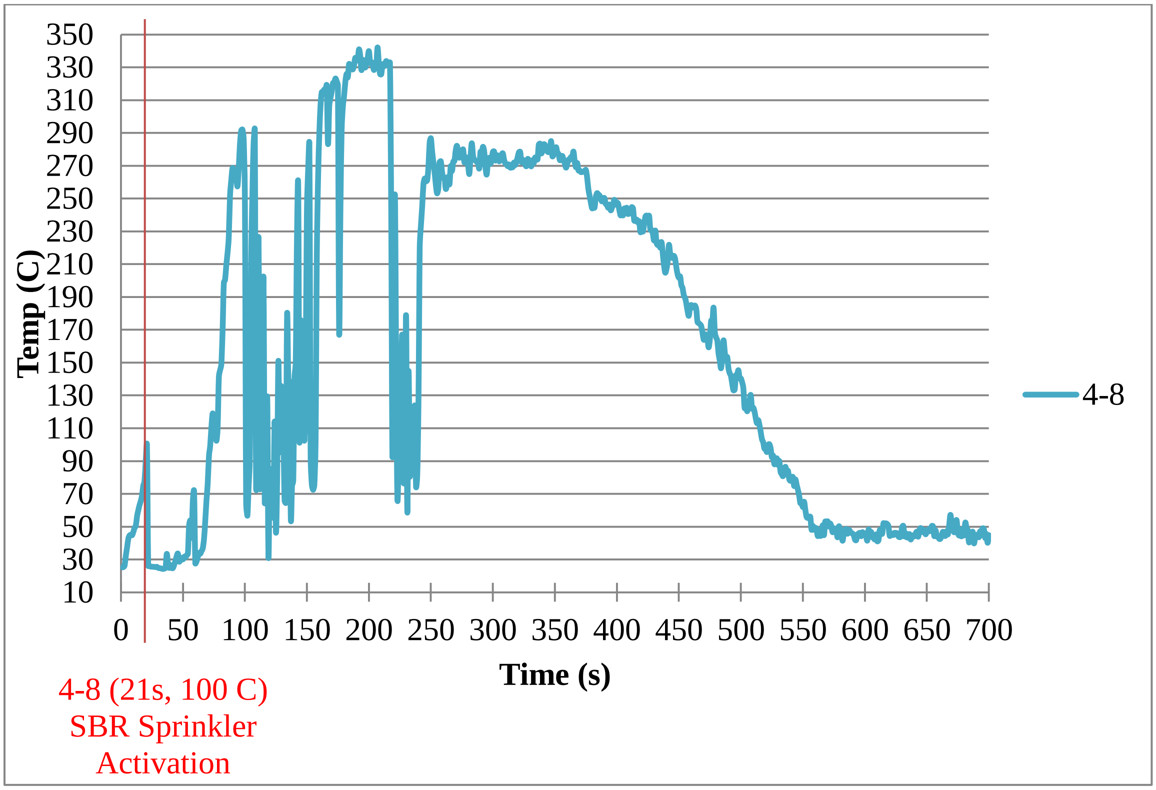

Figure 8.22. SBR sprinkler temperatures

Table 8.6. SBR and LBR sprinkler TC list

4-7	(s) sprinkler head fusible link in the LBR, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor ***(NO DATA, TC Malfunctioned)***
4-8	(s) sprinkler head fusible link in the SBR, 1.3m (4.3') from N wall 1.4m (4.6') from W wall, 2.8m (9.2') above floor

Figure 8.23. LBR sprinkler head after SBR fire test

8.3 LBR FIRE TEST 2 TEMPERATURES

8.3.1 LBR Thermocouple Tree

Figure 8.24 shows the thermocouple tree located inside the LBR and Figure 8.25 shows the thermocouple tree located above the SBR and LBR ceiling.

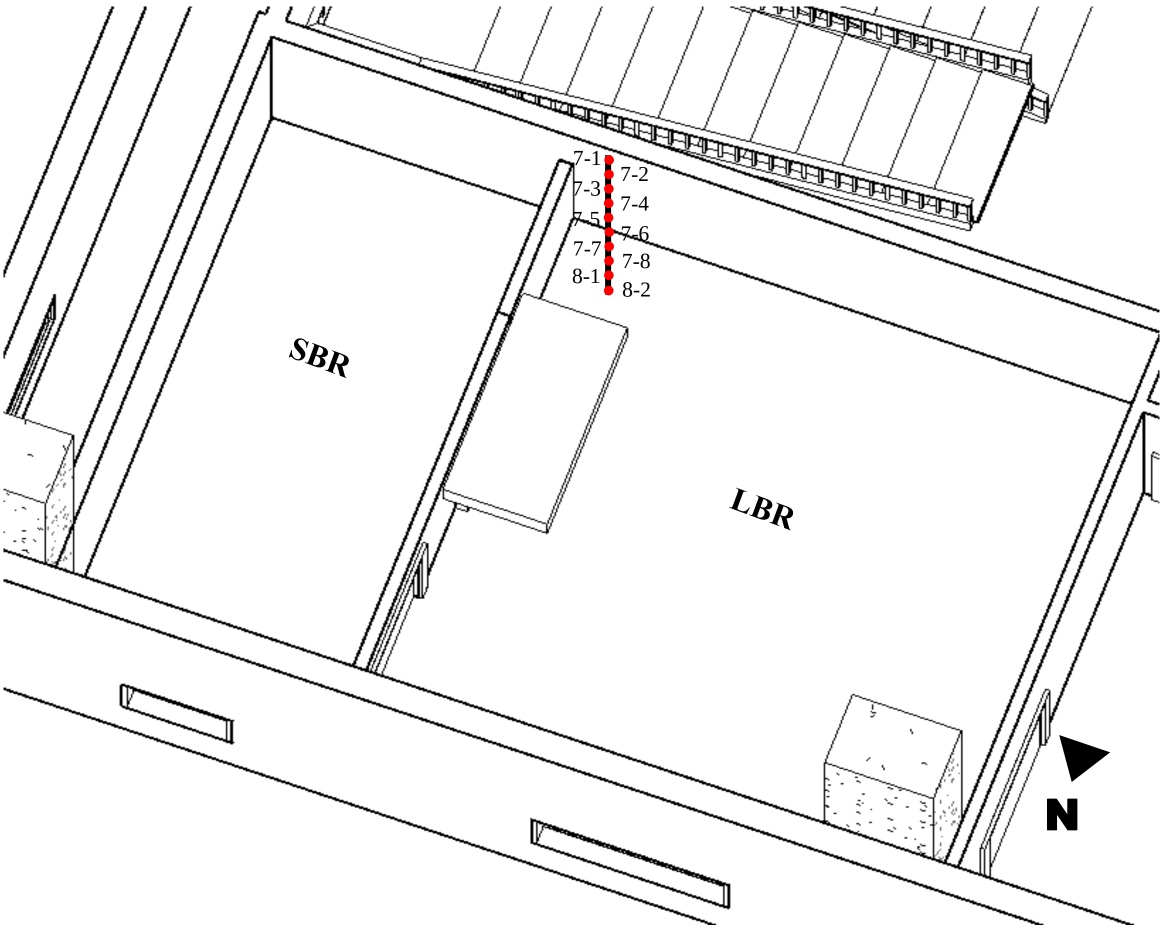

Figure 8.24. TC tree in LBR

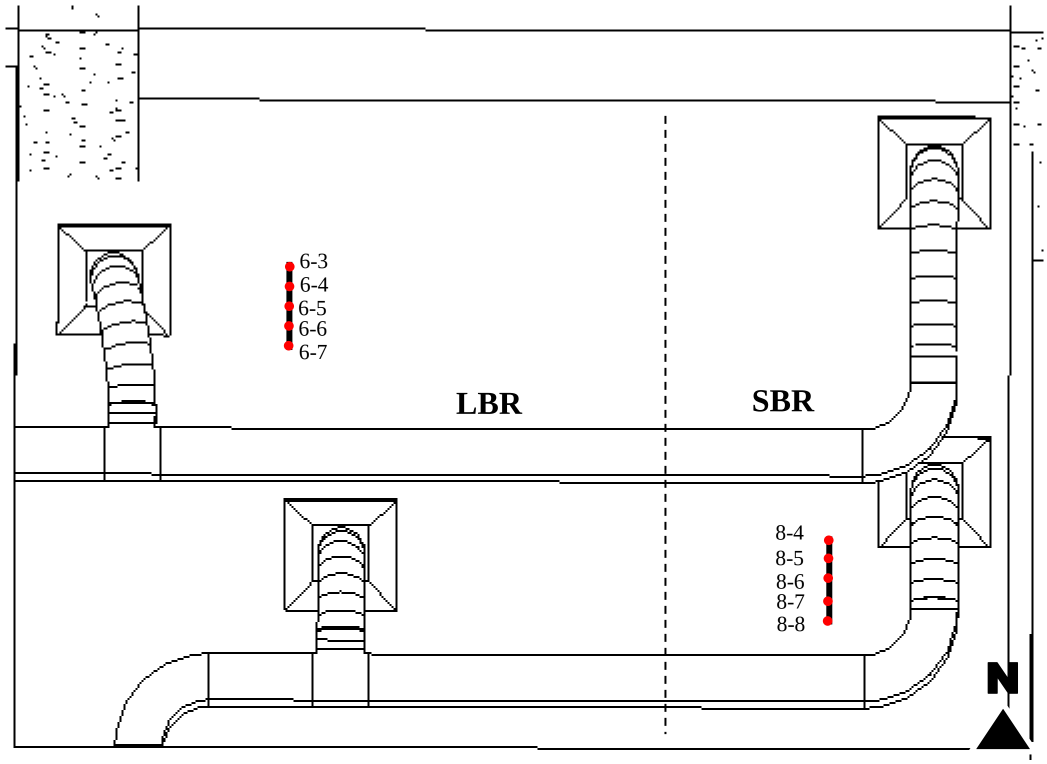

Figure 8.25. TC trees above LBR and SBR ceiling

Figure 8.26 shows the temperature data in the LBR and the space above the LBR ceiling space. Figure 8.27 shows the temperature data in the space above the SBR ceiling space.

Table 8.7 lists the locations of the LBR thermocouple tree and Table 8.8 lists the locations of the thermocouple trees above the LBR and SBR ceiling space.

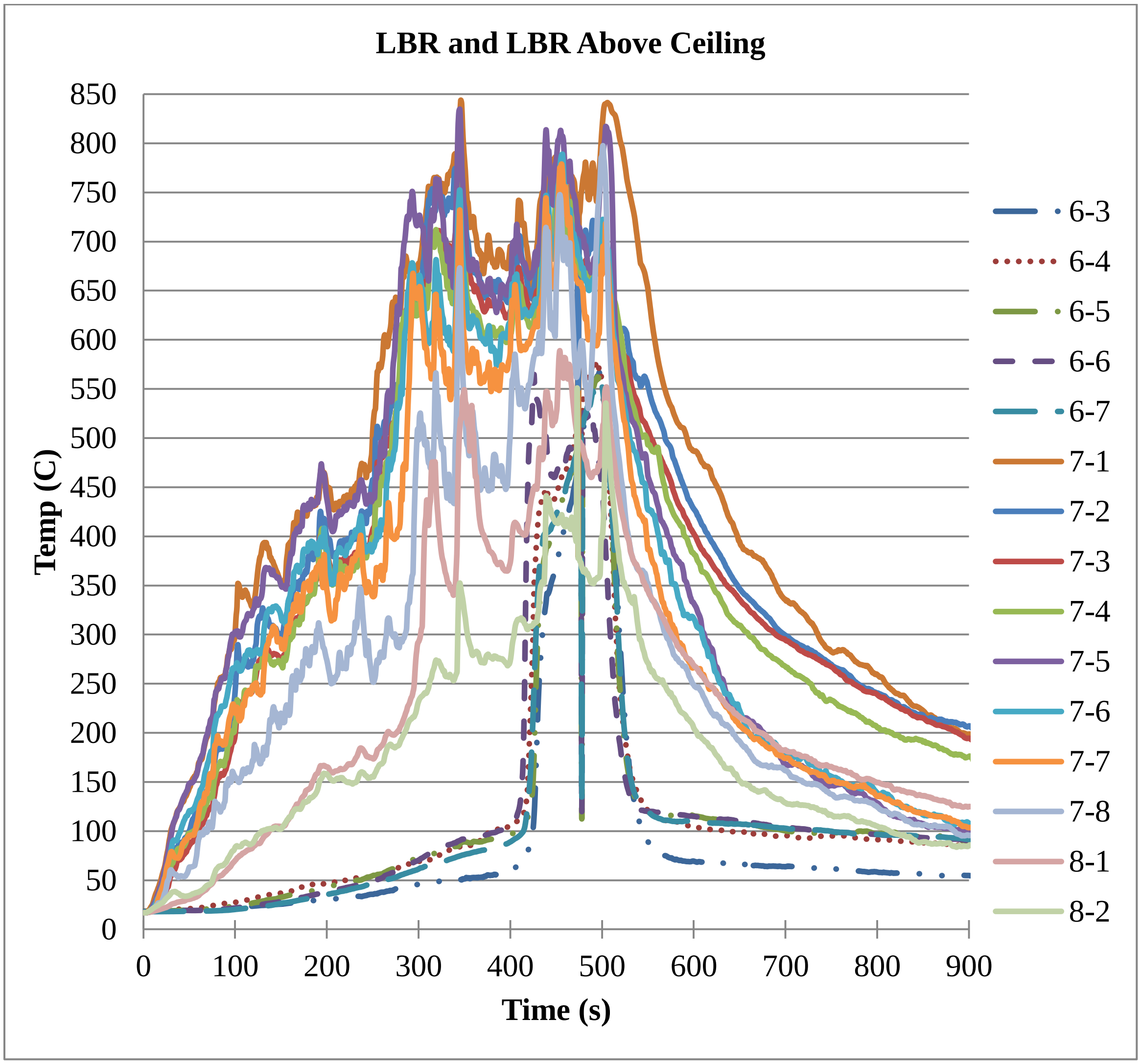

Figure 8.26. LBR and LBR above ceiling TC tree temperatures

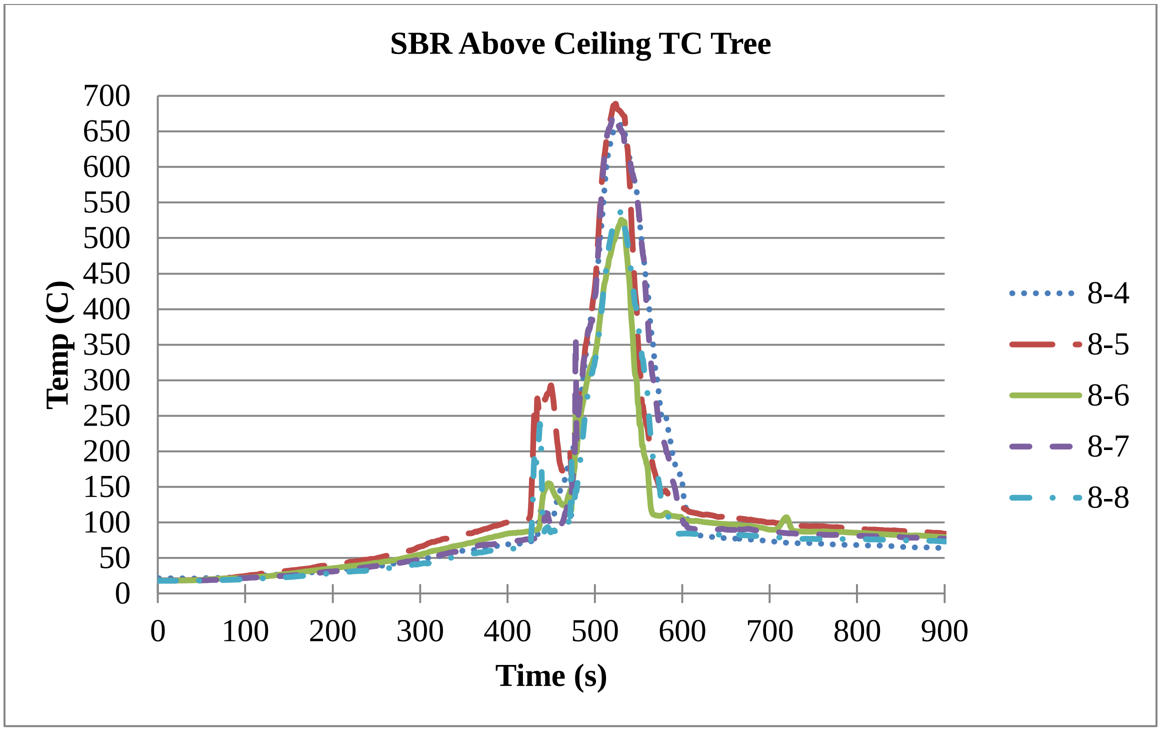

Figure 8.27. SBR above ceiling TC tree temperatures

Table 8.7. LBR TC tree list

7-1	TC tree below ceiling of LBR starting with 8-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 7-1 on top at 2.7m (8.9ft)
7-2	
7-3	
7-4	
7-5	
7-6	
7-7	
7-8	
8-1	
8-2	

Table 8.8. LBR and SBR above ceiling TC trees list

6-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top
6-4	
6-5	
6-6	
6-7	
8-4	TC tree hanging from 4th floor slab above ceiling of SBR starting with 8-8 right above ceiling and increasing in 0.3m (1ft) increments to 8-4 being on top
8-5	
8-6	
8-7	
8-8	

Flashover occurred during the LBR-2 fire test. Besides the thermocouple temperature data, post fire test visual inspection provided evidence of how high the temperatures got. Figure 8.28 shows door 1 had burned and the door knob melted as well as the pressure differential leaving the door open slightly. Figure 8.29 shows the key to the access panel had melted and fallen to the ground. The area around the north wall of the LBR above the ceiling of the room area after the LBR-2 fire test is shown in Figure 8.30.

Figure 8.28. Partition wall door 1 after LBR-2 fire test

Figure 8.29. LBR access panel after LBR-2 fire test

Figure 8.30. North wall of LBR above the ceiling after LBR-2 fire test

Figure 8.31. HVAC line connecting to the northwest vent of the LBR after LBR-2 fire test

8.3.2 Active Fire Systems Activation

Figure 8.32 shows the temperature of the fire door and SBR and LBR sprinklers. The LBR sprinkler activated after 28 seconds at 107C (224F) and the SBR sprinkler activated after 44 seconds at 59C (138F). The fire door activated after 51 seconds at 163C (325F). These thermocouple locations are listed with details in Table 8.9.

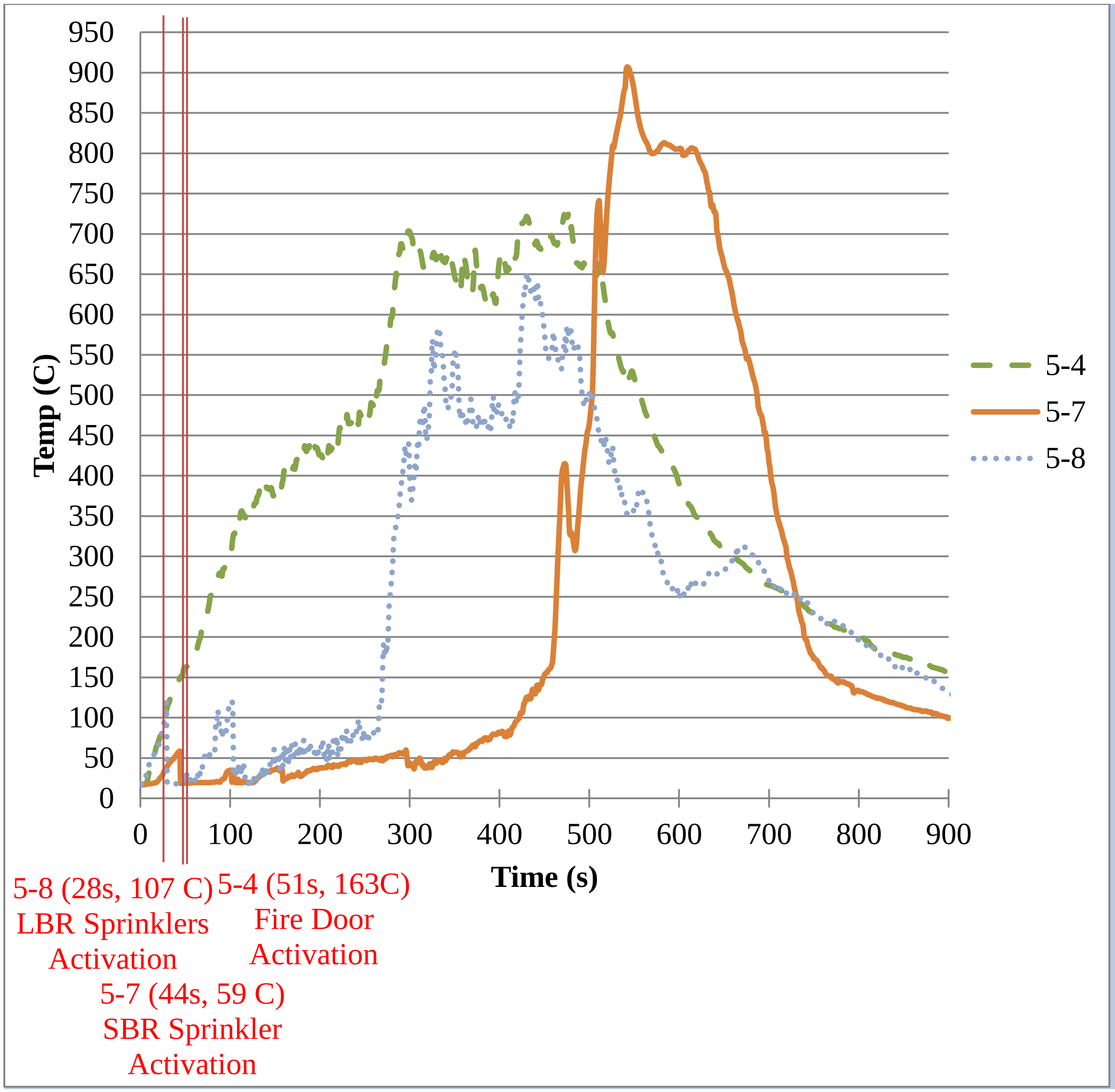

Figure 8.32. Fire door and LBR and SBR sprinkler temperatures

Table 8.9. LBR and SBR fire system TC list

5-2	(g) south part of fire door frame, 1.88m (6.2’) above floor
5-3	(g) south part of fire door frame, 0.3m (1’) above floor
5-4	(s) Fusible link of fire door, 1.5m (4.9’) from N wall, 0.24m (0.8’) below ceiling
5-5	(g) W wall of SBR gap above the fire door, 1.6m (5.2’) from N wall
5-6	Corner of the door frame between the SBR and LBR, 2.1m (6.9’) above floor, 1.1m (3.6’) from N wall
5-7	(s) SBR sprinkler head fusible link 1.3m (4.3’) from N wall, 1.4m (4.6’) from W wall 2.8m (9.2’) above floor
5-8	(s) LBR sprinkler head fusible link, 1.3m (4.3’) from N wall, 1.8m (5.9’) from E wall, 2.8m (9.2’) above floor

8.4 ES FIRE TEST TEMPERATURES

8.4.1 TC Trees in the Corridor and LBR Above Ceiling

Figure 8.33 shows the thermocouple trees located in the corridor and space above the LBR ceiling.

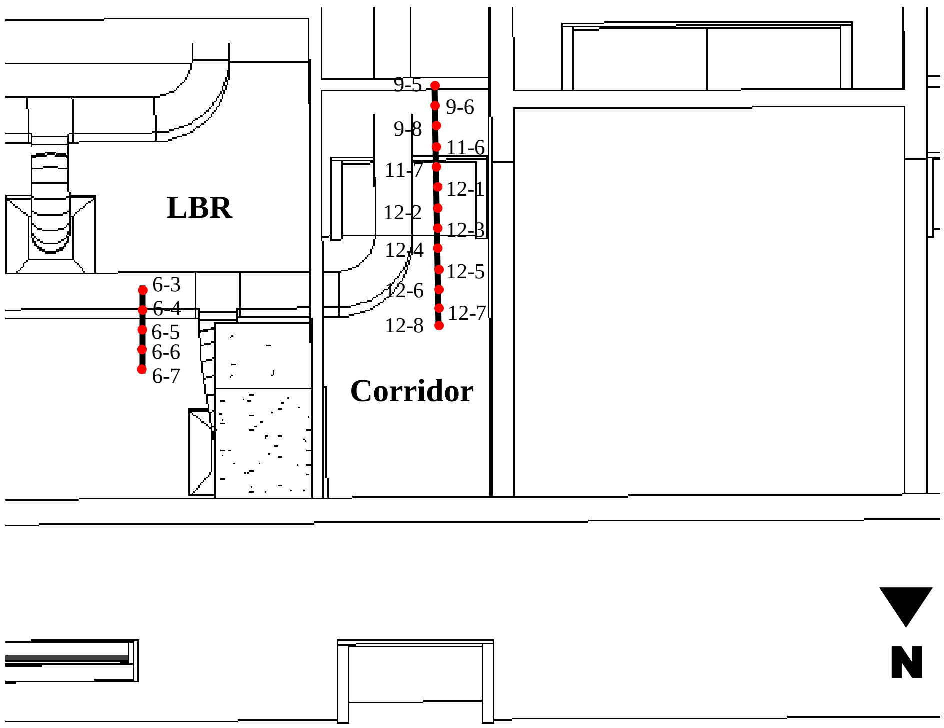

Figure 8.33. TC trees in corridor and above LBR ceiling

Figure 8.34 shows the temperature of the TC tree thermocouples located in the corridor. These thermocouple locations are listed with details in Table 8.10.

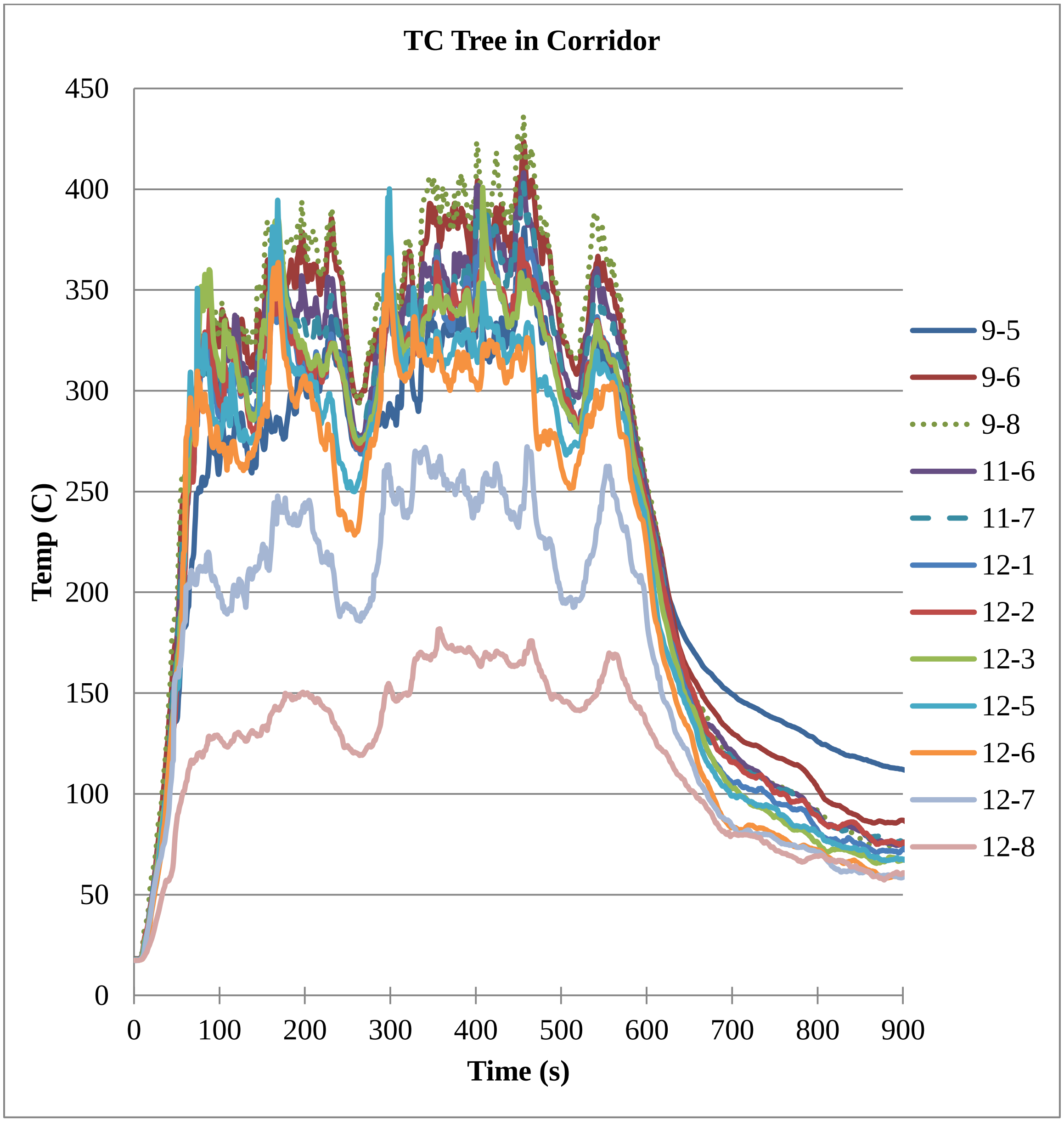

Figure 8.34. Thermocouple tree temperatures in the corridor

Table 8.10. Corridor and above LBR ceiling TC trees list

<table>
<tr><td>9-5</td><td rowspan="14">TC tree below 4th floor slab in corridor starting with 12-8 on bottom. 0.3m (1ft) above 3rd floor slab and increasing at 0.3m (1ft) increments to 9-5 on top at 3.9m (12.8ft)</td></tr>
<tr><td>9-6</td></tr>
<tr><td>9-8</td></tr>
<tr><td>11-6</td></tr>
<tr><td>11-7</td></tr>
<tr><td>11-8</td></tr>
<tr><td>12-1</td></tr>
<tr><td>12-2</td></tr>
<tr><td>12-3</td></tr>
<tr><td>12-4</td></tr>
<tr><td>12-5</td></tr>
<tr><td>12-6</td></tr>
<tr><td>12-7</td></tr>
<tr><td>12-8</td></tr>
</table>

Figure 8.35 shows the temperature of the TC tree thermocouples located in the space above the LBR ceiling. These thermocouple locations are listed with details in Table 8.11.

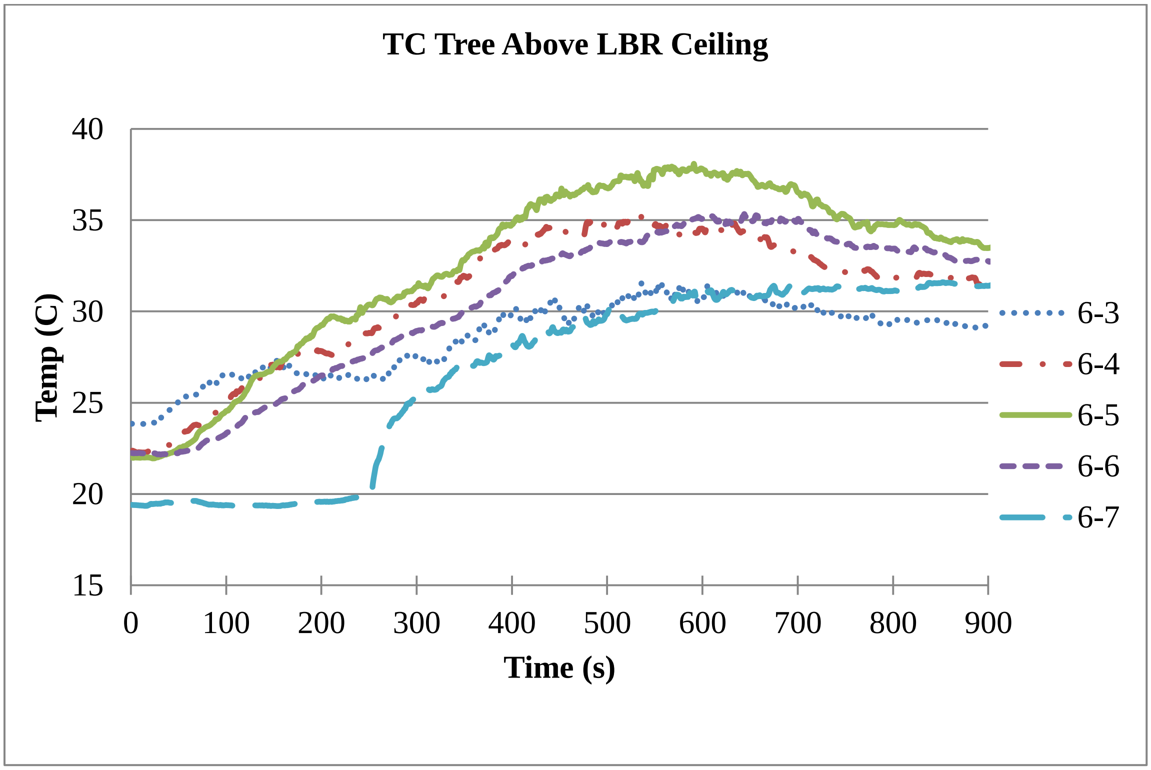

Figure 8.35. LBR above ceiling TC tree temperatures

Table 8.11. TC Tree list above LBR ceiling

6-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top
6-4	
6-5	
6-6	
6-7	

Figure 8.36 and Figure 8.37 shows horizontal firestops in the corridor area that intumesced. A vertical PVC pipe melted in the north of the elevator shaft as shown in Figure 8.38.

Figure 8.36. Horizontal pipe firestop in corridor after ES fire test

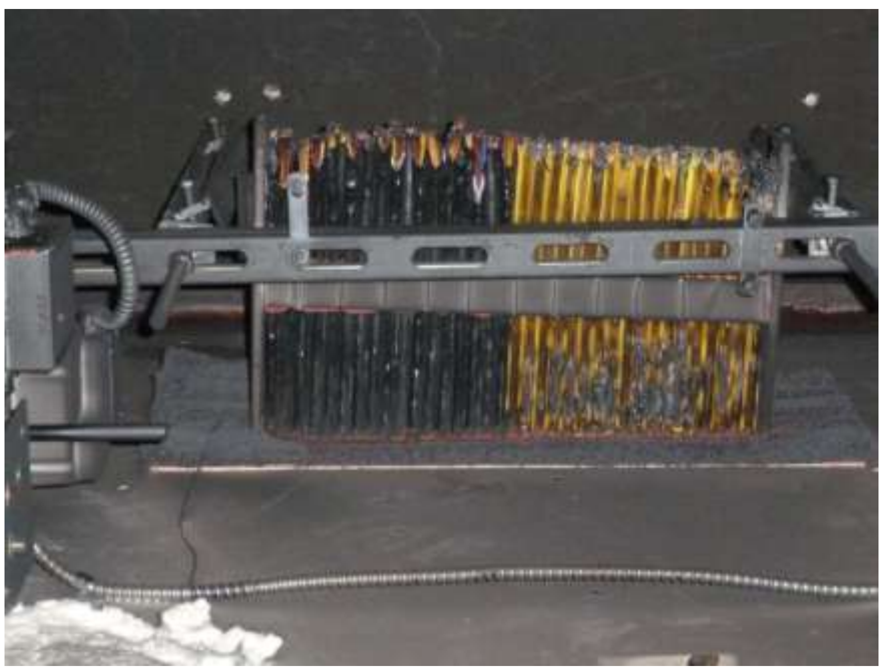

Figure 8.37. Cable tray firestop in corridor after ES fire test

Figure 8.38. North of elevator shaft after ES fire test

8.5 EL-1 FIRE TEST TEMPERATURES

8.5.1 TC Trees in the EL

Figure 8.39 shows the two thermocouple trees placed in the EL area.

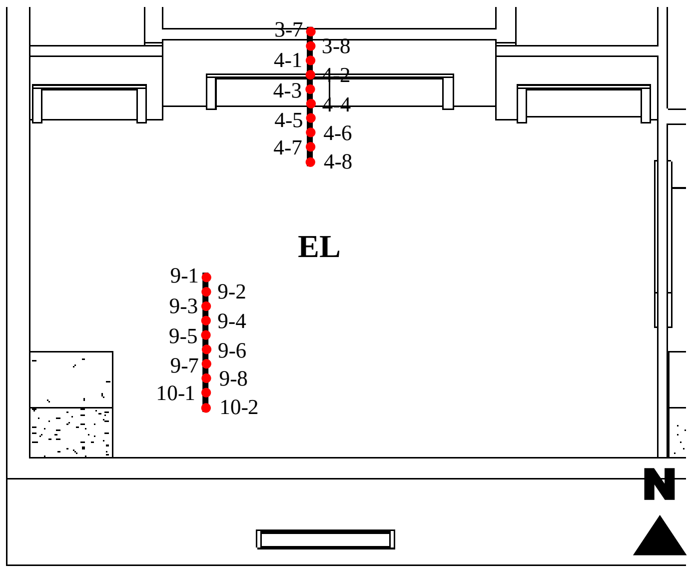

Figure 8.39. TC trees in EL

Figure 8.40 shows the temperature in front of the elevator door. These thermocouple locations are listed with details in Table 8.12.

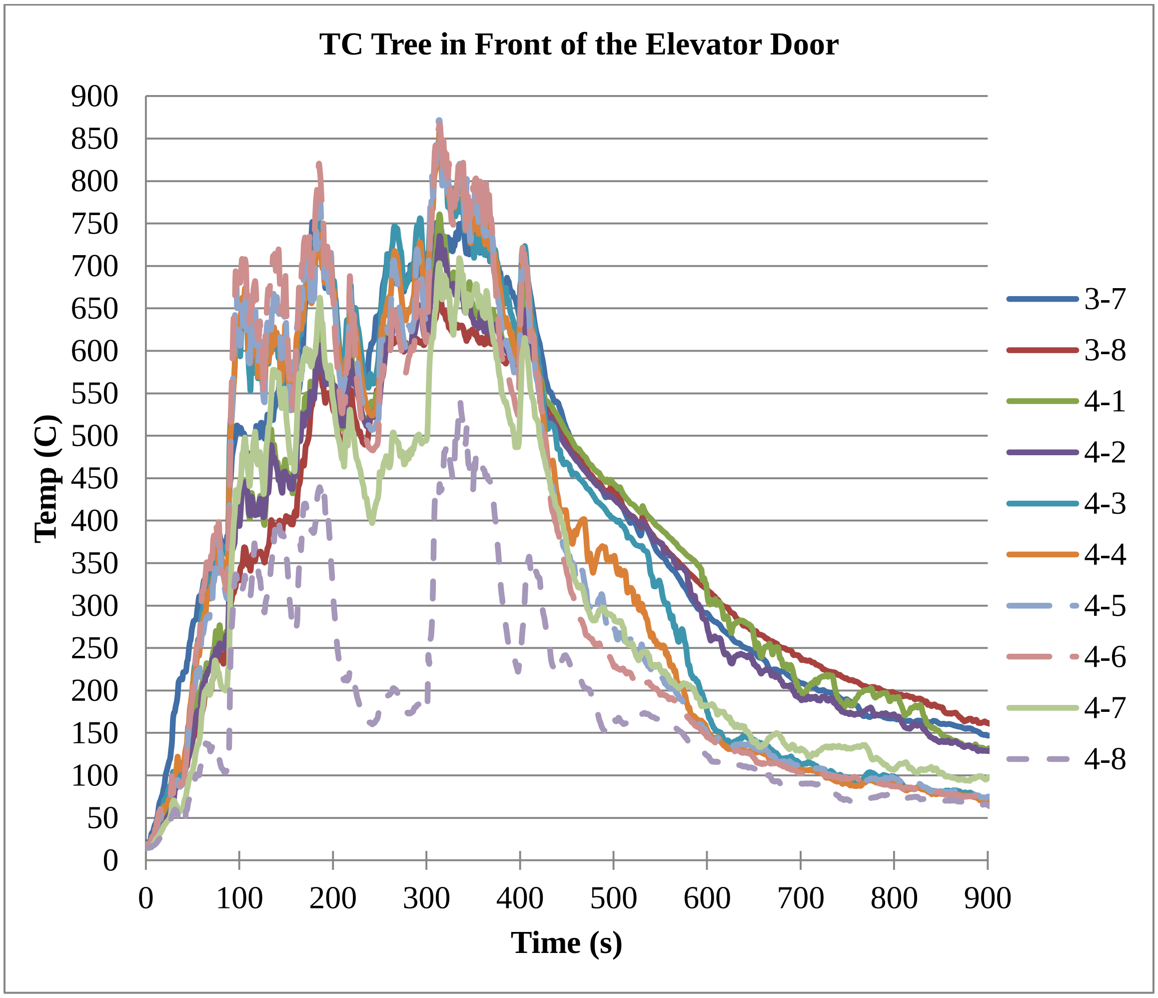

Figure 8.40. Temperature in front of the elevator door

Table 8.12. Front of elevator door TC tree list

3-7	TC tree in front of shaft door below ceiling of EL starting with 4-8 starting on the floor slab and increasing by 0.3m (1ft) increments to 3-7 on top at 2.7m (8.9ft)
3-8	
4-1	
4-2	
4-3	
4-4	
4-5	
4-6	
4-7	
4-8	

Figure 8.41 shows the temperature of the SW corner of the EL. These thermocouple locations are listed with details in Table 8.13. The camera mount and elevator switch panel melted off of the south wall of the elevator shaft as shown in Figure 8.42. Spalling occurred on the concrete slab near the pans as shown in Figure 8.43.

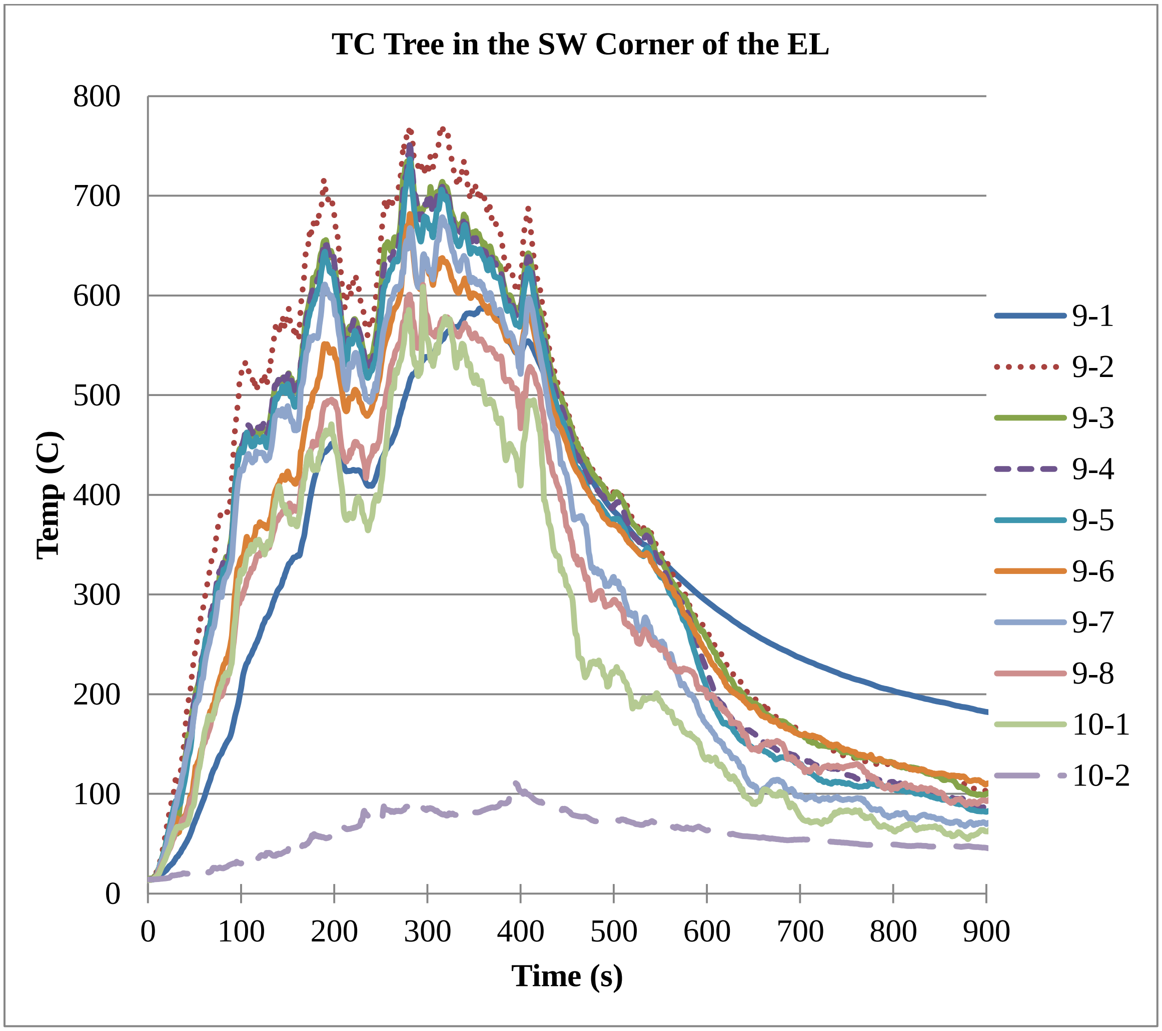

Figure 8.41. Temperature in the SW corner of the EL

Table 8.13. SW corner of EL TC tree list

9-1	TC tree in SW corner of EL below ceiling, starting with 10-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 9-1 on top at 2.7m (8.9ft)
9-2	
9-3	
9-4	
9-5	
9-6	
9-7	
9-8	
10-1	

Figure 8.42. Elevator shaft wall after EL-1 fire test

Figure 8.43. Floor 3 concrete slab after EL-1 fire test

8.5.2 TC Trees Above the EL Ceiling

Figure 8.44 shows the two thermocouple trees located above the ceiling of the EL. One thermocouple tree was located on the NW corner and the other was located on the SE corner.

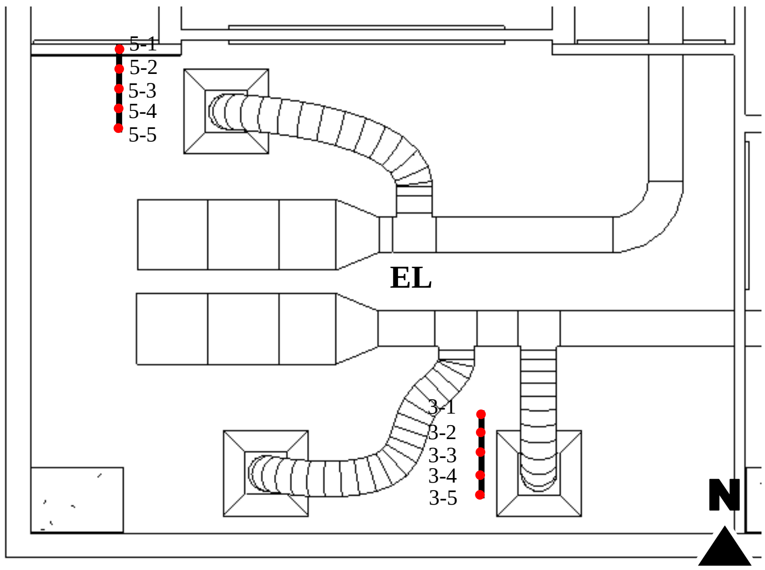

Figure 8.44. TC trees above EL ceiling

Figure 8.45 shows the SE corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table 8.14.

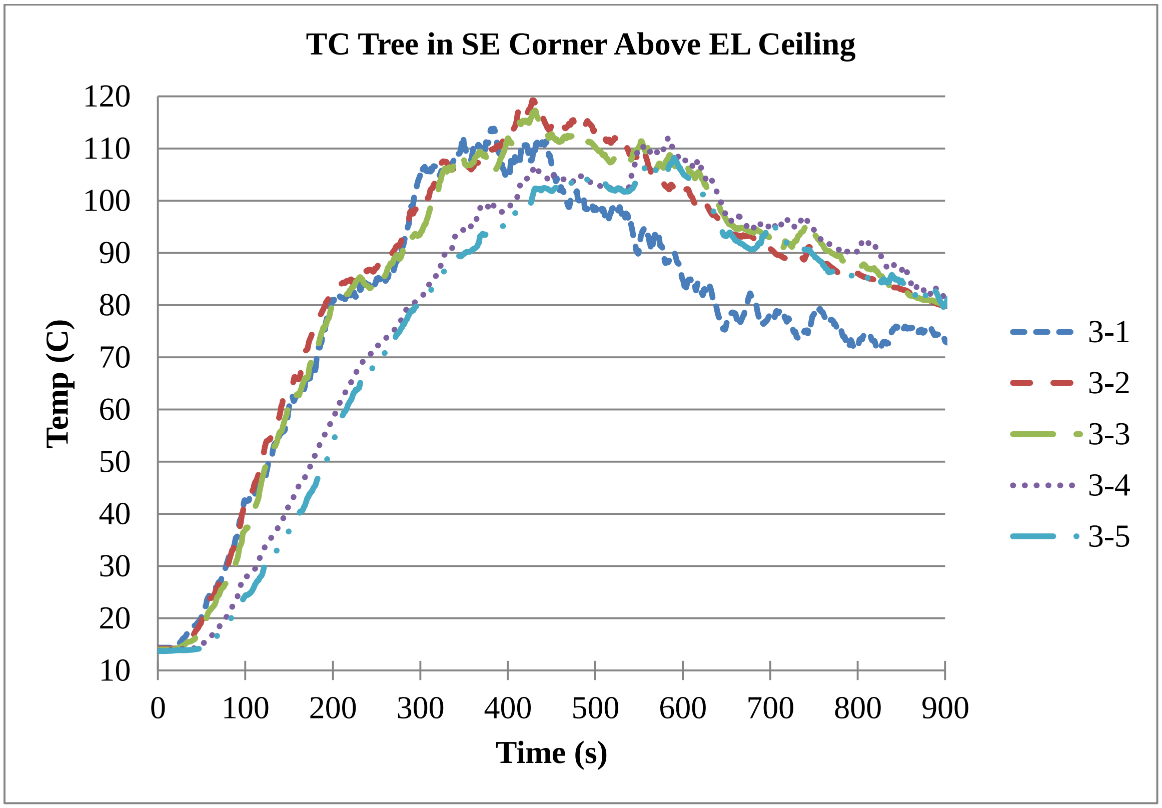

Figure 8.45. Temperature of the SE corner space above the EL ceiling

Table 8.14. EL SE corner above ceiling TC tree list

3-1	TC tree hanging from 4th floor slab above ceiling SE EL starting with 3-5 right above ceiling and increasing in 0.3m (1ft) increments to 3-1 being on top
3-2	
3-3	
3-4	
3-5	

Figure 8.46 shows the NW corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table 8.15.

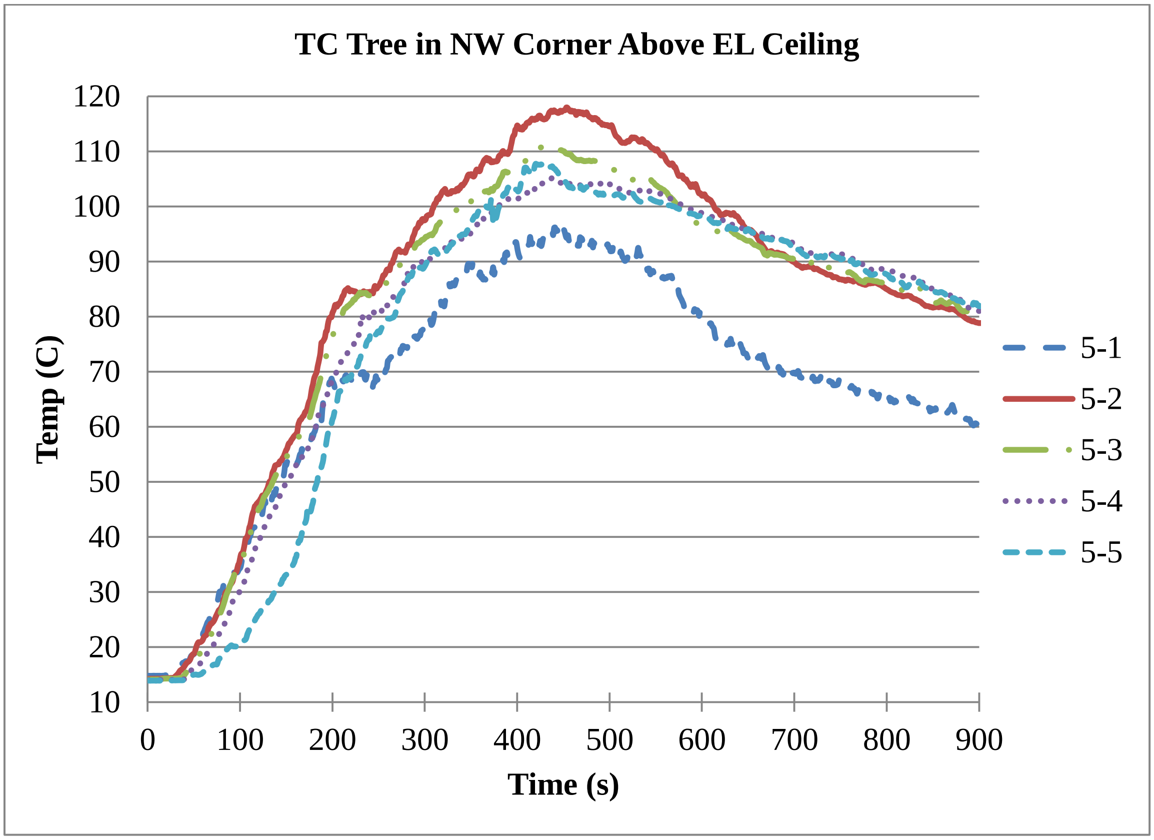

Figure 8.46. Temperature of the NW corner space above the EL ceiling

Table 8.15. EL NW corner above ceiling TC tree list

5-1	TC tree hanging from 4th floor slab above ceiling NW EL starting with 5-5 right above ceiling and increasing in 0.3m (1ft) increments to 5-1 being on top
5-2	
5-3	
5-4	
5-5	

8.5.4 Inside Elevator Shaft

Figure 8.47 shows the thermocouple tree located inside the elevator shaft.

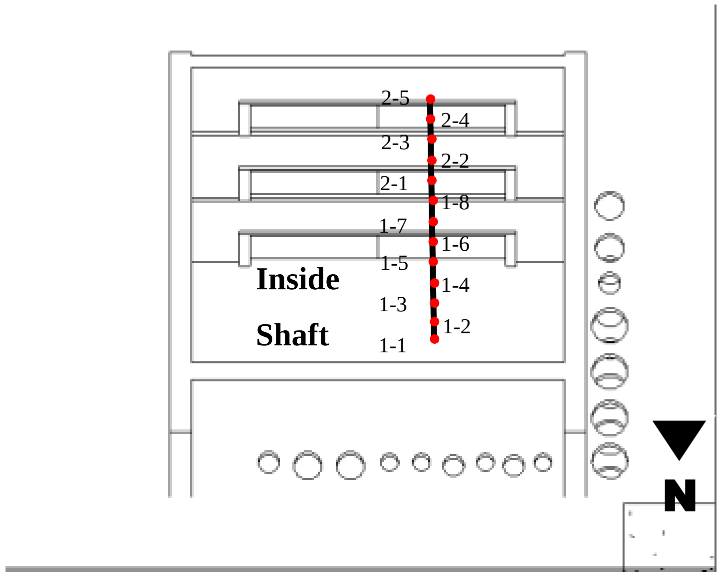

Figure 8.47. TC inside elevator shaft from 5th to 3rd floor

Figure 8.48 shows the temperature inside the elevator shaft from the 3rd floor up. These thermocouple locations are listed with details in Table 8.16.

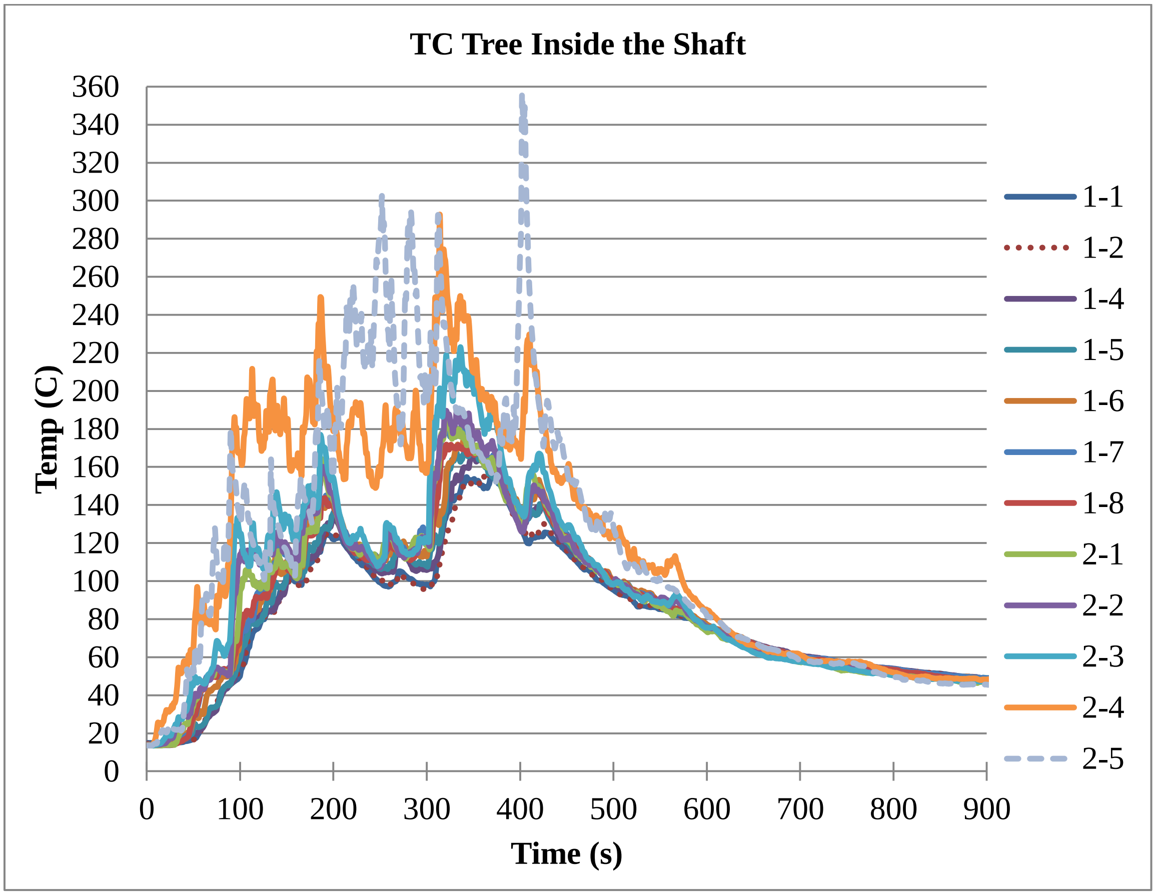

Figure 8.48. Inside the shaft temperature

Table 8.16. Inside elevator shaft from 5th to 3rd floor TC list

<table>
<tr><td>1-1</td><td rowspan="13">TC tree inside elevator shaft hanging down from the roof with 10-1 being 0.25m (10in) below the roof and decreasing at 0.9m (3ft) increments ending with 11-5 being 0.66m (2.2ft) above the 3rd floor slab</td></tr>
<tr><td>1-2</td></tr>
<tr><td>1-3</td></tr>
<tr><td>1-4</td></tr>
<tr><td>1-5</td></tr>
<tr><td>1-6</td></tr>
<tr><td>1-7</td></tr>
<tr><td>1-8</td></tr>
<tr><td>2-1</td></tr>
<tr><td>2-2</td></tr>
<tr><td>2-3</td></tr>
<tr><td>2-4</td></tr>
<tr><td>2-5</td></tr>
</table>

8.6 EL-2 FIRE TEST TEMPERATURES

8.6.1 TC Trees in the EL

Figure 8.49 shows the two thermocouple trees placed in the EL area.

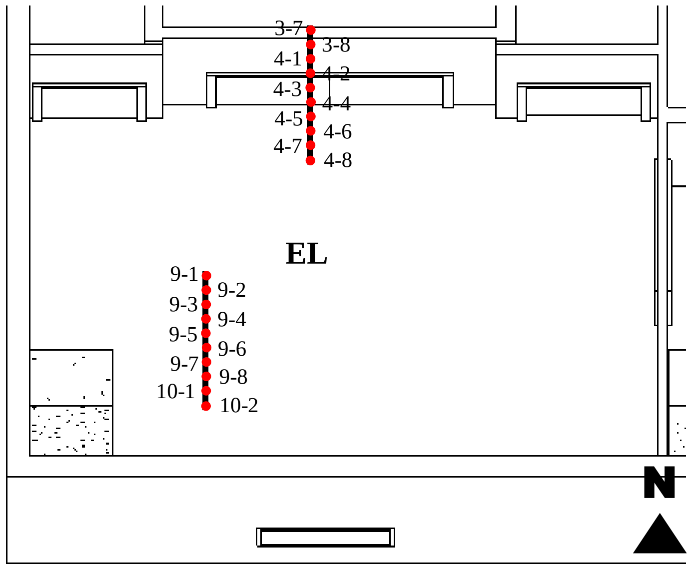

Figure 8.49. TC trees in EL

Figure 8.50 shows the temperature in front of the elevator door. These thermocouple locations are listed with details in Table 8.17.

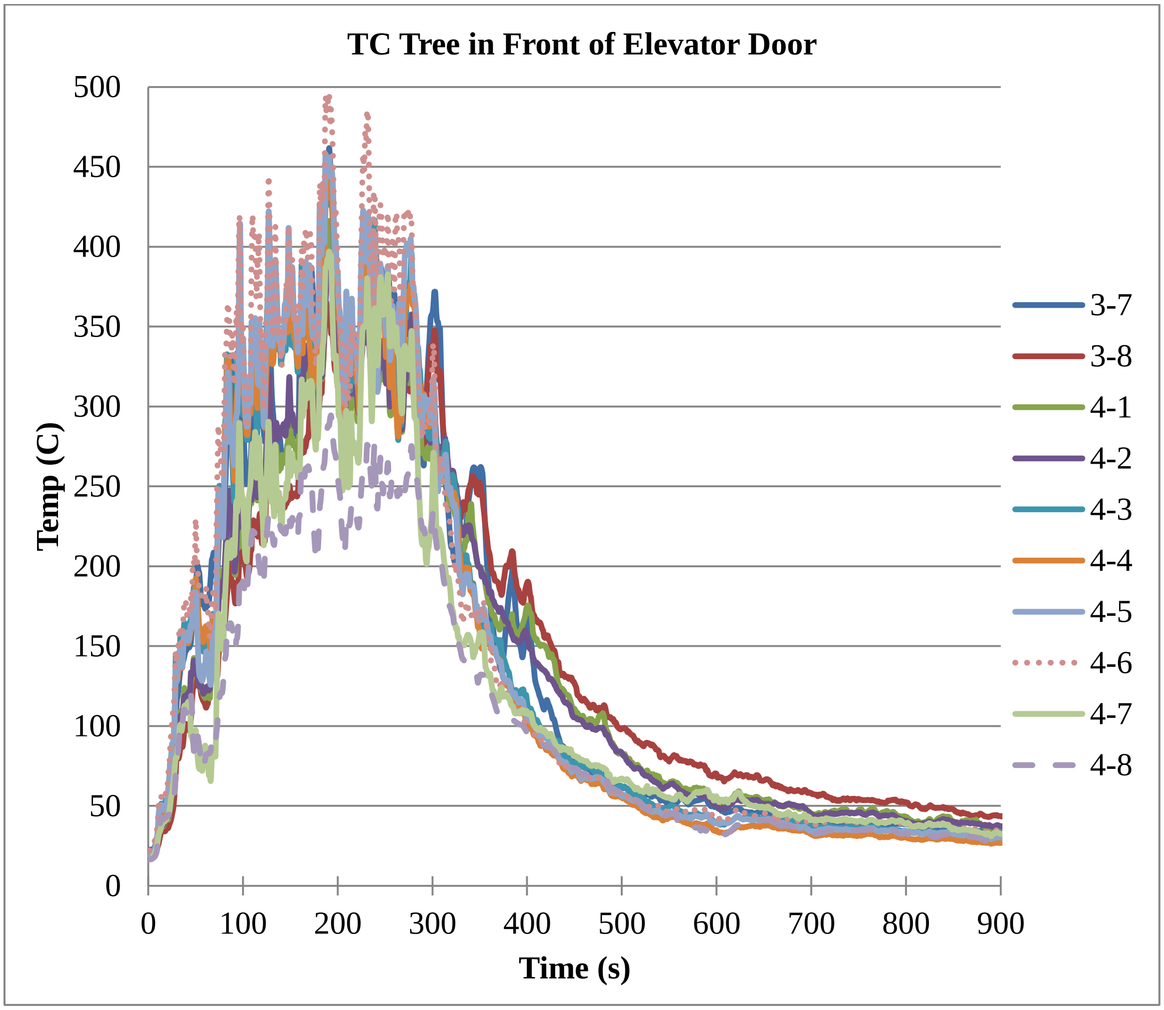

Figure 8.50. Temperature in front of the elevator door

Table 8.17. Front of elevator door TC tree list

3-7	TC tree in front of shaft door below ceiling of EL starting with 4-8 starting on the floor slab and increasing by 0.3m (1ft) increments to 3-7 on top at 2.7m (8.9ft)
3-8	
4-1	
4-2	
4-3	
4-4	
4-5	
4-6	
4-7	
4-8	

Figure 8.51 shows the temperature of the SW corner of the EL. These thermocouple locations are listed with details in Table 8.18. The gypsum wallboard got detached as shown in Figure 8.52. Door 3 was on fire as shown in Figure 8.53, and had to be extinguished using a water hose.

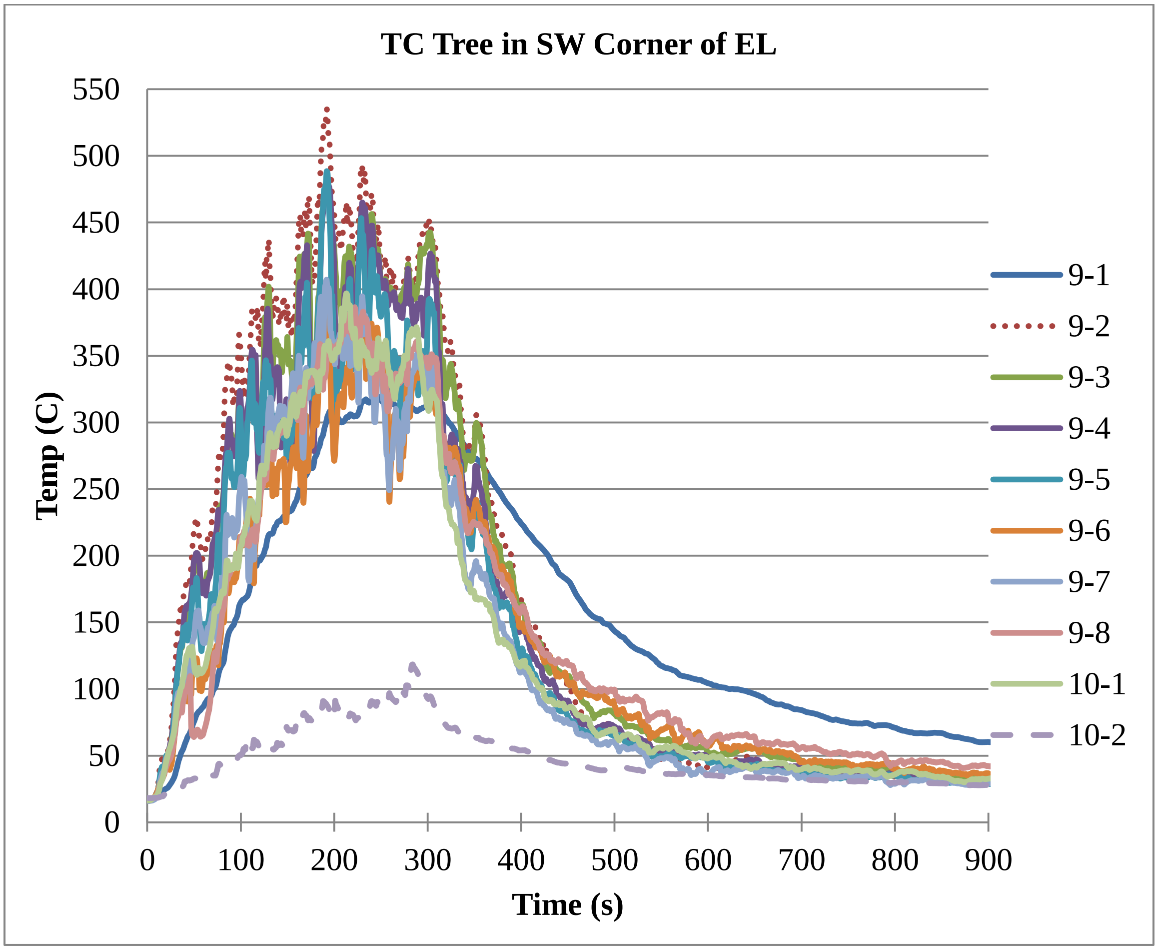

Figure 8.51. Temperature in the SW corner of the EL

Table 8.18. SW corner of EL TC tree list

9-1	TC tree in SW corner of EL below ceiling, starting with 10-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 9-1 on top at 2.7m (8.9ft)
9-2	
9-3	
9-4	
9-5	
9-6	
9-7	
9-8	
10-1	

Figure 8.52. South wall of elevator shaft after EL-2 fire test

Figure 8.53. Door 4 after EL-2 fire test

8.6.2 TC Trees Above the EL Ceiling

Figure 8.54 shows the two thermocouple trees located above the ceiling of the EL. One thermocouple tree was located on the NW corner and the other was located on the SE corner.

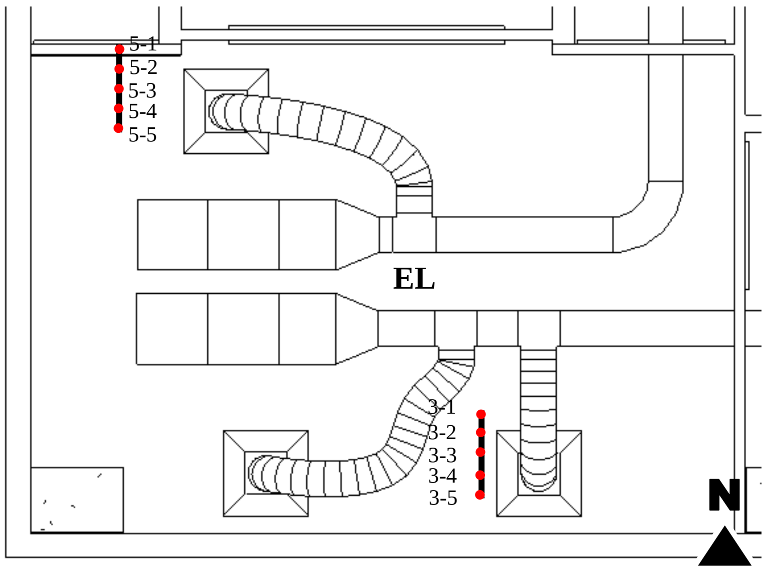

Figure 8.54. TC trees above EL ceiling

Figure 8.55 shows the SE corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table 8.19.

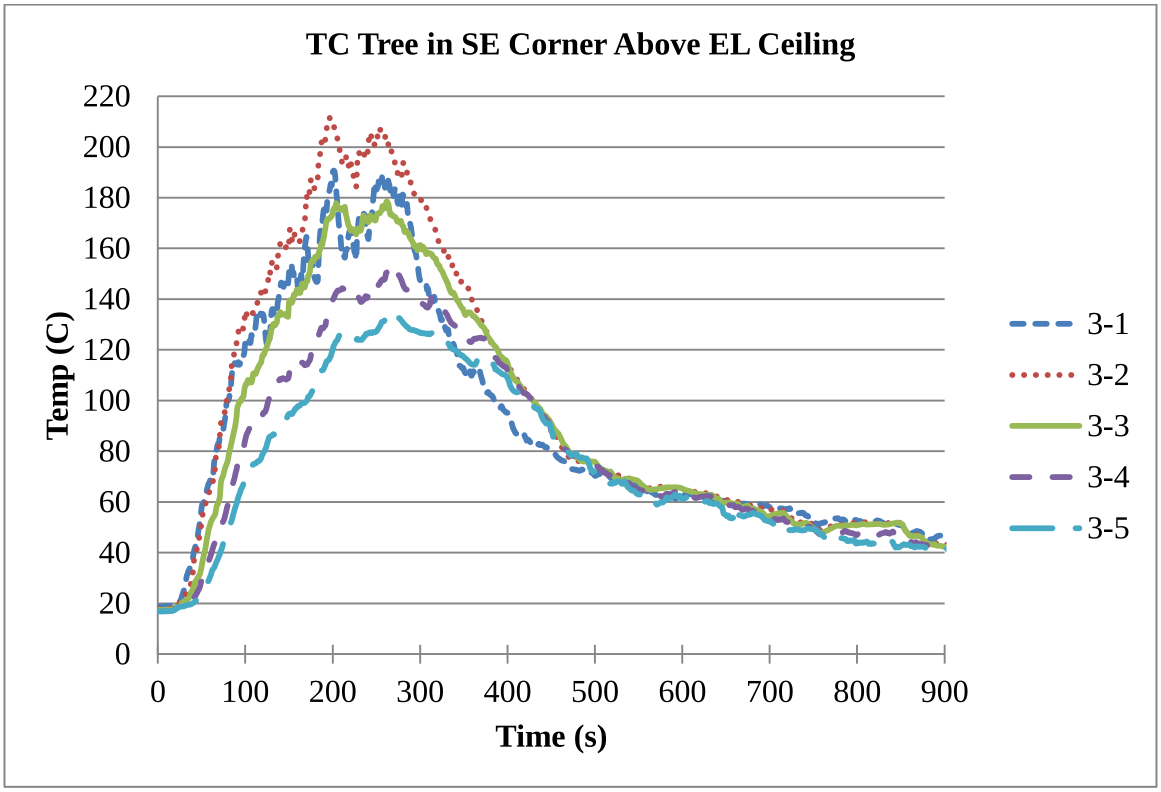

Figure 8.55. Temperature of the SE corner space above the EL ceiling

Table 8.19. EL SE corner above ceiling TC tree list

3-1	TC tree hanging from 4th floor slab above ceiling SE EL starting with 3-5 right above ceiling and increasing in 0.3m (1ft) increments to 3-1 being on top
3-2	
3-3	
3-4	
3-5	

Figure 8.56 shows the NW corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table 8.20.

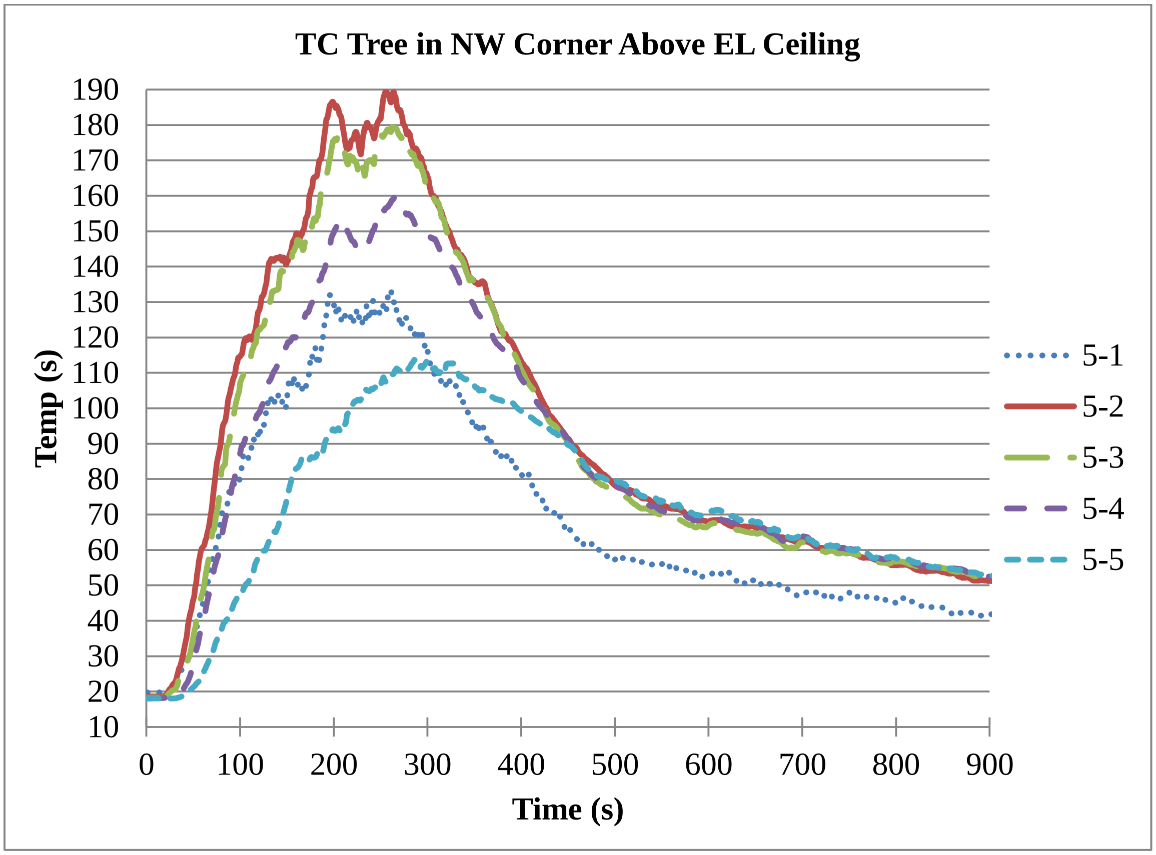

Figure 8.56. Temperature of the NW corner space above the EL ceiling

Table 8.20. EL NW corner above ceiling TC tree list

5-1	TC tree hanging from 4th floor slab above ceiling NW EL starting with 5-5 right above ceiling and increasing in 0.3m (1ft) increments to 5-1 being on top
5-2	
5-3	
5-4	
5-5	

8.6.4 Inside Elevator Shaft

Figure 8.57 shows the thermocouple tree located inside the elevator shaft.

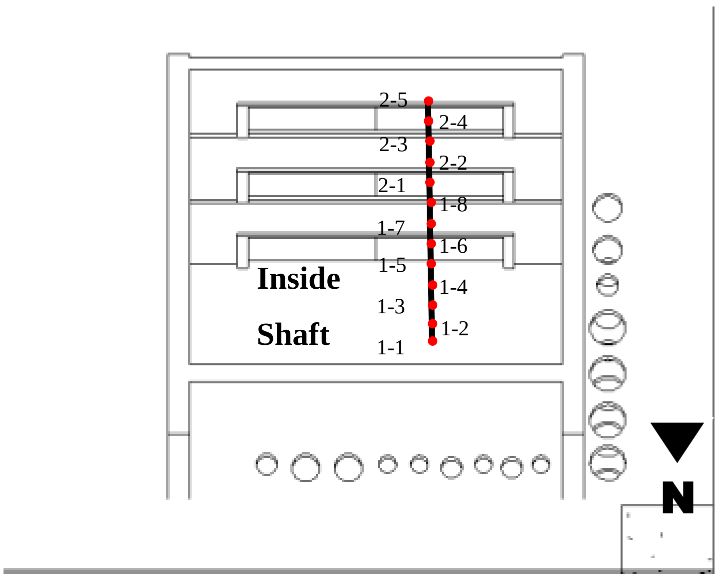

Figure 8.57. TC inside elevator shaft from 5th to 3rd floor

Figure 8.58 shows the temperature inside the elevator shaft from the 3rd floor up. These thermocouple locations are listed with details in Table 8.21.

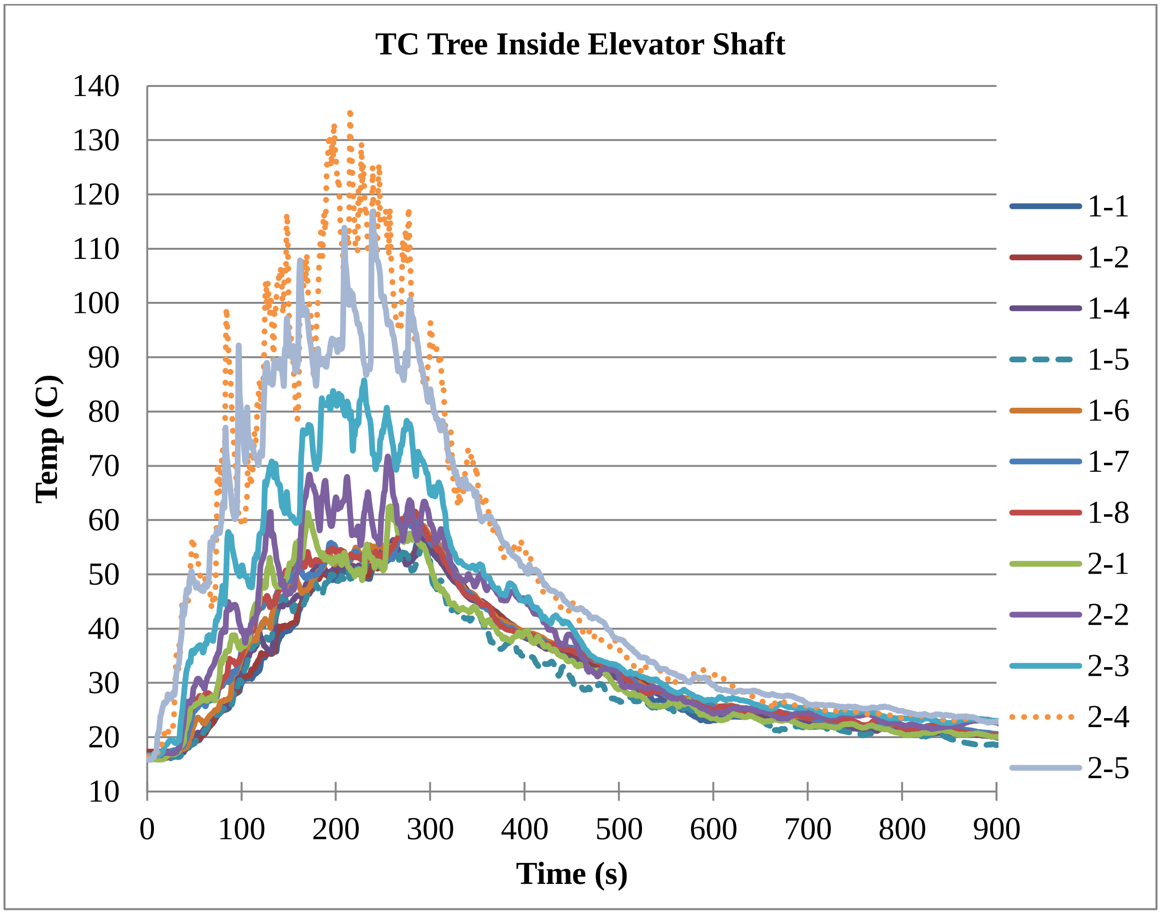

Figure 8.58. Inside the shaft temperature

Table 8.21. Inside elevator shaft from 5th to 3rd floor TC list

1-1	TC tree inside elevator shaft hanging down from the roof with 10-1 being 0.25m (10in) below the roof and decreasing at 0.9m (3ft) increments ending with 11-5 being 0.66m (2.2ft) above the 3rd floor slab
1-2	
1-3	
1-4	
1-5	
1-6	
1-7	
1-8	
2-1	
2-2	
2-3	
2-4	
2-5	

9 SUMMARY PRELIMINARY FINDINGS

Post-earthquake fires have some inherent differences when compared to general building fires as fire protection features of buildings and infrastructure can be damaged by earthquake and may not be available or may not operate as intended in fire conditions. Some of the fire protection features that are expected in general building fires are as follows:

- Active fire protection systems, such as automatic fire suppression / fire control systems, automatic fire detection / alarm / notification systems, and smoke control / management systems
- Passive fire protection systems for preventing fire spread beyond area of fire origin, including proper compartmentation for separation of fire and fire products from means of egress, between rated compartments and floors
- Provision of proper number, size and location of means of egress
- Adequate structural resiliency under thermal load
- Systems and features to support fire fighter suppression and rescue missions, such as standpipes, smoke control and building access

Unfortunately, it is possible that the performance of some of these features can be decreased either by direct seismic-induced damage, such as breakage of sprinkler piping or loss of a stairway, or by fire-related phenomena given an earthquake damaged state, such as the failure of load-bearing structure due to high heat exposure.

This series of tests aimed to understand the performance of these systems under a controlled set of seismic and fire tests. The following highlights preliminary observations relative to potential fire safety concerns as identified during these tests. It should be remembered that fire testing was only conducted on the third floor, and the observations of compartmentation and structural integrity performance on other floors were not directly assessed as part of the fire testing. However, a comprehensive set of observations are provided to help paint the overall picture of post-earthquake building performance.

9.1 FUEL DISTRIBUTION

There was no specific fuel item in the third floor during the seismic tests where the fire tests were conducted. In the second floor, however, a residential space and laboratory area had possible items such as TV, bookshelves with books in it, computer, tables, laboratory test equipment, storage, etc. Some of these were anchored and others were not to see the performance of seismic bracing fixtures. After FB-5 and FB-6, some anchored items such as TV were displaced and most unanchored items were widely spread on the floor. This widely spread items can deter the occupants movement in emergency condition and increase fuel area from which higher HRR and taller flame height can be derived. Further description and more pictures are available in SSRP report. A rigid steel pipe, representative of a fuel gas line, was damaged at a connection on Floor 1 following FB-6. Such damage to a real gas fuel line, without other protective measures (e.g., shutoff valves), could represent added fuel to a post-earthquake fire.

9.2 ACTIVE SYSTEMS

9.2.1 Sprinkler system

Sprinkler systems were not damaged from seismic tests and worked well in the fire tests. More detailed data are available in Appendix C under the section of active fire system activation analysis per each test.

9.2.2 Smoke detection system

The smoke detection system was not damaged from seismic tests and worked well in the fire tests.

9.2.3 Fire damper performance

After the seismic tests, one damper out of three was not fully closed. This was due to the damper’s blade rotation being prevented by a screw used for the damper installation which, once adjusted, allowed the damper to close completely following the motion tests.

9.3 PASSIVE FIRE PROTECTION SYSTEMS AND FEATURES

9.3.1 Balloon framing

From the 1st floor to the 3rd floor, the exterior walls are made of EIFS and weather proof coatings attached to the floors using steel brackets aligned vertically. The interior side of the exterior walls is made of 5/8 inch thick gypsum board attached to the bracket. After the seismic tests, about 1 inch gaps were formed following joint areas where the interior side of the exterior walls (gypsum board) meets the floor, column, ceiling, and any perpendicular bracing walls on the north and south sides. The east and west sides of exterior walls where less shear forces are applied thanks to the east-west seismic motion did not show any significant gaps.

During fire tests, smoke spread through this gap beyond the room of origin was observed. Figure 8.30 shows soot pattern on the north wall of the LBR above the ceiling as smoke leaked through the gaps formed on the joint area between the ceiling and the north wall of the LBR during the LBR-2 fire test. For the LBR-2 fire test when full room involvement occurred, even flames were intermittently observed from the SBR. In addition, the empty space between the steel brackets became a channel for the smoke spread such that smoke came out in the joint area between the exterior walls and concrete cladding for the 4th floor where the vertical steel bracket ended. Temperature data in the joint area are available in Appendix C.3.8.

9.3.2 Structural integrity of gypsum board

Gypsum board is widely used for interior walls. After FB-5 and FB-6, some of the gypsum boards used in space around elevator shafts and stairwells were detached and fell off as shown in Figure 6.6. Fallen gypsum boards can delay the evacuation of occupants and fire fighter’s access by decreasing the exit capacity, and the openings formed by detachment can be an inlet or outlet of smoke being connected with the channel between metal or wood studs, decreasing expected fire performance and smoke control attributes. Especially, the fallen gypsum board in the means of egress such as stairwell can be a serious fire hazard as it can lead to both smoke spread and decreased exit capacity.

9.3.3 Distorted door frame on swinging doors

Doors are intended to provide barriers to the spread of fire and smoke during fire events. Doors may be normally open or normally closed, and if normally open, may close automatically upon fire alarm. Both cases were tested.

During FB-5 and FB-6, some of the door frames for swinging doors were distorted. This meant that in some cases the doors were not able to fully close (those which were held open during seismic tests) as shown in Figure 5.7, and in other cases doors were jammed (those which were closed during motion tests). This has implications for fire control, access and egress. With respect to jamming, this might be a special concern for steel doors, which if jammed tightly can be difficult to open. With respect to doors that do not close, the openings formed by not-fully closed doors can be a path of smoke and fire spread, annulling all separation features for the compartmentation in fire conditions.

9.3.4 Firestop performance

A variety of firestops were tested at different locations in fire conditions. All dynamic and truly static firestop systems performed well. However, in earthquake conditions, some joints that would be static in normal building operation were not static anymore, and gaps of up to 25mm (1 inch) were observed in some locations, including the static joint areas where interior side of the exterior wall met column (Figure 5.5), floor, and ceiling. Firestop sealants applied in these areas were also detached and could not stop fire and smoke spread through the gap in the joints. Therefore, it may be necessary to apply dynamic firestop solutions even in the static joint areas in the building constructed in earthquake zones.

9.3.5 Fire door performance

The roll-down fire door performed well to the motion and fire testing.

9.3.6 Intensive care unit (ICU) breakout door performance

In the fourth floor, two smoke proof ICU breakout doors were subjected to the seismic motion tests. Overall, they performed well in most fixed base tests, but only after FB-5, one connection joint to the floor of the door facing stairs was displaced and the door was open which is shown in Figure 6.7. It may be difficult to say that ICU breakout doors performed poorly as they performed well even in FB-6, which had a stronger motion than FB-5. Further investigation may need to be conducted in the future.

9.3.7 Effects of open windows and wind on fire development and spread

Due to resource constraints actual glazing (windows, glass façade) was not able to be tested. However, window openings were included to test under a range of conditions (e.g., windows closed in LBR1 and SBR tests, and windows partially or fully opened in all others).

The first four fire tests were conducted in relatively quiescent environment, with the first two tests with windows closed, but on the last day, the two fire tests in the elevator lobby were conducted in the condition of 10~15 mph wind. The weather conditions throughout the fire tests are available in Table 7.6. Fire test schedule. The directions of smoke movement and flame angles were affected by wind. Swirling flames in front of the elevator door were observed and possibly excessive air seemed to accelerate combustion reaction. As the direction of smoke and fire spread is influenced by the wind direction, occupants during evacuation and fire fighters conducting suppression mission in and out of the building can be endangered if they are in the leeward direction. Wind effect on fire development and its effects on building fire safety performance need to be further researched.

9.3.8 Effects of metal pipe length on the firestop performance

It was observed that firestop applied to the vertical metal pipe penetration on the 4th floor were lifted about a few millimeters as the metal pipes were elongated due to thermal expansion as shown in Figure 9.1.

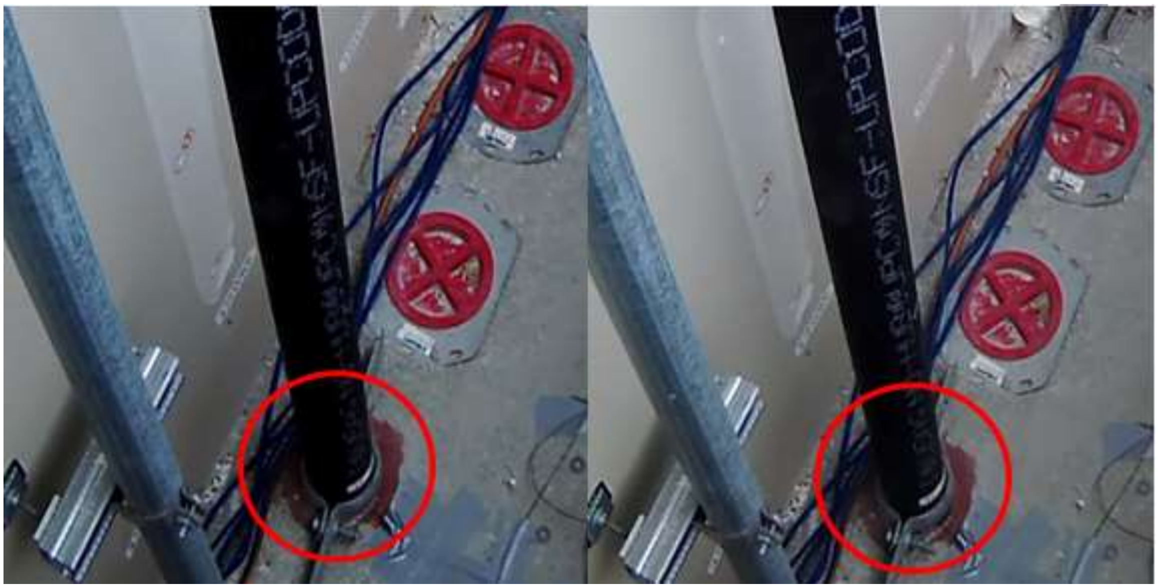

Figure 9.1. Lifting of vertical pipe penetration firestop during ES fire test

The firestop was not detached since only top portion of the 4m long pipe was exposed to the high heat. In conditions such as long horizontal pipes located near the ceiling where the entire pipe can be exposed to high heat, the thermal expansion could potentially be significant, depending on the ambient temperature (e.g. sprinklered or unsprinklered fire), the length of pipe exposed to the elevated temperature, and the pipe material's coefficient of thermal expansion. Plastic pipes, if not melted, burned by the fire, have much higher thermal expansion coefficients than metal and can create greatest challenges. However, even metal pipes will have notable, measurable expansion over the length of a room. This can lead to the possibility of firestop sealants applied to the horizontal penetration being detached due to thermal expansion of metal pipes. At the other end of the spectrum, there are firestop devices (e.g. pipe collars) that would allow unlimited movement in the longitudinal direction and would not be impaired by any amount of movement. ASTM Subcommittee E06.21 is currently in process of developing a test method to assess the ability of firestop systems to accommodate movement.

9.3.9 Flexible duct

In LBR-2, HVAC louvers on the ceiling were opened such that hot smoke could leave the room through the HVAC duct. To maintain the fire-rated ceiling assembly, proper protection measures were provided to ceiling assemblies including the lighting and the joint areas of the ducts above ceiling. However, flexible duct between the HVAC louvers and metal duct were not fire-rated and ruptured during the fire test as shown in Figure 8.31. Although all other fire-rated assemblies showed a good performance, the space above ceiling was exposed to hot smoke due to the failure of one item, the flexible duct. This is a good lesson for fire safety, which shows that just one item failure could lead to a poor performance of the entire system.

9.4 EGRESS / COMPARTMENTATION SYSTEMS

9.4.1 Detached stairs

After FB-5, the welds connecting the stair to the 2nd floor were broken, and after FB-6, the welds connecting the stair to the 2nd and the 3rd floors were broken. In addition, handrails were broken at the 3rd to 5th floor landings. The broken handrail at the 4th floor is shown in Figure 6.5.

As stairways are the most widely used means of egress components, it is expected that people will use stairways to evacuate the building in emergency conditions. In addition fire fighters also use stairways to conduct their rescue and suppression missions in the building. Unavailability of stairways by earthquake will become a serious challenge to both fire fighters and occupants, and even more serious if fires following earthquake occur.

9.4.2 Elevator malfunction

The elevator was not operational after FB-6 due damage to the elevator doors, which was observed from the 2nd to the 5th floors. The elevator door in th 3rd floor is shown Figure 5.8. In addition, the fire test EL-1 revealed that fire melted the elevator button panel which may cause the electrical shorts and make elevator unavailable.

As elevators are required to have a high operational safety condition, damage such as this can stop the entire elevator system. Since elevators can serve as accessible means of egress per IBC with appropriate sprinkler system, exit enclosure, smoke proof, and alarm and communication systems, maintaining elevator operability is essential. This is also the case where elevators are used for self-evacuation of occupants.

Also, if elevator doors are failed open on multiple floors, such as with the FB-6 test, smoke spread to non-fire floors through the elevator shaft is highly possible, especially given the stack effect and buoyancy of hot smoke. In these tests, even the possibility of fire spread through the elevator shaft is confirmed as the internal gas temperature was increased up to 300^{o}C as shown in Figure 8.48, which is high enough to ignite some materials.

9.5 STRUCTURAL INTEGRITY

After FB-6, a serious structural damage occurred in the joint of the middle-north column and connected east beam in the second floor (Figure 6.1). Due to the repetitive hinge motion, concrete spalling occurred and the rebar were exposed, which damaged the load bearing capacity. It was fortunate that this did not occur on the fire test floor, as fire tests would not likely have been possible. With the loss of concrete cover, the elevated temperatures from a fire can quickly affect the strength of the steel rebar facilitating failure. This is a concern that warrants further investigation.

9.6 FIREFIGHTER ACCESS AND OPERATIONS

As noted above, stairs on Floors 2 and 4 became disconnected due to broken welds and the elevator was not usable after FB-6, and significant structural damage was observed. Each of these factors presents significant challenges to first responders. Likewise, if windows are broken, wind-driven fires create additional concerns.

10 FUTURE WORK

Real-scale experimental studies generally have more test constraints compared to lab-based tests which may include increased costs, additional set-ups for test apparatus, and uncontrollable test environments. However, they provide incomparably valuable findings compared to lab-based tests; all the test specimens and components are installed as they are in real life, the experimental results can be directly applicable to the relevant practice, and the holistic performance of individual component can be identified. Especially, the real-scale fire tests along with earthquake damaged building produce excellent synergy effects as fire following earthquakes (FFE) is very common and lead to the most significant life loss and property damages, even more than the earthquake itself. As such, this BNCS project was very unique and produced valuable test results. At the same time, the test results also provided researchers, engineers, and practitioners with lessons and future subjects that they all need to consider further. Here some of these relevant to post-earthquake fire tests are introduced. More detailed analysis will be conducted with additional simulations using the current data in the future.

10.1 BUILDING FEATURES (BUILDING SYSTEMS AND BUILDING ELEMENTS)

Building systems which critically affect building fire safety performance needs to be fully operational in the building subjected to seismic motion tests. For example, HVAC system can contribute smoke spread throughout the entire buildings as shown in the MGM Grand Hotel fire, Las Vegas. If even one system component is not working properly after earthquake, then the entire HVAC system would not be performing as intended. In the BNCS projects, due to time schedule and budget limitation, systems subjected to the seismic and fire tests were not in the full operational status. Other building systems with additional individual components which are relevant to building fire safety performance are introduced below.

- In-house emergency backup power system (exit signs, elevator, sprinkler pump, smoke control system, means of egress illuminations, smoke proof stairwell: communication system and lighting)

- HVAC system (fire damper, duct work, air distribution system, control system interlocked with fire alarm system)
- Stair pressurization system
- Fire detection, alarm, and notification(or communication), public address system
- Fire sprinkler system with pumps
- Standpipe system
- Clean agent fire suppression system

Along with these system features, general building elements relevant to fire safety performance are listed below.

- Structural system
- Exterior walls
- Exterior windows
- Interior walls
- Interior doors (wood, steel, fire-rated, etc.)
- Airtight enclosed stairwell and emergency exit door discharge
- Emergency exterior stairs
- Horizontal exits

The seismic performance of these elements varies depending on the building construction type. For example, interior walls in Type I building will show different seismic and fire performance compared with the ones from Type V buildings. Likewise, the structural framing performance and resiliency may vary. Specific seismic ratings or installation method are also required depending on the local regulations and seismic characteristics of the site. As shown in the BNCS tests, the ceiling system common in the East coast in the first floor was damaged more than the ones in the third floor designed for seismic conditions. Since it is possible to have an intermediate level of earthquake in non-West coast areas, the building systems and elements typically designed for non-seismic zones are also worth being subjected to earthquake and fire tests.

10.2 MEASUREMENT IN FIRE TESTS

The building fire safety performance is determined generally by two methods: measurements of temperature, heat flux, flow velocity, and pressure and the visual records of smoke and fire spread. The measurements of these are valuable as actual values are directly used in fire protection engineering practice in fields. For example, steel structure temperature of 550 ^{o}C is known to be a critical temperature at which only 50% of its strength remains, which fire protection engineers design fire protection systems to avoid this temperature in steel structure. In the same way, the heat flux of 20 kW/m^2 at the floor level is known to cause flashover conditions. Visual records of smoke and fire spread are useful to identify the locations of leaks and smoke movement through hidden paths.

10.3 TEST BEFORE EARTHQUAKE DAMAGE

To compare the effects of earthquake on building fire safety performance, the best way is to run the same fire tests before and after the seismic motion tests. By comparing the measurements and visual records, the level of earthquake effects on fire performance including failure locations, the peak HRR and room temperature, the temperature of steel structure can be identified.

10.4 GAS BURNER SYSTEM AND HRR MEASUREMENT

Due to extremely tight time schedule and budget availability, it was not possible to use a gas burner system, which is much better for controlling the fire size and for measuring the HRR. Controlling fire size and measuring HRR are useful to estimate more precise fire phenomena and the responses of building. Particularly, HRR is one of the most important input values for fire modeling software program.

10.5 ELECTRICITY FOR DAQ SEPARATE FROM THE BUILDING ELECTRICITY

In the middle of ES fire test, electricity was gone in a very short time which stopped data logging in DAQ. The reason for this was unknown, but it is necessary to provide a separate power source for DAQ.

10.6 MORE MEASUREMENT PROBES

In on-site real-scale fire tests, wind and ambient temperature can affect the temperature distribution in the compartment, smoke movement, fuel burning rate, and many other results. Since these factors can-not be controlled, the best way to capture these effects is to locate more measurement probes in the test environment and analyze the effect of these factors linking with the measurements. To do that, multiple measurement probes at the right locations are required.

10.7 REPEATABILITY OF TESTS

Due to the tight test schedule, the beginning of dry season, and availability of local fire fighters, multiple tests were not possible. However, it is always good to run the same test multiple times to check the repeatability.

11 CONCLUSIONS

A series of live fire experiments were carried out in an earthquake-damaged, 5-story test specimen in order to help evaluate the potential for post-earthquake fire impact on buildings. Although most of the data regarding fire performance of the test specimen was limited to systems and configurations on the third floor, and the live fire tests were limited in number and scope, important data were collected and the following initial observations are made.

General observations regarding earthquake performance of the specimen, which could have an impact on fire performance of a building, include:

- Ceiling systems on Floor 1 showed progressive damage with increase ground motion intensity. The potential fire performance concern is loss of compartment integrity and spread of fire and smoke. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Contents indicative of residential and laboratory spaces on Floor 2, ranging from small items such as books, vases and a television set, to larger items such as bookshelves, storage shelves, and refrigeration units were displaced if not anchored. The potential fire performance concern is that most of the unanchored items were distributed on the floor, which would represent a distributed fuel load that is different that might be anticipated for a non-earthquake-damaged building. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Some of the magnetic door holders installed on Floor 3 experienced damage during the motion tests. In one case, the magnetic bond was stronger than the fasteners used to connect the strike plate to the door, ripping the strike plate off the door. The potential fire performance concern here is that improperly operating doors might impede occupant egress and firefighter access.
- Some of the doors installed on Floor 3 were not functioning properly after the motion tests. In some cases doors were not able to close completely because door frames were distorted and locks were damaged. The potential fire performance concern here is that smoke and fire could spread through a door, which was designed to be closed during fire, hindering occupant egress and safety. In another instance, a door on Floor

3 was jammed closed during a ground motion tests, requiring tools to be used to pry the door open. The potential fire performance concerns here are that occupants can be hindered when trying to escape, placing them at risk, and the fire service can be hindered when undertaking rescue and firefighting operations.

- In various locations within the test specimen, including around the elevator shaft on Floor 3 and within the stairwell on various levels, gypsum wallboard sections became detached during motion tests. The potential fire concerns are loss of compartment integrity and spread of fire and smoke, hindering occupants when trying to escape and placing them at risk, and hindering the fire service when undertaking rescue and firefighting operations. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Following the largest ground motions, the stair became detached from the stair landing and handrails were broken at locations between Floors 2 and 4. The potential fire performance concerns here are that occupants can be hindered when trying to escape, placing them at risk, and the fire service can be hindered when undertaking rescue and firefighting operations. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Following the largest ground motions, significant spalling occurred on various concrete beam-column connections on the lower floor, resulting in exposed steel rebars, degrading the structural load-bearing capacity and fire performance of the connection and structural system. The potential fire performance concerns here are that occupants can be hindered when trying to escape, placing them at risk, the fire service can be hindered when undertaking rescue and firefighting operations, and the building could be at risk of localized collapse or worse. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)
- Following the largest ground motions, one intensive care unit breakout door was detached from the door frame on Floor 4. Since the door provides a smoke barrier, the potential fire performance concern here is that smoke could spread through the opening, and occupants, who may be required to be protected in place, might be put at risk. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)

- Following the largest ground motions, a rigid steel pipe, representative of a fuel gas supply line, failed at a connection. Such a failure could lead to release of fuel gas in a building, if other protective measures are not in place (e.g., shutoff valves). Corrugated stainless steel tubing (CSST), also representative of a fuel gas supply line, did not experience such a failure. (See Chen et al., 2013 and Pantoli et al., 2013 for more details on these items.)

General observations regarding fire performance of the specimen, following the live fire tests, which could have an impact on fire performance of a building, include:

- The automatic sprinkler system functioned well during ground motion tests and activated as expected during the fire tests on Floor 3.
- The firestop systems installed on Floor 3 performed generally well during the motion tests and to the fire tests, with the exception of the static joint seals which did not work on those joints which became separated by the ground motion. The potential fire performance concern is loss of compartment integrity and spread of fire and smoke.
- The roll-down steel fire door performed well during the motion tests (no damage, see Chen et al., 2013 and Pantoli et al., 2013 for more details) and activated as expected during the fire tests.
- Smoke detectors activated as expected during the fire tests.
- The fire dampers on Floor 3 performed generally well during the motion tests and fire tests. Two fire dampers closed completely following each motion test. The third damper’s blade rotation was prevented by a screw used for damper installation which, once adjusted, allowed the damper to close completely following the motion tests. The potential fire performance concern is lack of smoke control, allowing smoke to spread from one compartment to another.
- The non-rated flexible duct melted and ruptured during some of the fire tests. The potential fire performance concern is lack of smoke control, allowing smoke to spread from one compartment to another.
- Significant gaps opened in several joint areas on Floor 3, as well as between steel brackets and the balloon framing. The gap between the balloon framing and slab was up to 10 cm (4 inches) in places (see Chen et al., 2013 and Pantoli et al., 2013 for more details). The potential fire performance concern is loss of compartment integrity

and spread of fire and smoke. Smoke leakage was observed during the fire tests in several locations.

- The elevator was non-operable following the largest ground motion because the elevator doors and frames became distorted on several floors, with openings as large as 24 cm (9.4 inches) on the third floor. One potential fire performance concern is loss of compartment integrity and spread of fire and smoke, in this case allowing for vertical smoke (and fire) spread. The elevator shaft interior temperatures were greatly increased as smoke and hot gases from the EL1 and EL 2 fires were entrained into the shaft through the opening on Floor 3. An additional potential fire performance concern is the loss of elevators for occupant egress and for fire department rescue and suppression support operations.
- A long vertical steel pipe went through thermal expansion under elevated temperatures during one fire test and the pipe shifted the firestop material that was applied on the vertical pipe penetration opening. The potential fire performance concern is lack of intended smoke control, allowing smoke to spread from one compartment to another.
- Depending on the test, flashover conditions were observed, even with relatively small fuel loads. In some cases the ventilation conditions played a significant role.
- Rigid steel fuel gas distribution systems, if damaged due to seismic motion, could result in additional fuel for post-earthquake fire, if not provided with additional safeguards (e.g., shutoff valves).
- Although it was not possible to test actual windows during these tests, window openings were provided and tested in various conditions, including completely closed, partially closed and fully open. In tests where the windows were fully opened, flame extension was observed, smoke venting was observed, and the test fires were exposed to wind-driven conditions, which affected the combustion rate, smoke spread and flame angle direction during the fire tests. The potential fire performance concerns here are that loss of windows could facilitate floor-to-floor fire spread, and that wind-driven conditions resulting from loss of windows could result in much different fire conditions that the building fire protection systems are designed for or the fire department might expect. This would place occupants and the fire service at risk.

Again, although most of the data on the fire performance of the test specimen was limited to systems and configurations on the third floor, and the live fire tests were limited in number and scope, important data were collected and the following initial observations are made. Since very few full-scale post-earthquake fire tests have been conducted to date, more testing is warranted to investigate in more depth the above situations, to assess the performance of other building constructions, contents and configurations, and to fill the gap of knowledge on post-earthquake building fire conditions. Some additional observations for future testing include the following:

- To better assess the potential for vertical fire spread and potential for and the effects of wind-driven fires, a variety of exterior glazing systems and window configurations should be tested.
- Post-earthquake fire experiments should be performed on a myriad of construction types as the code requirements, construction material and style vary across different regions. Test specimens utilizing lightweight steel construction, lightweight engineered wood construction, steel framed construction and combinations of construction (framing, interior and façade) systems should be tested. Multiple ceiling systems and components should be tested. Multiple door/frame systems, closers and hold-open devices should be tested.
- To best mimic real life conditions, it is important to have fully operating building and fire protection systems, including a fully functioning HVAC system.
- Measurements of the heat flux, flow velocity, temperature, pressure and visual records of smoke and fire spread should be collected directly during the fire tests. This will provide more data on building performance and can be helpful in simulation or performance.
- Instead of a fuel pan, a gas burner system should be used which allows for controlling the fire size and for measuring the HRR. This will allow more flexible test schemes, and larger and longer fires, which can be stopped as needed if the potential for structural damage exists.
- Any data acquisition, instrumentation and sensors should be powered separately from that of the test building as building electrical wires are prone to melting during the fire tests.

- Two sets of tests should be conducted on the same building conditions at the pre- and post-earthquake damaged state. Where possible, laboratory pre- and post-damage testing of representative configurations will help to yield additional data.
- Tests should be repeated under the same testing environment for a more reliable set of test data.
- Tests should be repeated under a range of test environments (e.g., relative humidity, temperature and wind speeds) for a broader data set.

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A FIRE SYSTEM SPECIFICATIONS

A.1 SPRINKLER SYSTEM SPECIFICATIONS

A.1.1 TY3131 and TY3231 K-5.6 Quick Response Upright and Pendent Sprinklers

tyco Fire Suppression & Building Products

Technical Services 800-381-9312 | +1-401-781-8220
www.tyco-fire.com

Series TY-FRB — 2.8, 4.2, 5.6, and 8.0 K-Factor Upright, Pendent, and Recessed Pendent Sprinklers Quick Response, Standard Coverage

General Description

The TYCO Series TY-FRB, 2.8, 4.2, 5.6, and 8.0 K-factor, Upright and Pendent Sprinklers described in this data sheet are quick response, standard coverage, decorative 3 mm glass bulb-type spray sprinklers designed for use in light or ordinary hazard, commercial occupancies such as banks, hotels, and shopping malls.

The recessed version of the Series TY-FRB Pendent Sprinkler, where applicable, is intended for use in areas with a finished ceiling. This recessed pendent sprinkler uses one of the following.

- A two-piece Style 10 (1/2 inch NPT) or Style 40 (3/4 inch NPT) Recessed Escutcheon with 1/2 inch (12,7 mm) of recessed adjustment or up to 3/4 inch (19,1 mm) of total adjustment from the flush pendent position, or a
- A two-piece Style 20 (1/2 inch NPT) or Style 30 (3/4 inch NPT) Recessed Escutcheon with 1/4 inch (6,4 mm) of recessed adjustment or up to 1/2 inch (12,7 mm) of total adjustment from the flush pendent position.

The adjustment provided by the Recessed Escutcheon reduces the accuracy to which the fixed pipe drops to the sprinklers must be cut.

IMPORTANT

Always refer to Technical Data Sheet TFP700 for the "INSTALLER WARNING" that provides cautions with respect to handling and installation of sprinkler systems and components. Improper handling and installation can permanently damage a sprinkler system or its components and cause the sprinkler to fail to operate in a fire situation or cause it to operate prematurely.

Corrosion-resistant coatings, where applicable, are utilized to extend the life of copper alloy sprinklers beyond that which would otherwise be obtained when exposed to corrosive atmospheres. Although corrosion-resistant coated sprinklers have passed the standard corrosion tests of the applicable approval agencies, the testing is not representative of all possible corrosive atmospheres. Consequently, it is recommended that the end user be consulted with respect to the suitability of these coatings for any given corrosive environment. The effects of ambient temperature, concentration of chemicals, and gas/chemical velocity, should be considered, as a minimum, along with the corrosive nature of the chemical to which the sprinklers will be exposed.

An intermediate level of the Series TY-FRB Pendent Sprinklers is detailed in Technical Data Sheet TFP356, and Sprinkler Guards are detailed in Technical Data Sheet TFP780.

NOTICE

The Series TY-FRB Concealed Pendent Sprinklers described herein must be installed and maintained in compliance with this document and with the applicable standards of the National Fire Protection Association, in addition to the standards of any authorities having jurisdiction. Failure to do so may impair the performance of these devices.

Owners are responsible for maintaining their fire protection system and devices in proper operating condition. The installing contractor or sprinkler manufacturer should be contacted with any questions.

Model/Sprinkler Identification Number (SIN)

TY1131:	Upright	2.8K, 1/2" NPT
TY1231:	Pendent	2.8K, 1/2" NPT
TY2131:	Upright	4.2K, 1/2" NPT
TY2231:	Pendent	4.2K, 1/2" NPT
TY3131:	Upright	5.6K, 1/2" NPT
TY3231:	Pendent	5.6K, 1/2" NPT
TY4131:	Upright	8.0K, 3/4" NPT
TY4231:	Pendent	8.0K, 3/4" NPT
TY4831:	Upright*	8.0K, 1/2" NPT
TY4931:	Pendent*	8.0K, 1/2" NPT

*Eastern Hemisphere Sales Only

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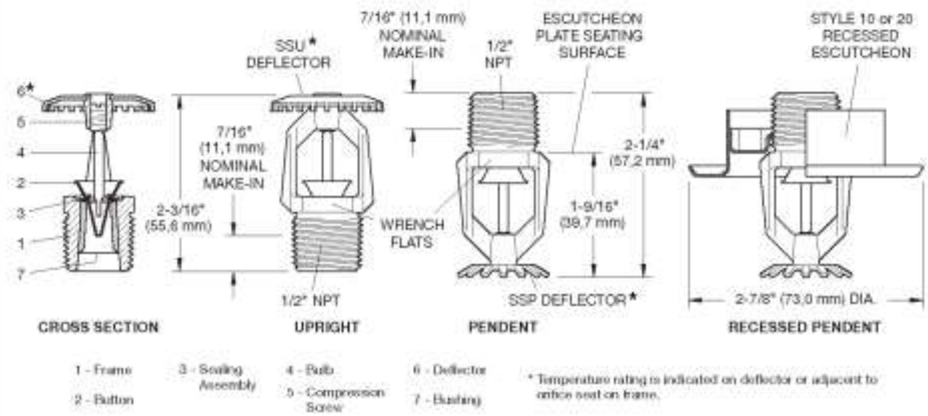

FIGURE 1
QUICK RESPONSE SERIES TY-FRB UPRIGHT (TY1131) AND PENDENT (TY1231) SPRINKLERS
2.8 K-FACTOR, 1/2 INCH NPT

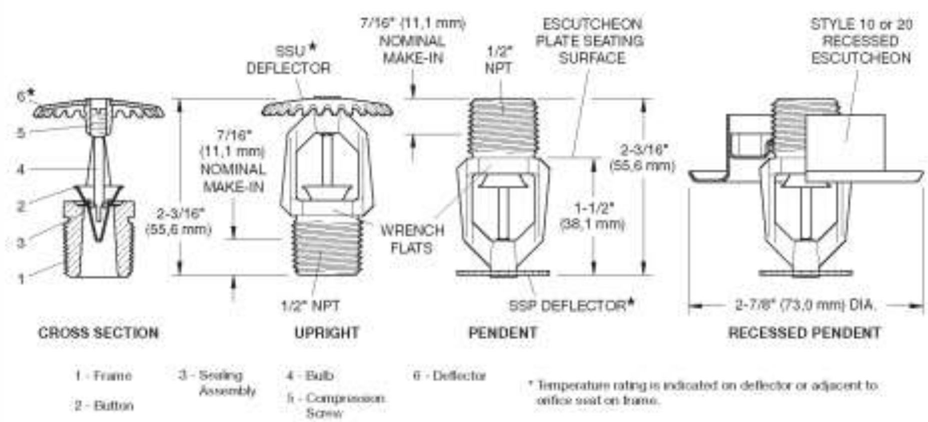

FIGURE 2
QUICK RESPONSE SERIES TY-FRB UPRIGHT (TY2131) AND PENDENT (TY2231) SPRINKLERS
4.2 K-FACTOR, 1/2 INCH NPT

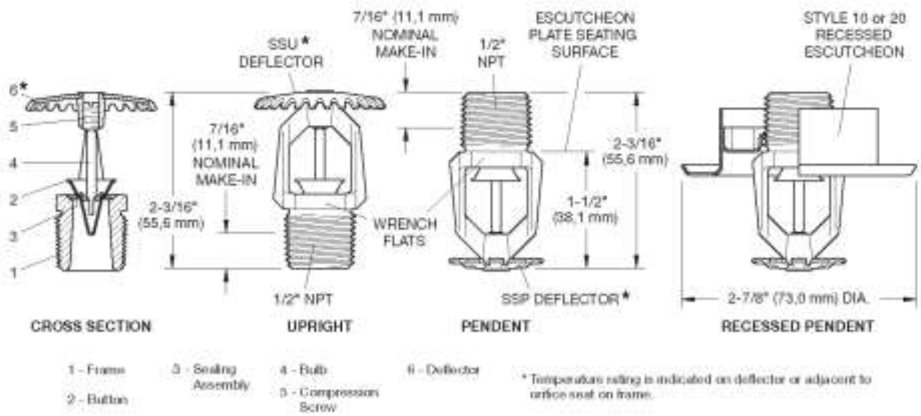

FIGURE 3
QUICK RESPONSE SERIES TY-FRB UPRIGHT (TY3131) AND PENDENT (TY3231) SPRINKLERS
5.6 K-FACTOR, 1/2 INCH NPT

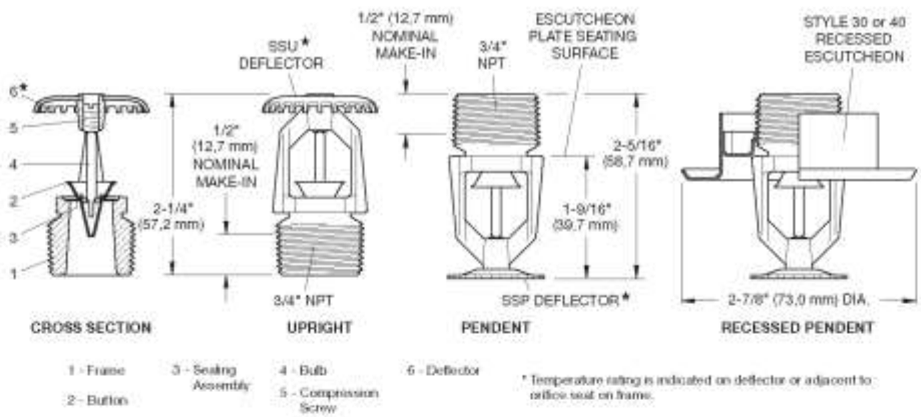

FIGURE 4
QUICK RESPONSE SERIES TY-FRB UPRIGHT (TY4131) AND PENDENT (TY4231) SPRINKLERS
8.0 K-FACTOR, 3/4 INCH NPT

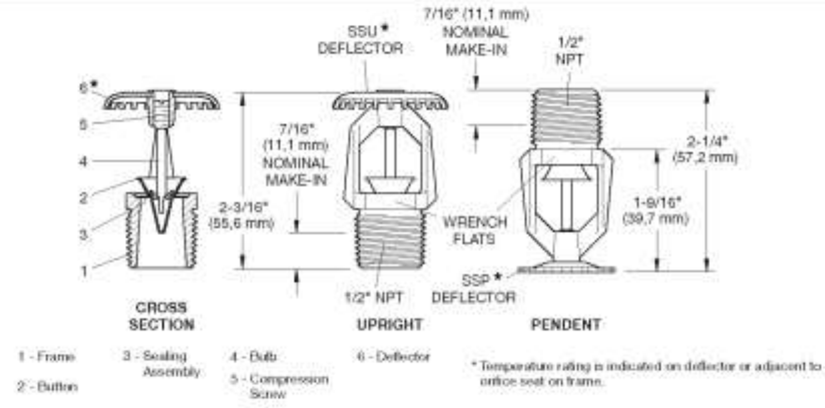

FIGURE 5
QUICK RESPONSE SERIES TY-FRB UPRIGHT (TY4831) AND PENDENT (TY4931) SPRINKLERS
8.0 K-FACTOR, 1/2 INCH NPT

Technical Data

Approvals
UL and C-UL Listed
FM, LPCB, and NYC Approved
Refer to Table A and B for complete approval information including corrosion-resistant status.

Maximum Working Pressure
Refer to Table C.

Discharge Coefficient

K=2.8 GPM/psi$^{1/2}$	(40,3 LPM/bar$^{1/2}$)
K=4.2 GPM/psi$^{1/2}$	(60,5 LPM/bar$^{1/2}$)
K=5.6 GPM/psi$^{1/2}$	(80,6 LPM/bar$^{1/2}$)
K=8.0 GPM/psi$^{1/2}$	(115,2 LPM/bar$^{1/2}$)

Temperature Rating
Refer to Table A and B.

Finishes
Sprinkler: Refer to Table A and B.
Recessed Escutcheon: White Coated, Chrome Plated, or Brass Plated.

Physical Characteristics

Frame	Bronze
Button	Brass/Copper
Sealing Assembly	Beryllium Nickel w/Teflon†
Bulb	Glass
Compression Screw	Bronze
Deflector	Copper/Bronze
Bushing (K=2.8)	Bronze

† Registered Trademark of Dupont

Operation

The glass Bulb contains a fluid that expands when exposed to heat. When the rated temperature is reached, the fluid expands sufficiently to shatter the glass Bulb, allowing the sprinkler to activate and water to flow.

Design Criteria

The TYCO Series TY-FRB Pendent and Upright Sprinklers are intended for fire protection systems designed in accordance with the standard installation rules recognized by the applicable Listing or Approval agency (such as, UL Listing is based on the requirements of NFPA 13, and FM Approval is based on the requirements of FM's Loss Prevention Data Sheets). Only the Style 10, 20, 30, or 40 Recessed Escutcheon, as applicable, is to be used for recessed pendent installations.

Installation

The TYCO Series TY-FRB Sprinklers must be installed in accordance with the following instructions.

NOTICE

Do not install any bulb-type sprinkler if the bulb is cracked or there is a loss of liquid from the bulb. With the sprinkler held horizontally, a small air bubble should be present. The diameter of the air bubble is approximately 1/16 inch (1,6 mm) for the 135°F/57°C and 3/32 inch (2,4 mm) for the 286°F/141°C temperature ratings.

Obtain a leak-tight 1/2 inch NPT sprinkler joint by applying a minimum to maximum torque of 7 to 14 ft.lbs. (9,5 to 19,0 Nm). Higher levels of torque can distort the sprinkler Inlet with consequent leakage or impairment of the sprinkler.

Do not attempt to compensate for insufficient adjustment in the Escutcheon Plate by under- or over-tightening the sprinkler. Re-adjust the position of the sprinkler fitting to suit.

The Series TY-FRB Pendent and Upright Sprinklers must be installed in accordance with the following instructions.

1. Install Pendent sprinklers in the pendent position. Install upright sprinklers in the upright position.
2. With pipe-thread sealant applied to the pipe threads, hand-tighten the sprinkler into the sprinkler fitting.
3. Tighten the sprinkler into the sprinkler fitting using only the W-Type 6 Sprinkler Wrench (Figure 14). With reference to Figures 1 through 5, apply the W-Type 6 Sprinkler Wrench to the sprinkler wrench flats.

<table>
<tr><th rowspan="2">K FACTOR</th><th rowspan="2">TYPE</th><th rowspan="2">TEMPERATURE</th><th colspan="5">SPRINKLER FINISH (See Note 5)</th></tr>
<tr><th>BULB LIQUID COLOR</th><th>NATURAL BRASS</th><th>CHROME PLATED</th><th>WHITE*** POLYESTER</th></tr>
<tr><td rowspan="13">2.8 1/2" NPT</td><td rowspan="5">PENDENT (TY1231) and UPRIGHT (TY1131)</td><td>135°F/57°C</td><td>Orange</td><td colspan="3" rowspan="5">1, 2, 3, 4</td></tr>
<tr><td>155°F/68°C</td><td>Red</td></tr>
<tr><td>175°F/79°C</td><td>Yellow</td></tr>
<tr><td>200°F/93°C</td><td>Green</td></tr>
<tr><td>286°F/141°C</td><td>Blue</td></tr>
<tr><td rowspan="4">RECESSED PENDENT (TY1231)* Figure 6</td><td>135°F/57°C</td><td>Orange</td><td colspan="3" rowspan="8">1, 2, 4</td></tr>
<tr><td>155°F/68°C</td><td>Red</td></tr>
<tr><td>175°F/79°C</td><td>Yellow</td></tr>
<tr><td>200°F/93°C</td><td>Green</td></tr>
<tr><td rowspan="4">RECESSED PENDENT (TY1231)** Figure 7</td><td>135°F/57°C</td><td>Orange</td></tr>
<tr><td>155°F/68°C</td><td>Red</td></tr>
<tr><td>175°F/79°C</td><td>Yellow</td></tr>
<tr><td>200°F/93°C</td><td>Green</td></tr>
<tr><td rowspan="13">4.2 1/2" NPT</td><td rowspan="5">PENDENT (TY2231) and UPRIGHT (TY2131)</td><td>135°F/57°C</td><td>Orange</td><td colspan="3" rowspan="13">1, 2</td></tr>
<tr><td>155°F/68°C</td><td>Red</td></tr>
<tr><td>175°F/79°C</td><td>Yellow</td></tr>
<tr><td>200°F/93°C</td><td>Green</td></tr>
<tr><td>286°F/141°C</td><td>Blue</td></tr>
<tr><td rowspan="4">RECESSED PENDENT (TY2231)* Figure 8</td><td>135°F/57°C</td><td>Orange</td></tr>
<tr><td>155°F/68°C</td><td>Red</td></tr>
<tr><td>175°F/79°C</td><td>Yellow</td></tr>
<tr><td>200°F/93°C</td><td>Green</td></tr>
<tr><td rowspan="4">RECESSED PENDENT (TY2231)** Figure 9</td><td>135°F/57°C</td><td>Orange</td></tr>
<tr><td>155°F/68°C</td><td>Red</td></tr>
<tr><td>175°F/79°C</td><td>Yellow</td></tr>
<tr><td>200°F/93°C</td><td>Green</td></tr>
</table>

NOTES:
1. Listed by Underwriters Laboratories, Inc., (UL) as Quick Response Sprinklers.
2. Listed by Underwriters Laboratories, Inc., for use in Canada (C-UL) as Quick Response Sprinklers.
3. Approved by Factory Mutual Research Corporation (FM) as Quick Response Sprinklers.
4. Approved by the City of New York under MEA 354-01-E.
5. Where Polyester Coated Sprinklers are noted to be UL and C-UL Listed, the sprinklers are UL and C-UL Listed as Corrosion-Resistant Sprinklers.

* Installed with Style 10 (1/2" NPT) or Style 40 (3/4" NPT) 3/4" Total Adjustment Recessed Escutcheon, as applicable.
** Installed with Style 20 (1/2" NPT) or Style 30 (3/4" NPT) 1/2" Total Adjustment Recessed Escutcheon, as applicable.
*** Frame and Deflector only. Listings and approvals apply to color (Special Order).
N/A: Not Available

TABLE A
LABORATORY LISTINGS AND APPROVALS FOR 2.8 AND 4.2 K-FACTOR SPRINKLERS

			SPRINKLER FINISH (See Note 8)				
K FACTOR	TYPE	TEMPERATURE	BULB LIQUID COLOR	NATURAL BRASS	CHROME PLATED	WHITE*** POLYESTER	LEAD COATED
5.6 1/2" NPT	PENDENT (TY3231) and UPRIGHT (TY3131)	135°F/57°C	Orange	1, 2, 3, 4, 5, 6, 7			1, 2, 3, 5
		155°F/68°C	Red				
		175°F/79°C	Yellow				
		200°F/93°C	Green				
		286°F/141°C	Blue				
	RECESSED PENDENT (TY3231)* Figure 10	135°F/57°C	Orange	1, 2, 4, 5			N/A
		155°F/68°C	Red				
		175°F/79°C	Yellow				
		200°F/93°C	Green				
		286°F/141°C	Blue				
	RECESSED PENDENT (TY3231)** Figure 11	135°F/57°C	Orange	1, 2, 3, 4, 5			N/A
		155°F/68°C	Red				
		175°F/79°C	Yellow				
		200°F/93°C	Green				
		286°F/141°C	Blue				
8.0 3/4" NPT	PENDENT (TY4231) and UPRIGHT (TY4131)	135°F/57°C	Orange	1, 2, 3, 4, 5, 6, 7			1, 2, 5
		155°F/68°C	Red				
		175°F/79°C	Yellow				
		200°F/93°C	Green				
		286°F/141°C	Blue				
	RECESSED PENDENT (TY4231)* Figure 12	135°F/57°C	Orange	1, 2, 5			N/A
		155°F/68°C	Red				
		175°F/79°C	Yellow				
		200°F/93°C	Green				
		286°F/141°C	Blue				
	RECESSED PENDENT (TY4231)** Figure 13	135°F/57°C	Orange	1, 2, 3, 5			N/A
		155°F/68°C	Red				
		175°F/79°C	Yellow				
		200°F/93°C	Green				
		286°F/141°C	Blue				
8.0 1/2" NPT	PENDENT (TY4931) and UPRIGHT (TY4831)	135°F/57°C	Orange	1, 2, 4, 5, 6			1, 2, 5
		155°F/68°C	Red				
		175°F/79°C	Yellow				
		200°F/93°C	Green				
		286°F/141°C	Blue				

NOTES:

1. Listed by Underwriters Laboratories, Inc., (UL) as Quick Response Sprinklers.
2. Listed by Underwriters Laboratories, Inc., for use in Canada (C-UL) as Quick Response Sprinklers.
3. Approved by Factory Mutual Research Corporation (FM) as Quick Response Sprinklers.
4. Approved by the Loss Prevention Certification Board (LPCB Ref. No. 007k/04) as Quick Response Sprinklers. However, LPCB does not rate the thermal sensitivity of recessed sprinklers.
5. Approved by the City of New York under MEA 354-01-E.
6. VdS Approved (For details, contact Tyco Fire Suppression & Building Products, Enschede, Netherlands, Tel. 31-53-428-4444/Fax 31-53-428-3377)
7. Approved by the Loss Prevention Certification Board (LPCB Ref. No. 094a/06) as Quick Response Sprinklers.
8. Where Polyester Coated and Lead-Coated Sprinklers are noted to be UL and C-UL Listed, the sprinklers are UL and C-UL Listed as Corrosion-Resistant Sprinklers. Where Lead-Coated Sprinklers are noted to be FM Approved, the sprinklers are FM Approved as a Corrosion-Resistant Sprinklers.

* Installed with Style 10 (1/2" NPT) or Style 40 (3/4" NPT) 3/4" Total Adjustment Recessed Escutcheon, as applicable.
** Installed with Style 20 (1/2" NPT) or Style 30 (3/4" NPT) 1/2" Total Adjustment Recessed Escutcheon, as applicable.
*** Frame and Deflector only. Listings and approvals apply to color (Special Order).
N/A: Not Available

TABLE B
LABORATORY LISTINGS AND APPROVALS FOR 5.6 AND 8.0 K-FACTOR SPRINKLERS

K FACTOR	TYPE	SPRINKLER FINISH: NATURAL BRASS	SPRINKLER FINISH: CHROME PLATED	SPRINKLER FINISH: WHITE POLYESTER	SPRINKLER FINISH: LEAD COATED
2.8 1/2" NPT	PENDENT (TY1231) and UPRIGHT (TY1131)	175 PSI (12,1 BAR)			N/A
	RECESSED PENDENT (TY1231)				
4.2 1/2" NPT	PENDENT (TY2231) and UPRIGHT (TY2131)	175 PSI (12,1 BAR)			N/A
	RECESSED PENDENT (TY2231)				
5.6 1/2" NPT	PENDENT (TY3231) and UPRIGHT (TY3131)	250 PSI (17,2 BAR) OR 175 PSI (12,1 BAR) (SEE NOTE 1)			175 PSI (12,1 BAR)
	RECESSED PENDENT (TY3231)				N/A
8.0 3/4" NPT	PENDENT (TY4231) and UPRIGHT (TY4131)	175 PSI (12,1 BAR)			175 PSI (12,1 BAR)
	RECESSED PENDENT (TY4231)				N/A
8.0 1/2" NPT	PENDENT (TY4931) and UPRIGHT (TY4831)	175 PSI (12,1 BAR)			175 PSI (12,1 BAR)

NOTES:
1. The maximum working pressure of 250 psi (17,2 bar) only applies to the Listing by Underwriters Laboratories Inc. (UL); the Listing by Underwriters Laboratories, Inc. for use in Canada (C-UL); and, the Approval by the City of New York.

TABLE C
MAXIMUM WORKING PRESSURE

The Series TY-FRB Recessed Pendent Sprinklers must be installed in accordance with the following instructions.

1. After installing the Style 10, 20, 30, or 40 Mounting Plate, as applicable, over the sprinkler threads and with pipe-thread sealant applied to the pipe threads, hand-tighten the sprinkler into the sprinkler fitting.
2. Tighten the sprinkler into the sprinkler fitting using only the W-Type 7 Recessed Sprinkler Wrench (Figure 15). With reference to Figures 1 to 4, apply the W-Type 7 Recessed Sprinkler Wrench to the sprinkler wrench flats.
3. After ceiling installation and finishing, slide on the Style 10, 20, 30, or 40 Closure over the Series TY-FRB Sprinkler and push the Closure over the Mounting Plate until its flange comes in contact with the ceiling.

Care and Maintenance

The TYCO Series TY-FRB must be maintained and serviced in accordance with the following instructions.

NOTICE

Before closing a fire protection system main control valve for maintenance work on the fire protection system that it controls, obtain permission to shut down the affected fire protection systems from the proper authorities and notify all personnel who may be affected by this action.

Absence of the outer piece of an escutcheon, which is used to cover a clearance hole, can delay sprinkler operation in a fire situation.

Exercise care to avoid damage to sprinklers before, during, and after installation. Never paint, plate, coat, or otherwise alter automatic sprinklers after they leave the factory.

Replace sprinklers that:

- were modified or over-heated.
- were damaged by dropping, striking, wrench twisting, wrench slippage, or the like.
- are leaking or exhibiting visible signs of corrosion.
- were exposed to corrosive products of combustion but have not operated, if you cannot easily remove combustion by-products with a cloth.
- have a cracked bulb or have lost liquid from the bulb. Refer to the Installation section in this data sheet.

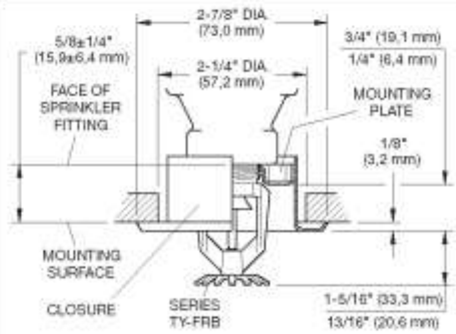

FIGURE 6
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 3/4 INCH TOTAL ADJUSTMENT STYLE 10 RECESSED ESCUTCHEON 2.8 K-FACTOR, 1/2 INCH NPT

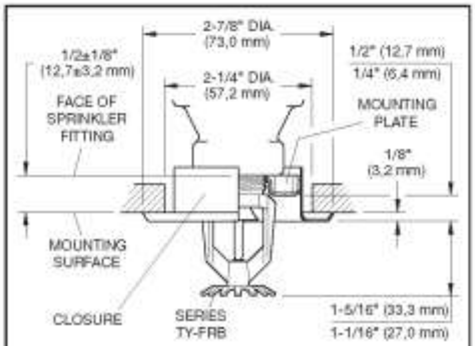

FIGURE 7
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 1/2 INCH TOTAL ADJUSTMENT STYLE 20 RECESSED ESCUTCHEON 2.8 K-FACTOR, 1/2 INCH NPT

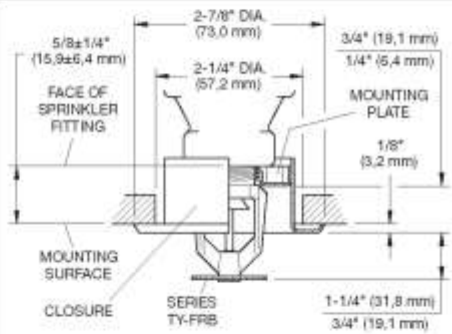

FIGURE 8
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 3/4 INCH TOTAL ADJUSTMENT STYLE 10 RECESSED ESCUTCHEON 4.2 K-FACTOR, 1/2 INCH NPT

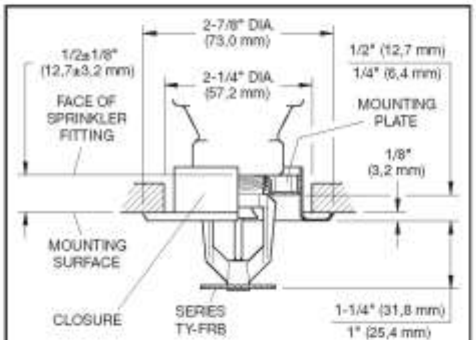

FIGURE 9
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 1/2 INCH TOTAL ADJUSTMENT STYLE 20 RECESSED ESCUTCHEON 4.2 K-FACTOR, 1/2 INCH NPT

Initial and frequent visual inspections of random samples are recommended for corrosion-resistant sprinklers to verify the integrity of the corrosion-resistant material of construction. Thereafter, annual inspections per NFPA 25 should suffice.

Inspections of corrosion-resistant sprinklers are recommended at close range, instead of from the floor level per NFPA. Inspection at close range can better determine the exact sprinkler condition and the long-term integrity of the corrosion-resistant material, which can be affected by the corrosive conditions present.

Responsibility lies with the owner for the inspection, testing, and maintenance of their fire protection system and devices in compliance with this document, as well as with the applicable standards of the National Fire Protection Association (for example, NFPA 25), in addition to the standards of any other authorities having jurisdiction. Contact the installing contractor or sprinkler manufacturer regarding any questions.

Automatic sprinkler systems are recommended to be inspected, tested, and maintained by a qualified Inspection Service in accordance with local requirements and/or national codes.

Care must be exercised to avoid damage to the sprinklers -before, during, and after installation. Sprinklers damaged by dropping, striking, wrench twist/slippage, or the like, must be replaced. Also, replace any sprinkler that has a cracked bulb or that has lost liquid from its bulb. (Ref. Installation Section).

Initial and frequent visual inspections of random samples are recommended for corrosion-resistant sprinklers to verify the integrity of the corrosion-resistant material of construction. Thereafter, annual inspections per NFPA 25 should suffice.

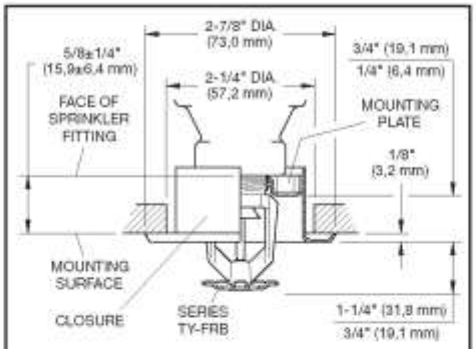

FIGURE 10
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 3/4 INCH TOTAL ADJUSTMENT STYLE 10 RECESSED ESCUTCHEON 5.6 K-FACTOR, 1/2 INCH NPT

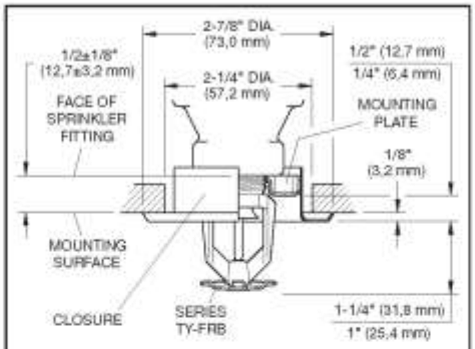

FIGURE 11
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 1/2 INCH TOTAL ADJUSTMENT STYLE 20 RECESSED ESCUTCHEON 5.6 K-FACTOR, 1/2 INCH NPT

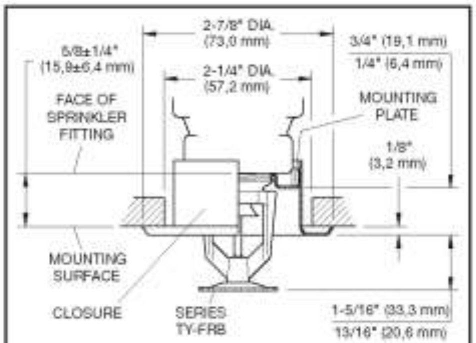

FIGURE 12
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 3/4 INCH TOTAL ADJUSTMENT STYLE 40 RECESSED ESCUTCHEON 8.0 K-FACTOR, 3/4 INCH NPT

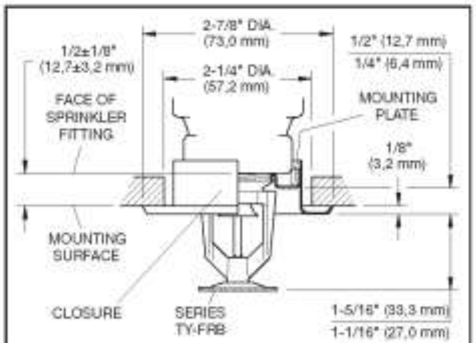

FIGURE 13
SERIES TY-FRB RECESSED PENDENT WITH TWO-PIECE 1/2 INCH TOTAL ADJUSTMENT STYLE 30 RECESSED ESCUTCHEON 8.0 K-FACTOR, 3/4 INCH NPT

Inspections of corrosion-resistant sprinklers are recommended at close range, instead of from the floor level per NFPA. Inspection at close range can better determine the exact sprinkler condition and the long-term integrity of the corrosion-resistant material, which can be affected by the corrosive conditions present.

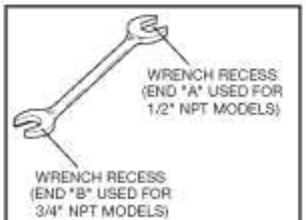

FIGURE 14
W-TYPE 6 SPRINKLER WRENCH

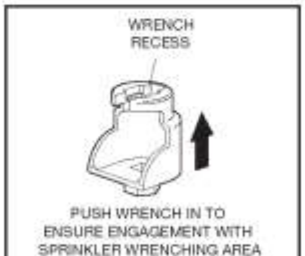

FIGURE 15
W-TYPE 7 RECESSED SPRINKLER WRENCH

P/N 57 – XXX – X – XXX

		MODEL/SIN
330	2.8K UPRIGHT (1/2"NPT)	TY1131
331	2.8K PENDENT (1/2"NPT)	TY1231
340	4.2K UPRIGHT (1/2"NPT)	TY2131
341	4.2K PENDENT (1/2"NPT)	TY2231
370	5.6K UPRIGHT (1/2"NPT)	TY3131
371	5.6K PENDENT (1/2"NPT)	TY3231
380	8.0K UPRIGHT (3/4"NPT)	TY4131
381	8.0K PENDENT (3/4"NPT)	TY4231
360	8.0K UPRIGHT (1/2"NPT)	TY4831*
361	8.0K PENDENT (1/2"NPT)	TY4931*

	SPRINKLER FINISH
1	NATURAL BRASS
4	WHITE POLYESTER
3	WHITE (RAL9010)*
9	CHROME PLATED
7	LEAD COATED

	TEMPERATURE RATINGS
135	135°F (57°C)
155	155°F (68°C)
175	175°F (79°C)
200	200°F (93°C)
286	286°F (141°C)

* Eastern Hemisphere sales only.

TABLE D
PART NUMBER SELECTION
SERIES TY-FRB PENDENT AND UPRIGHT SPRINKLERS

Limited Warranty

Products manufactured by Tyco Fire Suppression & Building Products (TFSBP) are warranted solely to the original Buyer for ten (10) years against defects in material and workmanship when paid for and properly installed and maintained under normal use and service. This warranty will expire ten (10) years from date of shipment by TFSBP. No warranty is given for products or components manufactured by companies not affiliated by ownership with TFSBP or for products and components which have been subject to misuse, improper installation, corrosion, or which have not been installed, maintained, modified or repaired in accordance with applicable Standards of the National Fire Protection Association, and/or the standards of any other Authorities Having Jurisdiction. Materials found by TFSBP to be defective shall be either repaired or replaced, at TFSBP's sole option. TFSBP neither assumes, nor authorizes any person to assume for it, any other obligation in connection with the sale of products or parts of products. TFSBP shall not be responsible for sprinkler system design errors or inaccurate or incomplete information supplied by Buyer or Buyer's representatives.

In no event shall TFSBP be liable, in contract, tort, strict liability or under any other legal theory, for incidental, indirect, special or consequential damages, including but not limited to labor charges, regardless of whether TFSBP was informed about the possibility of such damages, and in no event shall TFSBP's liability exceed an amount equal to the sales price.

<u>The foregoing warranty is made in lieu of any and all other warranties, express or implied, including warranties of merchantability and fitness for a particular purpose.</u>

This limited warranty sets forth the exclusive remedy for claims based on failure of or defect in products, materials or components, whether the claim is made in contract, tort, strict liability or any other legal theory.

This warranty will apply to the full extent permitted by law. The invalidity, in whole or part, of any portion of this warranty will not affect the remainder.

Ordering Procedure

Contact your local distributor for availability. When placing an order, indicate the full product name and Part Number (P/N).

Sprinkler Assemblies with NPT Thread Connections
Specify: (Specify Model/SIN), Quick Response, (specify K-factor), (specify temperature rating), Series TY-FRB (specify Pendent or Upright) Sprinkler with (specify type of finish or coating), P/N (specify from Table D).

Recessed Escutcheon:
Specify: Style (10, 20, 30, or 40) Recessed Escutcheon with (specify*) finish, P/N (specify*).

Sprinkler Wrench
Specify: W-Type 6 Sprinkler Wrench, P/N 56-000-6-387.

Specify: W-Type 7 Sprinkler Wrench, P/N 56-850-4-001.

* Refer to Technical Data Sheet TFP770.

A.1.2 TY 2524 K-4.9 Residential Concealed Pendent Sprinkler

tyco

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RAPID RESPONSE Series LFII Residential Sprinklers 4.9 K-factor Flat-Plate Concealed Pendent Wet Pipe and Dry Pipe Systems

General Description

The TYCO RAPID RESPONSE Series LFII Residential Flat-Plate Concealed Pendent Sprinklers (TY2524) are decorative, fast response, fusible solder sprinklers designed for use in residential occupancies such as homes, apartments, dormitories, and hotels.

The Cover Plate/Retainer Assembly conceals the sprinkler operating components above the ceiling. The flat profile of the Cover Plate provides the optimum aesthetically appealing sprinkler design. Additionally, the concealed design of the Series LFII Residential Flat-Plate Concealed Pendent Sprinklers provides 1/2 inch (12,8 mm) vertical adjustment. This adjustment provides a measure of flexibility when cutting fixed sprinkler drops.

The Series LFII Residential Flat-Plate Concealed Pendent Sprinklers are intended for use in the following systems:

- wet and dry pipe residential sprinkler systems for one- and two-family dwellings and mobile homes per NFPA 13D
- wet and dry pipe residential sprinkler systems for residential occupancies up to and including four stories in height per NFPA 13R
- wet and dry pipe sprinkler systems for the residential portions of any occupancy per NFPA 13.

The Series LFII Residential Sprinklers have been designed with heat sensitivity and water distribution characteristics proven to help in the control of residential fires and to improve the chance for occupants to escape or be evacuated.

IMPORTANT

Always refer to Technical Data Sheet TFP700 for the "INSTALLER WARNING" that provides cautions with respect to handling and installation of sprinkler systems and components. Improper handling and installation can permanently damage a sprinkler system or its components and cause the sprinkler to fail to operate in a fire situation or cause it to operate prematurely.

The Series LFII Residential Flat-Plate Concealed Pendent Sprinklers are shipped with a Disposable Protective Cap. The Protective Cap protects the sprinkler during ceiling installation or finish. After ceiling installation is complete, the Protective Cap is removed and the Cover Plate/Retainer Assembly is installed. Removing the Protective Cap is required for proper sprinkler performance.

Dry Pipe System Application

The Series LFII Residential Flat-Plate Concealed Pendent Sprinkler offers a laboratory approved option for designing dry pipe residential sprinkler systems, whereas, most residential sprinklers are laboratory approved for wet systems only.

Through extensive testing and as referenced in U.S. Patent 7,712,543, it has been determined that the number of design sprinklers (hydraulic design area) for the Series LFII Residential Flat-Plate Concealed Sprinklers (TY2524) need not be increased over the number of design sprinklers (hydraulic design area) specified for wet pipe sprinkler systems, as is customary for density/area sprinkler systems designed per NFPA 13, 13D, or 13R.

Consequently, the Series LFII Residential Flat-Plate Concealed Sprinklers (TY2524) offer the features of non-water filled pipe in addition to not having to increase the number of design sprinklers (hydraulic design area) for systems designed to NFPA 13, 13D, or 13R. Non-water filled pipe will permit options for areas sensitive to freezing.

NOTICE

The Series LFII Residential Flat-Plate Concealed Pendent Sprinklers (TY2524) described herein must be installed and maintained in compliance with this document and the applicable standards of the National Fire Protection Association, in addition to the standards of any authorities having jurisdiction. Failure to do so may impair the performance of these devices.

The owner is responsible for maintaining their fire protection system and devices in proper operating condition. The installing contractor or sprinkler manufacturer should be contacted with any questions.

Sprinkler Identification Number (SIN)

TY2524

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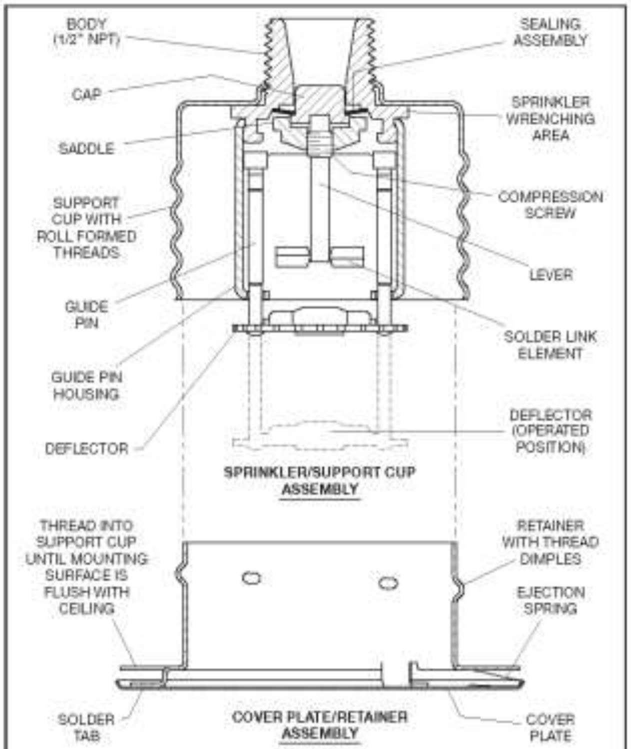


FIGURE 1
RAPID RESPONSE SERIES LFII RESIDENTIAL FLAT-PLATE CONCEALED PENDENT SPRINKLER (TY2524)
— ASSEMBLY —

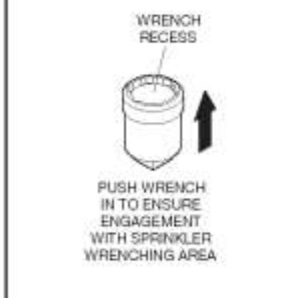


FIGURE 2
W-TYPE 18
— SPRINKLER WRENCH —

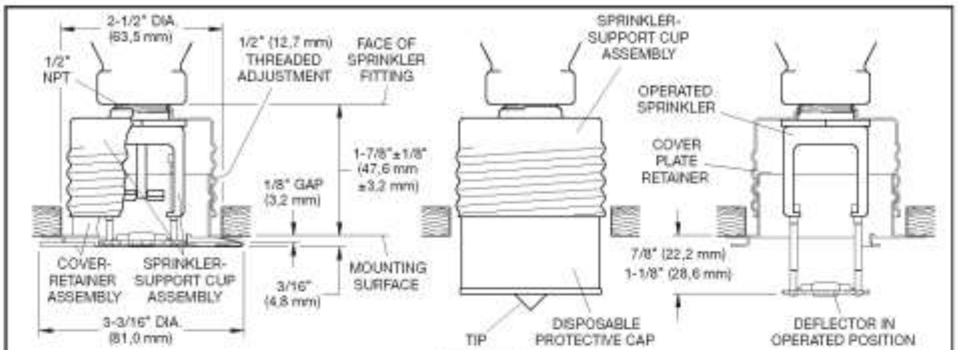


FIGURE 3
PROTECTIVE CAP AND ACTIVATED DEFLECTOR
— INSTALLATION DIMENSIONS —

Technical Data

Approvals
UL and C-UL Listed

The TYCO RAPID RESPONSE Series LFII Residential Flat-Plate Concealed Pendent Sprinklers are only listed with the Series LFII Concealed Cover Plates having a factory-applied finish.

For details on approvals, refer to the Design Criteria section.

Maximum Working Pressure
175 psi (12,1 bar)

Discharge Coefficient
K=4.9 GPM/psi$^{1/2}$ (70,6 LPM/bar$^{1/2}$)

Temperature Rating
Sprinkler: 160°F (71°C)
Cover Plate: 139°F (59°C)

Vertical Adjustment
1/2 inch (12,7 mm)

Finishes
Refer to the Ordering Procedure section.

Physical Characteristics
Cover Plate/Retainer Assembly:

Cover Plate	Copper
Ejection Spring	Stainless Steel
Retainer	Brass

Sprinkler/Support Cup Assembly:

Body	Brass
Cap	Bronze
Saddle	Brass
Sealing Assembly	Beryllium Nickel w/ TEFLON
Soldered Link Halves	Nickel
Lever	Bronze
Compression Screw	Brass
Deflector	Bronze
Guide Pin Housing	Bronze
Guide Pins	Bronze
Support Cup	Steel

Operation

When exposed to heat from a fire, the Cover Plate, which is normally soldered to the Retainer at three points, falls away to expose the Sprinkler/Support Cup Assembly. At this point, the Deflector, supported by the Guide Pins, drops down to its operated position.

The Solder Link Element of the Sprinkler/Support Cup Assembly is comprised of two link halves that are soldered together with a thin layer of solder. When the rated temperature is reached, the solder melts and the two link halves separate, allowing the sprinkler to activate and flow water.

Design Criteria

The TYCO RAPID RESPONSE Series LFII Residential Flat-Plate Concealed Pendent Sprinklers (TY2524) are UL and C-UL Listed for installation in accordance with this section:

Residential Sprinkler Design Guide
When conditions exist that are outside the scope of the provided criteria, refer to the Residential Sprinkler Design Guide TFP490 for the manufacturer's recommendations that may be acceptable to the authority having jurisdiction.

System Type
Per the UL Listing, wet pipe and dry pipe systems may be utilized. Per the C-UL Listing, only wet pipe systems may be utilized.

Refer to Technical Data Sheet TFP485 about the use of Residential Sprinklers in residential dry pipe systems.

Hydraulic Design (NFPA 13D and 13R)
For systems designed to NFPA 13D or NFPA 13R, the minimum required sprinkler flow rate are given in Tables A and B as a function of temperature rating and the maximum allowable coverage areas. The sprinkler flow rate is the minimum required discharge from each of the total number of "design sprinklers" as specified in NFPA 13D or NFPA 13R. The number of "design sprinklers" specified in NFPA 13D and 13R for wet pipe systems is to be applied when designing dry pipe systems.

Hydraulic Design (NFPA 13)
For systems designed to NFPA 13, the number of design sprinklers is to be the four most hydraulically demanding sprinklers. The minimum required discharge from each of the four sprinklers is to be the greater of the following:

- The flow rates given in Tables A and B as a function of temperature rating and the maximum allowable coverage area.
- A minimum discharge of 0.1 gpm/ft^2 over the "design area" comprised of the four most hydraulically demanding sprinklers for the actual coverage areas being protected by the four sprinklers.

The number of "design sprinklers" specified in NFPA 13 for wet pipe systems is to be applied when designing dry pipe systems.

Dry Pipe System Water Delivery
When using the Series LFII Residential Flat-Plate Concealed Pendent Sprinklers (TY2524) in dry pipe sprinkler systems, the time for water delivery exceed 15 seconds for the most remote operating sprinkler.

Obstruction to Water Distribution.
Sprinklers are to be located in accordance with the obstruction rules of NFPA 13D, 13R, and 13 as applicable for residential sprinklers as well as with the obstruction criteria described within the Technical Data Sheet TFP490.

Operational Sensitivity
Install sprinklers relative to the ceiling mounting surface as shown in Figure 3.

The Series LFII Residential Flat-Plate Concealed Pendent Sprinklers must not be used in applications where the air pressure above the ceiling is greater than that below. Down drafts through the Support Cup can delay sprinkler operation in a fire situation.

Sprinkler Spacing
The minimum spacing between sprinklers is 8 feet (2,4 m). The maximum spacing between sprinklers cannot exceed the length of the coverage area (Table A) being hydraulically calculated (e.g., a maximum of 12 feet for a 12 ft. x 12 ft. coverage area or 20 feet for a 20 ft. x 20 ft. coverage area.)

Maximum Coverage Area [a] Ft. x Ft. (m x m)	Maximum Spacing Ft. (m)	WET PIPE SYSTEM [e] Minimum Flow and Residual Pressure		
		Horizontal Ceiling [b, c, d] (Maximum 2 inch rise for 12 inch run)	Sloped Ceiling [b, c, d] (Greater than 2 inch rise up to maximum 4 inch rise for 12 inch run)	Sloped Ceiling [b, c, d] (Greater than 4 inch rise up to maximum 8 inch rise for 12 inch run)
		160°F (71°C) Sprinkler	160°F (71°C) Sprinkler	160°F (71°C) Sprinkler
12 x 12 (3,7 x 3,7)	12 (3,7)	13 GPM (49,2 LPM) 7.0 psi (0,48 bar)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)
14 x 14 (4,3 x 4,3)	14 (4,3)	13 GPM (49,2 LPM) 7.0 psi (0,48 bar)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)
16 x 16 (4,9 x 4,9)	16 (4,9)	13 GPM (49,2 LPM) 7.0 psi (0,48 bar)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)
18 x 18 (5,5 x 5,5)	18 (5,5)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)	22 GPM (83,3 LPM) 20.2 psi (1,39 bar)	22 GPM (83,3 LPM) 20.2 psi (1,39 bar)
20 x 20 (6,1 x 6,1)	20 (6,1)	20 GPM (75,7 LPM) 16.7 psi (1,15 bar)	24 GPM (90,8 LPM) 24.0 psi (1,65 bar)	24 GPM (90,8 LPM) 24.0 psi (1,65 bar)

(a) For coverage area dimensions less than or between those indicated, use the minimum required flow for the next highest coverage area for which Hydraulic Design section under the Design Criteria are stated.

(b) The Minimum Flow requirement is based on minimum flow in GPM (LPM) from each sprinkler. The associated residual pressures are calculated using the nominal K-factor. Refer to "Hydraulic Design" in the Design Criteria section for details.

(c) For NFPA 13D 2010 applications, Horizontal Ceiling criteria shall be used for certain sloped ceiling configurations up to 8:12 pitch. Refer to TIA 1028R for allowed sloped ceiling limitations when using horizontal ceiling criteria.

(d) For NFPA 13R applications, Horizontal Ceiling criteria may be used for sloped ceiling configurations up to 8:12 pitch when acceptable to the local authority having jurisdiction.

(e) For NFPA 13 residential applications, the greater of 0.1 gpm/ft.² over the design area or the flow in accordance with the criteria in this table must be used.

TABLE A
SERIES LFII RESIDENTIAL FLAT-PLATE CONCEALED PENDENT SPRINKLER (TY2524)
NFPA 13D, 13R, AND 13 HYDRAULIC DESIGN CRITERIA
— WET PIPE SYSTEMS —

Maximum Coverage Area [a] Ft. x Ft. (m x m)	Maximum Spacing Ft. (m)	DRY PIPE SYSTEM [c] Minimum Flow and Residual Pressure
		Horizontal Ceiling Minimum Flow and Residual Pressure [b] (Maximum 2 Inch Rise for 12 Inch Run)
		160°F (71°C) Sprinkler
12 x 12 (3,7 x 3,7)	12 (3,7)	15 GPM (56,8 LPM) 9.4 psi (0,65 bar)
14 x 14 (4,3 x 4,3)	14 (4,3)	15 GPM (56,8 LPM) 9.4 psi (0,65 bar)
16 x 16 (4,9 x 4,9)	16 (4,9)	16 GPM (60,6 LPM) 10,7 psi (0,74 bar)
18 x 18 (5,5 x 5,5)	18 (5,5)	17 GPM (64,3 LPM) 12.0 psi (0,83 bar)
20 x 20 (6,1 x 6,1)	20 (6,1)	21 GPM (79,5 LPM) 16,4 psi (1,27 bar)

(a) For coverage area dimensions less than or between those indicated, use the minimum required flow for the next highest coverage area for which Hydraulic Design section under the Design Criteria are stated.

(b) The Minimum Flow requirement is based on minimum flow in GPM (LPM) from each sprinkler. The associated residual pressures are calculated using the nominal K-factor. Refer to "Hydraulic Design" in the Design Criteria section for details.

(c) For NFPA 13 residential applications, the greater of 0.1 gpm/ft.² over the design area or the flow in accordance with the criteria in this table must be used.

TABLE B
SERIES LFII RESIDENTIAL FLAT-PLATE CONCEALED PENDENT SPRINKLER (TY2524)
NFPA 13D, 13R, AND 13 HYDRAULIC DESIGN CRITERIA
— DRY PIPE SYSTEMS —

Installation

The TYCO RAPID RESPONSE Series LFII Residential Flat-Plate Concealed Pendent Sprinklers must be installed in accordance with this section:

General Instructions
Damage to the Solder Link Element during installation can be avoided by handling the sprinkler by the Support Cup only; that is, do not apply pressure to the Solder Link Element (Figure 1).

A leak-tight 1/2 inch NPT sprinkler joint should be obtained by applying a minimum-to-maximum torque of 7 to 14 ft.-lbs. (9,5 to 19,0 Nm). Higher levels of torque can distort the sprinkler inlet with consequent leakage or impairment of the sprinkler.

Do not attempt to compensate for insufficient adjustment in the Cover Plate/Retainer Assembly by under- or over-tightening the sprinkler. Re-adjust the position of the sprinkler fitting to suit.

Step 1. Install pendent sprinklers in the pendent position, with the centerline of the sprinkler perpendicular to the mounting surface.

Step 2. Remove the Protective Cap.

Step 3. With pipe-thread sealant applied to the pipe threads, and using the W-Type 18 Wrench shown in Figure 2, install and tighten the Sprinkler/Support Cup Assembly into the fitting. The W-Type 18 Wrench accepts a 1/2 inch ratchet drive.

Step 4. Replace the Protective Cap by pushing it upwards until it bottoms out against the Support Cup. The Protective Cap helps prevent damage to the Deflector and Guide Pins during ceiling installation and/or during application of the finish coating of the ceiling.

NOTICE

As long as the protective Cap remains in place, the system is considered "Out Of Service".

Step 5. After the ceiling has been completed with the 2-1/2 inch (63 mm) diameter hole and in preparation for installing the Cover Plate/Retainer Assembly, remove and discard the Protective Cap, and verify that the Deflector moves up and down freely.

If the sprinkler has been damaged and the deflector does not move up and down freely, replace the entire sprinkler assembly. Do not attempt to modify or repair a damaged sprinkler.

Step 6. Screw on the Cover Plate/Retainer Assembly until its flange contacts the ceiling. Do not continue to screw on the Cover Plate/Retainer Assembly such that it lifts a ceiling panel out of its normal position.

If the Cover Plate/Retainer Assembly cannot be engaged with the Mounting Cup or the Cover Plate/Retainer Assembly cannot be engaged sufficiently to contact the ceiling, the Sprinkler Fitting must be repositioned.

Care and Maintenance

The TYCO RAPID RESPONSE Series LFII Residential Flat-Plate Concealed Pendent Sprinkler (TY2524) must be maintained and serviced in accordance with this section:

Before closing a fire protection system main control valve for maintenance work on the fire protection system that it controls, obtain permission to shut down the affected fire protection system from the proper authorities and notify all personnel who may be affected by this action.

Absence of a Cover Plate may delay the sprinkler operation in a fire situation.

The owner must assure that the sprinklers are not used for hanging any objects and that the sprinklers are only cleaned by means of gently dusting with a feather duster; otherwise, non-operation in the event of a fire or inadvertent operation may result.

When properly installed, there is a nominal 1/8 inch (3,2 mm) air gap between the lip of the Cover Plate and the ceiling, as shown in Figure 3. This air gap is necessary for proper operation of the sprinkler by allowing heat flow from a fire to pass below and above the Cover Plate to help assure appropriate release of the Cover Plate in a fire situation. If the ceiling needs repainting after sprinkler installation, exercise care to ensure that the new paint does not seal off any of the air gap. Failure to do so may impair sprinkler operation.

Factory painted Cover Plates must not be repainted. They should be replaced, if necessary, by factory painted units. Non-factory applied paint may adversely delay or prevent sprinkler operation in the event of a fire.

Do not pull the Cover Plate relative to the Retainer. Separation may result.

Sprinklers which are found to be leaking or exhibiting visible signs of corrosion must be replaced.

Automatic sprinklers must never be painted, plated, coated, or otherwise altered after leaving the factory. Modified or overheated sprinklers must be replaced.

Care must be exercised to avoid damage to the sprinklers - before, during, and after installation. Sprinklers damaged by dropping, striking, wrench twist/slippage, or the like, must be replaced.

The owner is responsible for the inspection, testing, and maintenance of their fire protection system and devices in compliance with this document, as well as with the applicable standards of the National Fire Protection Association (e.g., NFPA 25), in addition to the standards of any other authorities having jurisdiction. Contact the installing contractor or sprinkler manufacturer regarding any questions.

Automatic sprinkler systems are recommended to be inspected, tested, and maintained by a qualified Inspection Service in accordance with local requirements and/or national codes.

Limited Warranty

Products manufactured by Tyco Fire Production Products (TFPP) are warranted solely to the original Buyer for ten (10) years against defects in material and workmanship when paid for and properly installed and maintained under normal use and service. This warranty will expire ten (10) years from date of shipment by TFPP. No warranty is given for products or components manufactured by companies not affiliated by ownership with TFPP or for products and components which have been subject to misuse, improper installation, corrosion, or which have not been installed, maintained, modified or repaired in accordance with applicable Standards of the National Fire Protection Association, and/or the standards of any other authorities having jurisdiction. Materials found by TFPP to be defective shall be either repaired or replaced, at TFPP's sole option. TFPP neither assumes, nor authorizes any person to assume for it, any other obligation in connection with the sale of products or parts of products. TFPP shall not be responsible for sprinkler system design errors or inaccurate or incomplete information supplied by Buyer or Buyer's representatives.

In no event shall TFPP be liable, in contract, tort, strict liability or under any other legal theory, for incidental, indirect, special or consequential damages, including but not limited to labor charges, regardless of whether TFPP was informed about the possibility of such damages, and in no event shall TFPP's liability exceed an amount equal to the sales price.

<u>The foregoing warranty is made in lieu of any and all other warranties, express or implied, including warranties of merchantability and fitness for a particular purpose.</u>

This limited warranty sets forth the exclusive remedy for claims based on failure of or defect in products, materials or components, whether the claim is made in contract, tort, strict liability or any other legal theory.

This warranty will apply to the full extent permitted by law. The invalidity, in whole or part, of any portion of this warranty will not affect the remainder.

Ordering Procedure

Contact your local distributor for availability. When placing an order, indicate the full product description and Part Number (P/N).

Sprinkler/Support Cup Assembly
Specify: Series LFII (TY2524), K=4.9 (70,6), Residential Flat-Plate Concealed Pendent Sprinkler without Cover Plate/Retainer Assembly, P/N 51-114-1-160.

Cover Plate/Retainer Assembly for Horizontal or Sloped Ceiling Applications
Specify: Series LFII (TY2524), K=4.9 (70,6), Residential Flat-Plate Concealed Pendent Sprinkler Cover Plate/Retainer Assembly with (specify) finish, P/N (specify):

Off White	P/N 56-201-0-135
Pure White* (RAL9010)	P/N 56-201-3-135
Signal White** (RAL9003)	P/N 56-201-4-135
Standard White (Grey White) (RAL9002)	P/N 56-201-5-135
Custom	P/N 56-201-X-135

* Eastern Hemisphere sales only
** Previously known as Bright White

Note: *All Custom Cover Plates are painted using Sherwin Williams Interior Latex Paint. Contact TYCO Customer Service with any questions related to custom orders.*

Optional Cover Plate/Retainer Assembly for Horizontal Ceiling Applications Only
Specify: Series LFII (TY2524), K=4.9 (70,6), Residential Flat-Plate Concealed Pendent Sprinkler Cover Plate/Retainer Assembly with (specify) finish, P/N (specify):

Off White	P/N 56-122-0-135
Pure White* (RAL9010)	P/N 56-122-3-135
Signal White** (RAL9003)	P/N 56-122-4-135
Custom	P/N 56-122-X-135

* Eastern Hemisphere sales only
** Previously known as Bright White

Note: *All Custom Cover Plates are painted using Sherwin Williams Interior Latex Paint. Contact TYCO Customer Service with any questions related to custom orders.*

Sprinkler Wrench
Specify: W-Type 16 Sprinkler Wrench, P/N 56-000-1-265.

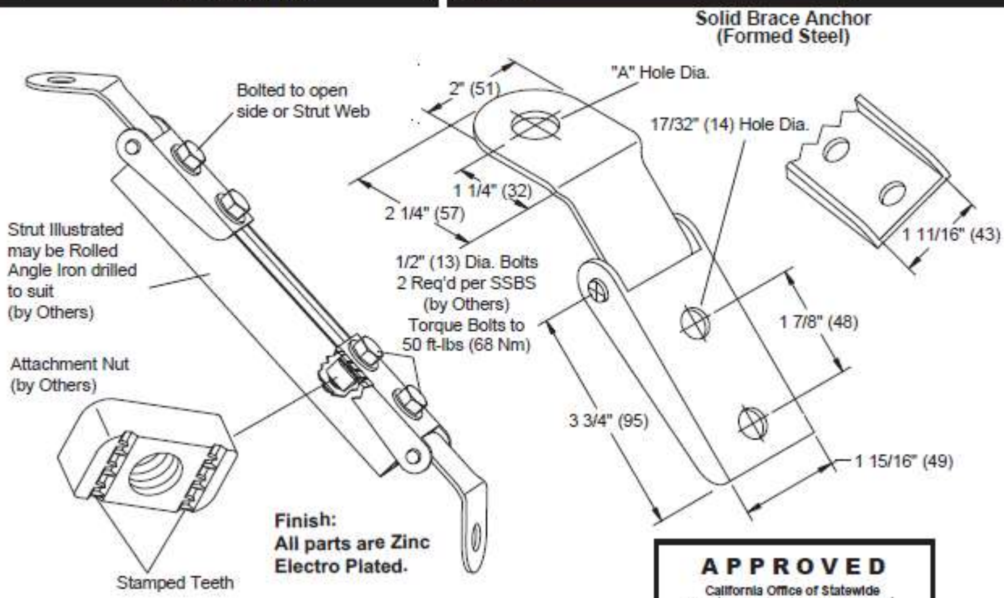
tyco

A.1.3 Mason Industries Seismic Solid Brace Strut Anchor (SSBS)

MASON INDUSTRIES, Inc.
Manufacturers of Vibration Control Products
350 Rabro Drive, Hauppauge, NY 11788, 631/348-0282, FAX 631/348-0279, Info@Mason-Ind.com
2101 W. Crescent Ave., Suite D, Anaheim, CA 92801, 714/535-2727, FAX 714/535-5738, Info@MasonAnaheim.com
www.Mason-Ind.com

JOB NAME
CUSTOMER
CUSTOMER P.O.
MASON M.I.
DWG. NO.

SSBS
Seismic Solid Brace Strut Anchor



APPROVED
California Office of Statewide Health Planning and Development
FIXED EQUIPMENT ANCHORAGE
OPA-0349 AUGUST 5, 2002
Bill Staehlin (916) 654-3362

* Attachment nuts must have stamped teeth to achieve these values.
Washers are required at all Bolted Connections.

Ratings are based on attachment to steel.
Assembly Ratings are the lowest value of either the Assembly Capacity, slippage of the Strut Attachment Nuts or the capacity of the single hole anchorage bolt. Ratings are based on the worst case angle.
Ratings may change depending on attachment methods to concrete.

Testing was supervised and certified by an independant engineer registered in the state of California.
Preferred installation ange is 45°. Maximum variation ±15°.

NOTE: Not to be used as a vertical hanger for equipment, ductwork or piping. To be used as a seismic restraint only.

Ratings are from test data and calculations used to obtain California OSHPD Preapproval Number OPA-0349.

TYPE SSBS DIMENSIONS AND RATINGS

Size	A (in)	A (mm)	Bolt Size (in)	Bolt Size (mm)	Rated Capacity* (lbs)	Rated Capacity* (kN)
SSBS-12	17/32	13	3/8	10	1000	4.5
SSBS-12	17/32	13	1/2	13	1250	5.6
SSBS-20	25/32	20	5/8	16	2000	8.9
SSBS-20	25/32	20	3/4	19	2500	11.2
SSBS-25	1-1/32	26	7/8	22	2500	11.2
SSBS-25	1-1/32	26	1	25	3000	13.4

QTY	SIZE	TAG	QTY	SIZE	TAG

Certification Form S-119 04/2011 | DWN: | CHKD: | DATE: | DWG. No.

A.2 FIRESTOP SPECIFICATIONS

A.2.1 CP604 Self-Leveling Firestop Sealant

Product Information

CP 604
Technical Data

At 73°F (23°C) and 50% relative humidity

Chemical basis
Neutral elastic silicone

Density
Approx. 1.35 g/cm³

Color
Gray

Application temperature
40°F to 104°F (5°C to 40°C)

Temperature resistance
−4°F to 248°F (−20°C to 120°C)

Curing time
Approx. 5 mm/3 days

Tensile strength (modulus of elasticity)
Approx. 0.7 N/mm²

Shore A Hardness
Approx. +20%

Joint movement capability
Approx. +20%

Surface burning characteristics (ASTM E 84-00)
Flame Spread: 5
Smoke Development: 60

Tested in accordance with
- UL 1479
- UL 2079
- ASTM E 1966
- ASTM E 814
- ASTM E 84
- CAN4-S115-95M
- ULC-S115-95M

Internationally tested and approved
- CAN4-S115-95M

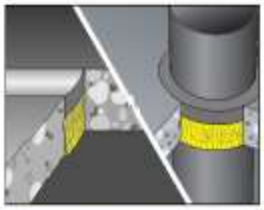
FILL, VOID OR CAVITY MATERIAL FOR USE IN THROUGH-PENETRATION FIRESTOP SYSTEMS, JOINT SYSTEMS AND PERIMETER FIRE CONTAINMENT SYSTEMS SEE UL FIRE RESISTANCE DIRECTORY 40FT

FM APPROVED

latest product information : www.ca.hilti.com

ordering information see page: 29

CP 604
Self-Leveling Firestop Sealant



System Advantage / Customer Benefits
- Meets 500 cycle requirements (ASTM E 1966 & UL 2079)
- Smoke, fumes and water resistant
- Meets UL requirement rating for class I W rating

Product description
- Self-leveling, single-component, silicone-based firestop sealant for use with through-penetrations as well as construction joints in floors

Product features
- Self-leveling–requires no tooling
- Excellent elongation/compression properties
- Resistant to smoke and water

Areas of application
- Sealing construction/expansion joints
- Metal pipes
- Cable bundles
- Sealing multiple penetrations in small or large openings

For use with
- Concrete floors rated up to 3-hours

Examples
- Penetrations for metal pipes between floor levels
- Construction joints and expansion joints in floors

Installation Instructions for CP 604

Opening

1. Clean the opening. Surfaces to which CP 604 will be applied must be sound, dry and free from dust, oil and grease.

Application of firestop

2. Insert fill of mineral wool (or backer as required).
3. Apply firestop over backer.
4. Allow firestop sealant to level. Once cured, CP 604 can only be removed mechanically.
5. For maintenance reasons, a penetration seal could be permanently marked with an identification plate. In such a case, mark the identification plate and fasten it in a visible position next to the seal.

Chemical resistance
- At room temperature the cured silicone sealant is resistant for a short time to diluted (15%) acids and lyes/alkalis as well as commercially available cleaning agents and disinfectants (except those containing iodine).
- Concentrated acids and lyes/alkalis destroy silicone rubber over time.
- Solvents and mineral oils cause cured silicone to swell. Consequently, proper functioning of the sealant should be checked after exposure to a solvent or mineral oil. Please contact your local sales representative or the nearest Hilti Center if special requirements for chemical resistance have to be met.

Notice about approvals
- When using Hilti CP 604 Self-Leveling Firestop Sealant, check that the joint or pipe application has been sealed according to the applicable drawing in the UL/cUL Fire Resistance Directory or Hilti Firestop Manual.

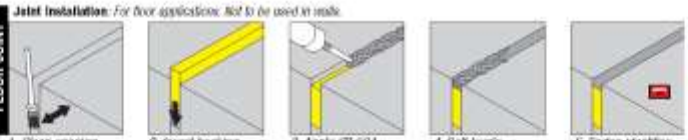
Not for use...
- In areas immersed in water
- Not to be painted

Safety precautions
- Keep out of reach of children
- Read the Material Safety Data Sheet
- Eyes and hands must be suitably protected
- Avoid contact with eyes/skin
- Only use in well ventilated areas

Storage
- Store only in the original packaging in a location protected from moisture at a temperature of 40°F (5°C) to 77°F (25°C)
- Observe expiration date on packaging

Joint Installation: *For floor applications. Not to be used in walls.*

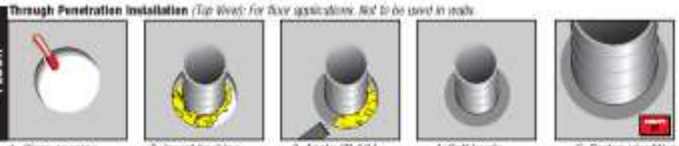
FLOOR JOINT



1. Clean opening | *2. Insert backing material* | *3. Apply CP 604* | *4. Self levels - no tooling required* | *5. Fasten identification plate (if required)*

Through Penetration Installation *(Top View): For floor applications. Not to be used in walls.*

FLOOR



1. Clean opening | *2. Insert backing material* | *3. Apply CP 604* | *4. Self levels - no tooling required* | *5. Fasten identification plate (if required)*

Material Safety Data Sheet

MSDS No.:	283C
Revision No.:	003
Revision Date:	06/17/04
Page:	1 of 2

Product identifier:	**CP 604 Self-Leveling Firestop Sealant**
Product use:	A self-leveling flexible sealant for firestopping construction joints and metal pipes
Supplier:	Hilti (Canada) Corporation, 6790 Century Avenue, Suite #300, Mississauga, Ontario L5N 2V8
Originator	Hilti, Inc., P. O. Box 21148, Tulsa, Oklahoma, USA 74121
Emergency number:	1 800 424 9300 (Chem-Trec)

INGREDIENTS INFORMATION

Ingredient	CAS Number	% (wt.)	LC_{50}, (rat)	LD_{50} (rat)	TLV	STEL
Polydimethylsiloxane diol	70131-67-8	35 – 45	N/Av	> 64 ml/kg	N/A (10 mg/m³)	N/E
Calcium carbonate	01317-65-3	35 – 45	N/Av	N/Av	N/A (10 mg/m³)	N/E
Polydimethylsiloxane	63148-62-9	10 – 15	N/Av	N/Av	N/E	N/E
Methyl oximino silane	22984-54-9	0.1 – 05	N/Av	N/Av	N/E	N/E
Vinyl oximino silane	02224-33-1	0.1 – 05	N/Av	N/Av	N/E	N/E
Fumed silica	68611-44-9	0.1 – 05	N/Av	N/Av	N/A (10 mg/m³)	N/E
Titanium dioxide	13463-67-7	0.1 – 05	N/Av	N/Av	N/A (10 mg/m³)	N/E
Ferric oxide	01309-37-1	0.1 – 05	N/Av	N/Av	N/E	N/E

PHYSICAL PROPERTIES

Appearance / Physical state:	Grey paste	Odour:	Mild odour
Specific gravity (at 20°C):	1.3 – 1.4	VOC Content:	53.0 g/L
Vapour pressure (at 20°C):	Not applicable.	Vapour density:	Not applicable.
Evaporation rate:	Not determined.	Boiling point:	Not determined.
Freezing point:	Not determined.	pH:	Not determined.
Coefficient of H2O / oil distrib:	Not determined.	Solubility in water:	Not easily mixed.

FIRE AND EXPLOSION DATA

Flash point / Method:	Not applicable.	Flammable limits:	Not applicable.
Conditions of flammability:	Not determined.	Auto-ignition temperature:	Not applicable.
Means of extinction:	As appropriate for surrounding fire (e.g. Water, CO_2, Dry Chemical, Foam).		
Special fire fighting procedures:	None known. A NIOSH-approved self-contained breathing apparatus (SCBA) should be worn when fighting fires involving chemicals.		
Hazardous combustion products:	None known. Thermal decomposition products can be formed; e.g. CO and CO_2		
Sensitivity to mechanical impact / static discharge:	Not susceptible to mechanical impact or to a static discharge.		

REACTIVITY DATA

Stability:	Stable.	Conditions of reactivity:	None known.
Incompatible materials:	None known.		
Hazardous decomposition products:	Thermal decomposition products can be formed; e.g. CO and CO_2.		

TOXICOLOGICAL PROPERTIES

Likely routes of exposure:	☐ None known ☒ Skin contact ☐ Skin absorption ☐ Eye contact ☒ Inhalation
Exposure limits:	See "Ingredients" section above.
Chronic effects of exposure:	None known.
Synergistic materials:	None known.
Acute effects of exposure:	**Eyes**: No effects expected. **Skin:** Prolonged and repeated contact can cause skin sensitization with some individuals (e.g. rash, itching, reddening). **Inhalation:** No ill effects expected. Ingestion: Effects of ingestion have not been determined. No ill effects expected. NOTE: Reaction with air and moisture during the curing process can release trace amounts of methyl ethyl ketoxime (MEKO). MEKO can be irritating to the eyes, skin and respiratory tract. The body easily metabolizes MEKO; therefore, no lasting or adverse effects are expected.

INTRODUCTION

APPLICATIONS / PRODUCTS

SYSTEM DETAILS

ESTIMATING TABLES / TECH DATA

HILTI

Material Safety Data Sheet

MSDS No.: 283C
Revision No.: 003
Revision Date: 08/17/04
Page: 2 of 2

FIRST AID MEASURES	
Eyes:	Flush with plenty of water. Call a physician if symptoms occur.
Skin:	Wash with soap and water. Seek medical attention if any effects persist.
Inhalation:	No ill effects expected. Should discomfort occur, move to fresh air.
Ingestion:	Seek medical attention. Do not induce vomiting unless directed to by a physician. Never give anything by mouth to an unconscious person.
Other:	Referral to a physician is recommended if there is any question about the seriousness of the injury/exposure
CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT	
Engineering controls:	General (natural or mechanically induced fresh air movements).
Eye protection:	As appropriate for the work area or other work being done.
Skin protection:	Recommended. Cloth gloves are suitable.
Respiratory protection:	None normally required.
Other:	No additional measures are normally required.
PRECAUTIONS FOR SAFE HANDLING AND USE	
Handling procedures and equipment:	For industrial use only. Use with adequate ventilation. Keep container closed when not in use. Avoid prolonged or repeated contact with the skin. Practice good hygiene; i.e., wash after using and before eating or smoking.
Storage requirements:	Keep out of reach of children. Store in a cool dry area. Keep from freezing. Store between 5º and 25º C.
Spill, leak or release:	Wear appropriate personal protective equipment. Allow to cure, scrape up and place in a salvage container for proper disposal. See disposal guidelines below.
Waste disposal:	No known restrictions. Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, provincial, and federal safety, health and environmental regulations.
Special shipping instructions:	Avoid temperature extremes. Keep from freezing.
REGULATORY INFORMATION	
WHMIS classification:	D2B
HMIS codes:	Health 1, Flammability 0, Reactivity 0, PPE A
TDG shipping name:	Not regulated.
PREPARATION INFORMATION / CONTACTS	
Prepared by:	Hilti, Inc., Tulsa, OK USA Emergency phone number: 1 800 424 9300
Customer Service:	Hilti (Canada) Corporation, Mississauga, Ontario; 1 800 363 4456
Health / Safety contacts:	Hilti, Inc., Tulsa, OK USA; 1 800 879 6000, Jerry Metcalf (x6704)
Abbreviations used:	**N/E** = None Established. **N/Ap** = Not Applicable. **N/Av** = Not Available. **HMIS:** Hazardous Materials Identification System

Certificate of Compliance

Certificate Number 20060214-R13240A
Report Reference 2006 February 14
Issue Date 2006 February 14

Page 1 of 1

Underwriters Laboratories Inc.

Issued to: Hilti, Inc.
5400 S 122ND East Ave
Tulsa, OK 74146 USA

This is to certify that representative samples of Fill, Void or Cavity Materials
CP604

Have been investigated by Underwriters Laboratories Inc.® in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: ANSI/UL 1479, ANSI/UL 2079, ASTM E2307, CAN/ULC-S115-05

Additional Information: CP604 Self-Leveling Firestop Sealant for use in Joint Systems, CP604 Self-Leveling Firestop Sealant for use in Perimeter Fire Containment Systems and CP604 Self-Leveling Firestop Sealant for use in Through-Penetration firestop Systems as currently described in the UL Fire Resistance Directory.

Only those products bearing the UL Classification Mark should be considered as being covered by UL's Classification and Follow-Up Service.

The UL Classification Mark includes: UL in a circle symbol: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

Look for the UL Classification Mark on the product

Issued by:
Mona Couloute
Mona Couloute
Underwriters Laboratories Inc.

Reviewed by:
Christopher Johnson
Underwriters Laboratories Inc.

A.2.2 CP606 Flexible Firestop Sealant

CP 606
Flexible Firestop Sealant

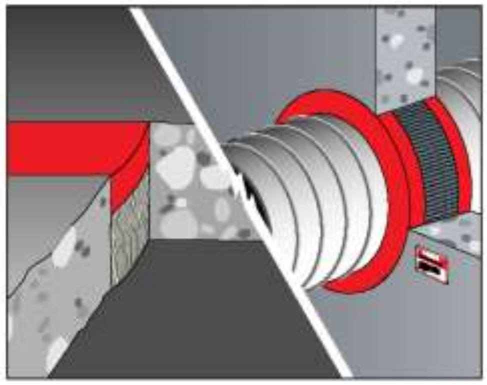
Product description
- An acrylic based firestop sealant that provides movement capability in fire rated joint applications

Areas of application
- Sealing construction/expansion joints
- Top-of-wall joints
- Metal pipes
- Cable bundles
- HVAC penetrations*

For use with
- Various base materials such as masonry, concrete, metal, etc.
- Wall and floor assemblies rated up to 3 hours

Examples
- Where a gypsum wall assembly meets the underside of a metal or concrete deck
- Sealing expansion joints to impede the passage of fire, smoke and toxic fumes
- Sealing around HVAC penetrations through fire-rated assemblies

System advantages/Customer benefits
- Paintable
- Meets 500 cycle requirements (ASTM E 1399 & UL 2079)
- Smoke, fume and water resistant
- Easy clean up with water



Internationally tested and approved

British Standard
BS 476

CP 606 Flexible Firestop Sealant

Description	Color	Package Contents	Volume	Item No.
CP 606, tube	red	10.5oz (310 ml)	18 in³	00337191
CP 606, foil	white	(Qty 20) 20.2oz (600 ml)	36 in³	00314272
CP 606, foil	red	(Qty 20) 20.2oz (600 ml)	36 in³	00337192
CP 606, pail	red	5 gallons (19 liter)	1155 in³	00337193
CB 200 PI-300/310 ml Dispenser				00055205
600 ml Foil Dispenser				00024669

* For metal ducts with damper, consult damper manufacturer.

CP 606 Flexible Firestop Sealant

Product description

- An acrylic based firestop sealant that provides movement capability in fire rated joint applications

Product features

- Silicone free
- Halogen, asbestos and solvent free
- UV-resistant

Tested in accordance with

- UL 2079
- ASTM E 1399
- UL 1479
- ASTM E 814
- ASTM E 84

Technical Data CP 606 Flexible Firestop Sealant

(at 73°F (23°C) and 50% relative air humidity)

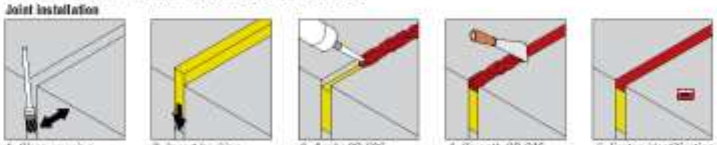
Density:	Approx. 1.5 g/cm³
Color:	Red and White
Application temperature:	40°F (5°C) to 77°F (25°C)
Skin-forming time:	Approx. 15 min.
Curing rate:	Approx. 1/16" in 3 days
Volume shrinkage:	Less than 20%
Movement capability:	Approx. 10%
Temperature resistance:	-40°F (-40°C) to 176°F (80°C)
Surface burning characteristics: (ASTM E84-98)	Flame spread: 0 Smoke development: 5
Sound transmission classification: (ASTM E 90-97)	50

Approvals

ICBO Evaluation Service, Inc.	Report No. ER-5614
California State Fire Marshal	Listing no. 1452-1200:112
City of New York	MEA 100-99-M

Installation instructions for CP 606

Joint installation



1. Clean opening 2. Insert backing material 3. Apply CP 606 4. Smooth CP 606 5. Fasten identification plate (if required)

Duct installation

1. Clean opening 2. Insert backing material 3. Apply CP 606 4. Smooth CP 606 5. Fasten identification plate (if required)

Opening

1. Clean the opening. Joint sides and surfaces to which CP 606 will be applied must be sound, dry and free from dust, oil and grease.

Application of firestop

2. Insert fill of mineral wool or backer (as required).
3. Apply firestop over backer.
4. Smooth firestop sealant with a trowel before the skin forms. Once cured, CP 606 can only be removed mechanically.
5. For maintenance reasons, a penetration seal could be permanently marked with an identification plate. In such a case mark the identification plate and fasten it in a visible position next to the seal.

Notice about approvals

- When using Hilti CP 606 Flexible Firestop Sealant, check that the joint or pipe application has been sealed according to the applicable drawing in the UL Fire Resistance Directory or Hilti Firestop Manual.

Not to be used...

- On areas immersed in water

Safety precautions

- Keep out of reach of children
- Read the Material Safety Data Sheet
- Eyes and hands must be suitably protected
- Avoid contact with eyes/skin
- Only use in well ventilated areas

Storage

- Store only in the original packaging in a location protected from moisture at a temperature of 40°F (5°C) to 77°F (25°C)
- Observe expiration date on package

Hilti (Canada) Limited

MSDS No.: 267C
Revision No.: 001
Prep. Date: 25 April, 2000
Page: 1 of 2

MATERIAL SAFETY DATA SHEET

Product identifier:	**CP 606 Flexible Firestop Sealant**
Product use:	Fire resistant acrylic based sealant for use in fire rated joint applications
Supplier:	Hilti (Canada) Limited, 6790 Century Avenue, Suite #300, Mississauga, Ontario L5N 2V8
Originator	Hilti, Inc., P. O. Box 21148, Tulsa, Oklahoma, USA 74121
Emergency number:	**Chem-Trec: 1 800 424 9300**

INGREDIENTS INFORMATION

Ingredient	CAS Number	% (wt.)	LC_{50}, (rat)	LD_{50} (rat)	TLV	STEL
Calcium carbonate	01317-65-3	50 - 55	N/Av	N/Av	N/Ap	N/E
Water	07732-18-5	15 - 20	N/Av	N/Av	N/E	N/E
Isononyl phthalate	28553-12-0	10 - 15	N/Av	N/Av	N/E	N/E
Polybutene	09003-29-6	01 - 05	N/Av	N/Av	N/E	N/E
Ethylene glycol	00107-21-1	01 - 05	N/Av	4700 mg/kg	N/E	N/A
Pigment	01309-37-1	01 - 05	N/Av	N/Av	N/Ap	N/E

PHYSICAL PROPERTIES

Appearance / Physical state:	Red paste.	**Odour:**	Mild odour.
Specific gravity (at 20°C):	1.55	**Odour threshold:**	Not determined.
Vapour pressure (at 20°C):	Not applicable.	**Vapour density:**	Not applicable.
Evaporation rate:	Not determined.	**Boiling point:**	Not determined.
Freezing point:	Not determined.	**pH:**	Not determined.
Coefficient of H_20 / oil distrib:	Not determined.	**Solubility in water:**	Miscible.

FIRE AND EXPLOSION DATA

Flash point / Method:	Nonflammable.	**Flammable limits:**	Not applicable.
Conditions of flammability:	Not applicable.	**Auto-ignition temperature:**	Not applicable.
Means of extinction:	Not applicable. As appropriate for surrounding fire (e.g. Water, CO_2, Dry Chemical, Foam).		
Special fire fighting procedures:	None known. A NIOSH-approved self-contained breathing apparatus (SCBA) should be worn when fighting fires involving chemicals.		
Hazardous combustion products:	Not determined.		
Sensitivity to mechanical impact / static discharge:	Not susceptible to mechanical impact or to a static discharge.		

REACTIVITY DATA

Stability:	Stable.	**Incompatible materials:**	Strong oxidizing agents.
Conditions of reactivity:	None known.		
Hazardous decomposition products:	Not determined.		

TOXICOLOGICAL PROPERTIES

Routes of exposure:	☒ Skin contact ☐ Skin absorption ☒ Eye contact ☐ Inhalation ☐ Ingestion
Exposure limits:	See "Ingredients" section above.
Acute effects of exposure:	**Eyes** – Slightly alkaline material; can cause irritation but injury is unlikely. **Skin** - Can cause irritation with some individuals. **Inhalation** - No effects expected. **Ingestion** - Not a likely route of exposure. Effects of ingestion have not been determined.
Chronic effects of exposure:	None known.
Synergistic materials:	None known.

FIRST AID MEASURES	
Eyes:	Flush immediately with plenty of water. Call a physician if symptoms occur.
Skin:	Wash with soap and water. Seek medical attention if any effects persist.
Inhalation:	No ill effects expected. Should discomfort occur, move to fresh air.
Ingestion:	Do not induce vomiting unless large amounts are ingested. If conscious, give plenty of water to drink. Never give anything by mouth to an unconscious person. Contact a physician immediately.
Other:	Referral to a physician is recommended if there is any question about the seriousness of the injury/exposure.

CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT	
Engineering controls:	General (natural or mechanically induced fresh air movements).
Eye protection:	As appropriate for the work area.
Skin protection:	Cloth gloves are suitable.
Respiratory protection:	None normally required.
Other:	No additional measures are normally required.

PRECAUTIONS FOR SAFE HANDLING AND USE	
Handling procedures and equipment:	For industrial use only. Keep container sealed when not in use to prevent curing of the product. Avoid contact with the eyes and skin. Practice good hygiene; i.e. wash after using and before eating or smoking.
Storage requirements:	Keep out of reach of children. Store in a cool dry area. Keep from freezing. Shelf life is one year from date of manufacture if stored between 40° and 77° F (5 - 25° C).
Spill, leak or release:	Immediately wipe away spilled material before it hardens. Place in a container for proper disposal in accordance with all applicable local, state, or federal requirements.
Waste disposal:	Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, provincial, and federal safety, health and environmental regulations.
Special shipping instructions:	Avoid temperature extremes. Keep from freezing.

REGULATORY INFORMATION	
WHMIS classification:	D2B
HMIS codes:	Health 0, Flammability 0, Reactivity 0, PPE A
TDG shipping name:	Not regulated.

PREPARATION INFORMATION / CONTACTS	
Prepared by:	Hilti, Inc., Tulsa, OK USA **Emergency phone number:** 1 800 424 9300
Customer Service:	Hilti (Canada) Limited, Mississauga, Ontario; 1 800 363 4458
Health / Safety contacts:	Hilti, Inc., Tulsa, OK USA; 1 800 879 8000 Steve Gerrard (x6309), Jerry Metcalf (x6704)
Abbreviations used:	**N/E** = None Established. **N/A** = Not Applicable. **N/Av** = Not Available. **H** = Hours. **HMIS:** Hazardous Materials Identification System

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

Certificate of Compliance – CP 606 HILTI

Underwriters Laboratories Inc.®

Northbrook, Illinois • (847) 272-8800
Melville, New York • (516) 271-6200
Santa Clara, California • (408) 985-2400
Research Triangle Park, North Carolina • (919) 549-1400
Camas, Washington • (360) 817-5500

CERTIFICATE OF COMPLIANCE

CERTIFICATE NUMBER: 240798 - R16355
ISSUE DATE: July 24, 1998

Issued to:	Hilti Construction Chemicals Inc. 5400 S. 122nd East Avenue Tulsa, OK 74146 USA
Report Reference:	R16355, August 11, 1998
This is to Certify that representative samples of:	Flexible Firestop Sealant, designated CP 606

Have been investigated by Underwriters Laboratories Inc. in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety:	UL 1479, Fire Tests of Through-Penetration Firestops; UL 2079, Tests for Fire Resistance of Building Joint Systems.
Additional Information:	This material is one part sealant and is intended to be used as a Classified Fill, Void or Cavity Material in various Through-Penetration Firestop Systems as specified in Volume 2 of UL's Fire Resistance Directory.

Only those products bearing the UL Classification Marking should be considered as being covered by UL's Classification and Follow-Up Service

The UL Classification Marking includes: the name "Underwriters Laboratories Inc." the word "Classified"; a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

LOOK FOR THE UL CLASSIFICATION MARKING ON THE PRODUCT

Engineer: Underwriters Laboratories Inc. Nikola Momcilovic

Review Engineer: Underwriters Laboratories Inc. A. M. Ramirez

2000-44C (4/96)

A.2.3 CP653 Speed Sleeve

Product Information

CP 653 Speed Sleeve

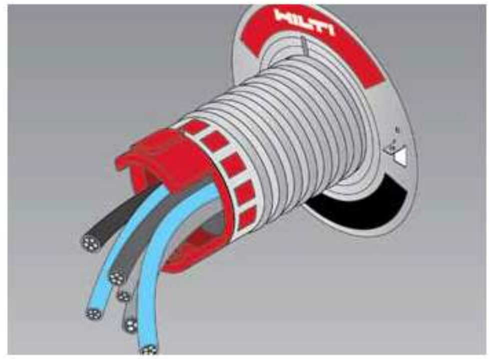
Product description
- Re-penetrable cable management device for electrical and telecom professionals

Product features
- Fast installation
- Easy penetration and re-penetration
- Low L-ratings
- Withstands the rigors of usage and time
- Can be installed in wall and floor applications

Areas of application
- Cable and cable bundles

For use with
- Concrete floor rated up to 3 hours
- Gypsum walls rated up to 2 hours

Examples
- Electrical wiring
- Premise wiring
- Low voltage and datacom



Technical Data	CP 653	
	2" (50 mm)	4" (102 mm)
OD (device only)	2.3" (60 mm)	4.3" (110 mm)
OD (flange)	4.7" (120 mm)	6.7" (170 mm)
ID	1.7" (48 mm)	3.6" (92 mm)
Total length	12.4" (315 mm)	12.4" (315 mm)
Weight (device and flanges)	1.5 lbs	2.6 lbs
Temperature resistance	22° F to 212° F (-6° C to 100° C)	
Intumescent activation	Approx. 320° F (160° C)	
Expansion ratio (unrestricted)	1:40	
Metal	Steel with zinc coating	
Plastic	ABS	
Fabric	Glass-fiber	

Approvals
- California State Fire Marshal - No. 4485-1200:138
- City of New York - MEA 413-07-M

Tested in accordance with
- UL 1479
- ASTM E 814

FIRESTOP DEVICE
FOR USE IN THROUGH-PENETRATION
FIRESTOP SYSTEMS
SEE UL FIRE RESISTANCE DIRECTORY
SN75

FM APPROVED

Installation instructions for CP 653

Notice
Always refer to the MSDS before use and the UL Fire Resistance Directory or Hilti Firestop Systems Guide for complete installation information.

Instructions for use
1. Use either a 2.5" or 4.5" hole saw to create the appropriate hole.
2. Insert the sleeve.
3. Seal the gap with firestop sealant to impede smoke and gas migration. Repeat on other side of the wall
4. Spin the flange clockwise onto the device. Repeat on other side of the wall.
5. To open the device:

   (a) On one side of the wall, press the clip closures inward.

   (b) Twist the device counterclockwise and pull the red housing outwards to eliminate the bunching of the smoke seal fabric. A yellow label will be visible to indicate that the device is open.
6. To close the device:

   (a) On the same side of the wall, press the clip closures inward.

   (b) Twist the device clockwise until finger-tight, allowing it to engage with a click.

For repenetration of cables, repeat steps 5 and 6.

For installation options not presented here, consult your local Hilti representative for other rated firestop systems.

Hilti Firestop
Saving lives through innovation and education

Hilti. Outperform. Outlast.

HILTI®

MSDS No.:	321
Revision No.:	000
Revision Date:	10/05/07
Page:	1 of 2

MATERIAL SAFETY DATA SHEET

Product name:	CP 653 - Speed Sleeve
Description:	Reusable Firestop Insert containing a black intumescent material.
Supplier:	Hilti, Inc. P.O. Box 21148, Tulsa, OK 74121
Emergency # (Chem-Trec.):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)

INGREDIENTS AND EXPOSURE LIMITS

Not applicable. This product is considered to be an "article" as defined in the federal OSHA Hazard Communication Standard 29 CFR 1910.1200 / 1926.59.

PHYSICAL DATA

Appearance:	Galvanized metal sleeve with red plastic ends	Odor:	None.
Vapor Density: (air = 1)	Not applicable.	Vapor Pressure:	Not applicable.
Boiling Point:	Not applicable.	VOC Content:	7.6 g/l
Evaporation Rate:	Not applicable.	Solubility in Water:	Not determined.
Specific Gravity:	Not determined.	pH:	Not applicable.

FIRE AND EXPLOSION HAZARD DATA

Flash Point:	Not applicable.	Flammable Limits:	Not applicable.
Extinguishing Media:	Use extinguishing media appropriate for surrounding fire.		
Special Fire Fighting Procedures:	None known.		
Unusual Fire and Explosion Hazards:	None known. Product serves as a firestop; intumescent material metal sleeve expands when exposed to temperatures > 160° C / 320° F.		

REACTIVITY DATA

Stability:	Stable.	Hazardous Polymerization:	Will not occur.
Incompatibility:	None known.	Decomposition Products:	None known.
Conditions to Avoid:	None known.		

HEALTH HAZARD DATA

Known Hazards:	None known.	Routes of Exposure:	None known.
Signs and Symptoms of Exposure:	None expected from routine use/installation according to manufacturer's specifications and technical guides.		
Carcinogenicity:	No ingredients are classified as a carcinogen by IARC, NTP or OSHA.		
Medical Conditions Aggravated by Exposure:	None known.		

EMERGENCY AND FIRST AID PROCEDURES

Eyes:	Immediately flush with plenty of water. Call a physician if symptoms occur.
Skin:	Not applicable. Practice good hygiene; i.e. wash hands during breaks, before eating or smoking, and after work.
Inhalation:	Not applicable.
Ingestion:	Not a potential route of exposure.
Other:	Referral to a physician is recommended if there is any question about the seriousness of any injury/exposure.

CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT	
Ventilation:	General (natural or mechanically induced fresh air movements).
Eye Protection:	Not required, however, safety glasses should be worn in most industrial settings.
Skin Protection:	None required; however, gloves recommended.
Respiratory Protection:	No respiratory protection is needed for normal application of this product.

PRECAUTIONS FOR SAFE HANDLING AND USE	
Handling and Storing Precautions:	Store in a cool dry area. Follow installation instructions.
Spill Procedures:	No special requirements.

REGULATORY INFORMATION	
Hazard Communication:	This product is considered to be an "article" as defined in the federal OSHA Hazard Communication Standard.
DOT Shipping Name:	Not regulated.
IATA / ICAO Shipping Name:	Not regulated.
TSCA Inventory Status:	Chemical components listed on TSCA inventory.
SARA Title III, Section 313:	This product is classified as an "article" and is not subject to reporting under Section 313 of SARA Title III (40 CFR Part 372).
EPA Waste Code(s):	Not regulated by EPA as a hazardous waste.
Waste Disposal Methods:	Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, state, and federal safety, health and environmental regulations.

CONTACTS			
Customer Service:	1 800 879 8000	**Technical Service:**	1 800 879 8000
Health / Safety:	1 800 879 8000 Jerry Metcalf (x6704)		
Emergency # (Chem-Trec):	1 800 424 9300 (USA, PR; Virgin Islands, Canada); 001 703 527 3887 (other countries)		

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

MSDS 321, Page 2 of 2

Certificate of Compliance

Certificate Number 20071018-R15431
Report Reference 2007 October 18
Issue Date 2007 October 18

Page 1 of 1

Underwriters Laboratories Inc.

Issued to: Hilti, Inc.

5400 S 122ND East Ave.
Tulsa, OK 74146 USA

This is to certify that representative samples of Firestop Devices
CP 653 2" Speed Sleeve, CP 653 4" Speed Sleeve

Have been investigated by Underwriters Laboratories Inc.® (UL) or any authorized licensee of UL in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: ANSI/UL 1479, CAN/ULC-S115-05

Additional Information: CP 653 for use in Through-Penetration Firestop Systems as currently described in the UL Fire Resistance Directory.

Only those products bearing the UL Classification Mark should be considered as being covered by UL's Classification and Follow-Up Service.

The UL Classification Mark includes: UL in a circle symbol: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

Look for the UL Classification Mark on the product

Issued by: Mona Couloute
Mona Couloute
Underwriters Laboratories Inc.

Reviewed by: Steve Hoffman
Steve Hoffman
Underwriters Laboratories Inc.

A.2.4 CP657 Firestop Brick

Hilti Firestop Systems — HILTI

Firestop brick
CP 657

An expanding flexible firestop brick based on a two-component polyurethane foam

Applications

- Temporary or permanent sealing of cables, cable trays, and pipes in wall and floor openings. Installation specific approvals.
- Single or multiple penetrations.
- Cables and cable trays
- Plastic pipes and metal pipes

Advantages

- Particulary suitable for remedial work
- Economical in use owing to short installation time
- Easy installation as no special tool is required immediately functional after installation
- Ideal for use in floors as no formwork is required
- High movement capability
- Free from dust and fibres

Technical data*

	CP 657
Fire rating	Up to 3 h
Base materials	Concrete, Concrete (porous), Masonry, Drywall
Application temperature range	5°C - 40°C
Acoustics performance	Up to 58dB
Density	0.27 g/cm³
Colour	Red
Application temperature	5° C to 40° C
Temperature resistance	-15° C to 60° C
Intumescent activation	Approx. 300°C
Expansion ratio (unrestricted)	Up to 1:3

*At 73°F (23°C) and 50% relative humidity

	Wall (mm)	Floor (mm)
Min. thickness of building component	100	150
Min. distance between penetrating items and opening surface:		
• Cables tray	60 mm	60 mm
• PVC pipes	100 mm	100 mm
• Metal pipes	100 mm	100 mm
Min. distance between penetrating items	25 mm	25 mm
Max. dimensions of penetrating items		
Max. opening loading (as % of opening size)	60%	60%
Cables diameter	26 mm	26 mm
PVC pipe diameter	50 mm	50 mm
Insulated metal pipe diameter	168 mm	-
Metal pipe diameter non insulated	60 mm	60 mm

Ordering

Order description	Package Contents	Package Quantity	Item number
Firestop brick CP 657-L	20 x CP 657L firestop brick	-	00363523
Firestop sealant CP 611A	intumescent mastic (310ml)	1 pc	00362846
Dispenser CB 200-P1	manual dispenser (310ml)	1 pc	00055205

49 Visit the Hilti Firestop Design Centre Register today at www.hilti.co.uk/cfs

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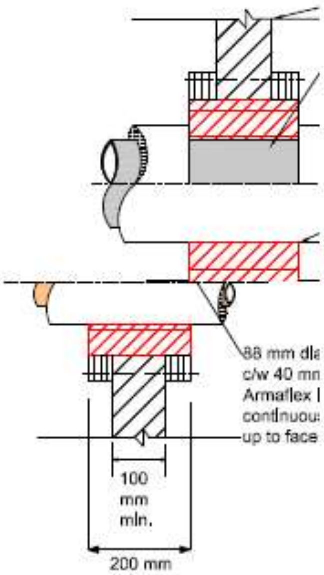
Technical Informatio



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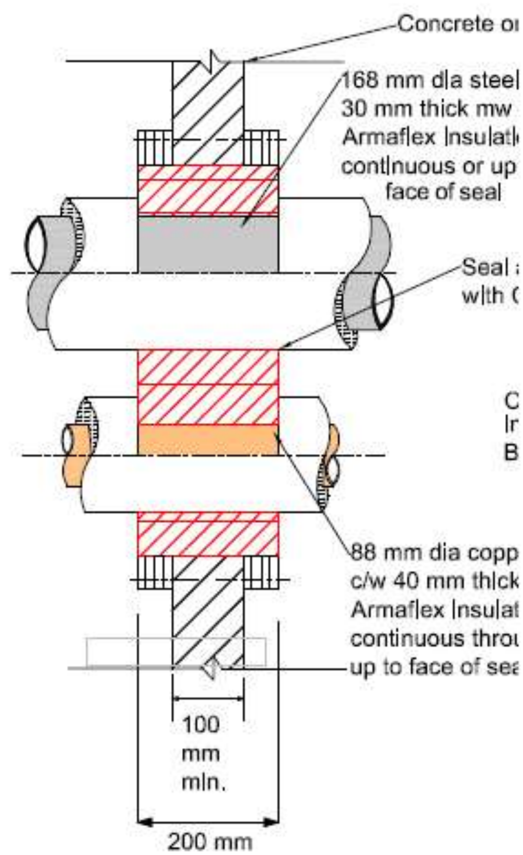
Technical Information



Installation instructions for CP 657

Notice

- Before handling, read Material Safety Data Sheet and product label for safe usage and health information.
- Instructions below are general guidelines

Opening

1. Clean the opening. Penetration and penetration supporting structures must be installed in compliance with local building and electrical standards.

Appli

2a.If n
Blc

2b.If p
Blc
to

3. Finish building up Fire Blocks until entire opening is filled.
4. Completely fill cable spaces, gaps between blocks and pipes, and joints with CP 611A Firestop Sealant.
5. For maintenance reasons, a penetration seal could be permanently marked with an identification plate. In such a case, mark the identification plate and fasten it in a visible position next to the seal.

blocks or a hole can be drilled through a block using a sharpened piece of metal pipe or tubing.

Not for use

- In wet rooms, outdoors or exposed to the weather or UV radiation (can be done only after applying an additional silicone coating, i.e. CP 611A).

Storage

- Store only in the original packaging in a location protected from moisture and direct sunlight

1. Clean opening. | 2a. Build up blocks | 2b. Cut blocks to size for penetrations in place | 3. Build up blocks | 4. Fill gaps with CP 611 | 5. Fasten identification plate in place (if required)

Hilti. Outperform. Outlast. 50

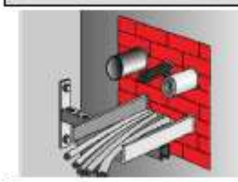
HILTI **Standard firestop detail**

Hilti CP 657 Intumescent Bricks

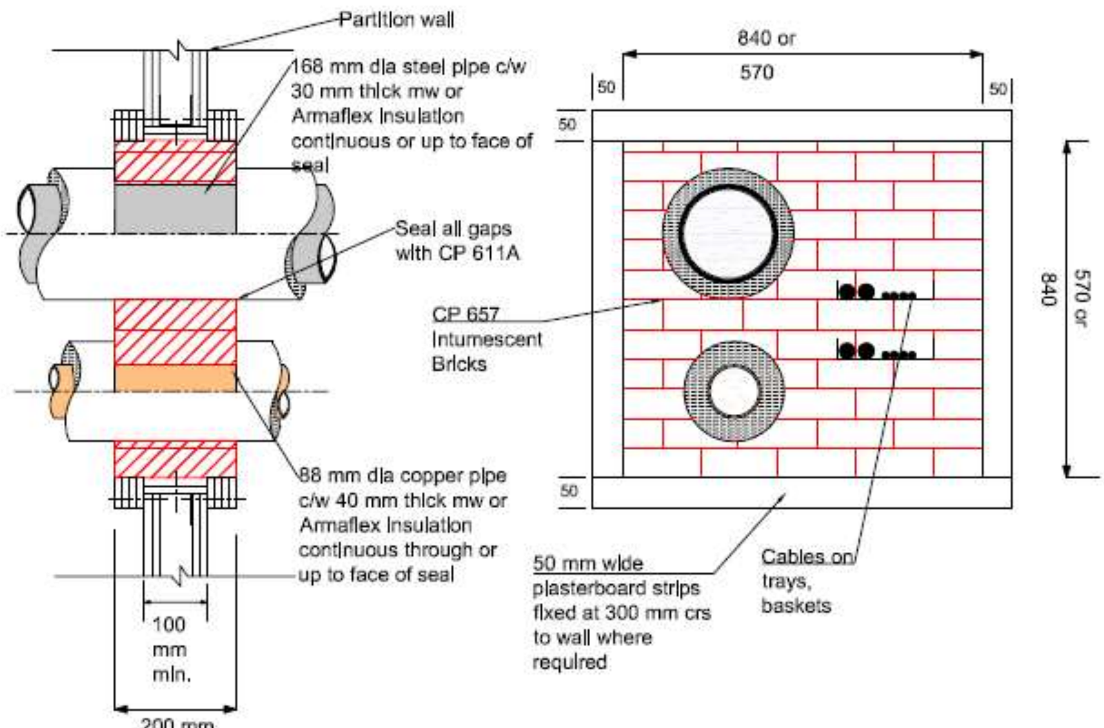
Test	Up to
Fire Integrity	2 hr
Insulation	2 hr
Acoustics	53 dB
Air Tightness	✓
Age Testing	30 years

Approvals
BS476 pt 20
EN 1366-3

APPLICATION



Service penetration through partition wall



The above applications are not exhaustive. For further details please contact

1. The application limits on this detail are for guidance purposes only. For more detailed information on the full range of available test results please contact a Hilti Firestop Specialist on 0800 886100.
2. The product and application has been fire tested as a minimum to BS 476. It may have additional European and worldwide testing. Please contact Hilti for further information.
3. All installations should be carried out in accordance with Hilti's installation instructions, by competent, experienced installers using Hilti branded products.

15.03.11	Drawn by	A Brockett		FS	114	Issue	01

Hilti (Gt. Britain) Limited | 1 Trafford Wharf Road | Trafford Park | Manchester M17 1BY Freephone: 0800 886 100 | Freefax: 0800 886 200 | www.hilti.co.uk

HILTI CP 657

Additional Properties of CP 657 – Firestop Brick

Property	Test regime	Notes	
Fire	BS 476 - 20		✓
	LPCB LPS 1132: Issue 4 : 1999 - Requirements and tests for LPCB Approval of Wall and Floor Penetration and Linear gap Seals		090a(9)
	FM approval (Class 4990)		✓
Acoustic	EN ISO 20 140-10: 1992	Dnw	57 dB
	EN ISO 20 140-10: 1992	Cables	Dn,e,w, 58 dB
Ageing	DIBT		✓
	DAfSTB		✓
	Fire test after ageing		✓
Air sealing	DIN 1026		✓
	Pressure difference 50Pa		
	Pressure difference 200Pa		✓
Electrical resistance	Surface resistance		✓
	Volume resistivity		✓
	Insulator		Yes
Water resistance	Rain Resistance		N.R
	Water tightness	UL 1479	N.R
VOC	LEED 2009	LEED 3.0	4.4 g/l
Chemical Resistance	Contact Hilti Technical Advisory Service with details of type, concentration, duration and ambient temperature of exposure conditions		

N.R Not relevant
✓ Meets standard

Hilti (Gt. Britain) Limited,
1 Trafford Wharf Road, Trafford Park, Manchester M17 1BY
Telephone:
0800 886 100

HILTI | CP 657

CP 657 –Firestop Brick - BREEAM criteria

BREEAM Section		
Management construction site impact	No power tools required for installation (no energy source required)	✓
	Dust free installation	✓
	Saves water during application No water pollution	✓
Health and wellbeing	Low VOC* (air quality)	✓
	No ozone depletion potential (ODP)	✓
	Low global warming potential (GWP)	✓
	Smoke and gas tightness	✓
	Noise reduction	✓
Energy	Air tightness	✓
	Avoidance of air infiltration	✓
Materials	Product Carbon Footprint or LCA Data	✓
	Thermal insulation	✓
Waste	Recycling of packaging	✓
	Reuse of materials	✓
	Repenetration in existing opening (No waste)	✓

Product contributes to Green Building under this clause	✓
Not applicable for this product	NA
Product makes No contribution to green Building under this clause	x

Hilti (Gt. Britain) Limited,
1 Trafford Wharf Road, Trafford Park, Manchester M17 1BY

Telephone:
0800 886 100

A.2.5 CP660 Expanding Fire Seal

Hilti Firestop Systems HILTI

Expanding fire seal
CP 660

Applications

- Permanent firestop seals in small and medium-sized openings (optimum size range: 100 x 100 mm to 400 x 400 mm)
- Cable trays, bunched and single cables
- Openings accommodating pipes and cables
- Plastic pipes in conjunction with Hilti firestop collars and / or wraps
- Metal pipes (uninsulated or with flammable or non-flammable insulation)
- Plastic pipes up to 50mm

Advantages

- Tested in unlined dry wall openings
- Clean installation without need for formwork or other aids
- Easily applied using the ergonomically-designed Hilti dispensers
- Safety first: CP 660 complies with the requirements of international fire protection directives
- Neat and tidy application, easily shapeable foam and remains flexible
- Very quick and easy to install, a reliable firestop seal with only one product
- Repenetrable

British Standard BS 476 EN 1366-3 LPCB 30

Technical data

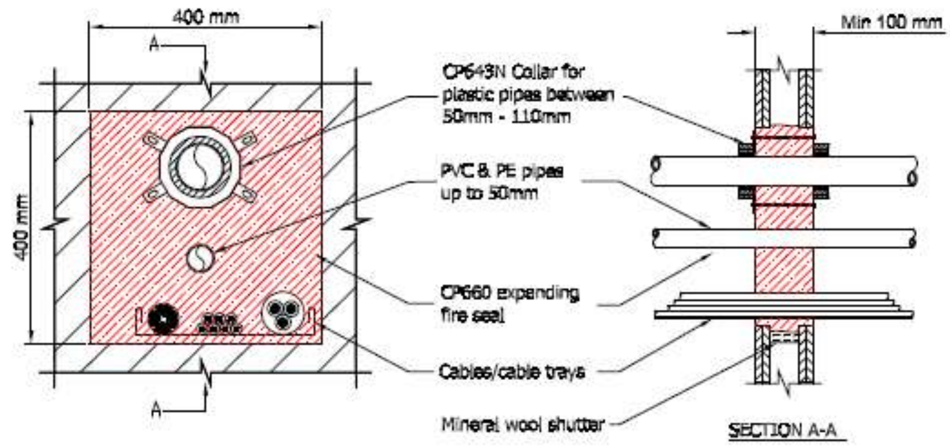
	CP 660
Fire rating	Up to 2 hours in walls Up to 3 hours in floors
Base materials	Concrete, Masonry, Drywall, Brick
Application temperature range	5°C - 40°C
Acoustics performance	Up to 47dB
Colour	Red
Air Leakage Rating	0.0007 m^3/h (min)

Ordering

Order description	Package Contents	Package Quantity	Item number
Firestop foam CP 660 INT	CP 660 expanding fire seal, mixing nozzle, instructions for use	1 pc	00203517
Dispenser CP 660	Manual dispenser kit in a Hilti case	1 pc	00238584

Can also be installed with standard Hilti HIT dispensers (MD 2000, ED 3500-A).

Technical Information



For more standard details and technical information register online at the Hilti Firestop Design Centre at www.hilti.co.uk/cfs

Installation instructions for CP 660

Notice

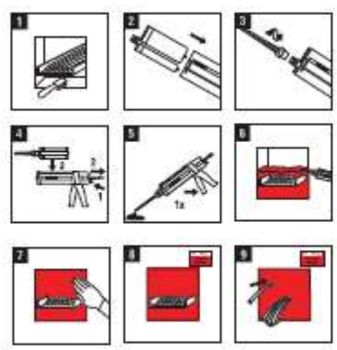
- Before handling, read Material Safety Data Sheet and product label for safe usage and health information.

Application of firestop

1. Clean the opening to be sealed free from dust or grease.
2. Slide the foil pack into the holder.
3. Remove the cap. Screw the mixing nozzle all the way onto the foil pack and tighten it securely.
4. Insert the holder containing the foil pack into the dispenser.
5. Discard the unevenly mixed initial quantity.
6. Apply the firestop foam in the opening to be sealed. The mixed components of the foam react and begin to expand approx. 30 seconds after application (at 23°C). Fill the opening completely with firestop foam, including gaps between individual cables, etc.
7. The foam can be shaped or smoothed by hand (if necessary) after approx. 5 minutes (at 23°C). Wear protective gloves! After approx. 10 minutes (at 23°C) the foam becomes hard and it can then be cut.
8. Mount the installation identification plate beside the correctly sealed opening.
9. Additional cables or pipes can be installed in the opening without difficulty. Do not exceed the approved maximum number and size of cables or pipes. The cable or pipe may be pushed directly through the foam. Where necessary, use a suitable tool (screwdriver or drill bit, etc.) to make a hole in the foam before pushing the cable or pipe through. Seal any remaining caps carefully with CP 660

Storage

- Store in a cool, dry, dark place at a temperature of +5°C to +25°C / +41°F to +77°F.
- Observe expiry date on package



HILTI

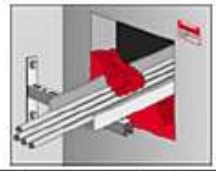
Standard firestop detail

Hilti CP 660 Expanding fire seal

Test	Up to
Fire Integrity	2 hr
Insulation	2 hr
Acoustics	47dB
Air Tightness	✓
Age Testing	30 years

Approvals
BS476 pt 20
EN 1366-3

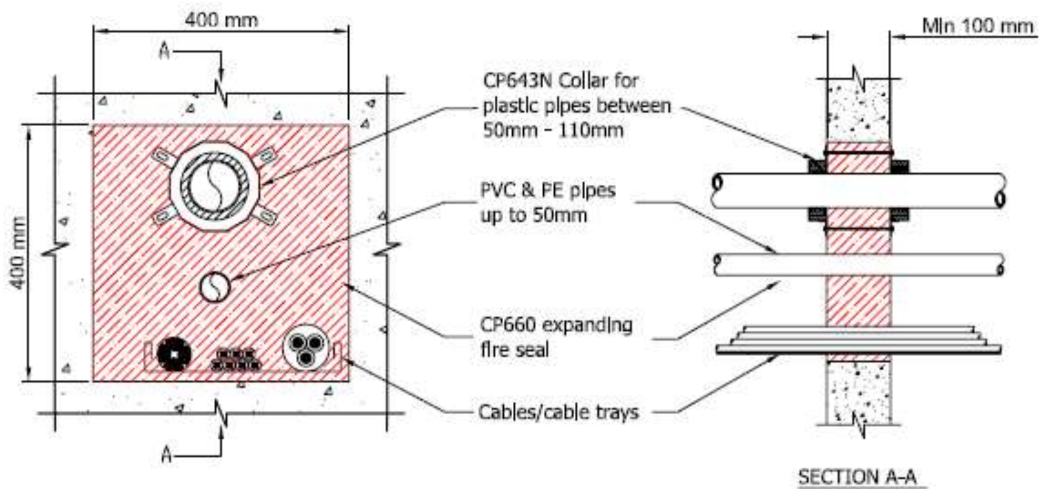
APPLICATION



Plastic pipe/Cables

passing through

Solid wall



CP648 Intumescent wraps may be used as an alternative to the CP643N collars for combustible pipes between 50mm - 110 mm.

The above applications are not exhaustive. For further details please contact

1. The application limits on this detail are for guidance purposes only. For more detailed information on the full range of available test results please contact a Hilti Firestop Specialist on 0800 886100.
2. The product and application has been fire tested as a minimum to BS 476. It may have additional European and worldwide testing. Please contact Hilti for further information.
3. All installations should be carried out in accordance with Hilti's Installation Instructions, by competent, experienced installers using Hilti branded products.

08.01.08	Drawn by	R Wakefield		FS	064	Issue	01

Hilti (Gt. Britain) Limited | 1 Trafford Wharf Road | Trafford Park | Manchester M17 1BY Freephone: 0800 886 100 | Freefax: 0800 886 200 | www.hilti.co.uk

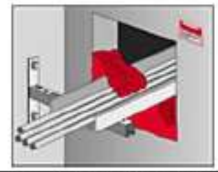
Standard firestop detail

Hilti CP 660 Expanding fire seal

Test	Up to
Fire Integrity	2 hr
Insulation	2 hr
Acoustics	47dB
Air Tightness	✓
Age Testing	30 years

Approvals
BS476 pt 20
EN 1366-3

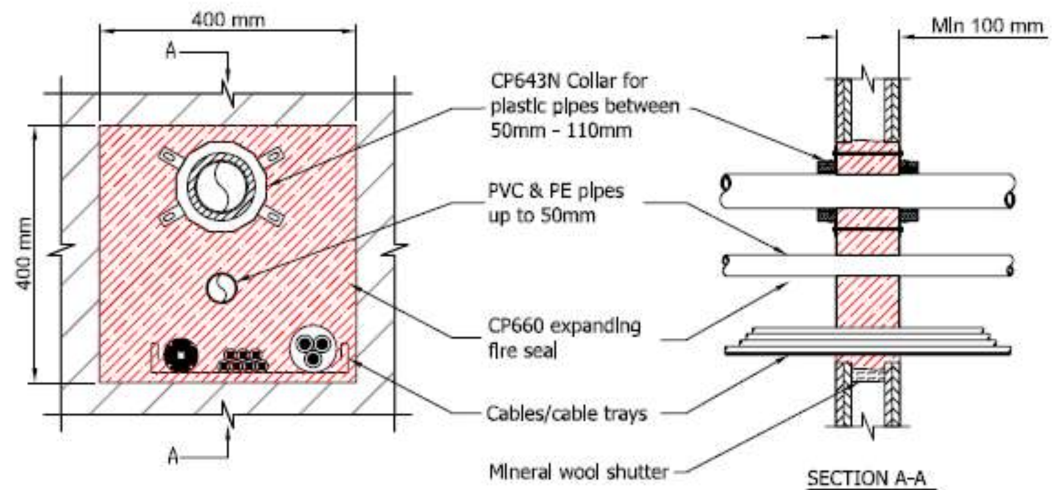
APPLICATION



Plastic pipe/Cables

passing through

Drywall



CP648 Intumescent wraps may be used as an alternative to the CP643N collars for combustible pipes between 50mm - 110 mm.
CP660 has been tested within an unlined aperture with just a mineral wool shutter used to support the seal as it expands.

The above applications are not exhaustive. For further details please contact

1. The application limits on this detail are for guidance purposes only. For more detailed information on the full range of available test results please contact a Hilti Firestop Specialist on 0800 886100.
2. The product and application has been fire tested as a minimum to BS 476. It may have additional European and worldwide testing. Please contact Hilti for further information.
3. All installations should be carried out in accordance with Hilti's Installation Instructions, by competent, experienced installers using Hilti branded products.

08.01.08	Drawn by	R Wakefield		FS	065	Issue	01

Hilti (Gt. Britain) Limited | 1 Trafford Wharf Road | Trafford Park | Manchester M17 1BY Freephone: 0800 886 100 | Freefax: 0800 886 200 | www.hilti.co.uk

HILTI

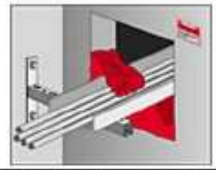
Standard firestop detail

Hilti CP 660 Expanding fire seal

Test	Up to
Fire Integrity	3 hr
Insulation	3 hr
Acoustics	47dB
Air Tightness	✓
Age Testing	30 years

Approvals
BS476 pt 20
EN 1366-3
UL
FM
LPCB

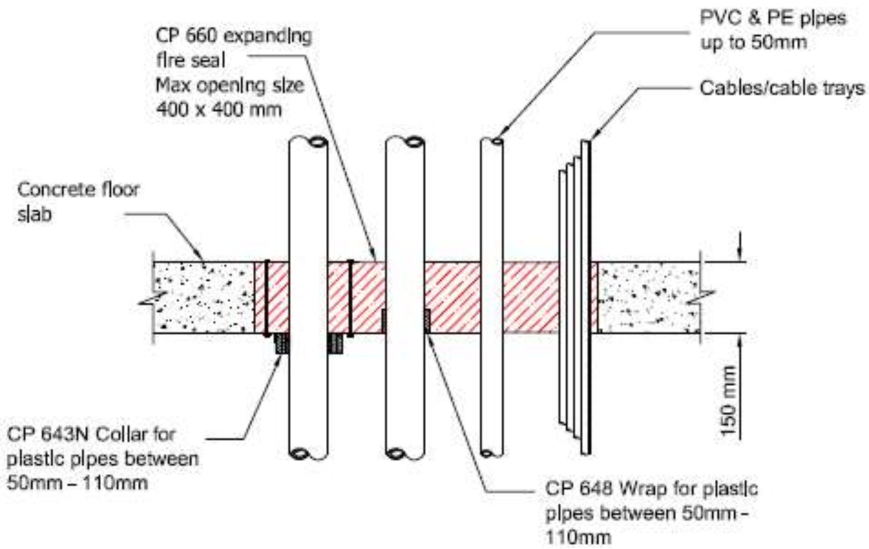
APPLICATION



Plastic pipe/Cables

passing through

Solid floor



The above applications are not exhaustive. For further details please contact

1. The application limits on this detail are for guidance purposes only. For more detailed information on the full range of available test results please contact a Hilti Firestop Specialist on 0800 886100.
2. The product and application has been fire tested as a minimum to BS 476. It may have additional European and worldwide testing. Please contact Hilti for further information.
3. All installations should be carried out in accordance with Hilti's installation instructions, by competent, experienced installers using Hilti branded products.

22.09.11	Drawn by	A Brockett		FS	076	Issue	02

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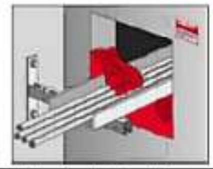
HILTI **Standard firestop detail**

Hilti CP 660 Expanding fire seal

Test	Up to
Fire Integrity	2 hr
Insulation	2 hr
Air Tightness	✓
Age Testing	30 years

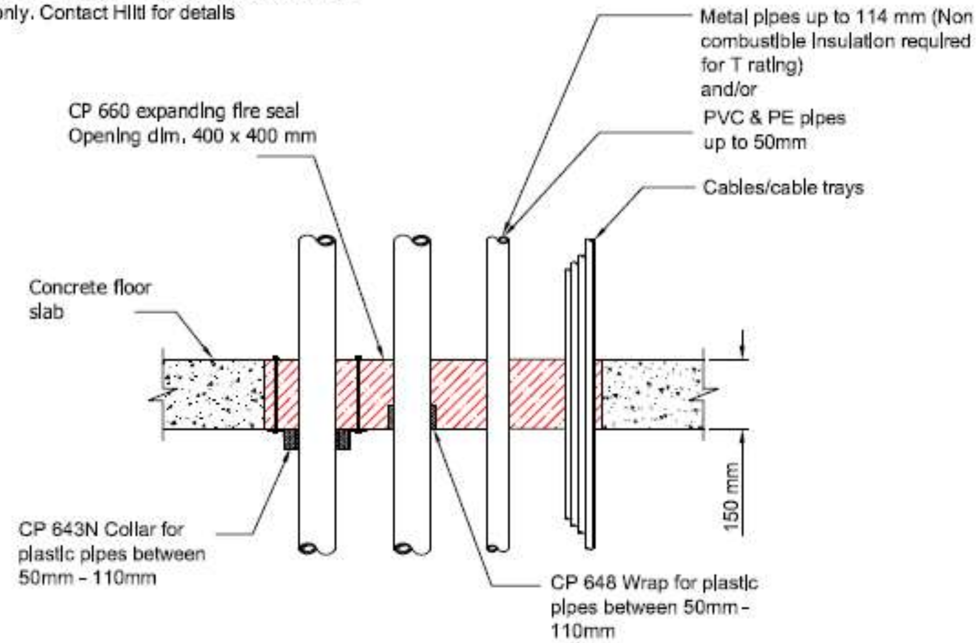
Approvals
BS476 pt 20
EN 1366-3
LPCB

APPLICATION



Plastic/Metal pipe
passing through
Solid floor

Note: Higher ratings can be achieved for plastic pipes only. Contact Hilti for details



1. The application limits on this detail are for guidance purposes only. For more detailed information on the full range of available test results please contact a Hilti Firestop Specialist on 0800 886100.
2. The product and application has been fire tested as a minimum to BS 476. It may have additional European and worldwide testing. Please contact Hilti for further information.
3. All installations should be carried out in accordance with Hilti's installation instructions, by competent, experienced installers using Hilti branded products.

17.12.10	Drawn by	A Brockett		FS	107	Issue	01

Hilti (Gt. Britain) Limited | 1 Trafford Wharf Road | Trafford Park | Manchester M17 1BY Freephone: 0800 886 100 | Freefax: 0800 886 200 | www.hilti.co.uk

HILTI | CP 660

Additional Properties of CP 660 – Expanding Fire seal

Property	Test regime	Notes	
Fire	BS 476 - 20		✓
	BS EN 1366-3		✓
	LPCB LPS 1132: Issue 4 : 1999 - Requirements and tests for LPCB Approval of Wall and Floor Penetration and Linear gap Seals		Certificate 090a/09
	ETA		✓
Acoustic	EN 20 140-10: 1992-09		47 dB
Ageing	DAfSTB		✓
	Fire test after ageing		✓
Air sealing	DIN 1026		✓
	Pressure difference 50Pa		
	Pressure difference 200Pa		✓
Water resistance	Mold and Mildew resistance	ISO 846	Class 0-1
VOC	LEED 2009	LEED 3.0	34.5 g/l

Chemical Resistance: Contact Hilti Technical Advisory Service with details of type, concentration, duration and ambient temperature of exposure conditions

N.R Not relevant
✓ Meets standard

Hilti (Gt. Britain) Limited,
1 Trafford Wharf Road, Trafford Park, Manchester M17 1BY

Telephone:
0800 886 100

HILTI | CP 660

CP 660 –Firestop Expanding Fire Seal - BREEAM criteria

BREEAM Section		
Management construction site impact	No power tools required for installation (no energy source required)	✓
	Dust free installation	✓
	Saves water during application No water pollution	✓
Health and wellbeing	Low VOC* (air quality)	✓
	No ozone depletion potential (ODP)	✓
	Low global warming potential (GWP)	✓
	Smoke and gas tightness	✓
	Noise reduction	✓
Energy	Air tightness	✓
	Avoidance of air infiltration	✓
Materials	Product Carbon Footprint or LCA Data	✓
	Thermal insulation	✓
Waste	Recycling of packaging	✓
	Reuse of materials	✓
	Repenetration in existing opening (No waste)	✓

Product contributes to Green Building under this clause	✓
Not applicable for this product	NA
Product makes No contribution to green Building under this clause	x

Hilti (Gt. Britain) Limited,
1 Trafford Wharf Road, Trafford Park, Manchester M17 1BY
Telephone:
0800 886 100

HILTI | CP 660

CP 660 –Firestop Expanding Fire Seal - NBS specification clauses

This page is to be used in conjunction with the NBS Specification clauses in the introduction to the Hilti Firestop Specifiers Binder.

Application: Imperfections of fit of building components and Service penetrations through fire rated walls and floors requiring treatment to reinstate the fire performance of said walls and floors

P12 FIRE STOPPING SYSTEMS

PRODUCTS

335 INTUMESCENT FOAMS

- A graphite and PU based, two part, intumescent sealant. For permanent sealing of medium and large penetrations in walls and floors and for use in concrete, porous concrete, masonry and partition walls from 100mm to 200mm thickness depending on opening type and size, floors of 150mm
- Tested to BS 476: Part 20: 1987 and BS EN 1366-3:2004.
- Fire Resistance: up to 2 hours
- Age tested as defined in the DafStb guidelines, with subsequent fire testing.
- Manufacturer: Hilti (Gt Britain) Ltd, 1Trafford Wharf Road, Manchester M17 1BY, Tel no 0800 886 100, Fax 0800 886 200. Website www.hilti.co.uk.

- Product Reference: CP 660 **Expanding Sealant**

Hilti (Gt. Britain) Limited,
1 Trafford Wharf Road, Trafford Park, Manchester M17 1BY

Telephone:
0800 886 100

A.2.6 CP680 Cast-In Firestop Devices

Product Information

CP 680-P and CP 680-M Cast-In Firestop Devices

For use in
- Dust and fiber free environments such as hospitals, computer centers and laboratories
- Concrete floor assemblies rated up to 4 hours

Product description
- A one-step cast-in firestop device for a variety of pipe materials and diameters
- Helps reduce labor costs and increase productivity
- Ready-to-use out of the package
- Internationally tested and approved by UL and FM
- Reduces the chance of project delays due to failed inspections

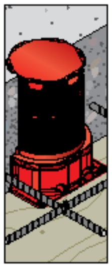
Product features
- Quick and simple installation
- SpeedLine Alignment system promotes faster layout
- QuickTurn System creates fast, simple vertical connections
- Integrated moisture and smoke seal
- Innovative adapter for metal deck applications

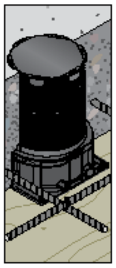
Installation and applications
- Concrete floors from 2.5" (63 mm) thickness for either flat concrete or concrete over metal deck

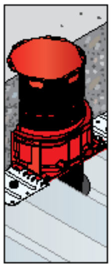
  CP 680-M:
  - Insulated and non-insulated metal pipes
  - EMT and electrical conduits
  - Cable bundles
  - Multiple pipes

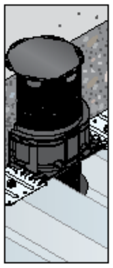
  CP 680-P:
  Addresses all applications for CP 680-M as well as the following:
  - Plastic pipes such as PVC, CPVC, ABS, ENT and FRPP
  - Fresh and waste water pipes

Not suited for
- Areas with high condensation
- Outdoor areas
- Wall applications


CP680-P in concrete over wood forms


CP680-M in concrete over wood forms


CP 680-P over metal deck


CP 680-M over metal deck

Technical Data		CP 680-P and CP 680-M
ID	Footprint	Opening required thru metal deck
2"	3-3/4" x 4-1/2"	3-1/2" diameter
3"	4-3/4" x 5-5/8"	4-1/2" diameter
4"	6-3/8" x 6-3/4"	5-1/2" diameter
6"	9" x 9-1/2"	7-1/4" diameter
Expansion temperature		392°F (200°C)
Expansion rate		1:50 (unrestrained) 1:30 (Load expansion, Load = 20g/cm²)
Standard height		8"
Temperature resistance		Maximum 212°F (100°C)
Color		CP 680-P: red CP 680-M: black

Approvals
- California State Fire Marshal - No. 4485-1200:135, 4485-1200:136
- City of New York - MEA 1-07-M, MEA 2-07-M

Tested in accordance with
- UL 1479
- ASTM E 814

Internationally tested and approved

FIRESTOP DEVICE
FOR USE IN THROUGH-PENETRATION FIRESTOP SYSTEMS
SEE UL FIRE RESISTANCE DIRECTORY
SN76

FM APPROVED

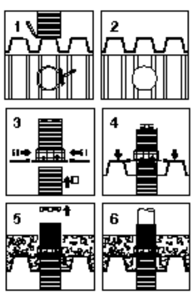
FBC SYSTEM COMPATIBLE

Installation instructions

Notice
- Before handling, read Material Safety Data Sheet and product label for safe usage and health information.
- Instructions below are general guidelines — always refer to the applicable drawing in the UL Fire Resistance Directory or Hilti Firestop Systems Guide for complete installation information

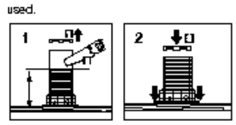
Instructions for use
- Before pouring concrete, secure the cover cap in place, thereby preventing the flow of concrete into the cast-in device
- Do not use for wall applications

Concrete floor with metal decking
For concrete floor with metal decking applications use the correct size CP 680 Metal Deck Adapter for installed cast-in device and follow the illustrations.



Concrete floor

Installation option
Follow the illustrations if CP 680 has to be cut to slab thickness before installation, or when riser clamps are used.



Hilti Firestop
Saving lives through innovation and education

Hilti. Outperform. Outlast.

HILTI®

MSDS No.:	315
Revision No.:	000
Revision Date:	11/10/06
Page:	1 of 2

MATERIAL SAFETY DATA SHEET

Product name:	**CP 680-P / CP 680-M - Cast-in Firestop Devices**
Description:	CP 680-P - Black intumescent material enclosed in a red plastic housing
	CP 680-M - Black intumescent material enclosed in a black plastic housing
Supplier:	Hilti, Inc. P.O. Box 21148, Tulsa, OK 74121
Emergency # (Chem-Trec.):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)

INGREDIENTS AND EXPOSURE LIMITS

Not applicable. This product is considered to be an "article" as defined in the federal OSHA Hazard Communication Standard 29 CFR 1910.1200 / 1926.59.

PHYSICAL DATA

Appearance:	Red plastic sleeve (CP 680-P) Black plastic sleeve (CP 680-M)	Odor:	None.
Vapor Density: (air = 1)	Not applicable.	Vapor Pressure:	Not applicable.
Boiling Point:	Not applicable.	VOC Content:	7.6 g/l
Evaporation Rate:	Not applicable.	Solubility in Water:	Not determined.
Specific Gravity:	Not determined.	pH:	Not applicable.

FIRE AND EXPLOSION HAZARD DATA

Flash Point:	Not applicable.	Flammable Limits:	Not applicable.
Extinguishing Media:	Use extinguishing media appropriate for surrounding fire.		
Special Fire Fighting Procedures:	None known.		
Unusual Fire and Explosion Hazards:	None known. Product serves as a firestop; intumescent material inside plastic collar expands when exposed to temperatures > 160° C / 320° F.		

REACTIVITY DATA

Stability:	Stable.	Hazardous Polymerization:	Will not occur.
Incompatibility:	None known.	Decomposition Products:	None known.
Conditions to Avoid:	None known.		

HEALTH HAZARD DATA

Known Hazards:	None known.	Routes of Exposure:	None known.
Signs and Symptoms of Exposure:	None expected from routine use/installation according to manufacturer's specifications and technical guides.		
Carcinogenicity:	No ingredients are classified as a carcinogen by IARC, NTP or OSHA.		
Medical Conditions Aggravated by Exposure:	None known.		

EMERGENCY AND FIRST AID PROCEDURES

Eyes:	Immediately flush with plenty of water. Call a physician if symptoms occur.
Skin:	Not applicable. Practice good hygiene; i.e. wash hands during breaks, before eating or smoking, and after work.
Inhalation:	Not applicable.
Ingestion:	Not a potential route of exposure.
Other:	Referral to a physician is recommended if there is any question about the seriousness of any injury/exposure.

CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT

Ventilation:	General (natural or mechanically induced fresh air movements).
Eye Protection:	Not required, however, safety glasses should be worn in most industrial settings.
Skin Protection:	None required; however, (cotton) gloves recommended.
Respiratory Protection:	No respiratory protection is needed for normal application of this product.

PRECAUTIONS FOR SAFE HANDLING AND USE	
Handling and Storing Precautions:	Store in a cool dry area. Follow installation instructions.
Spill Procedures:	No special requirements.

REGULATORY INFORMATION	
Hazard Communication:	This product is considered to be an "article" as defined in the federal OSHA Hazard Communication Standard.
DOT Shipping Name:	Not regulated.
IATA / ICAO Shipping Name:	Not regulated.
TSCA Inventory Status:	Chemical components listed on TSCA inventory.
SARA Title III, Section 313:	This product is classified as an "article" and is not subject to reporting under Section 313 of SARA Title III (40 CFR Part 372).
EPA Waste Code(s):	Not regulated by EPA as a hazardous waste.
Waste Disposal Methods:	Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, state, and federal safety, health and environmental regulations.

CONTACTS			
Customer Service:	1 800 879 8000	**Technical Service:**	1 800 879 8000
Health / Safety:	1 800 879 6000 Jerry Metcalf (x6704)		
Emergency # (Chem-Trec):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)		

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

MSDS 315, Page 2 of 2

Certificate of Compliance

Certificate Number 20061214-R15431
Report Reference 2006 December 14
Issue Date 2006 December 14

Page 1 of 1

Underwriters Laboratories Inc.®

Issued to: **Hilti, Inc.**
5400 S 122ND East Ave
Tulsa, OK 74146 USA

This is to certify that representative samples of **Firestop Devices**
CP 680-M 2 in., CP 680-M 3 in., CP 680-M 4 in., CP 680-M 6 in.,
CP 680-P 2 in., CP 680-P 3 in., CP 680-P 4 in., CP 680-P 6 in., and CP 681

Have been investigated by Underwriters Laboratories Inc.® in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: ANSI/UL 1479, CAN/ULC-S115-05

Additional Information: CP 680-M 2 in., CP 680-M 3 in., CP 680-M 4 in., CP 680-M 6 in.,
CP 680-P 2 in., CP 680-P 3 in., CP 680-P 4 in., CP 680-P 6 in., and CP 681
for use in Through-Penetration Firestop Systems as currently described in the UL Fire Resistance Directory.

Only those products bearing the UL Classification Mark should be considered as being covered by UL's Classification and Follow-Up Service.

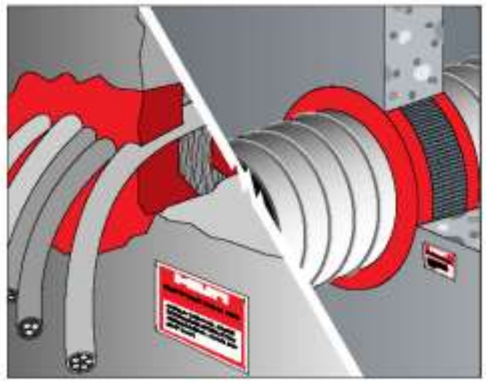
The UL Classification Mark includes: UL in a circle symbol: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

Look for the UL Classification Mark on the product

A.2.7 FS-ONE Intumescent Firestop Sealant

Product Information HILTI

FS-ONE
High Performance
Intumescent Firestop Sealant



Product description
- Intumescent (expands when exposed to fire) firestop sealant that helps protect combustible and non-combustible penetrations for up to 4 hours fire rating

Areas of application
- Steel, copper and EMT pipes
- Insulated steel and copper pipes
- Cable bundles
- Closed or vented plastic pipes
- HVAC penetrations

For use with
- Concrete, masonry, drywall and wood floor assemblies
- Wall and floor assemblies rated up to 4 hours

Examples
- Sealing around plastic pipe penetrations in fire rated construction
- Sealing around combustible and non-combustible penetrations in fire rated construction

Internationally tested and approved

CLASSIFIED UL
FILL, VOID OR CAVITY MATERIALS
CLASSIFIED BY
UNDERWRITERS LABORATORIES, INC
FOR USE IN THROUGH-PENETRATION
FIRESTOP SYSTEMS
SEE UL FIRE RESISTANCE DIRECTORY

FM
APPROVED

System advantage/Customer benefits
- Protects most typical firestop penetration applications
- Easy to work with and fast clean up
- Can be repenetrated when laying new cables
- Can be painted

FS-ONE
Intumescent Firestop Sealant

Ordering Description	Color	Package contents	Volume	Item No.
FS-ONE, tube	red	10.1 oz. (300 ml)	18 in³	00259579
FS-ONE, foil	red	(Qty 20) 20.2 oz. (600 ml)	36 in³	00311387
FS-ONE, pail	red	5 Gallons (19 liter)	1155 in³	00259578
CB 200 PI-300/310 ml Dispenser				00055205
600 ml Foil Dispenser				00024669

FS-ONE
High Performance Intumescent Firestop Sealant

Product description

- Intumescent (expands when exposed to fire) firestop sealant that helps protect combustible and non-combustible penetrations for up to 4 hours fire rating

Product features

- Smoke, gas and water resistant
- Contains no halogen, solvents or asbestos
- High fire rating properties
- Water based, easy to clean

Tested in accordance with

- UL 1479
- ASTM E 814
- ASTM E 84

Technical Data

FS-ONE Intumescent Firestop

(at 73°F (23°C) and 50% relative humidity)

Chemical basis:	Water-based intumescent acrylic dispersion
Density:	Approx. 1.5 g/cm³
Color:	Red
Working time:	Approx. 20-30 min
Curing time:	Approx. 14-21 days
Shore A Hardness:	Approx. 35
Movement capability:	Approx. 5%
Intumescent Activation:	Approx 250°F (121°C)
Expansion rate (unrestricted):	Up to 3-5 times original volume
Temperature resistance (cured):	-40°F (-40°C) to 212°F (100°C)
Application temperature:	35°F (2°C) to 100°F (38°C)
Surface burning characteristics: (ASTM E 84-96)	Flame Spread: 0 Smoke Development: 5
Sound transmission classification: ASTM E 90-97	50

Approvals

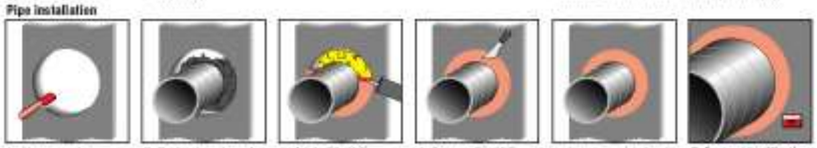
ICBO Evaluation Service, Inc.	Report No. 5071
California State Fire Marshal	Listing No. 1200:108
City of New York	MEA 326-96-M Vol. II

Installation instructions for FS-ONE

Cable installation

1. Clean opening. 2. Pack mineral wool. (If required) 3. Apply FS-ONE. 4. Smooth FS-ONE. 5. Leave completed seal undisturbed for 48 hours. 6. Fasten identification plate (if required).

Pipe installation



1. Clean opening. 2. Pack mineral wool. (If required) 3. Apply FS-ONE. 4. Smooth FS-ONE. 5. Leave completed seal undisturbed for 48 hours. 6. Fasten identification plate (if required).

Opening

1. Clean the opening. Surfaces to which FS-ONE will be applied should be cleaned of loose debris, dirt, oil, moisture, frost and wax. Structures supporting penetrating items must be installed in compliance with local building and electrical standards.

Application of firestop sealant

2. Install the prescribed backfilling material type and depth to obtain the desired rating (if required). Leave sufficient depth for applying FS-ONE.
3. Application of firestop sealant: Apply FS-ONE to the required depth in order to obtain the desired fire rating. Make sure FS-ONE contacts all surfaces to provide maximum adhesion. For application of FS-ONE use a standard caulking gun, foil pack gun, bulk loader and bulk gun. With FS-ONE buckets, Graco type sealant pumps may be used. (Contact pump manufacturer for proper selection).
4. Smoothing of firestop sealant: To complete the seal, tool immediately to give a smooth appearance. Excess sealant, prior to curing, can be cleaned away from adjacent surfaces and tools with water.
5. Leave completed seal undisturbed for 48 hours.
6. For maintenance reasons, a penetration seal could be permanently marked with an identification plate. In such a case, mark the identification plate and fasten it in a visible position next to the seal.

Notice about approvals

- Check that the penetration has been sealed according to the specified drawing in the UL Fire Resistance Directory or Hilti Firestop Manual. For further advice, please contact Hilti customer service. Refer to Hilti product literature and UL fire resistance directory for specific application details.

Not for use...

- High movement expansion joints
- Underwater
- On materials where oil, plasticizers or solvents may bleed i.e. impregnated wood, oil based seals, green or partially vulcanized rubber
- In any penetration other than those specifically described in this manual or the test reports

Safety precautions

- Before handling, read the product and Material Safety Data Sheet for detailed use and health information
- Keep out of reach of children
- Wear suitable gloves and eye protection

Storage

- Store only in the original packaging in a location protected from moisture at temperatures between 40°F (5°C) and 86°F (30°C)
- Observe expiration date on the packaging

Material Safety Data Sheet

HILTI, INC.:	**P.O. Box 21148, Tulsa, OK 74121; Ph: 1 800 879 6000; Emergency No.: 1 800 879 4444**		
PRODUCT NAME:	**FS-ONE High Performance Intumescent Firestop Sealant**	MSDS No.:	259
		Revision No.:	008
DESCRIPTION:	**One-part acrylic-based sealant**	Date:	05/19/99
		Page:	1 of 2

INGREDIENTS AND EXPOSURE LIMITS

Ingredients:	*CAS Number:*	*PEL:*	*TLV:*	*TEL:*
Calcium carbonate	01317-65-3	5 mg/m^3 (T)	10 mg/m^3 (T)	NE
Ammonium polyphosphate	68333-79-9	NE	NE	NE
Boron trioxide	01303-86-2	15 mg/m^3 (R)	10 mg/m^3	NE
Alkylphenolethersulfate, sodium salt	69011-84-3	NE	NE	NE
Talc	14807-96-6	20 mppcf	2 mg/m^3	NE
Zinc oxide	01314-13-2	5 mg/m^3 (T)	10 mg/m^3	NE
Expandable graphite	12777-87-6	5 mg/m^3 (T)	2 mg/m^3 (T)	NE
Ethylene glycol	00107-21-1	NE	C:100 mg/m^3 (A)	NE
Polybutene	09003-29-6	NE	NE	NE
Iron oxide	01309-37-1	10 mg/m^3	5 mg/m^3	NE
Glass filament	65997-17-3	NE	5 mg/m^3 (T)	NE
Silicon dioxide	14808-60-7	0.05 mg/m^3 (T)	0.1 mg/m^3 (T)	NE

Abbreviations: PEL = OSHA Permissible Exposure Limit. TLV = ACGIH Threshold Limit Value. C = Ceiling. STEL = Short Term Exposure Limit. NE = None Established. NA = Not Applicable. (T) indicates "as total dust". (R) indicates "as respirable fraction". (A) indicates "as an aerosol". mppcf = million particles per cubic foot.

PHYSICAL DATA

Appearance:	Red paste.	Odor:	Odorless.
Vapor Density: (air = 1)	Not determined.	Vapor Pressure:	23mbar @ 20C / 68F
Boiling Point:	Not applicable.	VOC Content:	None.
Evaporation Rate:	Not applicable.	Solubility in Water:	Soluble.
Specific Gravity:	1.5	pH:	Notdetermined.

FIRE AND EXPLOSION HAZARD DATA

Flash Point:	Non-flammable.
Flammable Limits:	Not applicable.
Extinguishing Media:	Not applicable. Use extinguishing media as appropriate for surrounding fire.
Special Fire Fighting Procedures:	None known. Use a self-contained breathing apparatus when fighting fires involving chemicals.
Unusual Fire and Explosion Hazards:	None known. Thermal decomposition products can be formed.

REACTIVITY DATA

Stability:	Stable.
Hazardous Polymerization:	Will not occur.
Incompatibility:	Strong acids, peroxides, and oxidizing agents.
Decomposition Products:	Thermal decomposition can yield CO and CO2.
Conditions to Avoid:	None known.

HEALTH HAZARD DATA

Known Hazards:	None known.
Carcinogenicity:	IARC classifies crystalline silica (quartz sand) as Gp I based upon evidence among workers in industries where there has been long-term and chronic exposure (via inhalation) to silica dust; e.g. mining, quarry, stone crushing, refractory brick and pottery workers. This product does not pose a dust hazard; therefore, this classification is not relevant. Based upon the nature and intended use of this product, it does not pose an increased cancer risk to workers.

HILTI **Material Safety Data Sheet**

Signs and Symptoms of Exposure:	Possibly irritating upon contact with the eyes or upon repeated contact with the skin.
Routes of Exposure:	Dermal.
Medical Conditions Aggravated by Exposure:	Eye and skin conditions.

EMERGENCY AND FIRST AID PROCEDURES

Eyes:	Immediately flush with plenty of water. Call a physician if symptoms occur.
Skin:	Immediately wipe off material and wash with soap and water. Material can adhere to the skin. If material has adhered to the skin, use an abrasive containing hand cleaner. If material does not come off, buff with a pumice stone.
Inhalation:	Move victim to fresh air if discomfort develops. Call a physician if symptoms persist.
Ingestion:	Seek medical attention. Do not induce vomiting unless directed by a physician. Never give anything by mouth to an unconscious person.
Other:	Referral to a physician is recommended if there is any question about the seriousness of the injury/exposure.

CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT

Ventilation:	General (natural or mechanically induced fresh air movements).
Eye Protection:	Not required, however, safety glasses should be worn in most industrial settings.
Skin Protection:	Avoid skin contact. Cloth gloves are suitable for hand protection.
Respiratory Protection:	None normally required. Where ventilation is inadequate to control vapors, use a NIOSH-approved respirator with organic vapor cartridges. Never enter a confined space without an appropriate air-supplied respirator.

PRECAUTIONS FOR SAFE HANDLING AND USE

Handling and Storing Precautions:	Store in a cool, dry area preferably between 50° and 100° F. Keep from freezing. Do not store in direct sunlight. Avoid contact with the eyes or skin. Practice good hygiene; i.e. always wash thoroughly after handling and before eating or smoking. For industrial use only. Keep out of reach of children. Follow label/use instructions.
Spill Procedures:	Immediately wipe away spilled material before it hardens. Place in a container for proper disposal in accordance with all applicable local, state, or federal requirements.

REGULATORY INFORMATION

Hazard Communication:	This MSDS has been prepared in accordance with the federal OSHA Hazard Communication Standard 29 CFR 1910.1200.
HMIS Codes:	Health 1, Flammability 0, Reactivity 0, PPE B
DOT Shipping Name:	Not regulated.
TSCA Inventory Status:	Chemical components listed on TSCA inventory.
SARA Title III, Section 313:	This product contains 1-5% ethylene glycol (CAS 107-21-1) and 1-5% zinc oxide (re: zinc compounds) which are subject to reporting under Section 313 of SARA Title III (40 CFR Part 372).
EPA Waste Code(s):	Not regulated by EPA as a hazardous waste.
Waste Disposal Methods:	Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, state, and federal safety, health and environmental regulations.

CONTACTS

Customer Service:	1 800 879 8000
Technical Service:	1 800 879 8000
Emergency:	1 800 879 4444
Health / Safety:	1 800 879 6000 Steve Gerrard (x6309) Jerry Metcalf (x6704)

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

Certificate of Compliance – FS-ONE

HILTI

Underwriters Laboratories Inc.®

Northbrook, Illinois • (708) 272-8800
Melville, New York • (516) 271-6200
Santa Clara, California • (408) 985-2400
Research Triangle Park, North Carolina • (919) 549-1400

CERTIFICATE OF COMPLIANCE

CERTIFICATE NUMBER: 211097 - R13240A
ISSUE DATE: October 21, 1997

Issued to: Hilti Construction Chemicals Inc.
5400 S. 122nd East Avenue
Tulsa, OK 74146 USA

Report Reference: R13240, February 14, 1997

This is to Certify that representative samples of: Fill, Void or Cavity Materials, one part Sealant designated as FS One (also identified as CP 612)

Have been investigated by Underwriters Laboratories Inc. in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: UL 1479, Fire Tests of Through-Penetration Firestops;
UL 2079, Tests for Fire Resistance of Building Joint Systems.

Additional Information: This material is a one part intumescent firestop sealant for use in through-penetration firestop systems. These sealants are Classified as "Fill, Void or Cavity Materials" for use in various Through-Penetration Firestop Systems as specified in Volume 2 of UL's Fire Resistance Directory.

Only those products bearing the UL Classification Marking should be considered as being covered by UL's Classification and Follow-Up Service.

The UL Classification Marking includes: the name "Underwriters Laboratories Inc."; the word "Classified"; a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

LOOK FOR THE UL CLASSIFICATION MARKING ON THE PRODUCT

Engineer: Underwriters Laboratories Inc. Nikola Momcilovic

Review Engineer: Underwriters Laboratories Inc. A. M. Ramirez

2000-44C (6/92)

A.2.8 CFP-S WB Fire Protection Steel Spray

Fire Protection Steel Spray CFP-S WB

Features

- Tested to ASTM E119 for up to 4 hr fire rating
- Water based, low VOC — allows for fast, easy clean up
- Reduced dry time permits additional coats to be applied faster
- Infinite color options possible with approved topcoats

Applications

- Wide flange steel columns
- Hollow section columns
- Restrained and unrestrained beams
- Concrete and steel floor units

Cross bracing protected with intumescent coating

Typical Hilti Fire Protection Steel Spray application

Hilti innovation meets steel protection.

Fire Protection Steel Spray CFP-S WB

Bringing the same quality professionals have come to rely on to a new fire protection steel spray, Hilti announces yet another market innovation. The new Fire Protection Steel Spray CFP-S WB is a water-based, low VOC spray which allows for fast, easy and safe clean up.

Featuring a reduced dry time, it helps increase productivity for a variety of applications. And with up to a 4 hour fire rating, common uses include wide flange steel columns, hollow section columns, restrained and unrestrained beams and steel floor and form unit.

The combination of outstanding service and superior products solidifies Hilti's ability to deliver unmatched value to architects and fire protection contractors.

Technical Data	CFP-S WB
Packaging	55 lb pail (25 kg pail)
Chemical basis	Water based polymer dispersion
Consistency	Sprayable liquid
Color	White
UL test design	Up to 4 hours fire rating (ASTM E119)
Surface burning characteristics	Flame spread 0 (ASTM E84) Smoke development 20 (ASTM E84)
Solid substance content	72 ±2 (% v/v)
Density	11.1 lb/gal (1.33 kg/l)
Ph-value	8-9
Recommended storage temperature	41°F to 104°F (5°C to 40°C)
Recommended application temperature	50°F to 104°F (10°C to 40°C)
Drying time	Approx. 6 hours at 75° F (24° C) and 50% relative humidity for 30 mils (0.76 mm) WFT
Adhesion	210 psi (ASTM D4541)
Durometer hardness	61 shore D (ASTM D2240)
Impact resistance	72.6 in lbs (ASTM D2794)
Abrasion resistance	0.468 g / 1000 cycles (ASTM D4060)
VOC	49 g/L

Order Information

Order Description	Qty	Item No.
Fire Protection Steel Spray CFP-S WB	1	00433115
Fire Protection Steel Spray CFP-S WB (Pallet)	18	03465272

Fire Protection Steel Spray CFP-S WB

Product description
- Fire protection dispersion to help protect load bearing steel structures in interior environments against the effects of fire

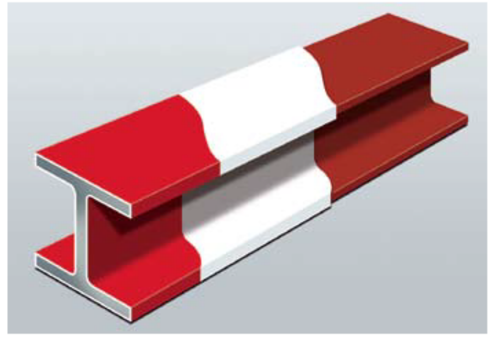
Product features
- Tested to ASTM E119 for up to 4 h fire rating
- Water Based, low VOC — allows for fast, easy and safe clean up
- Reduced dry time permits additional coats to be applied faster
- Infinite color options possible with approved topcoats

Areas of application
- Wide flange steel columns
- Hollow steel sections
- Restrained and unrestrained beams
- Restrained and unrestrained concrete and steel floor units

Primer
- The primer used should be of the phenolic resin modified alkyd type. A corresponding listing of tested and approved primers can be found at the Hilti Technical Services Department.

Top coats
If desired or required the following tested and approved top coats may be applied for decorative purposes.
- Glidden Premium Exterior Latex Semi-Gloss GL68XX
- Benjamin Moore Moorglo® Soft Gloss Fortified Acrylic House Paint
- Sherwin Williams Steel Master 9500 30% Silicone Alkyd

UL-Listing
- BXUV.Y611 — for wide flange steel columns
- BXUV.Y612 — for hollow sections columns
- BXUV.N631 — for beams
- BXUV.D975 — for concrete and steel floor units



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Abrasion resistance	0.468 g / 1000 cycles (ASTM D4060)
VOC	49 g/L

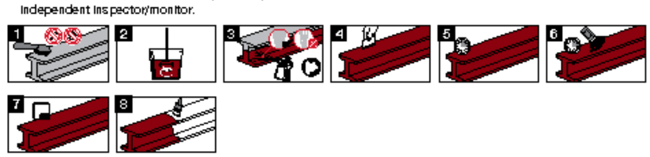
Mastic and Intumescent Coating Fire Resistance Classification. See UL Fire resistance Directory BXUV.

Installation instructions for CFP-S WB

Precaution

1. All structural steel to be coated with Hilti Fire Protection Steel Spray must be primed with an approved primer. The primer must be applied in full compliance with the manufacturer's recommendations, and must be fully cured. The surface must be clean, dry and free of grease, oil or any other contaminant that may inhibit bonding with the steel surface.
2. Hilti Fire Protection Steel Spray must be thoroughly mixed before use. A drill type mixer is recommended.
3. To achieve an optimum appearance, apply Hilti Fire Protection Steel Spray in several thin coats with an airless sprayer. The maximum coating thickness per coat is 62 mil wet film thickness (WFT) via airless sprayer.
4. Check the wet film thickness by using a wet film thickness gauge.
5. Allow each layer sufficient time to dry before applying further coats.
6. After the last coat has been applied, allow the Fire Protection Steel Spray to dry sufficiently before measuring the dry film thickness (DFT) via permanent magnetic type (banana gauge) or electronic electromagnetic type gauge. The product has cured sufficiently when periodic DFT measurements provide a consistent reading. Monitor the dry film thickness at multiple places of the steel member, subtracting the thickness of the primer.
7. Once finished, the work can be inspected by an independent inspector/monitor.
8. If desired, one of the above listed tested and approved top coats may be applied for decorative purposes.

Storage and shelf life
- Shelf life is 12 month when stored between 41°F (5°C) to 104°F (40°C) in original, unopened container. See side of pail for Batch Number/Expiry Date (e.g. xxxxxx MM.YYYY).



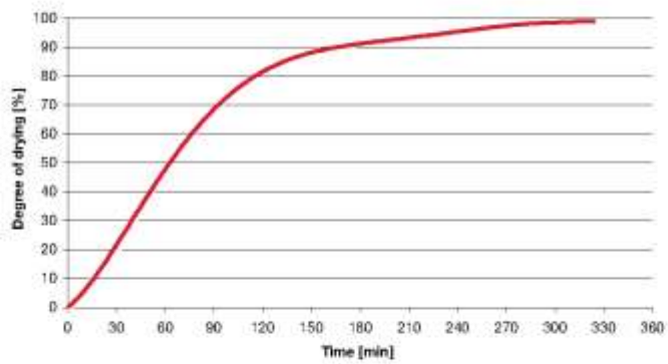
Coverage

Dry film thickness		Wet film thickness		Coverage	
mils	mm	mils	mm	(ft²) per gal	(ft²) per 5 gal
1	0.03	1.4	0.04	1155	5775
20	0.51	28	0.71	58	290
50	1.27	69	1.75	23	115
100	2.54	139	3.53	12	60
150	3.81	208	5.28	8	40
200	5.08	278	7.06	6	30

The coverage values shown are theoretical values, which have been calculated based on the solid content of the material. Actual coverage depends on surface, substrate, application technique and method. No allowance is made for waste.

Drying time

Drying time of a 30 mils (0.76 mm) layer at 75°F (24°C) / 50% r.H.



The drying curve shown is based on lab tests results and is exemplary for the given conditions. Overall the drying time strongly depends on the ventilation, temperature and humidity on the jobsite as well as on the applied coat thickness.

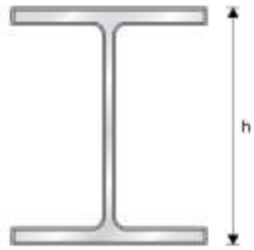
HILTI

Fire Protection Steel Spray CFP-S WB

Overview UL Listings*

UL-listing BXUV.Y611 — Wide Flange Steel Columns

Steel Size	W/D***	1 Hr		1-1/2 Hr		2 Hr		3 Hr		4 Hr	
		Minimum dry thickness		Minimum dry thickness		Minimum dry thickness		Minimum dry thickness		Minimum dry thickness	
		mils	mm	mils	mm	mils	mm	mils	mm	mils	mm
W8 x 10**	0.33	145	3.68	266	6.76	-	-	-	-	-	-
W12 x 14	0.36	133	3.38	263	6.68	-	-	-	-	-	-
W12 x 16	0.41	117	2.97	230	5.84	-	-	-	-	-	-
W6 x 12	0.44	109	2.77	215	5.46	338	8.59	-	-	-	-
W8 x 15	0.48	100	2.54	197	5.00	310	7.87	-	-	-	-
W10 x 22	0.52	92	2.34	182	4.62	286	7.26	-	-	-	-
W4 x 13	0.55	87	2.21	172	4.37	271	6.88	-	-	-	-
W6 X 16	0.58	83	2.11	163	4.14	257	6.53	504	12.80	-	-
W8 x 24	0.59	75	1.91	130	3.30	213	5.41	504	12.80	-	-
W14 x 34	0.63	75	1.91	130	3.30	213	5.41	489	12.42	-	-
W8 x 28	0.68	70	1.78	130	3.30	213	5.41	453	11.51	-	-
W8 x 35	0.74	65	1.65	128	3.25	201	5.11	416	10.57	-	-
W10 x 39	0.78	61	1.55	121	3.07	191	4.85	395	10.03	-	-
W10 x 49	0.84	57	1.45	113	2.87	177	4.50	367	9.32	-	-
W10 x 45	0.89	54	1.37	106	2.69	167	4.24	346	8.79	-	-
W16 x 57	0.95	50	1.27	99	2.51	157	3.99	324	8.23	-	-
W8 x 48	1.00	48	1.22	95	2.41	149	3.78	308	7.82	-	-
W14 x 90	1.07	45	1.14	88	2.24	139	3.53	288	7.32	-	-
W10 x 68	1.14	42	1.07	83	2.11	131	3.33	270	6.86	-	-
W18 x 97	1.21	40	1.02	78	1.98	123	3.12	255	6.48	-	-
W10 x 77	1.28	38	0.97	74	1.88	116	2.95	241	6.12	-	-
W16 x 100	1.36	36	0.91	69	1.75	109	2.77	227	5.77	-	-
W10 x 88	1.45	34	0.86	65	1.65	103	2.62	213	5.41	-	-
W14 x 132	1.54	32	0.81	61	1.55	97	2.46	200	5.08	-	-
W12 x 120	1.64	30	0.76	58	1.47	91	2.31	188	4.78	-	-
W14 x 159	1.77	28	0.71	56	1.42	85	2.16	187	4.75	-	-
W14 x 176	1.95	25	0.64	51	1.30	77	1.96	178	4.52	-	-
W14 x 193	2.12	23	0.58	47	1.19	71	1.80	164	4.17	-	-
W14 x 211	2.30	23	0.58	43	1.09	66	1.68	151	3.84	-	-
W14 x 233	2.52	23	0.58	40	1.02	60	1.52	138	3.51	-	-
W14 x 257	2.75	23	0.59	36	0.91	55	1.40	126	3.20	-	-
W14 x 283	3.00	23	0.58	33	0.84	50	1.27	116	2.95	194	4.93



* See UL listing for complete information

** e.g. W8 x 10; [W = shape, 8 = h (height) in inches, 10 = lb/ft]

*** W/D= Weight of steel member per linear foot (lbs)/Perimeter of the member exposed to fire (inches)

UL-listing BXUV.Y612 — Hollow Steel Sections

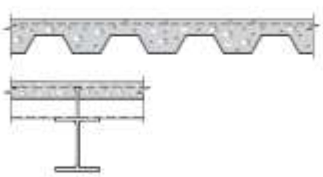
Steel size	Hp/A*	A/P**	1 Hr Minimum dry thickness mils	1 Hr mm	1-1/2 Hr Minimum dry thickness mils	1-1/2 Hr mm	2 Hr Minimum dry thickness mils	2 Hr mm	3 Hr Minimum dry thickness mils	3 Hr mm
SP 4.5 x 0.313	135	0.29	117	2.99	-	-	-	-	-	-
SP 8 x 0.875	49	0.79	97	2.46	97	2.46	120	3.05	-	-
SP 8.625 x 0.5	85	0.47	97	2.46	138	3.50	202	5.14	-	-
ST 3.5 x 3.5 x 3/16	224	0.18	165	4.18	-	-	-	-	-	-
ST 5 x 3 x 1/4	169	0.23	104	2.65	252	6.39	400	10.15	-	-
ST 5 x 3 x 5/16	135	0.29	84	2.13	218	5.54	353	8.96	-	-
ST 8 x 6 x 3/8	114	0.35	74	1.87	173	4.40	280	7.12	-	-
ST 8 x 6 x 7/16	100	0.41	74	1.87	151	3.84	244	6.21	-	-
ST 5 x 3 x 1/2	93	0.44	74	1.87	127	3.23	207	5.27	-	-
ST 8 x 8 x 1/2	85	0.47	74	1.87	95	2.41	164	4.17	327	8.31

* Hp/A = Heated Perimeter / Area
** A/P = Area / Perimeter
SP = Steel Pipe
ST = Steel Tube

UL-listing BXUV.N631 — Beams

Steel size	W/D	1 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained beam mils	mm	1-1/2 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained beam mils	mm	2 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained beam mils	mm	3 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained beam mils	mm
W6x12	0.52	73	1.83	73	1.83	99	2.50	73	1.83	171	4.34	101	2.56	-	-	-	-
W8x24	0.7	53	1.34	53	1.34	66	1.67	53	1.34	115	2.92	71	1.78	-	-	158	4.00

UL-listing BXUV.D975 — Concrete and Steel Floor Units



Beams size	W/D	1 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained Assembly mils	mm	1-1/2 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained Assembly mils	mm	2 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained Assembly mils	mm	3 Hr Minimum dry thickness: Unrestrained beam mils	mm	Restrained Assembly mils	mm
W6x12	0.52	73	1.83	-	-	123	3.10	-	-	-	-	73	1.83	-	-	123	3.10
W8x24	0.7	53	1.34	-	-	95	2.41	-	-	-	-	53	1.34	-	-	95	2.41
Steel Floor Units				**W/D**													
Fluted or Cellular				0.7		109	2.62	-	-	-	-	103	2.62	-	-	-	-
Cellular				0.7		179	4.55	-	-	341	8.67	179	4.55	-	-	341	8.66

Application Instructions

Prior to use of product follow instructions for use and recommended safety precautions

Required material

- Adequate airless spray pump with hose and spray gun. Pump must have minimum fluid pressure of 2,500 psi and Volume transport of > 0.8 gal/min.
- High pressure hoses, rated to match pump capacity, with minimum inner diameter of 3/8". Maximum hose length of 150 ft should not be exceeded
- Appropriate spray gun and tips. A contractor grade spray gun capable of handing 2,500 psi fluid pressure should be used. Recommended tip sizes are .223, .225, .323, .325, .327, .423, .425, .427, .523, .527 and .623
- Appropriate Steel members to be fire proofed (Note that steel members must have been primed minimum 24 hours prior to conducting this application walk through).
- Hilti Fire Protection Steel Spray. Check freeze tag on Hilti Spray.
- 1/2" cam action or impact drill
- Shielded mixer
- Empty bucket
- Wet film thickness gauge
- Dry film thickness gauge

Application conditions

- Confirm that ambient temperature meets required application range. Lower temperatures increase curing time and reduce spray ability. Higher temperatures cause fast drying time and overspray. Hilti Fire Protection Steel Spray should only be applied when the ambient air temperature is between 50°F (10°C) and 104°F (40°C). The minimum temperature must be maintained for a minimum of 24 hours after application. Contractors may provide enclosure and heat to maintain proper temperature levels.
- For optimum performance humidity levels should be below 75%. If the relative humidity exceeds 75%, precautions should be taken to avoid condensation from forming on the steel during application. Adequate ventilation must be provided and maintained during application and curing process to ensure proper drying.
- Confirm approved primer was used. A list of approved primers can be sourced with the Hilti Technical Services team.
- Measure and document the primer thickness utilizing the dry film thickness gauge. Utilizing the DFT gauge is simple, simply place it against the surface and read the measurement on the screen.
- Ensure no obstructions are in the way of the application area, guaranteeing a minimum of two feet clearance to allow proper spraying.
- Check steel members for intact, cured and proper primer. Clean from grease, dirt, dust and mill scale

Spray pump safety precautions

- Always wear proper safety gear
- When not in use, safety lock should be engaged at all times
- Never use the spray pump with the front safety housing removed
- When servicing the tip housing, always hold the spray gun with the fingers behind the trigger
- Never point spray gun towards others
- Never place spray gun against any body part.
- When not in use, always release pump pressure
- Make sure all filters have been removed from pump and all connections are tight on hose and spray gun

Set up instructions

- The instructions below will provide you a step by step guide to set up the Spray in the pump and start spraying.

1. Open Spray pail and remove the plastic liner.
2. Using the 1/2" drill motor and shielded mixer, mix the material thoroughly for 2 to 5 minutes until you achieve a uniform consistency.
3. Remove spray tip and safety housing and leave them inside a bucket of water to keep spray from drying on the tip.
4. Ensure pressure switch is turned down and pump is in the off position.
5. Place pump into pail of Hilti Spray.
6. Pointing the spray gun into a spare bucket, hold trigger down and slowly turn up the pump pressure about half to three quarters until only Hilti Spray starts flowing from the spray gun.
7. Turn the pressure down and stop the flow.
8. Move spray gun from the spare bucket to Hilti Steel Spray pail, circulating material at a lower pressure for approximately 30 seconds.
9. Install desire spray tip into safety housing and Install safety housing on spray gun.
10. Turn pump pressure all the way up or to the desired pressure setting and do a test spot on a scrap cardboard to check for proper fan and desired pressure.
11. Now you are ready to start spraying.

Application Instructions (continued)

Interruption of work and clean up procedure

- Hilti Fire Protection Steel Spray can remain in the hose for up to 1 hour.
- When interrupting work for longer than one hour and at the end of the day a thorough clean up procedure must be followed to prevent material from curing in the tip and spray gun. Make sure a pail of clean water is readily available.

1. Turn off power
2. Turn down pump pressure
3. Remove spray tip and spray housing
4. Place spray tip and housing inside pail of clean water
5. Replace Hilti Spray pail with a pail of clean water and slowly dispense all material contained in the hose into Hilti Spray pail. Once water starts flowing from spray gun, release trigger to avoid diluting the original Hilti Spray.
6. Turn down pump pressure
7. Place spray gun into pail of clean water and flush system for approximately 5 minutes to wash all fibers from spray gun and hose line.
8. Roll up pump hose
9. Leave spray gun, tip and housing into pail of water.
10. Place a plastic liner on top of the remaining Hilti Spray and replace pail lid to avoid product from curing in the pail.

Final measurements and top coat application

- Once all required coats have been applied and fully cured, a simple measurement of mill thickness can be done utilizing a dry film thickness gauge. In most projects this is mandatory and is often performed by third party inspection firms. The DFT reading should be taken as soon as the coating is sufficiently hard to avoid indenting the surface. Dry film thicknesses (DFT) may be measured using a permanent magnetic type banana gauge or an electronic electromagnetic type gauge. These measurements should be taken on a daily basis and a record kept until a constant DFT reading is achieved
- The DFT of Hilti Fire Protection Steel Spray can be calculated from the total DFT by subtracting the primer DFT
- Only after the Hilti Fire Protection Steel Spray is fully cured, according to specifications and site conditions, a Hilti approved topcoat can be applied. Typical curing time before a top coat is applied varies between three and five days. A top coat is not required on interior applications. If desired, the following tested and approved top coats may be applied for decorative purposes:
  - Glidden Evermore: Premium Exterior Latex Semi-Gloss GL68XX
  - Benjamin Moore Moorglo Soft Gloss Fortified Acrylic House Paint
  - Sherwin Williams: Sherwin Williams Steel Master 9500 30% Silicone Alkyd.

Material storage and shelf life

- Hilti Fire Protection Steel Spray must be stored in the original unopened pail. It must be protected from water and direct sunlight and maintained at a temperature between 41°F (5°C) and 104°F (40°C) during shipping and storage. The product must not be stored at freezing temperatures.
- When stored properly, Hilti Fire Protection Steel Spray has a shelf life of 12 months from the date of manufacture. See product label for expiration date.

Primer additional information

- All structural steel to be coated with Hilti Fire Protection Steel Spray must be primed with an approved primer. The primer must be applied in full compliance with the manufacturer's recommendations, and must be fully cured.
- Approved primers are generally of the phenolic resin modified alkyd type. Organic and inorganic zinc silicate primers are not suitable for use with Hilti Fire Protection Steel Spray. Please contact Hilti Technical service department for confirmation of primer compatibility.

Other specifications

- Maximum wet film thickness (WFT): per pass at 68°F and 50% relative humidity
  - Utilizing spray: 63 mil
  - Utilizing brush: 30 mil
- **Number of coats:** For airless spraying, several thinner coats of 20 mil as opposed to one heavy coat of 40 mil (1.0 mm) allow the sprayer greater control over thickness and finish, and reduce the drying time.
- **Drying time:** The drying time is dependent on the wet film thickness, temperature, air movement, and relative humidity. A coat of 16 mil (0.4 mm) WFT takes approx. 6 hours at 68°F (20°C) and 50% relative humidity to dry. It may be possible to apply two coats in one day if the air temperature is above 68°F (20°C), there is good air movement and the relative humidity is between 30% and 50%. Brush or roller application increases drying time by approximately 20%.

HILTI Fire Protection Steel Spray CFP-S WB

MSDS No.:	332
Revision No.:	001
Revision Date:	07/19/10
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Product name:	**CFP-S WB**
Description:	Fire Protection Spray for Steel
Supplier:	Hilti, Inc. P.O. Box 21148, Tulsa, OK 74121
Emergency # (Chem-Trec.):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)

INGREDIENTS AND EXPOSURE LIMITS

Ingredients:	CAS Number:	TLV: mg/m^3	PEL: mg/m^3	STEL: mg/m^3
Fused Silica	60676-86-0	NE	$\frac{30\ mg/m^3}{\%SiO_2 + 2}$	NE
Titanium dioxide	13463-67-7	10	15 (T)	NE
2-Butoxyethanol	111-76-2	97	240 (S)	NE

Abbreviations: PEL = OSHA Permissible Exposure Limit. **TLV** = ACGIH Threshold Limit Value. **STEL** = Short Term Exposure Limit. **NE** = None Established. **T** = Total dust. **R** = Respirable dust. **S** = Skin exposure.

PHYSICAL DATA

Appearance:	White sprayable paste	**Odor:**	Mild odor
Vapor Density: (air = 1)	<1	**Vapor Pressure:**	Not determined
Boiling Point:	210° F	**VOC Content:**	49 g/l
Evaporation Rate:	Not determined	**Solubility in Water:**	Soluble
Specific Gravity:	1.33	**pH:**	8-9

FIRE AND EXPLOSION HAZARD DATA

Flash Point:	Not applicable	**Flammable Limits:**	Not applicable
Extinguishing Media:	As appropriate for surrounding fire (e.g. Water, Carbon Dioxide, Dry Chemical, Foam)		
Special Fire Fighting Procedures:	Wear full protective clothing. A NIOSH-approved self-contained breathing apparatus (SCBA) should be worn when fighting fires involving chemicals.		
Unusual Fire and Explosion Hazards:	None known. Thermal decomposition products can be produced under fire conditions. See below.		

REACTIVITY DATA

Stability:	Stable.	**Hazardous Polymerization:**	Will not occur.
Incompatibility:	Strong oxidizing agents		
Decomposition Products:	Thermal decomposition can yield CO, CO_2, NO_x, ammonia, and oxides of phosphorous.		
Conditions to Avoid:	Avoid temperature extremes which could shorten the shelf-life of this product; i.e. below 40° and above 77° F. (See handling and storage requirements).		

HEALTH HAZARD DATA

Known Hazards:	**Acute:** May cause skin and eye irritation. **Chronic:** None known
Signs and Symptoms of Exposure:	**Eyes:** Can cause irritation or watering but injury is unlikely. **Skin:** Irritation is possible with some individuals. **Inhalation:** No effects expected. **Ingestion:** Effects of ingestion have not been determined.
Routes of Exposure:	Skin/eye contact.
Carcinogenicity:	No ingredients are classified as a carcinogen by IARC, NTP or OSHA.
Medical Conditions Aggravated by Exposure:	May promote asthmatic response in persons with asthma who are sensitive to airway irritants.

Fire Protection Steel Spray CFP-S WB

HILTI

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EMERGENCY AND FIRST AID PROCEDURES

Eyes:	Flush with plenty of water for at least 15 minutes. Contact a Physician if symptoms occur.
Skin:	Wash with soap and water. Remove contaminated clothing. Contact a Physician if symptoms occur
Inhalation:	Move victim to fresh air. Contact a Physician if symptoms occur.
Ingestion:	Do not induce vomiting unless directed by a Physician. Contact a Physician immediately.
Other:	Referral to a Physician is recommended if there is any question about the seriousness of the injury/ exposure.

CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT

Ventilation:	General (natural or mechanically induced fresh air movements).
Eye Protection:	While spraying, chemical goggles are recommended.
Skin Protection:	Impermeable gloves recommended. Use other protective clothing as required to prevent skin contact.
Respiratory Protection:	None normally required. Where ventilation is inadequate to control vapors, use a NIOSH approved respirator with organic vapor cartridge. If dusts are generated during demolition or removal, wear an appropriate dust mask or respirator.

PRECAUTIONS FOR SAFE HANDLING AND USE

Handling and Storing Precautions:	Store in a cool dry area. Keep from freezing. Store between 40° and 77° F. For industrial use only. Keep out of reach of children. Use with adequate ventilation. Keep container closed when not in use. Do not get into the eyes. Avoid prolonged or repeated contact with the skin. Practice good hygiene; i.e. wash after using and before eating or smoking.
Spill Procedures:	Wipe away spilled material before it hardens. Place in a container for proper disposal in accordance with all applicable local, state, or federal requirements.

REGULATORY INFORMATION

Hazard Communication:	This MSDS has been prepared in accordance with the federal OSHA Hazard Communication Standard. 29 CFR 1910.1200.
HMIS Codes:	Health 1, Flammability 0, Reactivity 0, PPE B (Glasses, Gloves)
DOT Shipping Name:	Not regulated.
IATA / ICAO Shipping Name:	Not regulated.
TSCA Inventory Status:	Chemical components listed on TSCA inventory.
SARA Title III, Section 313:	This product does not contain any toxic chemicals which are subject to reporting under Section 313 of SARA Title III (40 CFR Part 372).
EPA Waste Code(s):	Not regulated by EPA as a hazardous waste
Waste Disposal Methods:	Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, state, and federal safety, health and environmental regulations.

CONTACTS

Customer Service:	1 800 879 8000	**Technical Service:**	1 800 879 8000
Health / Safety:	1 800 879 6000 Jerry Metcalf (x1003704)		
Emergency # (Chem-Trec):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)		

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

August 6, 2010

To Whom It May Concern:

Re: Hilti CFP-S WB Steel Spray — LEED Info.

The Hilti CFP-S WB Steel Spray is manufactured in Germany.

The CFP-S WB Steel Spray pail is made of polyethylene and can be completely recycled. There is no post-consumer or post-industrial content in CFP-S WB Steel Spray and it cannot be recycled. The CFP-S WB Steel Spray does not contain any Rapidly Renewable Materials. The VOC content in CFP-S WB Steel Spray is 49 g/l.

CFP-S WB Steel Spray is not regulated as a hazardous waste by the Federal EPA Standards. The regulations for the disposal of non-regulated industrial waste can vary from state to state and even city to city. For this reason, you should consult your local and state regulatory agencies for direction on disposal.

Please feel free to contact me at (918) 872-3704 if you have questions.

Sincerely,

Jerry Metcalf MPH, CHMM
Safety/Environmental Manager
Hilti Inc
w (918) 872 3704
jerry.metcalf@hilti.com

Rev. Date: 8/6/10-1

Hilti, Inc. (US)
5400 South 122nd East Avenue
Tulsa, OK 74146

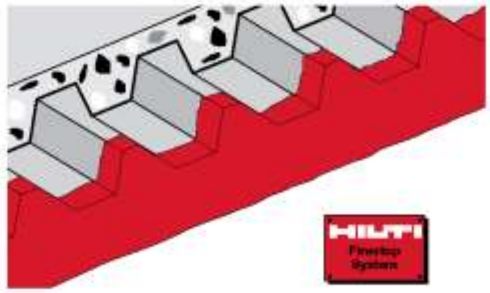
1-800-879-8000
www.us.hilti.com

A.2.9 CFS-SP WB Firestop Joint Spray

Product Information

CFS-SP WB Firestop Joint Spray

NEW



Product description

- A sprayable fire-rated mastic for construction joints where maximum movement is required

Product features

- Sprayable or apply by brush
- Maximum flexibility, meets 500 cycle requirements (Class II and III Approval) (ASTM E 1966 and UL 2079)
- Quick and easy installation with the Titan 600 or 1100 Sprayers can help save you time and money
- Contains no halogens, solvents or asbestos
- Water based formulation so spills and over-spray clean up quickly and easily
- Paintable
- Meets LEED™ requirements for indoor environmental quality credit 4.1 Low Emitting Materials, Sealants and Adhesives and 4.2 Paints and Coatings

Areas of application

- Top-of-wall joints
- Curtain wall/edge of slab
- Expansion joints

For use with

- Concrete, masonry and gypsum wall assemblies
- Wall and floor/wall assemblies rated up to 4 hours

Examples

- Where a gypsum wall assembly meets the underside of a metal or concrete deck
- Where a concrete floor assembly meets with non-rated exterior wall (concrete, glass, etc.)
- Where two concrete floor/wall assemblies meet

Technical Data*	CFS-SP WB
Density	Approx. 10.8 lb/gal (1.3 g/cm³)
Color	Available in red, white and gray**
Application temperature	39°F to 104°F (4°C to 40°C)
Temperature resistance	-40°F to 176°F (-40°C to 80°C)
Consistency	Sprayable liquid
Chemical basis	Acrylic-water-based-dispersion
Curing time	24 to 48 hours @ 73°F, 50% humidity for 1/8" depth
Ph-value	Approx. 8-9
Movement capability	Up to 50%
Surface burning characteristics (ASTM E 84-06)	Flame spread: 5 Smoke development: 10
Sound transmission classification (ASTM E 90-99)	In progress

Approvals

- California State Fire Marshal - In progress
- City of New York – MEA 99-96-M
  MEA 132-01-M

Tested in accordance with

- UL 2079 • ASTM E 1966 • ASTM E 84
- UL 1479 • ASTM E 814 • ASTM E 2307

*At 73°F (23°C) and 50% relative humidity
**Gray color requires six (6) weeks lead time

FILL, VOID OR CAVITY MATERIAL FOR USE IN THROUGH-PENETRATION FIRESTOP SYSTEMS, AND/OR JOINT SYSTEMS, AND/OR PERIMETER FIRE CONTAINMENT SYSTEMS SEE UL FIRE RESISTANCE DIRECTORY

FM APPROVED

Installation instructions for CFS-SP WB Firestop Joint Spray

Notice

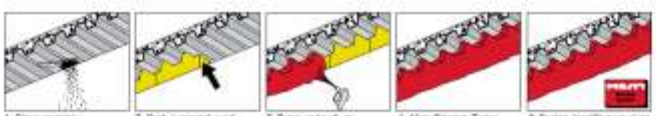
- Before handling, read Material Safety Data Sheet and product label for safe usage and health information.
- Instructions below are general guidelines — always refer to the applicable drawing in the UL Fire Resistance Directory or Hilti Firestop Systems Guide for complete installation information.

Opening

1. Clean the opening. Surfaces to which Firestop Joint Spray will be applied should be cleaned of loose debris, dirt, oil, wax and grease. The surface should be moisture and frost free.

Application of Firestop Joint Spray

2. Mineral wool packing: Install the prescribed back filling material type and depth to obtain desired rating.
3. Application of Firestop Joint Spray: Apply Firestop Joint Spray to the required depth in order to obtain the desired rating. Make sure Firestop Joint Spray contacts all surfaces and overlaps beyond all surrounding surfaces (Refer to UL System). Titan Sprayers have been successful in applying Firestop Joint Spray. Hilti recommends the use of the Titan 600 (for application temperatures above 50°F) or Firestop Joint Spray may also be brushed on with a paint brush. Contact Hilti Technical Support for more information.
4. Curing time: Allow 24 to 48 hours for typical application thickness (@ 73°F / 23°C) 50% humidity for 1/8" depth for the Firestop Joint Spray to fully cure.
5. Identification: For maintenance reasons all Firestop Joint Spray applications can be permanently marked with an identification plate and fastened in a visible position next to the seal.



1. Clean opening
2. Pack in mineral wool compressed per UL System
3. Spray or brush on Firestop Spray
4. Allow Firestop Spray to cure
5. Fasten identification plate (if required)

Not for use

- In areas immersed in water
- On hot surfaces (above 176°F)

Storage

- Store only in the original packaging at temperatures 39°F to 77°F (4°C to 25°C)
- Observe expiration date on package

Hilti. Outperform. Outlast.

Hilti, Inc. (U.S.) 1-800-879-8000 • **www.us.hilti.com** • en español 1-800-879-5000 • Hilti Firestop Systems Guide

MSDS No.:	331
Revision No.:	000
Revision Date:	04/27/10
Page:	1 of 2

MATERIAL SAFETY DATA SHEET

Product name:	**CFS-SP WB Firestop Joint Spray**
Description:	Fire rated mastic for construction joints
Supplier:	Hilti, Inc. P.O. Box 21148, Tulsa, OK 74121
Emergency # (Chem-Trec.):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)

INGREDIENTS AND EXPOSURE LIMITS

This is not a Hazardous Material as defined in the OSHA Hazard Communication Standard

PHYSICAL DATA

Appearance:	Red, grey, or white sprayable paste	Odor:	Mild odor
Vapor Density: (air = 1)	Not applicable	Vapor Pressure:	Not determined
Boiling Point:	Not determined	VOC Content:	Not determined
Evaporation Rate:	Not determined	Solubility in Water:	Soluble
Specific Gravity:	1.3	pH:	8.0 - 9.0

FIRE AND EXPLOSION HAZARD DATA

Flash Point:	None	Flammable Limits:	Not applicable
Extinguishing Media:	As appropriate for surrounding fire (e.g. Water, Carbon Dioxide, Dry Chemical, Foam)		
Special Fire Fighting Procedures:	A NIOSH-approved self-contained breathing apparatus (SCBA) should be worn when fighting fires involving chemicals		
Unusual Fire and Explosion Hazards:	None known. Thermal decomposition products such as carbon monoxide and carbon dioxide can be produced under fire conditions. See below		

REACTIVITY DATA

Stability:	Stable	Hazardous Polymerization:	Will not occur.
Incompatibility:	None known		
Decomposition Products:	Thermal decomposition can yield carbon monoxide and carbon dioxide.		
Conditions to Avoid:	Avoid temperature extremes which could shorten the shelf-life of this product; i.e. below 40° and above 77° F. (See handling and storage requirements).		

HEALTH HAZARD DATA

Known Hazards:	**Acute**: No effects expected; irritation is possible. **Chronic**: None known
Signs and Symptoms of Exposure:	**Eyes**: Can cause irritation or watering but injury is unlikely. **Skin**: Irritation is possible with some individuals. **Inhalation**: No effects expected. **Ingestion**: Effects of ingestion have not been determined. Considered to have a low acute oral toxicity.
Routes of Exposure:	Contact
Carcinogenicity:	No ingredients are classified as a carcinogen by IARC, NTP or OSHA
Medical Conditions Aggravated by Exposure:	None known

EMERGENCY AND FIRST AID PROCEDURES

Eyes:	Flush with plenty of water. Contact a Physician if symptoms occur.
Skin:	Wash with soap and water. Seek medical attention if any effects persist.
Inhalation:	Move victim to fresh air. Contact a Physician if symptoms occur.
Ingestion:	Do not induce vomiting unless directed by a Physician. Contact a Physician immediately.
Other:	Referral to a Physician is recommended if there is any question about the seriousness of the injury/exposure.

CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT	
Ventilation:	General (natural or mechanically induced fresh air movements).
Eye Protection:	While spraying, chemical goggles are recommended. As a minimum, wear safety glasses with side shields.
Skin Protection:	Impermeable (neoprene or rubber) gloves recommended. Use other protective clothing as required to prevent skin contact when spraying product.
Respiratory Protection:	None normally required.

PRECAUTIONS FOR SAFE HANDLING AND USE	
Handling and Storing Precautions:	Store in a cool dry area. Keep from freezing. Store between 40° and 77° F. For industrial use only. Keep out of reach of children. Use with adequate ventilation. Keep container closed when not in use. Do not get into the eyes. Avoid prolonged or repeated contact with the skin. Practice good hygiene; i.e. wash after using and before eating or smoking.
Spill Procedures:	Wipe away spilled material before it hardens. Place in a container for proper disposal in accordance with all applicable local, state, or federal requirements.

REGULATORY INFORMATION	
Hazard Communication:	This MSDS has been prepared in accordance with the federal OSHA Hazard Communication Standard. 29 CFR 1910.1200.
HMIS Codes:	Health 1, Flammability 0, Reactivity 0, PPE B (Glasses, Gloves)
DOT Shipping Name:	Not regulated.
IATA / ICAO Shipping Name:	Not regulated.
TSCA Inventory Status:	Chemical components listed on TSCA inventory.
SARA Title III, Section 313:	This product does not contain any chemicals which are subject to reporting under Section 313 of SARA Title III (40 CFR Part 372).
EPA Waste Code(s):	Not regulated by EPA as a hazardous waste
Waste Disposal Methods:	Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, state, and federal safety, health and environmental regulations.

CONTACTS			
Customer Service:	1 800 879 8000	**Technical Service:**	1 800 879 8000
Health / Safety:	1 800 879 8000 Jerry Metcalf (x1003704)		
Emergency # (Chem-Trec):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)		

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

Certificate of Compliance

Certificate Number **20100527-R13240**
Report Reference **2010 May 27**
Issue Date **2010 May 27**

Page **1 of 1**

Underwriters Laboratories Inc.®

Issued to: Hilti, Inc.

54 S 122ND East AVe
Tulsa, OK 74146 USA

This is to certify that representative samples of Fill, Void or Cavity Materials
CFS-SP WB

Have been investigated by Underwriters Laboratories Inc.® (UL) or any authorized licensee of UL in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: ANSI/UL 2079 "Tests for Fire Resistance of Building Joint Systems," Fourth Edition, revised June 30, 2008. ANSI/ASTM E2307-04, "Standard Test Method for Determining Fire Resistance of Perimeter Fire Barriers Using Intermediate-Scale, Multi-story Test Apparatus."
Standard CAN/ULC-S115-05, Standard Method of Fire Tests of Firestop Systems

Additional Information: CFS-SP WB Firestop Spray for use in Joint System, Perimeter Fire Containment System and Through-Penetration Firestop Systems Certified for Canada as currently described in the UL Fire Resistance Directory.

Only those products bearing the UL Classification Mark should be considered as being covered by UL's Classification and Follow-Up Service.

The UL Classification Mark includes: UL in a circle symbol: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

Look for the UL Classification Mark on the product

Issued by: Mona Couloute
Underwriters Laboratories Inc.

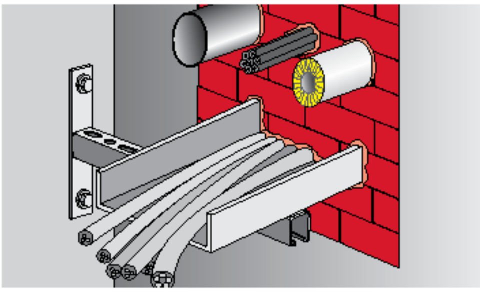
Reviewed by: Steven Hoffman
Underwriters Laboratories Inc.

Any information and documentation involving UL Mark services are provided on behalf of Underwriters Laboratories Inc. (UL) or any authorized licensee of UL.

A.2.10 CFS-BL Firestop Block

HILTI **Product Information**

Firestop Block CFS-BL



Product description

- Ready-to-use, intumescent flexible block designed to seal medium to large size openings

Product features

- Integrated "Grid-Tech" increases Annular Space up to 12"
- Suitable for re-penetration or new penetrations
- Economical to use with short installation times
- Easy installation — no special tools required
- Ideal for use in floors — no forming required
- One sided wall systems available
- Halogen, asbestos and solvent free
- Operational immediately after installation
- Smoke resistant

Areas of application

- Sealing single or multiple penetrations in small to large openings
- Temporary or permanent sealing of cables and cable tray penetrations
- Temporary or permanent sealing of insulated and non-insulated metallic pipes and combustible pipe penetrations

For use with

- Walls (UL tested up to max. opening 72" x 36")
- Floors (UL tested up to max. opening 72" x 36")
- Concrete, porous concrete, masonry and gypsum wall assemblies
- Wall assemblies rated up to 4 hours
- Floor assemblies rated up to 3 hours

Examples

- Completely dust and fiber free rooms and places where electrical installations are frequently used (ie: computer centers, hospitals, laboratories, etc.)
- New buildings in the construction phase and during renovation
- Large openings containing multiple penetrations as found in production bays, warehouses, hospitals etc.

Technical Data*	CFS-BL
Color	Red
Application temperature	40° F to 104° F (5° C to 40° C)
Temperature resistance	5° F to 140° F (-15° C to 60° C)
Intumescent activation	Approx. 392° F (200° C)
Expansion ratio (unrestricted)	Up to 1:3
Surface burning characteristics (ASTM E84-10b)	Flame Spread Index: 10 Smoke Development Index: 15
Sound transmission classification (ASTM E 90)	STC Rating: 52
Approvals ▪ California State Fire Marshal - In Progress	
Tested in accordance with ▪ UL 1479 ▪ ASTM E 814 ▪ ASTM E 84 ▪ CAN/ULC S115	

*At 73°F (23°C) and 50% relative humidity

FILL, VOID OR CAVITY MATERIAL FOR USE IN THROUGH-PENETRATION FIRESTOP SYSTEMS
SEE UL FIRE RESISTANCE DIRECTORY
66Y7

FM APPROVED

Installation instructions for Firestop Block CFS-BL

Notice

- Before handling, read Material Safety Data Sheet and product label for safe usage and health information.
- Instructions below are general guidelines — always refer to the applicable drawing in the UL Fire Resistance Directory or Hilti Firestop Systems Guide for complete installation information

Opening

1. Clean the opening. Penetration and penetration supporting structures must be installed in compliance with local building and electrical standards.

Application of Firestop Blocks

2a. If no penetrations are located, build up Firestop Block CFS-BL, firmly seated, within opening.

2b. If penetrations are located, build up Firestop Block CFS-BL, firmly seated, while cutting blocks with a knife to suit the placed penetrations.

3. Finish building up Firestop Blocks until entire opening is filled.

4. Completely fill cable spaces, gaps between blocks and pipes, and joints with FS-ONE Firestop Sealant (as required).

5. For maintenance reasons, a penetration seal could be permanently marked with an identification plate. In such a case, mark the identification plate and fasten it in a visible position next to the seal.

Re-installing cables or other penetrations

- Remove or cut the block from the seal.
- Install the penetrant and re-lay the block in compliance with the approval. Fill gaps and spaces with FS-ONE Firestop Sealant (as required).
  Single cables can be run through joints between blocks or a hole can be drilled through a block using a sharpened piece of metal pipe or tubing.

Not for use

- In wet rooms, outdoors or exposed to the weather or UV radiation (can be done only after applying an additional silicone coating, i.e. CP 601S).

Storage

- Store only in the original packaging in a location protected from moisture and direct sunlight

1. Clean opening. 2a. Build up blocks 2b. Cut blocks to size for penetrations in place 3. Build up blocks 4. Fill gaps with FS-ONE, CP617 or CP 618 putty (as required). 5. Fasten identification plate in place (if required)

Hilti Firestop
Saving lives through innovation and education

Hilti. Outperform. Outlast.

Hilti (Canada) Corp. 1-800-363-4458 ▪ www.hilti.ca ▪ Hilti Firestop Systems Guide

HILTI ®
Hilti (Canada) Corporation

MSDS No.:	336C
Revision No.:	000
Revision Date:	10/16/11
Page:	1 of 2

MATERIAL SAFETY DATA SHEET

Product identifier:	**CFS-BL Firestop block; CFS-PL Firestop Plug**
Product use:	Intumescent polyurethane foam block for fire stopping openings in walls and floors
Supplier:	Hilti (Canada) Corporation, 2360 Meadowpine Blvd., Mississauga, Ontario L5N 6S2
Originator	Hilti, Inc., P. O. Box 21148, Tulsa, Oklahoma, USA 74121
Emergency number:	**Chem-Trec: 1 800 424 9300**

HAZARDOUS INGREDIENTS

Not a hazardous chemical as defined by the Controlled Products Regulations SOR/88-66; classified as a manufactured "article".

PHYSICAL PROPERTIES

Appearance / Physical state:	Red (rust) colored foam block.	**Odor:**	None
Specific gravity (at 20°C):	0.24 – 0.30 gm/cm^3	**VOC content:**	CFS-BL = 5.4g/l CFS-PL = 4.9 g/l
Vapor pressure (at 20°C):	Not applicable.	**Vapor density:**	Not applicable.
Evaporation rate:	Not applicable.	**Boiling point:**	Not applicable.
Freezing point:	Not applicable.	**pH:**	Not applicable.
Coefficient of H_20 / oil distrib:	Not applicable.	**Solubility in water:**	Not Soluble

FIRE AND EXPLOSION DATA

Flash point / Method	Not applicable.	**Flammable limits:**	Not applicable.
Conditions of flammability:	Not flammable.	**Auto-ignition temperature:**	Not applicable.
Means of extinction:	Not applicable.		
Special fire fighting procedures:	Not applicable.		
Hazardous combustion products:	Refer to "Hazardous decomposition products" (next section).		
Sensitivity to mechanical impact / static discharge:	Not susceptible to mechanical impact or static discharge.		

REACTIVITY DATA

Stability:	Stable. Hazardous polymerization will not occur.
Incompatible materials:	None known. See special handling and storage instructions.
Conditions of reactivity:	None known.
Hazardous decomposition products:	If heated to decomposition, can yield COx, NOx, HCN, HCl and/or HF.

TOXICOLOGICAL PROPERTIES

Likely routes of exposure:	☒ None known ☐ Skin contact ☐ Skin absorption ☐ Eye contact ☐ Inhalation
Exposure limits:	None established.
Acute effects of exposure:	Not applicable.
Chronic effects of exposure:	None known.
Synergistic materials:	None known.

FIRST AID MEASURES	
Eyes:	No effects expected.
Skin:	No effects expected. Practice good hygiene; i.e., wash hands during breaks, before eating or smoking, and after work.
Inhalation:	Not a route of exposure.
Ingestion:	Not a likely route of exposure.
Other:	Referral to a physician is recommended if there is any question about the seriousness of the injury/exposure.

PREVENTIVE MEASURES	
Engineering controls:	General (natural or mechanically induced fresh air movements).
Eye protection:	As appropriate for the work area or the work being done.
Skin protection:	Cloth gloves are suitable.
Respiratory protection:	None normally required. Never enter a confined space without an appropriate air supplied respirator.
Other:	Depending on exposure and on workplace standards.
Handling procedures and equipment:	For industrial use only. Keep out of reach of children. Observe good hygiene practices; i.e., wash after using and before eating or smoking.
Storage requirements:	Store in a cool dry area out of direct sunlight. Storage above 60 C may degrade product.
Spill, leak or release:	No special requirements.
Waste disposal:	Consult federal, provincial and local regulations for allowed means of disposal.
Special shipping instructions:	None known.

REGULATORY INFORMATION	
WHMIS classification:	None / exempt (manufactured article).
HMIS codes:	Health 0, Flammability 0, Reactivity 0, PPE A
IATA/ICAO Shipping Name:	Not regulated.
TDG shipping name:	Not regulated.

PREPARATION INFORMATION / CONTACTS				
Prepared by:	Hilti, Inc., Tulsa, OK USA	Date of Preparation: October 16,2011	**Emergency phone number:**	1 800 424 9300
Customer Service:	Hilti (Canada) Corporation, Mississauga, Ontario; 1 800 363 4458			
Health / Safety contacts:	Hilti, Inc., Tulsa, OK USA; 1 800 879 6000, Jerry Metcalf (x1003704)			
Abbreviations used:	**N/E** = None Established. **N/A** = Not Applicable. **N/Av** = Not Available. **H** = Hours. **HMIS:** Hazardous Materials Identification System			

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

Certificate of Compliance

Certificate Number 20111214-R13240
Report Reference File R13240
Issue Date 2011 December 14

Page 1 of 1

Underwriters Laboratories

Issued to: Hilti Construction Chemicals, Div of Hilti Inc.
5400 S 122nd East Ave
Tulsa, OK 74146

This is to certify that representative samples of Fill, Void or Cavity Materials

CFS-BL Firestop Block

Have been investigated by Underwriters Laboratories in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: ANSI/UL 1479, "Fire Tests of Through-Penetration Firestops,"
CAN/ULC-S115, "Standard Method of Fire Tests of Firestop Systems."
Third Edition revised March 1, 2010

Additional Information: See UL On-line Certification Directory at WWW.UL.COM for additional information.

CFS-BL Firestop Block for use in Through-Penetration Firestop Systems as currently described in the UL Fire Resistance Directory.

Only those products bearing the UL Classification Mark should be considered as being covered by UL's Classification and Follow-Up Service.

The UL Classification Mark includes: UL in a circle symbol: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL; a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

Look for the UL Classification Mark on the product

William R. Carney
Director, North American Certification Programs

Underwriters Laboratories Inc.
Any information and documentation involving UL Mark services are provided on behalf of Underwriters Laboratories Inc. (UL) or any authorized licensee of UL.

For questions, please contact a local UL Customer Service Representative at http://www.ul.com/global/eng/pages/corporate/contactus

A.2.11 CFS-DID Firestop Drop-In Device

Drop-In Device and Adapter

Firestop Drop-In Device CFS-DID

Features and Applications

- One-step firestop solution for a variety of pipe materials and diameters
- Integrated moisture and smoke seal
- Simple, quick and error free installation
- Easily identifiable to building inspectors
- Solution for renovation/retrofit as well as new construction
- Buy American compliant

FIRESTOP DEVICE
FOR USE IN THROUGH-PENETRATION FIRESTOP SYSTEMS
SEE UL FIRE RESISTANCE DIRECTORY SNTS

FM APPROVED

Technical Data	CFS-DID
Expansion temperature	- 356°F (- 180°C)
Expansion rate	1:15 load expansion, load = $5g/cm^2$ 1:40 free expansion
Temperature resistance	-4° up to + 190°F (20° up to +88°C)
Storage temperature	23° up to 122°F (-5° up to +50°C)

Description	For use with	Core bit size	Qty	Pipe size	Item No.
Drop-In Device CFS-DID 2" C	6" to 12" thick concrete / metal deck	4"	1	up to 2" *	02008097
Drop-In Device CFS-DID 3" C		5"	1	3"	02008098
Drop-In Device CFS-DID 4" C		6"	1	4"	02008099
Drop-In Device CFS-DID 6" C		9"	1	6"	02008250
Drop-In Device CFS-DID 2" MD	2-1/2" to 8" thick concrete / metal deck	4"	1	up to 2" *	02008251
Drop-In Device CFS-DID 3" MD		5"	1	3"	02008252
Drop-In Device CFS-DID 4" MD		6"	1	4"	02008253
Drop-In Device CFS-DID 6" MD		9"	1	6"	02015574
Drop-In Device CFS-DID 2" HC8	7-1/2" to 8-1/2" thick hollow core	4"	1	up to 2" *	02008254
Drop-In Device CFS-DID 3" HC8		5"	1	3"	02008255
Drop-In Device CFS-DID 4" HC8		6"	1	4"	02008256
Drop-In Device CFS-DID 2" HC10	9-1/2" to 10-1/2" thick hollow core	4"	1	up to 2"*	02008257
Drop-In Device CFS-DID 3" HC10		5"	1	3"	02008258
Drop-In Device CFS-DID 4" HC10		6"	1	4"	02008259
Drop-In Device CFS-DID 2" HC12	11-1/2" to 12-1/2" thick hollow core	4"	1	up to 2" *	02008260
Drop-In Device CFS-DID 3" HC12		5"	1	3"	02008261
Drop-In Device CFS-DID 4" HC12		6"	1	4"	02008262
Adapter CFS-DID 2" • Adapter to hold top seal plug in place • Adds 1" to the overall height	All Drop-In Device sizes 2"		6		02008266

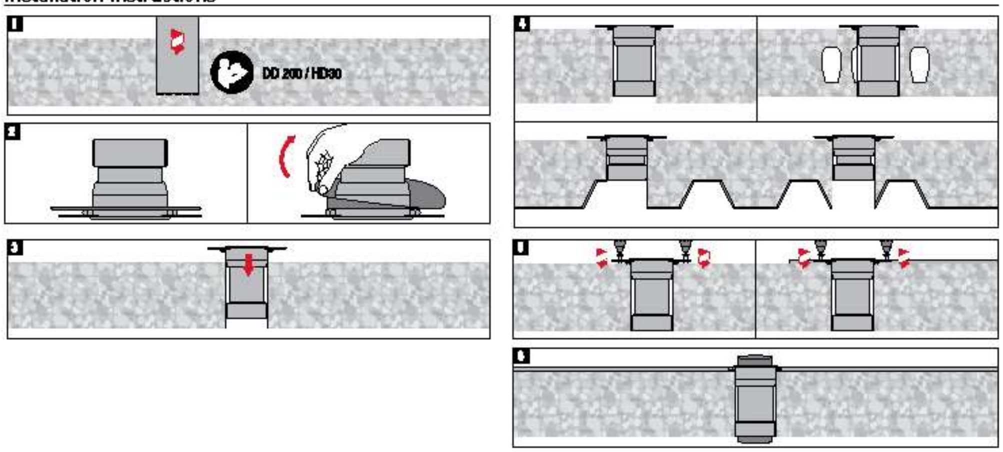
*For pipes smaller than 2", use adapter and top seal plug
Tested in accordance with ASTM E-814 • UL 1479 • CAN/ULC-S115

CFS-DID from above (no cap)

CFS-DID from above (with cap)

CFS-DID from below

Installation Instructions



Hilti. Outperform. Outlast.

Hilti, Inc. (U.S.) 1-800-879-8000 www.us.hilti.com • en español 1-800-879-5000 • Hilti (Canada) Corp. 1-800-363-4458 www.hilti.ca

HILTI®

MSDS No.:	335
Revision No.:	000
Revision Date:	04/25/11
Page:	1 of 2

MATERIAL SAFETY DATA SHEET

Product name:	CFS-DID
Description:	Metal Firestop Drop in Device containing a black intumescent material.
Supplier:	Hilti, Inc. P.O. Box 21148, Tulsa, OK 74121
Emergency # (Chem-Trec.):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)

INGREDIENTS AND EXPOSURE LIMITS

Not applicable. This product is considered to be an "article" as defined in the federal OSHA Hazard Communication Standard 29 CFR 1910.1200 / 1926.59.

PHYSICAL DATA

Appearance:	Galvanized metal sleeve with red plastic top cap	Odor:	None.
Vapor Density: (air = 1)	Not applicable.	Vapor Pressure:	Not applicable.
Boiling Point:	Not applicable.	VOC Content:	0.19 g/l
Evaporation Rate:	Not applicable.	Solubility in Water:	Not determined.
Specific Gravity:	Not determined.	pH:	Not applicable.

FIRE AND EXPLOSION HAZARD DATA

Flash Point:	Not applicable.	Flammable Limits:	Not applicable.
Extinguishing Media:	Use extinguishing media appropriate for surrounding fire.		
Special Fire Fighting Procedures:	None known.		
Unusual Fire and Explosion Hazards:	None known. Product serves as a firestop; intumescent material sleeve expands when exposed to temperatures > 160° C / 320° F.		

REACTIVITY DATA

Stability:	Stable.	Hazardous Polymerization:	Will not occur.
Incompatibility:	None known.	Decomposition Products:	None known.
Conditions to Avoid:	None known.		

HEALTH HAZARD DATA

Known Hazards:	None known.	Routes of Exposure:	None known.
Signs and Symptoms of Exposure:	None expected from routine use/installation according to manufacturer's specifications and technical guides.		
Carcinogenicity:	The enclosed intumescent strip contains carbon black which has been classified by the IARC as 2B – "Possibly Carcinogenic to Humans". This data is based on long term inhalation studies. As this product is used, no carbon black dust is present or produced, so this classification is not relevant.		
Medical Conditions Aggravated by Exposure:	None known.		

EMERGENCY AND FIRST AID PROCEDURES

Eyes:	Immediately flush with plenty of water. Call a physician if symptoms occur.
Skin:	Not applicable. Practice good hygiene; i.e. wash hands during breaks, before eating or smoking, and after work.
Inhalation:	Not applicable.
Ingestion:	Not a potential route of exposure.
Other:	Referral to a physician is recommended if there is any question about the seriousness of any injury/exposure.

CONTROL MEASURES AND PERSONAL PROTECTIVE EQUIPMENT	
Ventilation:	General (natural or mechanically induced fresh air movements).
Eye Protection:	Not required, however, safety glasses should be worn in most industrial settings.
Skin Protection:	None required; however, gloves recommended.
Respiratory Protection:	No respiratory protection is needed for normal application of this product.

PRECAUTIONS FOR SAFE HANDLING AND USE	
Handling and Storing Precautions:	Store in a cool dry area. Follow installation instructions.
Spill Procedures:	No special requirements.

REGULATORY INFORMATION	
Hazard Communication:	This product is considered to be an "article" as defined in the federal OSHA Hazard Communication Standard.
DOT Shipping Name:	Not regulated.
IATA / ICAO Shipping Name:	Not regulated.
TSCA Inventory Status:	Chemical components listed on TSCA inventory.
SARA Title III, Section 313:	This product is classified as an "article" and is not subject to reporting under Section 313 of SARA Title III (40 CFR Part 372).
EPA Waste Code(s):	Not regulated by EPA as a hazardous waste.
Waste Disposal Methods:	Consult with regulatory agencies or your corporate personnel for disposal methods that comply with local, state, and federal safety, health and environmental regulations.

CONTACTS			
Customer Service:	1 800 879 8000	**Technical Service:**	1 800 879 8000
Health / Safety:	1 800 879 6000 Jerry Metcalf (x1003704)		
Emergency # (Chem-Trec):	1 800 424 9300 (USA, PR, Virgin Islands, Canada); 001 703 527 3887 (other countries)		

The information and recommendations contained herein are based upon data believed to be correct; however, no guarantee or warranty of any kind expressed or implied is made with respect to the information provided.

Certificate of Compliance

Certificate Number **20110422-R15431**
Report Reference **2011 April 22**
Issue Date **2011 April 22**

Page **1** of **1**

Underwriters Laboratories

Issued to: Hilti Inc.

5400 S 122ND East Ave
Tulsa, OK 74146

This is to certify that representative samples of

Firestop Devices

CFS-DID for use in Through-Penetration Firestop Systems as currently described in the UL Fire Resistance Directory.

Have been investigated by Underwriters Laboratories Inc.® (UL) or any authorized licensee of UL in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: ANSI/UL 1479, "Fire Tests of Through-Penetration Firestops." CAN/ULC-S115-2005, "Standard Method of Fire Tests of Firestop Systems."

Additional Information: See UL On-Line Certification Directory at www.UL.com for additional information.

Only those products bearing the UL Classification Mark should be considered as being covered by UL's Classification and Follow-Up Service.

The UL Classification Mark includes: UL in a circle symbol: with the word "CLASSIFIED" (as shown); a control number (may be alphanumeric) assigned by UL, a statement to indicate the extent of UL's evaluation of the product; and, the product category name (product identity) as indicated in the appropriate UL Directory.

Look for the UL Classification Mark on the product

William R. Carney
Director, North American Certification Programs
Underwriters Laboratories Inc.

A.3 FIRE DOOR SPECIFICATIONS

LAWRENCE DOORS

Model SL Fire Doors
STANDARD SPECIFICATIONS

UL File No. R2820
CSFM Listing No. 3515-1587:100

PART 1 GENERAL

1.01 SUMMARY

A. Model SL Fire Doors shall be manufactured by Lawrence Roll-Up Doors, Inc.

1.02 SYSTEM DESCRIPTION

A. Doors shall be designed for 10,000 cycles usage.
B. Doors shall be for use on openings up to 14'-0" wide and 14'-0" high.
C. Doors shall be fire rated up to 3 hours for installation on walls of masonry or non-masonry construction.

1.03 QUALITY ASSURANCE

A. Doors shall be Underwriters Laboratories classified (UL), Underwriters Laboratories certified for Canada (c-UL), and listed by the California State Fire Marshal (CSFM). Doors to 12'-0" wide, 12'-0" high, 120 sq. ft. shall be provided with a UL/c-UL label. Larger doors shall be provided with a UL/c-UL oversize door label.

1.04 WARRANTY

A. Doors shall be warranted against defects in workmanship and materials for one year from date of shipment, provided designed cycle life is not exceeded. Factory finishes are excluded from warranty.

PART 2 PRODUCTS

2.01 MATERIALS

A. **Curtain** shall be assembled from interlocking Type C (3 1/4" x 9/16") curved slats, roll-formed from 22 gauge galvanized steel strip. Endlocks shall be riveted to ends of alternate slats.
B. **Bottom bar** shall be formed by two 1 1/2" x 1 1/2" x 1/8" minimum steel angles bolted together and attached to bottom of curtain. Provision shall be made for thermal expansion at assembly bolts.
C. **Guides** shall be 12 gauge minimum formed steel channels, sized to retain curtain, bolted to 3/16" minimum structural steel wall angles, sized to support door. Guides shall be assembled and attached to wall with 3/8" minimum bolts no more than 24" on center. Provision shall be made for thermal expansion at assembly and wall bolts. Removable curtain stops shall be provided.
D. **Barrel** shall be 4 1/2" minimum diameter steel pipe, sized to contain counterbalance assembly and support curtain with a maximum deflection of 0.03" per ft. of width. Counterbalance assembly shall consist of torsion spring(s) and fittings mounted to a continuous cold finished steel shaft. Grease packed sealed bearings shall be used to support each end of counterbalance assembly. Spring tension shall be adjustable by adjusting wheel outside bracket.
E. **Brackets** shall be 1/8" minimum steel plates bolted to wall angles. Plates shall be sized to support curtain and barrel and provided with 1/8" flanges for hood attachment. Bracket on operator side shall be fitted with a grease packed sealed bearing.
F. **Hood** shall be formed from 24 gauge galvanized steel sheet with top and bottom reinforcements to reduce deflection. Intermediate support shall be provided on doors over 13'-6" wide.
G. **Operation** of doors shall be as follows:
PUSH-UP operated on doors to 10'-0" wide, 8'-0" high with 22 gauge slats.
"*EASY-RESET*" CHAIN operated (on larger doors) with hand chain to open door and pull cable to close door [option on doors with push-up operation].
"*EASY-RESET*" CRANK operated (on doors to 14'-0" wide, 10'-0" high) with removable handle to open door and pull cable to close door [option on all doors].
"*EASY-RESET*" MOTOR operated with UL Listed inline gear drive assembly, mounted horizontally in front of and parallel to door coil, and not requiring additional clearance above top of coil [option on all doors].
NOTE: For ease of drop-test and reset, "Easy-Reset" chain, crank or motor operator is recommended on all doors.
H. **Automatic closing** of doors shall be thermally activated by 165 deg. F. fusible links. A governor shall be provided to control the rate of descent. Average closing speed shall be approximately 9" to 12" per second, but no less than 6" nor more than 24" per second per the requirements of NFPA-80. All doors shall be easily reset with a single-side release. "*Easy-Reset*" chain, crank and motor operators shall include an internal release and governor, designed for automatic closing without a loss of spring tension, and reset by reconnecting fusible link cable and reopening door.
I. **Locking** shall be by slide locks on bottom bar of push-up, chain hoist and awning crank operated doors.
NOTE: Motor operators provide self-locking gear reduction - if slide locks are required on motor operated doors, guide mounted electrical interlocks are required to prevent opening door with locks engaged.

2.02 FINISHES

A. Galvanized steel slats and hood shall have a baked-on primer and polyester top coat (tan color opposite coil side with off-white color coil side (colors may be reversed), or grey color both sides). Steel bottom bar, guides and brackets shall be shop painted with a black color rust-inhibiting primer.

PART 3 EXECUTION

3.01 INSTALLATION

A. Doors shall be installed in accordance with Lawrence Roll-Up Doors, Inc. installation instructions and NFPA-80.

3.02 FIELD QUALITY CONTROL

A. Doors shall be tested for proper operation and full closure at time of installation. A written record shall be maintained.

3.03 SCHEDULES

A. Doors shall be maintained, inspected and tested in accordance with NFPA-80.

Brackets [ ] denote an available option.
Lawrence Roll-Up Doors, Inc. reserves the right to change specifications without notice or obligation.

SL-12/11

LAWRENCE DOORS

Model SL Fire Doors
AVAILABLE OPTIONS

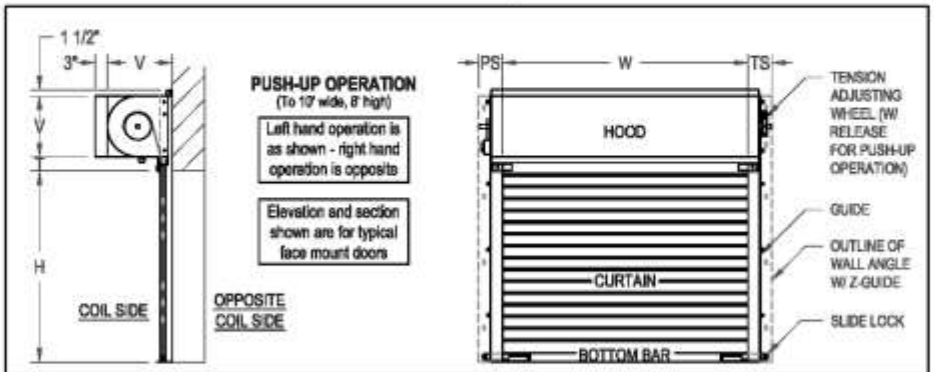
Classification	FM Approved (includes flame baffle inside hood) UL or FM S-label for air leakage rated smoke doors (includes UL listed brush guide and header seals and field installed UL recognized heat resistant caulking)
Rating	4-hour fire rating
Windload	Designs to withstand specified windloads for doors on exterior openings
Mounting	Between-jamb mounting (includes filler angles) Under lintel mounting (includes fascia) Tube mounting system (face of wall, between-jamb, or guides and brackets directly attached, to independent support tubes either in front of, or concealed inside of, rated wall construction – *tubes must be provided by Lawrence Doors – consult factory for details*)
Curtain	Heavier than standard gauge Type C slats (20 gauge maximum) Type F (2" x 9/16") flat slats (22 or 20 gauge) Vision lites of single or multiple (16 maximum) 4" x 1" cut-outs spaced at least 2 1/2" apart, covered with UL classified glazing material (available with Type F slats)
Bottom Bar	Vinyl bottom seal to reduce smoke and air infiltration Sensing edge to reverse closing of a motor operated door upon contact with an obstruction Sloping bottom bar for non-level sills (1/2" per foot of width maximum slope)
Guides	UL Listed brush seals to reduce smoke and air infiltration (Type F slats recommended)
Hood & Covers	Heavier than standard gauge hood (20 gauge maximum) UL Listed brush header seal, field installed, to reduce smoke and air infiltration between wall and curtain Flame baffle inside hood, activated by fusible link, to close area between hood and curtain when door is closed Fascia to close area behind brackets when no wall or fire barrier is present End caps to enclose operating or tension brackets (recommended when bottom of coil is less than 8 feet above the floor and required to protect mechanisms on doors mounted to the exterior of a building) Motor cover (recommended on motor operators less than 8 feet above the floor or on the exterior of a building)
Operation	Keyed handle release to close and test chain or crank operated doors and prevent unauthorized use (requires field installed conduit from enclosure to operator mounting bracket to conceal pull cable) "*Easy-Reset PLUS*" chain, crank and motor operators, designed for detector/alarm activated and failsafe closing upon a loss of power through the operator's internal release and governor – to reset, clear alarm/restore power, reconnect fusible link cable, and open door "*Auto-Reset*" chain, crank or motor operators, designed for detector/alarm activated and failsafe closing upon a loss of power through the operator's internal release and governor – to reset, clear alarm/restore power and open door "*Auto-Reset PLUS*" motor operator, designed for detector/alarm activated motor controlled closing if power is present, or failsafe closing upon a loss of power through the operator's internal release and governor – will stop upon sensing an obstruction while closing and continue closed when the obstruction is removed if power is present and sensing edge is functioning, or will close through the internal release and governor – to reset, clear alarm/restore power and activate open control (requires door be provided with a monitored sensing edge) *NOTE: "Easy-Reset PLUS", "Auto-Reset" and "Auto-Reset PLUS" operators require connection to a 24vac/vdc detector/alarm; "Easy-Reset PLUS" and "Auto-Reset" chain and crank operators require connection to a 115vac power source*
Finishes	Galvanized steel bottom bar, guides and brackets Powder coated slats, bottom bar, guides and hood
Closing Systems	Failsafe time delayed release for detector/alarm activated and failsafe closing upon a loss of power through release of the fusible link cable (not required with "*Easy-Reset PLUS*" chain and crank operators, "*Auto-Reset*" or "*Auto-Reset PLUS*" operators) Audible, visible and voice warnings prior to automatic closing Photo-electronic smoke, ionization and heat detectors

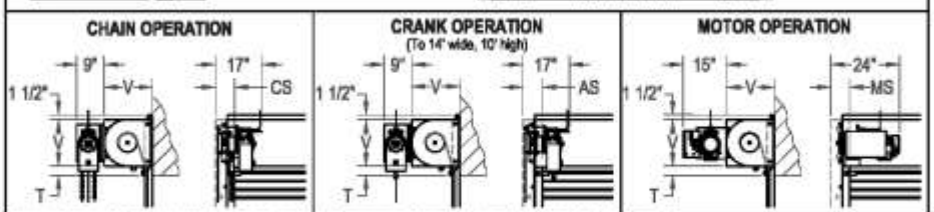
All options may not be available on all doors. Other options may also be available.
Lawrence Roll-Up Doors, Inc. reserves the right to change specifications without notice or obligation.

SLO-12/11

LAWRENCE DOORS

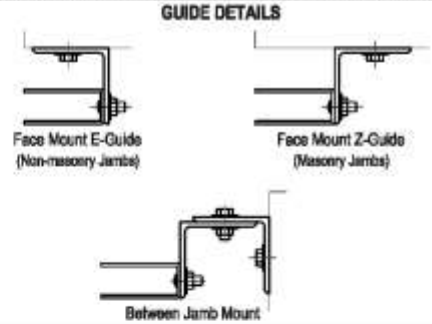
Model SL
Fire Doors



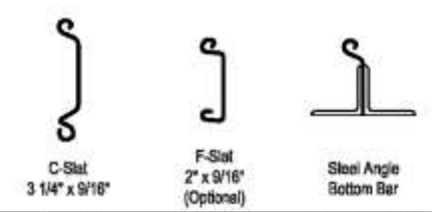


*ADD 2" FOR "EASY-RESET PLUS" AND "AUTO-RESET" CHAIN AND CRANK OPERATORS ON DOORS TO 10' HIGH

GUIDE DETAILS



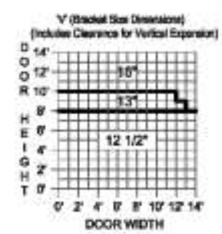
CURTAIN & BOTTOM BAR DETAILS



CLEARANCES

Door Width "W"	TS	PS	CS	AS	MS
To 8' #	6"	6"	6"	6"	6"
Over 8' to 12'	6 1/2"	6 1/2"	6 1/2"	6 1/2"	6 1/2"
Over 12' to 14'	7 1/2"	N/A	7 1/2"	7 1/2"	7 1/2"

For Between Jamb Mount, add 1/4" to dimensions.
#Use next category for 4-hour rated doors.



V	T
12 1/2"	3"
13"	3"
16"	3 1/2"

GENERAL NOTES:
Clearances are based upon standard door construction. Some options may require additional clearance. Shop drawings for specific applications are available. Consult factory for any information not shown.

 Lawrence Roll-Up Doors, Inc. reserves the right to change specifications without notice or obligation. SL-12/11

Toll Free (866) 939-3399 www.lawrencedoors.com Fax (626) 869-0841

A.4 FIRE DAMPER SPECIFICATIONS

RUSKIN®

3900 Dr. Greaves Rd. • Kansas City, MO 64030 • (816) 761-7476 • FAX (816) 765-8955

FSD60, FSD60LP COMBINATION FIRE AND SMOKE DAMPER

1½ HOUR UL555 RATED, UL555S LEAKAGE CLASS 1

APPLICATION

Ruskin FSD60 Series ultra low leakage combination fire and smoke dampers provide point-of-origin fire and smoke containment. The FSD60 includes high strength one-piece airfoil blades to ensure the lowest resistance to airflow and is rated up to 4000 fpm (20.3 m/s) and 8 in. wg (2 kPa).

Ruskin FSD60LP ultra low leakage, low profile, and low pressure drop combination fire and smoke damper is provided with an integral sleeve/frame design. All FSD60 Series dampers may be installed vertically in walls or horizontally in masonry floors and are rated for airflow and leakage in either direction.

STANDARD CONSTRUCTION		
Description	**FSD60**	**FSD60LP**
Frame	5" x 16 gage (127 x 1.6) galvanized, single piece, hat-shaped channel, structurally superior to 13 (2.3) gage channel frame.	Integral sleeve and frame 20 (1.0) gage galvanized single piece.
Blades	One-piece airfoil, 6" (152) wide and 16 (1.6) gage galvanized steel equivalent thickness. Blades are approximately 6" (152) on center.	One-piece low profile aerodynamic shape, 20 gage (1.0) galvanized.
Bearings	Stainless steel sleeve type, pressed into frame.	Stainless steel sleeve type, pressed into frame.
Jamb Seal	Stainless steel, flexible metal compression type.	Stainless steel, flexible metal compression type.
Blade Seal	Silicone edge type for smoke seal to 450°F (232°C) and galvanized steel for flame seal to 1900°F (1038°C) mechanically fastened to the blade edge.	Stainless steel, flexible metal compression type.
Linkage	Concealed in frame.	N/A

DAMPER SIZES

Sizes indicated below are for ratings of 2000 FPM (10.2 m/s) and 4 in. w.g. (1 kPa)

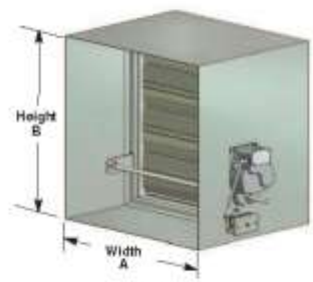
MINIMUM SIZE
- **FSD60LP** - 6"w x 6"h (152 x 152)
- **FSD60** - 8"w x 6"h (203 x 152)

MAXIMUM SIZE
- **FSD60LP**
  - **Single Section Vertical or Horizontal** – 36"w x 14"h (914 x 356)
- **FSD60**
  - **Single Section Vertical** – 32"w x 48"h (813 x 1219)
  - **Single Section Horizontal** – 30"w x 48"h (762 x 1219)
- **FSD60**
  - **Multiple Section Vertical**
    - 120"w x 96"h (3048 x 2438)
  - **Multiple Section Horizontal**
    - **Electric Actuator** – 120"w x 96"h (3048 x 2438)
    - **Pneumatic Actuators** – 144"w x 96"h (3658 x 2438)

CONTROLLED CLOSURE DEVICE (HEAT-ACTUATED)
- **EFL** (Electric Fuse Link) - 165°F (74°C) standard. 212°F (100°C), 250°F (121°C), 350°F (177°C) available.
- **PFL** (Pneumatic Fuse Link) - 165°F (74°C) standard. 212°F (100°C), 285°F (141°C) available.

NOTES

1. Dampers are furnished approximately 1/4" (6) smaller than given opening dimensions.
2. Dimensions shown in parentheses ( ) indicate millimeters.



FSD60

MAXIMUM OPERATIONAL RATINGS		
Description	**FSD60**	**FSD60LP**
UL555S Leakage Rating	Class I	Class I
UL555 Hourly Rating	1½ Hour	1½ Hour
Maximum Velocity	4000 FPM (20.3 m/s)	2000 FPM (10.2 m/s)
Maximum Pressure	8 in. wg (2 kPa)	4 in. wg (1 kPa)
Temperature	350°F (177°C)	350°F (177°C)

OPTIONS

- **FM Approvals** as Specification Tested Product.
- **DTS** (Damper Test Switch) test switch for cycle testing.
- **TS150 FireStat** for reopenable operation in dynamic smoke management systems.
- **DSDF/DSDN Duct Smoke Detector** (Flow rated or No-Flow).
- **SP100 Switch Package** to allow remote indication of damper blade position.
- **MCP** control panels for test purposes or smoke management systems.
- **Factory Sleeves** of various lengths and gages to ensure field compliance with UL installation requirements.
- **FAST Angle** factory supplied for labor saving angle one-side installation. Other angles of various sizes and gages also available for one-side or two-side installation.

UL CLASSIFIED
UL555 Listing R5531

Model FSD60 series meets the requirements for smoke dampers established by:
- **National Fire Protection Association** NFPA Standards 80, 90A, 92A, 92B and 101
- **ICC International Building Codes**
- **CSFM California State Fire Marshal** Listing (#3235-0245:0126)
- **New York City** (BSA Listing #176-82-SM)

Spec FSD60-211/Replaces FSD60-909 **ALL STATED SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE OR OBLIGATION.**

FSD60 AMCA LICENSED AIR PERFORMANCE DATA

amca CERTIFIED RATINGS AIR performance AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC.

Ruskin Company certifies that the FSD60 shown hereon is licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 511 and comply with the requirements of the AMCA Certified Ratings Program. The AMCA Certified Ratings Seal applies to air performance for the FSD60.

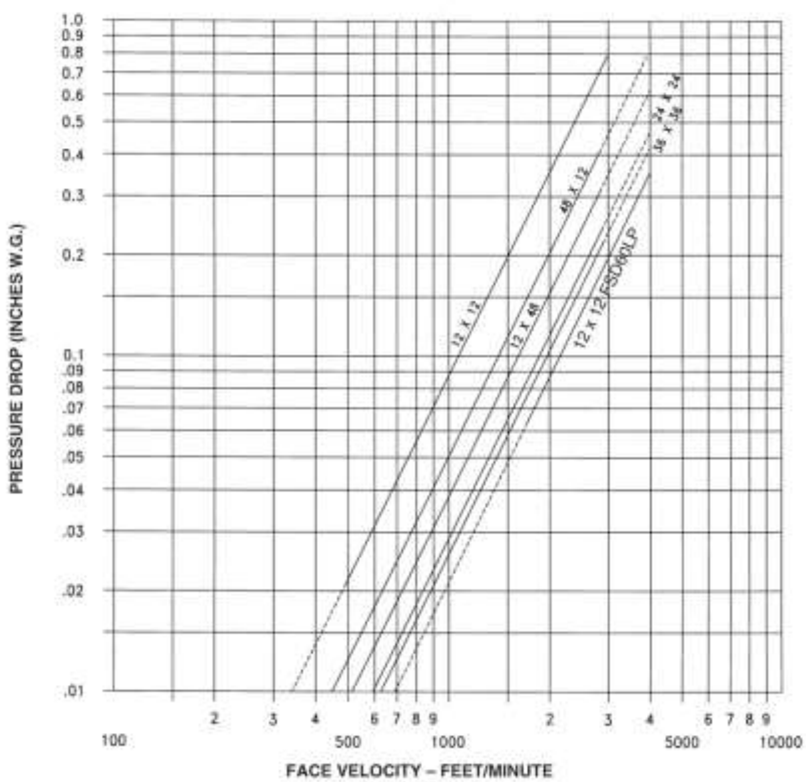
The FSD60LP pressure drop depicted on the chart below is preliminary data only. AMCA Certified testing pending.

To determine the AMCA Licensed air performance:

Locate the applicable feet per minute face velocity on the bottom of the velocity vs. pressure drop chart below. Move up the chart to the most appropriate size damper line. From the intersection point, move left to determine the pressure drop on the left side of the chart.

For other damper sizes refer to **Air Performance Data For All Fire and Smoke Dampers** spec sheet.

VELOCITY vs. PRESSURE DROP



AMCA Fig. 5.3

EXTENDED OPERATIONAL RATINGS (FSD60 ONLY)

The UL555 and UL555S Test Standards require all fire smoke dampers to prove closure or operation against heated air flow velocities of at least 2,000 feet per minute (10.2 m/s) and 4 inches of water (1 kPa) and minimum operating temperature of 250°F. All Ruskin fire smoke dampers in all sizes meet the minimum requirements. In addition Ruskin FSD60 dampers exceed those minimum requirements. Ruskin FSD60 dampers exceed these minimum requirements in many cases.

2,000 FPM Fail Close Operation				
MODEL	**SIZE**	**STATIC PRESSURE**	**TEMPERATURE**	**INSTALLATION**
FSD60	120" x 96"	4" w.g.	350°	Vertical
FSD60	144" x 96"	4" w.g.	350°	Horizontal
FSD60LP	36" x 14"	4" w.g.	350°	Vertical or Horizontal
3,000 FPM Fail Close Operation				
FSD60	64" x 72" 120" x 36" 32" x 96"	4" w.g.	250°	Vertical
FSD60	60" x 72" 120" x 36" 30" x 96"	4" w.g.	250°	Horizontal
FSD60	64" x 64" 120" x 32" 32" x 96"	4" w.g.	350°	Vertical
FSD60	60" x 64" 120" x 32" 30" x 96"	4" w.g.	350°	Horizontal
FSD60	120" x 96"	6" w.g.	250°	Vertical
FSD60	144" x 96"	6" w.g.	250°	Horizontal
4,000 FPM Fail Close Operation				
FSD60	48" x 48" 96" x 24" 24" x 96"	8" w.g.	250°	Vertical or Horizontal

ACTUATOR REQUIREMENTS

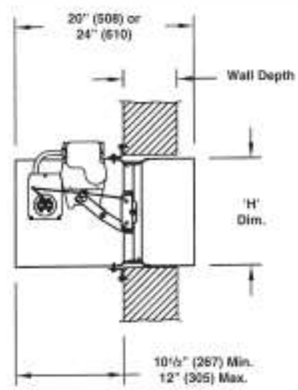
- * UL555S requires that all smoke dampers have factory mounted actuators in order to bear the UL label.
- Fire smoke dampers larger than single section may require multiple actuators. See "Smoke Damper Multiple Section Detail" spec sheet for details.
- Ruskin's smoke dampers are UL555S labeled with either electric or pneumatic actuators mounted internal (in air stream) or external (out of air stream).
- Fire smoke dampers utilizing multiple actuators must have all actuators **field** wired to a common point for simultaneous closure. All field wiring shall be in accordance with applicable codes, ordinances and regulations.

FSD60LP SLEEVE DIMENSIONAL DATA

The drawing shows the standard position of the FSD60LP when installed. The mounting location provides enough space for the actuators, controls (FAST) retaining angles and duct connections. The minimum sleeve length is 20" (508). Consult Ruskin for shorter sleeve lengths.

NOTES

1. The entire frame is not required to be installed within the wall. The center line of the closed blade, should be contained within the wall.
2. See basic UL installation instructions for complete installation requirements.



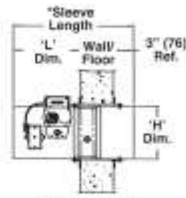
FSD60 SLEEVE DIMENSIONAL DATA

The drawing and corresponding table show the position of the damper when mounted in a factory sleeve. The standard mounting locations provide enough space for the mounting of actuators, controls, installation of retaining angles, and duct connections. The minimum factory sleeve length is 17" (432). Consult Ruskin for shorter sleeve lengths.

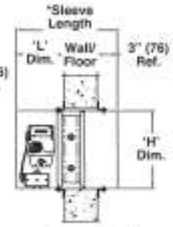
The standard location of a damper mounted in a factory sleeve ("L" dimension) is shown at right.

***Minimum Sleeve Length Formula:**
Sleeve Length = "L" dimension + wall/floor thickness + 3" sleeve non-motor side

NOTE:
1. The entire damper frame is not required to be installed within the wall. The damper blades, when closed should be contained within the wall.
2. See basic UL installation instructions for complete installation requirements.



'H' High and Under



Over 'H' High

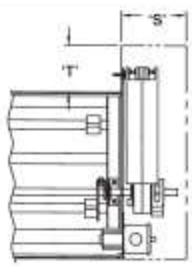
Actuator Side	All dampers with EFL or PFL		All dampers with TS150, SP100 or DTS							
			Electric Actuators		Pneumatic Actuators					
					331-4827(P)		331-2961(P)		331-3060(P)	
	'H' Over 10" (254) High	'H' 10" (254) High and Under	'H' Over 21" (533) High (see note)	'H' 21" (533) High and Under (see note)	'H' Over 28" (711) High	'H' 28" (711) High & Under	'H' Over 32" (813) High	'H' 32" (813) High & Under	'H' Over 40" (1016) High	'H' 40" (1016) High & Under
"L"	7⅛" (181)	10⅝" (270)	7⅛" (181)	10⅝" (270)	7⅛" (181)	10⅝" (270)	7⅛" (181)	10⅝" (270)	7⅛" (181)	10⅝" (270)

Note: The 21" (533) dimension becomes 32" (813) when the MS4120, MS8120, GGD221 or FSNF and FSAF Series are utilized.

FSD60 SERIES SPACE ENVELOPE

Combination fire smoke dampers are required by the UL listing to have all actuators and accessories factory mounted, wired and/or piped. The Ruskin standard is for the actuator to be located on the right hand side of the damper (onto a factory installed sleeve or side plate) as viewed from the jackshaft face of the unit. Larger units may require multiple actuators which are located on the right, left and maybe internal mount locations. See the "Multiple Section Detail" specification sheet for details. Ruskin's fire smoke dampers are not air flow directional, so the dampers may be rotated 180° or turned over as long as the blades are running horizontally in a position to accommodate installation obstructions.

The adjacent chart indicates an "S" and a "T" dimension for the space envelope that each actuator requires for installation. The "S" dimension is the "side" clearance, the "T" dimension is the "top" clearance required for the various actuators approved for use with Ruskin fire smoke dampers.



Ruskin recommends 6" (152) of additional space beyond the "S" dimension for ease of maintenance.

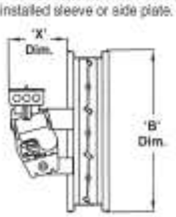
ACTUATORS	S	T
ML, FSLF, H2000 MS4209	4" (102)	2" (51)
FSNF, FSAF, MS4120	5" (127)	5" (127)
331-4827	5" (127)	6" (152)
331-2961	8" (203)	8" (203)
331-3060	9" (229)	11" (279)

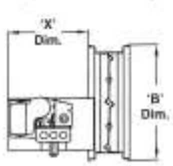
NOTES
1. The dimensions shown in the chart above are for dampers 14" (356) tall.
2. Dampers shorter than 14" (356) tall, increase the "T" dimension by 1" (25) for every 1" (25) the damper is less than 14" (356).
3. Dampers taller than 14" (356) high reduce the "T" dimension by 1" (25) for every 1" (25) the damper height is greater than 14" (356).

Example:
a) 12" (305) tall damper with a FSLF actuator, "T" = 2" (52) and "S" = 4" (102).
b) 18" (457) tall damper with a FSNF actuator, "T" = 1" (25) and "S" = 5" (127).

FSD60 INTERNAL MOUNT ACTUATOR DIMENSION

Ruskin model FSD60 has been tested for internal mount actuators and accessories. These applications may be preferred where space is limited on the outside of the damper. Internally mounted actuators do not require the damper to have a factory installed sleeve or side plate.

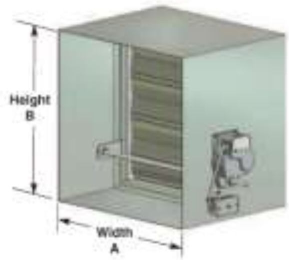




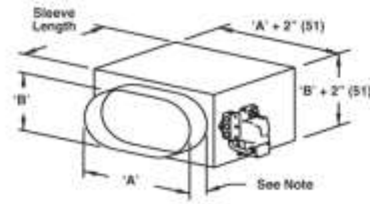
ACTUATORS	B Dim and Above		B Dim and Above	
	B	X	B	X
ML, FSLF, H2000 MS4209	10" (154)	10" (154)	18" (457)	7½" (191)
FSNF, FSAF, MS4120	12" (305)	12¾" (324)	21" (533)	5½" (533)
331-4827	16" (406)	15" (381)	21" (533)	7½" (191)
331-2961	16" (406)	17" (432)	24" (610)	7½" (191)
331-3060	20" (508)	19" (483)	26" (660)	9" (229)

(Model FSD60LP not available with internal mount actuators)

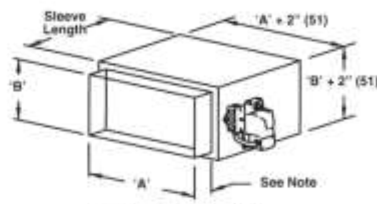
FSD60 DIMENSIONAL INFORMATION



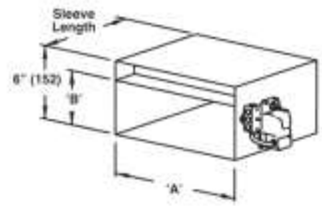
FSD60 Style A



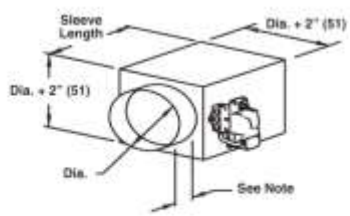
FSD60 Style LO,CO & WO
FSD60LP Style LO & CO



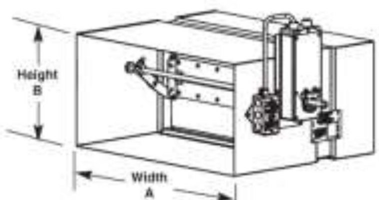
FSD60 Style C and WC
FSD60LP Style C



FSD60(LP) Style B



FSD60 Style R, CR and WR
FSD60LP Style R & CR



FSD60LP Style A

DUCT TRANSITION CONNECTIONS

FSD60 Series dampers may be supplied with Round, Oval and Rectangular duct connections.

Style	Description
B	Units Under 6" Tall
R	Round Non-Sealed (Low Pressure)
CR	Round Sealed (Medium Pressure)
WR	Round Welded (High Pressure)
C	Rectangular Sealed (Low and Medium Pressure)
WC	Rectangular Welded (High Pressure)
LO	Oval Non-Sealed (Low Pressure)
CO	Oval Sealed (Medium Pressure)
WO	Oval Welded (High Pressure)

The square damper size will be 2" (51) larger in width and height than the round, oval or rectangular duct size ordered.

MINIMUM and MAXIMUM SIZES

Round Transitions
Minimum 4" (102) diameter
Maximum 94" (2388) diameter

Rectangular and Oval Transitions
Minimum 6"w x 4"h (152 x 102)
Maximum 118"w x 94"h (2997 x 2388) in diameter

'B' Style Transitions
Minimum height 4" (102) 'B' style transitions are utilized on units where the damper height is less than 6" (152).

Consult Ruskin for other available styles and sizes.

Note: For medium pressure units (Styles CR, C and CO) the collar extends 1½" (38) beyond the sleeve length and for low pressure and high pressure units (Styles R, WR, WC and LO) the collar extends 2½" (64) beyond the sleeve length.

Approximate damper assembly weight: 17 lbs. per sq. ft. for Style A assembly

SPECIFICATION

Combination fire smoke dampers meeting or exceeding the following specifications shall be furnished and installed at locations shown on plans or as described in schedules. Combination fire smoke dampers shall be produced in an ISO 9001 certified factory and shall be warranted to be free from defects in material and workmanship for a period of 5 years after date of shipment. Dampers shall meet the requirements of NFPA80, 90A, 92A and 92B and shall have a fire rating of 1½ hours in accordance with the latest edition of UL555 and shall be classified as Leakage Class I Smoke Dampers in accordance with the latest version of UL555S. Dampers shall be AMCA Licensed and shall bear the AMCA certified rating seal for air performance. AMCA certified testing shall verify pressure drop does not exceed .03" w.g. at a face velocity of 1000 fpm on a 24" x 24" damper.

Damper frame (when size permits) shall be constructed using the UniFrame Design Concept (UDC) and shall be minimum 16 gage (1.6) galvanized steel formed into a structural hat channel superior to 13 gage (2.30) channel frame. Assemblies less than 36" (914) wide x 14" (356) high shall be Low Profile (LP) design to maximize the free area of these smaller dampers. LP frame and blade shall be 20 gage (1.0) and shall include an integral sleeve. Damper blades shall be single piece airfoil shaped with 14 (2.0) gage equivalent thickness. Blade edge seals shall be inflatable silicone mechanically locked into blade edge. Jamb seals shall be stainless steel compression type. Bearings shall be stainless steel, permanently lubricated sleeve type turning in an extruded hole in the frame for maximum life.

Combination fire smoke dampers and their actuators shall be qualified in accordance with UL555S to an elevated temperature of 250°F (121°C) or 350°F (177°C) depending upon the actuator. Appropriate electric or pneumatic actuators **(specifier select one)** shall be installed by the damper manufacturer at time of damper fabrication. Electric actuators, factory installed on dampers, shall have been tested for prolonged periods of holding (minimum 1 year) with no evidence of reduced spring return performance. Each damper shall be rated for leakage and airflow in either direction through the damper. In addition to the leakage ratings already specified, the dampers shall be AMCA licensed for Air Performance.

Optional FM Approvals Specification

Each combination fire smoke damper shall be listed in Factory Mutual (FM) approvals Specification Tested Product and labeled accordingly.

Combination fire smoke dampers shall be Ruskin FSD60 Series.

(Consult www.ruskin.com for electronic version of this "Quick" spec as well as for complete 3-part CSI MasterFormat Specifications)

RUSKIN®

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A.5 DOOR SPECIFICATIONS

A.5.1 Particleboard Door

Flush "Economy" Particleboard Core

- **Specifications**: 3, 5, 7 Ply construction. Meets or exceeds industry standards of WDMA I.S.1 All 20 minute doors have been tested in conformance to the following standards: ASTM-E-152, CSFM-43.7, CAN 4-S104, NFPA-252, UBC-7-2-97, UL 10C
- **Lay Up Method**: Loose
- **Maximum Sizes**: Width - 4/0; Length - Depends on faces (See faces below for available length)
- **Thickness**: 1-3/8" and 1-3/4" ONLY
- **Stiles**: Softwood (Fir, Pine, Spruce, Basswood) Mill option, Width = 1" Nominal, 13/16" Minimum after prefit size.
- **Rails**: 1-3/8" Thickness = MDF, 1-5/8" Nominal, 1" Minimum after undercut; 1-3/4" Thickness = MDF, 2-1/4" Nominal, 1" Minimum after undercut
- **Core**: 28-30lb Particleboard, ANSI A208.1 Grade LD-1
- **Fire Rating**: 1-3/4" Thickness 20 Minute Rated*
- **Faces**: Raw only Lauan (Okuome) 3 ply, 8/0 Max length; Raw only RN Birch 2 Ply, MDF Back, 1/64" Face Veneer, 8/0 Max length; Raw only PS Red Oak 2 Ply, MDF Back, 1/64" Face Veneer, 8/0 Max length; Raw MDF Single Ply, 10/0 Max length; Primed MDF Single Ply, 10/0 Max length; Embossed Primed MDF Single Ply, 8/0 Max length; Embossed Prefinished MDF (Legacy) Single Ply, 8/0 Max length
- **Adhesive**: Type-1 PVA, Interior installation only.
- **Machining**: To Specification
- **Lites**: To Specification
- **Louvers**: To Specification
- **Acoustical Rating**: 32 STC In Operable; 20 STC Opearble (No Seal); 29 STC Operable (With seal / Pemko S773)
- **Warranty**: Standard two year. See limited warranty for details.
- **Description Abreviations**: E-1-3/8 = Economy 1-3/8" Thick PBC; E-20NL = Economy 1-3/4" Thick PBC, Non Rated; E-20NP = Economy 1-3/4" Thick PBC, 20 Minute Neutral Pressure E-20B = Economy 1-3/4" Thick PBC, 20 Minute Category B; E-20A = Economy 1-3/4" Thick PBC, 20 Minute Category A
- **Recommended Use**: Residential and Light Commercial

**See fire door specifications section in catalogue for details on sizes, hardware and construction limitations. All 20 minute doors have been tested in conformance to the following standards: ASTM-E-152, CSFM-43.7, CAN 4-S104, NFPA-252, UBC-7-2-97, UL 10C*

Flush "Standard" Particleboard Core

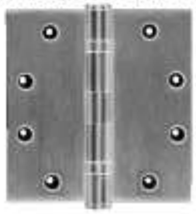
- **Specifications**: 3, 5, 7 Ply construction. Meets or exceeds industry standards of WDMA I.S.1 All 20 minute doors have been tested in conformance to the following standards: ASTM-E-152, CSFM-43.7, CAN 4-S104, NFPA-252, UBC-7-2-97, UL 10C
- **Lay Up Method**: Loose
- **Maximum Sizes**: Width - 4/0; Length - Depends on faces (See faces below for available length)
- **Thickness**: 1-3/8" and 1-3/4" ONLY
- **Stiles**: Paint Grade = FJ Hardwood, Raw Stain Grade = Matching Hardwood; Prefinished = FJ Hardwood with matching edge banding over; P-lam = FJ Hardwood with matching edge banding over; CAT-A = Special CAT-A Stile with matching edge banding over Width = 1" Nominal, 13/16" Minimum after prefit size.
- **Rails**: 1-3/8" Thickness = MDF, 1-5/8" Nominal, 1" Minimum after undercut 1-3/4" Thickness = MDF, 2-1/4" Nominal, 1" Minimum after undercut
- **Core**: 28-30lb Particleboard, ANSI A208.1 Grade LD-1
- **Fire Rating**: 1-3/4" Thickness 20 Minute Rated*
- **Faces**: Raw only RN Birch 2 Ply, MDF Back, 1/64" Face Veneer, 8/0 Max length; Raw only PS Red Oak 2 Ply, MDF Back, 1/64" Face Veneer, 8/0 Max length; Raw MDF Single Ply, 10/0 Max length; Primed MDF Single Ply, 10/0 Max length; Primed MDO 2 Ply HDF Back, 10/0 Max length; Select Species Raw & Prefinished 3 Ply, 1/42" Face, 9/0 Max length; Select Species Raw & Prefinished 2 Ply, 1/42" Face, 10/0 Max length; Plastic Laminate 2 Ply, 1/50" Face, 10/0 Max length; All laminates meet or exceed NEMA standards
- **Adhesive**: Type-1 PVA, Interior installation only.
- **Machining**: To Specification
- **Lites**: To Specification
- **Louvers**: To Specification
- **Acoustical Rating**: 32 STC In Operable; 20 STC Opearble (No Seal); 29 STC Operable (With seal / Pemko S773)
- **Warranty**: Standard two year. See limited warranty for details.
- **Description Abreviations**: S-1-3/8 = Standard 1-3/8" Thick PBC; S-20NL = Standard 1-3/4" Thick PBC, Non Rated; S-20NP = Standard 1-3/4" Thick PBC, 20 Minute Neutral Pressure; S-20B = Standard 1-3/4" Thick PBC, 20 Minute Category B; S-20A = Standard 1-3/4" Thick PBC, 20 Minute Category A
- **Recommended Use**: Residential and Light Commercial

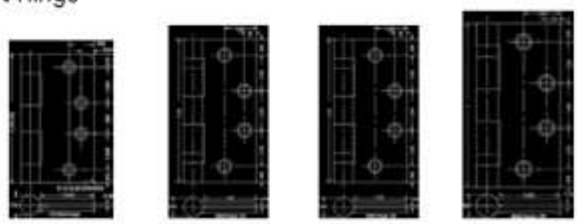
**See fire door specifications section in catalogue for details on sizes, hardware and construction limitations. All 20 minute doors have been tested in conformance to the following standards: ASTM-E-152, CSFM-43.7, CAN 4-S104, NFPA-252, UBC-7-2-97, UL10C*

Price Page | **Doormerica** | Vendor Site

DH-179 & DH-BB179 - 4 x 4, 4-1/2 x 4, 4-1/2 x 4-1/2, 5 x 4-1/2

Full Mortise, Standard Weight Hinge





4 x 4 | 4-1/2 x 4 | 4-1/2 x 4-1/2 | 5 x 4-1/2

Features:

- Full mortise, square corner, standard weight steel template hinge.
- Material Gauge - .123, 4" - .134, 4-1/2" -.134, 5" - .145
- Plain Bearing or Ball Bearing
- Screw packages - All Machine Screws (AMS) and - All Wood Screws (AWS).
- Machine Screws - Phillips(#1) Flat-head - 12 x 24 x 1/2"
- Wood Screws - Phillips(#1) Flat-head - 12 x 1-1/4"
- Also available NRP non removable pin

Options:

- NRP - Non-Removable pin with set screw.
- DH-BB179-SS - Stainless Steel Base Metal. (32D).
- DH-BB179 BR (brass based)

Stocked Products:

DH179 4" X 4" and 4-1/2" X 4-1/2"	US3,US4,10B,26,26D
DHBB179 4" X 4"	US3,US4,10B,26,26D
DHBB179 4-1/2" X 4"	US3,26
DHBB179 4-1/2" X 4-1/2"	US3,US4,10B,26,26D,32D
DHBB179 5" X 4-1/2"	26D
DHBB179BR 4-1/2' X4-1/2"	10B,26D

Packaging Information:

- Size 4" & 4-1/2" - 3 Hinges per BOX and 48 per Carton. Size 5" - 3 Hinges per BOX and 24 per Carton.

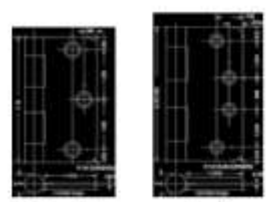
Note: NRP (non removable pin) available on most sizes. Contact sales department for availability

DH-RC179 & DH-RCBB179 – 3-1/2 x 3-1/2, 4 x 4

1/4" Radius Corner Standard Weight Plain & Ball Bearing Hinge

Features:

- Full mortise, 1 /4" Radius Corner, Standard Weight Steel Template Hinge.
- Material Gauge - 3-1 /2" =.119, 4" =.129
- Plain Bearing
- Ball Bearing Available Only in 4 x 4.
- Screw packages - All Machine Screws (AMS) and All Wood Screws (AWS).
- 3-1/ 2" - AMS (10 x 24 x 1/2) and AWS (9 x 1")
- 4" - AMS (12 x 24 x 1/2) and AWS (12 x 1-1/4")
- NRP - non removable pin stocked 4 x 4 size only RC179



3-1/2 x 3-1/2 | 4 x 4

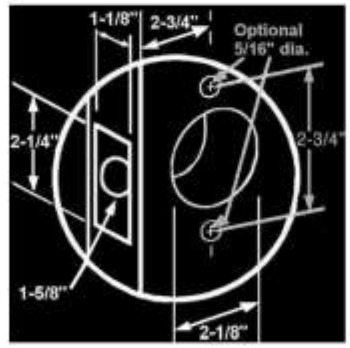
Stocked Product

DHRC179 3-1/2" X 3-1/2"and 4" X 4"	US3,US4,10B,15,26,26D
DHRCBBRC179 4" X 4"	US3,US4,10B,15,26,26D

ABS-AMERICAN BUILDING SUPPLY, INC.

Price Page **Doormerica** Vendor Site

LSV - Standard Duty Commercial Cylindrical Lever Locks-Grade 2



Features:

- Non-Handed and Reversible.
- 2-3/4" Backset, 1-1/8" x 2-1/4" Face Plate, UL 3 Hour Fire Listed Stainless Steel Latch or Dead-latch.
- Standard With Removable Thru-Bolts
- 1-1/4" x 4-7/8" ANSI Strike.
- Schlage "C" 6 Pin Keyway Standard.
- Barrier Free & Returns within 1/2" from Door Face.
- Saturn and Sparta Lever Trim.
- Door Thickness 1-3/8" - 1-3/4"
- RTB- Removable thru bolts supplied but NOT installed.

Options:

- CL - Clutch Function - Lever Rotates without unlatching the door
- IC - Best Type Figure 8 Interchangeable lever. Interchangeable Core NOT included.
- NLSV-SL238 2-3/8" Backset Spring Latch.
- NLSV-DL238 2-3/8" Backset Dead Latch.
- Suffix "1" -1" X 2-1/4" Latch Face Plate.
- PLK-EXT-5 - Extension for 5" Backset.

Code compliance:

- ANSI A156.2 Grade 2. UL10C and UBC 7.2 for positive pressure.
- ANSIA117.1 and ADA for barrier-free accessibility
- C-UBC - California Amended Uniform Builders Code - 2001
- NFPA-80 National Fire Protection Assoc.-1999
- NFPA101 National Fire Protection-Life Safety - 2000

3 YEAR WARRANTY

Stocked Product

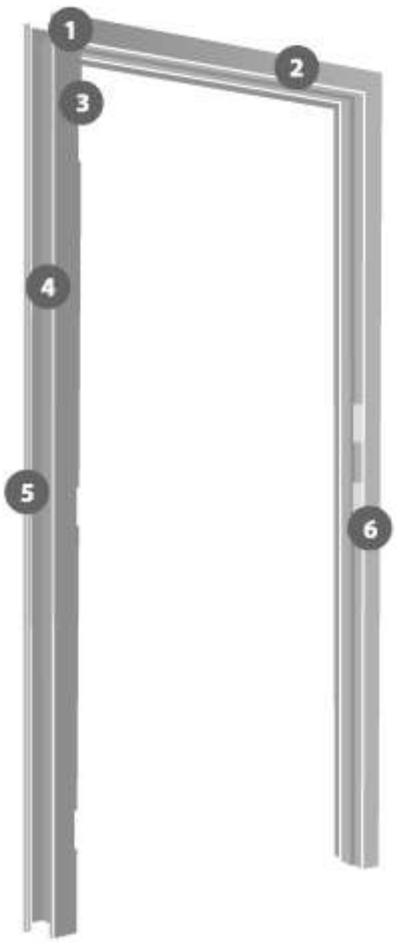
LSV10,LSV20,LSV40,LSV53,LSV70,LSV80,LSV170:	Saturn/Sparta	26D
LSV10,LSV40,LSV53,LSV70,LSV80	Saturn/Spara	US3,10B,26
LSV53,LSV70,LSV80 IC core less core	Saturn	26D
LSV53,LSV70,LSV80 with Clutch	Saturn	10B, 26D

16 American Building Supply, Inc. 03/11

A.5.2 Metal Door

DOOR COMPONENTS INC
Knowledge, Quality & Service

3 Sided Frames



Features

- 1 Face weld
- 16-gauge A60 galvannealed steel standard
- 7-gauge hinge reinforcements standard
- 12-gauge for closers standard
- Rust-inhibitive prime coat ANSI/SDI 250.10-1998
- 3 Any manufacturer's hinge locations
- 6 Any manufacturer's strike prep location
- 5 Anchors to meet all wall construction
- Any width and height
- Any jamb depth
- Available in KD Drywall or Masonry

Material Options

- 14-gauge and 12-gauge steel
- Available in Stainless Steel

Feature Options

- Continuous weld
- 4 Up to 3 hour fire label
- Hospital stop

Hardware Reinforcements

- 2 Optional prep to accept all manufacturers' hardware requirements

866.989.3667 7980 Redwood Ave, Fontana CA 92336 www.doorcomponents.com

DOOR COMPONENTS INC.

METAL DOORS

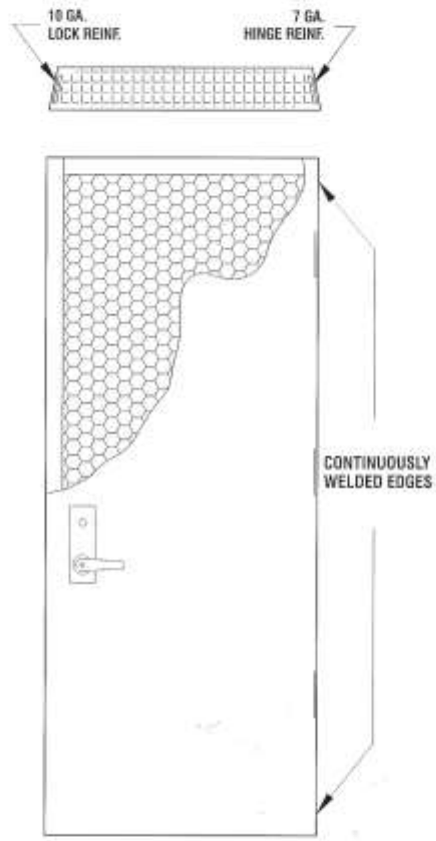
"H" SERIES DOOR

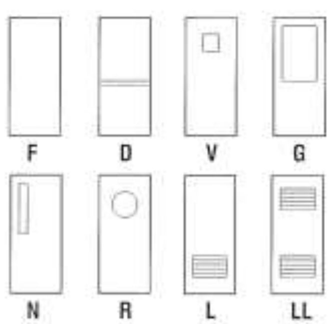
- ECONOMICAL
- IMPACT RESISTANT
- INTERIOR OR EXTERIOR USAGE
- 1 ¾" STANDARD, ALSO AVAILABLE IN 1 ⅜"
- 1" HEXCELLS FOR MAXIMUM STRENGTH, RIGIDITY AND FLATNESS
- 18-GAUGE STEEL STANDARD.
  (16-GAUGE OR 14-GAUGE STEEL OPTIONAL.)
  (G90 GALVANIZED STEEL OPTIONAL.)
- RUST INHIBITIVE PRIME COAT
- 18-GAUGE TOP AND BOTTOM CHANNELS SPOTWELDED TO FACE SHEETS.
- CONTINUOUSLY WELDED VERTICAL EDGES (SEAMLESS) *STANDARD*
- 1" HONEYCOMB CELLS PERMANENTLY BONDED TO BOTH FACE SHEETS. IMPACT RESISTANCE - 45 PSI CRUSHING STRENGTH OF HONEYCOMB
- FIRE LABELED

HARDWARE REINFORCEMENTS

- 3/16" FOR HINGES
- 10-GAUGE FOR LOCKS
- 12-GAUGE FOR CLOSERS

UL Listed





Other combinations available

MAXIMUM SIZE

	PAIR	SINGLE
1½ HOUR	8'0" x 9'0"	4'0" x 9'0"

We use A60 Hot Dipped Galvanized Steel ASTM A526 as a standard not an option.

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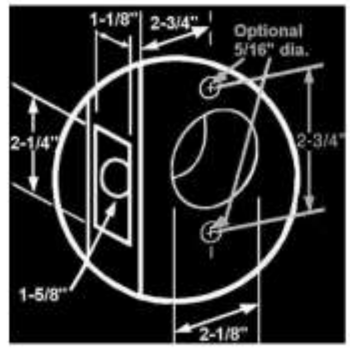
ABS-AMERICAN BUILDING SUPPLY, INC.

Price Page

Doormerica

Vendor Site

LSV - Standard Duty Commercial Cylindrical Lever Locks-Grade 2



Features:

- Non-Handed and Reversible.
- 2-3/4" Backset, 1-1/8" x 2-1/4" Face Plate, UL 3 Hour Fire Listed Stainless Steel Latch or Dead-latch.
- Standard With Removable Thru-Bolts
- 1-1/4" x 4-7/8" ANSI Strike.
- Schlage "C" 6 Pin Keyway Standard.
- Barrier Free & Returns within 1/2" from Door Face.
- Saturn and Sparta Lever Trim.
- Door Thickness 1-3/8" - 1-3/4"
- RTB- Removable thru bolts supplied but NOT installed.

Options:

- CL - Clutch Function - Lever Rotates without unlatching the door
- IC - Best Type Figure 8 Interchangeable lever. Interchangeable Core NOT included.
- NLSV-SL238 2-3/8" Backset Spring Latch.
- NLSV-DL238 2-3/8" Backset Dead Latch.
- Suffix "1" -1" X 2-1/4" Latch Face Plate.
- PLK-EXT-5 - Extension for 5" Backset.

Code compliance:

- ANSI A156.2 Grade 2. UL10C and UBC 7.2 for positive pressure.
- ANSIA117.1 and ADA for barrier-free accessibility
- C-UBC - California Amended Uniform Builders Code - 2001
- NFPA-80 National Fire Protection Assoc.-1999
- NFPA101 National Fire Protection-Life Safety - 2000

3 YEAR WARRANTY

Stocked Product

LSV10,LSV20,LSV40,LSV53,LSV70,LSV80,LSV170:	Saturn/Sparta	26D
LSV10,LSV40,LSV53,LSV70,LSV80	Saturn/Spara	US3,10B,26
LSV53,LSV70,LSV80 IC core less core	Saturn	26D
LSV53,LSV70,LSV80 with Clutch	Saturn	10B, 26D

ABS-AMERICAN BUILDING SUPPLY, INC.

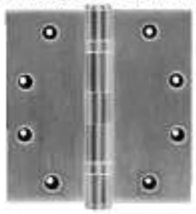
Price Page

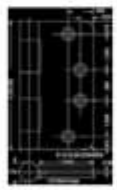
Doormerica

Vendor Site

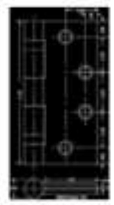
DH-179 & DH-BB179 - 4 x 4, 4-1/2 x 4, 4-1/2 x 4-1/2, 5 x 4-1/2

Full Mortise, Standard Weight Hinge

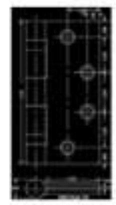




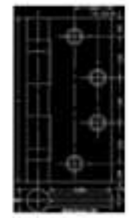
4 x 4



4-1/2 x 4



4-1/2 x 4-1/2



5 x 4-1/2

Features:

- Full mortise, square corner, standard weight steel template hinge.
- Material Gauge - .123, 4" - .134, 4-1/2"
  -.134, 5"- .145
- Plain Bearing or Ball Bearing
- Screw packages - All Machine Screws (AMS) and
  - All Wood Screws (AWS).
- Machine Screws - Phillips(#1) Flat-head
  - 12 x 24 x 1/2"
- Wood Screws - Phillips(#1) Flat-head
  - 12 x 1-1/4"
- Also available NRP non removable pin

Options:

- NRP - Non-Removable pin with set screw.
- DH-BB179-SS - Stainless Steel Base Metal. (32D).
- DH-BB179 BR (brass based)

Stocked Products:

DH179 4" X 4" and 4-1/2" X 4-1/2"	US3,US4,10B,26,26D
DHBB179 4" X 4"	US3,US4,10B,26,26D
DHBB179 4-1/2" X 4"	US3,26
DHBB179 4-1/2" X 4-1/2"	US3,US4,10B,26,26D,32D
DHBB179 5" X 4-1/2"	26D
DHBB179BR 4-1/2' X4-1/2"	10B,26D

Packaging Information:

- Size 4" & 4-1/2" - 3 Hinges per BOX and 48 per Carton.
  Size 5" - 3 Hinges per BOX and 24 per Carton.

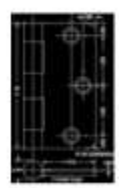
Note: NRP (non removable pin) available on most sizes. Contact sales department for availability

DH-RC179 & DH-RCBB179 – 3-1/2 x 3-1/2, 4 x 4

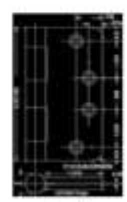
1/4" Radius Corner Standard Weight Plain & Ball Bearing Hinge

Features:

- Full mortise, 1 /4" Radius Corner, Standard Weight Steel Template Hinge.
- Material Gauge - 3-1 /2" =.119, 4" =.129
- Plain Bearing
- Ball Bearing Available Only in 4 x 4.
- Screw packages - All Machine Screws (AMS) and All Wood Screws (AWS).
- 3-1/ 2" - AMS (10 x 24 x 1/2) and AWS (9 x 1")
- 4" - AMS (12 x 24 x 1/2) and AWS (12 x 1-1/4")
- NRP - non removable pin stocked 4 x 4 size only RC179



3-1/2 x 3-1/2



4 x 4

Stocked Product

DHRC179 3-1/2" X 3-1/2"and 4" X 4"	US3,US4,10B,15,26,26D
DHRCBBRC179 4" X 4"	US3,US4,10B,15,26,26D

A.6 SMOKE DETECTOR SPECIFICATIONS

GE
Security

FireworX Fire & Life Safety
Conventional Initiating Devices

Overview

The TX-6010-01-1 supervised photoelectric smoke alarms are self-diagnostic Learn Mode wireless sensors with a 319.5MHz transmitter, built-in sounder, low battery annunciation, diagnostic/status LED, and integrated fixed temperature and rate-of-rise heat sensors. Each unit will communicate an alarm and trouble condition to a GE compatible control panel. In addition, the mounting tamper will send a trouble condition as necessary.

The TX Series photoelectric smoke alarms continually monitor operational status and provide a visual trouble condition if they drift out of the sensitivity range or fail internal diagnostics.

The series meets NFPA 72 field sensitivity testing requirements without the need for external meters. The alarm sensitivity level can be determined at the unit.

Another feature is built-in drift compensation that allows the alarm to adjust sensitivity automatically as it becomes dirty over time. The drift compensation feature dramatically increases the time between cleaning, as well as reducing the chance of a nuisance alarm.

A low battery pre-alarm feature sends a signal to the alarm company control station long before the smoke alarm begins its low battery chirp. This ensures a pro-active response to replace the battery in a timely manner and without the disturbance caused by an alarm beeping continuously when it nears the end of its life.

Standard Features

- Long life 3V lithium battery operated
- Learn Mode for easy programming
- Reliable 319.5MHz crystal transmitter
- Low battery pre-alarm sent to control station
- Field replaceable optical chamber
- Automatic drift compensation
- Integral heat detection
- Built-in 85dB temporal sounder
- Hush feature
- Low battery pre-alarm sent to control station

Supervised Wireless Smoke Alarms

TX-6010-01-1

Data Sheet FX89001-0601 Issue 1
Not to be used for installation purposes. Page 1 of 2

GE
Security

U.S.
T 888-GESECURITy
F 503-691-7566

Canada
T 519 376 2430
F 519 376 7258

Asia
T 852 2907 8108
F 852 2142 5063

Latin America
T 305 593 4301
F 305 593 4300

www.gesecurity.com/fireworx

Specifications

Electrical	
Voltage	3 VDC
Average standby current	35 µA, typical
Test current	2 mA, typical
Alarm current	70 mA, typical
Battery type (Note 1)	3V lithium-Duracell® 123, Sanyo® and Panasonic® CR123A
Low battery threshold	2.7 V causes low battery signal
Features	
Sounder	85dB at 10 ft., temporal pattern
Low battery beep rate	1 every 45 ±2 seconds
Sensitivity	2.3% ± 0.890%
Environmental	
Operating temperature	40 to 100°F (4 to 38°C)
Operating humidity range	0 to 95% noncondensing
RF immunity	20V/minute minimum; 1 to 1000 MHz
Drift compensation adjustment	0.5%/ft. maximum
Rate of rise	15°F/minute > 105°F (8.3°C/minute > 40.6°C)
Fixed	135°F ± 5°F (57.2°C ± 2.8°C)
RF frequency	319.5 MHz
Transmitter ID	Preprogrammed, 1 million codes
Modulation type	AM
Signal format	Pulse-width modulation
Output types	Alarm, restore, tamper, low battery, trouble, 1 hour Supervisory
Physical	
Color	White
Alarm dimensions	5.6 × 2.4 in. (142 × 61 mm)
Base dimensions	5.4 × 0.46 in. (137 × 12 mm)
Regulatory	
Listings	FCC, CSFM

Note 1: These batteries are the ONLY brands that have been tested and approved for use with the 560/570 series.

Ordering Information

TX-6010-01-1	Supervised residential wireless smoke detector for use with all compatible GE Security panels, 85dBa sounder, fixed/rate-of-rise alarm, transmitter, 2-Lithium batteries. UL 319.5
TX-6010-01-1-10PKG	Same as above - Package of 10 smoke alarms
Accessories	
SM-200-12PKG	Smoke in a Can® (aerosol spray) for functional testing of smoke detectors, pack of 12
SM-EXT1	Smoke in a Can extension tube
211 -10PKG	Replacement optical chambers, pack of 10
401	Test magnet in a plastic shell for pole mounting

imagination at work

Data Sheet FX85001-0601 Issue 1
Not to be used for installation purposes. Page 2 of 2

B THERMOCOUPLE LOCATIONS

B.1 LBR-1 AND SBR FIRE TESTS TC LOCATIONS

Two thermocouple trees were located in the LBR-1 and SBR fire tests as shown in Figure B.1. The thermocouple tree with thermocouples 5-1 through 6-2 was installed in the SE corner of the LBR area. The thermocouple tree with thermocouples 10-1 through 11-2 was installed in the southwest corner of the SBR area. The heights of the thermocouples are listed in Table B.1 and Table B.2.

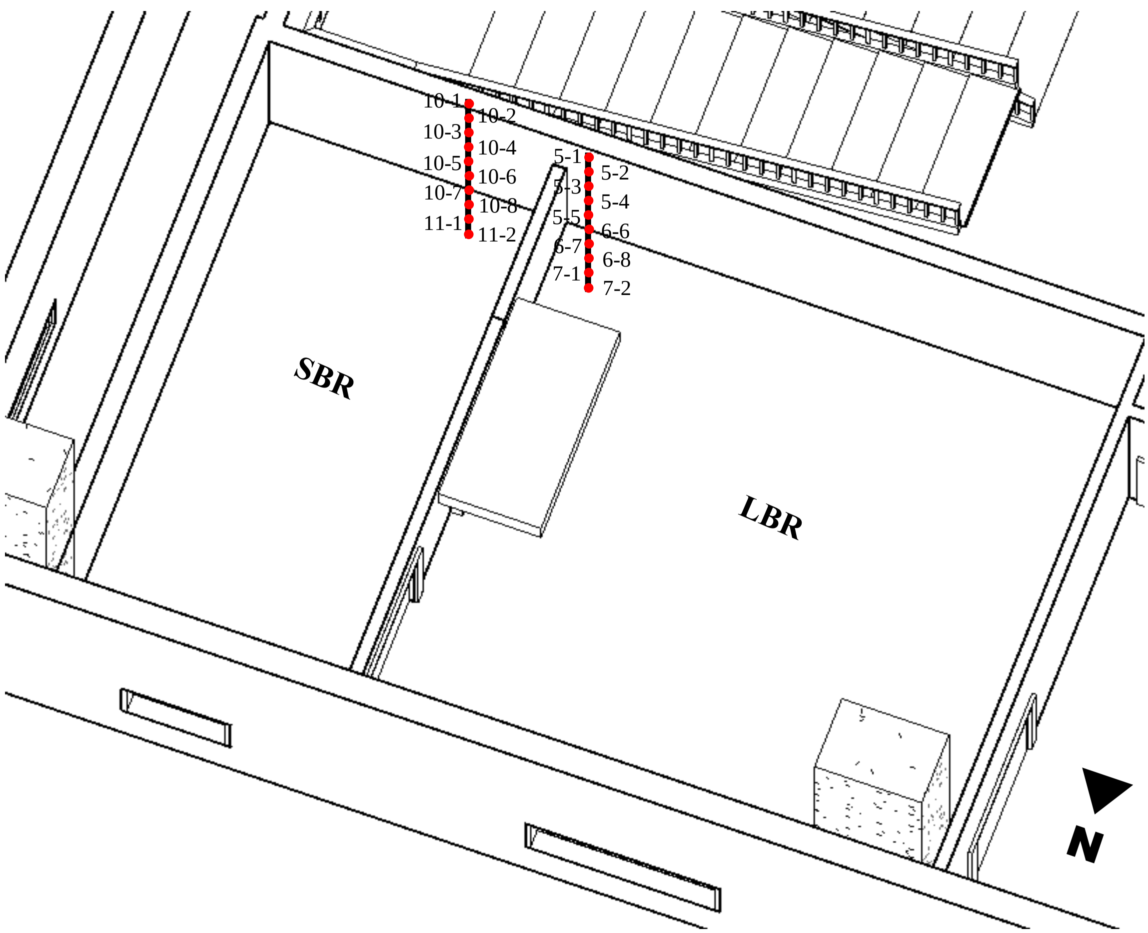


Figure B.1. TC trees in the SBR and LBR

Two thermocouple trees were located above the ceiling space in the LBR-1 and SBR fire tests as shown in Figure B.2. The thermocouple tree with thermocouples 6-3 through 6-7 was installed above the ceiling of the LBR area. The thermocouple tree with thermocouples 11-3 through 11-7 was installed above the ceiling of the SBR area. The heights of the thermocouples are listed in Table B.1 and Table B.2.

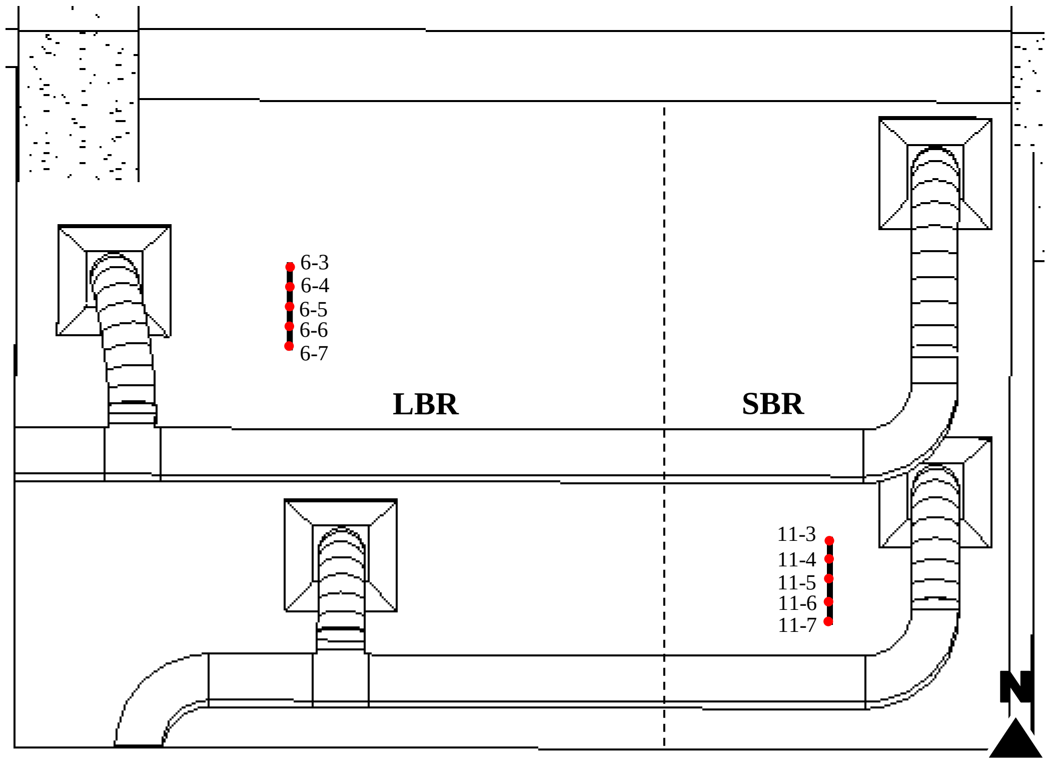


Figure B.2. TC trees above ceiling

Table B.1. LBR TC trees list

<table>
<tr><td>5-1</td><td rowspan="10">TC tree below ceiling of LBR starting with 6-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 5-1 on top at 2.7m (8.9ft)</td></tr>
<tr><td>5-2</td></tr>
<tr><td>5-3</td></tr>
<tr><td>5-4</td></tr>
<tr><td>5-5</td></tr>
<tr><td>5-6</td></tr>
<tr><td>5-7</td></tr>
<tr><td>5-8</td></tr>
<tr><td>6-1</td></tr>
<tr><td>6-2</td></tr>
<tr><td>6-3</td><td rowspan="5">TC tree hanging from 4^{th} floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top</td></tr>
<tr><td>6-4</td></tr>
<tr><td>6-5</td></tr>
<tr><td>6-6</td></tr>
<tr><td>6-7</td></tr>
</table>

Table B.2. SBR TC trees list

<table>
<tr><td>10-1</td><td rowspan="10">TC tree below ceiling of LBR starting with 11-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 10-1 on top at 2.7m (8.9ft)</td></tr>
<tr><td>10-2</td></tr>
<tr><td>10-3</td></tr>
<tr><td>10-4</td></tr>
<tr><td>10-5</td></tr>
<tr><td>10-6</td></tr>
<tr><td>10-7</td></tr>
<tr><td>10-8</td></tr>
<tr><td>11-1</td></tr>
<tr><td>11-2</td></tr>
<tr><td>11-3</td><td rowspan="5">TC tree hanging from 4^{th} floor slab above ceiling of LBR starting with 11-7 right above ceiling and increasing in 0.3m (1ft) increments to 11-3 being on top</td></tr>
<tr><td>11-4</td></tr>
<tr><td>11-5</td></tr>
<tr><td>11-6</td></tr>
<tr><td>11-7</td></tr>
</table>

Thermocouples 1-4 to 1-6 and 2-1 to 2-3 were placed in gaps formed between the north column and the west and north walls of the LBR. Thermocouples 1-7 and 1-8 were located in the cracks formed on the S wall of the LBR. The locations and heights of these thermocouples are listed in Figure B.3 and Table B.3 respectively.

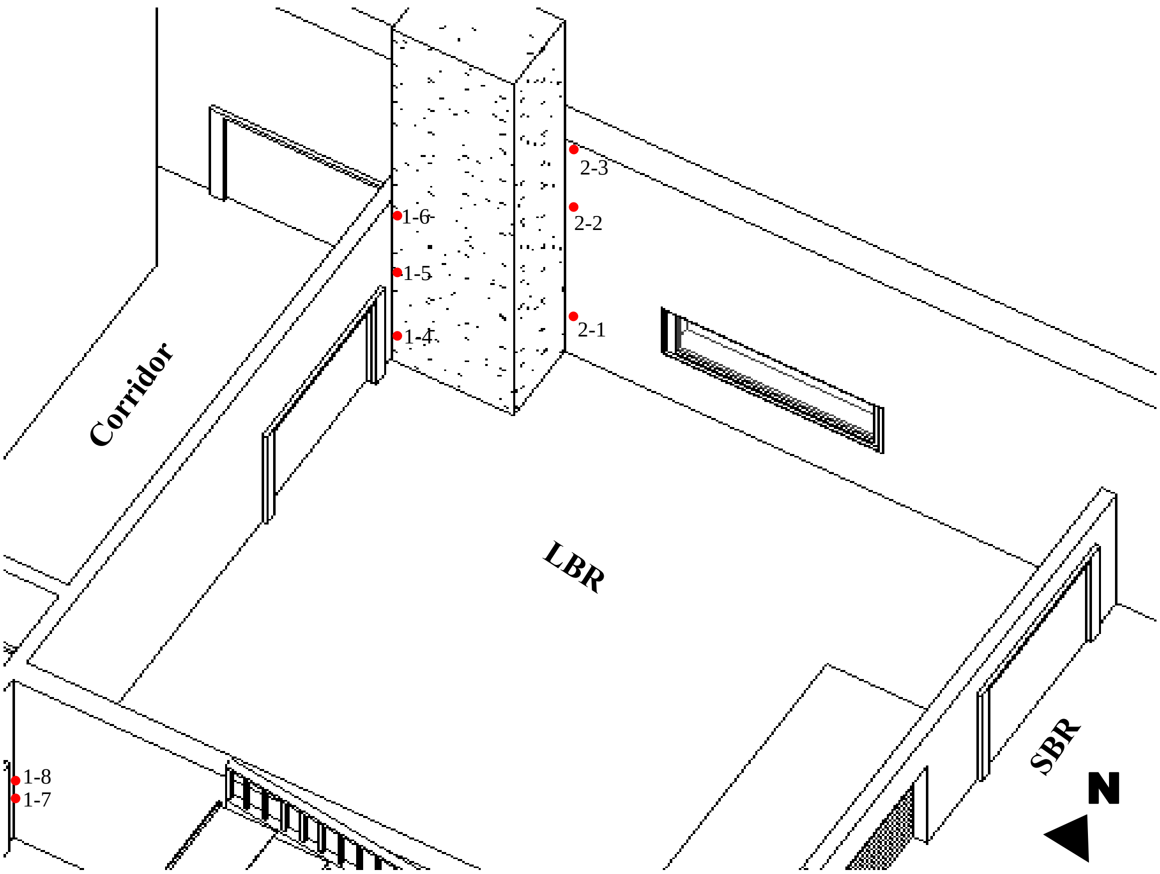


Figure B.3. TC in the LBR column gaps and S wall cracks

Table B.3. LBR column gaps and S wall cracks TC list

1-4	(g) On the SW corner gap of the N column, 0.59m (1.94’) above floor
1-5	(g) On the SW corner gap of the N column, 2.03m (6.66’) above floor
1-6	(g) On the SW corner gap of the N column, 0.1m (0.33’) below ceiling
1-7	(g) SW corner of room, 1.22m (4.00’) above floor (LBR temp)
1-8	(g) SW corner of room, 1.24m (4.07’) above floor (stair landing temp)
2-1	(g) on the NE corner gap of the N column 0.6m (1.97’) above floor
2-2	(g) on the NE corner gap of the N column 2m (6.56’) above floor
2-3	(g) on the NE corner gap of the N column 2.7m (8.86’) above floor

Thermocouples 2-4 and 2-5 were located on the northwest corner diffuser tile of the LBR. Thermocouple 3-3 was located above ceiling of the LBR between the north column and west wall of the LBR. Thermocouples 3-4 through 3-6 were located above the ceiling adjacent to the west wall of the LBR. Thermocouples 3-7 through 4-2 were located above the ceiling adjacent to the north wall of the LBR. The thermocouple locations are shown in Figure B.4. These thermocouple locations are listed in detail with dimensions in Table B.4.

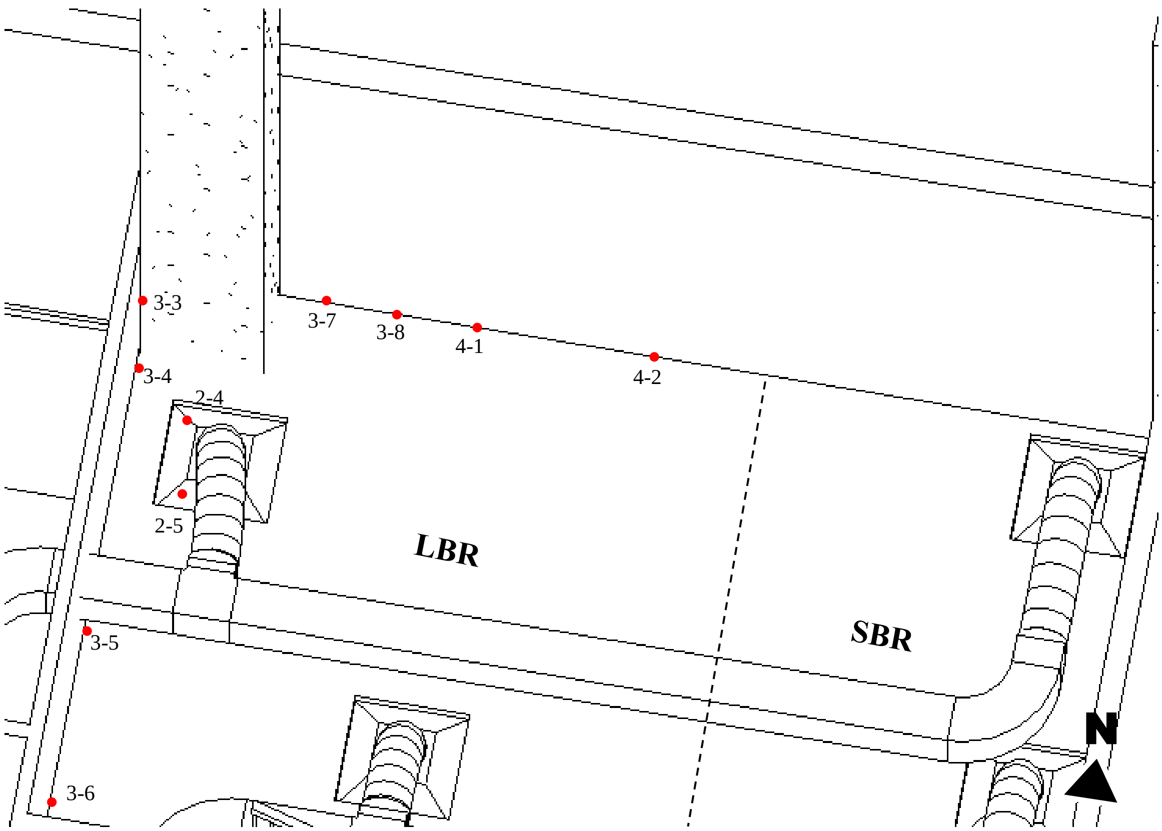


Figure B.4. TC above LBR ceiling

Table B.4. LBR above ceiling TC list

2-4	(s) on the NW corner diffuser
2-5	(s) on the NW corner diffuser
3-3	(g) above ceiling on SW corner gap of the N column, .32 above ceiling
3-4	(s) above ceiling of the W wall, 0.13m (0.43’) from N column
3-5	(s) above ceiling of the W wall, 1.5m (4.92’) from S wall
3-6	(s) above ceiling of the W wall, 0.1m (0.3’) from S wall
3-7	(s) above ceiling of the N wall, 0.3m (1’) from N column
3-8	(s) above ceiling of the N wall, 0.7m (2.3’) from N column
4-1	(s) above ceiling of the N wall, 1.2m (3.9’) from N column
4-2	(s) above ceiling of the N wall, 2.4m (7.9’) from N column

Thermocouples 2-6 through 3-2 were located on the firestops on the west wall of the LBR above the ceiling. Thermocouple 4-3 was located on the LBR west lighting box firestop above the ceiling. The thermocouples are shown in Figure B.5. These thermocouple locations are listed in detail with dimensions in Table B.5.

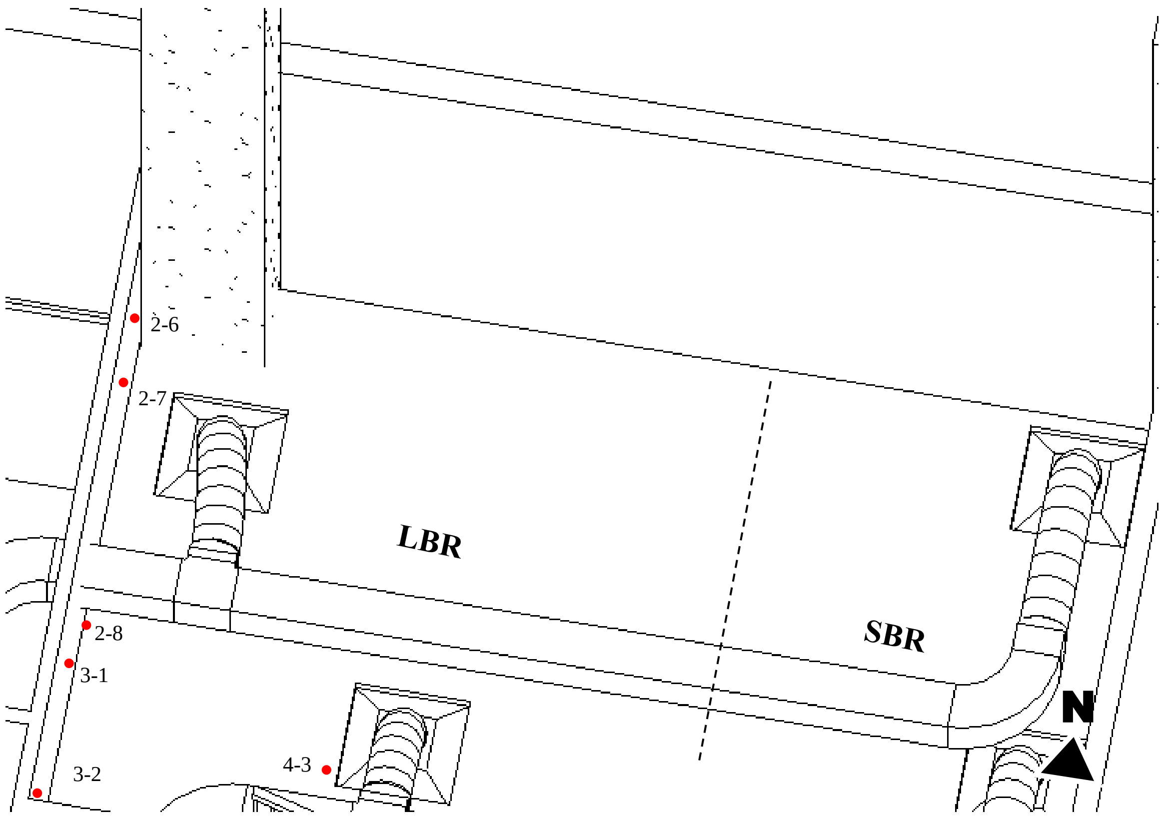


Figure B.5. TC on LBR firestops above ceiling

Table B.5. LBR firestops above ceiling TC list

2-6	(s) above ceiling on firestop, 0.19m (0.6’) from N column, 0.37m (1.2’) below 4th floor slab
2-7	(s) above ceiling on firestop, 0.52m (1.7’) from N column,0.42m (1.4’) below 4th floor slab
2-8	(s) above ceiling on firestop, 1.6m (5.2’) from S wall, 0.87m (2.9’) below 4th floor slab
3-1	(s) above ceiling on firestop, 1.4m (4.6’) from S wall, 0.45m (1.5’) below 4th floor slab
3-2	(s) above ceiling on firestop, 0.65m (2.1’) from S wall, 0.1m (0.3’) below 4th floor slab
4-3	(g) above ceiling, SE corner of the W lighting, 2.7m (8.9’) from N wall, 1.4m (4.6’) from W wall

Thermocouples 4-4 and 4-5 were placed on the door frame of the fire door. Thermocouple 4-6 was located on the fusible link of the fire door. Thermocouples 4-7 and 4-8 were located on the LBR and SBR sprinkler heads respectively. Thermocouples 12-1 and 12-2 were located on the door frame of the partition wall between the LBR and SBR. The thermocouple locations are shown in Figure B.6 and listed in details in Table B.6.

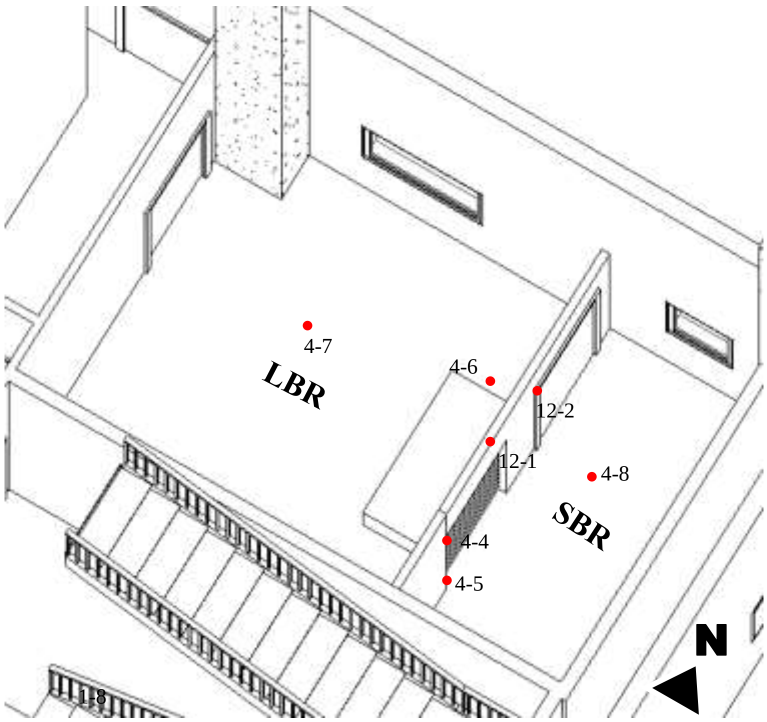


Figure B.6. TC on LBR and SBR fire systems

Table B.6. LBR and SBR fire systems TC list

4-4	(g) south part of fire door frame, 1.88m (6.2') above floor
4-5	(g) south part of fire door frame, 0.3m (1') above floor
4-6	(s) Fusible link of fire door, 1.5m (4.9') from N wall, 0.24m (0.8') below ceiling
4-7	(s) sprinkler head fusible link in the LBR, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor
4-8	(s) sprinkler head fusible link in the SBR, 1.3m (4.3') from N wall 1.4m (4.6') from W wall, 2.8m (9.2') above floor
12-1	(g) W wall of SBR gap above the fire door, 1.6m (5.2') from N wall
12-2	Corner of the door frame in the partition wall, 2.1m (6.9') above floor, 1.1m (3.6') from N wall

Thermocouples 6-8 through 7-8 were located in the gap between the partition wall and the north wall of the building. The thermocouple locations are shown in Figure B.7 and listed in details in Table B.7.

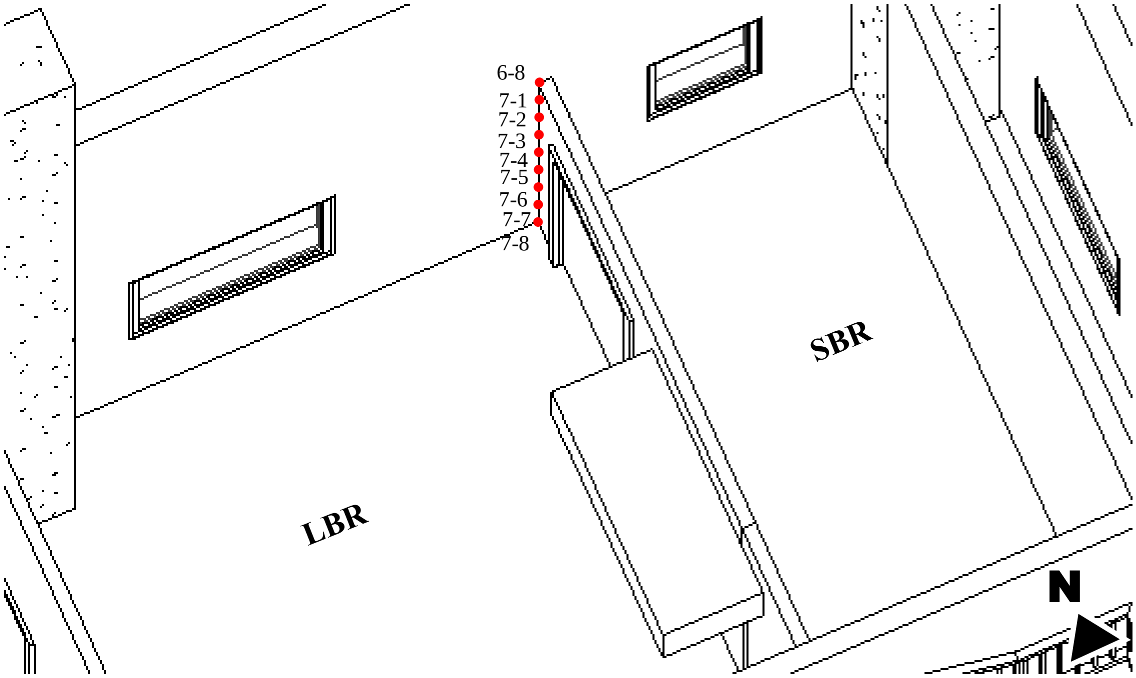


Figure B.7. TC in Gap between partition wall and building N wall

Table B.7. Gap between partition wall and building N wall TC list

6-8	(g) NW corner gap of the SBR 2.7m (8.9') above floor
7-1	(g) NW corner gap of the SBR 2.4m (7.9') above floor
7-2	(g) NW corner gap of the SBR 2.1m (6.9') above floor
7-3	(g) NW corner gap of the SBR 1.8m (5.9') above floor
7-4	(g) NW corner gap of the SBR 1.5m (4.9') above floor
7-5	(g) NW corner gap of the SBR 1.2m (3.9') above floor
7-6	(g) NW corner gap of the SBR 0.9m (3') above floor
7-7	(g) NW corner gap of the SBR 0.6m (2') above floor
7-8	(g) NW corner gap of the SBR 0.3m (1') above floor

Thermocouples 8-1 and 8-2 were located above the ceiling of the SBR adjacent to the north wall of the building. Thermocouples 8-3 and 8-4 were located above the ceiling on the northeast corner of the SBR at different heights. Thermocouples 8-5 through 8-7 were located above the ceiling of the SBR adjacent to the east wall of the building. The thermocouple locations are shown in Figure B.8 and listed in details in Table B.8.

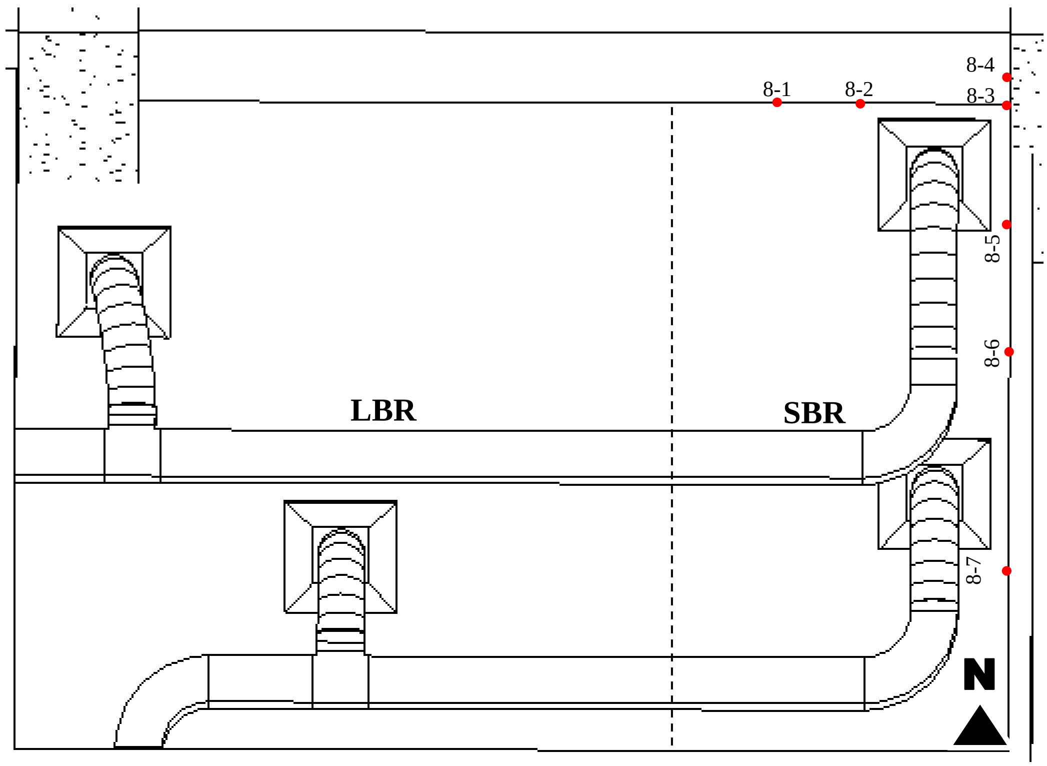


Figure B.8. Above SBR ceiling

Table B.8. Above SBR ceiling TC list

8-1	(s) above ceiling of N wall, 1.5m (4.9’) from E wall
8-2	(s) above ceiling of N wall, 0.9m (3’) from E wall
8-3	(s) above ceiling of NE corner of the SBR
8-4	(g) above ceiling of NE corner of the SBR
8-5	(s) above ceiling of E wall, 0.6m (2’) from N wall
8-6	(s) above ceiling of E wall, 1.4m (4.6’) from N wall
8-7	(s) above ceiling of E wall, 2.6m (8.5’) from N wall

Thermocouples 8-8 through 9-3 were located at various cracks on the south wall of the SBR. Thermocouples 9-4 and 9-5 were located on the south wall of SBR firestops. Thermocouple 9-6 was located on the firestop between the 3rd floor slab and the east wall of the SBR joint. Thermocouple 9-7 was located on the southeast corner gap of the SBR. The thermocouple locations are shown in Figure B.9 and listed in details in Table B.9.

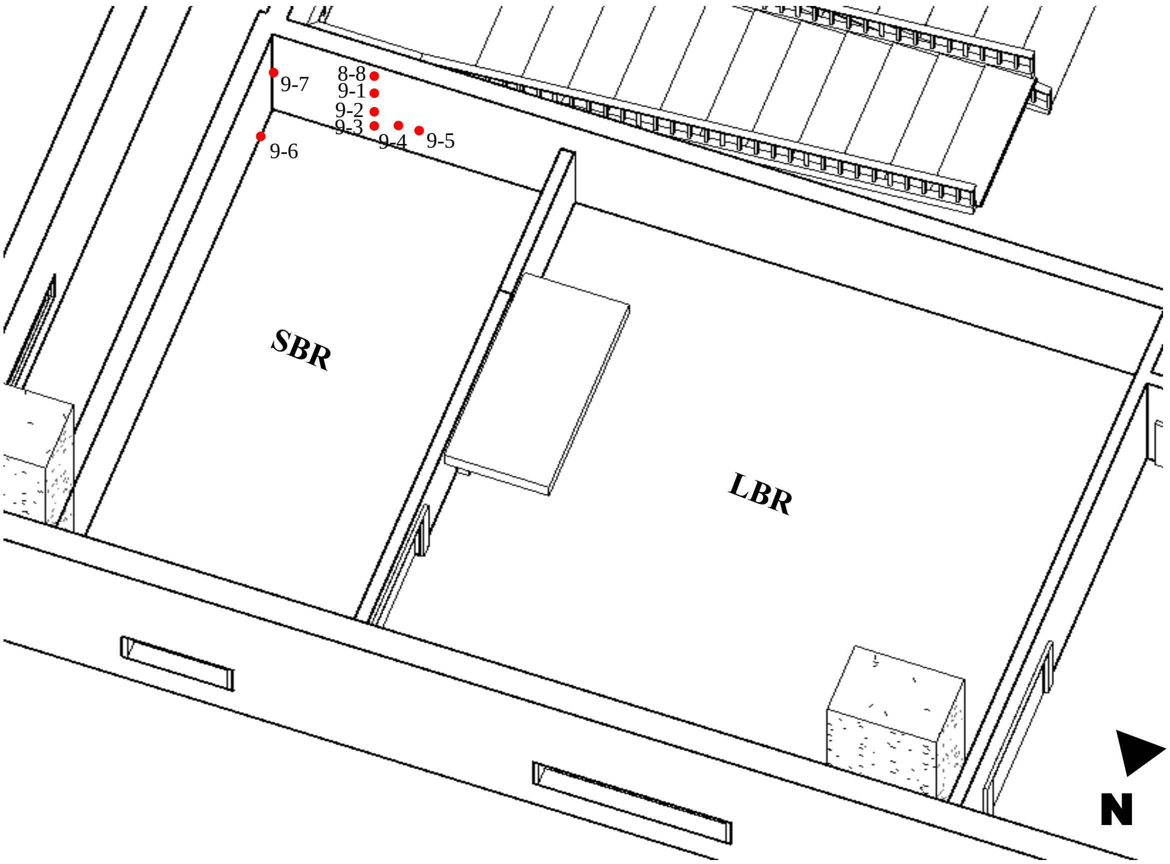


Figure B.9. TC on S wall of SBR

Table B.9. S wall of SBR TC list

8-8	(g) gap on S wall, 1.12m (3.7’) from SW corner, 2.24 (7.3’) above floor
9-1	(g) gap on S wall, 1.12m (3.7’) from SW corner, 1.84m (6’) above floor
9-2	(g) gap on S wall, 1.12m (3.7’) from SW corner 1.16 (3.8’) above floor
9-3	(g) gap on S wall, 1.12m (3.7’) from SW corner, 0.74 (2.4’) above floor
9-4	(g) S wall firestop on opening, 0.99m (3.2’) from SW corner, 0.8m (2.6’) above floor
9-5	(g) S wall firestop on opening, 0.83m (2.7’) from SW corner, 0.81m (2.7’) above floor
9-6	(g) E wall to slab firestop gap, 0.19m (0.6’) from SE corner
9-7	(g) SE corner of SBR, 1.68m (5.5’) above floor

Thermocouples 1-1 through 1-3 were located on the north exterior wall balloon framing of the building. The thermocouple locations are shown in Figure B.10 and listed in details in Table B.10.

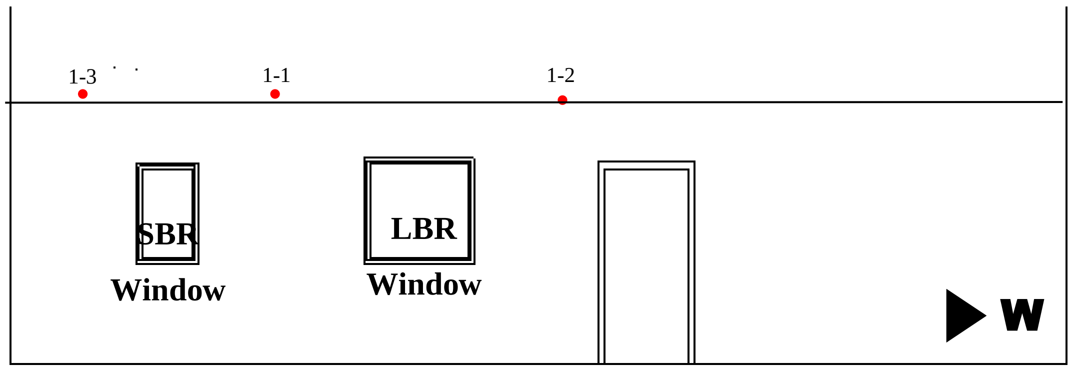


Figure B.10. TC on N balloon frame of building

Table B.10. N balloon frame of building TC list

1-1	(g) NE Balloon Framing from LBR
1-2	(g) NW balloon framing from LBR
1-3	(g) Balloon framing from SBR

B.2 LBR-2 FIRE TEST TC LOCATIONS

One thermocouple tree was located in the southeast corner of the LBR as shown in Figure B.11. The thermocouple tree consisted of thermocouples 7-1 through 8-2. The thermocouple locations are shown in Figure B.11 and listed in details in Table B.11.

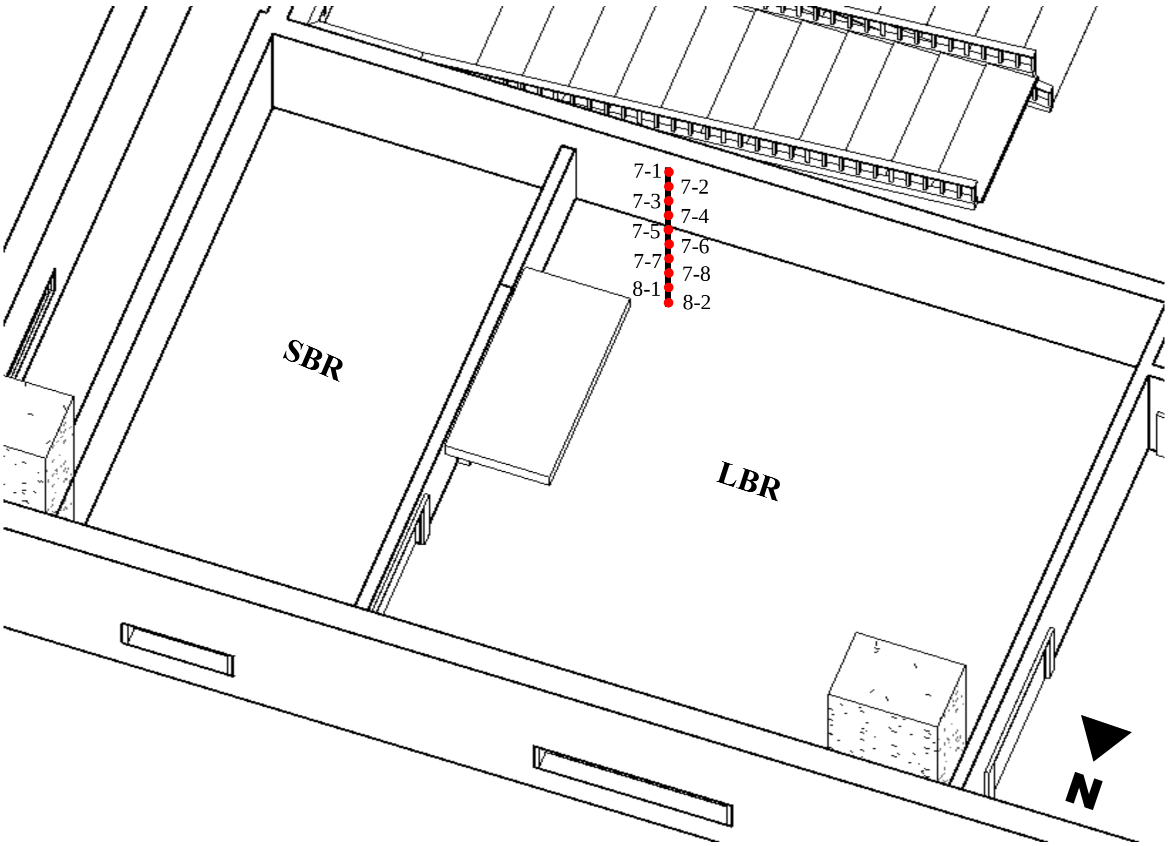


Figure B.11. TC tree in LBR

Table B.11. LBR TC tree list

7-1	TC tree below ceiling of LBR starting with 8-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 7-1 on top at 2.7m (8.9ft)
7-2	
7-3	
7-4	
7-5	
7-6	
7-7	
7-8	
8-1	
8-2	

Two thermocouple trees were located above the ceiling space in the as shown in Figure B.12. The thermocouple tree with thermocouples 6-3 through 6-7 was installed above the ceiling of the LBR area. The thermocouple tree with thermocouples 8-4 through 8-8 was installed above the ceiling of the SBR area. The heights of the thermocouples are listed in Table B.12.

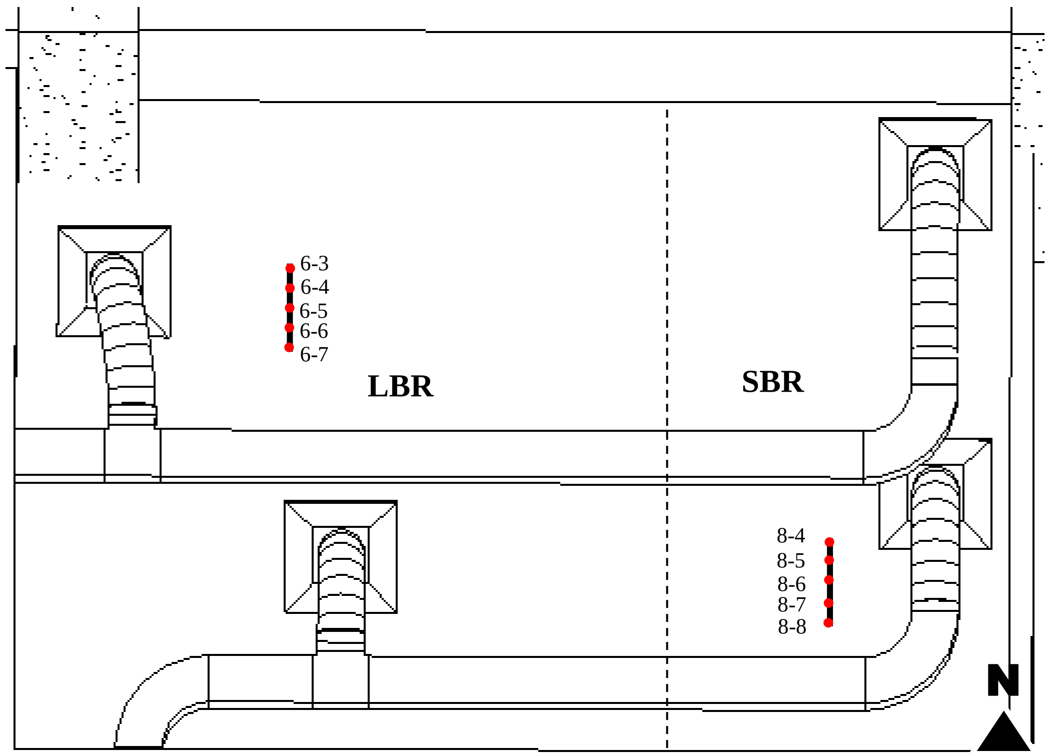


Figure B.12. TC trees above LBR and SBR ceiling

Table B.12. LBR and SBR above ceiling TC trees list

6-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top
6-4	
6-5	
6-6	
6-7	
8-4	TC tree hanging from 4th floor slab above ceiling of SBR starting with 8-8 right above ceiling and increasing in 0.3m (1ft) increments to 8-4 being on top
8-5	
8-6	
8-7	
8-8	

Thermocouples 1-4 to 1-6 and 2-1 to 2-3 were placed in gaps formed between the north column and the west and north walls of the LBR. Thermocouples 1-7 and 1-8 were located in the cracks formed on the south wall of the LBR. The locations and heights of these thermocouples are listed in Figure B.13 and Table B.13 respectively.

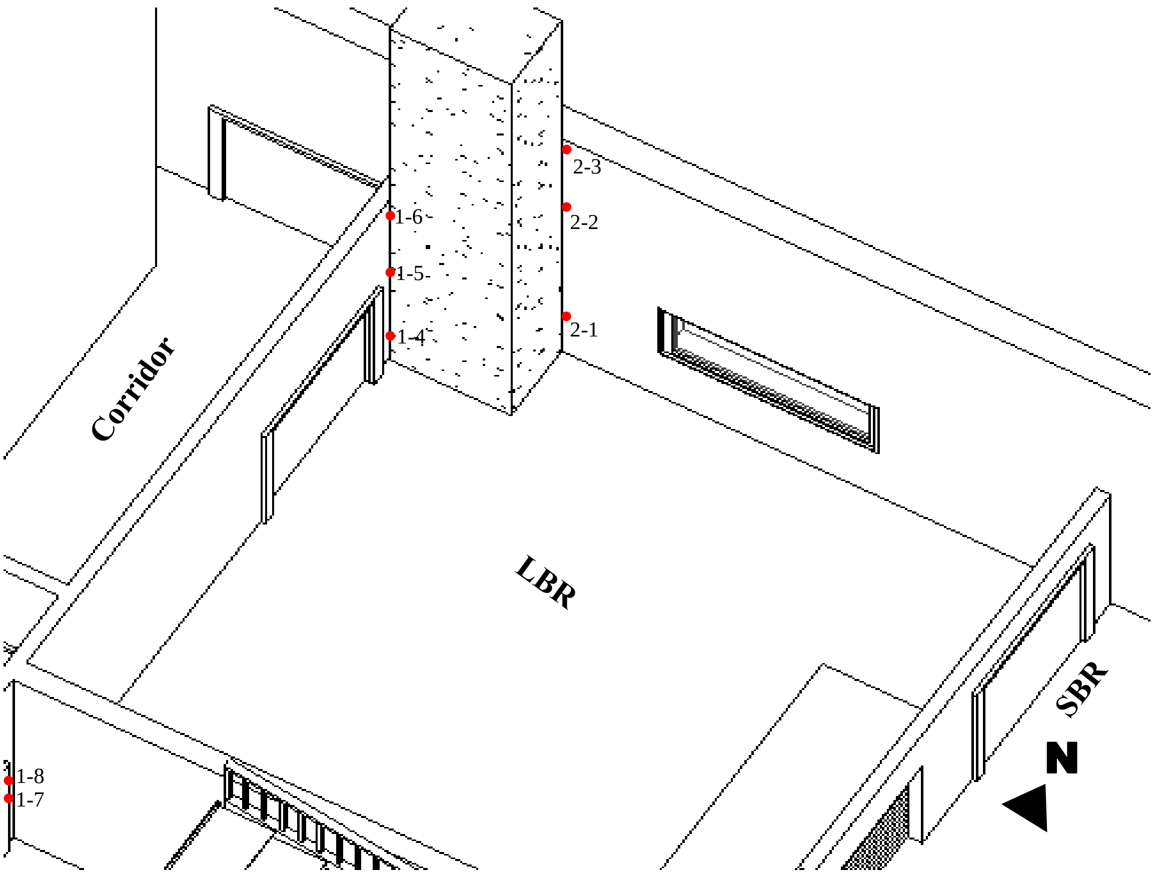


Figure B.13. TC in gaps in LBR column and in SW corner of LBR

Table B.13. LBR column and SW corner of LBR gaps TC list

1-4	(g) On the SW corner gap of the N column, 0.59m (1.9') above floor
1-5	(g) On the SW corner gap of the N column, 2.03m (6.7') above floor
1-6	(g) On the SW corner gap of the N column, 0.1m (03') below ceiling
1-7	(g) SW corner of room, 1.22m (4') above floor, (LBR temp)
1-8	(g) SW corner of room, 1.24m (4.1') above floor (stair landing temp)
2-1	(g) on the NE corner gap of the N column 0.6m (2') above floor
2-2	(g) on the NE corner gap of the N column 2m (6.6') above floor
2-3	(g) on the NE corner gap of the N column 2.7m (8.9') above floor

Thermocouple 1-3 was located above the ceiling on the firestop of the west lighting box of the LBR. Thermocouples 2-4 and 2-5 were located on the northwest corner diffuser tile of the LBR. Thermocouple 3-3 was located above ceiling of the LBR between the north column and west wall of the LBR. Thermocouples 3-4 through 3-6 were located above the ceiling adjacent to the west wall of the LBR. Thermocouples 3-7, 3-8, 6-1 and 6-2 were located above the ceiling adjacent to the north wall of the LBR. The thermocouple locations are shown in Figure B.14 and listed in details in Table B.14.

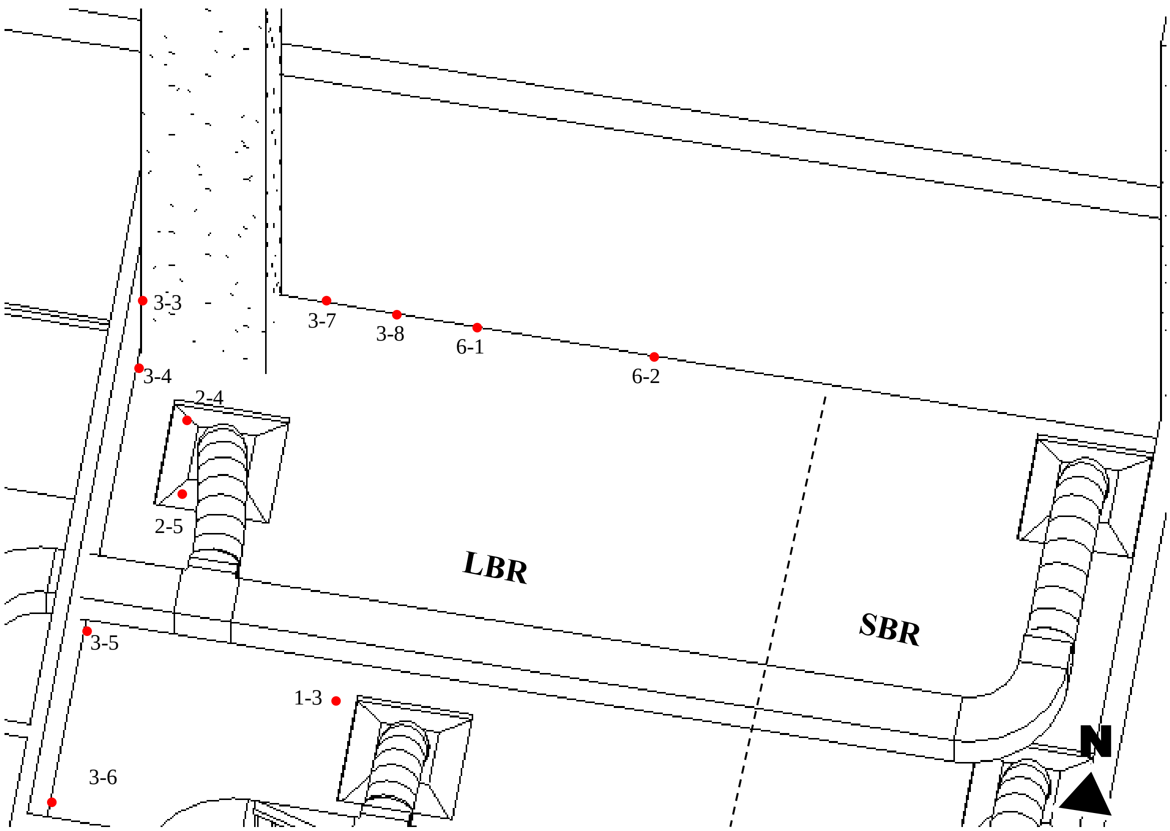


Figure B.14. TC above LBR ceiling

Table B.14. Above LBR ceiling TC list

1-3	(g) above ceiling, SE corner of the W lighting, 2.7m (8.9’) from N wall, 1.4m (4.6’) from W wall
2-4	(s) on the NW corner diffuser
2-5	(s) on the NW corner diffuser
3-3	(g) above ceiling on SW corner gap of the N column, 0.32m (1.1’) above ceiling
3-4	(s) above ceiling of the W wall, 0.13m (0.4’) from N column
3-5	(s) above ceiling of the W wall, 1.5m (4.9’) from S wall
3-6	(s) above ceiling of the W wall, 0.1m (0.3’) from S wall
3-7	(s) above ceiling of the N wall, 0.3m (1’) from N column
3-8	(s) above ceiling of the N wall, 0.7m (2.3’) from N column
6-1	(s) above ceiling of the N wall, 1.2m (3.9’) from N column
6-2	(s) above ceiling of the N wall, 2.4m (7.9’) from N column

Thermocouples 2-6 through 3-2 were located on the firestops on the west wall of the LBR above the ceiling. The thermocouple locations are shown in Figure B.15 and listed in details in Table B.15.

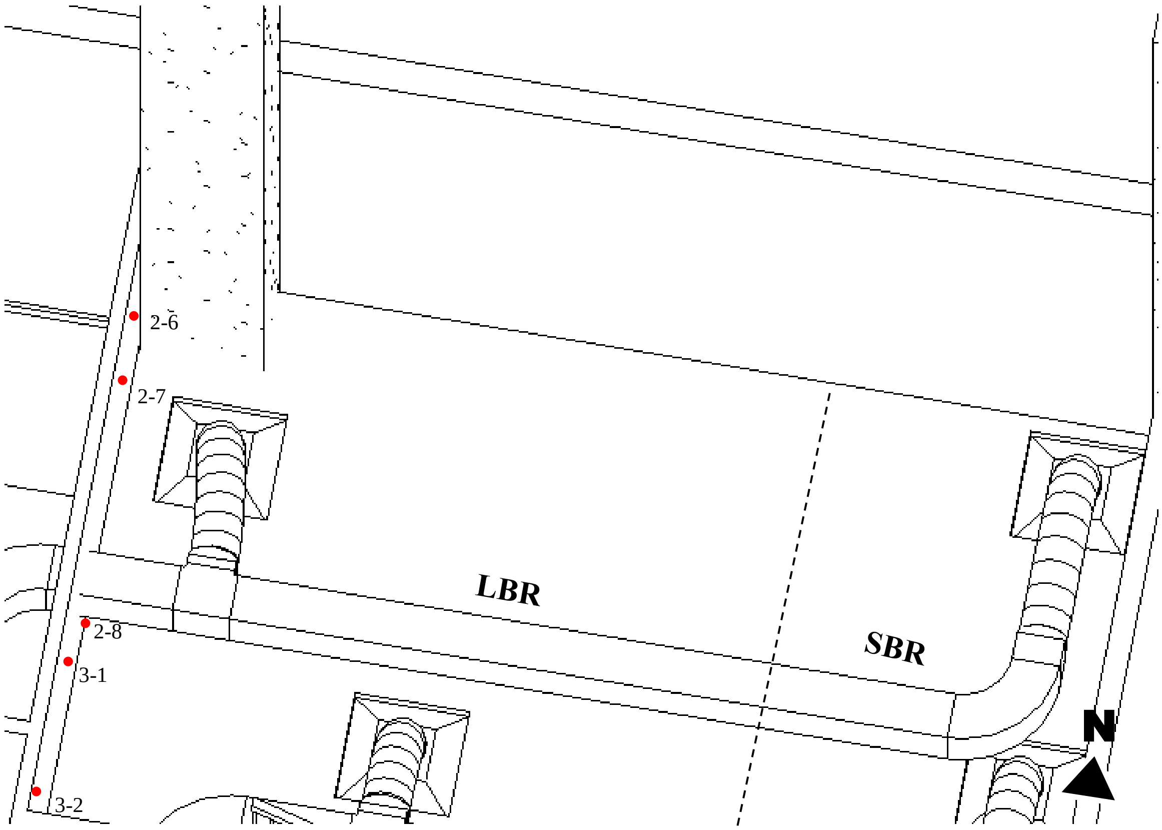


Figure B.15. TC on LBR firestops above ceiling

Table B.15. LBR firestops above ceiling TC list

2-6	(s) above ceiling on firestop, 0.19m (0.6') from N column, 0.37m (1.2') below 4th floor slab
2-7	(s) above ceiling on firestop, 0.52m (1.7') from N column, 0.42m (1.4') below 4th floor slab
2-8	(s) above ceiling on firestop, 1.6m (5.2') from S wall 0.87m (2.9') below 4th floor slab
3-1	(s) above ceiling on firestop, 1.4m (4.6') from S wall, 0.45m (1.5') below 4th floor slab
3-2	(s) above ceiling on firestop, 0.65m (2.1') from S wall, 0.1m (0.3') below 4th floor slab

Thermocouples 4-1 through 5-1 were located in the gap between the partition wall and the north wall of the building. The thermocouple locations are shown in Figure B.16 and listed in details in Table B.16.

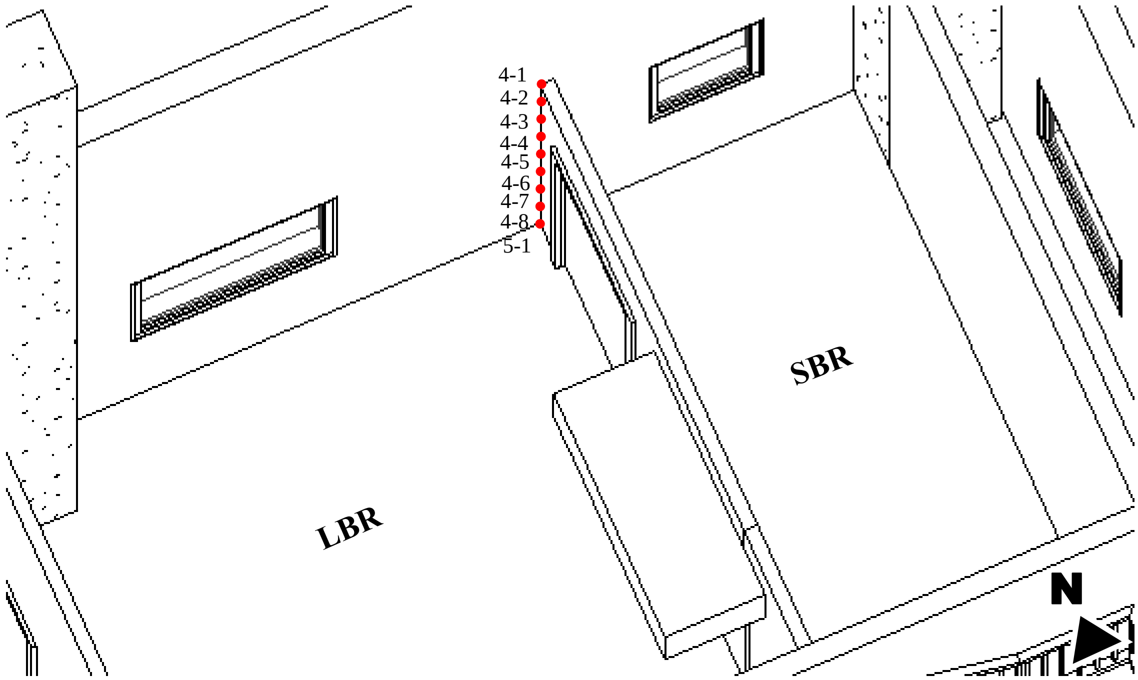


Figure B.16. TC in gap between LBR and N wall of building

Table B.16. Gap between LBR and N wall of building TC list

4-1	(g) NW corner gap of the SBR 2.7m (8.9’) above floor
4-2	(g) NW corner gap of the SBR 2.4m (7.9’) above floor
4-3	(g) NW corner gap of the SBR 2.1m (6.9’) above floor
4-4	(g) NW corner gap of the SBR 1.8m (5.9’) above floor
4-5	(g) NW corner gap of the SBR 1.5m (4.9’) above floor
4-6	(g) NW corner gap of the SBR 1.2m (3.9’) above floor
4-7	(g) NW corner gap of the SBR 0.9m (3’) above floor
4-8	(g) NW corner gap of the SBR 0.6m (2’) above floor
5-1	(g) NW corner gap of the SBR 0.3m (1’) above floor

Thermocouples 5-2 and 5-3 were placed on the door frame of the fire door. Thermocouple 5-4 was located on the fusible link of the fire door and thermocouple 5-5 was located on the gap of the west wall of the SBR above the fire door. Thermocouple 5-6 was located on the door frame of the partition wall between the LBR and SBR Thermocouples 5-7 and 5-8 were located on the LBR and SBR sprinkler heads respectively. The thermocouple locations are shown in Figure B.17 and listed in details in Table B.17.

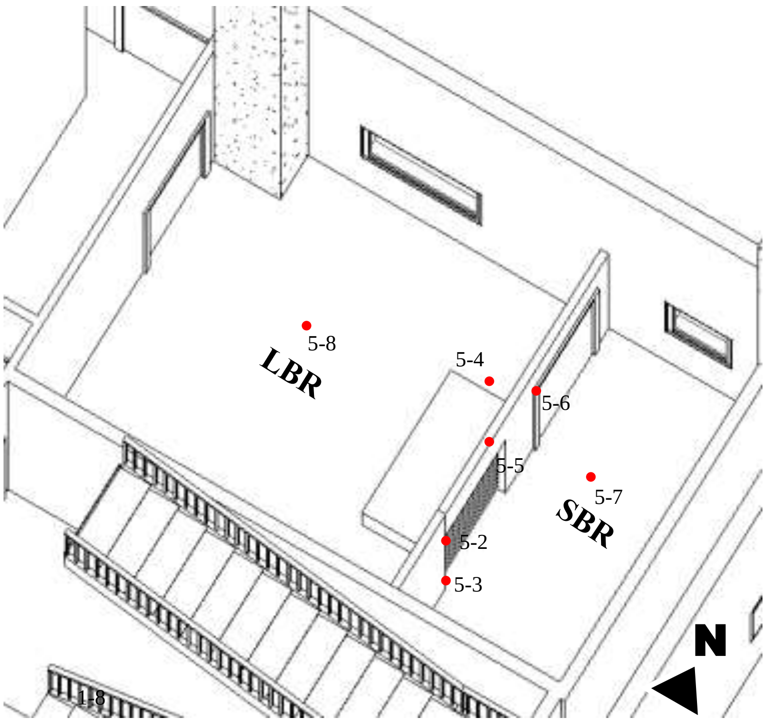


Figure B.17. TC on LBR and SBR fire systems

Table B.17. LBR and SBR fire system TC list

5-2	(g) south part of fire door frame, 1.88m (6.2’) above floor
5-3	(g) south part of fire door frame, 0.3m (1’) above floor
5-4	(s) Fusible link of fire door, 1.5m (4.9’) from N wall, 0.24m (0.8’) below ceiling
5-5	(g) W wall of SBR gap above the fire door, 1.6m (5.2’) from N wall
5-6	Corner of the door frame between the SBR and LBR, 2.1m (6.9’) above floor, 1.1m (3.6’) from N wall
5-7	(s) SBR sprinkler head fusible link 1.3m (4.3’) from N wall, 1.4m (4.6’) from W wall 2.8m (9.2’) above floor
5-8	(s) LBR sprinkler head fusible link, 1.3m (4.3’) from N wall, 1.8m (5.9’) from E wall, 2.8m (9.2’) above floor

Thermocouples 12-1 through 12-4 were located at various cracks on the south wall of the SBR. Thermocouples 12-5 and 12-6 were located on the firestops on the south wall of the SBR. Thermocouple 12-7 was located on the firestop between the 3rd floor slab and the east wall of the SBR joint. Thermocouple 12-8 was located on the southeast corner gap of the SBR. The thermocouple locations are shown in Figure B.18 and listed in details in Table B.18.

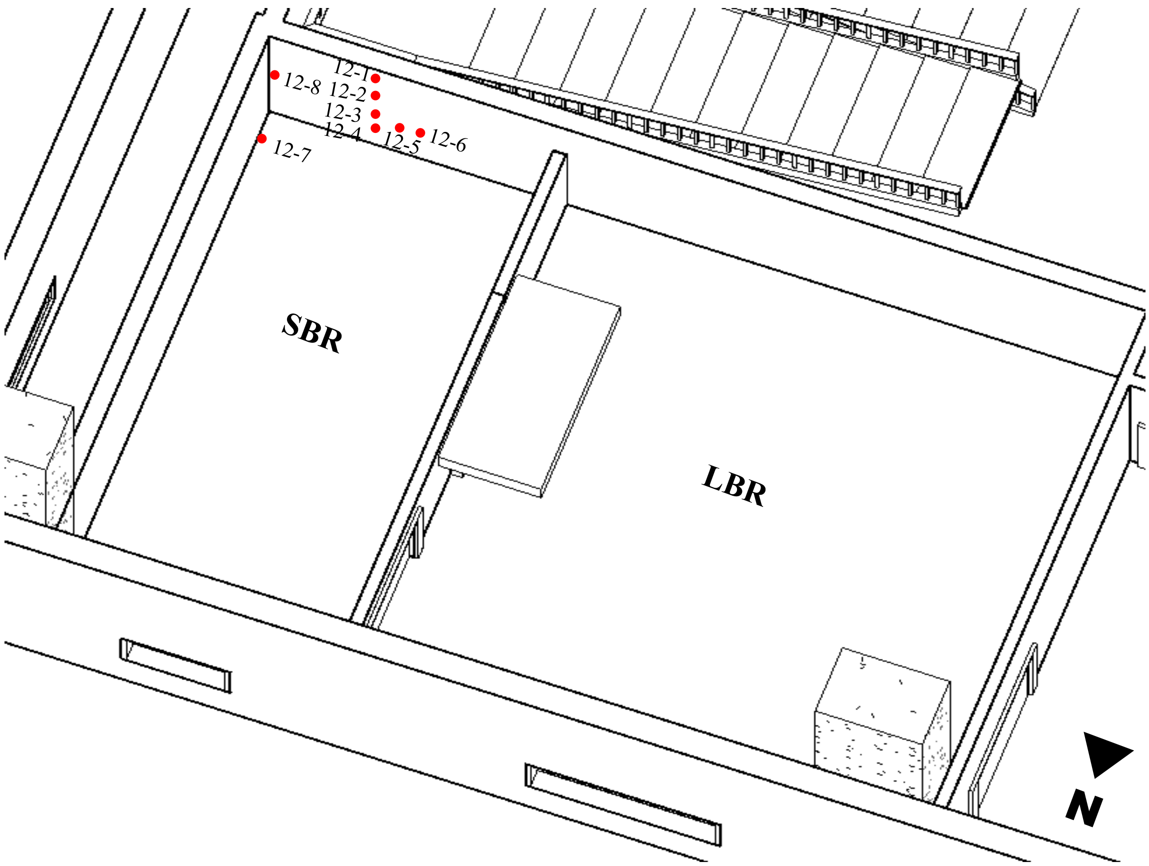


Figure B.18. TC on S wall of SBR

Table B.18. S wall of SBR TC list

12-1	(g) gap on S wall, 1.12m (3.7’) from SW corner, 2.24 (7.3’) above floor
12-2	(g) gap on S wall, 1.12m (3.7’) from SW corner, 1.84m (6’) above floor
12-3	(g) gap on S wall, 1.12m (3.7’) from SW corner 1.16 (3.8’) above floor
12-4	(g) gap on S wall, 1.12m (3.7’) from SW corner, 0.74 (2.4’) above floor
12-5	(g) S wall firestop on opening, 0.99m (3.2’) from SW corner, 0.8m (2.6’) above floor
12-6	(g) S wall firestop on opening, 0.83m (2.7’) from SW corner, 0.81m (2.7’) above floor
12-7	(g) E wall to slab firestop gap, 0.19m (0.6’) from SE corner
12-8	(g) SE corner of SBR, 1.68m (5.5’) above floor

Thermocouples 1-1 and 1-2 were located on the north exterior wall balloon framing of the building. Thermocouples 9-1 through 10-1 were located on the thermocouple tree hanging out of the west of the LBR window. The thermocouple locations are shown in Figure B.19 and listed in details in Table B.19.

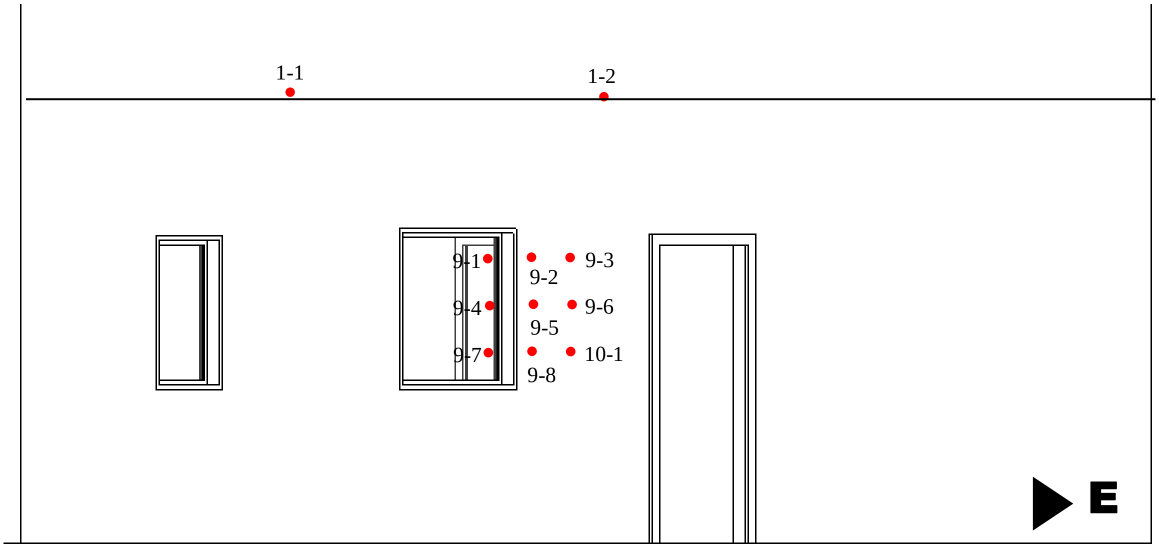


Figure B.19. TC on N wall balloon frame and TC tree hanging out on west of LBR window

Table B.19. List of N wall balloon frame TC and TC tree hanging out on west of LBR window

1-1	(g) NE Balloon Framing from LBR
1-2	(g) NW balloon framing from LBR
9-1	0.25m (10in) from the W side of LBR window frame, spaced 0.3m (1ft) vertically and horizontally
9-2	
9-3	
9-4	
9-5	
9-6	
9-7	
9-8	
10-1	

Thermocouples 10-2 through 11-2 were located on the thermocouple tree hanging out of the east of the LBR window. The thermocouple locations are shown in Figure B.20 and listed in details in Table B.20.

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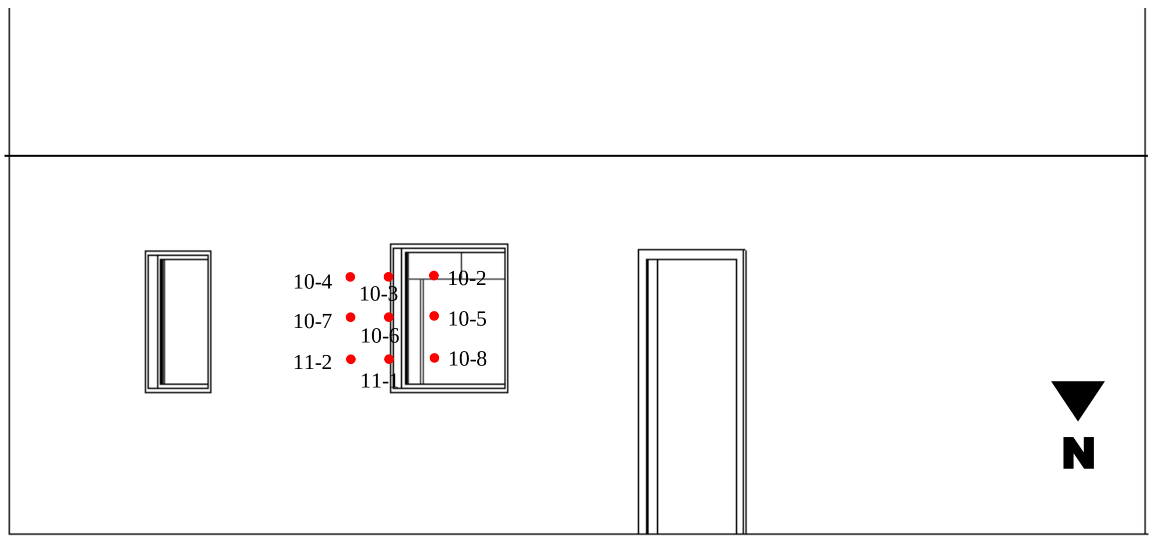

Figure B.20. TC tree hanging out on east of LBR window

Table B.20. TC tree hanging out of east side of LBR window TC list

<table>
<tr><td>10-2</td><td rowspan="9">0.33m (13in) from the E side of LBR window frame, spaced 0.3m (1ft) vertically and horizontally</td></tr>
<tr><td>10-3</td></tr>
<tr><td>10-4</td></tr>
<tr><td>10-5</td></tr>
<tr><td>10-6</td></tr>
<tr><td>10-7</td></tr>
<tr><td>10-8</td></tr>
<tr><td>11-1</td></tr>
<tr><td>11-2</td></tr>
</table>

Thermocouple 11-5 was located in the HVAC duct portion near the damper in the corridor space. Thermocouple 11-6 was located in the HVAC duct portion near the damper in the stair landing area. The thermocouple locations are shown in Figure B.21 and listed in details in Table B.21.

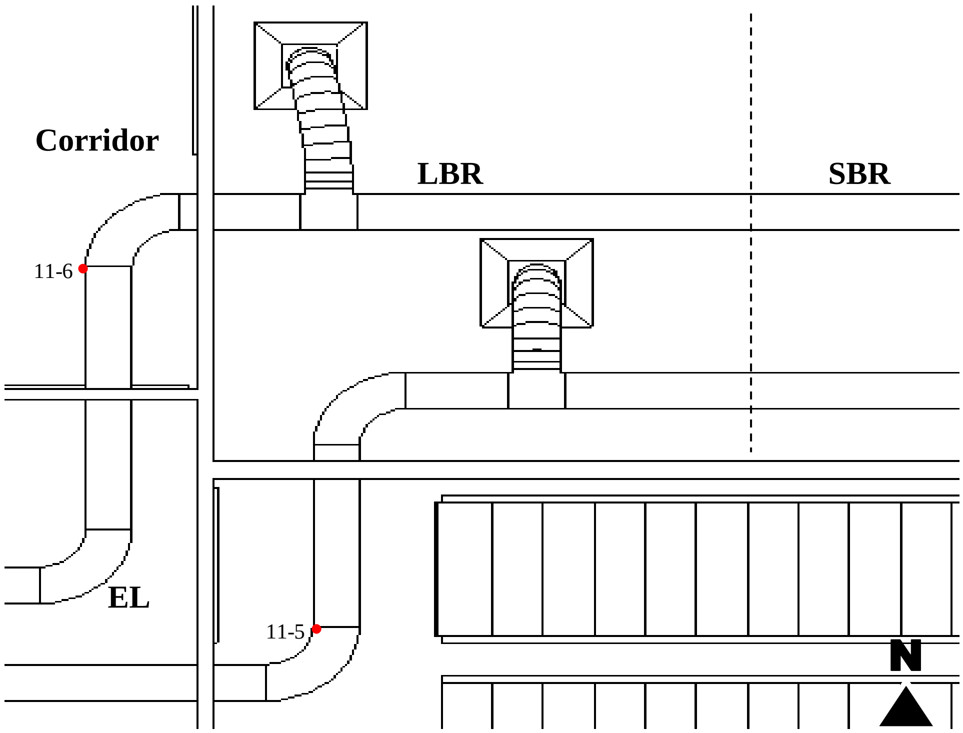

Figure B.21. TC on HVAC duct dampers

Table B.21. HVAC duct dampers TC list

11-5	Damper in the stairwell landing area
11-6	Damper in elevator shaft area

B.4 ES FIRE TEST TC LOCATIONS

A thermocouple tree was located in the corridor east of the shaft and another was located above the ceiling of the LBR. The thermocouple tree in the corridor consisted of thermocouples 9-5 through 12-8. The thermocouple tree in the LBR above the ceiling consisted of thermocouples 6-3 through 6-7. The thermocouple locations are shown in Figure B.22 and listed in details in Table B.22.

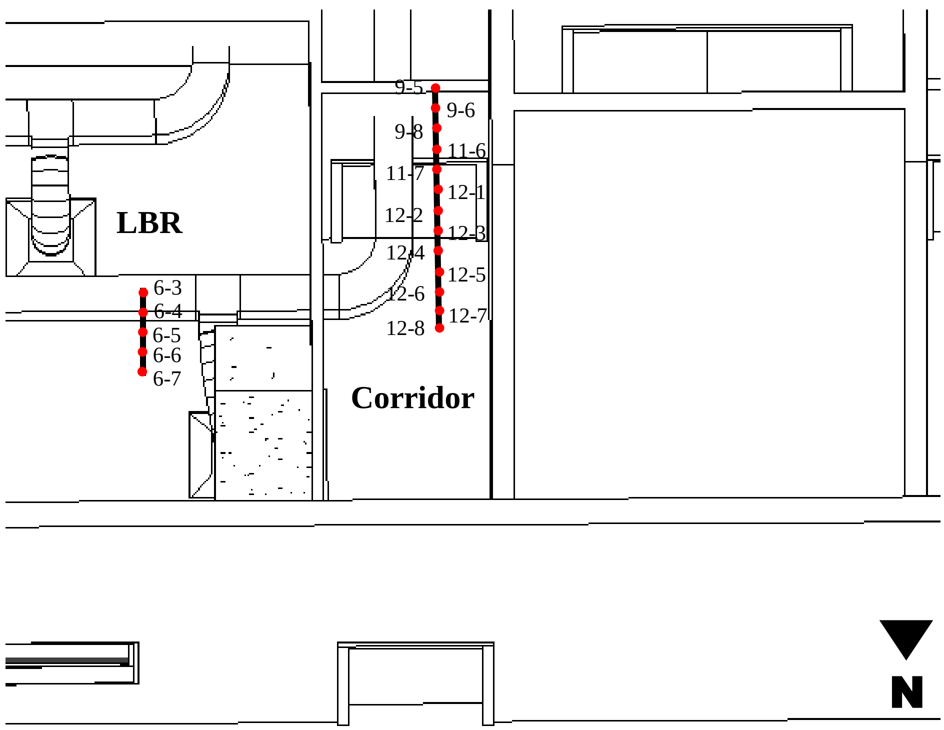

Figure B.22. TC trees in corridor and above LBR ceiling

Table B.22. Corridor and above LBR ceiling TC trees list

9-5	TC tree below 4th floor slab in corridor starting with 12-8 on bottom. 0.3m (1ft) above 3rd floor slab and increasing at 0.3m (1ft) increments to 9-5 on top at 3.9m (12.8ft)
9-6	
9-8	
11-6	
11-7	
12-1	
12-2	
12-3	
12-4	
12-5	
12-6	
12-7	
12-8	
6-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top
6-4	
6-5	
6-6	
6-7	

Thermocouple 1-3 was located above the ceiling on the firestop of the west lighting box of the LBR. Thermocouples 2-4 and 2-5 were located on the northwest corner diffuser tile of the LBR. Thermocouple 3-3 was located above ceiling of the LBR between the north column and west wall of the LBR. Thermocouples 3-4 through 3-6 were located above the ceiling adjacent to the west wall of the LBR. Thermocouples 3-7, 3-8, 6-1 and 6-2 were located above the ceiling adjacent to the north wall of the LBR. The thermocouple locations are shown in Figure B.23 and listed in details in Table B.23.

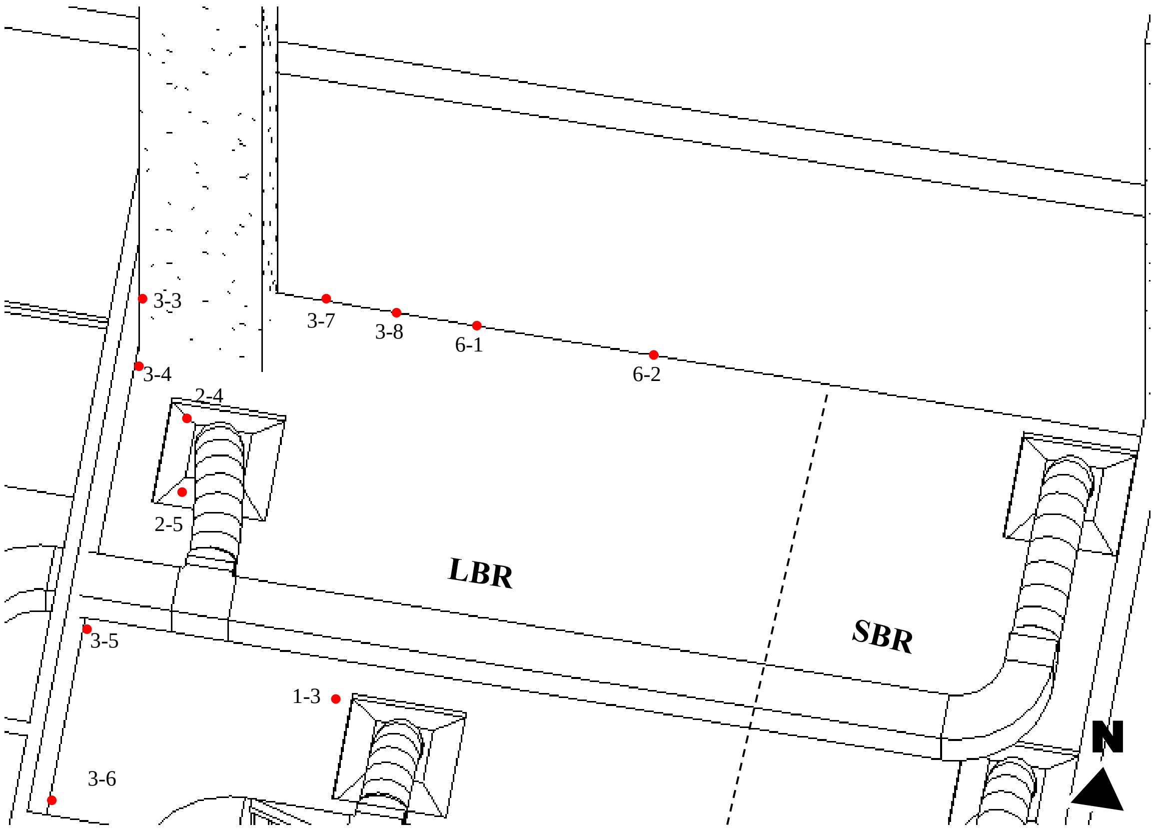

Figure B.23. TC above LBR ceiling

Table B.23. Above LBR ceiling TC list

1-3	(g) above ceiling, SE corner of the W lighting, 2.7m (8.9’) from N wall, 1.4m (4.6’) from W wall
2-4	(s) on the NW corner diffuser
2-5	(s) on the NW corner diffuser
3-3	(g) above ceiling on SW corner gap of the N column, 0.32 (1’) above ceiling
3-4	(s) above ceiling of the W wall, 0.13m (0.4’) from N column
3-5	(s) above ceiling of the W wall, 1.5m (4.9’) from S wall
3-6	(s) above ceiling of the W wall, 0.1m (0.3’) from S wall
3-7	(s) above ceiling of the N wall, 0.3m (1’) from N column
3-8	(s) above ceiling of the N wall, 0.7m (2.3’) from N column
6-1	(s) above ceiling of the N wall, 1.2m (3.9’) from N column
6-2	(s) above ceiling of the N wall, 2.4m (7.9’) from N column

Thermocouples 1-4 to 1-6 and 2-1 to 2-3 were placed in gaps formed between the north column and the west and north walls of the LBR. Thermocouples 1-7 and 1-8 were located in the cracks formed on the south wall of the LBR. The thermocouple locations are shown in Figure B.24 and listed in details in Table B.24.

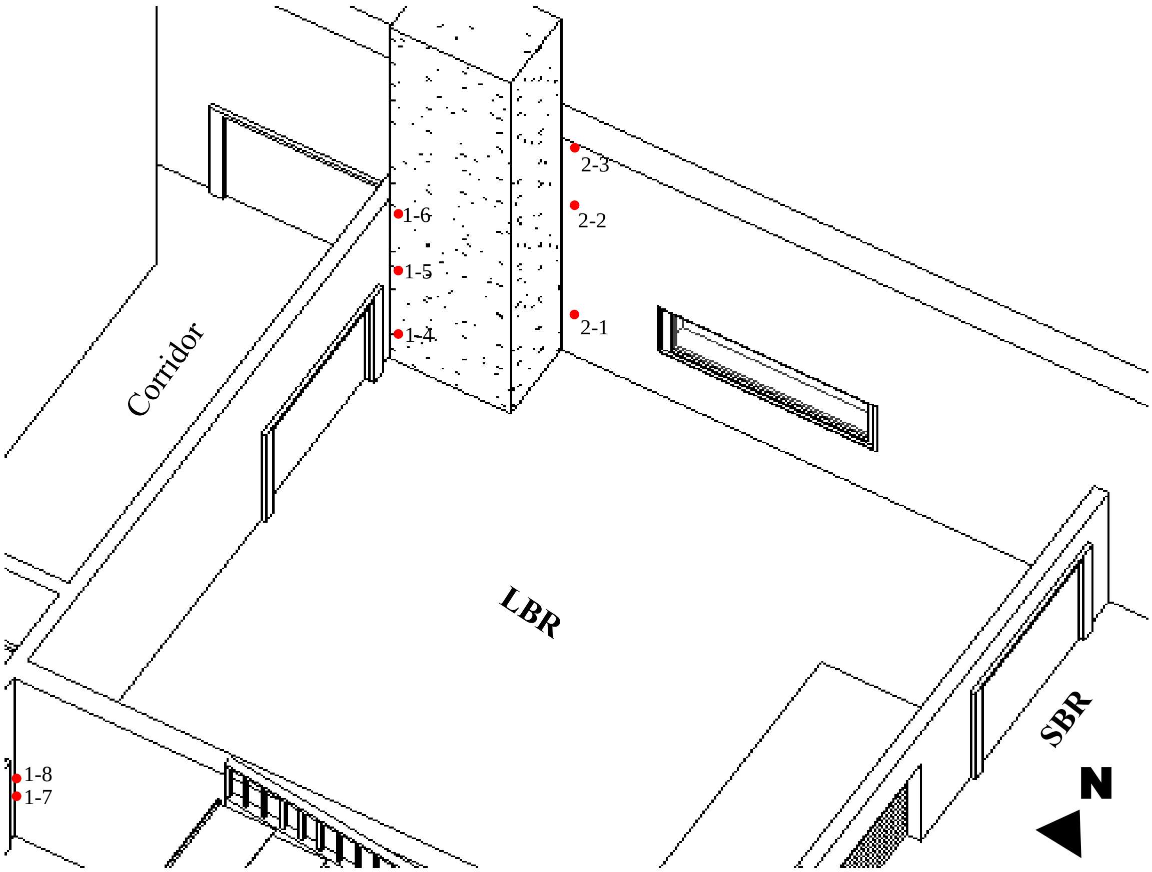

Figure B.24. TC on LBR SW corner and column gap

Table B.24. LBR SW corner and column gap TC list

1-4	(g) On the SW corner gap of the N column, 0.59m (1.9’) above floor
1-5	(g) On the SW corner gap of the N column, 2.03m (6.7’) above floor
1-6	(g) On the SW corner gap of the N column, 0.1m (0.3’) below ceiling
1-7	(g) SW corner of room, 1.22m (4’) above floor, (LBR temp)
1-8	(g) SW corner of room, 1.24m (4.1’) above floor (stair landing temp)
2-1	(g) on the NE corner gap of the N column 0.6m (2’) above floor
2-2	(g) on the NE corner gap of the N column 2m (6.6’) above floor
2-3	(g) on the NE corner gap of the N column 2.7m (8.9’) above floor

Thermocouples 2-6 through 3-2 were located on the firestops on the west wall of the LBR above the ceiling. Thermocouples 4-1 through 4-5 were located on the opposite side of the same firestops from the corridor side which is shown in parentheses on the respective firestops. The thermocouple locations are shown in Figure B.25 and listed in details in Table B.25.

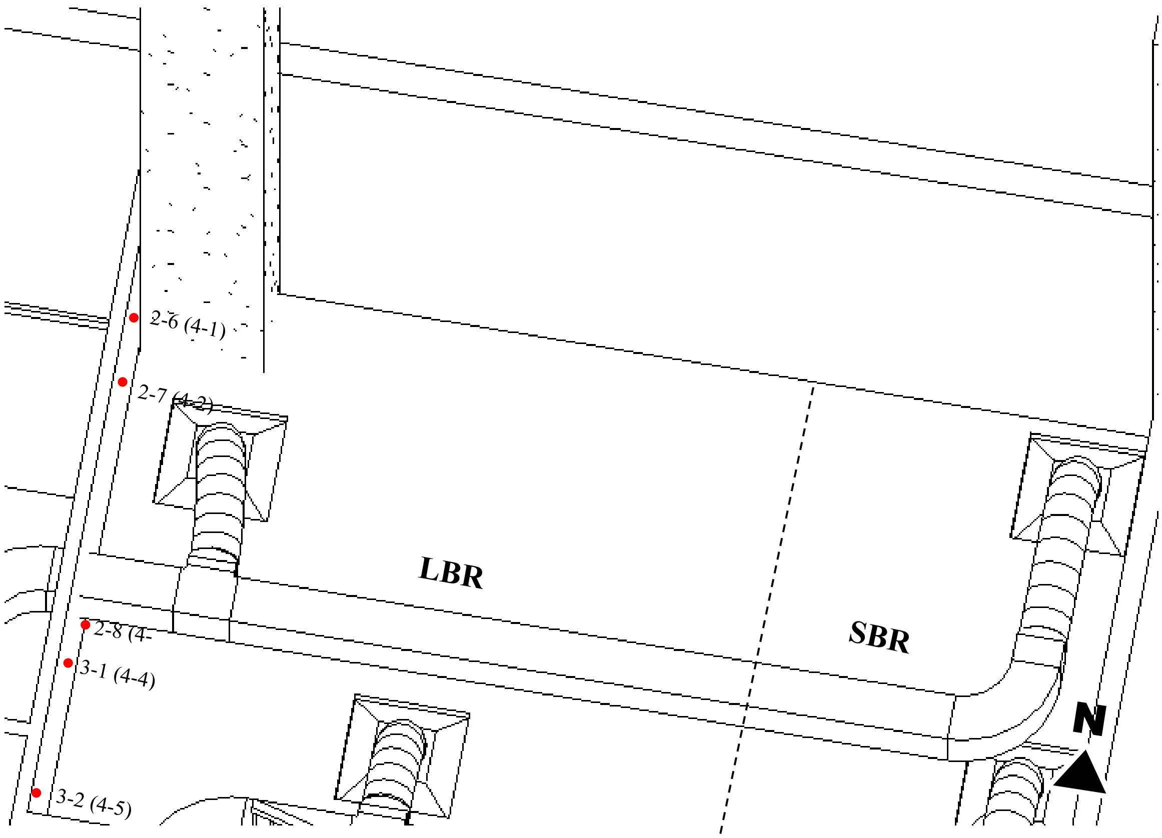

Figure B.25. TC on both sides of the firestops above LBR ceiling

Table B.25. LBR above ceiling firestops TC list

2-6	(s) above ceiling on firestop, 0.19m (0.6’) from N column, 0.37m (1.2’) (below 4th floor slab
2-7	(s) above ceiling on firestop, 0.52m (1.7’) from N column 0.42m (1.4’) below 4th floor slab
2-8	(s) above ceiling on firestop, 1.6m (5.2’) from S wall 0.87m (2.9’) below 4th floor slab
3-1	(s) above ceiling on firestop, 1.4m (4.6’) from S wall 0.45m (1.5’) below 4th floor slab
3-2	(s) above ceiling on firestop, 0.65m (2.1’) from S wall 0.1m (0.3’) below 4th floor slab
4-1	(s) firestop on E wall of corridor, 3.4m (11.1’) above floor 0.6m (2’) from N wall of building
4-2	(s) firestop on E wall of corridor, 3.4m (11.1’) above floor 1.1m (3.6’) from N wall of building
4-3	(s) firestop on E wall of corridor, 0.86m (2.8’) below 4th floor slab, 1.05m (3.4’) from corridor S wall
4-4	(s) firestop on E wall of corridor, 0.38m (1.2’) below 4th floor slab, 0.9m (3’) from S wall of corridor
4-5	(s) firestop on E wall of corridor, 0.06m (0.2’) below 4th floor slab, 0.06m (0.2’) from S wall of corridor

Thermocouples 4-6 through 4-8 were located on the firestops located on the south wall of the corridor. Thermocouples 5-1 and 5-2 were located on the north wall of the shaft. Thermocouples 5-3 through 5-5 were located on the north wall of the building. The thermocouple locations are shown in Figure B.26 and listed in detail in Table B.26.

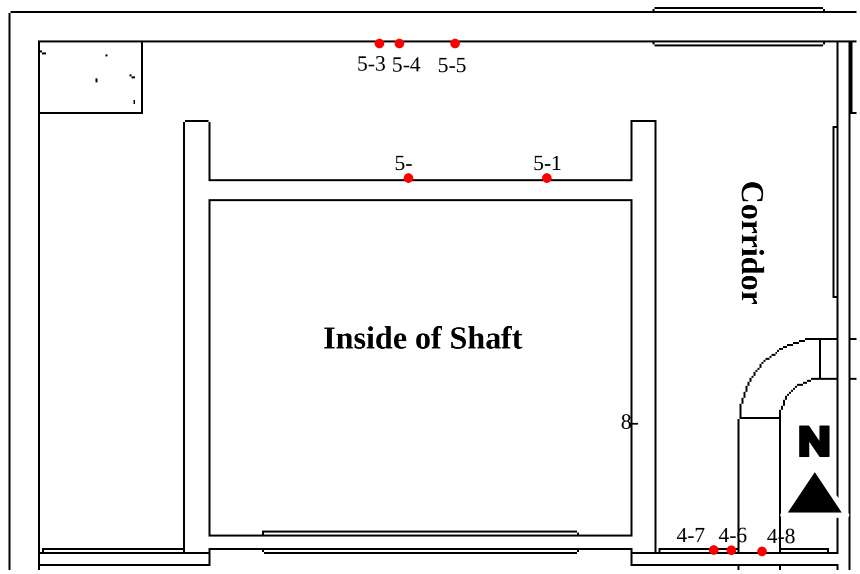

Figure B.26. TC on S wall of corridor firestops and north of elevator shaft

Table B.26. S wall of corridor firestops TC list

4-6	(s) firestop on S wall of corridor, .05m (0.2') below 4th floor slab, 0.66m (2.2') from E wall of corridor
4-7	(s) firestop on S wall of corridor, 0.3m (1') below 4th floor slab, 0.6m (2') from E wall of corridor
4-8	(s) firestop on S wall of corridor, 0.09m (0.3') below 4th floor slab, 0.48m (1.6') from E wall of corridor
5-1	(g) N wall of shaft, 4.1m (13.4') above floor, 0.8m (2.6') from E wall of shaft
5-2	(g) N wall of shaft, 4.1m (13.4') above floor, 2.1m (6.9') from E wall of shaft
5-3	(g) N wall of building, 2.5m (8.2') above floor, 1.8m (5.9') from NW corner column of building
5-4	(g) N wall of building, 4.2m (13.8') above floor/1.8m from NW corner column of building
5-5	(g) N wall of building, 4.2m (13.8') above floor, 2.8m (9.2') from NW corner column of building

Thermocouples 7-1 through 7-7 were located on the 4th floor slab vertical firestops on the north side of the elevator shaft. Thermocouple 7-8 was located on the concrete surface. The thermocouple locations are shown in Figure B.27 and listed in details in Table B.27.

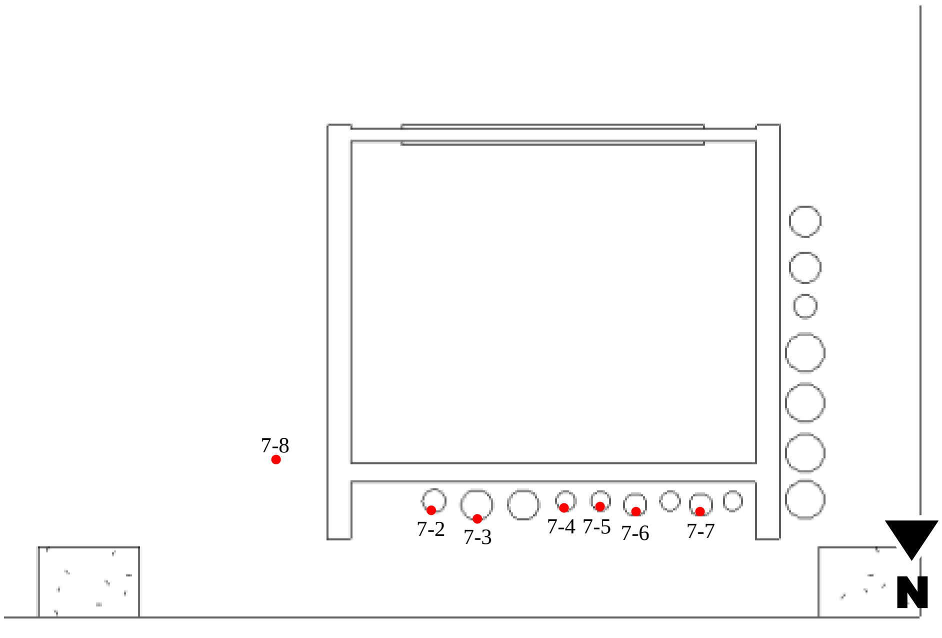

Figure B.27. TC on 4th floor firestops N of shaft

Table B.27. 4th floor firestops N of shaft TC list

7-1	(g) Inside shaft from NE corner of shaft on 4th floor slab level
7-2	(s) N wall of shaft openings/firestop, 0.33m (1.1') from E wall of shaft
7-3	(s) N wall of shaft openings/firestop, 0.57m (1.9') from E wall of shaft
7-4	(s) N wall of shaft openings/firestop, 1.05m (3.4') from E wall of shaft
7-5	(s) N wall of shaft openings/firestop, 1.40m (4.6') from E wall of shaft
7-6	(s) N wall of shaft openings/firestop, 1.60m (5.2') from E wall of shaft
7-7	(g) N wall of shaft openings/firestop, 2.1m (6.9') from E wall of shaft
7-8	(s) concrete slab temperature, 1.87m (6.1') from N wall of building, 0.62m (2') from E wall of elevator shaft, east side of the space around elevator shaft

Thermocouples 8-1 and 8-2 were located on the vents on the EL in the 4th floor. Thermocouples 8-3 through 8-8 were located on the 4th floor slab vertical firestops on the north side of the elevator shaft. The thermocouple locations are shown in Figure B.28 and listed in details in Table B.28.

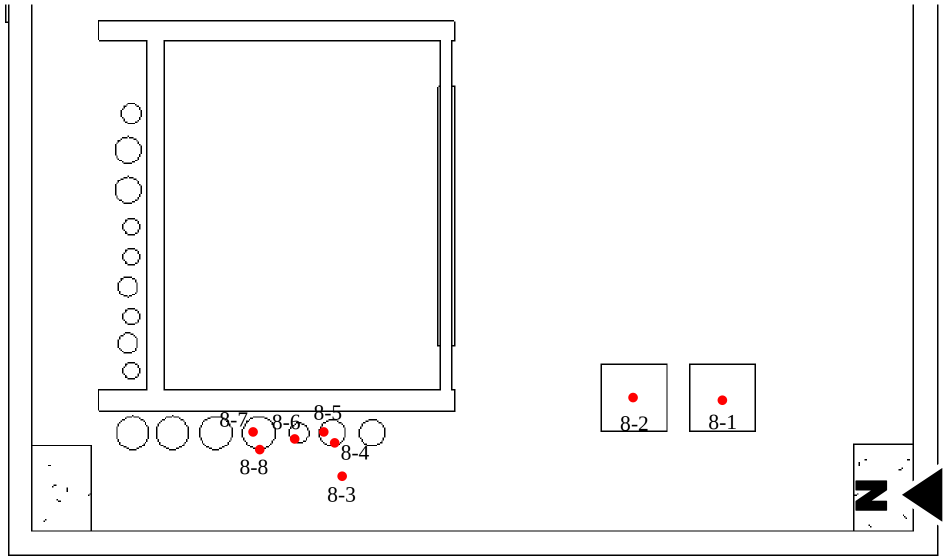

Figure B.28. TC on 4th floor vents and W of shaft firestops

Table B.28. 4th floor vents and W of shaft firestops TC list

8-1	(g) S vent on 4th floor west of elevator shaft, 5m (16.4’) from N wall of building
8-2	(g) N vent on 4th floor west of elevator shaft, 4.2m (13.8’) from N wall of building
8-3	(s) concrete slab temp of west side of elevator shaft
8-4	(s) sprinkler pipe
8-5	(s) sprinkler pipe firestop gap
8-6	(s) mineral wool on 4th opening from NW corner of building, 2.3m (7.5’) from N wall of building
8-7	(s) Mineral wool on 3rd opening from NW corner of building, 1.8m (5.9’) from N wall of building
8-8	(s) Firestop on 3rd opening from NW corner of building, 1.5m (4.9’) from N wall of building

Thermocouples 1-1, 1-2, 9-1 and 9-1 were located on the north exterior balloon framing of the building. Thermocouples 9-3 and 9-4 were located on the west exterior balloon framing of the building. The thermocouple locations are shown in Figure B.29 and listed in details in Table B.29.

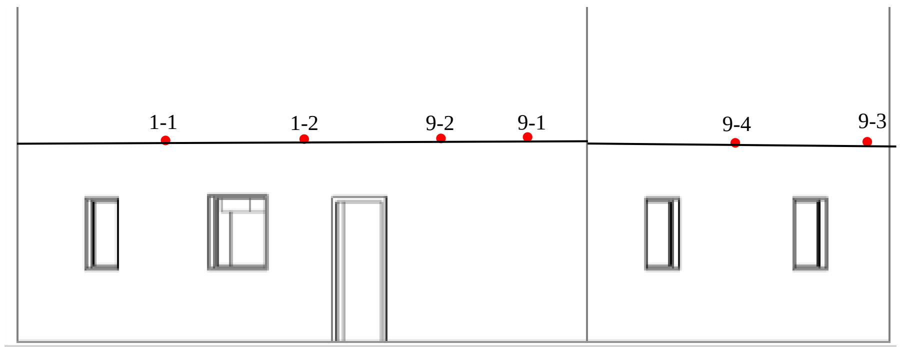

Figure B.29. TC on N and W exterior balloon framing walls

Table B.29. N and W exterior balloon framing TC list

1-1	(g) NE Balloon Framing from LBR
1-2	(g) NW balloon framing from LBR
9-1	(g) W side of N wall of building
9-2	(g) E side of N wall of building
9-3	(g) S side of W wall of building
9-4	(g) N side of W wall of building

Thermocouples 10-1 through 11-5 were located inside the elevator shaft from the 3rd to the 5th floor. The thermocouple locations are shown in Figure B.30 and listed in details in Table B.30.

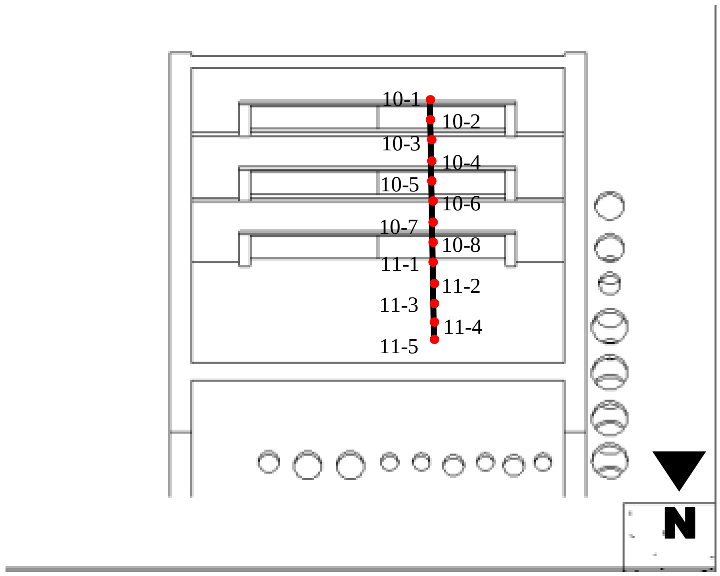

Figure B.30. TC inside elevator shaft from 5th to 3rd floor

Table B.30. Inside elevator shaft from 5th to 3rd floor TC list

10-1	TC tree inside elevator shaft hanging down from the roof with 10-1 being 0.25m (10in) below the roof and decreasing at 0.9m (3ft) increments ending with 11-5 being 0.66m (2.2ft) above the 3rd floor slab
10-2	
10-3	
10-4	
10-5	
10-6	
10-7	
10-8	
11-1	
11-2	
11-3	
11-4	
11-5	

B.5 EL-1 AND EL-2 FIRE TESTS TC LOCATIONS

A thermocouple tree was located in the southwest corner of the EL and another one in front of the shaft door as shown in Figure B.31. The thermocouple tree in front of the shaft door consisted of thermocouples from 3-7 through 4-8. The southwest corner thermocouple tree consisted of thermocouples 9-1 through 10-2. The thermocouple locations are shown in Figure B.31 and listed in details in Table B.31.

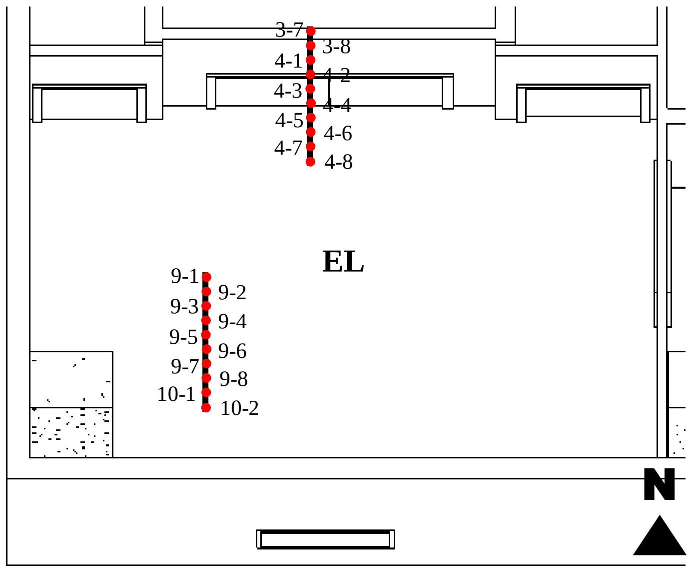

Figure B.31. TC trees in EL

Table B.31. EL TC trees list

<table>
<tr><td>3-7</td><td rowspan="10">TC tree in front of shaft door below ceiling of EL starting with 4-8 starting on the floor slab and increasing by 0.3m (1ft) increments to 3-7 on top at 2.7m (8.9ft)</td></tr>
<tr><td>3-8</td></tr>
<tr><td>4-1</td></tr>
<tr><td>4-2</td></tr>
<tr><td>4-3</td></tr>
<tr><td>4-4</td></tr>
<tr><td>4-5</td></tr>
<tr><td>4-6</td></tr>
<tr><td>4-7</td></tr>
<tr><td>4-8</td></tr>
<tr><td>9-1</td><td rowspan="10">TC tree in SW corner of EL below ceiling, starting with 10-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 9-1 on top at 2.7m (8.9ft)</td></tr>
<tr><td>9-2</td></tr>
<tr><td>9-3</td></tr>
<tr><td>9-4</td></tr>
<tr><td>9-5</td></tr>
<tr><td>9-6</td></tr>
<tr><td>9-7</td></tr>
<tr><td>9-8</td></tr>
<tr><td>10-1</td></tr>
<tr><td>10-2</td></tr>
</table>

Two thermocouple trees were located in the EL above the ceiling in the fire tests as shown in Figure B.32. The thermocouple tree with thermocouples 3-1 through 3-5 was installed above the ceiling of the northwest corner of the EL area. The thermocouple tree with thermocouples 5-1 through 5-5 was installed above the ceiling of the southeast corner of the EL area. The heights of the thermocouples are listed in Table B.32.

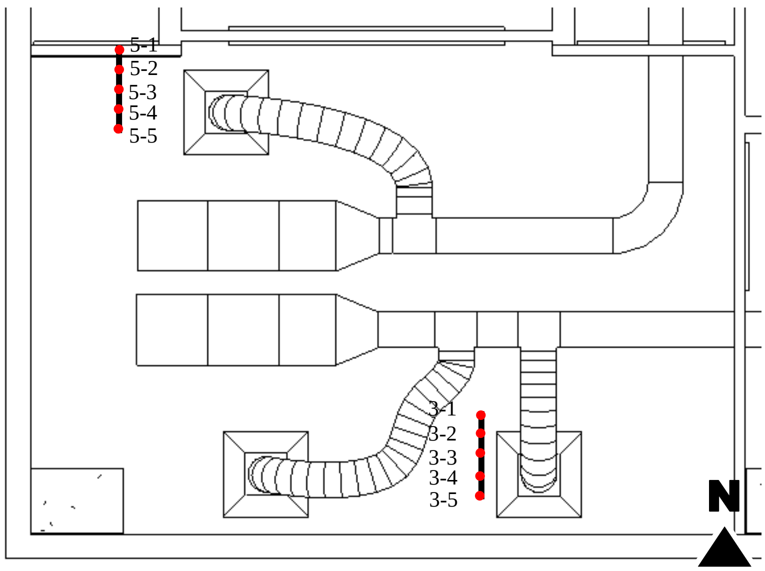

Figure B.32. TC trees above EL ceiling

Table B.32. EL above ceiling TC trees list

3-1	TC tree hanging from 4th floor slab above ceiling SE EL starting with 3-5 right above ceiling and increasing in 0.3m (1ft) increments to 3-1 being on top
3-2	
3-3	
3-4	
3-5	
5-1	TC tree hanging from 4th floor slab above ceiling NW EL starting with 5-5 right above ceiling and increasing in 0.3m (1ft) increments to 5-1 being on top
5-2	
5-3	
5-4	
5-5	

Thermocouples 1-1 through 2-2 were located inside the elevator shaft from the 3rd to the 5th floor. The thermocouple locations are shown in Figure B.33 and listed in details in Table B.33.

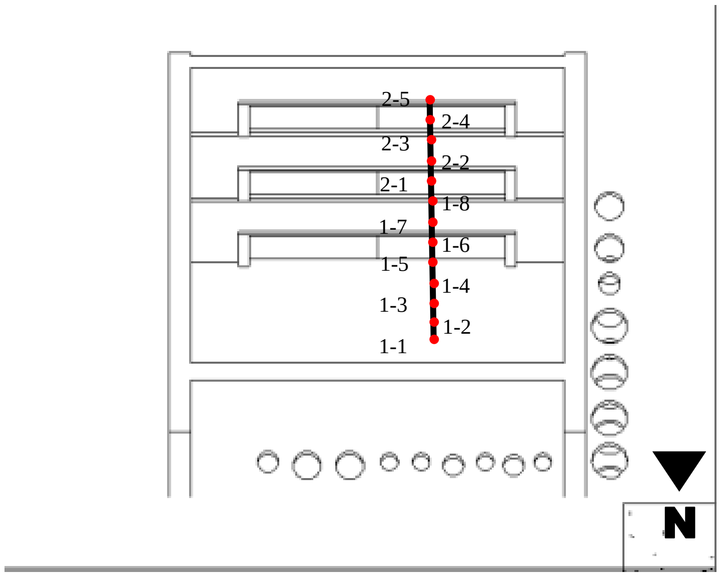

Figure B.33. TC inside elevator shaft from 5th to 3rd floor

Table B.33. Inside elevator shaft from 5th to 3rd floor TC list

<table>
<tr><td>1-1</td><td rowspan="13">TC tree inside elevator shaft hanging down from the roof with 10-1 being 0.25m (10in) below the roof and decreasing at 0.9m (3ft) increments ending with 11-5 being 0.66m (2.2ft) above the 3rd floor slab</td></tr>
<tr><td>1-2</td></tr>
<tr><td>1-3</td></tr>
<tr><td>1-4</td></tr>
<tr><td>1-5</td></tr>
<tr><td>1-6</td></tr>
<tr><td>1-7</td></tr>
<tr><td>1-8</td></tr>
<tr><td>2-1</td></tr>
<tr><td>2-2</td></tr>
<tr><td>2-3</td></tr>
<tr><td>2-4</td></tr>
<tr><td>2-5</td></tr>
</table>

Thermocouples 7-1 and 7-2 were located on the south exterior balloon framing of the building. Thermocouples 7-3 and 7-4 were located on the west exterior balloon framing of the building. The thermocouple locations are shown in Figure B.34 and listed in details in Table B.34.

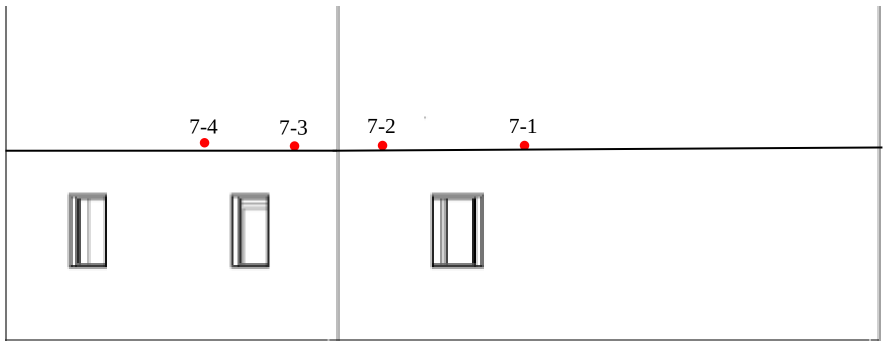

Figure B.34. TC on S and W exterior balloon framing walls

Table B.34. S and W exterior balloon framing walls TC list

7-1	Balloon framing south wall East
7-2	Balloon framing south wall west
7-3	Balloon framing west wall south
7-4	Balloon framing west wall north

Thermocouple 12-7 was located on the north vent of the 4th floor. Thermocouple 12-8 was located in the HVAC duct near the fire damper in the stair landing area. The thermocouple locations are shown in Figure B.35 and listed in details in Table B.35.

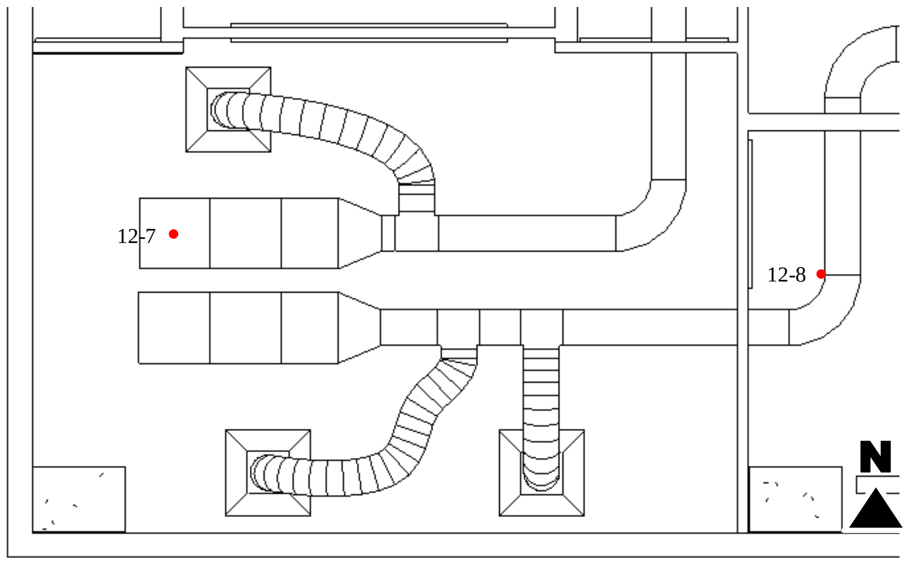

Figure B.35. TC in HVAC duct damper and 4th floor vent

Table B.35. HVAC duct damper and 4th floor vent TC list

12-7	Vent temperature in the fourth floor
12-8	TC in the duct of the stairwell landing

C FIRE TEST RESULTS

C.1 LBR-1 FIRE TEST TEMPERATURES

C.1.1 Thermocouple Trees

Figure C.1 shows the TC trees that were placed in the LBR and the SBR. Figure C.2 shows the TC trees that were placed above the ceiling of the LBR and SBR.

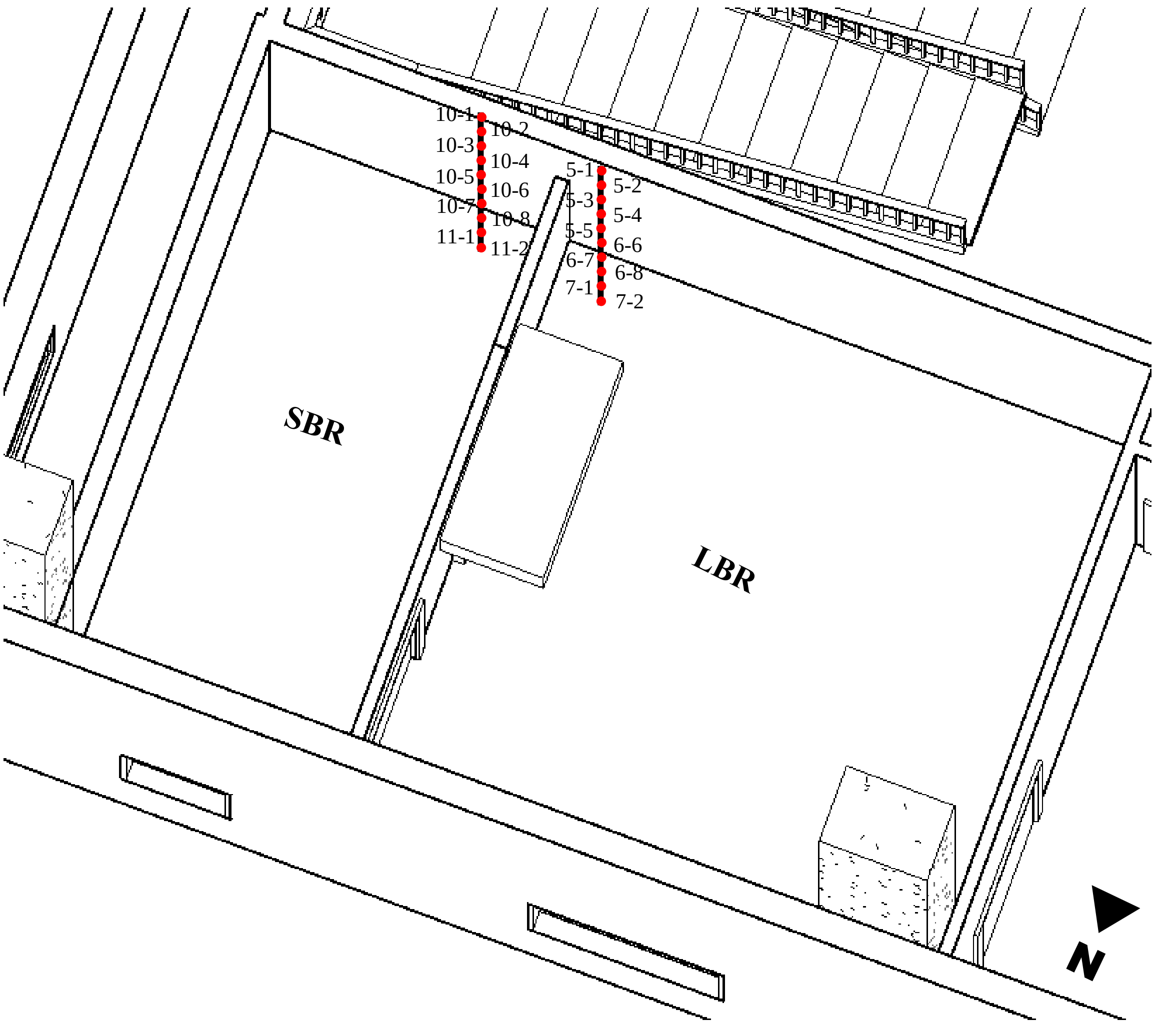

Figure C.1. TC Trees in the SBR and LBR

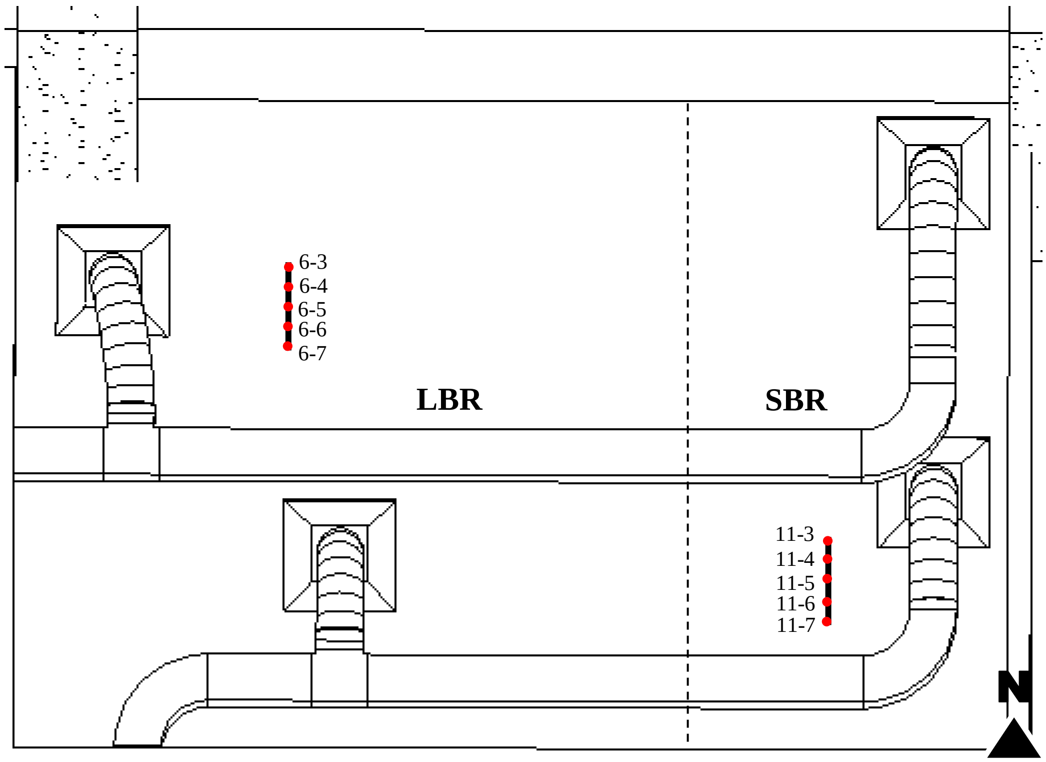

Figure C.2. TC trees above ceiling of LBR and SBR

Figure C.3 shows the temperatures recorded by the thermocouple trees in the LBR and space above the LBR ceiling. The thermocouple location details are listed in Table C.1.

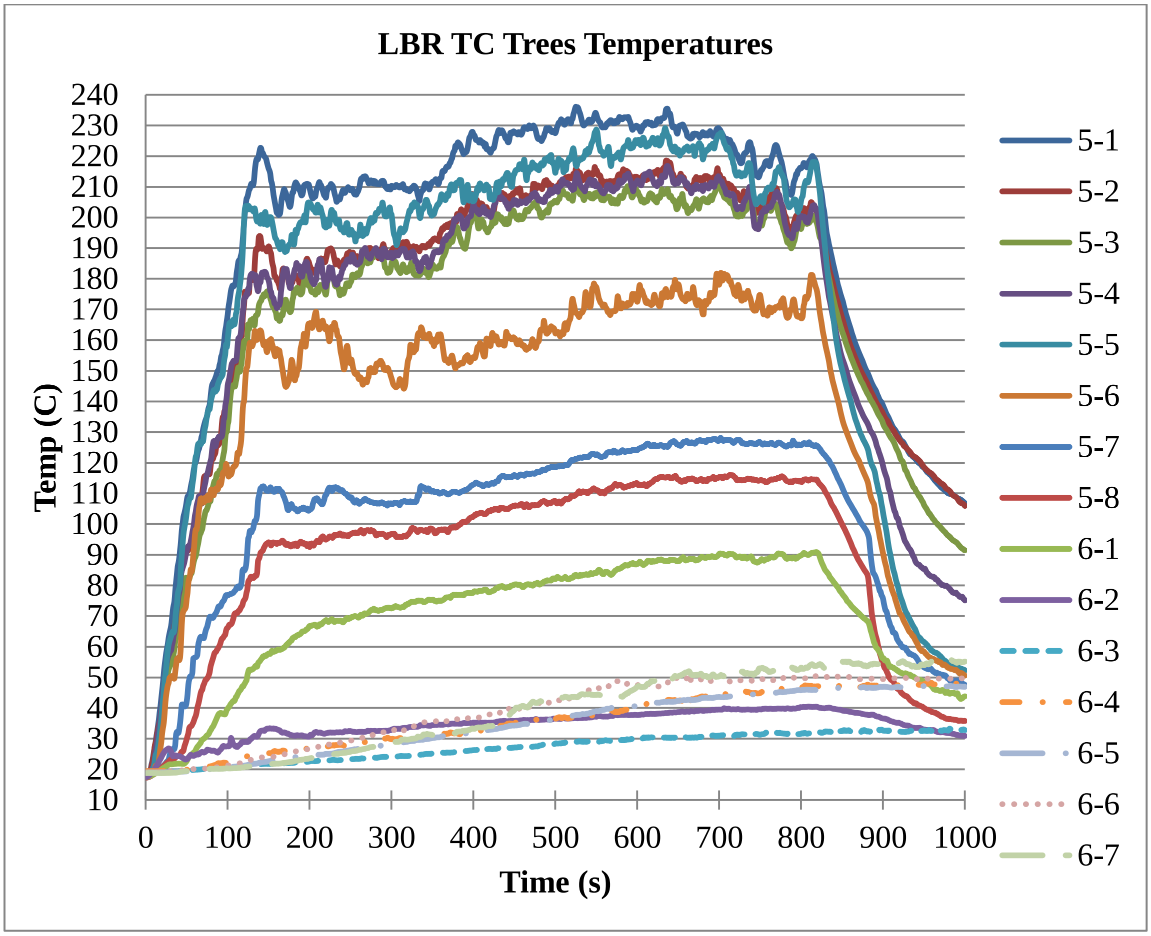

Figure C.3. LBR and space above LBR ceiling temperatures

Table C.1. LBR TC trees list

<table>
<tr><td>5-1</td><td rowspan="10">TC tree below ceiling of LBR starting with 6-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 5-1 on top at 2.7m (8.9ft)</td></tr>
<tr><td>5-2</td></tr>
<tr><td>5-3</td></tr>
<tr><td>5-4</td></tr>
<tr><td>5-5</td></tr>
<tr><td>5-6</td></tr>
<tr><td>5-7</td></tr>
<tr><td>5-8</td></tr>
<tr><td>6-1</td></tr>
<tr><td>6-2</td></tr>
<tr><td>6-3</td><td rowspan="5">TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top</td></tr>
<tr><td>6-4</td></tr>
<tr><td>6-5</td></tr>
<tr><td>6-6</td></tr>
<tr><td>6-7</td></tr>
</table>

Figure C.4 shows the temperatures recorded by the thermocouple trees in the SBR and space above the SBR ceiling. The thermocouple location details are listed in Table C.2.

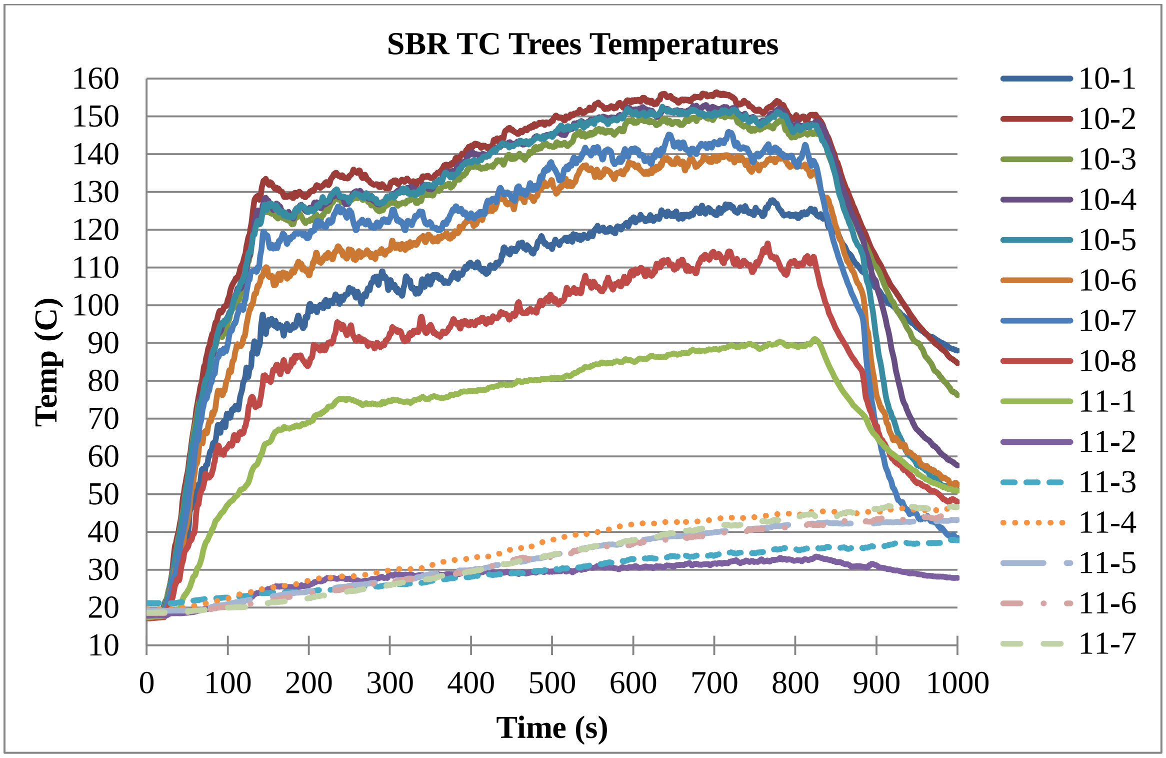

Figure C.4. SBR and space above SBR ceiling temperatures

Table C.2. SBR TC trees list

10-1	TC tree below ceiling of LBR starting with 11-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 10-1 on top at 2.7m (8.9ft)
10-2	
10-3	
10-4	
10-5	
10-6	
10-7	
10-8	
11-1	
11-2	
11-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 11-7 right above ceiling and increasing in 0.3m (1ft) increments to 11-3 being on top
11-4	
11-5	
11-6	
11-7	

C.1.3 LBR Column Gap

Figure C.5 shows the thermocouples that were located in the gaps formed between the north column and west and north walls of the LBR and the thermocouples that were located in the cracks formed on the south wall of the LBR.

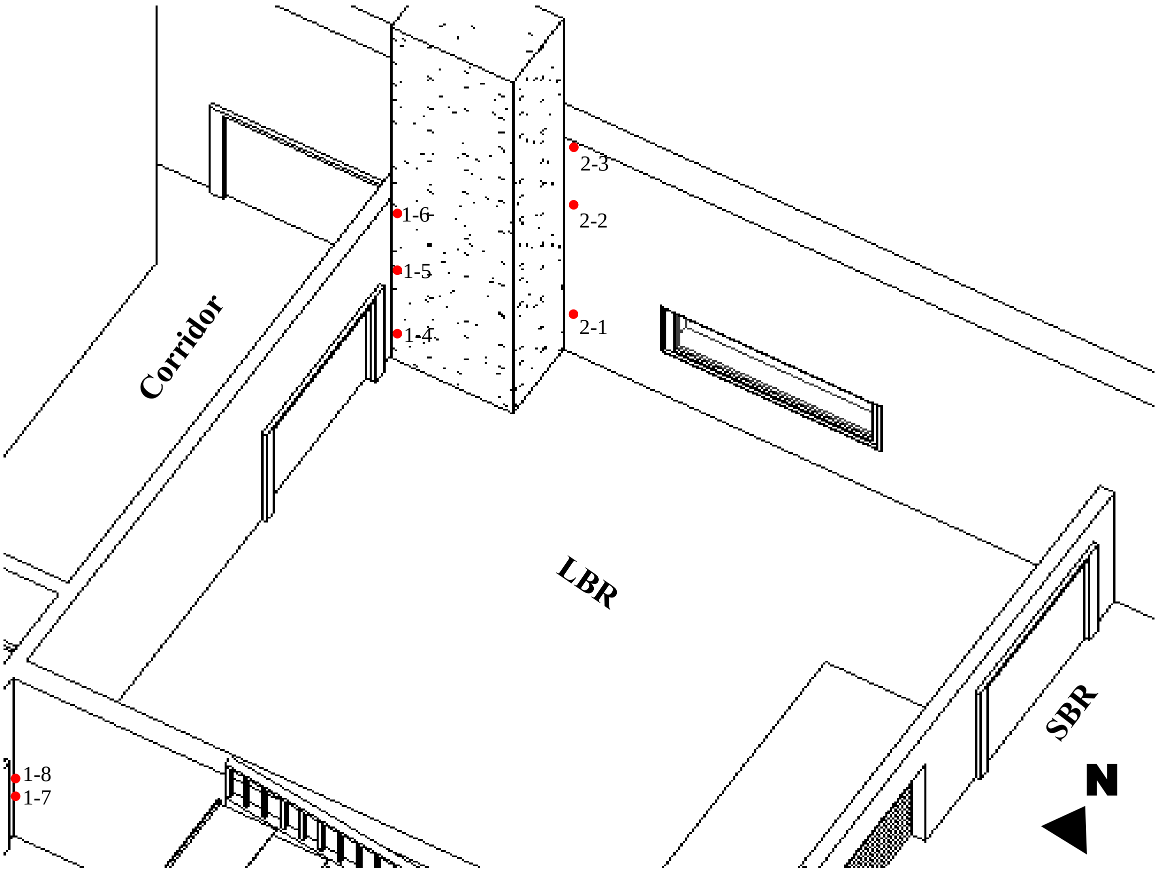

Figure C.5. TC in the LBR column gaps and south wall cracks

Figure C.6 shows the temperatures of the thermocouples recorded inside the column gaps and south wall of LBR cracks. These thermocouple locations are listed in detail in Table C.3.

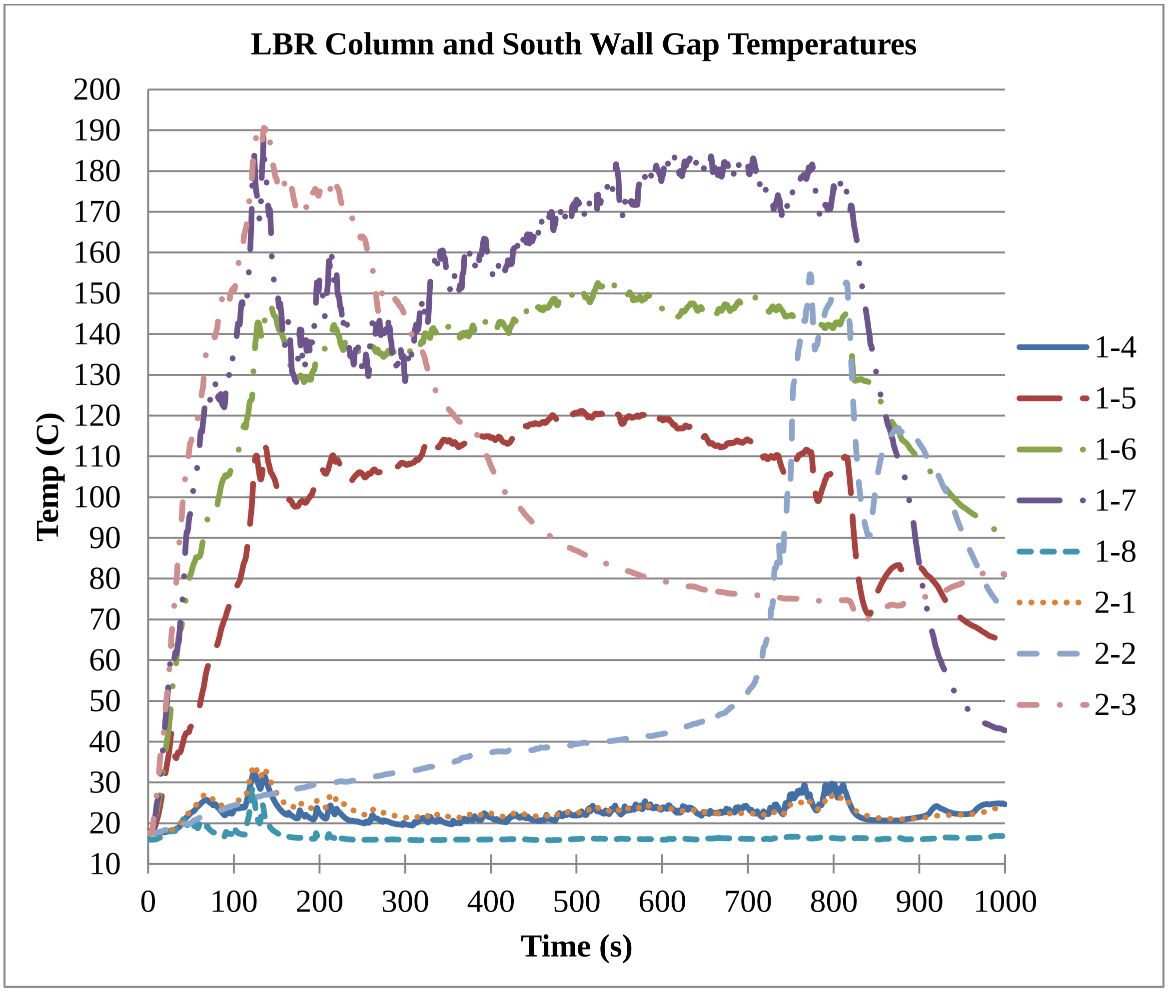

Figure C.6. LBR column and south wall gap temperatures

Table C.3. LBR column gaps and S wall cracks TC list

1-4	(g) On the SW corner gap of the N column, 0.59m (1.94’) above floor
1-5	(g) On the SW corner gap of the N column, 2.03m (6.66’) above floor
1-6	(g) On the SW corner gap of the N column, 0.1m (0.33’) below ceiling
1-7	(g) SW corner of room, 1.22m (4.00’) above floor (LBR temp)
1-8	(g) SW corner of room, 1.24m (4.07’) above floor (stair landing temp)
2-1	(g) on the NE corner gap of the N column 0.6m (1.97’) above floor
2-2	(g) on the NE corner gap of the N column 2m (6.56’) above floor
2-3	(g) on the NE corner gap of the N column 2.7m (8.86’) above floor

C.1.4 LBR Space Above Ceiling

Figure C.7 shows the thermocouples that were placed in the space above the ceiling of the LBR.

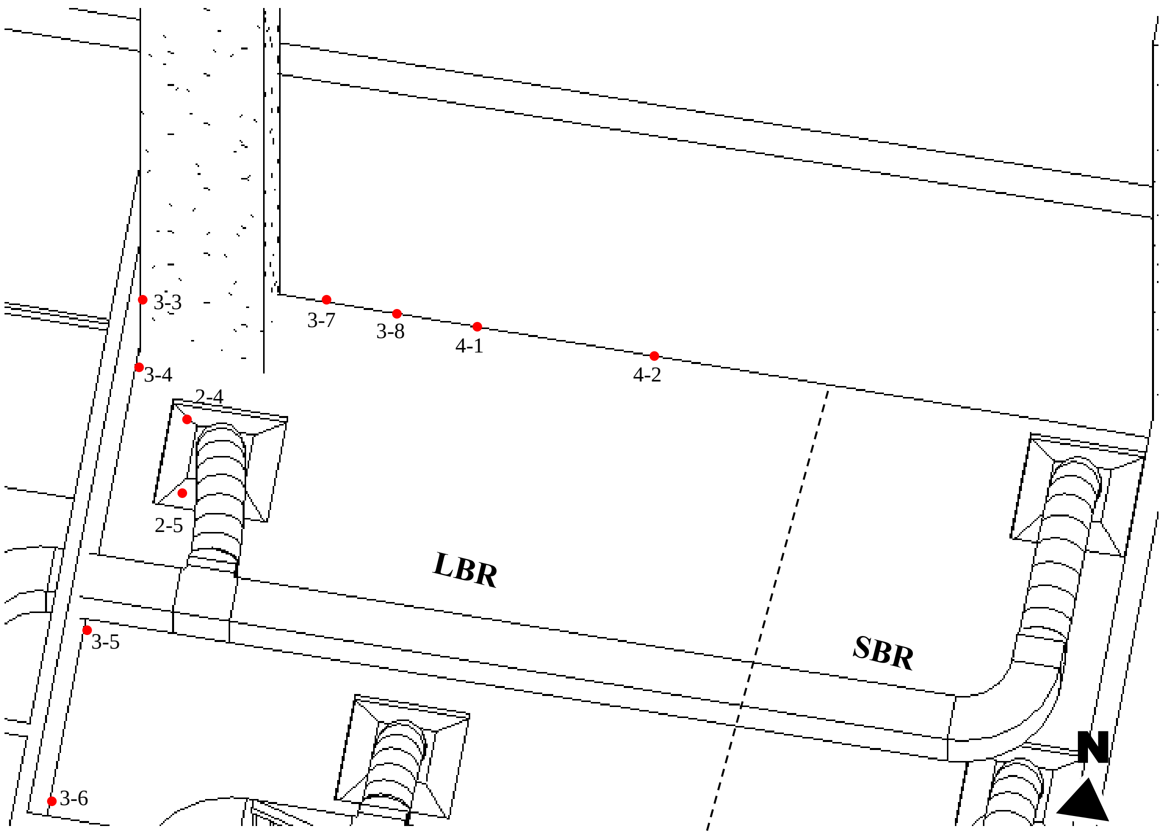

Figure C.7. TCs above LBR ceiling

Figure C.8 shows the temperatures recorded by the thermocouples above the LBR ceiling space. These thermocouple locations are listed in details in Table C.4.

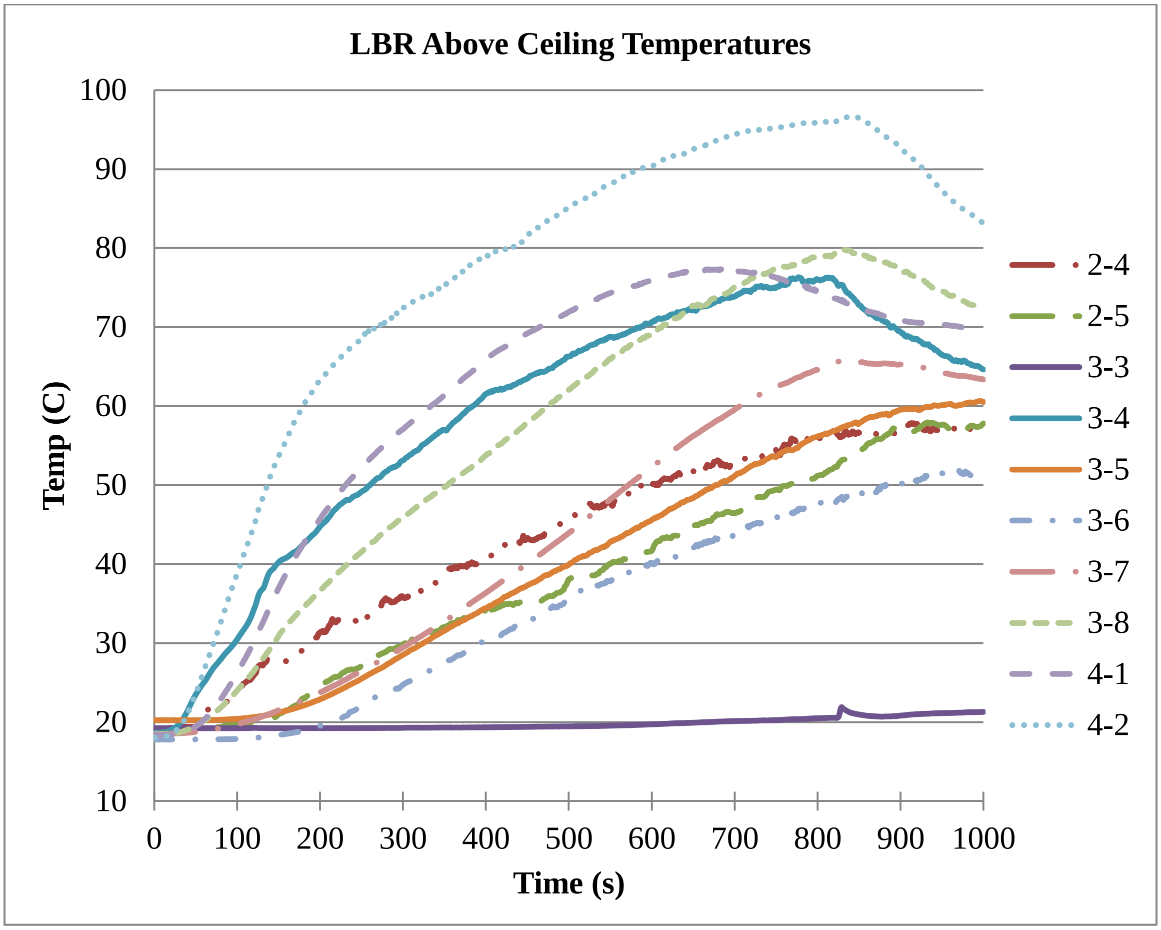

Figure C.8. Space above LBR ceiling temperatures

Table C.4. LBR above ceiling TC list

2-4	(s) on the NW corner diffuser
2-5	(s) on the NW corner diffuser
3-3	(g) above ceiling on SW corner gap of the N column, .32 above ceiling
3-4	(s) above ceiling of the W wall, 0.13m (0.43’) from N column
3-5	(s) above ceiling of the W wall, 1.5m (4.92’) from S wall
3-6	(s) above ceiling of the W wall, 0.1m (0.3’) from S wall
3-7	(s) above ceiling of the N wall, 0.3m (1’) from N column
3-8	(s) above ceiling of the N wall, 0.7m (2.3’) from N column
4-1	(s) above ceiling of the N wall, 1.2m (3.9’) from N column
4-2	(s) above ceiling of the N wall, 2.4m (7.9’) from N column

C.1.5 Above LBR Ceiling Firestops

Figure C.9 shows the thermocouples that were placed on the firestops in the LBR above the ceiling.

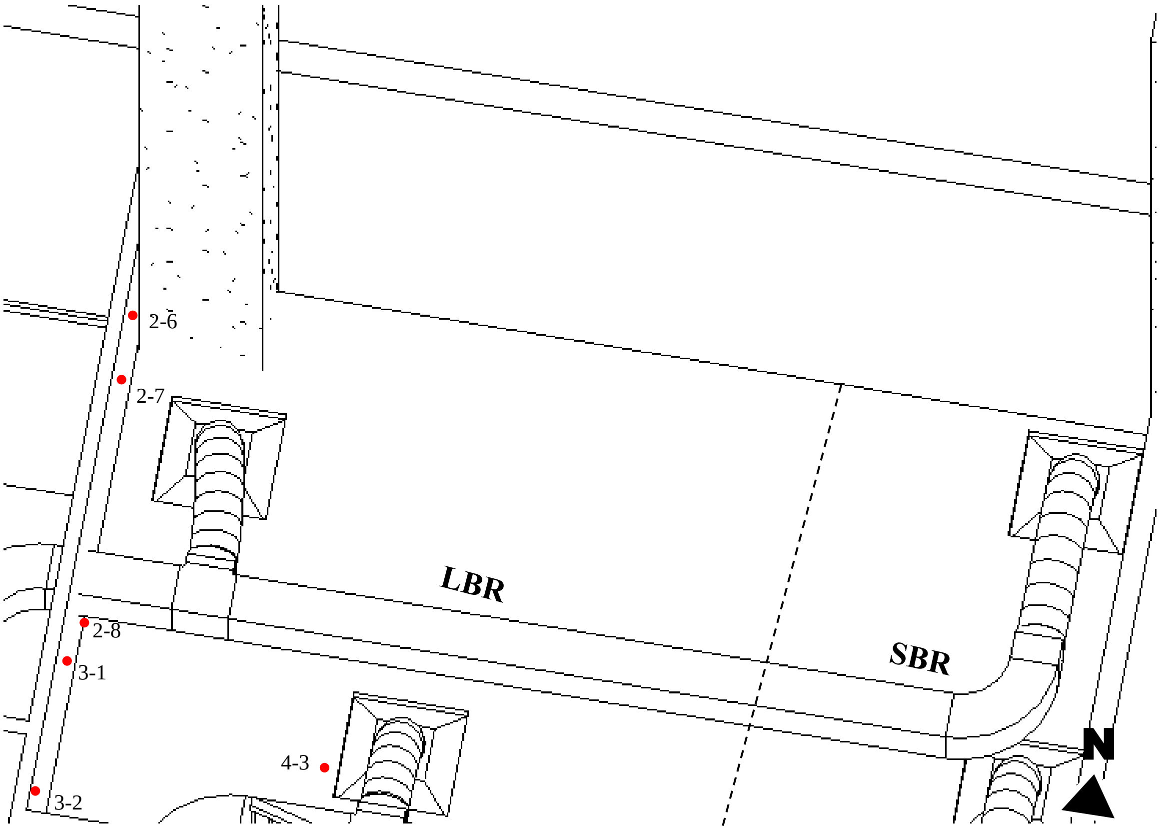

Figure C.9. TCs on LBR firestops above ceiling

Figure C.10 shows the temperatures of the firestops above the LBR ceiling space. These thermocouple locations are listed in Table C.5.

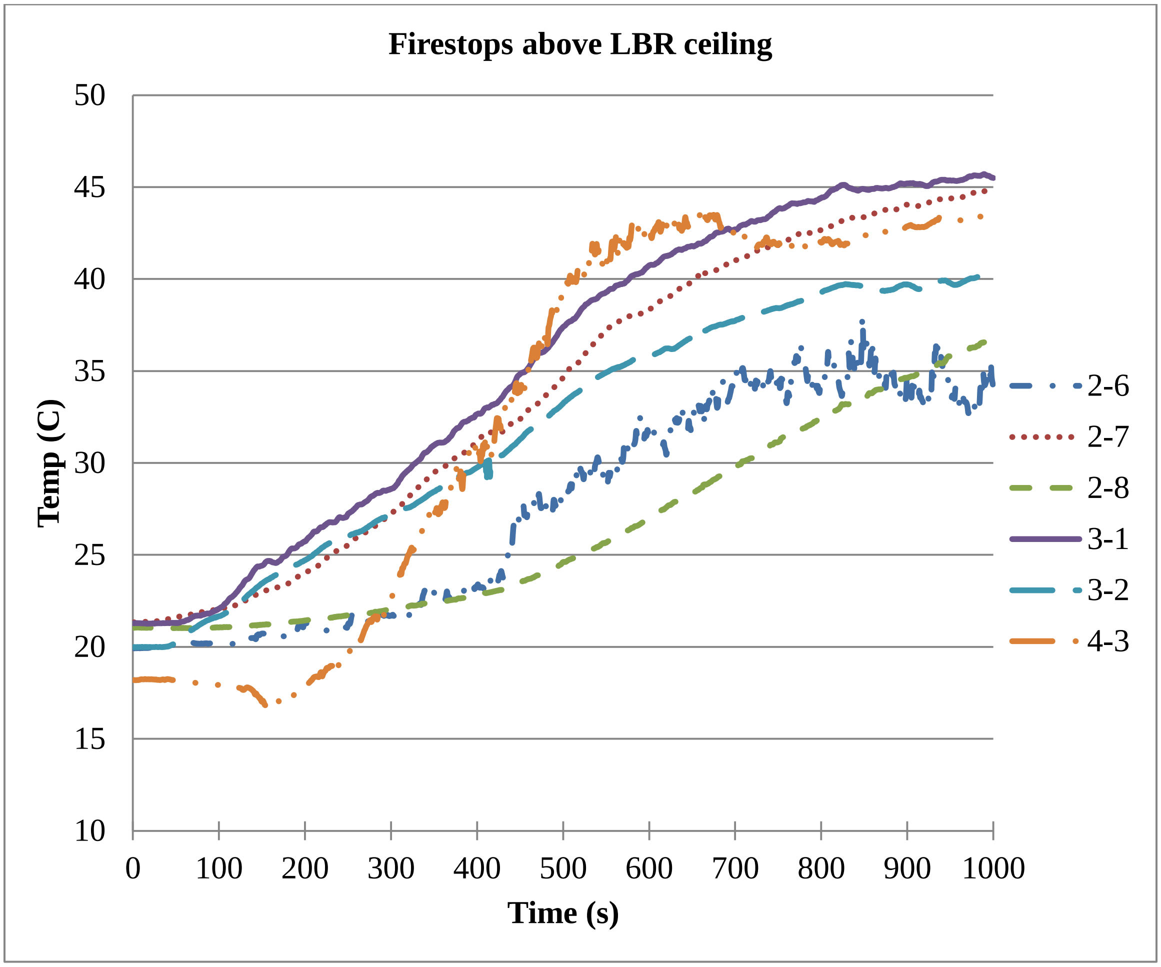

Figure C.10. Firestop temperatures above the LBR ceiling

Table C.5. LBR firestops above ceiling TC list

2-6	(s) above ceiling on firestop, 0.19m (0.6') from N column, 0.37m (1.2') below 4th floor slab
2-7	(s) above ceiling on firestop, 0.52m (1.7') from N column,0.42m (1.4') below 4th floor slab
2-8	(s) above ceiling on firestop, 1.6m (5.2') from S wall, 0.87m (2.9') below 4th floor slab
3-1	(s) above ceiling on firestop, 1.4m (4.6') from S wall, 0.45m (1.5') below 4th floor slab
3-2	(s) above ceiling on firestop, 0.65m (2.1') from S wall, 0.1m (0.3') below 4th floor slab
4-3	(g) above ceiling, SE corner of the W lighting, 2.7m (8.9') from N wall, 1.4m (4.6') from W wall

C.1.6 Active Fire Systems in the LBR and SBR

Figure C.11 shows the thermocouples that were located on the fire protection systems in the LBR and SBR areas.

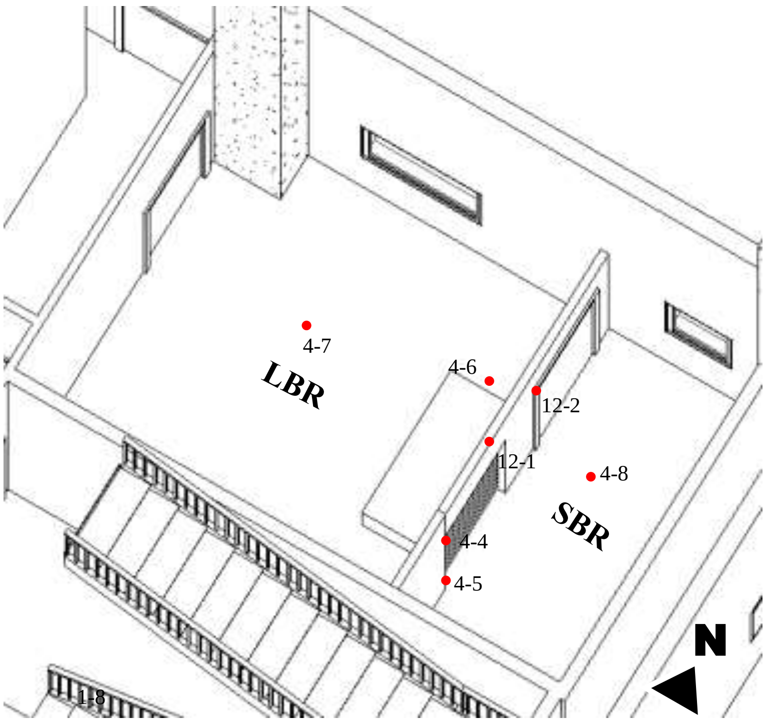

Figure C.11. TC on LBR and SBR fire systems

Figure C.12 shows the temperatures recorded of the fire protection systems in the LBR and SBR. These thermocouple locations are listed in details in Table C.6.

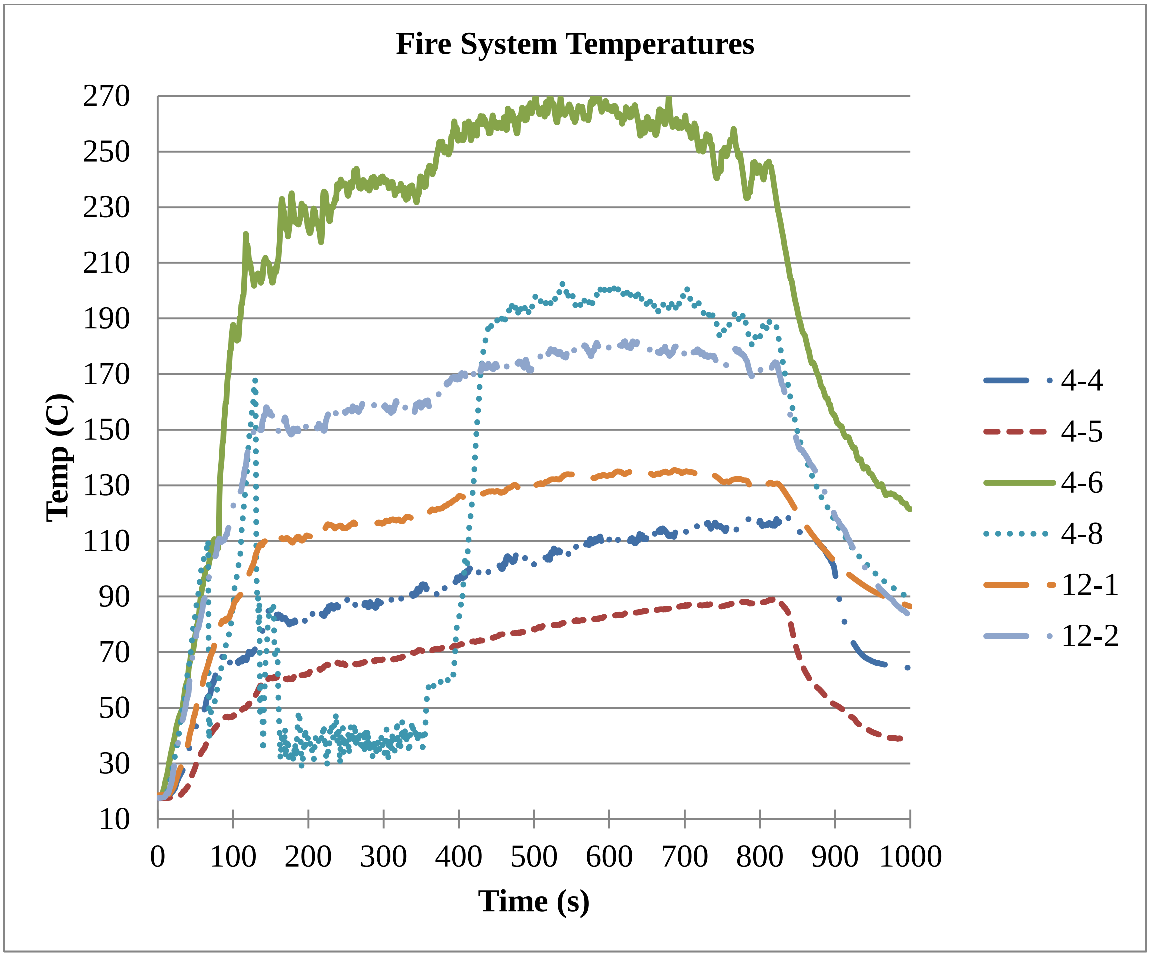

Figure C.12. Temperatures of fire systems in the LBR and SBR

Table C.6. LBR and SBR fire systems TC list

4-4	(g) south part of fire door frame, 1.88m (6.2') above floor
4-5	(g) south part of fire door frame, 0.3m (1') above floor
4-6	(s) Fusible link of fire door, 1.5m (4.9') from N wall, 0.24m (0.8') below ceiling
4-7	(s) sprinkler head fusible link in the LBR, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor
4-8	(s) sprinkler head fusible link in the SBR, 1.3m (4.3') from N wall 1.4m (4.6') from W wall, 2.8m (9.2') above floor
12-1	(g) W wall of SBR gap above the fire door, 1.6m (5.2') from N wall
12-2	Corner of the door frame in the partition wall, 2.1m (6.9') above floor, 1.1m (3.6') from N wall

C.1.7 Gap Between Partition Wall and North Wall of Building

Figure C.13 shows the thermocouples that were located in the gap between the partition wall and north wall of the building.

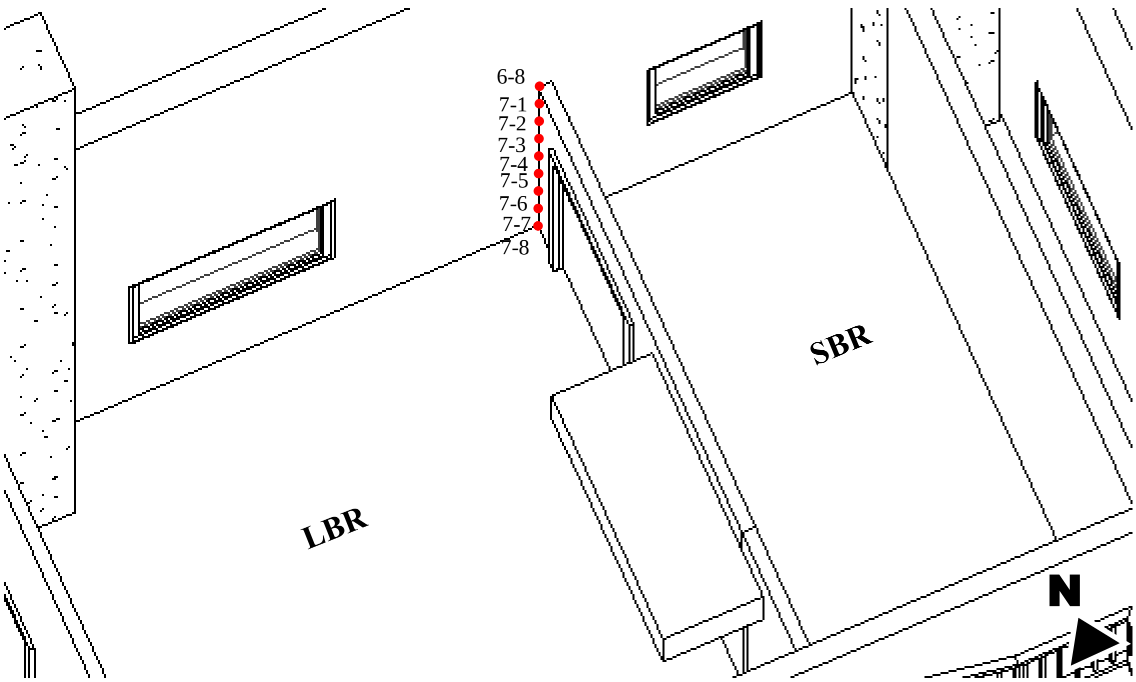

Figure C.13. TC in Gap between partition wall and building N wall

Figure C.14 shows the temperatures in the gap formed between the partition wall and north wall of the building. These thermocouple locations are listed in Table C.7.

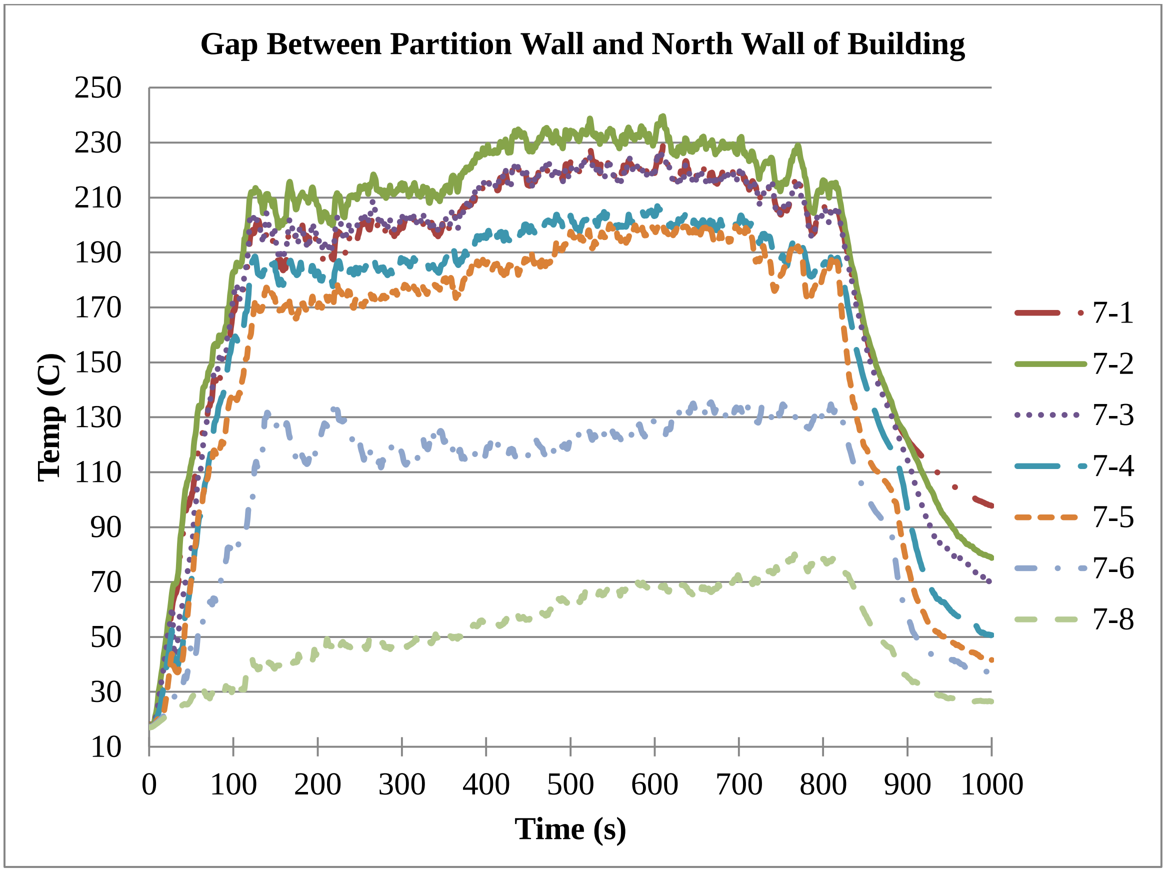

Figure C.14. Temperatures in the gap between the partition wall and north wall of building

Table C.7. Gap between partition wall and building N wall TC list

6-8	(g) NW corner gap of the SBR 2.7m (8.9’) above floor
7-1	(g) NW corner gap of the SBR 2.4m (7.9’) above floor
7-2	(g) NW corner gap of the SBR 2.1m (6.9’) above floor
7-3	(g) NW corner gap of the SBR 1.8m (5.9’) above floor
7-4	(g) NW corner gap of the SBR 1.5m (4.9’) above floor
7-5	(g) NW corner gap of the SBR 1.2m (3.9’) above floor
7-6	(g) NW corner gap of the SBR 0.9m (3’) above floor
7-7	(g) NW corner gap of the SBR 0.6m (2’) above floor
7-8	(g) NW corner gap of the SBR 0.3m (1’) above floor

C.1.8 SBR Space Above Ceiling

Figure C.15 shows the thermocouples that were located in the space above the SBR ceiling.

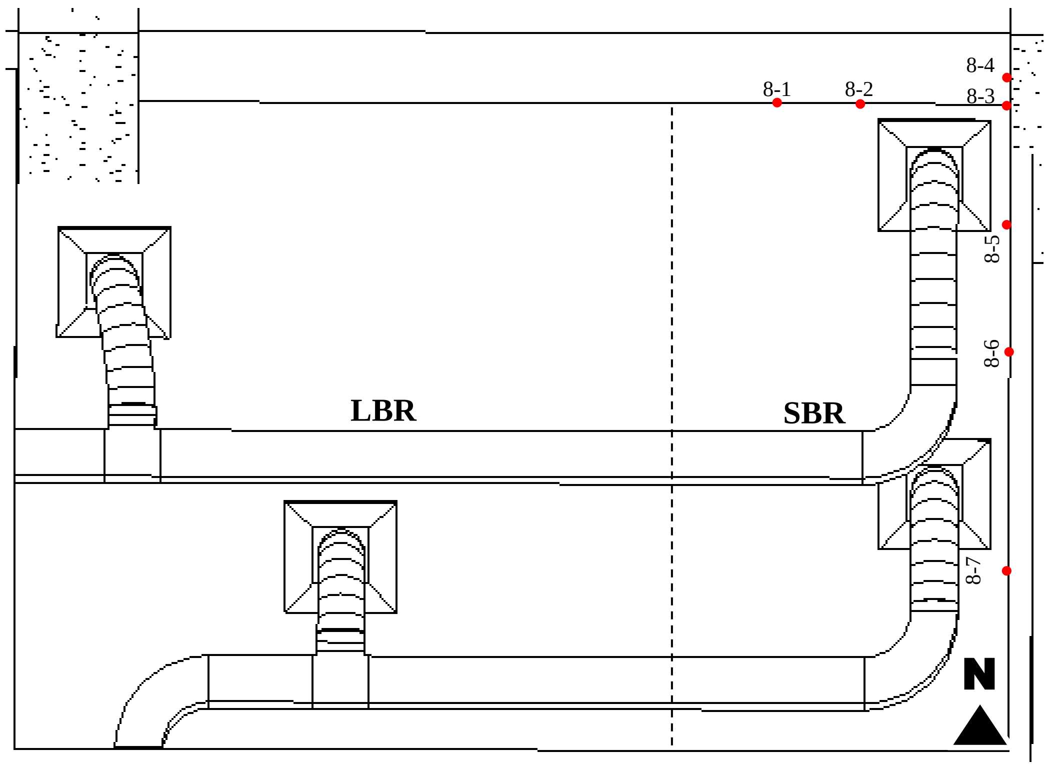

Figure C.15. SBR above ceiling space

Figure C.16 shows the temperatures in the space of the SBR above the ceiling. These thermocouple locations were listed in details in Table C.8.

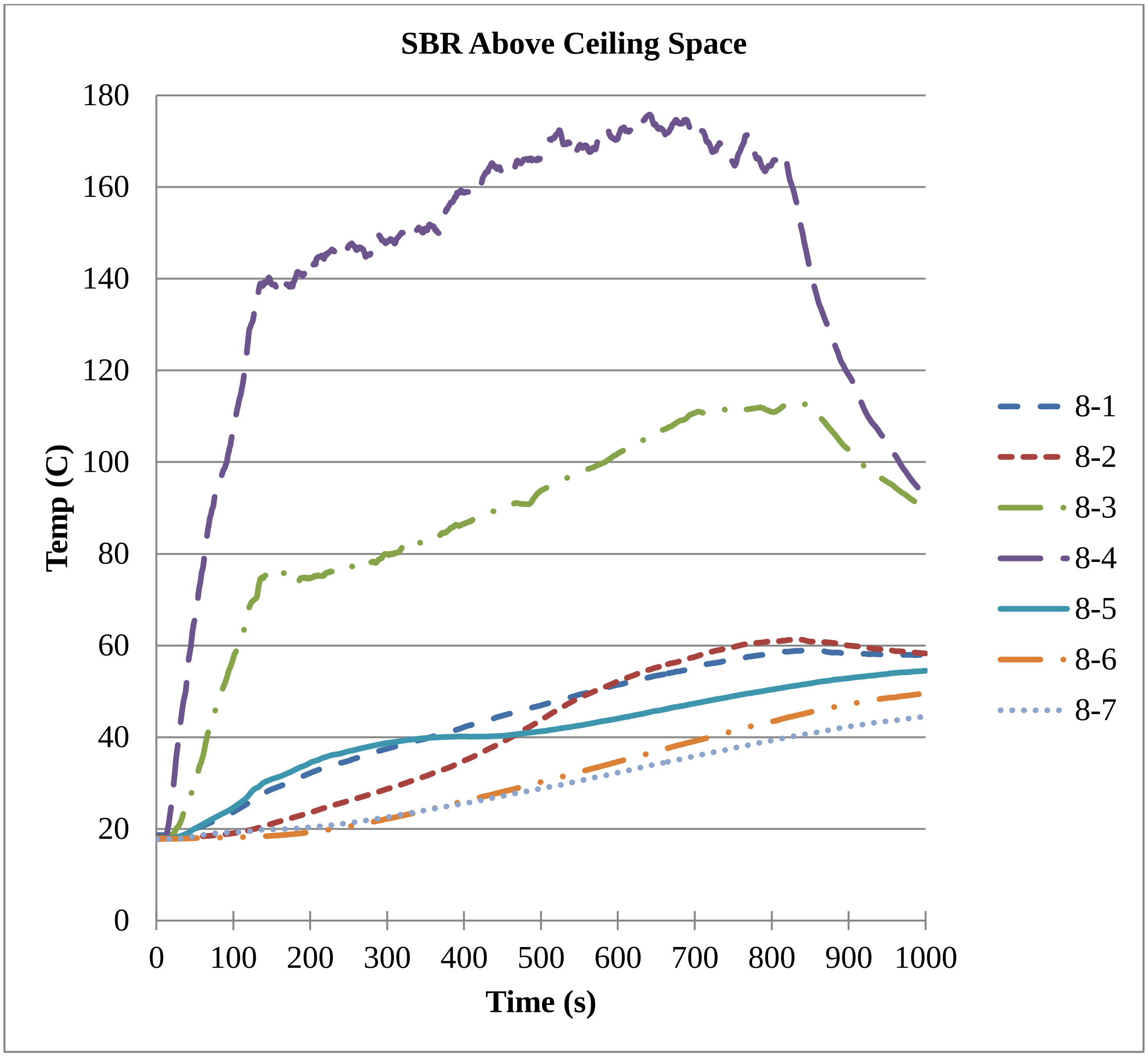

Figure C.16. SBR above ceiling space temperatures

Table C.8. Above SBR ceiling TC list

8-1	(s) above ceiling of N wall, 1.5m (4.9’) from E wall
8-2	(s) above ceiling of N wall, 0.9m (3’) from E wall
8-3	(s) above ceiling of NE corner of the SBR
8-4	(g) above ceiling of NE corner of the SBR
8-5	(s) above ceiling of E wall, 0.6m (2’) from N wall
8-6	(s) above ceiling of E wall, 1.4m (4.6’) from N wall
8-7	(s) above ceiling of E wall, 2.6m (8.5’) from N wall

C.1.9 South Wall of SBR

Figure C.17 shows the thermocouples that were located on the south wall of the SBR.

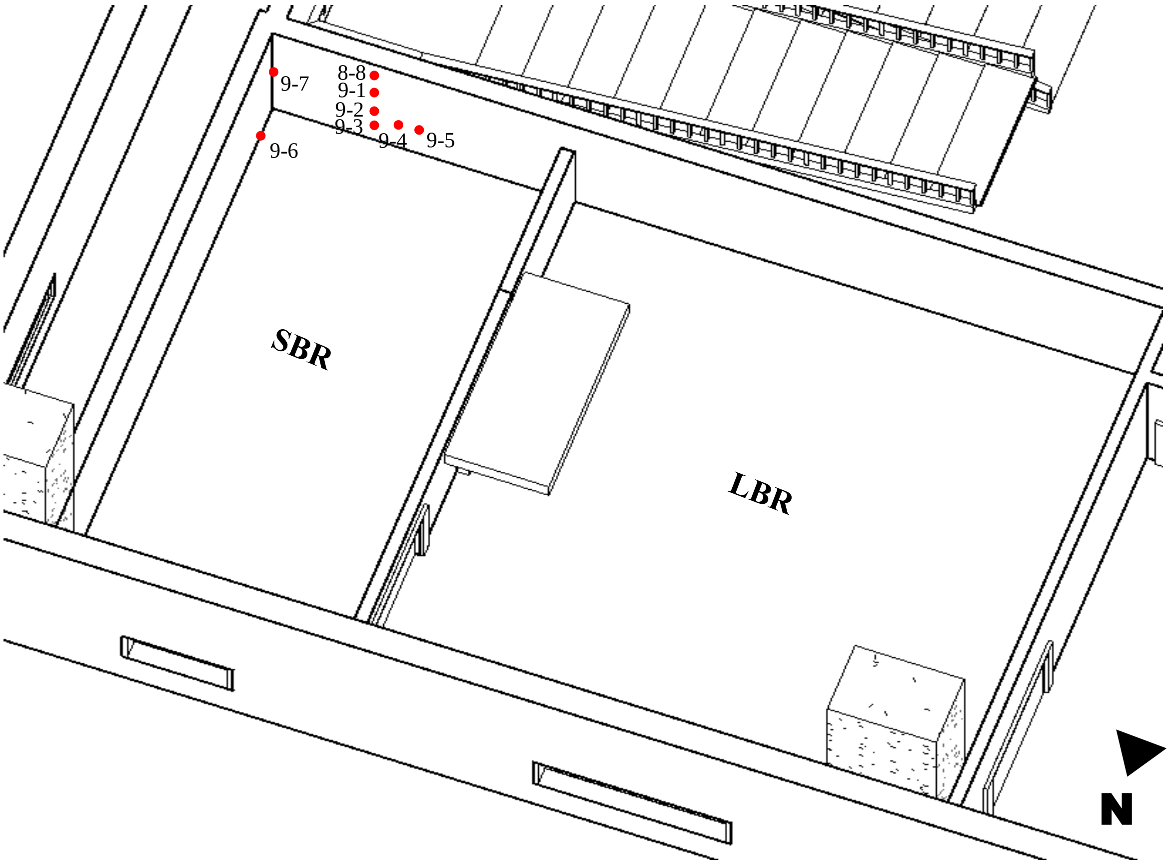

Figure C.17. TC on south wall of SBR

Figure C.18 shows the temperatures in the gaps formed on the south wall of the SBR. These thermocouple locations are listed in details in Table C.9.

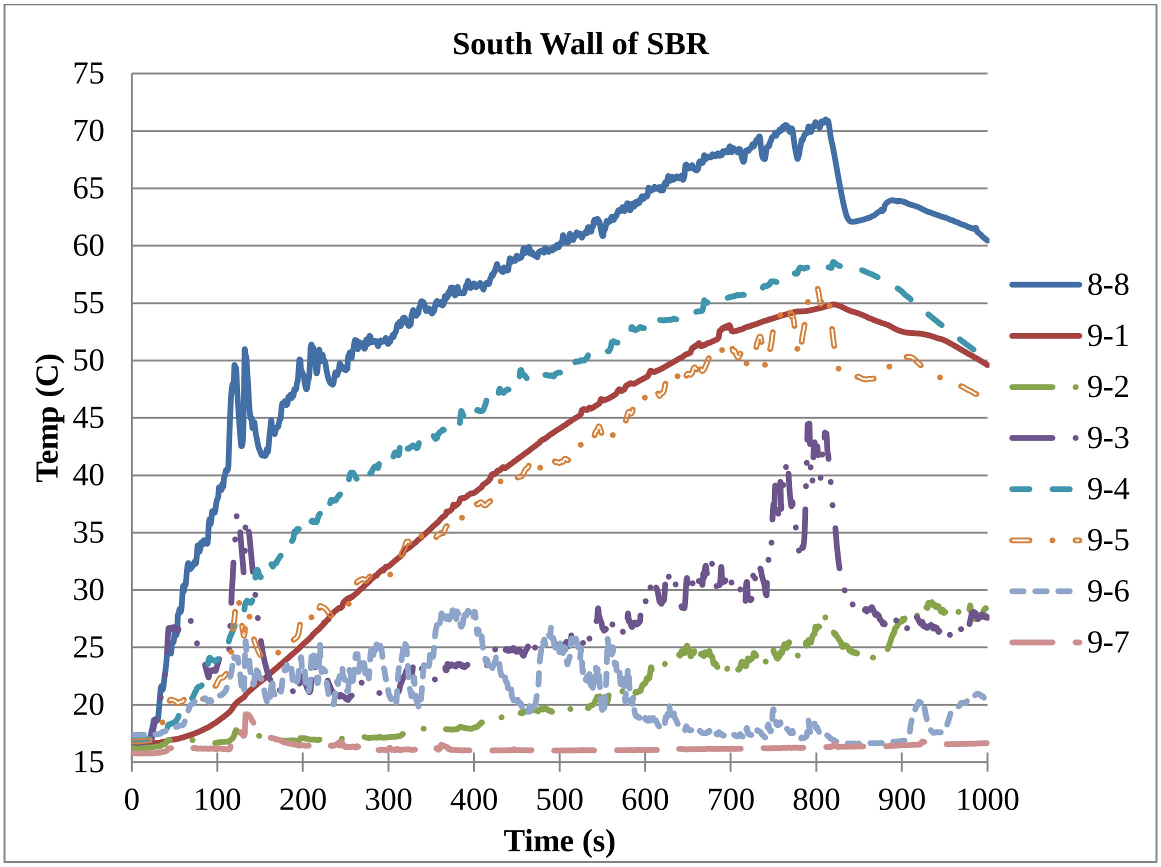

Figure C.18. Temperatures in the gaps of the south wall of SBR

Table C.9. S wall of SBR TC list

8-8	(g) gap on S wall, 1.12m (3.7') from SW corner, 2.24 (7.3') above floor
9-1	(g) gap on S wall, 1.12m (3.7') from SW corner, 1.84m (6') above floor
9-2	(g) gap on S wall, 1.12m (3.7') from SW corner 1.16 (3.8') above floor
9-3	(g) gap on S wall, 1.12m (3.7') from SW corner, 0.74 (2.4') above floor
9-4	(g) S wall firestop on opening, 0.99m (3.2') from SW corner, 0.8m (2.6') above floor
9-5	(g) S wall firestop on opening, 0.83m (2.7') from SW corner, 0.81m (2.7') above floor
9-6	(g) E wall to slab firestop gap, 0.19m (0.6') from SE corner
9-7	(g) SE corner of SBR, 1.68m (5.5') above floor

C.1.10 North Exterior Wall of Building

Figure C.19 shows the thermocouples that were placed on the north exterior balloon frame of the building.

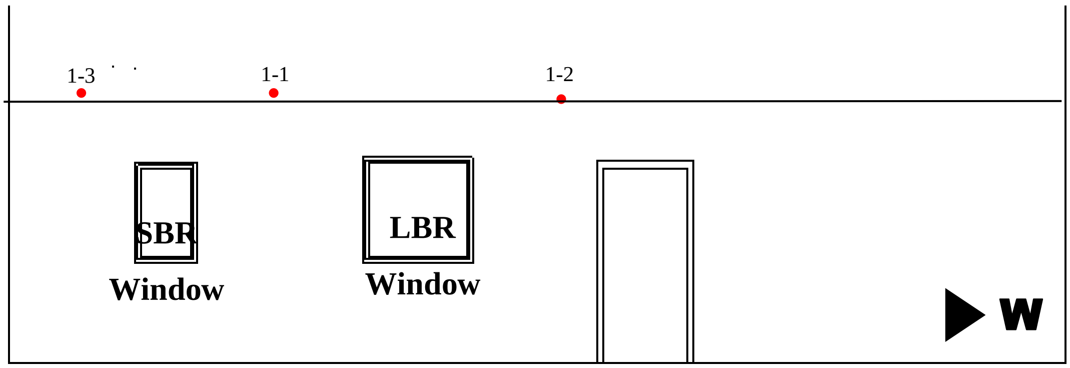

Figure C.19. TC on N balloon frame of building

Figure C.20 shows the north exterior balloon framing temperatures of the building. These thermocouple locations are listed in details in Table C.10.

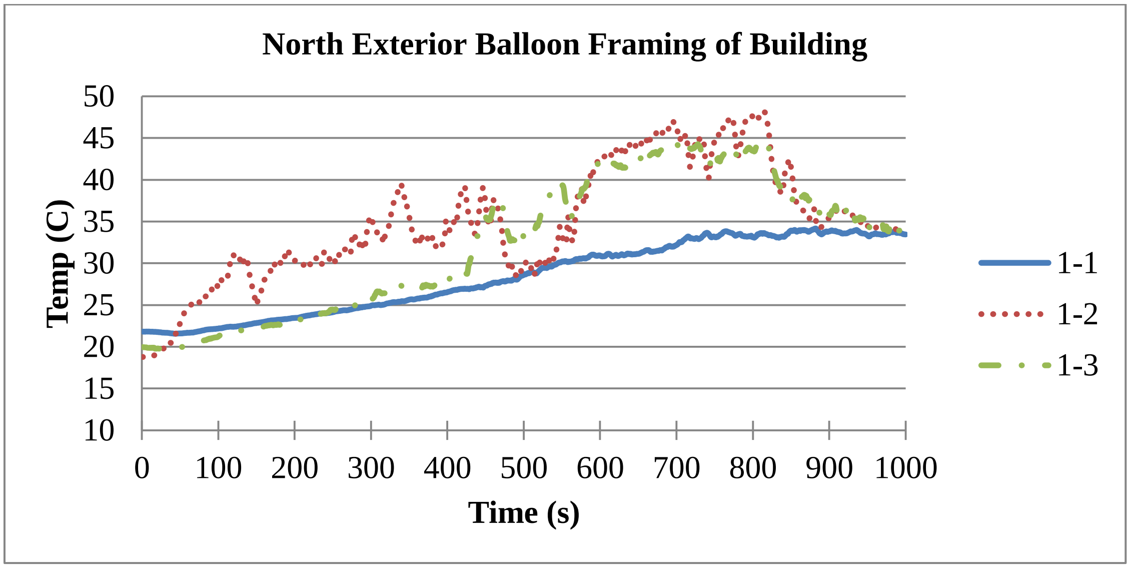

Figure C.20. Temperatures of the north exterior balloon framing of the building

Table C.10. N balloon frame of building TC list

1-1	(g) NE Balloon Framing from LBR
1-2	(g) NW balloon framing from LBR
1-3	(g) Balloon framing from SBR

C.1.11 Active Fire Systems Activation Analysis

Figure C.21 shows the temperatures of the fire door and the SBR sprinkler. The SBR sprinkler activated at 66 seconds at 109C (228F). The thermocouple locations are listed in Table C.11.

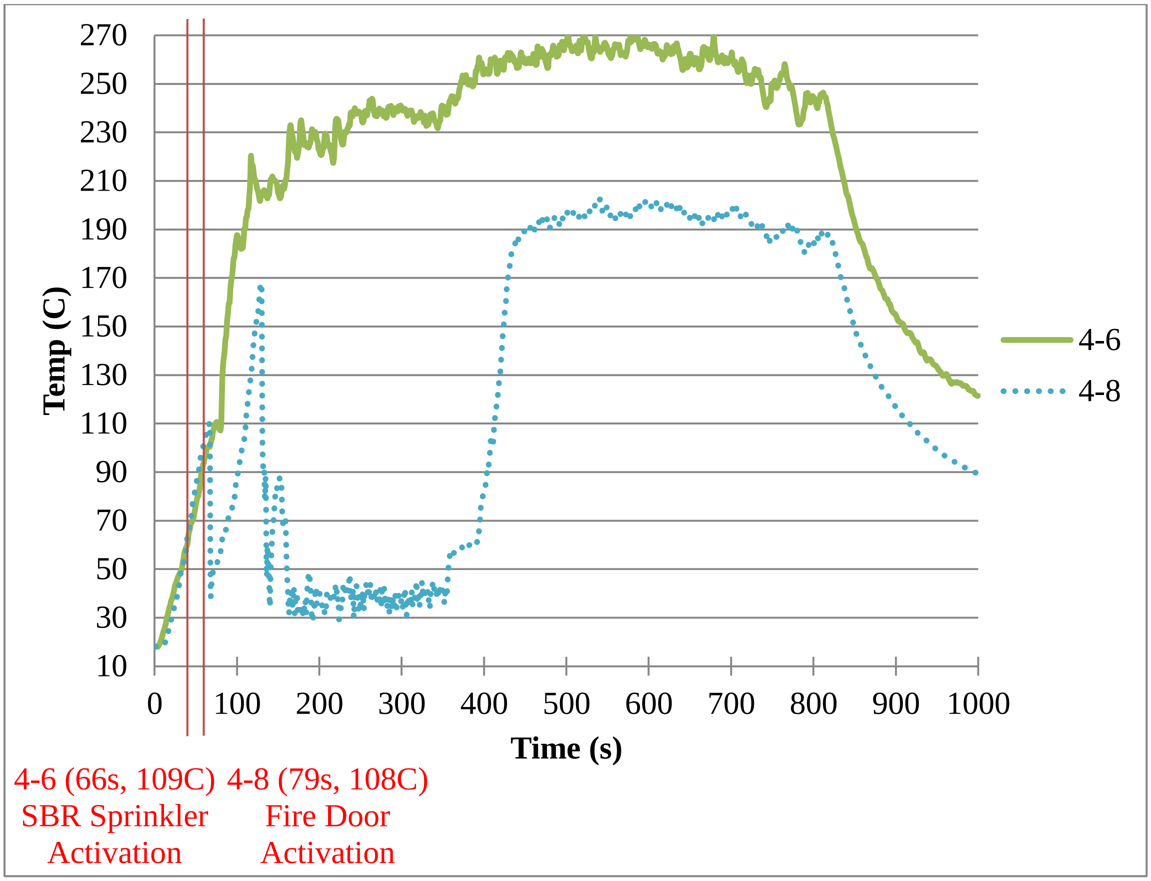

Figure C.21. Temperatures of fire door and SBR sprinkler

Table C.11. Fire door and SBR sprinkler TC list

4-6	(s) Fusible link of fire door, 1.5m (4.9') from N wall, 0.24m (0.8') below ceiling
4-7	(s) sprinkler head fusible link in the LBR, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor ***(NO DATA, TC Malfunctioned)***
4-8	(s) sprinkler head fusible link in the SBR, 1.3m (4.3') from N wall 1.4m (4.6') from W wall, 2.8m (9.2') above floor

C.2 SBR FIRE TEST TEMPERATURES

C.2.1 Thermocouple Trees

Figure C.22 shows the TC trees that were placed in the LBR and the SBR. Figure C.23 shows the TC trees that were placed above the ceiling of the LBR and SBR.

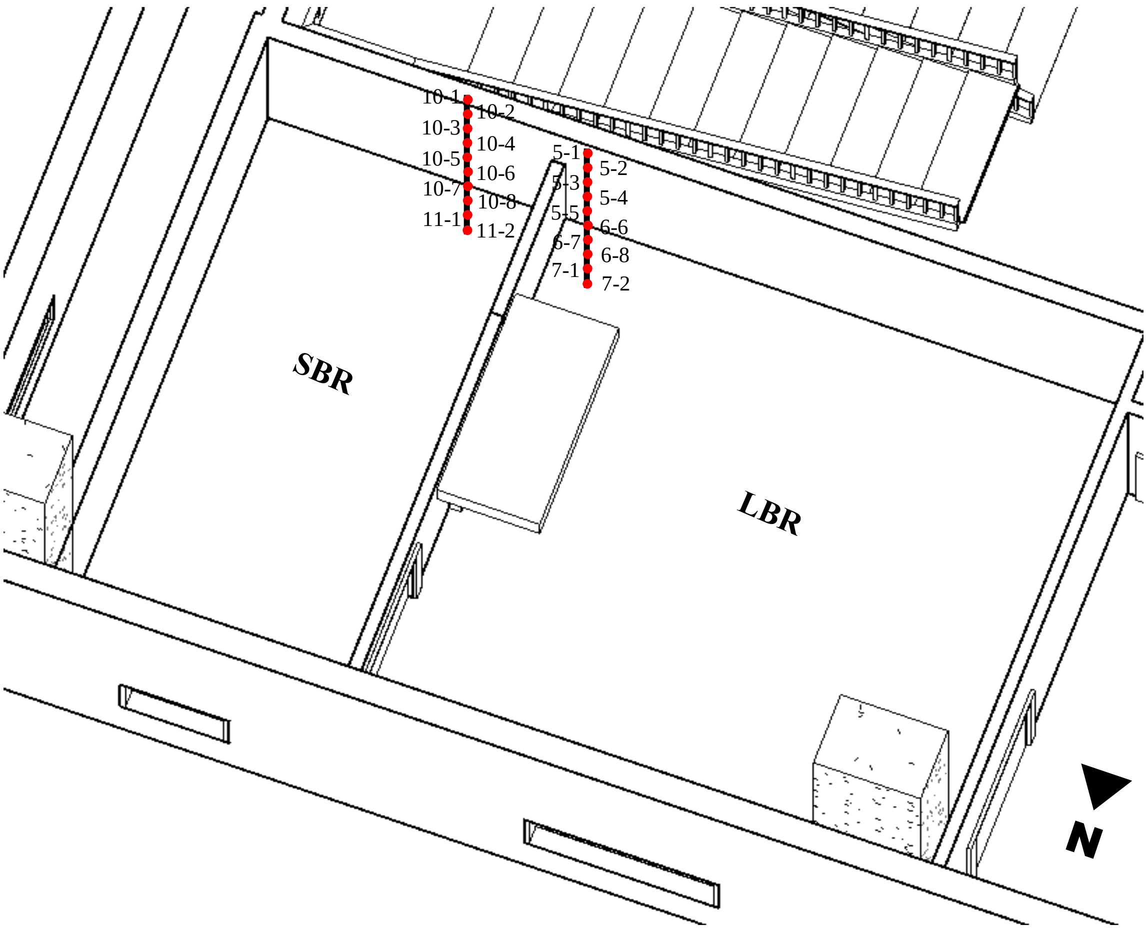

Figure C.22. TC Trees in the SBR and LBR

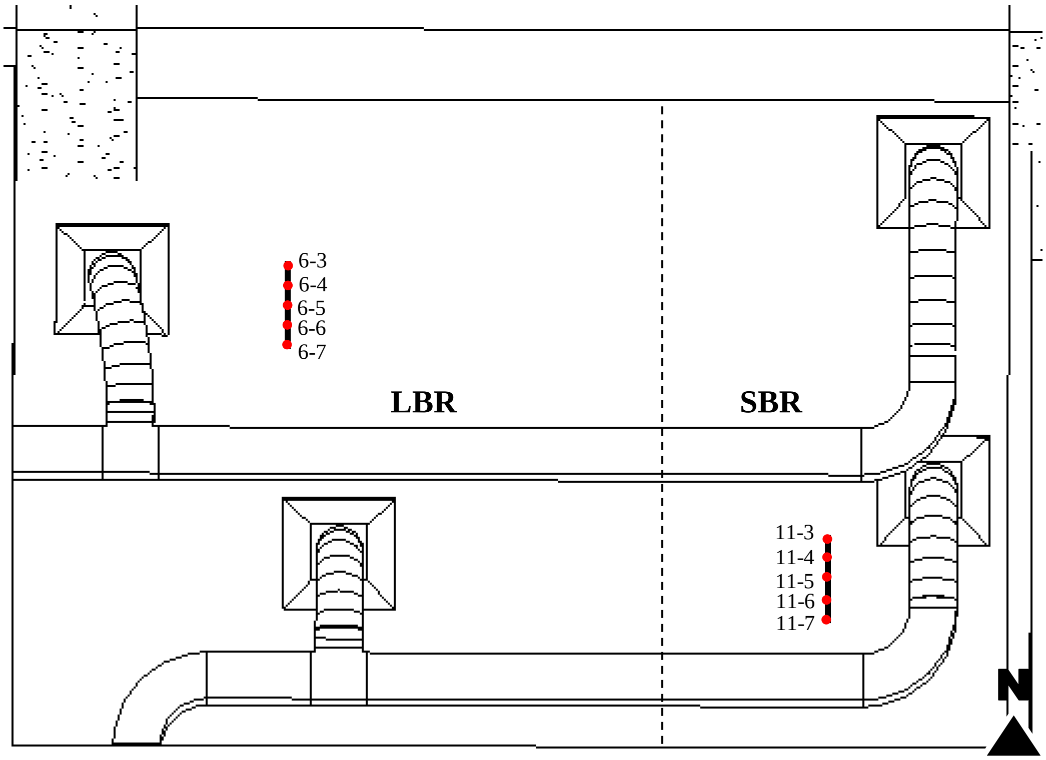

Figure C.23. TC trees above ceiling of LBR and SBR

Figure C.24 shows the temperatures recorded by the thermocouple trees in the SBR and space above the SBR ceiling. The thermocouple location details are listed in Table C.12.

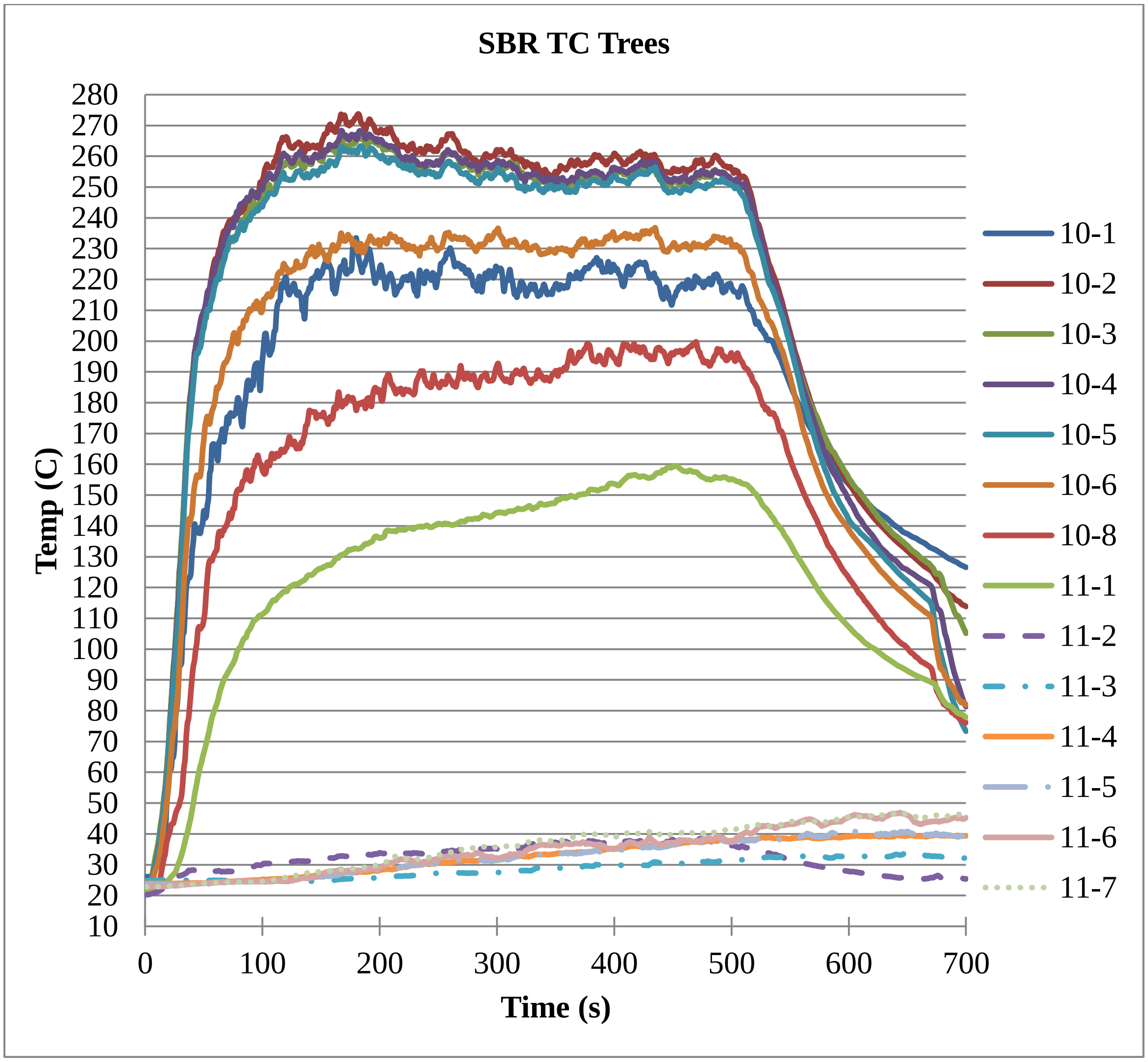

Figure C.24. SBR and space above SBR ceiling temperatures

Table C.12. SBR TC trees list

10-1	TC tree below ceiling of LBR starting with 11-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 10-1 on top at 2.7m (8.9ft)
10-2	
10-3	
10-4	
10-5	
10-6	
10-7	
10-8	
11-1	
11-2	
11-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 11-7 right above ceiling and increasing in 0.3m (1ft) increments to 11-3 being on top
11-4	
11-5	
11-6	
11-7	

Figure C.25 shows the temperatures recorded by the thermocouple trees in the LBR and space above the LBR ceiling. The thermocouple location details are listed in Table C.13.

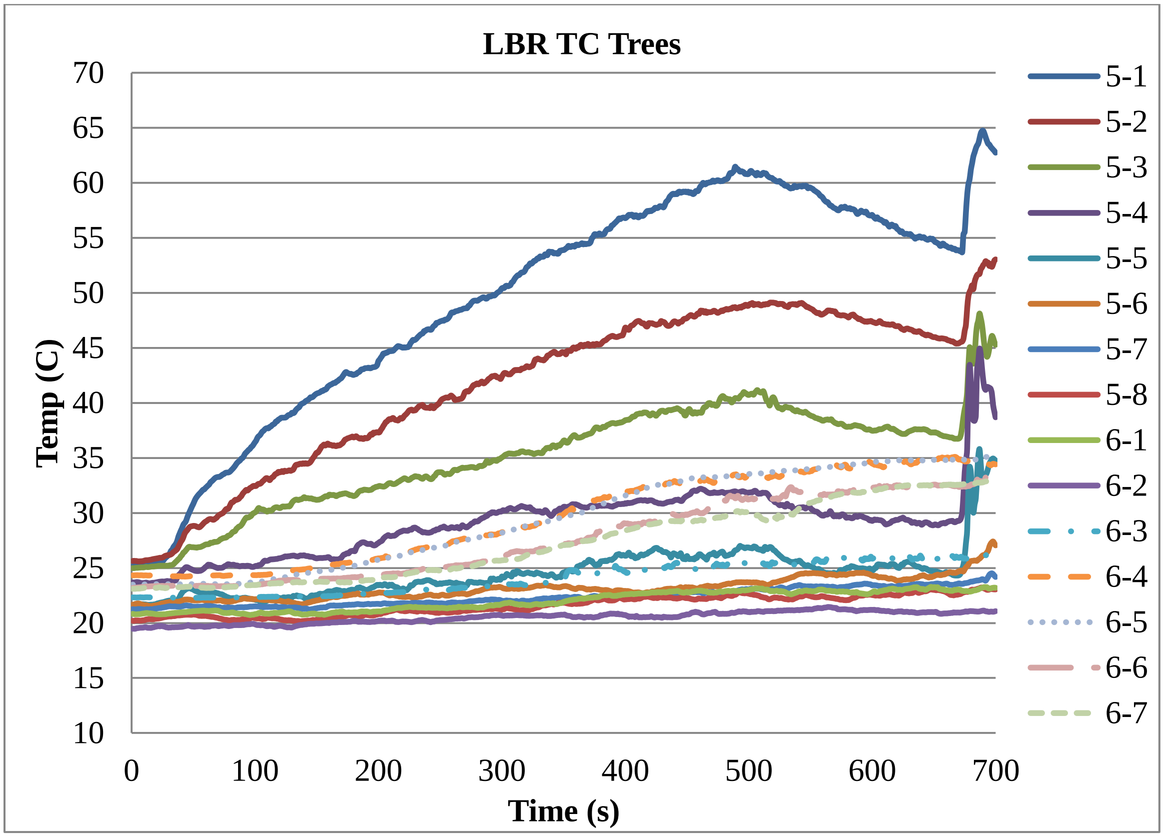

Figure C.25. LBR and space above LBR ceiling temperatures

Table C.13. LBR TC trees list

5-1	TC tree below ceiling of LBR starting with 6-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 5-1 on top at 2.7m (8.9ft)
5-2	
5-3	
5-4	
5-5	
5-6	
5-7	
5-8	
6-1	
6-2	
6-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top
6-4	
6-5	
6-6	
6-7	

C.2.2 SBR Above Ceiling Space

Figure C.26 shows the thermocouples that were located in the space above the SBR ceiling.

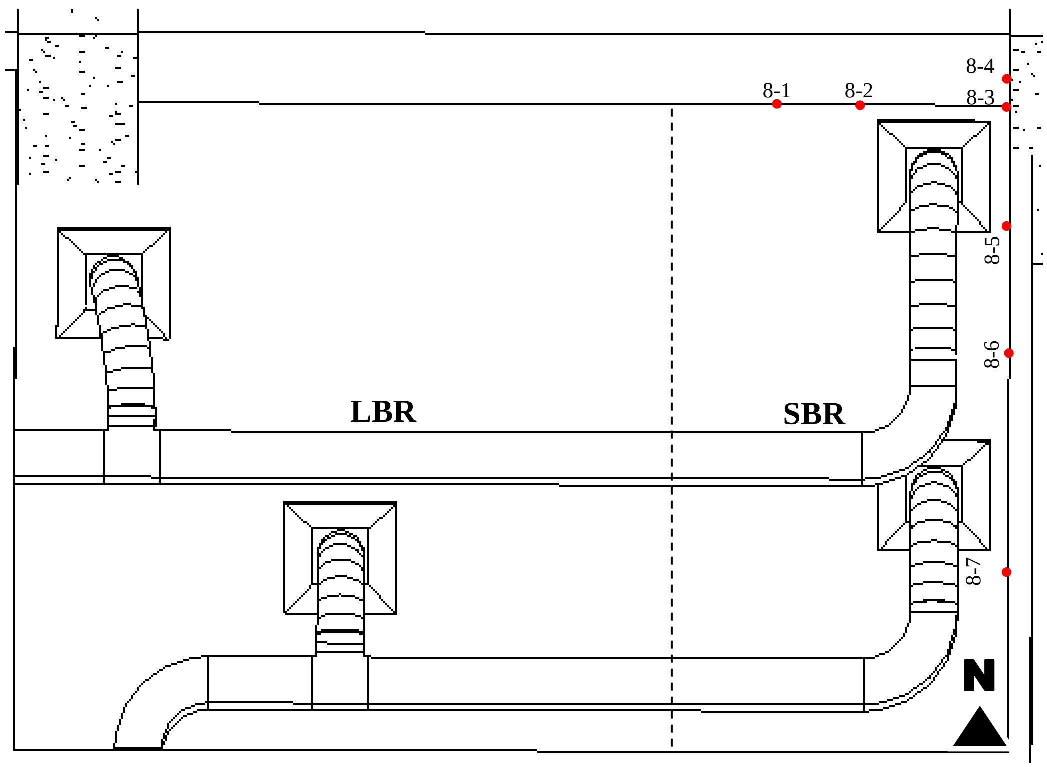

Figure C.26. SBR above ceiling space

Figure C.27 shows the temperatures in the space of the SBR above the ceiling. These thermocouple locations were listed in details in Table C.14.

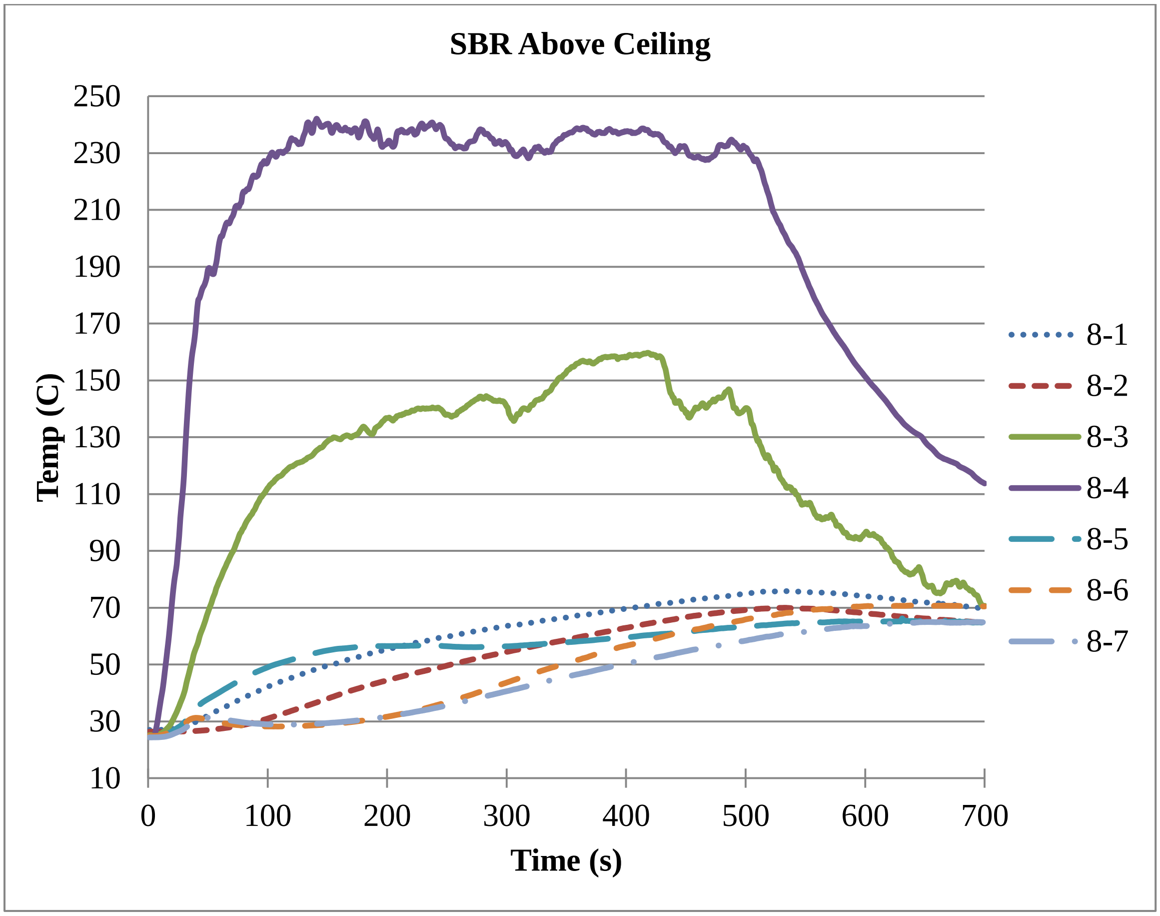

Figure C.27. SBR above ceiling space temperatures

Table C.14. Above SBR ceiling TC list

8-1	(s) above ceiling of N wall, 1.5m (4.9') from E wall
8-2	(s) above ceiling of N wall, 0.9m (3') from E wall
8-3	(s) above ceiling of NE corner of the SBR
8-4	(g) above ceiling of NE corner of the SBR
8-5	(s) above ceiling of E wall, 0.6m (2') from N wall
8-6	(s) above ceiling of E wall, 1.4m (4.6') from N wall
8-7	(s) above ceiling of E wall, 2.6m (8.5') from N wall

Gap between Partition wall and north wall of building Figure C.28 shows the thermocouples that were located in the gap between the partition wall and north wall of the building.

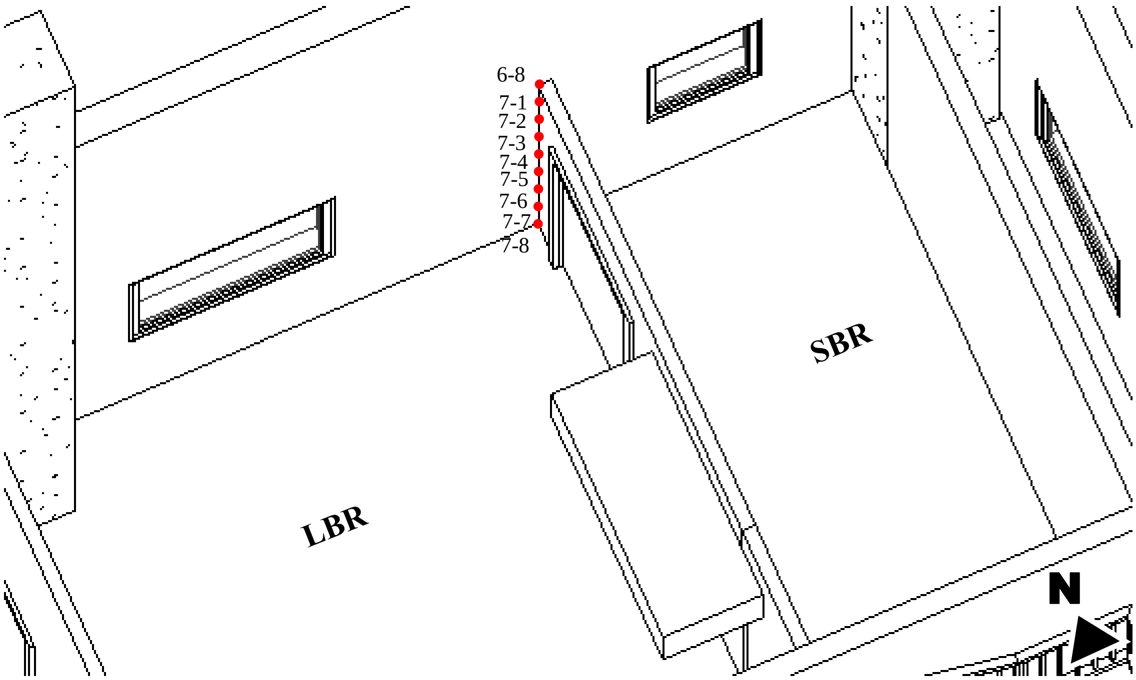

Figure C.28. TC in Gap between partition wall and building N wall

Figure C.29 shows the temperatures in the gap formed between the partition wall and north wall of the building. These thermocouple locations are listed in Table C.15.

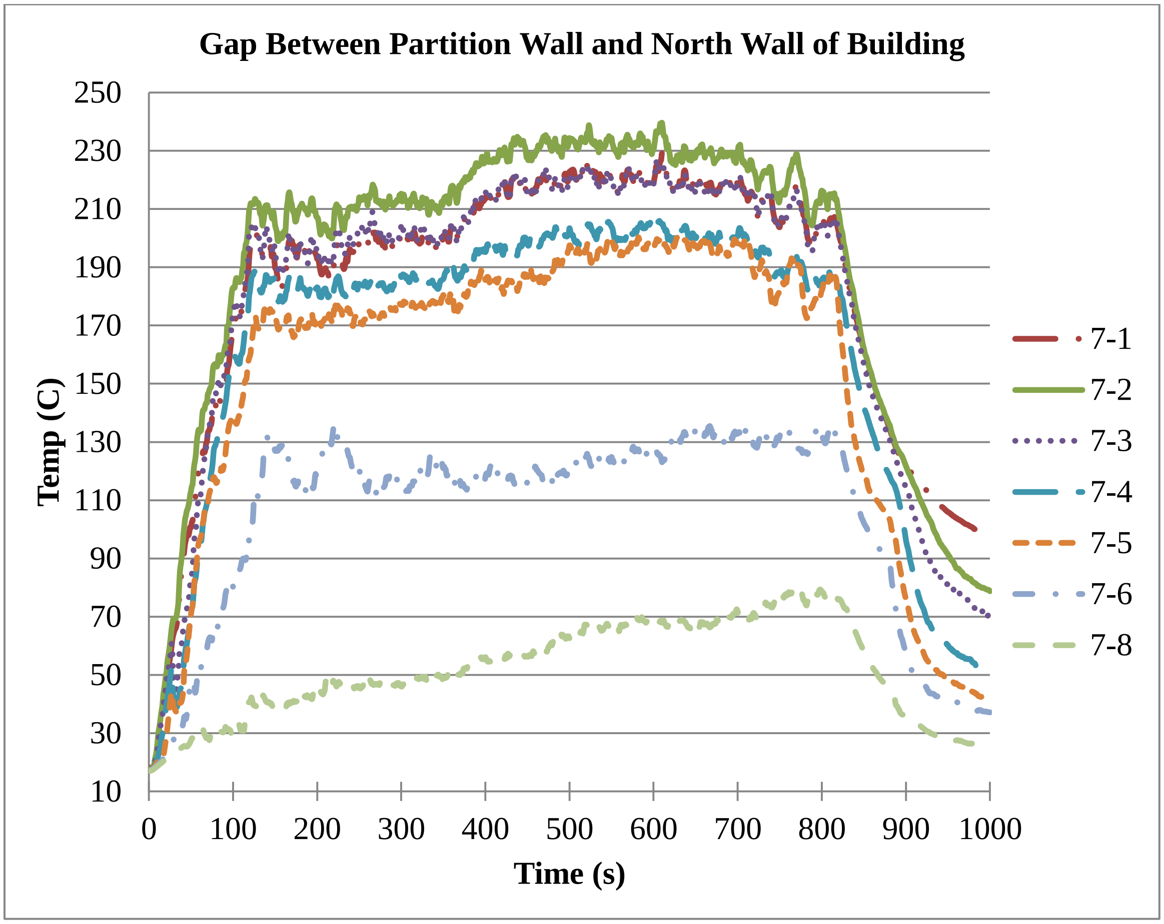

Figure C.29. Temperatures in the gap between the partition wall and north wall of building

Table C.15. Gap between partition wall and building N wall TC list

6-8	(g) NW corner gap of the SBR 2.7m (8.9’) above floor
7-1	(g) NW corner gap of the SBR 2.4m (7.9’) above floor
7-2	(g) NW corner gap of the SBR 2.1m (6.9’) above floor
7-3	(g) NW corner gap of the SBR 1.8m (5.9’) above floor
7-4	(g) NW corner gap of the SBR 1.5m (4.9’) above floor
7-5	(g) NW corner gap of the SBR 1.2m (3.9’) above floor
7-6	(g) NW corner gap of the SBR 0.9m (3’) above floor
7-7	(g) NW corner gap of the SBR 0.6m (2’) above floor
7-8	(g) NW corner gap of the SBR 0.3m (1’) above floor

C.2.3 South Wall of SBR

Figure C.30 shows the thermocouples that were located on the south wall of the SBR.

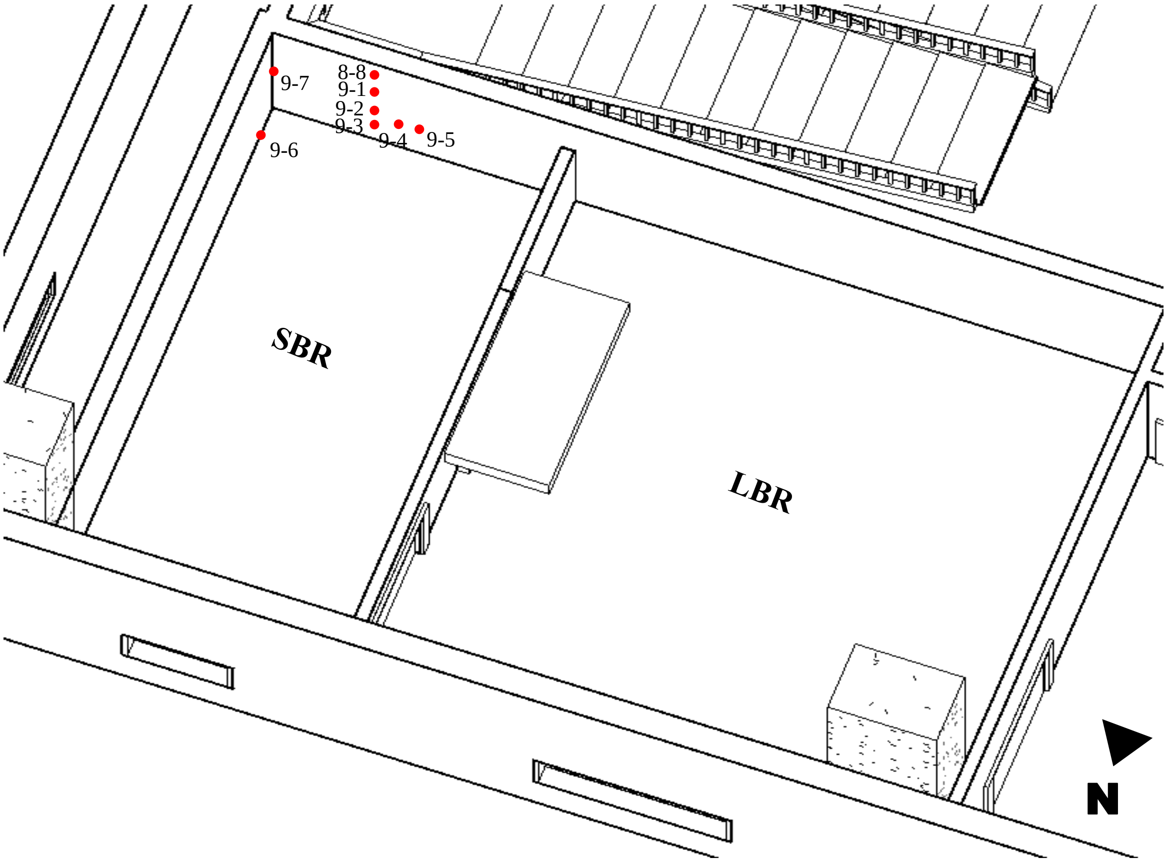

Figure C.30. TC on S wall of SBR

Figure C.31 shows the temperatures in the gaps formed on the south wall of the SBR. These thermocouple locations are listed in details in Table C.16.

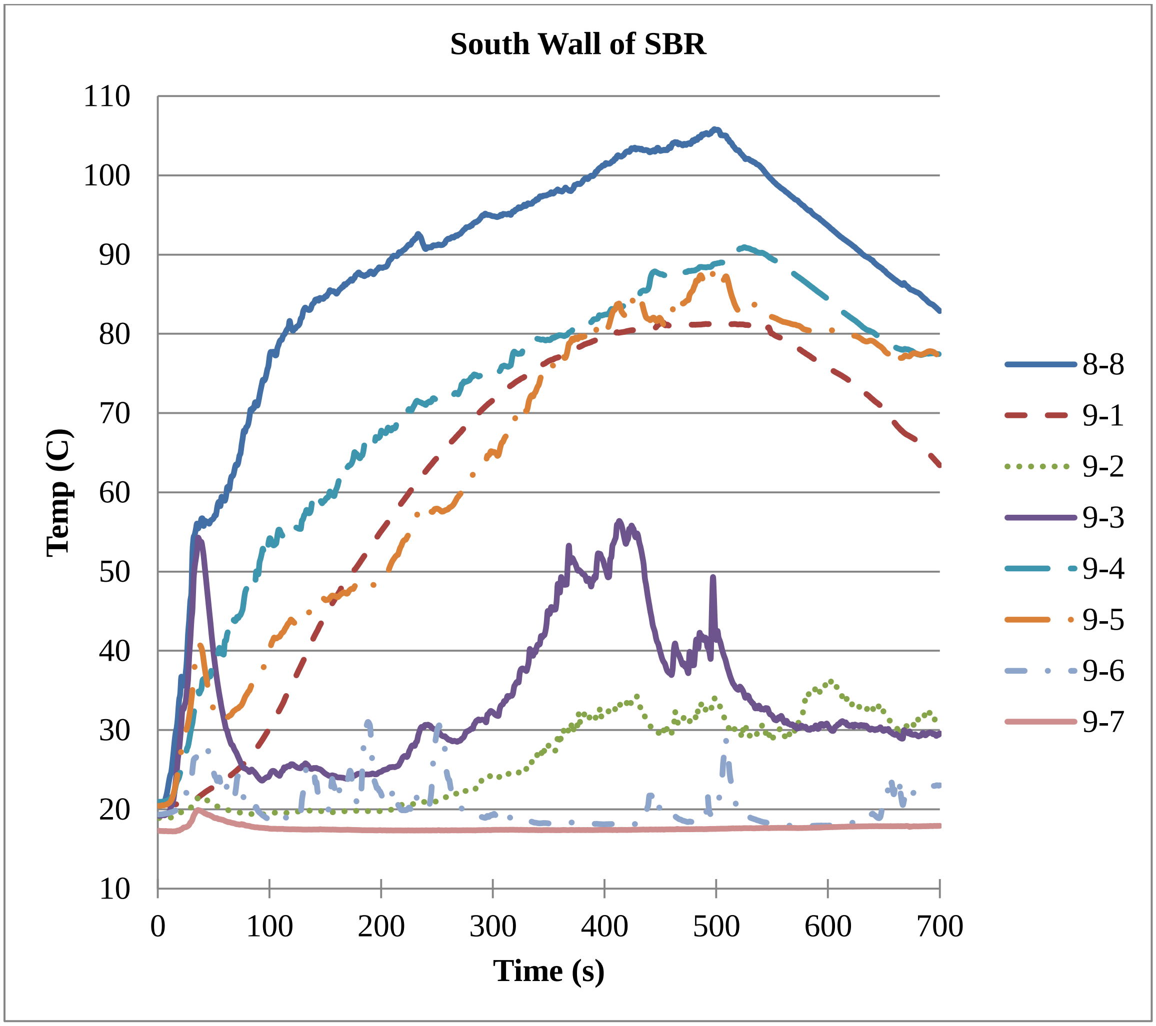

Figure C.31. Temperatures in the gaps of the south wall of SBR

Table C.16. S wall of SBR TC list

8-8	(g) gap on S wall, 1.12m (3.7') from SW corner, 2.24 (7.3') above floor
9-1	(g) gap on S wall, 1.12m (3.7') from SW corner, 1.84m (6') above floor
9-2	(g) gap on S wall, 1.12m (3.7') from SW corner 1.16 (3.8') above floor
9-3	(g) gap on S wall, 1.12m (3.7') from SW corner, 0.74 (2.4') above floor
9-4	(g) S wall firestop on opening, 0.99m (3.2') from SW corner, 0.8m (2.6') above floor
9-5	(g) S wall firestop on opening, 0.83m (2.7') from SW corner, 0.81m (2.7') above floor
9-6	(g) E wall to slab firestop gap, 0.19m (0.6') from SE corner
9-7	(g) SE corner of SBR, 1.68m (5.5') above floor

C.2.4 LBR Column Gap

Figure C.32 shows the thermocouples that were located in the gaps formed between the north column and west and north walls of the LBR and the thermocouples that were located in the cracks formed on the south wall of the LBR.

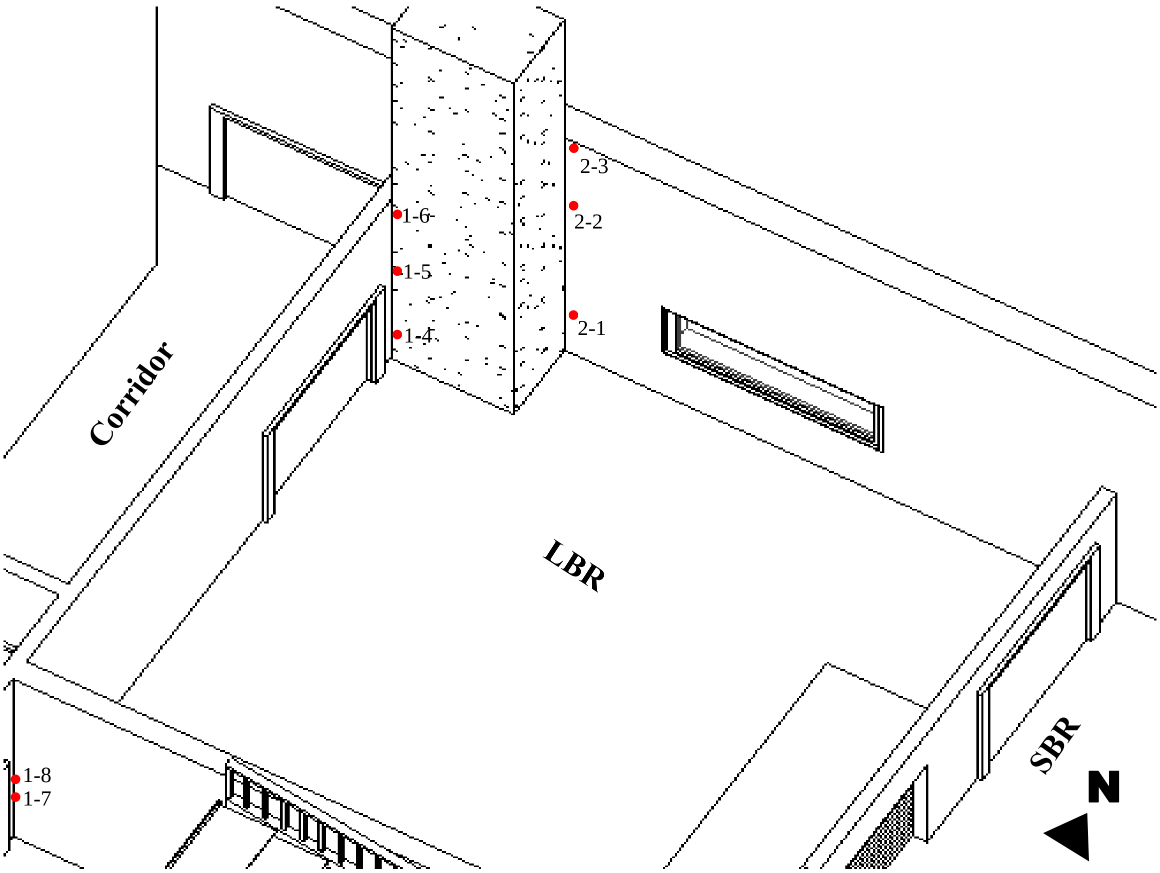

Figure C.32. TC in the LBR column gaps and south wall cracks

Figure C.33 shows the temperatures of the thermocouples recorded inside the column gaps and south wall of LBR cracks. These thermocouple locations are listed in detail in Table C.17.

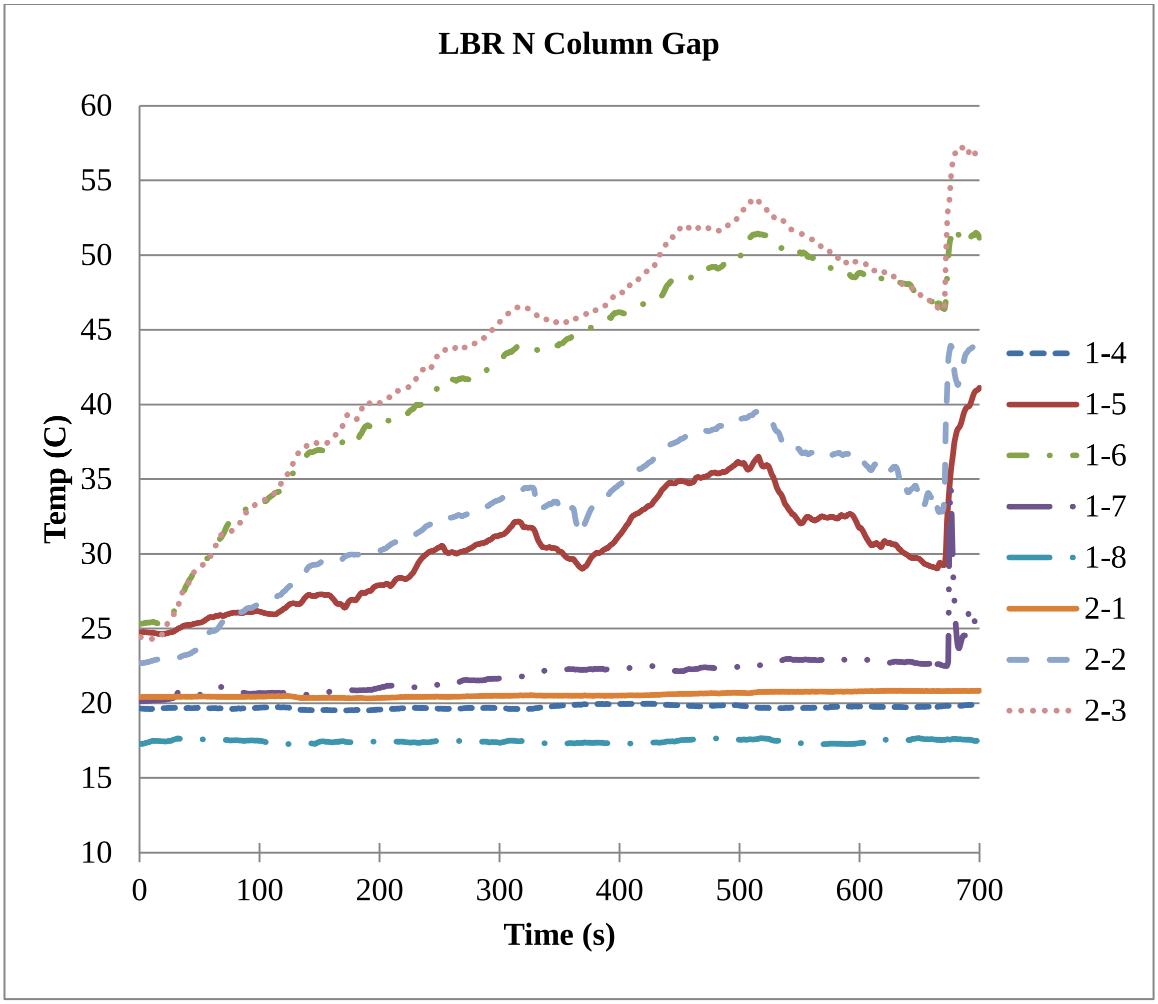

Figure C.33. LBR column and south wall gap temperatures

Table C.17. LBR column gaps and S wall cracks TC list

1-4	(g) On the SW corner gap of the N column, 0.59m (1.94') above floor
1-5	(g) On the SW corner gap of the N column, 2.03m (6.66') above floor
1-6	(g) On the SW corner gap of the N column, 0.1m (0.33') below ceiling
1-7	(g) SW corner of room, 1.22m (4.00') above floor (LBR temp)
1-8	(g) SW corner of room, 1.24m (4.07') above floor (stair landing temp)
2-1	(g) on the NE corner gap of the N column 0.6m (1.97') above floor
2-2	(g) on the NE corner gap of the N column 2m (6.56') above floor
2-3	(g) on the NE corner gap of the N column 2.7m (8.86') above floor

C.2.5 LBR Above Ceiling Space

Figure C.34 shows the thermocouples that were placed in the space above the ceiling of the LBR.

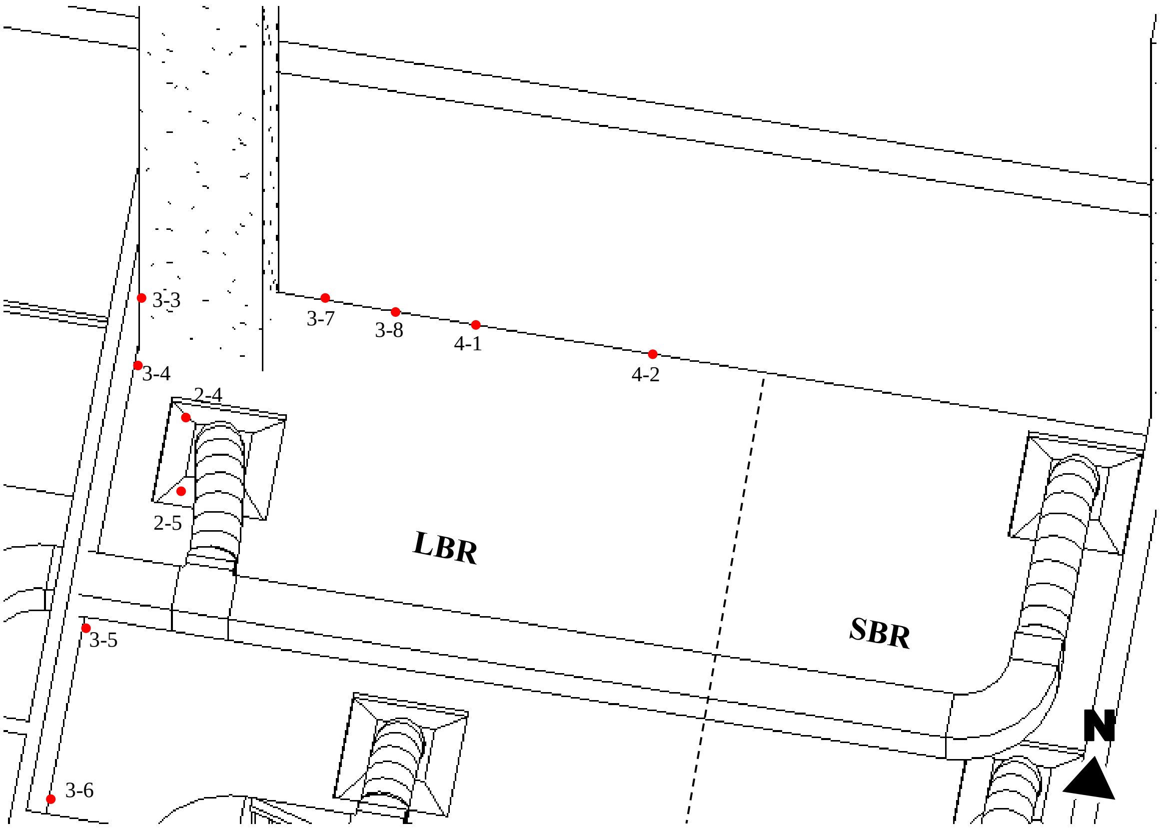

Figure C.34. TCs above LBR ceiling

Figure C.35 shows the temperatures recorded by the thermocouples above the LBR ceiling space. These thermocouple locations are listed in details in Table C.18.

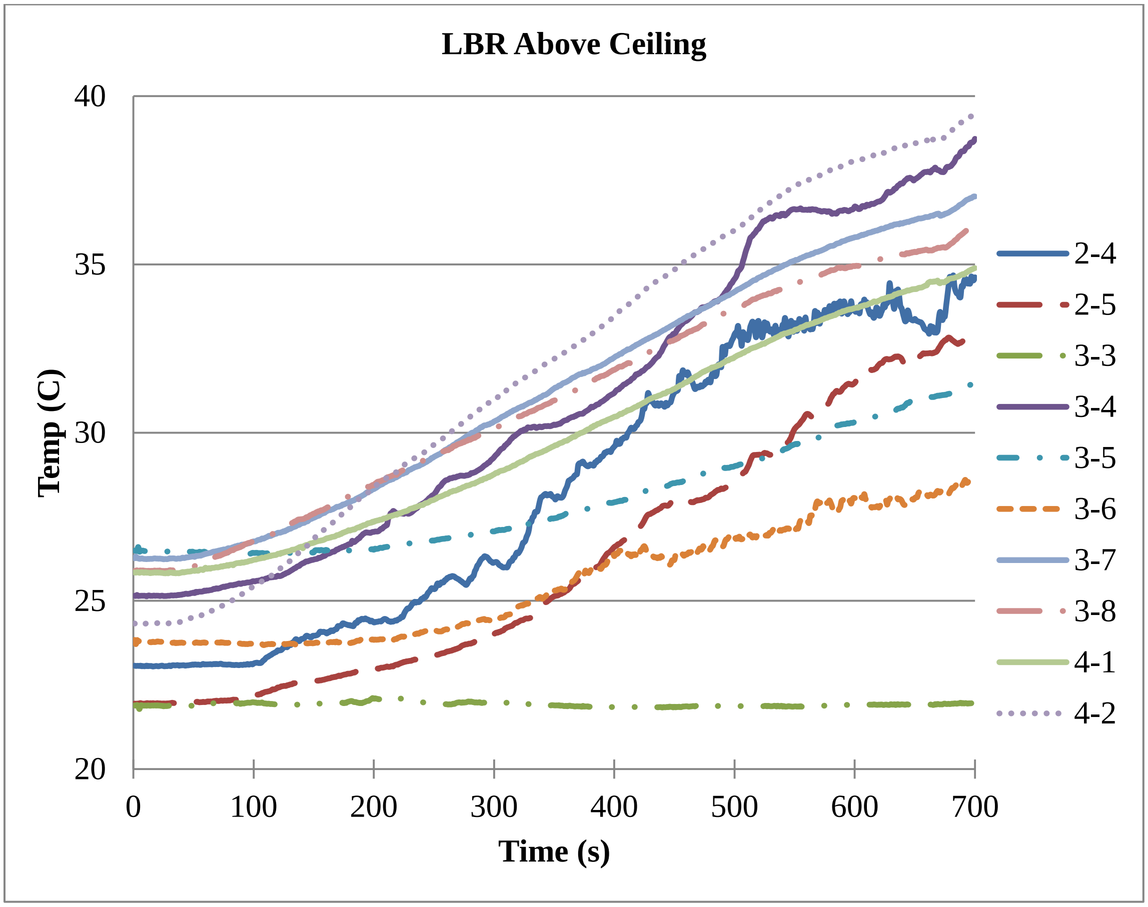

Figure C.35. Space above LBR ceiling temperatures

Table C.18. LBR above ceiling TC list

2-4	(s) on the NW corner diffuser
2-5	(s) on the NW corner diffuser
3-3	(g) above ceiling on SW corner gap of the N column, .32 above ceiling
3-4	(s) above ceiling of the W wall, 0.13m (0.43’) from N column
3-5	(s) above ceiling of the W wall, 1.5m (4.92’) from S wall
3-6	(s) above ceiling of the W wall, 0.1m (0.3’) from S wall
3-7	(s) above ceiling of the N wall, 0.3m (1’) from N column
3-8	(s) above ceiling of the N wall, 0.7m (2.3’) from N column
4-1	(s) above ceiling of the N wall, 1.2m (3.9’) from N column
4-2	(s) above ceiling of the N wall, 2.4m (7.9’) from N column

C.2.6 Firestops Above LBR Ceiling

Figure C.36 shows the thermocouples that were placed on the firestops in the LBR above the ceiling.

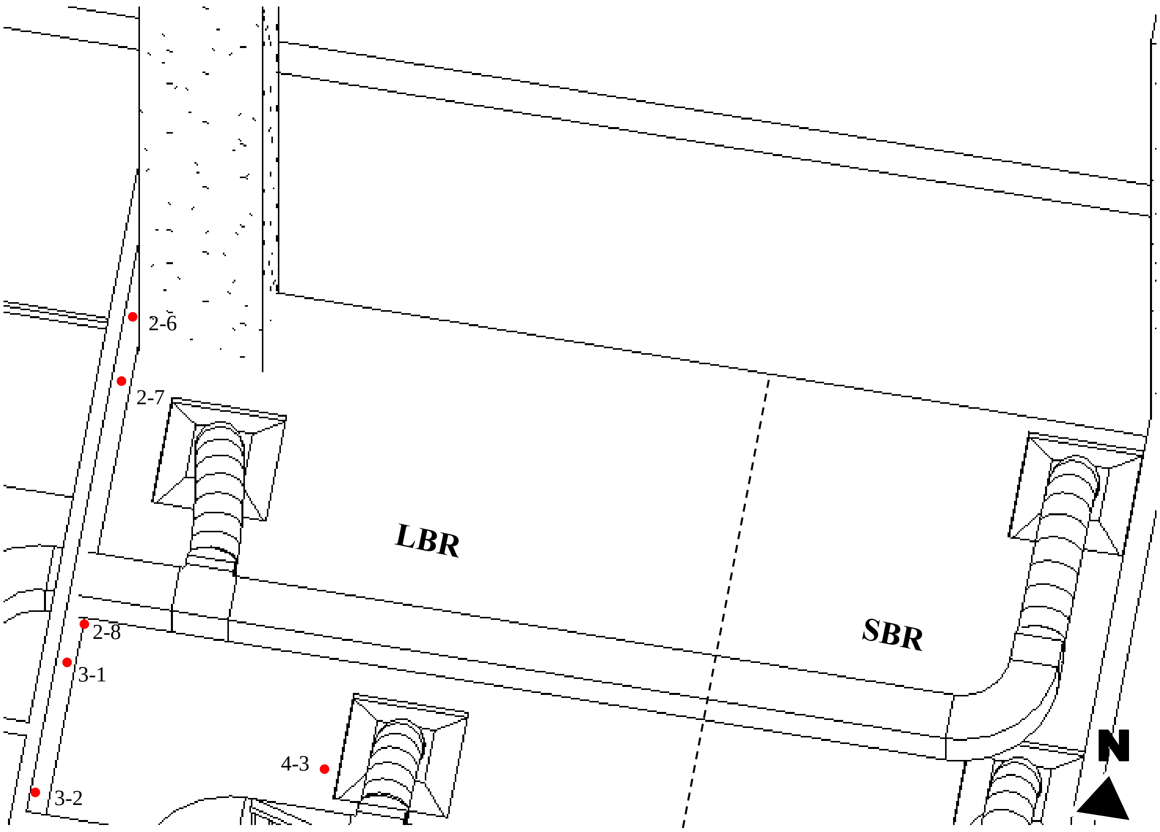

Figure C.36. TCs on LBR firestops above ceiling

Figure C.37 shows the temperatures of the firestops above the LBR ceiling space. These thermocouple locations are listed in Table C.19.

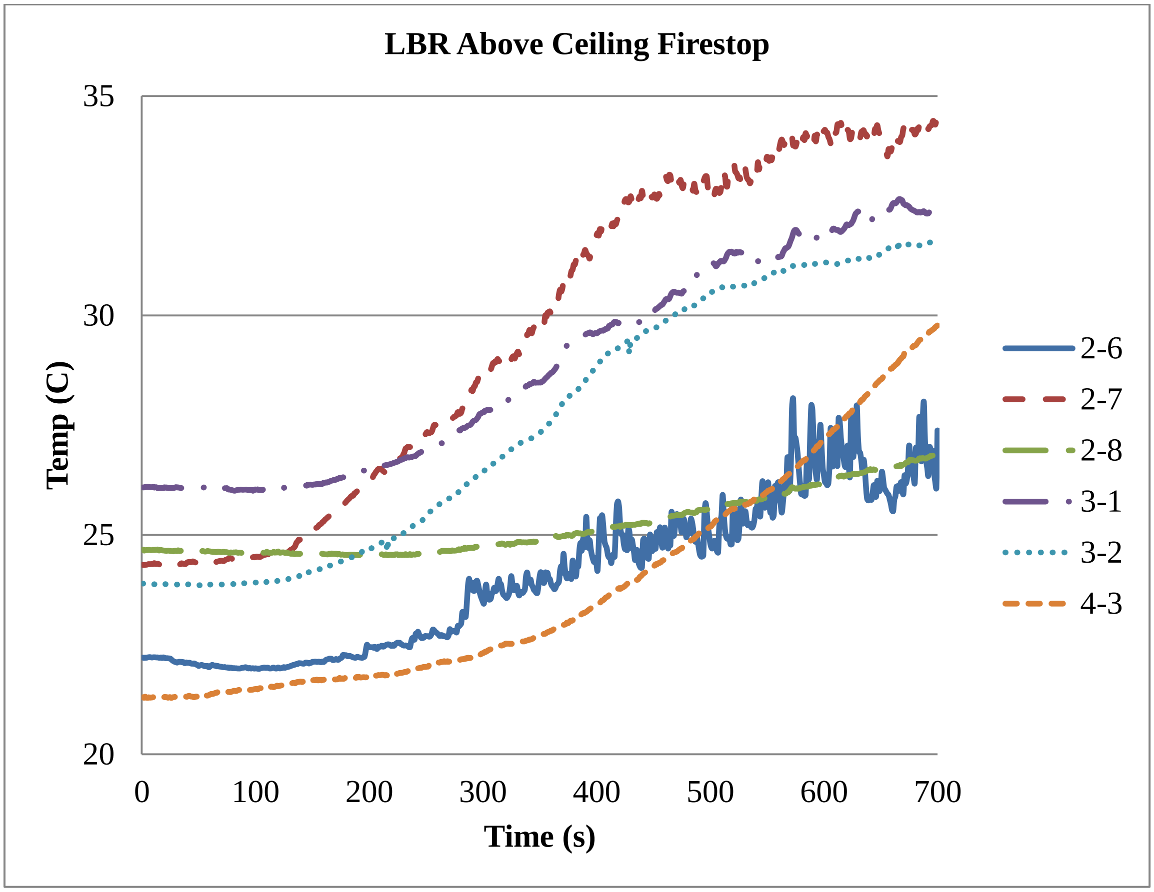

Figure C.37. Firestop temperatures above the LBR ceiling

Table C.19. LBR firestops above ceiling TC list

2-6	(s) above ceiling on firestop, 0.19m (0.6') from N column, 0.37m (1.2') below 4th floor slab
2-7	(s) above ceiling on firestop, 0.52m (1.7') from N column,0.42m (1.4') below 4th floor slab
2-8	(s) above ceiling on firestop, 1.6m (5.2') from S wall, 0.87m (2.9') below 4th floor slab
3-1	(s) above ceiling on firestop, 1.4m (4.6') from S wall, 0.45m (1.5') below 4th floor slab
3-2	(s) above ceiling on firestop, 0.65m (2.1') from S wall, 0.1m (0.3') below 4th floor slab
4-3	(g) above ceiling, SE corner of the W lighting, 2.7m (8.9') from N wall, 1.4m (4.6') from W wall

C.2.7 Active Fire Systems in the LBR and SBR

Figure C.38 shows the thermocouples that were located on the fire protection systems in the LBR and SBR areas.

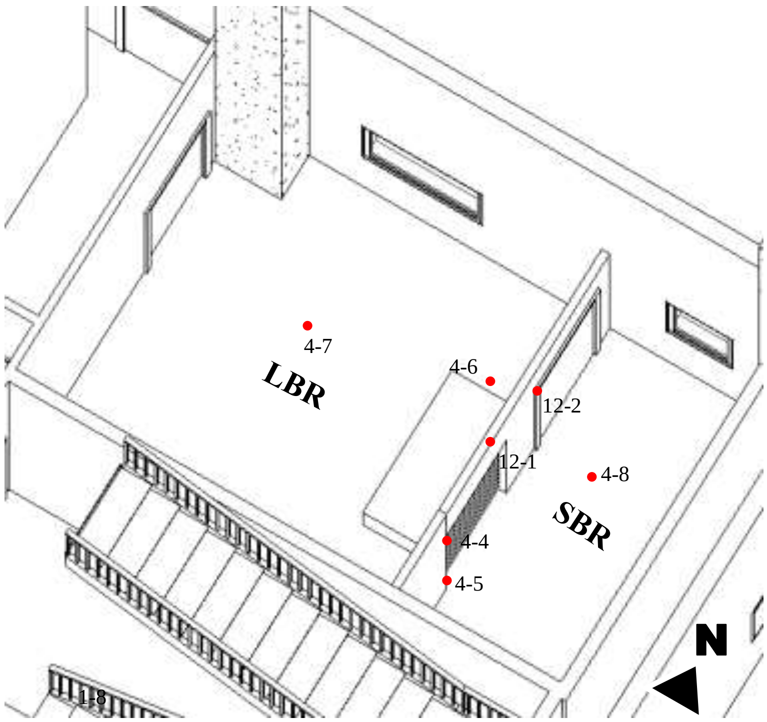

Figure C.38. TC on LBR and SBR fire systems

Figure C.39 shows the temperatures recorded of the fire protection systems in the LBR and SBR. These thermocouple locations are listed in details in Table C.20.

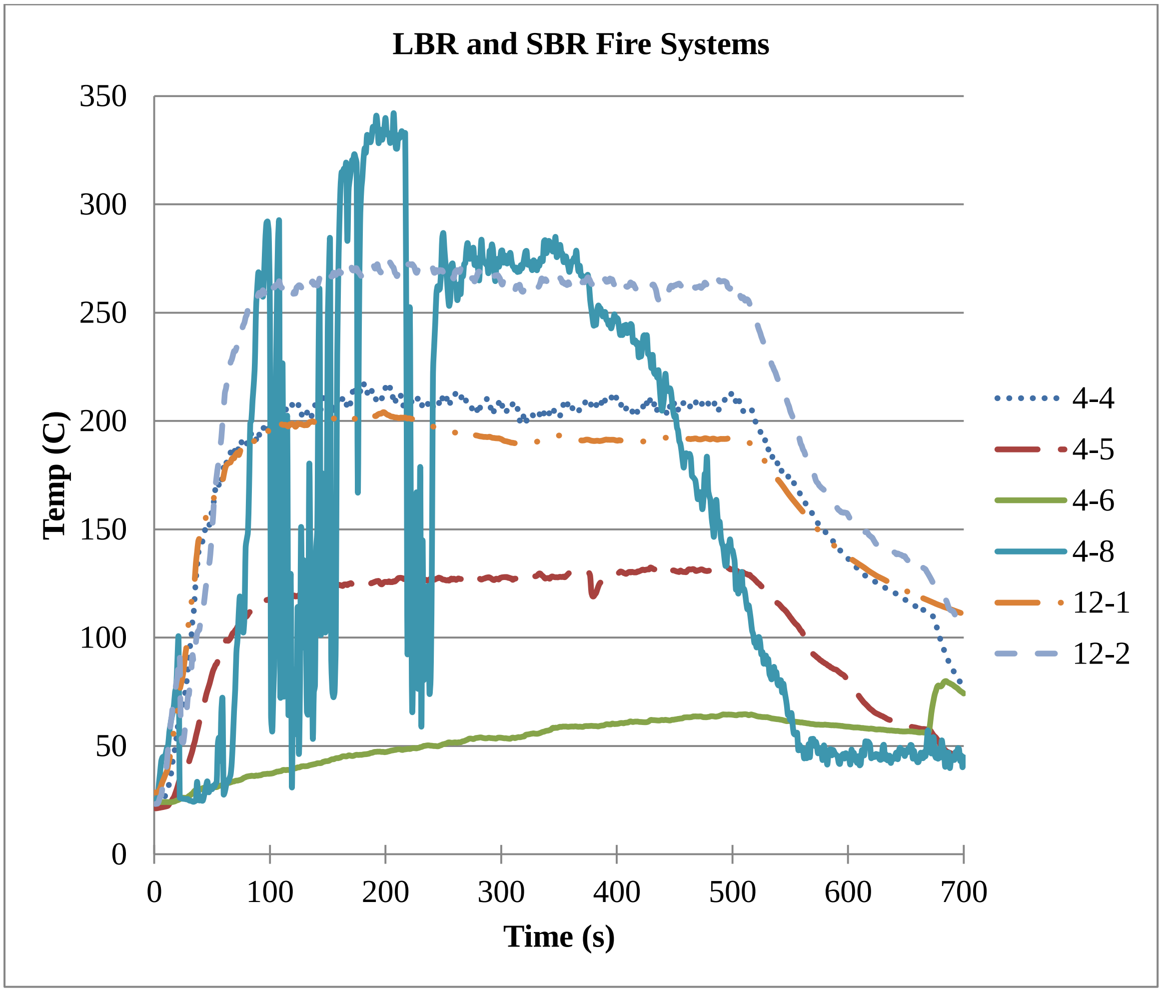

Figure C.39. Temperatures of fire systems in the LBR and SBR

Table C.20. LBR and SBR fire systems TC list

4-4	(g) south part of fire door frame, 1.88m (6.2') above floor
4-5	(g) south part of fire door frame, 0.3m (1') above floor
4-6	(s) Fusible link of fire door, 1.5m (4.9') from N wall, 0.24m (0.8') below ceiling
4-7	(s) sprinkler head fusible link in the LBR, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor
4-8	(s) sprinkler head fusible link in the SBR, 1.3m (4.3') from N wall 1.4m (4.6') from W wall, 2.8m (9.2') above floor
12-1	(g) W wall of SBR gap above the fire door, 1.6m (5.2') from N wall
12-2	Corner of the door frame in the partition wall, 2.1m (6.9') above floor, 1.1m (3.6') from N wall

C.2.8 North Exterior Wall of Building

Figure C.40 shows the thermocouples that were placed on the north exterior balloon frame of the building.

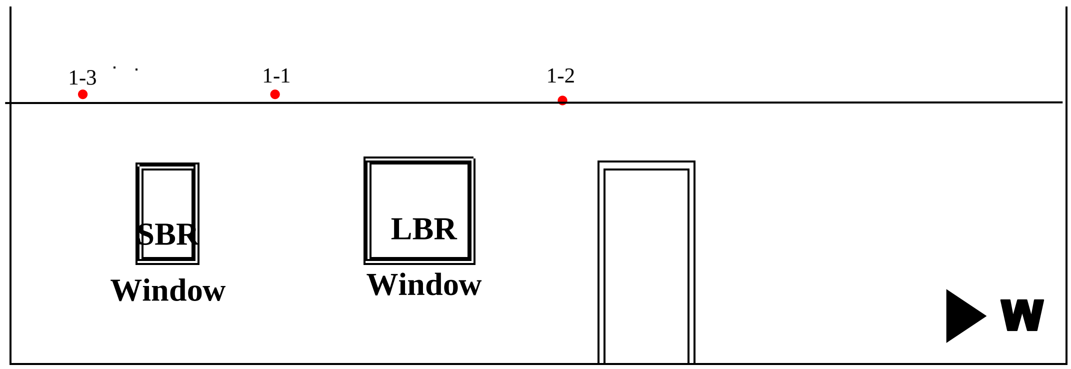

Figure C.40. TC on N balloon frame of building

Figure C.41 shows the north exterior balloon framing temperatures of the building. These thermocouple locations are listed in details in Table C.21.

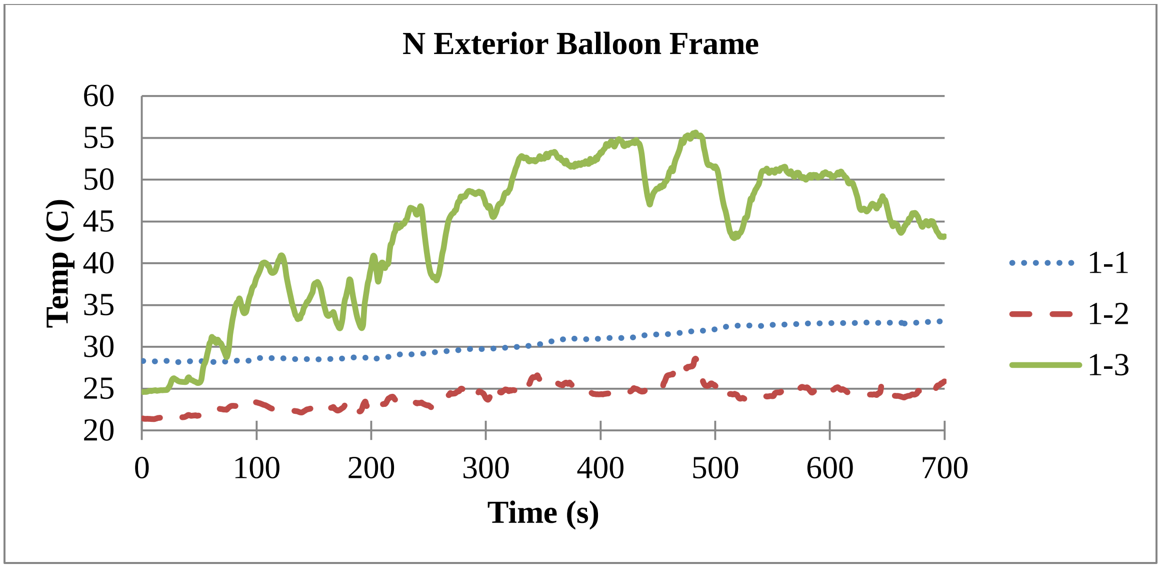

Figure C.41. Temperatures of the north exterior balloon framing of the building

Table C.21. N balloon frame of building TC list

1-1	(g) NE Balloon Framing from LBR
1-2	(g) NW balloon framing from LBR
1-3	(g) Balloon framing from SBR

C.2.9 Active Fire Systems Activation

Figure C.42 shows the temperature of the SBR sprinkler. The graph indicates the SBR sprinkler activated at 21 seconds at 100C (212F). Although thermocouple 4-7 malfunctioned, post fire test visual inspection revealed the LBR sprinkler did not activate. The thermocouple location is listed in detail in Table C.22.

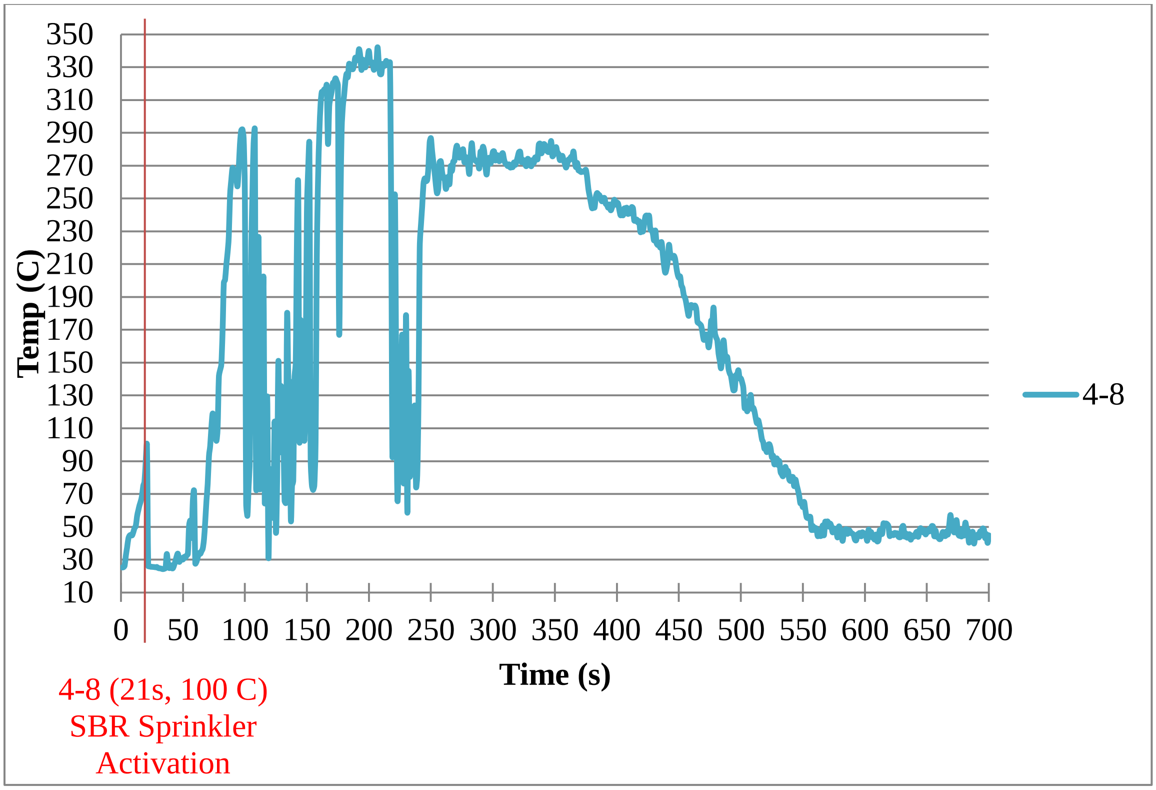

Figure C.42. SBR sprinkler temperatures

Table C.22. SBR and LBR sprinkler TC list

4-7	(s) sprinkler head fusible link in the LBR, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor ***(NO DATA, TC Malfunctioned)***
4-8	(s) sprinkler head fusible link in the SBR, 1.3m (4.3') from N wall 1.4m (4.6') from W wall, 2.8m (9.2') above floor

C.3 LBR FIRE TEST 2 TEMPERATURES

C.3.1 LBR Thermocouple Tree

Figure C.43 shows the thermocouple tree located inside the LBR and Figure C.44 shows the thermocouple tree located above the SBR and LBR ceiling.

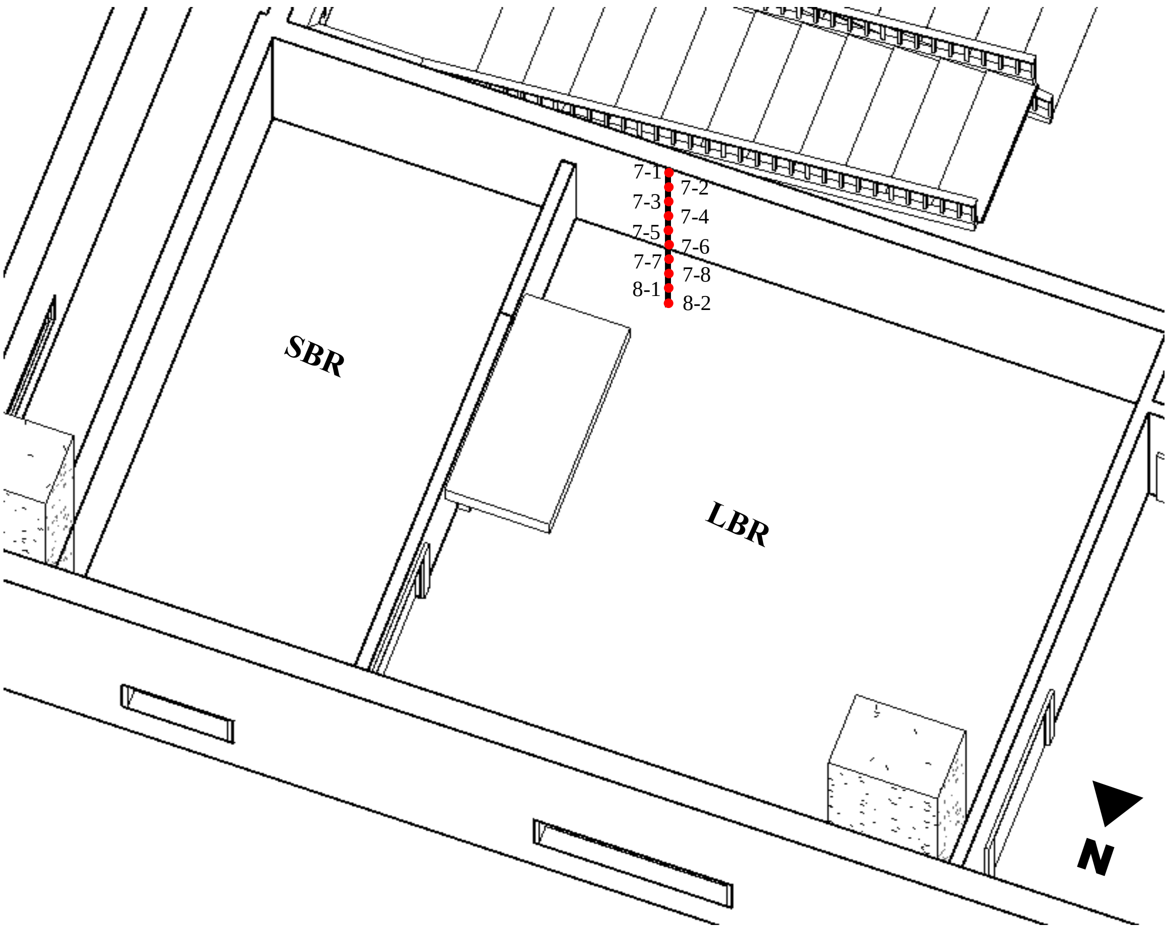

Figure C.43. TC tree in LBR

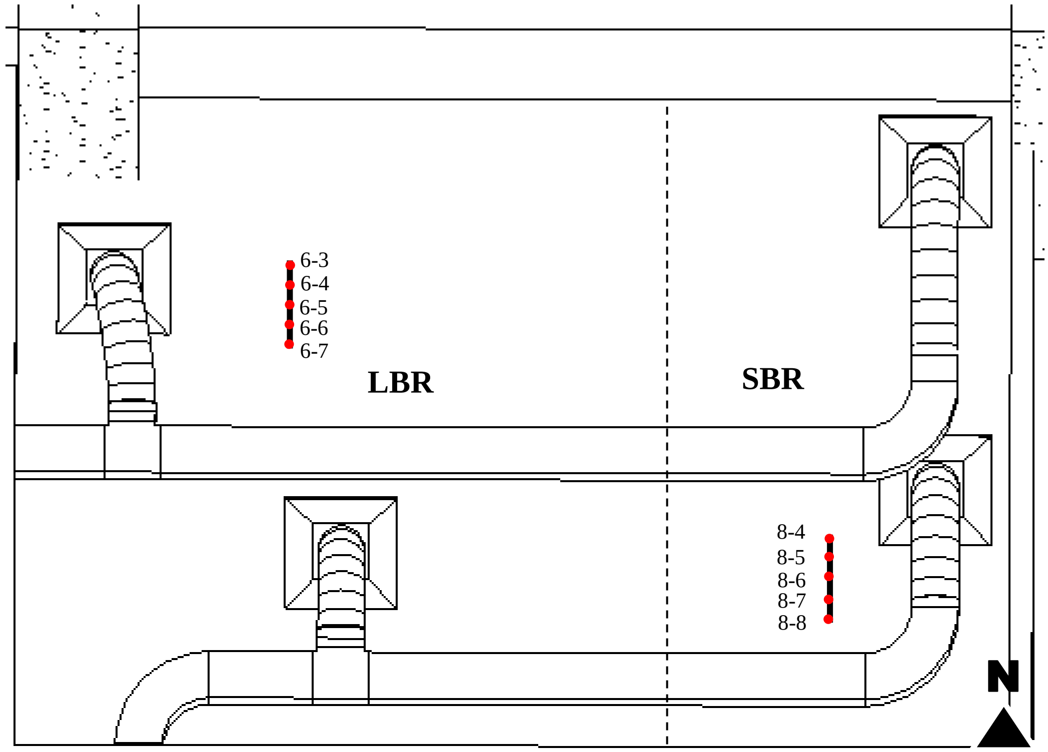

Figure C.44. TC trees above LBR and SBR ceiling

Figure C.45 shows the temperature data in the LBR and the space above the LBR ceiling space. Figure C.46 shows the temperature data in the space above the SBR ceiling space. Table C.23 lists the locations of the LBR thermocouple tree and Table C.24 lists the locations of the thermocouple trees above the LBR and SBR ceiling space.

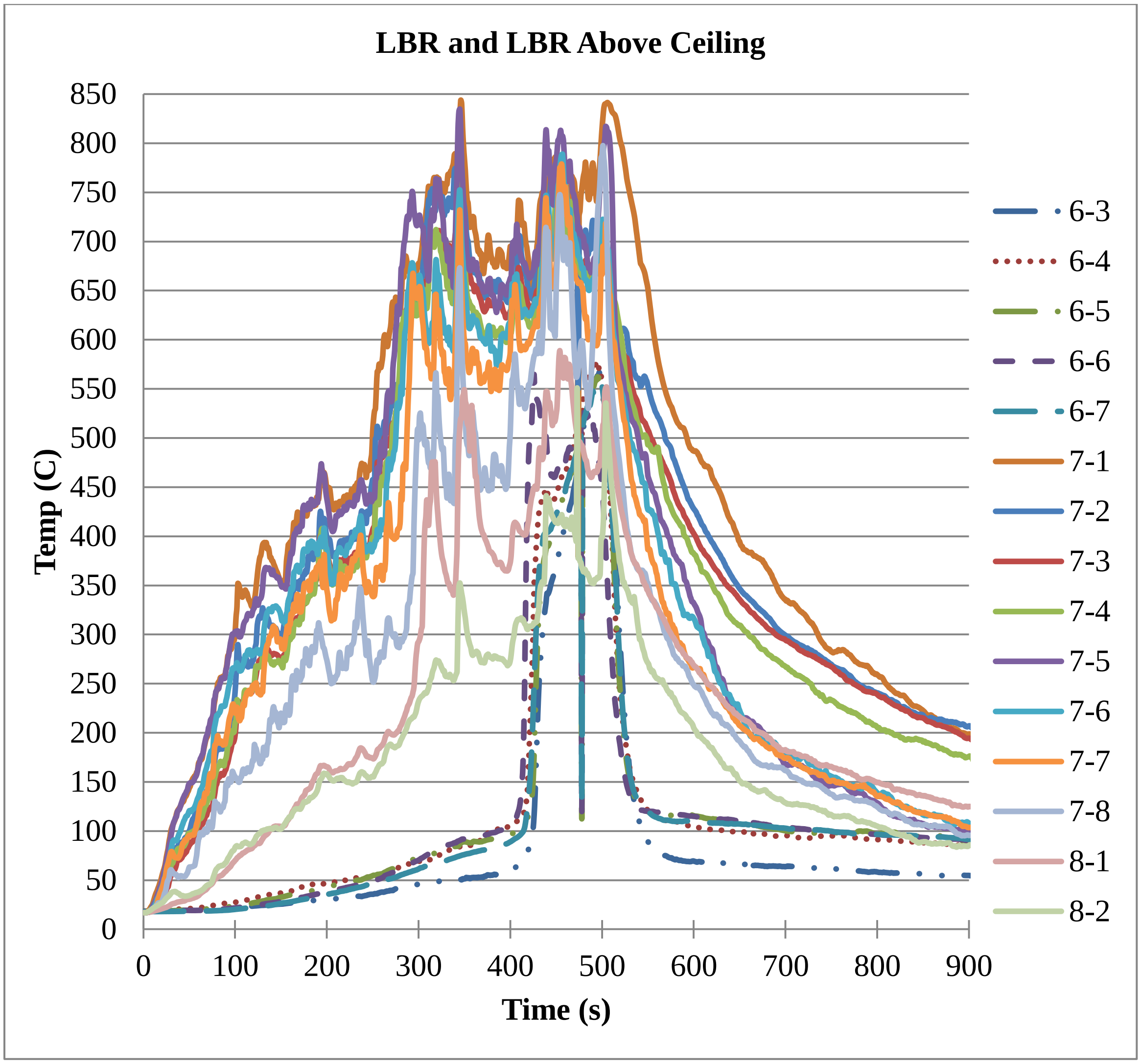

Figure C.45. LBR and LBR above ceiling TC tree temperatures

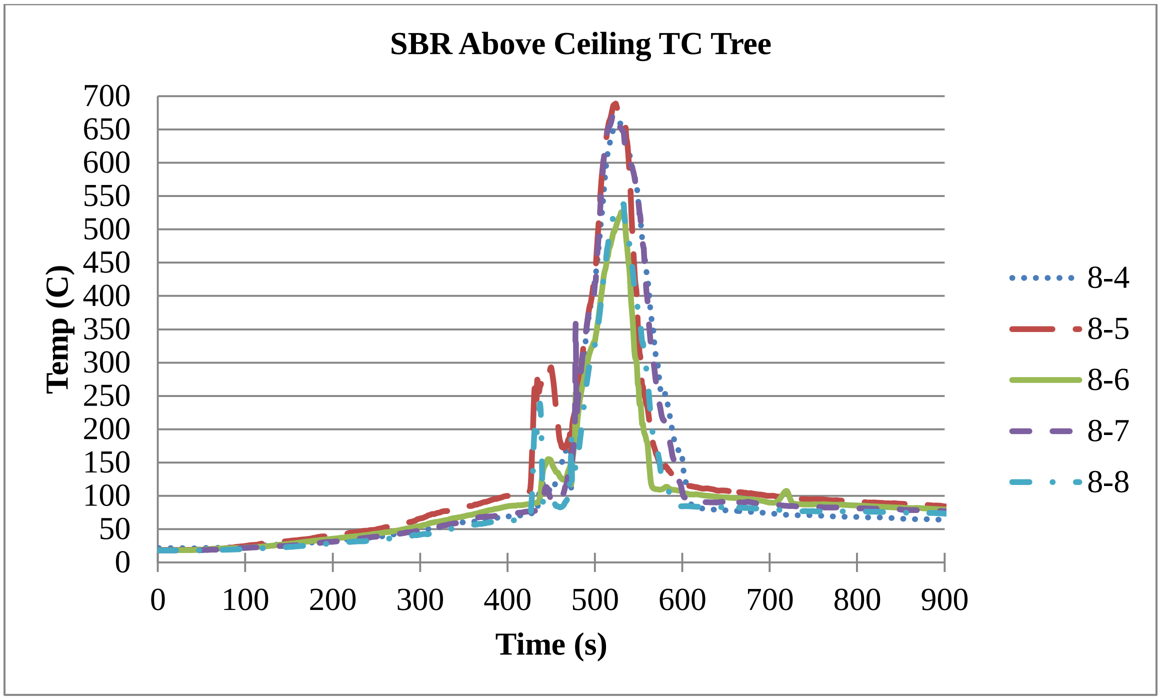

Figure C.46. SBR above ceiling TC tree temperatures

Table C.23. LBR TC tree list

7-1	TC tree below ceiling of LBR starting with 8-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 7-1 on top at 2.7m (8.9ft)
7-2	
7-3	
7-4	
7-5	
7-6	
7-7	
7-8	
8-1	
8-2	

Table C.24. LBR and SBR above ceiling TC trees list

6-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top
6-4	
6-5	
6-6	
6-7	
8-4	TC tree hanging from 4th floor slab above ceiling of SBR starting with 8-8 right above ceiling and increasing in 0.3m (1ft) increments to 8-4 being on top
8-5	
8-6	
8-7	
8-8	

C.3.2 LBR Column Gap and South Wall of LBR Gap

Figure C.47 shows the thermocouples that were located in the gaps formed between the north column and west and north walls of the LBR and the thermocouples that were located in the cracks formed on the south wall of the LBR.

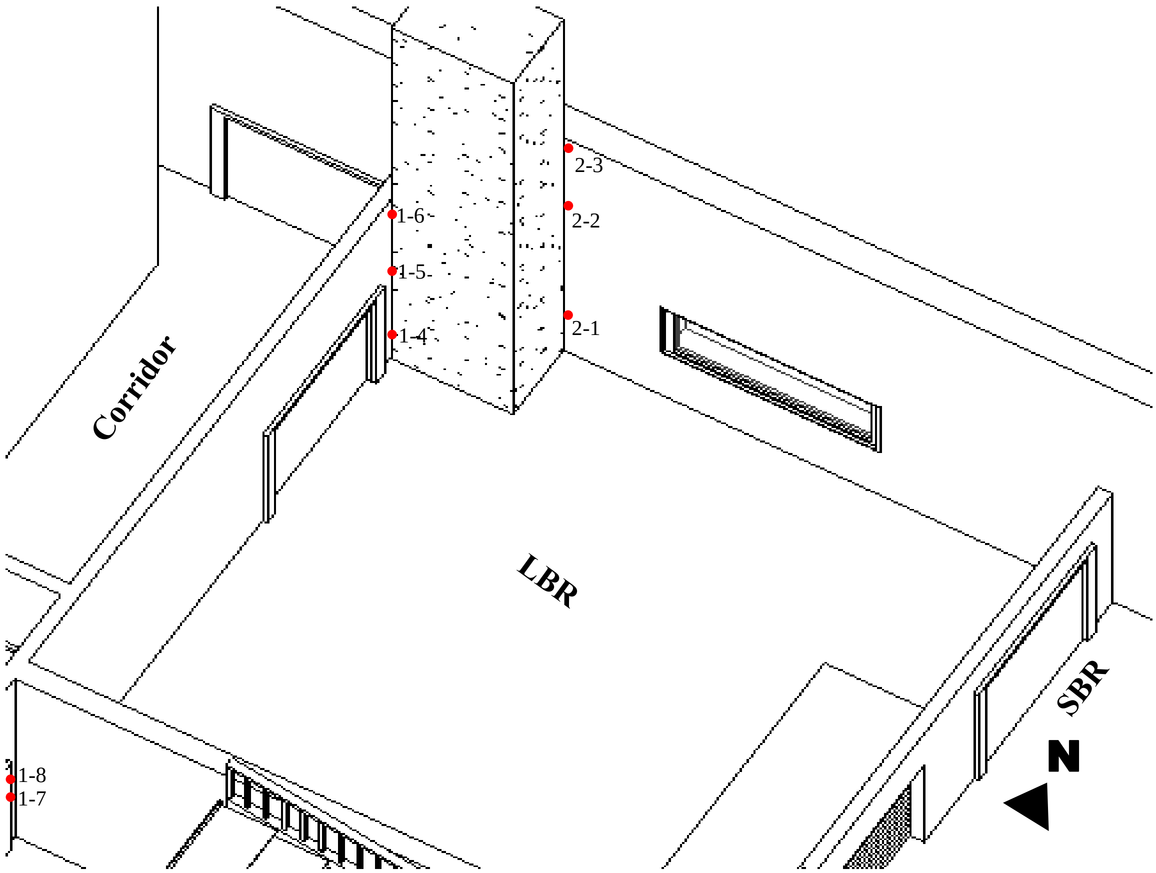

Figure C.47. TC in gaps in LBR column and in SW corner of LBR

Figure C.48 shows the temperatures of the LBR column and south wall gaps. These thermocouple locations are shown in Table C.25.

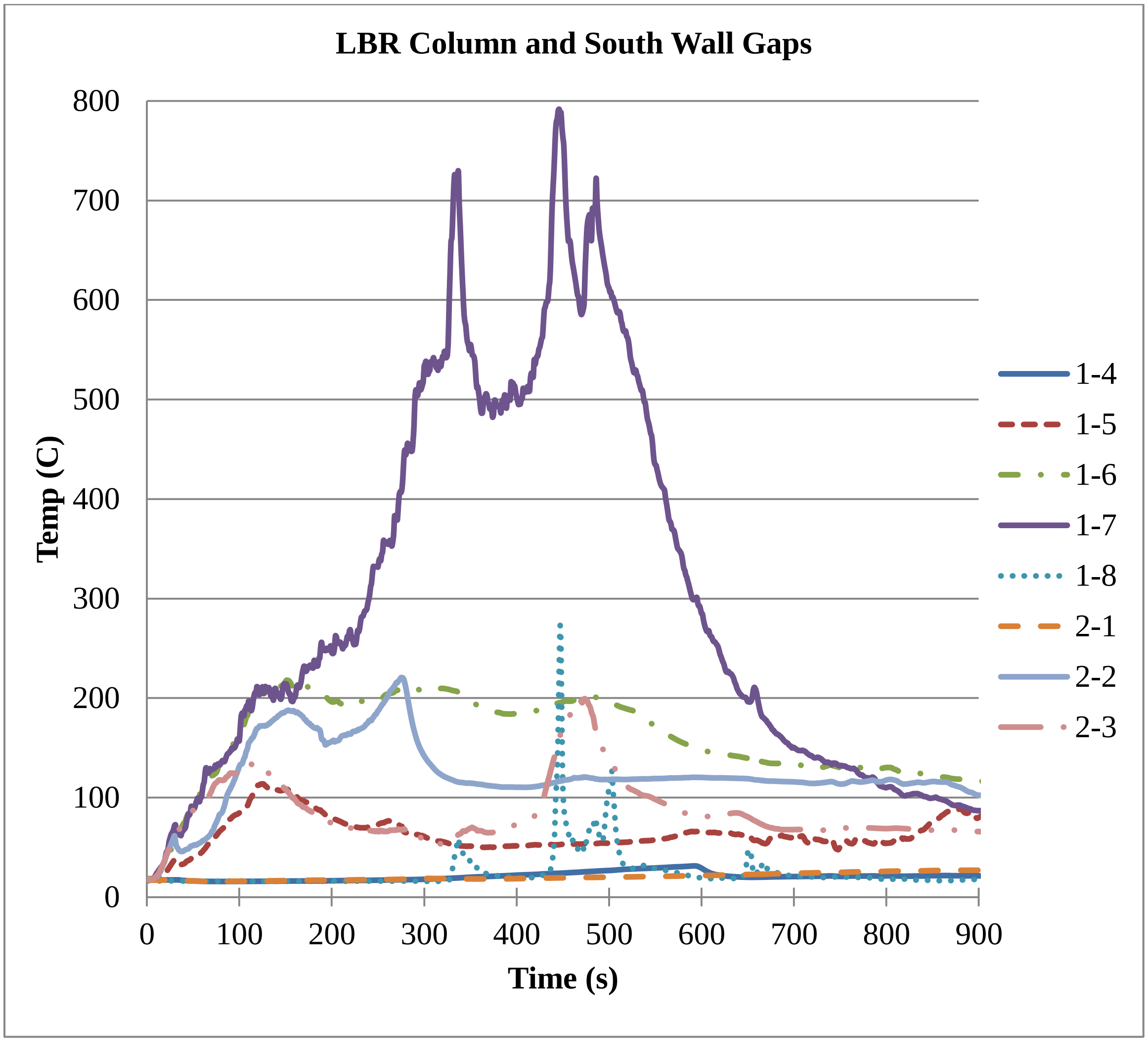

Figure C.48. LBR column gap temperatures

Table C.25. LBR column and SW corner of LBR gaps TC list

1-4	(g) On the SW corner gap of the N column, 0.59m (1.9') above floor
1-5	(g) On the SW corner gap of the N column, 2.03m (6.7') above floor
1-6	(g) On the SW corner gap of the N column, 0.1m (03') below ceiling
1-7	(g) SW corner of room, 1.22m (4') above floor, (LBR temp)
1-8	(g) SW corner of room, 1.24m (4.1') above floor (stair landing temp)
2-1	(g) on the NE corner gap of the N column 0.6m (2') above floor
2-2	(g) on the NE corner gap of the N column 2m (6.6') above floor
2-3	(g) on the NE corner gap of the N column 2.7m (8.9') above floor

C.3.3 LBR Above Ceiling

Figure C.49 shows the thermocouples located in the space above the LBR ceiling.

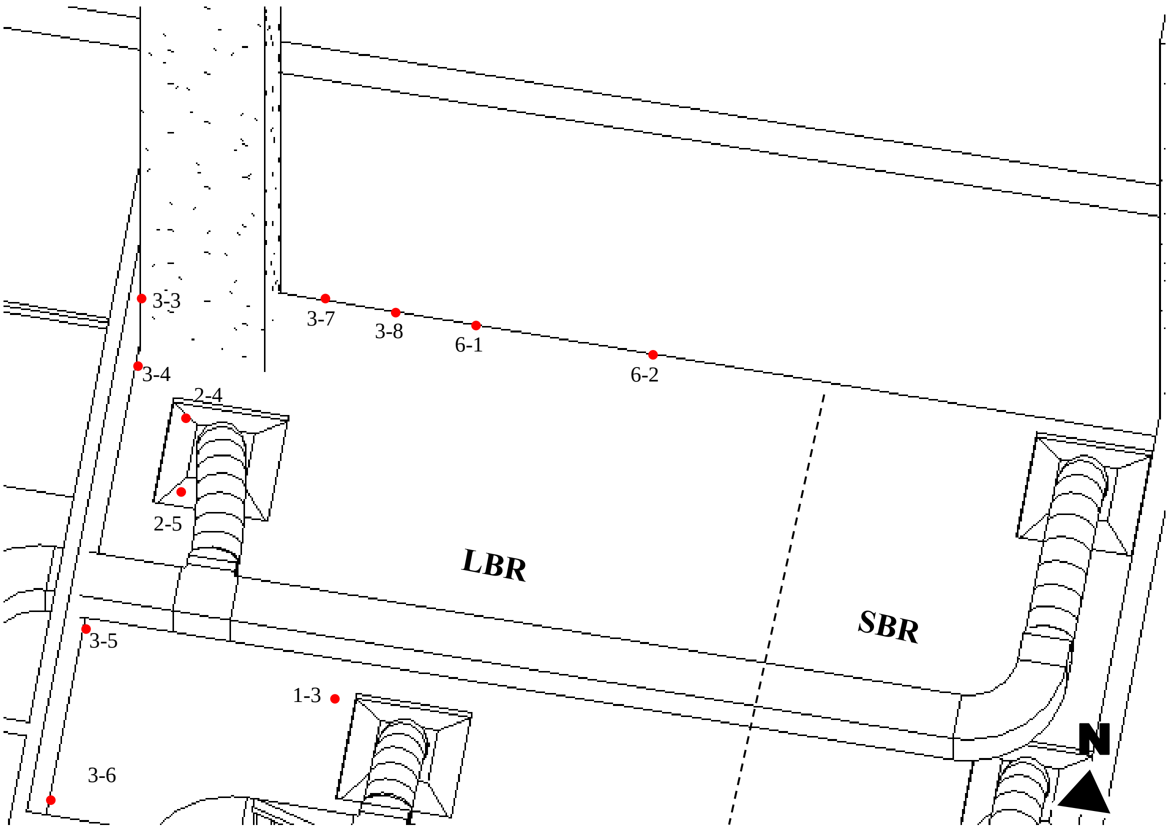

Figure C.49. TC above LBR ceiling

Figure C.50 shows the temperatures above the ceiling space of the LBR. These thermocouple locations are listed in details in Table C.26.

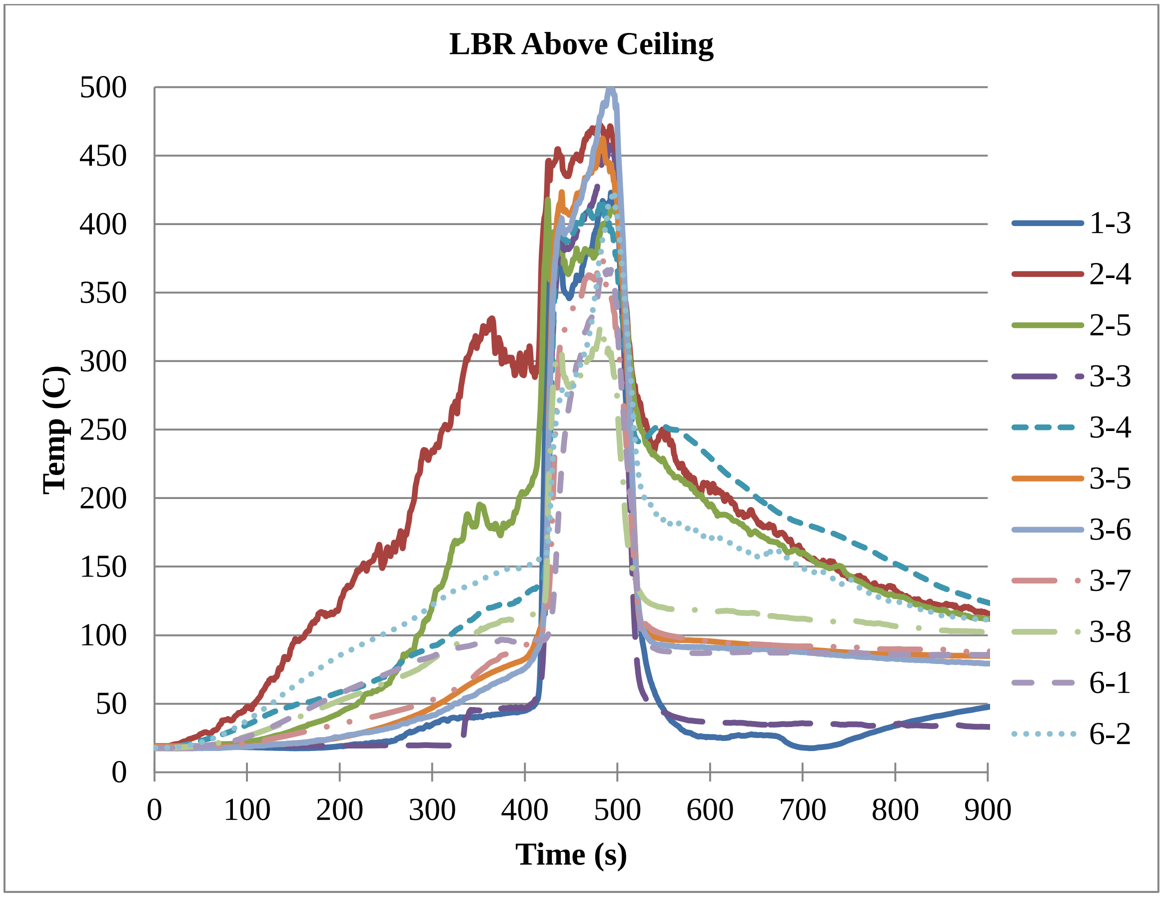

Figure C.50. LBR above ceiling temperatures

Table C.26. Above LBR ceiling TC list

1-3	(g) above ceiling, SE corner of the W lighting, 2.7m (8.9’) from N wall, 1.4m (4.6’) from W wall
2-4	(s) on the NW corner diffuser
2-5	(s) on the NW corner diffuser
3-3	(g) above ceiling on SW corner gap of the N column, 0.32m (1.1’) above ceiling
3-4	(s) above ceiling of the W wall, 0.13m (0.4’) from N column
3-5	(s) above ceiling of the W wall, 1.5m (4.9’) from S wall
3-6	(s) above ceiling of the W wall, 0.1m (0.3’) from S wall
3-7	(s) above ceiling of the N wall, 0.3m (1’) from N column
3-8	(s) above ceiling of the N wall, 0.7m (2.3’) from N column
6-1	(s) above ceiling of the N wall, 1.2m (3.9’) from N column
6-2	(s) above ceiling of the N wall, 2.4m (7.9’) from N column

C.3.4 Firestop Above LBR Ceiling

Figure C.51 shows the thermocouples located on the firestops above the LBR ceiling.

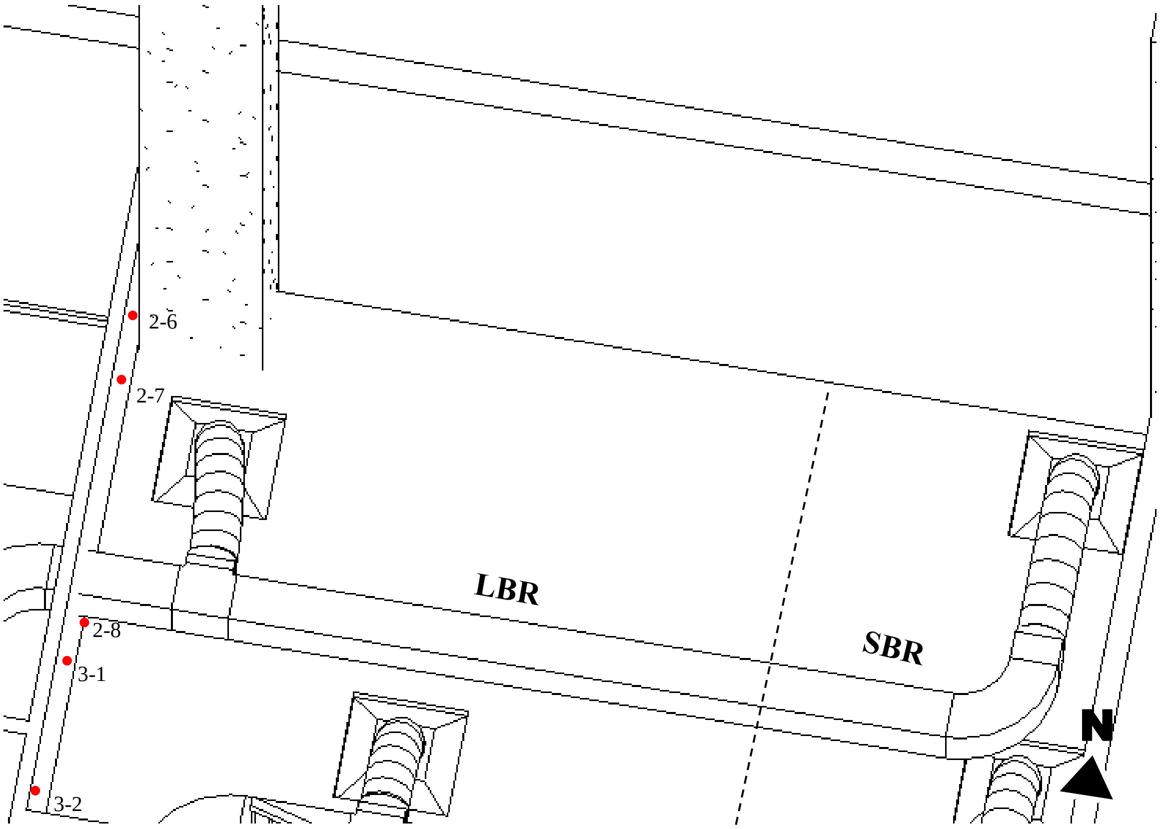

Figure C.51. TC on LBR firestops above ceiling

Figure C.52 shows the temperatures of the firestops above the LBR ceiling. These thermocouple locations are listed in details in Table C.27.

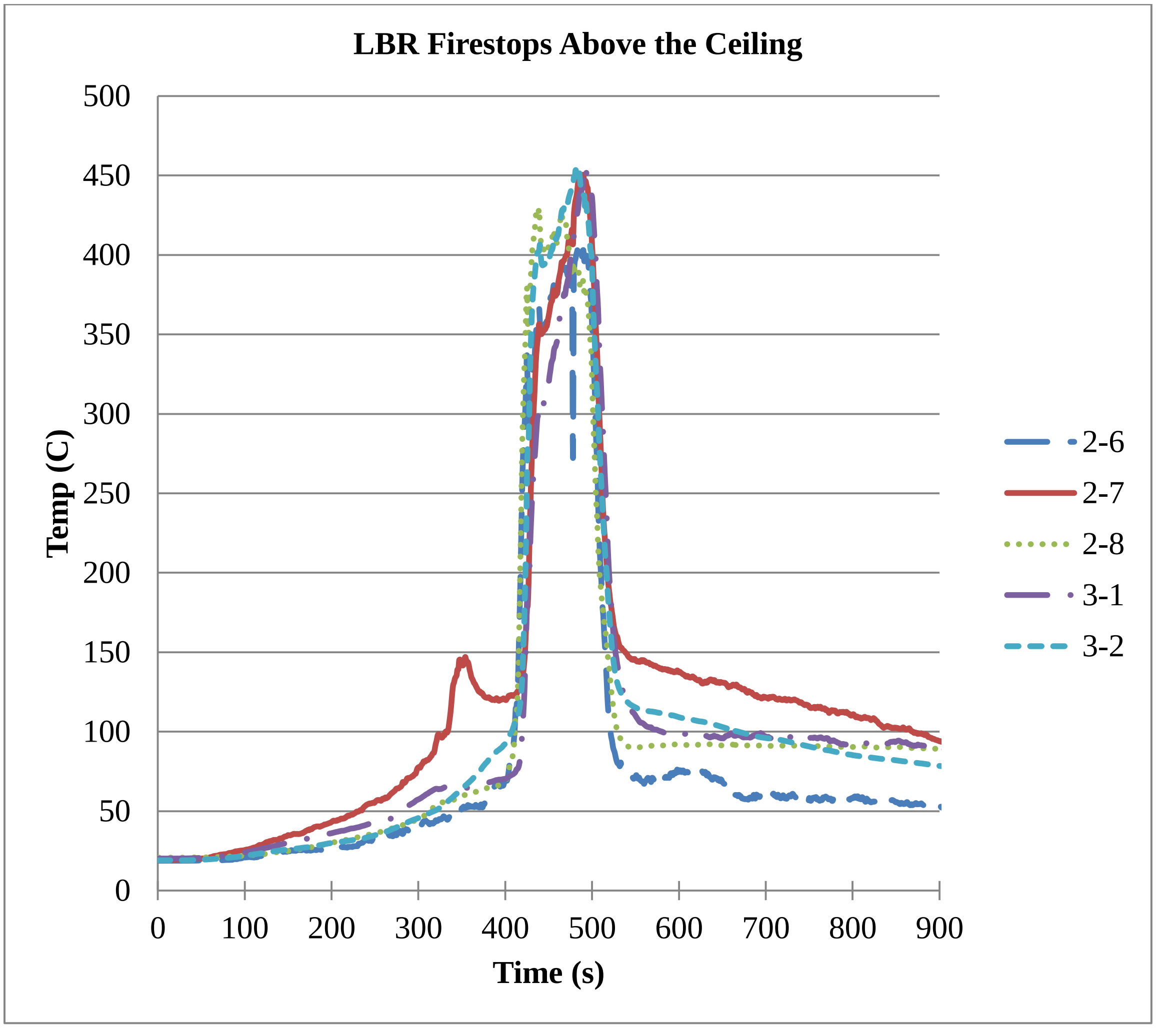

Figure C.52. LBR firestops above the ceiling temperatures

Table C.27. LBR firestops above ceiling TC list

2-6	(s) above ceiling on firestop, 0.19m (0.6') from N column, 0.37m (1.2') below 4th floor slab
2-7	(s) above ceiling on firestop, 0.52m (1.7') from N column, 0.42m (1.4') below 4th floor slab
2-8	(s) above ceiling on firestop, 1.6m (5.2') from S wall 0.87m (2.9') below 4th floor slab
3-1	(s) above ceiling on firestop, 1.4m (4.6') from S wall, 0.45m (1.5') below 4th floor slab
3-2	(s) above ceiling on firestop, 0.65m (2.1') from S wall, 0.1m (0.3') below 4th floor slab

C.3.5 Partition Wall Gap

Figure C.53 shows the thermocouples located in the gap formed between the partition wall and the north wall of the building.

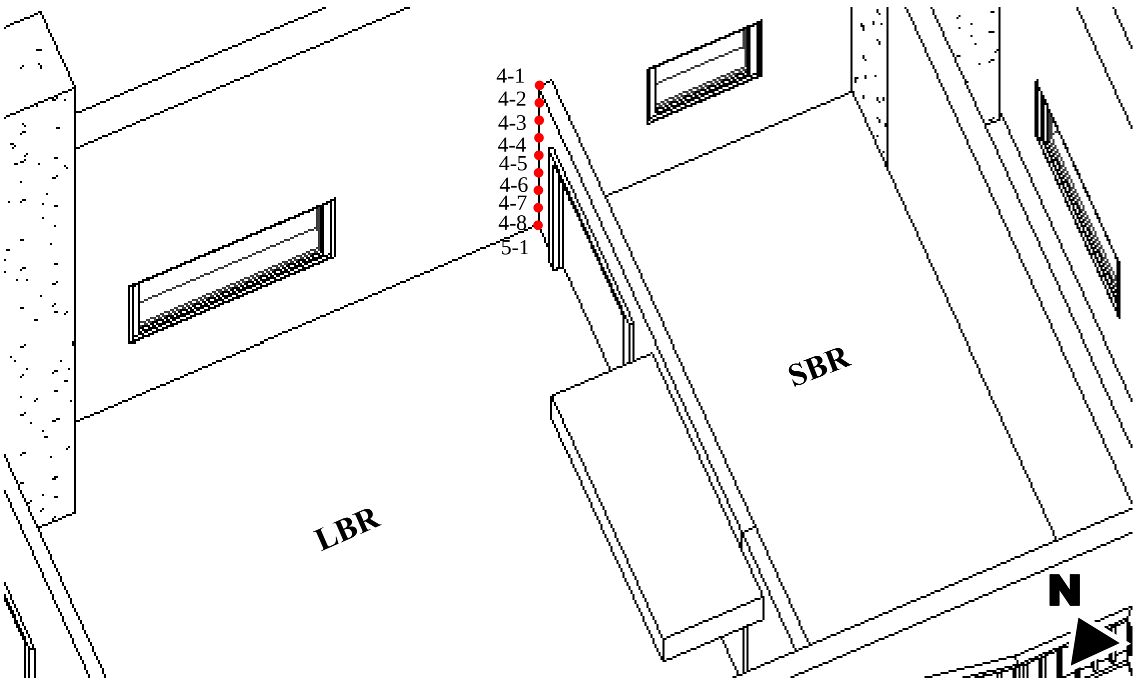

Figure C.53. TC in gap between partition wall and N wall of building

Figure C.54 shows the thermocouple temperatures in the gap between the partition wall and the north wall of the building. These thermocouple locations are listed in details in Table C.28.

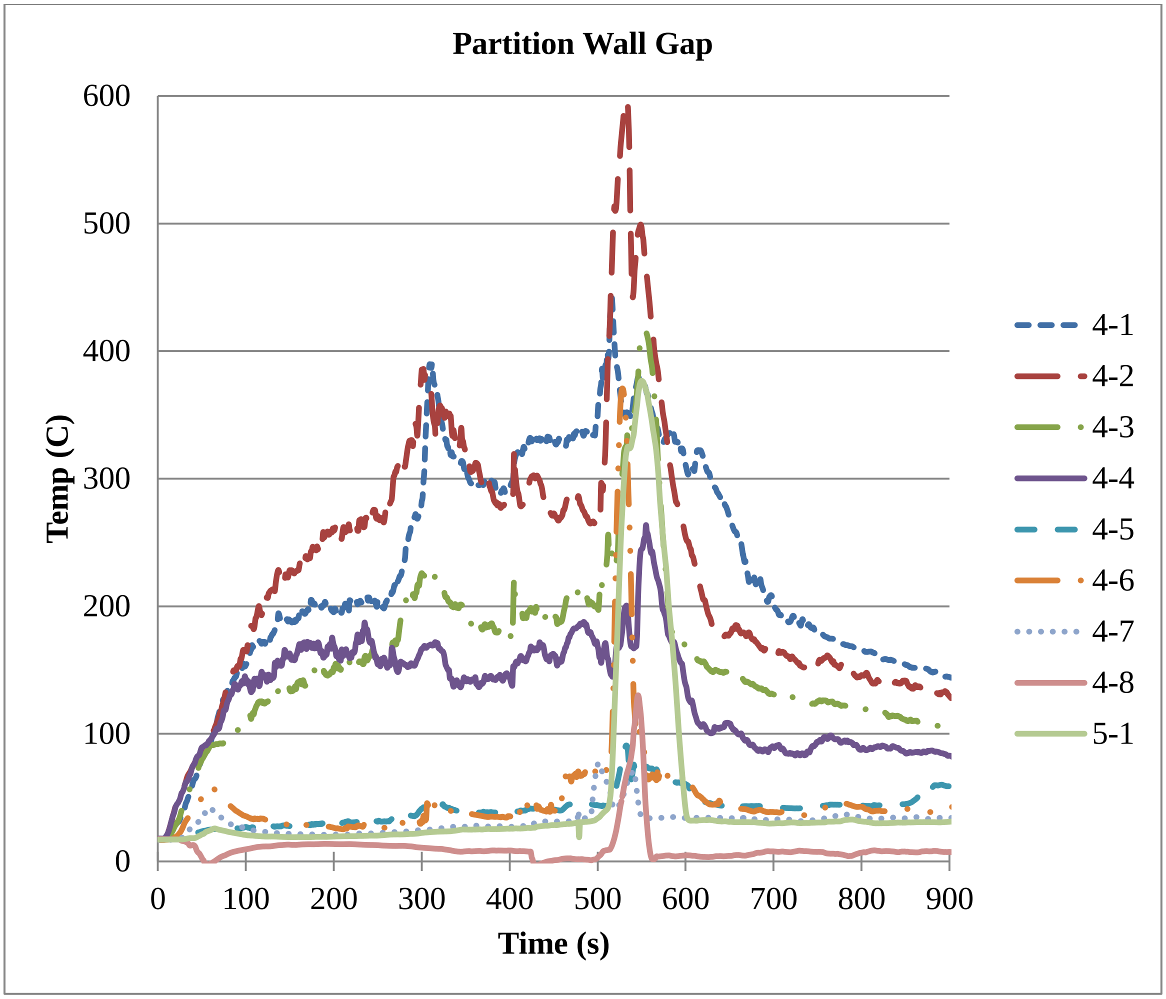

Figure C.54. Partition wall gap temperatures

Table C.28. Gap between LBR and N wall of building TC list

4-1	(g) NW corner gap of the SBR 2.7m (8.9') above floor
4-2	(g) NW corner gap of the SBR 2.4m (7.9') above floor
4-3	(g) NW corner gap of the SBR 2.1m (6.9') above floor
4-4	(g) NW corner gap of the SBR 1.8m (5.9') above floor
4-5	(g) NW corner gap of the SBR 1.5m (4.9') above floor
4-6	(g) NW corner gap of the SBR 1.2m (3.9') above floor
4-7	(g) NW corner gap of the SBR 0.9m (3') above floor
4-8	(g) NW corner gap of the SBR 0.6m (2') above floor
5-1	(g) NW corner gap of the SBR 0.3m (1') above floor

C.3.6 Active Fire Systems

Figure C.55 shows the thermocouples located on the active fire protection systems in the LBR and SBR.

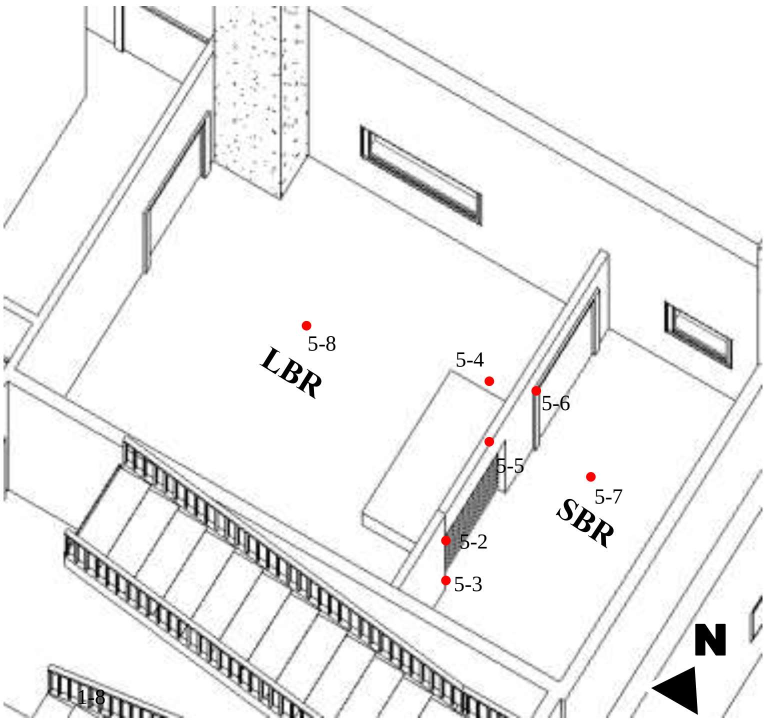

Figure C.55. TC on LBR and SBR fire systems

Figure C.56 shows the temperature data of the active fire protection systems in the LBR and SBR. These thermocouple locations are listed in details in Table C.29.

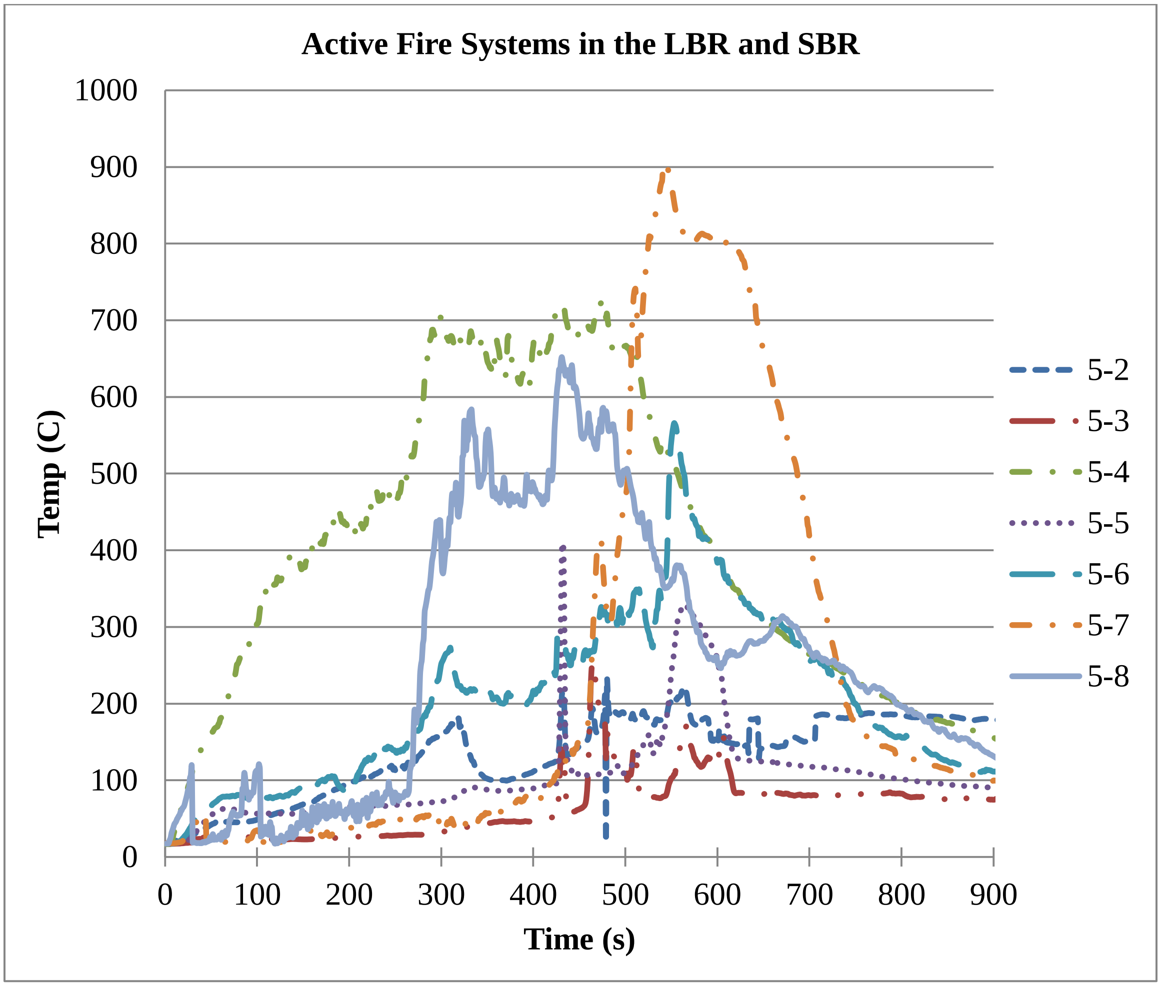

Figure C.56. Temperatures of the active fire systems in the LBR and SBR

Table C.29. LBR and SBR fire system TC list

5-2	(g) south part of fire door frame, 1.88m (6.2') above floor
5-3	(g) south part of fire door frame, 0.3m (1') above floor
5-4	(s) Fusible link of fire door, 1.5m (4.9') from N wall, 0.24m (0.8') below ceiling
5-5	(g) W wall of SBR gap above the fire door, 1.6m (5.2') from N wall
5-6	Corner of the door frame between the SBR and LBR, 2.1m (6.9') above floor, 1.1m (3.6') from N wall
5-7	(s) SBR sprinkler head fusible link 1.3m (4.3') from N wall, 1.4m (4.6') from W wall 2.8m (9.2') above floor
5-8	(s) LBR sprinkler head fusible link, 1.3m (4.3') from N wall, 1.8m (5.9') from E wall, 2.8m (9.2') above floor

C.3.7 South Wall of SBR Gaps

Figure C.57 shows the thermocouples located in the south wall gaps in the SBR.

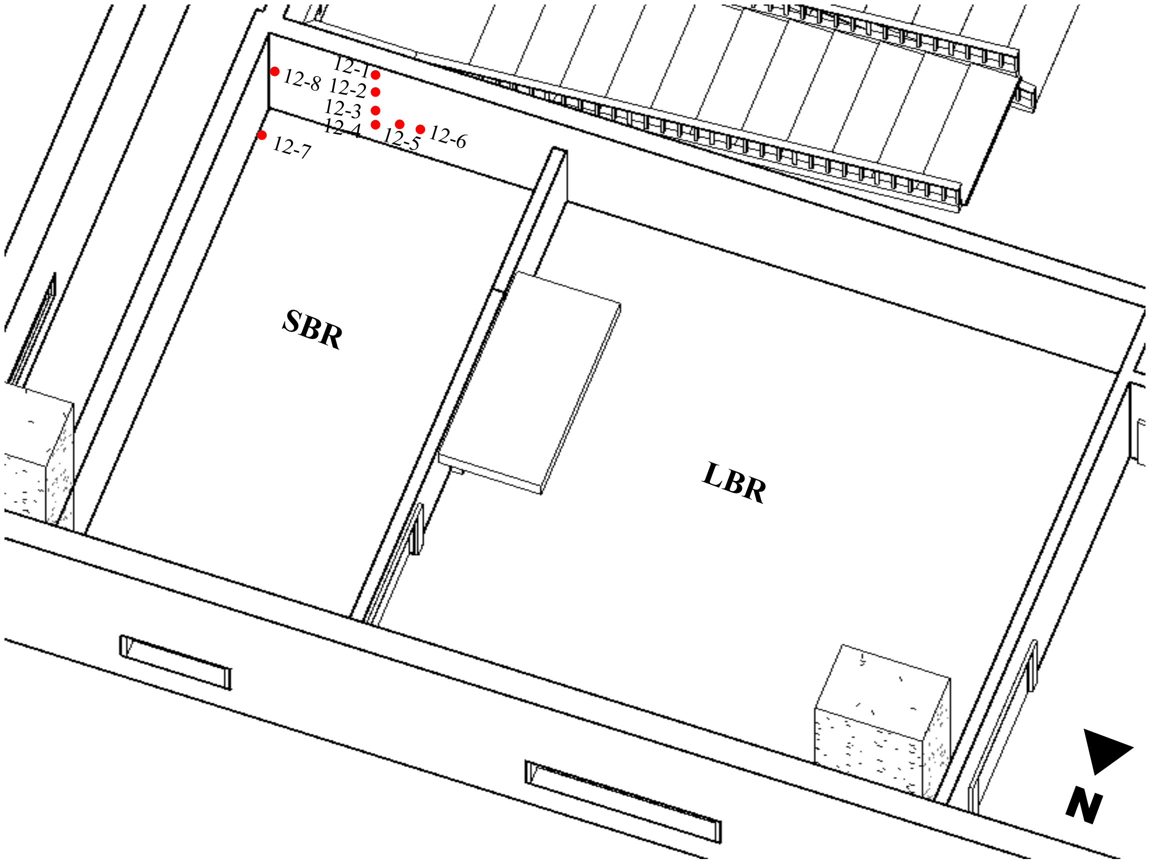

Figure C.57. TC on S wall of SBR

Figure C.58 shows the temperature data on the gaps of the south wall of the SBR. These thermocouple locations are listed in details in Table C.30.

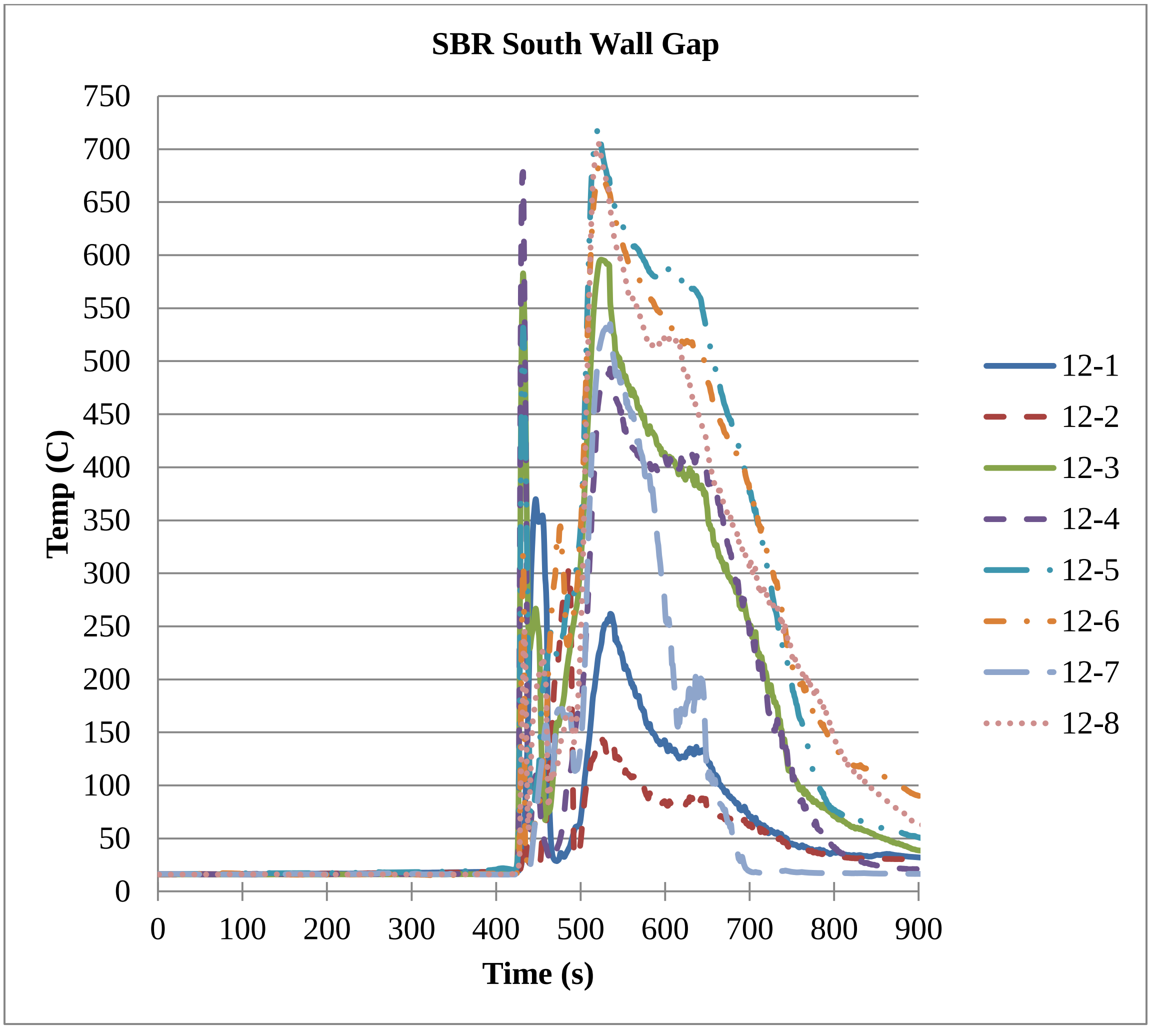

Figure C.58. SBR south wall gap temperatures

Table C.30. S wall of SBR TC list

12-1	(g) gap on S wall, 1.12m (3.7') from SW corner, 2.24 (7.3') above floor
12-2	(g) gap on S wall, 1.12m (3.7') from SW corner, 1.84m (6') above floor
12-3	(g) gap on S wall, 1.12m (3.7') from SW corner 1.16 (3.8') above floor
12-4	(g) gap on S wall, 1.12m (3.7') from SW corner, 0.74 (2.4') above floor
12-5	(g) S wall firestop on opening, 0.99m (3.2') from SW corner, 0.8m (2.6') above floor
12-6	(g) S wall firestop on opening, 0.83m (2.7') from SW corner, 0.81m (2.7') above floor
12-7	(g) E wall to slab firestop gap, 0.19m (0.6') from SE corner
12-8	(g) SE corner of SBR, 1.68m (5.5') above floor

C.3.8 Exterior Gas Temperatures

Figure C.59 shows the thermocouples located on the north exterior balloon frame and a thermocouple tree sticking out of the LBR window.

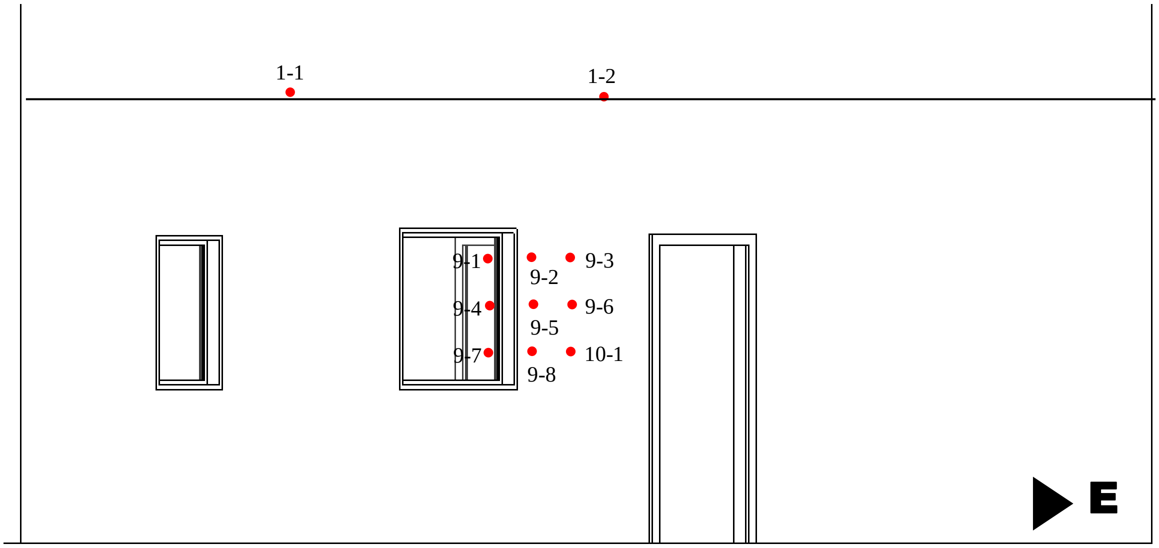

Figure C.59. TC on N wall balloon frame and TC tree hanging out on west of LBR window

Figure C.60 shows the temperature data on the exterior north balloon frame and the temperature of the hot gases leaving the LBR window. The thermocouple locations are listed in details in Table C.31.

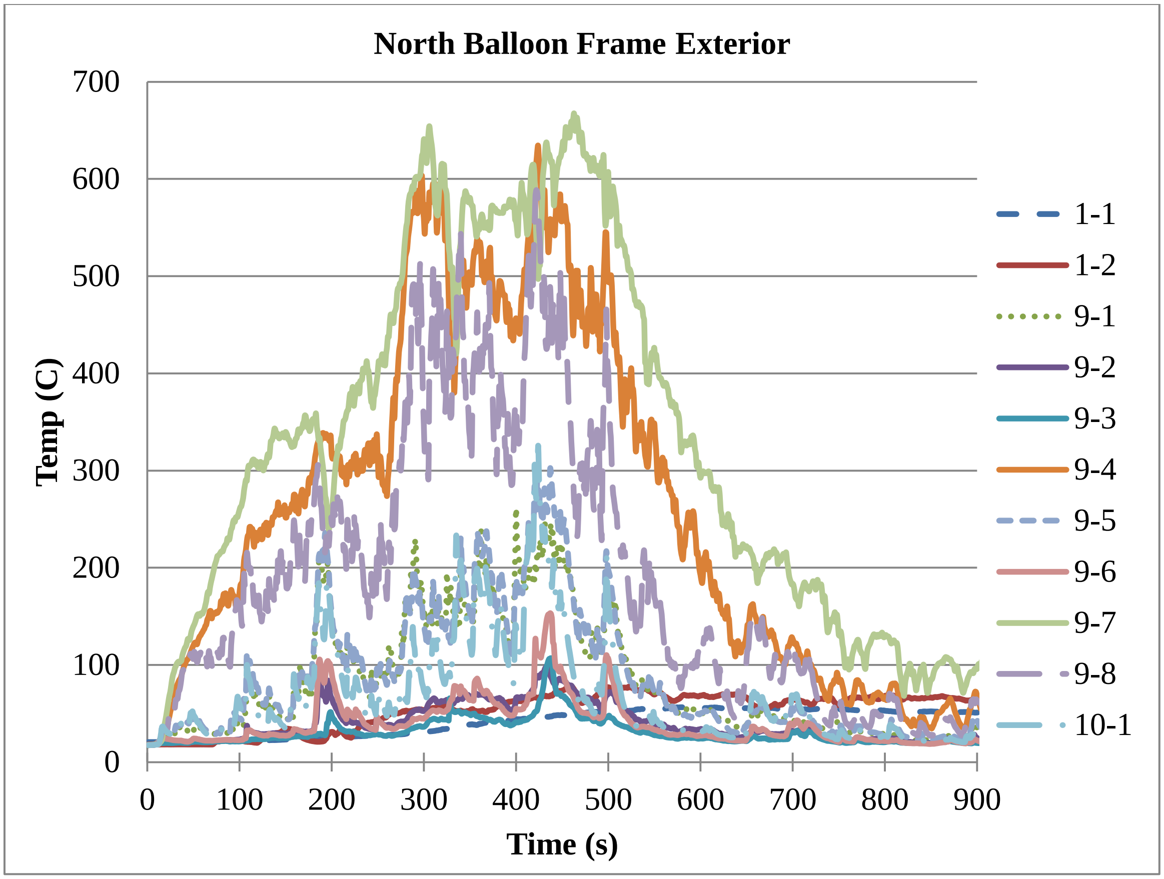

Figure C.60. Exterior gas temperatures

Table C.31. List of N wall balloon frame TC and TC tree hanging out on west of LBR window

1-1	(g) NE Balloon Framing from LBR
1-2	(g) NW balloon framing from LBR
9-1	0.25m (10in) from the W side of LBR window frame, spaced 0.3m (1ft) vertically and horizontally
9-2	
9-3	
9-4	
9-5	
9-6	
9-7	
9-8	
10-1	

Figure C.61 shows the thermocouples located on the north exterior balloon frame and a thermocouple tree sticking out of the LBR window.

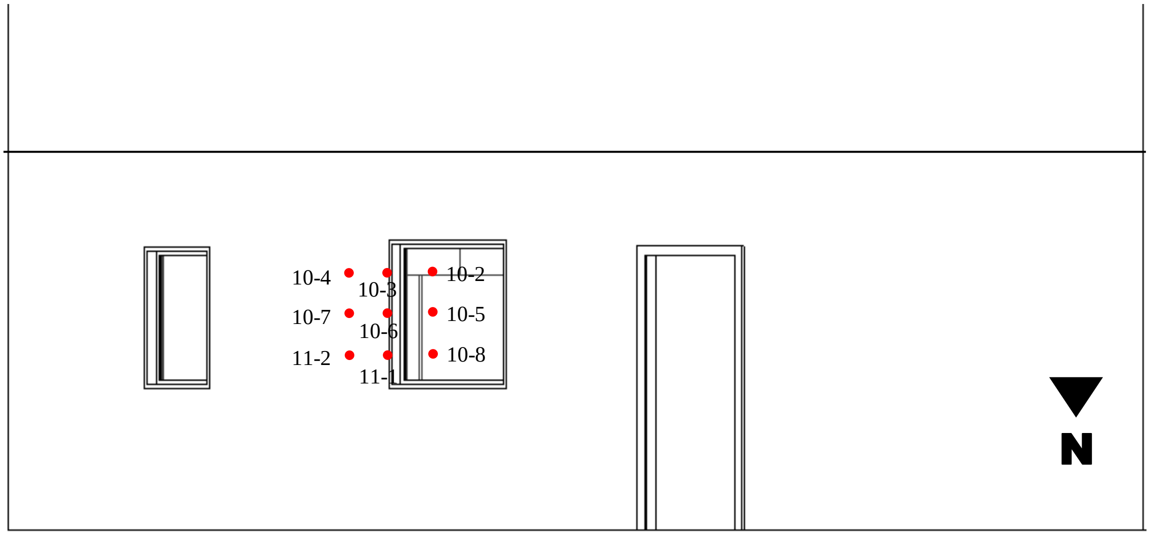

Figure C.61. TC tree hanging out on east of LBR window

Figure C.62 shows the temperature data of the temperature of the hot gases leaving the LBR window. The thermocouple locations are listed in details in Table C.32.

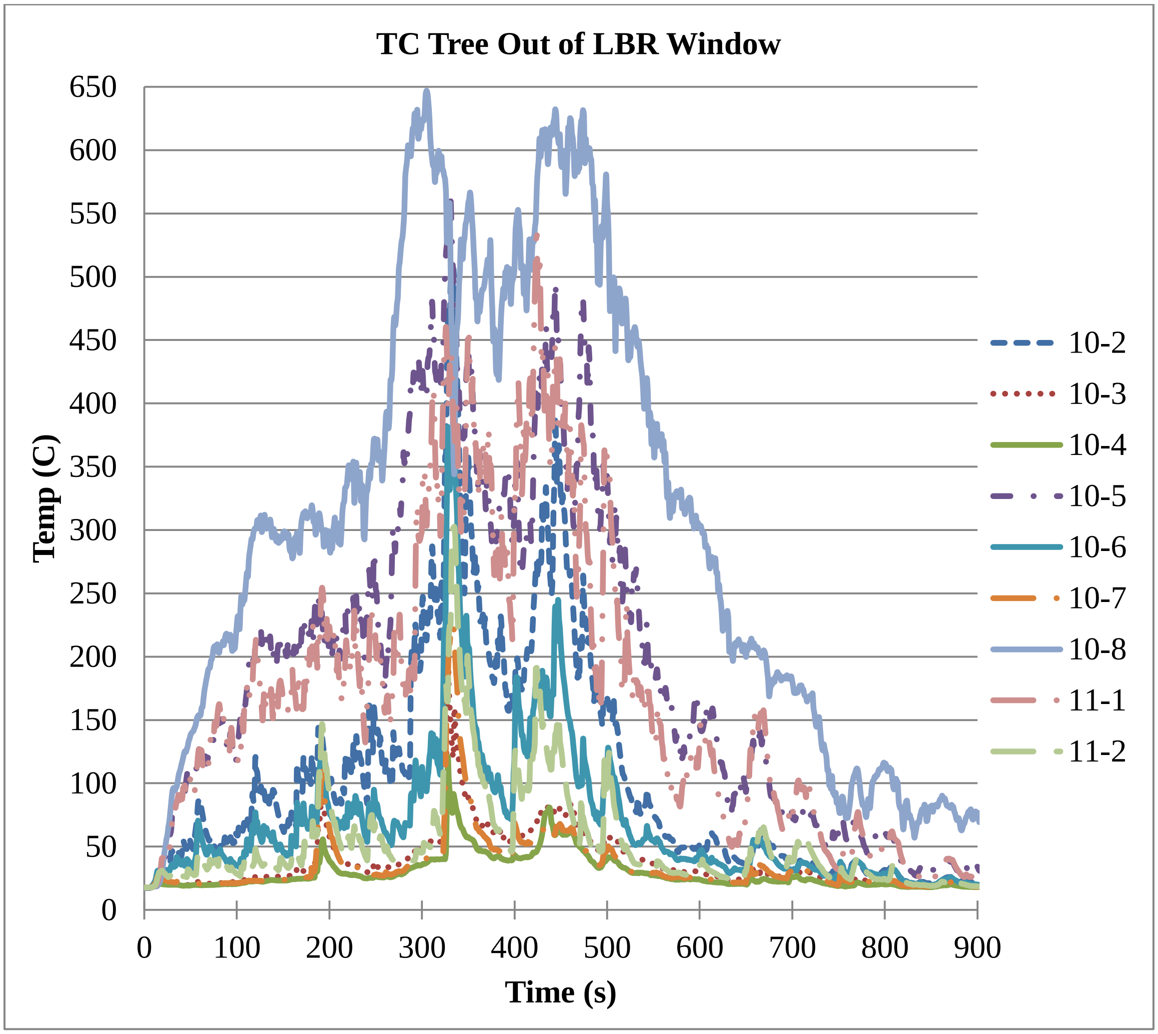

Figure C.62. TC tree out of LBR window temperatures

Table C.32. TC tree hanging out of east side of LBR window TC list

10-2	0.33m (13in) from the E side of LBR window frame, spaced 0.3m (1ft) vertically and horizontally
10-3	
10-4	
10-5	
10-6	
10-7	
10-8	
11-1	
11-2	

C.3.9 Fire Damper

Figure C.62 shows the thermocouples located in the HVAC duct behind the fire dampers.

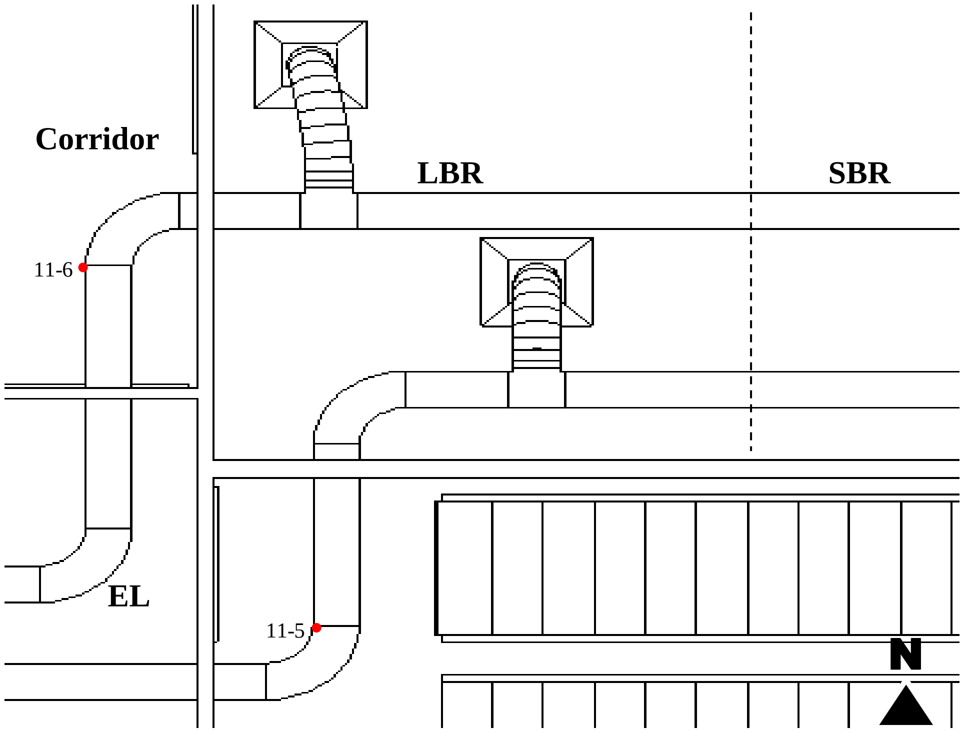

Figure C.63. TC on HVAC duct dampers

Figure C.64 shows the temperature data of the HVAC ducts right behind the fire dampers. These thermocouple locations are listed with details in Table C.33.

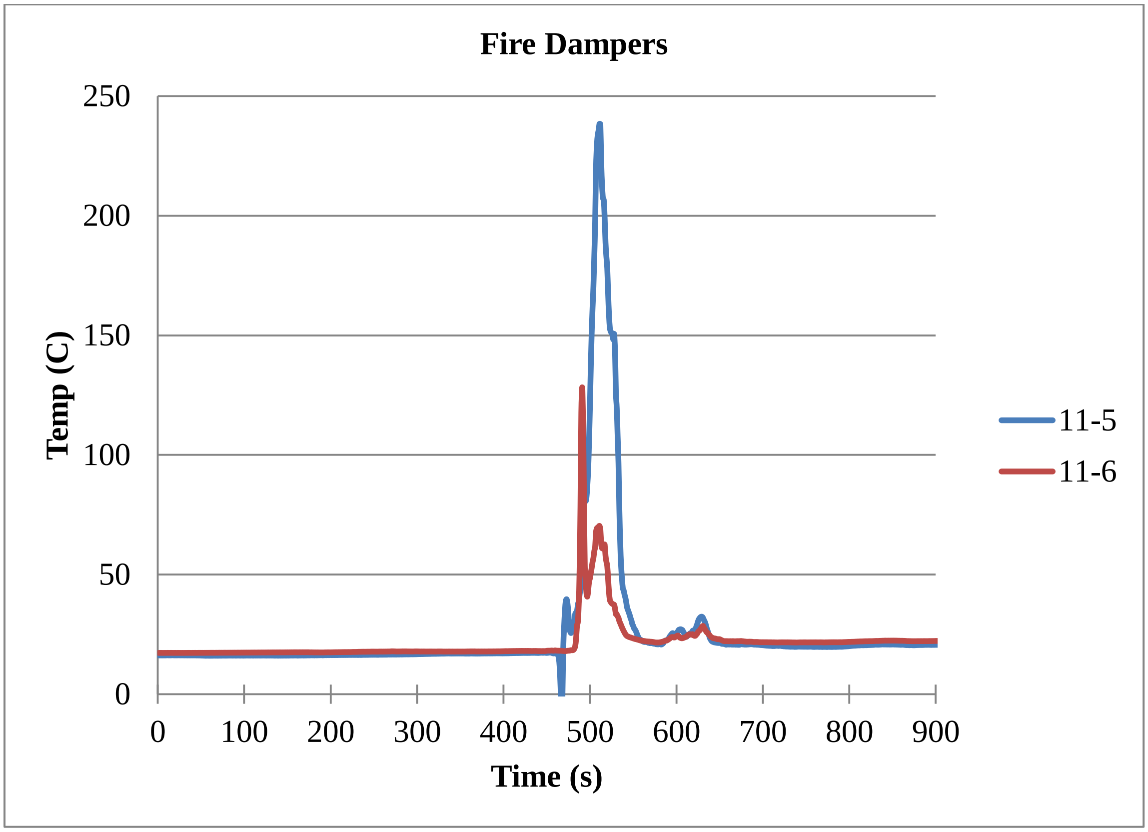

Figure C.64. HVAC duct temperatures behind the fire dampers

Table C.33. HVAC duct dampers TC list

11-5	Damper in the stairwell landing area
11-6	Damper in elevator shaft area

C.3.10 Active Fire Systems Activation

Figure C.65 shows the temperature of the fire door and SBR and LBR sprinklers.. The LBR sprinkler activated after 28 seconds at 107C (224F) and the SBR sprinkler activated after 44 seconds at 59C (138F). The fire door activated after 51 seconds at 163C (325F). These thermocouple locations are listed with details in Table C.34.

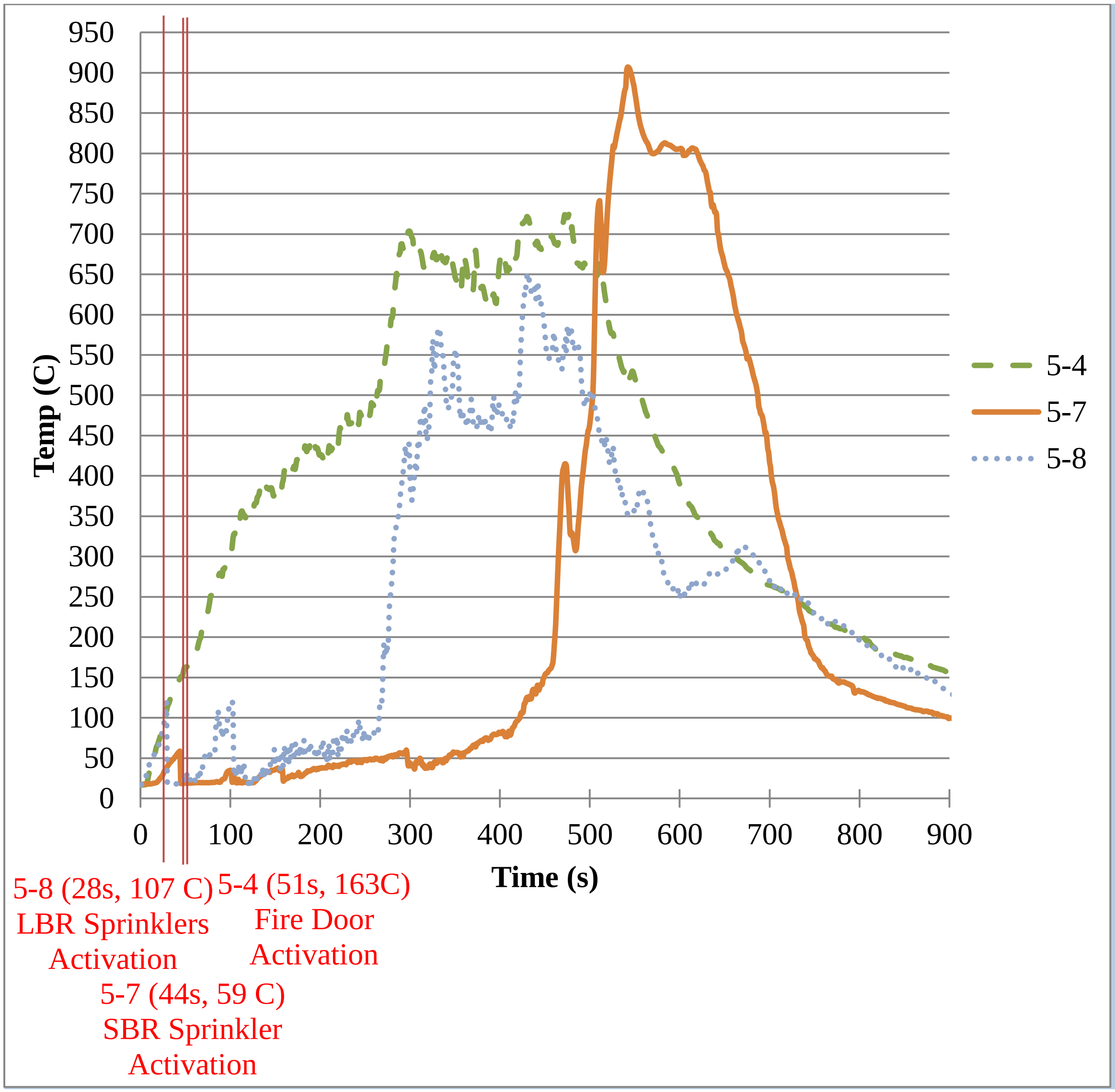

Figure C.65. Fire door and LBR and SBR sprinkler temperatures

Table C.34. LBR and SBR fire system TC list

5-2	(g) south part of fire door frame, 1.88m (6.2’) above floor
5-3	(g) south part of fire door frame, 0.3m (1’) above floor
5-4	(s) Fusible link of fire door, 1.5m (4.9’) from N wall, 0.24m (0.8’) below ceiling
5-5	(g) W wall of SBR gap above the fire door, 1.6m (5.2’) from N wall
5-6	Corner of the door frame between the SBR and LBR, 2.1m (6.9’) above floor, 1.1m (3.6’) from N wall
5-7	(s) SBR sprinkler head fusible link 1.3m (4.3’) from N wall, 1.4m (4.6’) from W wall 2.8m (9.2’) above floor
5-8	(s) LBR sprinkler head fusible link, 1.3m (4.3’) from N wall, 1.8m (5.9’) from E wall, 2.8m (9.2’) above floor

C.4 ES FIRE TEST TEMPERATURES

C.4.1 TC Trees in the Corridor and LBR Above Ceiling

Figure C.66 shows the thermocouple trees located in the corridor and space above the LBR ceiling.

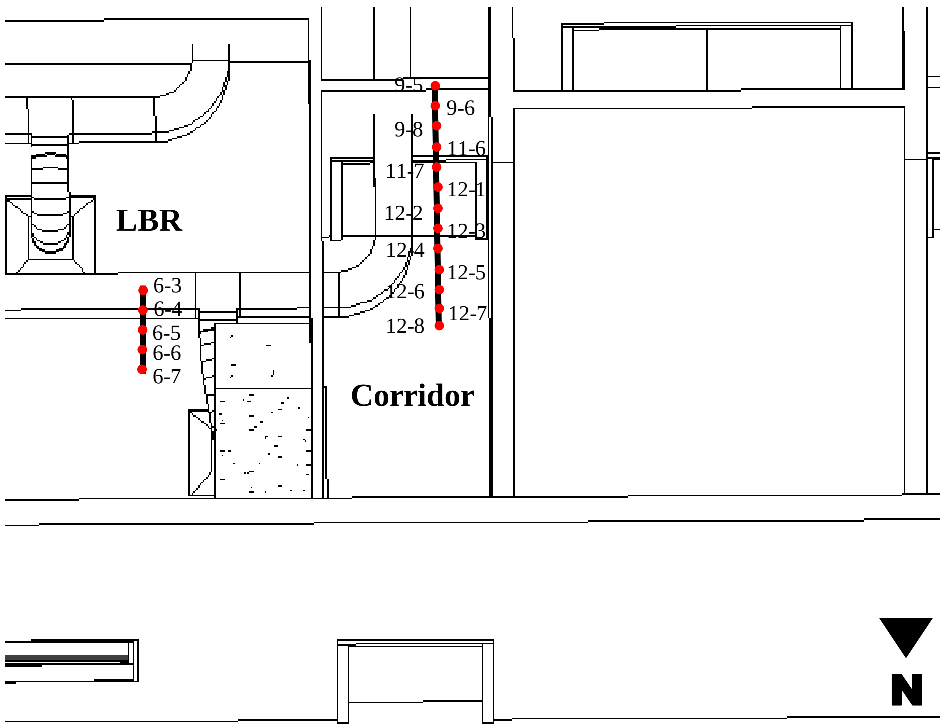

Figure C.66. TC trees in corridor and above LBR ceiling

Figure C.67 shows the temperature of the TC tree thermocouples located in the corridor. These thermocouple locations are listed with details in Table C.35.

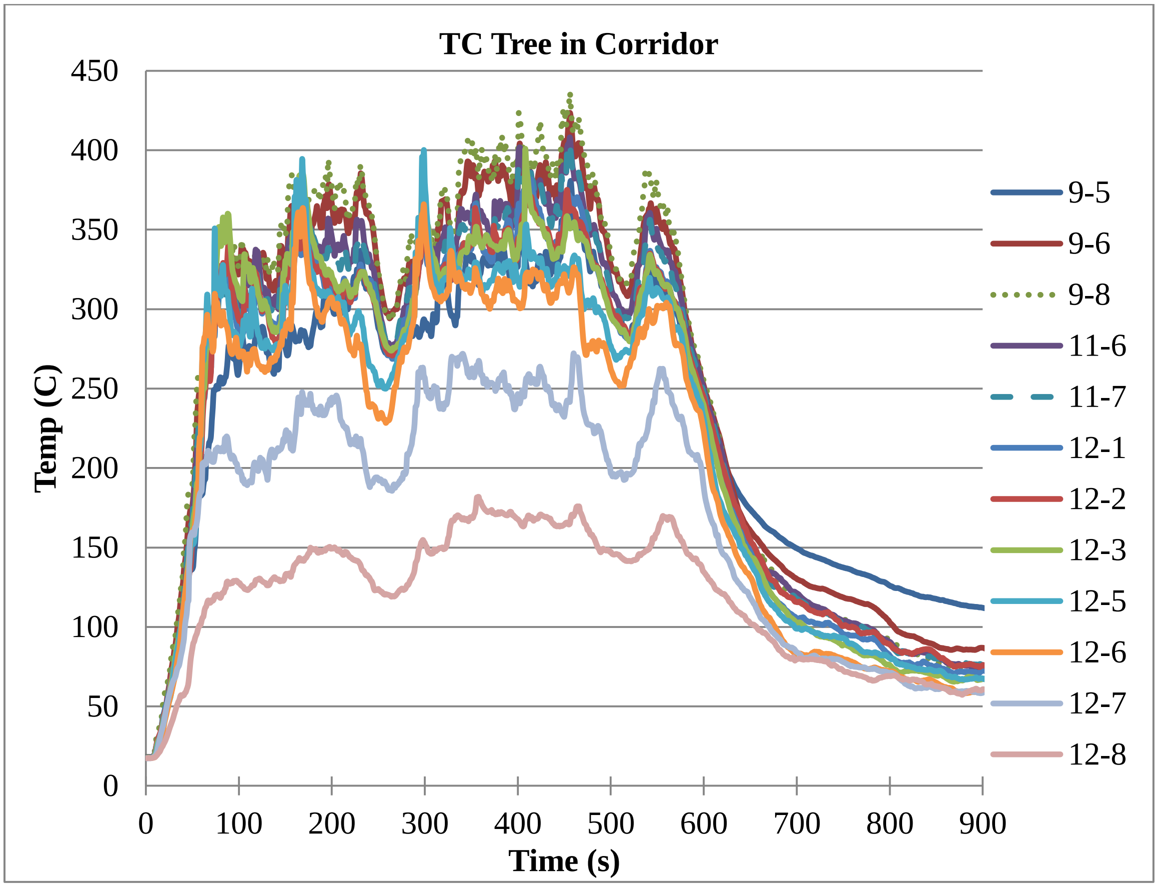

Figure C.67. Thermocouple tree temperatures in the corridor

Table C.35. Corridor and above LBR ceiling TC trees list

<table>
<tr><td>9-5</td><td rowspan="13">TC tree below 4th floor slab in corridor starting with 12-8 on bottom. 0.3m (1ft) above 3rd floor slab and increasing at 0.3m (1ft) increments to 9-5 on top at 3.9m (12.8ft)</td></tr>
<tr><td>9-6</td></tr>
<tr><td>9-8</td></tr>
<tr><td>11-6</td></tr>
<tr><td>11-7</td></tr>
<tr><td>12-1</td></tr>
<tr><td>12-2</td></tr>
<tr><td>12-3</td></tr>
<tr><td>12-4</td></tr>
<tr><td>12-5</td></tr>
<tr><td>12-6</td></tr>
<tr><td>12-7</td></tr>
<tr><td>12-8</td></tr>
</table>

Figure C.68 shows the temperature of the TC tree thermocouples located in the space above the LBR ceiling. These thermocouple locations are listed with details in Table C.36.

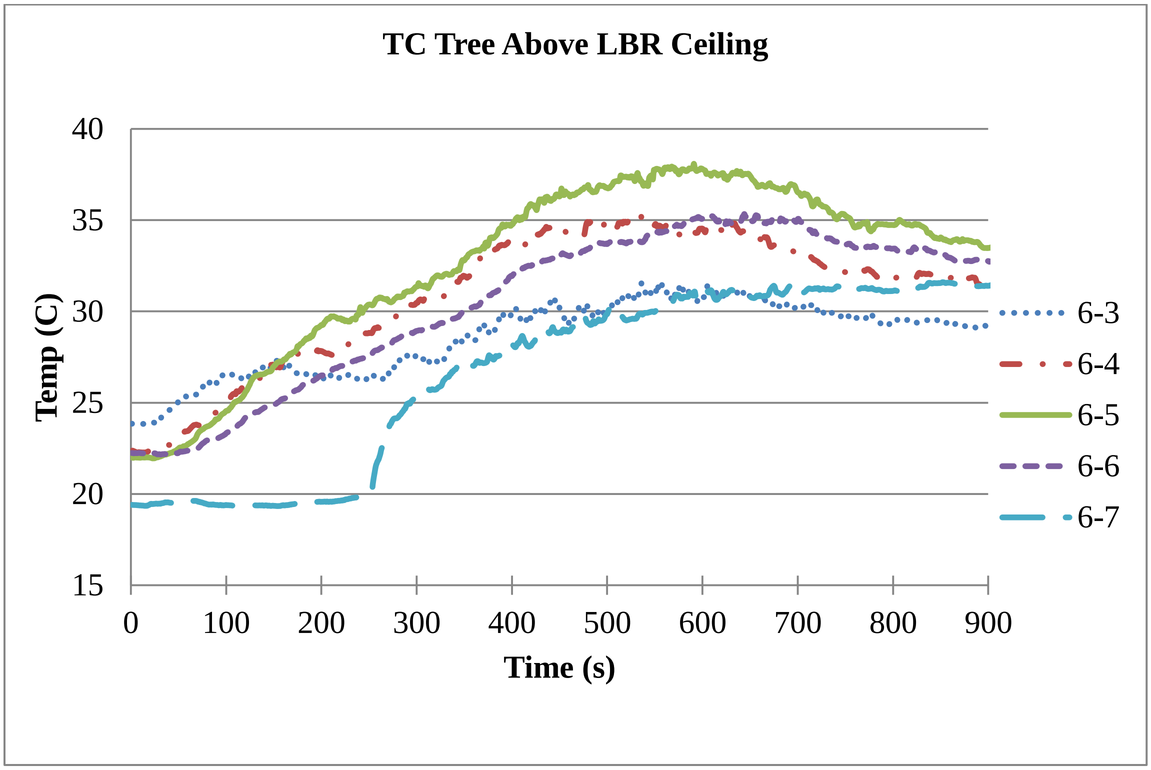

Figure C.68. LBR above ceiling TC tree temperatures

Table C.36. TC Tree list above LBR ceiling

6-3	TC tree hanging from 4th floor slab above ceiling of LBR starting with 6-7 right above ceiling and increasing in 0.3m (1ft) increments to 6-3 being on top
6-4	
6-5	
6-6	
6-7	

C.4.2 LBR Above Ceiling

Figure C.69 shows the thermocouples that were located in the space above the LBR ceiling.

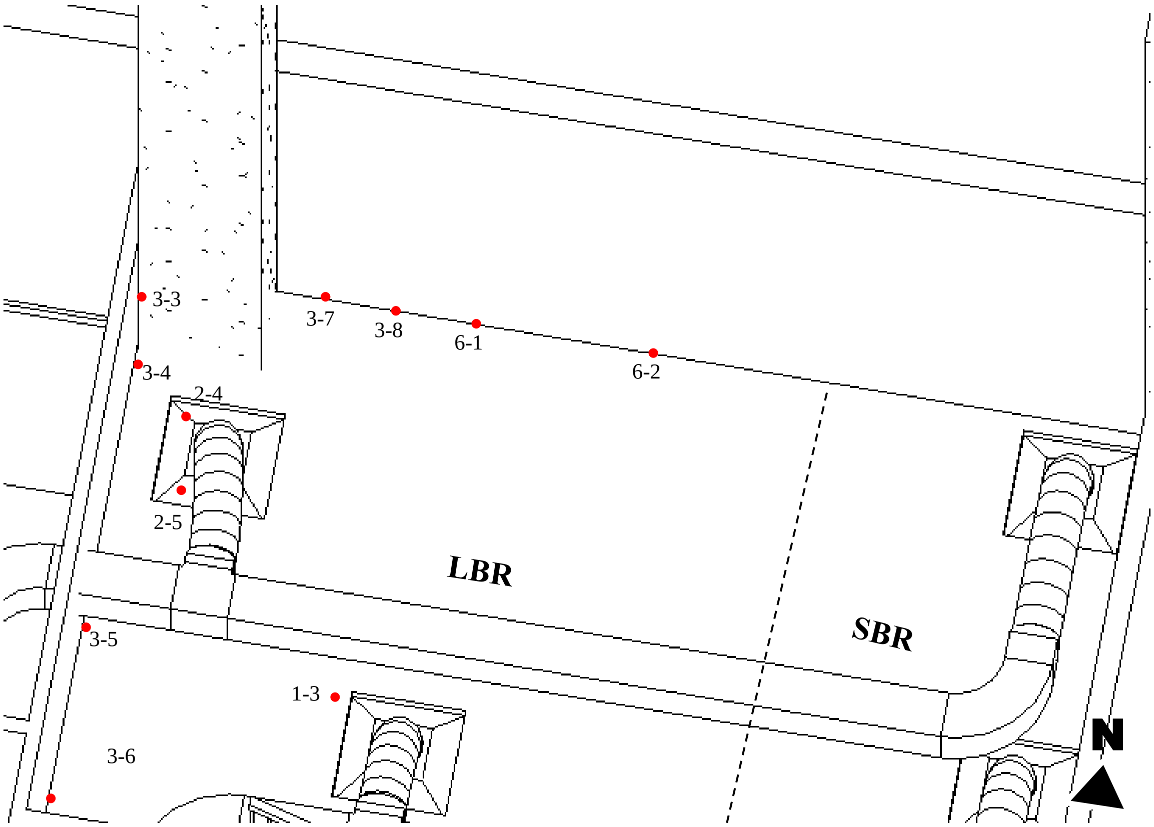

Figure C.69. TC above LBR ceiling

Figure C.70 shows the temperatures of the space above the LBR ceiling. These thermocouple locations are listed with details in Table C.37.

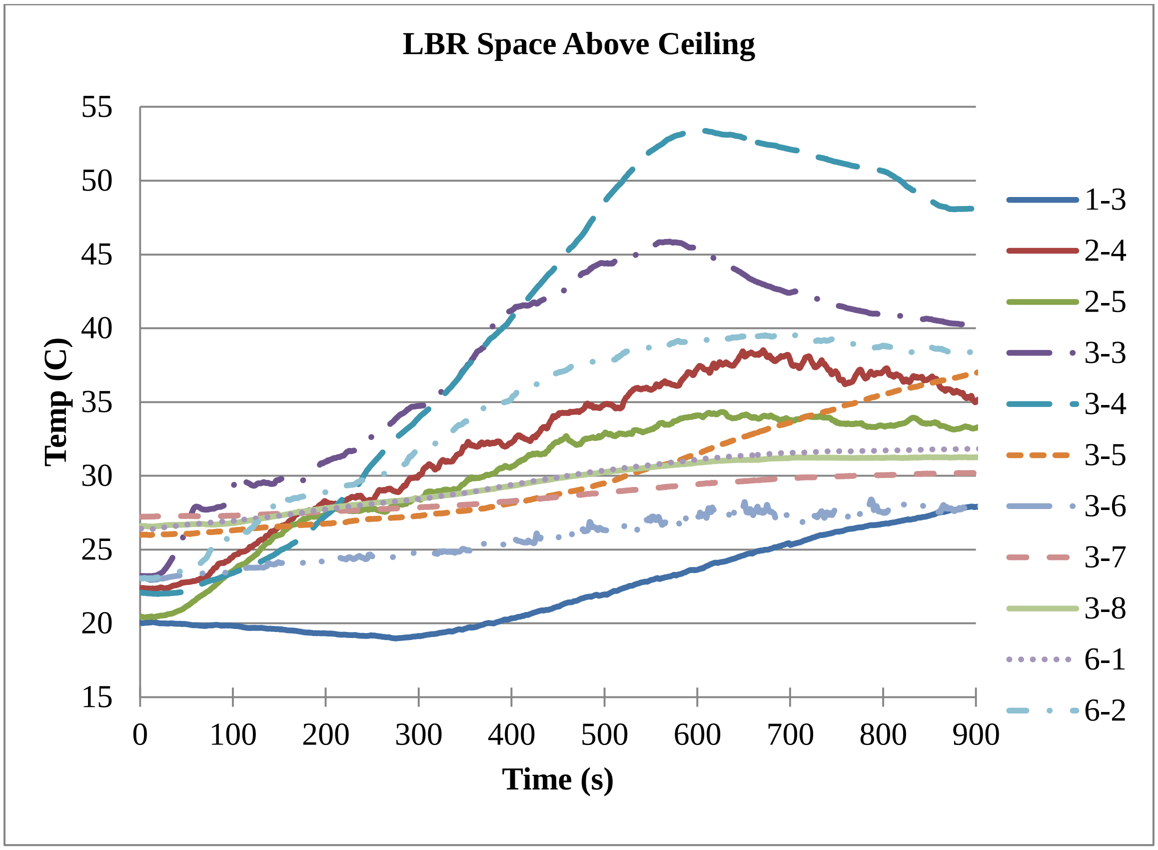

Figure C.70. LBR space above the ceiling temperatures

Table C.37. Above LBR ceiling TC list

1-3	(g) above ceiling, SE corner of the W lighting, 2.7m (8.9’) from N wall, 1.4m (4.6’) from W wall
2-4	(s) on the NW corner diffuser
2-5	(s) on the NW corner diffuser
3-3	(g) above ceiling on SW corner gap of the N column, 0.32 (1’) above ceiling
3-4	(s) above ceiling of the W wall, 0.13m (0.4’) from N column
3-5	(s) above ceiling of the W wall, 1.5m (4.9’) from S wall
3-6	(s) above ceiling of the W wall, 0.1m (0.3’) from S wall
3-7	(s) above ceiling of the N wall, 0.3m (1’) from N column
3-8	(s) above ceiling of the N wall, 0.7m (2.3’) from N column
6-1	(s) above ceiling of the N wall, 1.2m (3.9’) from N column
6-2	(s) above ceiling of the N wall, 2.4m (7.9’) from N column

C.4.3 LBR Column Gap

Figure C.71 shows the thermocouple locations inside the gaps created between the LBR column and the west and north walls as well as the gaps formed in the south wall of the LBR.

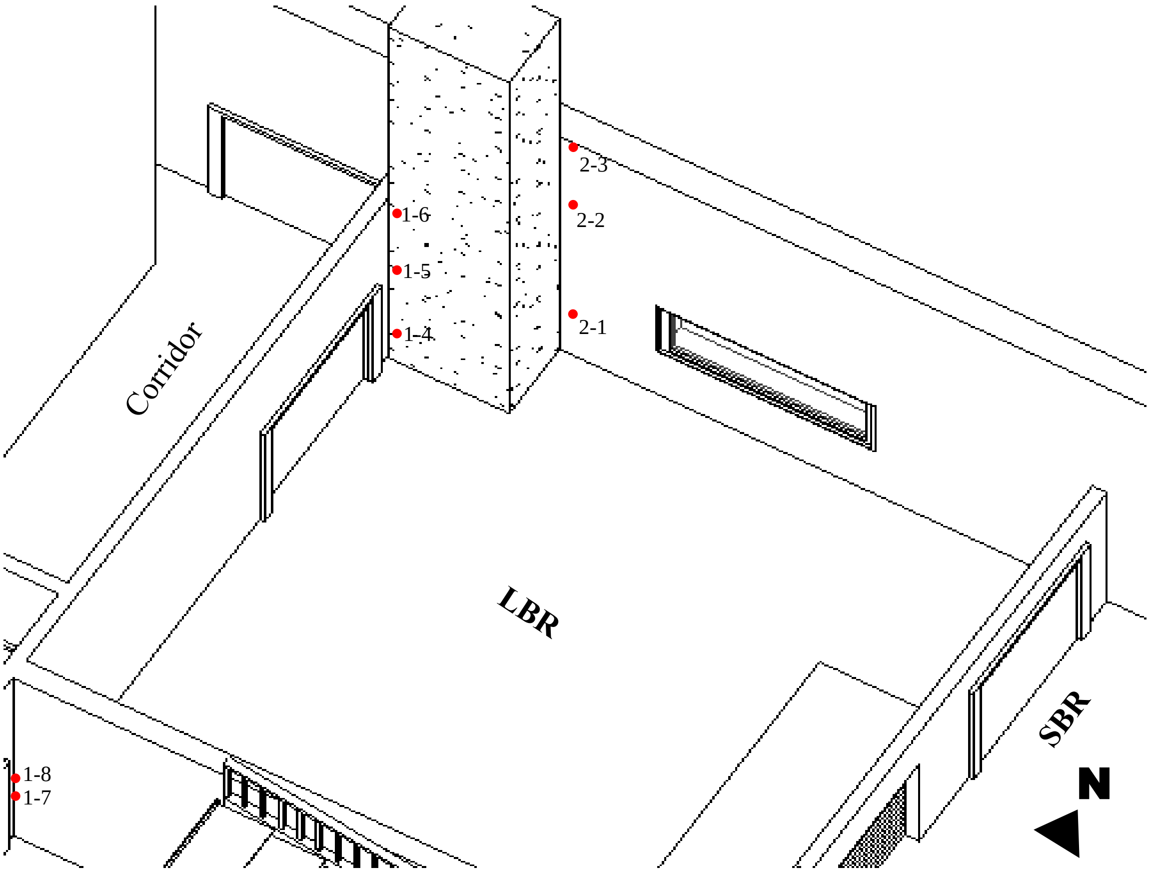

Figure C.71. TC on LBR SW corner and column gap

Figure C.72 shows the temperatures in the gaps between the LBR column and west and north wall of the LBR as well as the gaps formed in the south wall of the LBR. These thermocouple locations are listed with details in Table C.38.

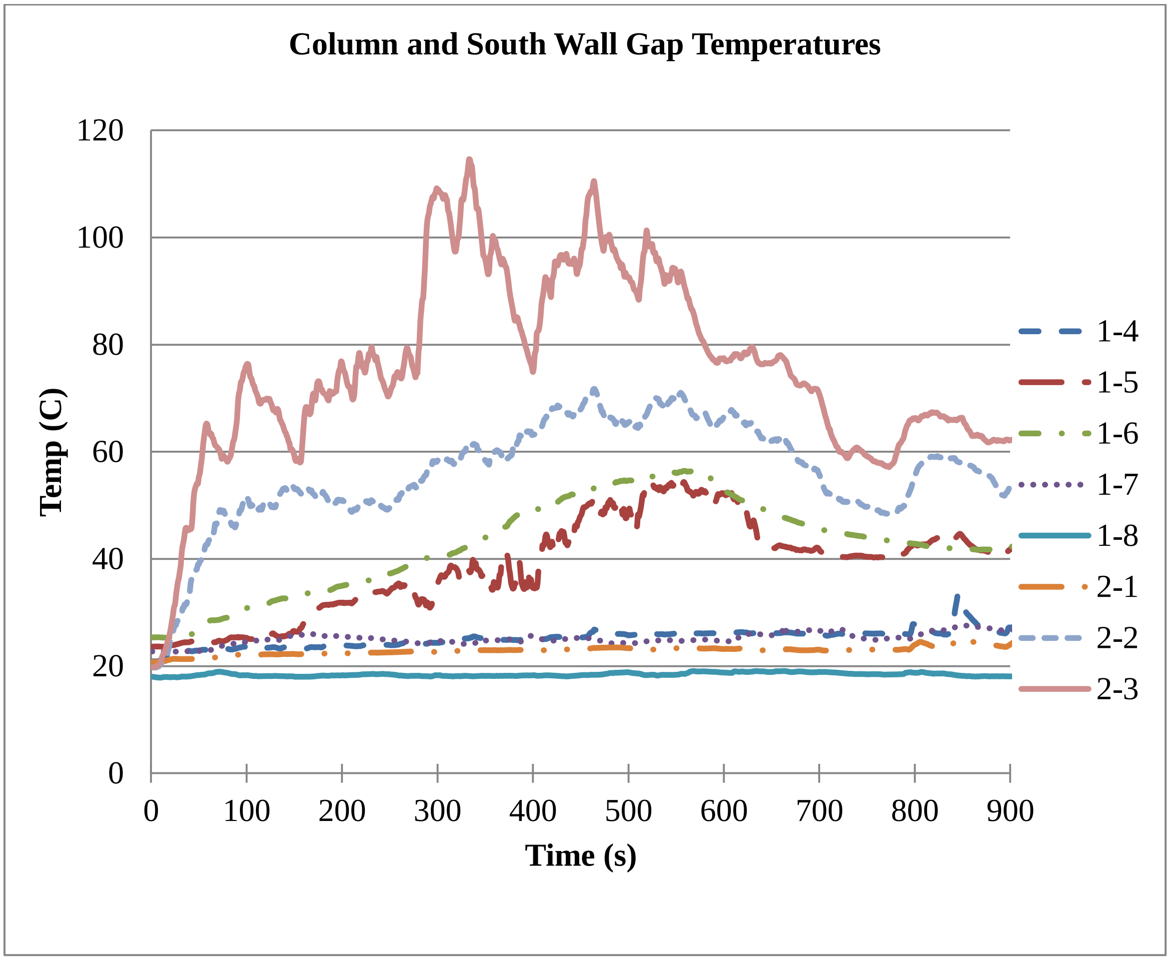

Figure C.72. LBR Column and south wall gap temperatures

Table C.38. LBR SW corner and column gap TC list

1-4	(g) On the SW corner gap of the N column, 0.59m (1.9') above floor
1-5	(g) On the SW corner gap of the N column, 2.03m (6.7') above floor
1-6	(g) On the SW corner gap of the N column, 0.1m (0.3') below ceiling
1-7	(g) SW corner of room, 1.22m (4') above floor, (LBR temp)
1-8	(g) SW corner of room, 1.24m (4.1') above floor (stair landing temp)
2-1	(g) on the NE corner gap of the N column 0.6m (2') above floor
2-2	(g) on the NE corner gap of the N column 2m (6.6') above floor
2-3	(g) on the NE corner gap of the N column 2.7m (8.9') above floor

C.4.4 LBR/Corridor Firestops

Figure C.73 shows the thermocouples that were placed on both sides of the firestops above the LBR ceiling.

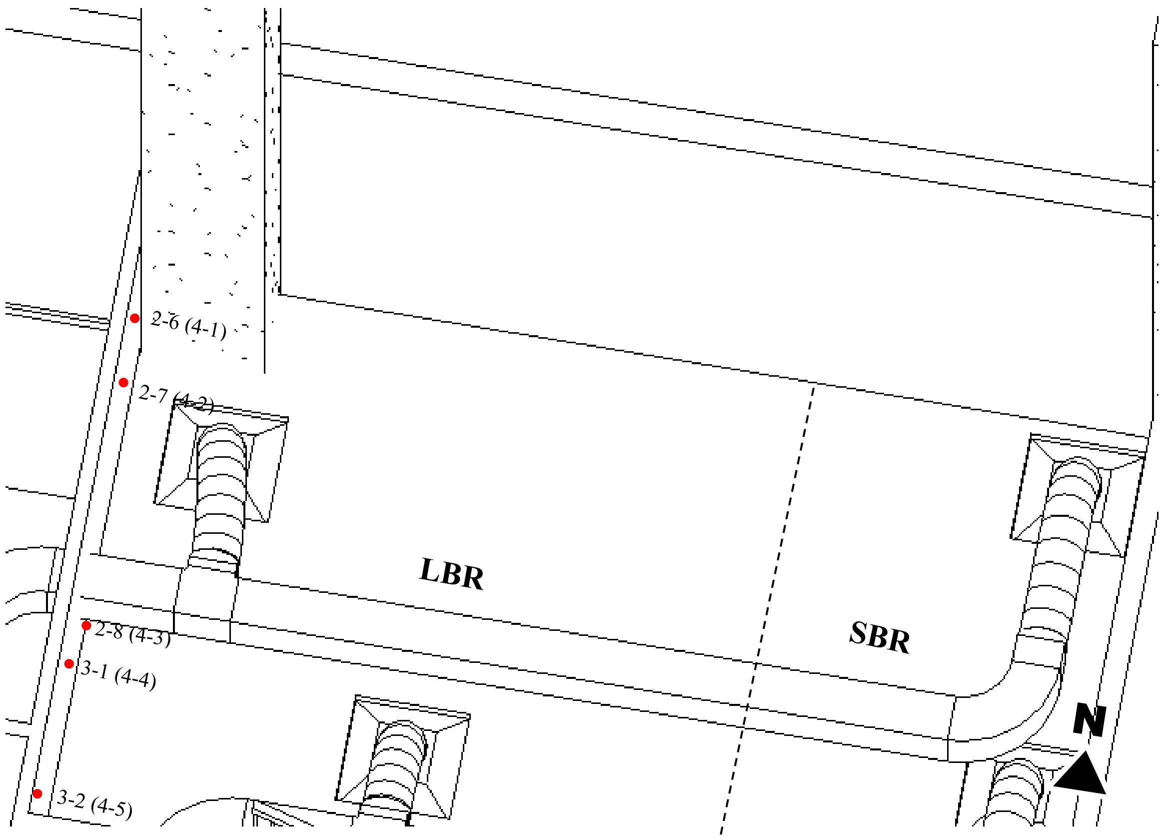

Figure C.73. TC on both sides of firestops above LBR ceiling

Figure C.74 shows the firestop temperatures on both sides. These thermocouple locations are listed with details in Table C.39.

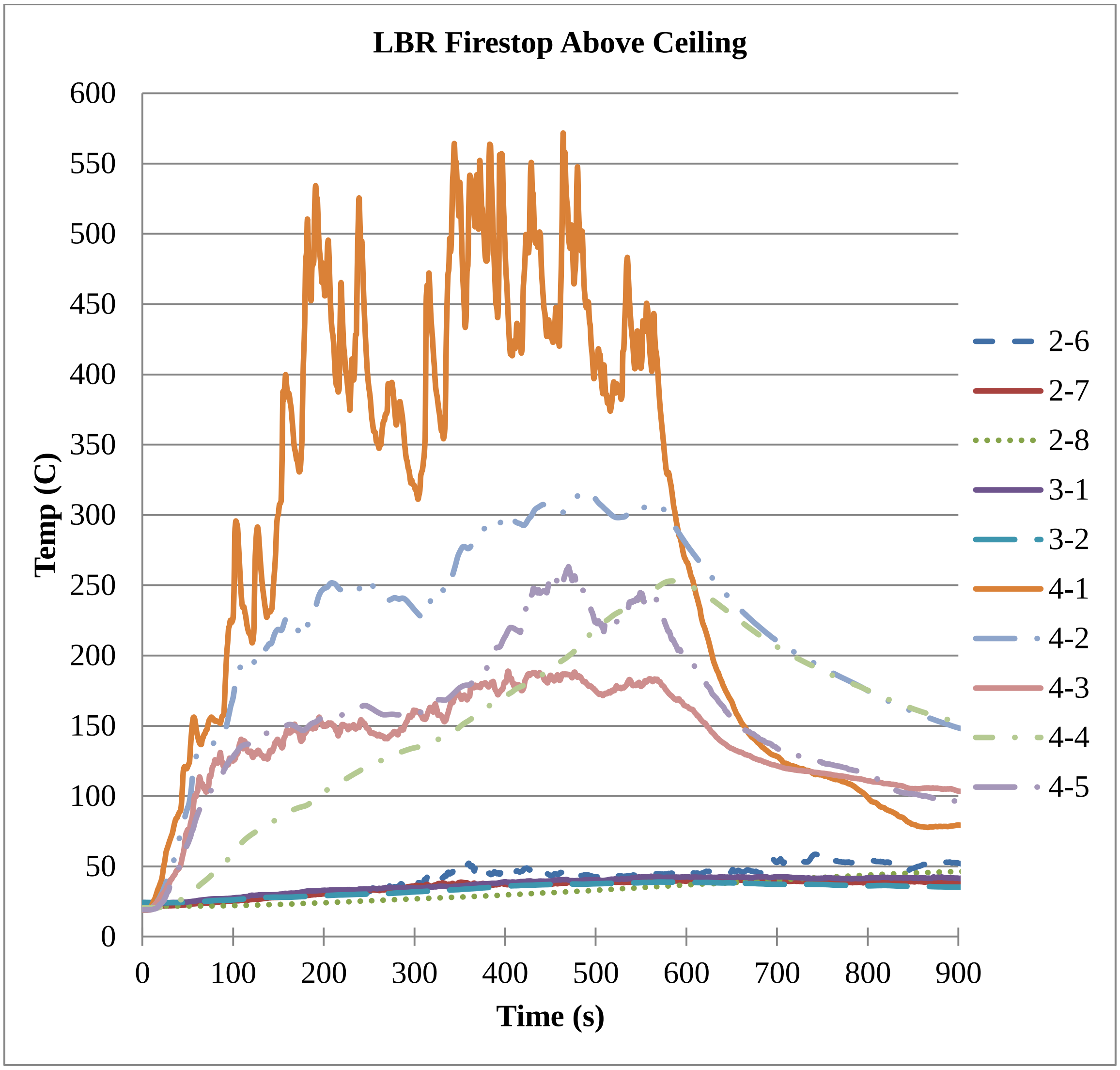

Figure C.74. Firestop temperatures on both sides

Table C.39. LBR above ceiling firestops TC list

2-6	(s) above ceiling on firestop, 0.19m (0.6’) from N column, 0.37m (1.2’) (below 4th floor slab
2-7	(s) above ceiling on firestop, 0.52m (1.7’) from N column 0.42m (1.4’) below 4th floor slab
2-8	(s) above ceiling on firestop, 1.6m (5.2’) from S wall 0.87m (2.9’) below 4th floor slab
3-1	(s) above ceiling on firestop, 1.4m (4.6’) from S wall 0.45m (1.5’) below 4th floor slab
3-2	(s) above ceiling on firestop, 0.65m (2.1’) from S wall 0.1m (0.3’) below 4th floor slab
4-1	(s) firestop on E wall of corridor, 3.4m (11.1’) above floor 0.6m (2’) from N wall of building
4-2	(s) firestop on E wall of corridor, 3.4m (11.1’) above floor 1.1m (3.6’) from N wall of building
4-3	(s) firestop on E wall of corridor, 0.86m (2.8’) below 4th floor slab, 1.05m (3.4’) from corridor S wall
4-4	(s) firestop on E wall of corridor, 0.38m (1.2’) below 4th floor slab, 0.9m (3’) from S wall of corridor
4-5	(s) firestop on E wall of corridor, 0.06m (0.2’) below 4th floor slab, 0.06m (0.2’) from S wall of corridor

C.4.6 Corridor Firestops and North of Elevator Shaft

Figure C.75 shows the thermocouples located on the firestops on the south wall of the corridor and on the space on the north wall of the elevator shaft and north wall of the building.

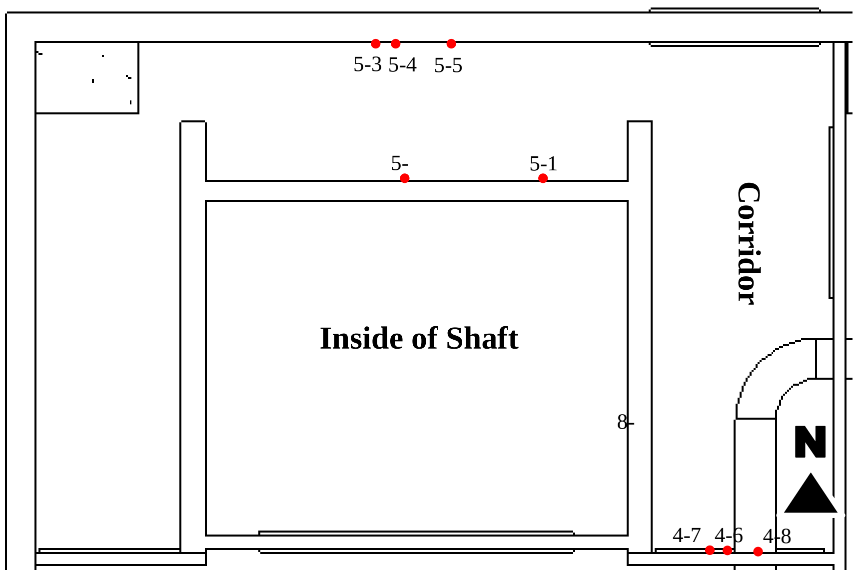

Figure C.75. TC on S wall of corridor firestops

Figure C.76 shows the corridor firestops and north of elevator shaft temperatures. These thermocouple locations are listed with details in Table C.40.

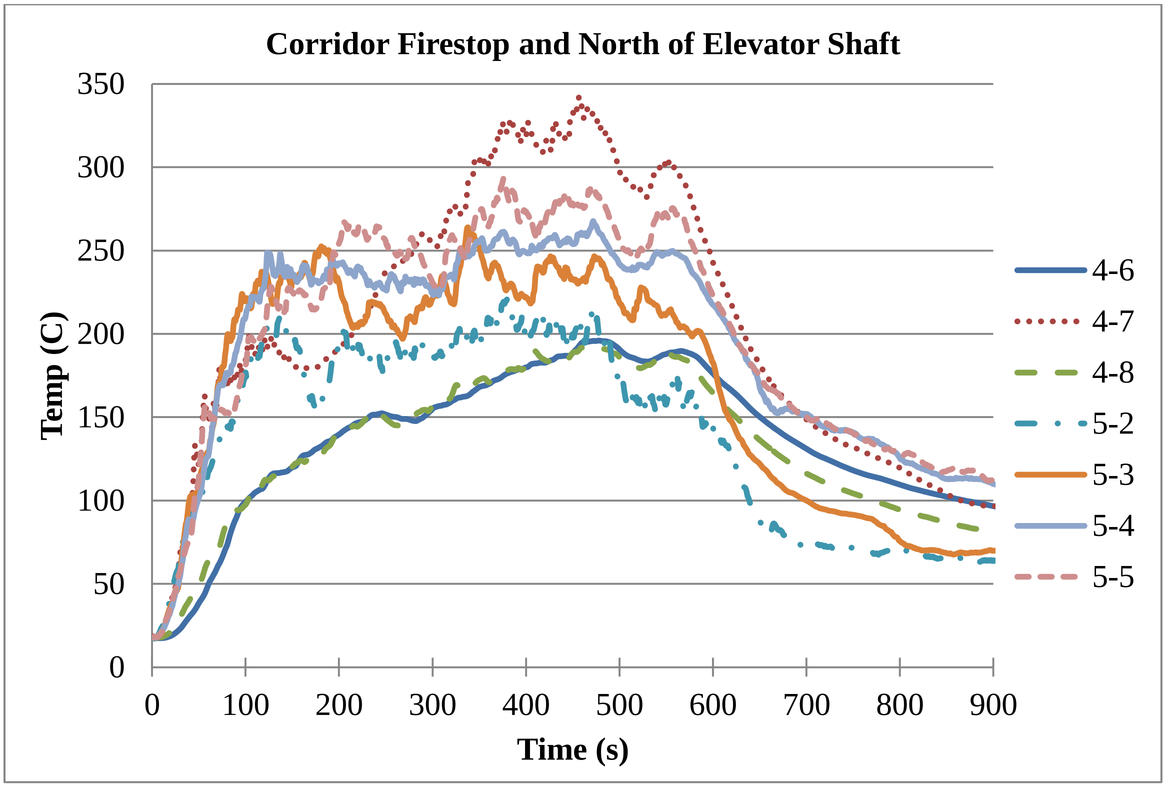

Figure C.76. Corridor firestops and north of elevator shaft temperatures

Table C.40. S wall of corridor firestops and north of elevator shaft TC list

4-6	(s) firestop on S wall of corridor, .05m (0.2’) below 4th floor slab, 0.66m (2.2’) from E wall of corridor
4-7	(s) firestop on S wall of corridor, 0.3m (1’) below 4th floor slab, 0.6m (2’) from E wall of corridor
4-8	(s) firestop on S wall of corridor, 0.09m (0.3’) below 4th floor slab, 0.48m (1.6’) from E wall of corridor
5-1	(g) N wall of shaft, 4.1m (13.4’) above floor, 0.8m (2.6’) from E wall of shaft
5-2	(g) N wall of shaft, 4.1m (13.4’) above floor, 2.1m (6.9’) from E wall of shaft
5-3	(g) N wall of building, 2.5m (8.2’) above floor, 1.8m (5.9’) from NW corner column of building
5-4	(g) N wall of building, 4.2m (13.8’) above floor/1.8m from NW corner column of building
5-5	(g) N wall of building, 4.2m (13.8’) above floor, 2.8m (9.2’) from NW corner column of building

C.4.7 4th Floor North of Elevator Shaft

Figure C.77 shows the thermocouple locations on the north of the elevator shaft on the 4th floor.

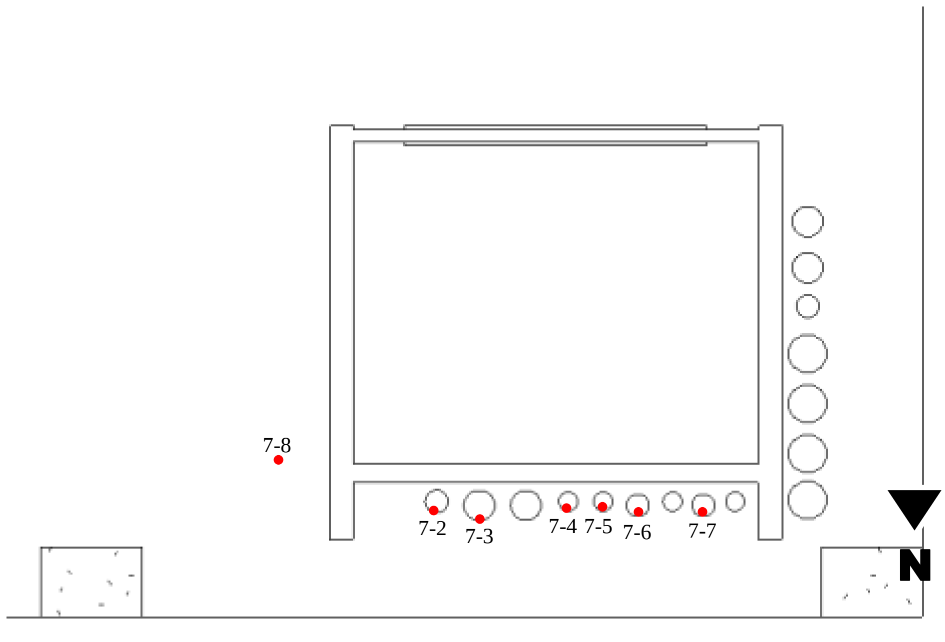

Figure C.77. TC on 4th floor firestops N of shaft

Figure C.78 shows the 4th floor north of elevator shaft temperatures. These thermocouple locations are listed with details in Table C.41.

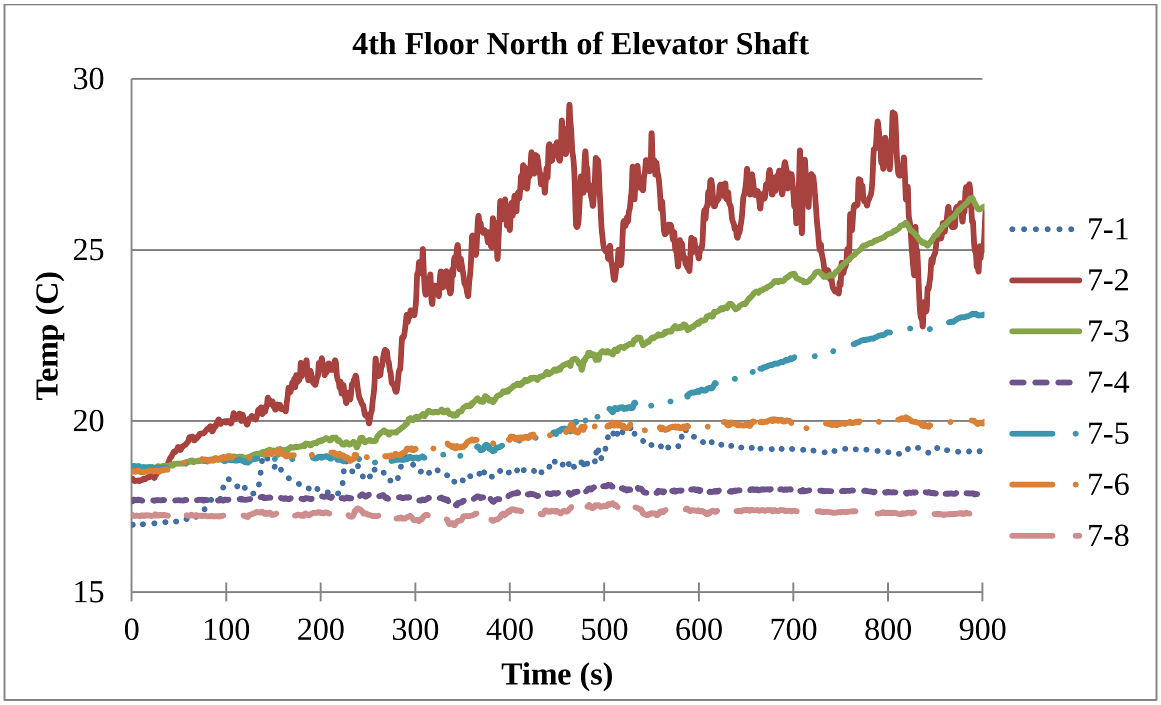

Figure C.78. 4th floor north of elevator shaft temperatures

Table C.41. 4th floor firestops N of shaft TC list

7-1	(g) Inside shaft from NE corner of shaft on 4th floor slab level
7-2	(s) N wall of shaft openings/firestop, 0.33m (1.1') from E wall of shaft
7-3	(s) N wall of shaft openings/firestop, 0.57m (1.9') from E wall of shaft
7-4	(s) N wall of shaft openings/firestop, 1.05m (3.4') from E wall of shaft
7-5	(s) N wall of shaft openings/firestop, 1.40m (4.6') from E wall of shaft
7-6	(s) N wall of shaft openings/firestop, 1.60m (5.2') from E wall of shaft
7-7	(g) N wall of shaft openings/firestop, 2.1m (6.9') from E wall of shaft
7-8	(s) concrete slab temperature, 1.87m (6.1') from N wall of building, 0.62m (2') from E wall of elevator shaft, east side of the space around elevator shaft

C.4.9 4th Floor West of Elevator Shaft

Figure C.79 shows the thermocouples that were placed on the 4th floor vents and west of the elevator shaft.

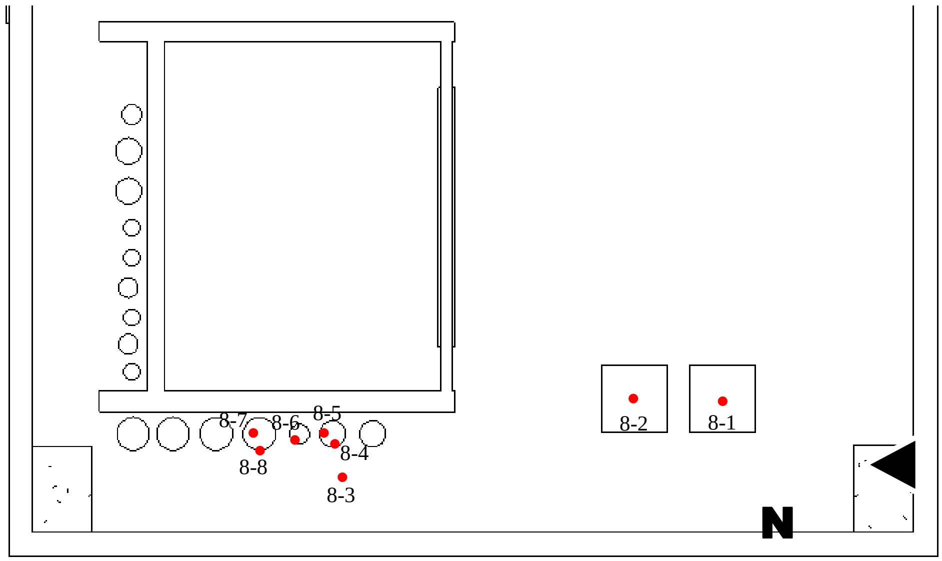

Figure C.79. TC on 4th floor vents and W of shaft firestops

Figure C.80 shows the temperatures of the vents and firestops in the 4th floor west of the shaft. These thermocouple locations are listed with details in Table C.42.

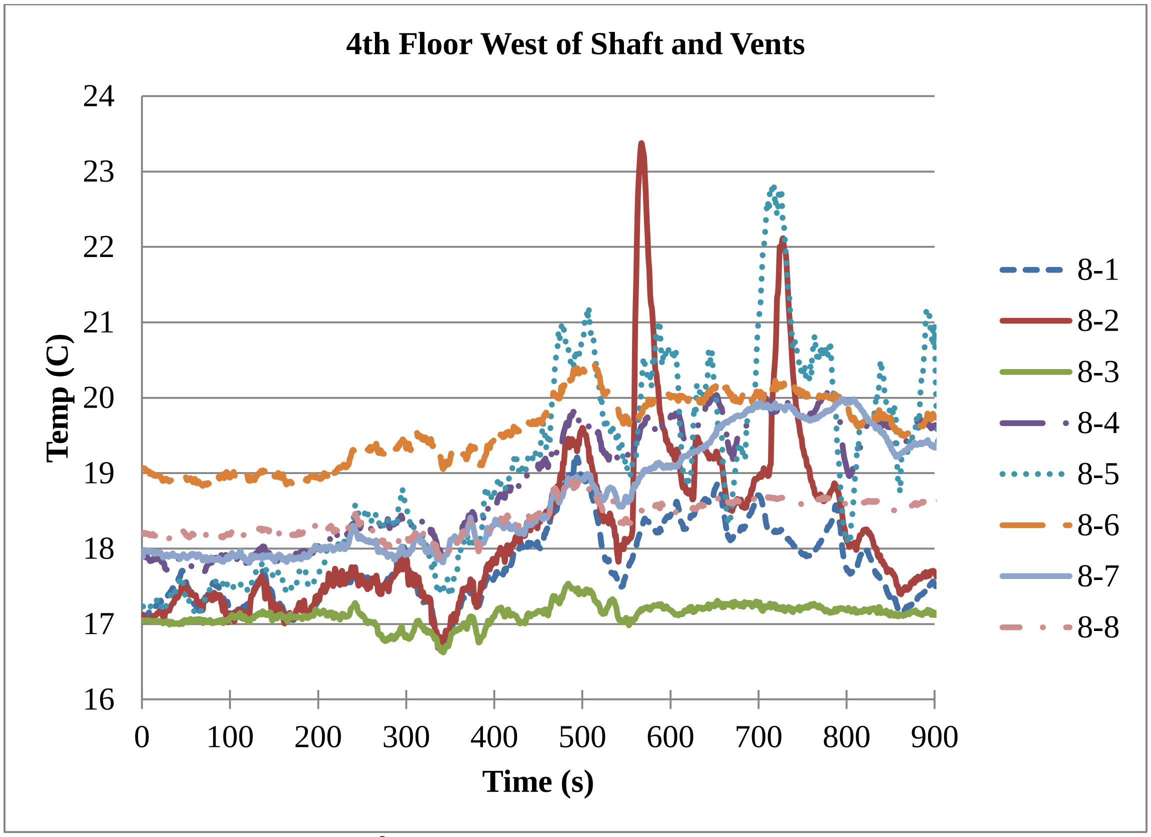

Figure C.80. 4th floor west of shaft and vents temperatures

Table C.42. 4th floor vents and W of shaft firestops TC list

8-1	(g) S vent on 4th floor west of elevator shaft, 5m (16.4') from N wall of building
8-2	(g) N vent on 4th floor west of elevator shaft, 4.2m (13.8') from N wall of building
8-3	(s) concrete slab temp of west side of elevator shaft
8-4	(s) sprinkler pipe
8-5	(s) sprinkler pipe firestop gap
8-6	(s) mineral wool on 4th opening from NW corner of building, 2.3m (7.5') from N wall of building
8-7	(s) Mineral wool on 3rd opening from NW corner of building, 1.8m (5.9') from N wall of building
8-8	(s) firestop on 3rd opening from NW corner of building, 1.5m (4.9') from N wall of building

C.4.11 Exterior Gas Temperatures

Figure C.81 shows the thermocouples that were located on the north and west exterior balloon frames.

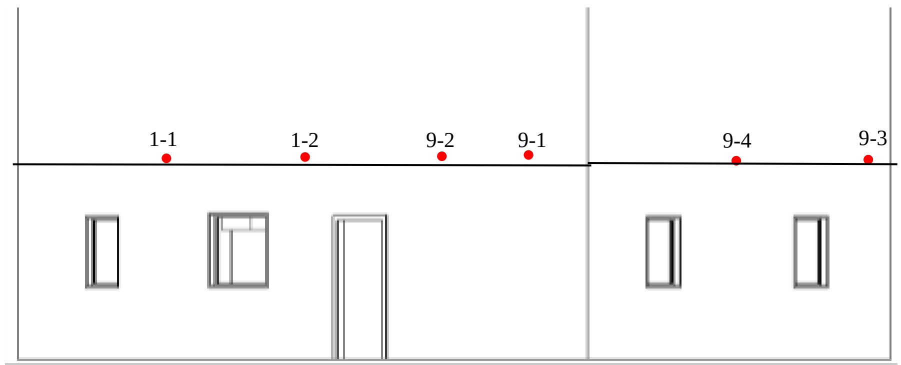

Figure C.81. TC on N and W exterior balloon framing walls

Figure C.82 shows the temperatures of the north and west exterior balloon frames. These thermocouple locations are listed with details in Table C.43.

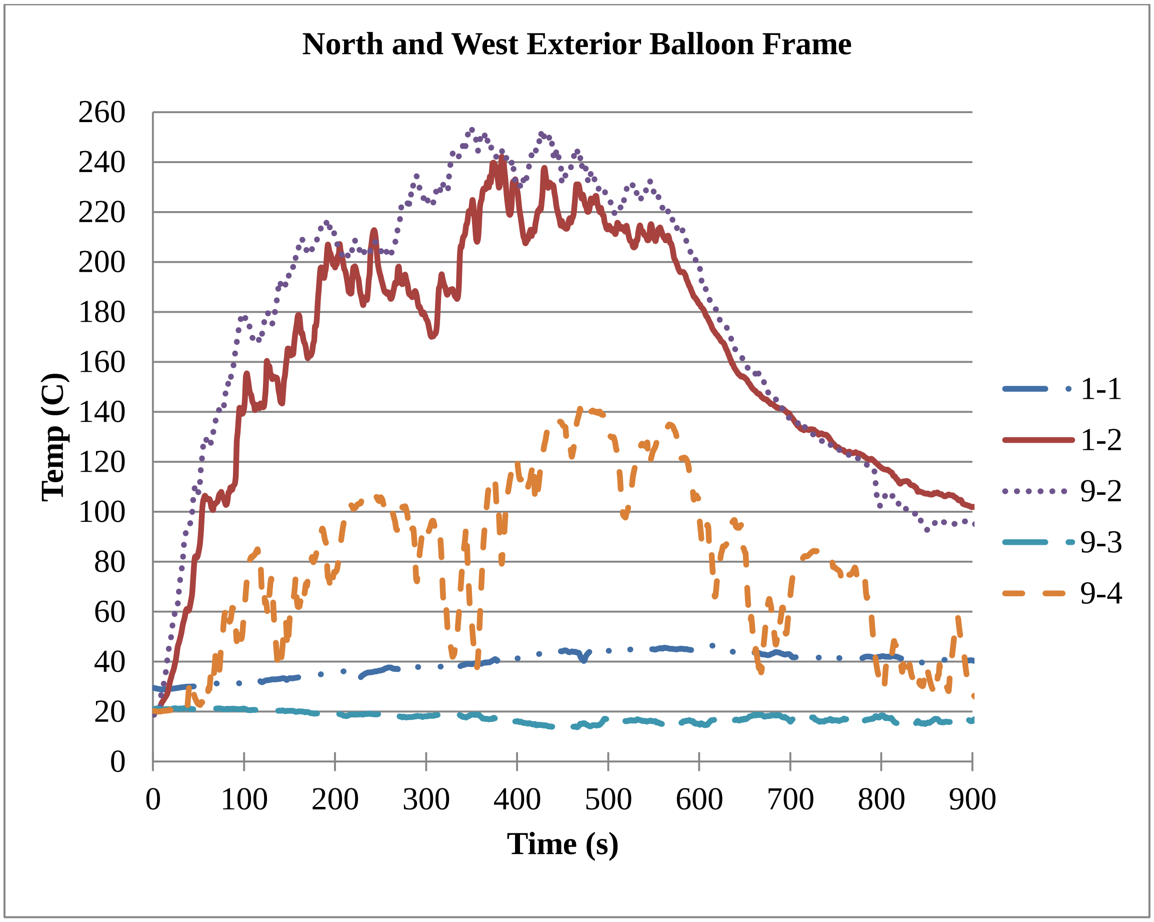

Figure C.82. North and west exterior balloon frame temperatures

Table C.43. N and W exterior balloon framing TC list

1-1	(g) NE Balloon Framing from LBR
1-2	(g) NW balloon framing from LBR
9-1	(g) W side of N wall of building
9-2	(g) E side of N wall of building
9-3	(g) S side of W wall of building
9-4	(g) N side of W wall of building

C.4.12 Inside the Elevator Shaft

Figure C.83 shows the thermocouple tree located inside the elevator shaft.

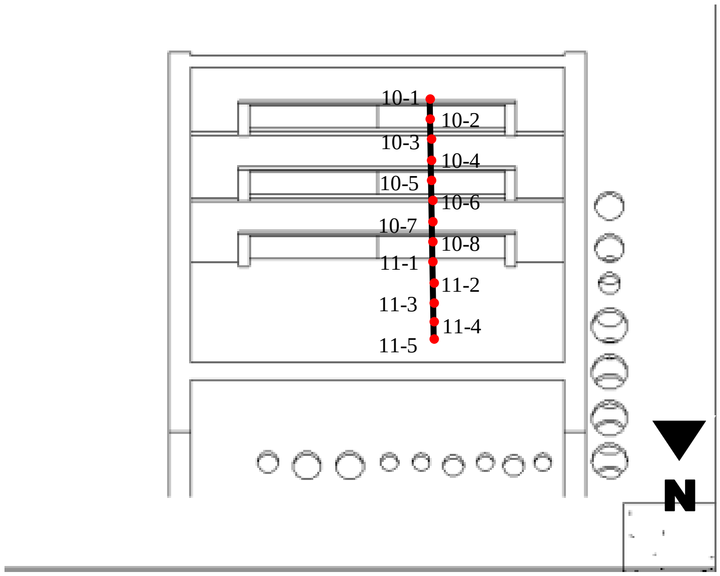

Figure C.83. TC inside elevator shaft from 5th to 3rd floor

Figure C.84 shows the temperature inside the elevator shaft from the 3rd floor up. These thermocouple locations are listed with details in Table C.44.

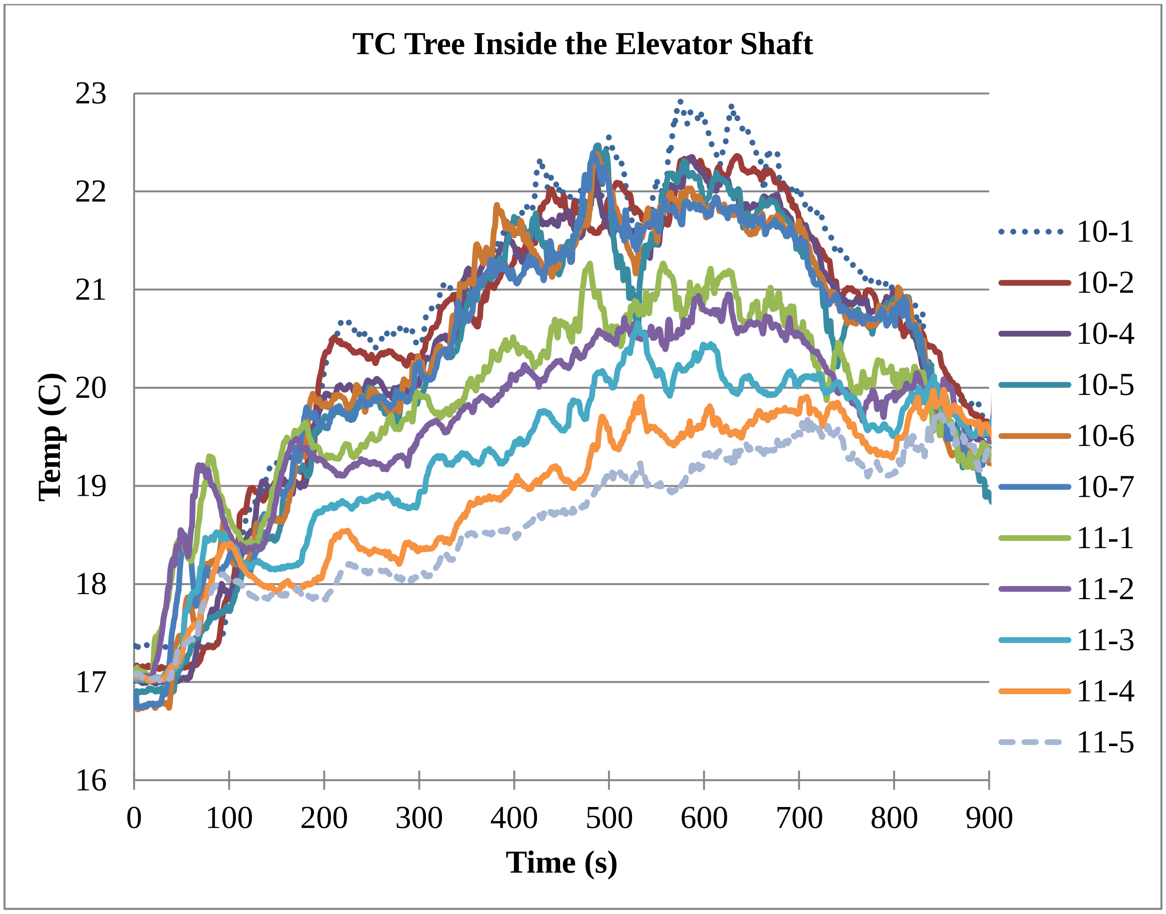

Figure C.84. Temperature inside the elevator shaft

Table C.44. Inside elevator shaft from 5th to 3rd floor TC list

10-1	TC tree inside elevator shaft hanging down from the roof with 10-1 being 0.25m (10in) below the roof and decreasing at 0.9m (3ft) increments ending with 11-5 being 0.66m (2.2ft) above the 3rd floor slab
10-2	
10-3	
10-4	
10-5	
10-6	
10-7	
10-8	
11-1	
11-2	
11-3	
11-4	
11-5	

C.5 EL-1 FIRE TEST TEMPERATURES

C.5.1 TC Trees in the EL

Figure C.85 shows the two thermocouple trees placed in the EL area.

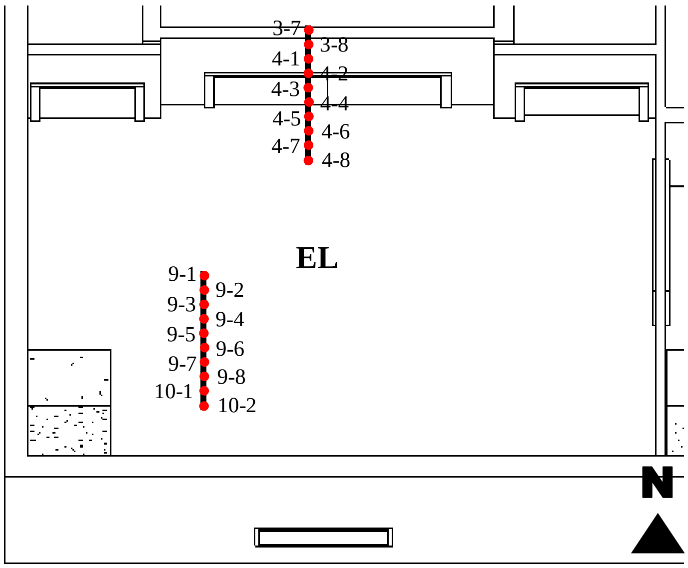

Figure C.85. TC trees in EL

Figure C.86 shows the temperature in front of the elevator door. These thermocouple locations are listed with details in Table C.45.

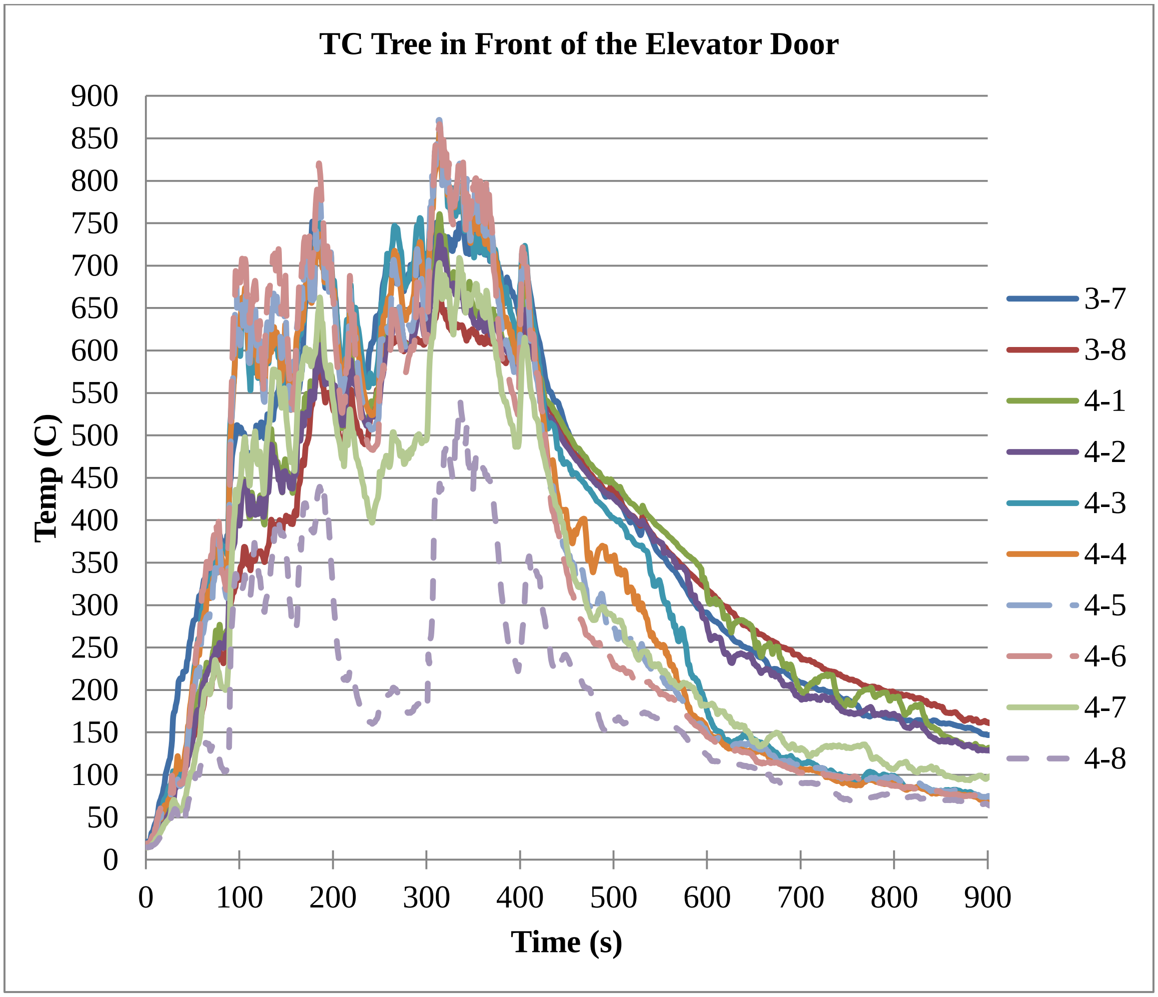

Figure C.86. Temperature in front of the elevator door

Table C.45. Front of elevator door TC tree list

3-7	TC tree in front of shaft door below ceiling of EL starting with 4-8 starting on the floor slab and increasing by 0.3m (1ft) increments to 3-7 on top at 2.7m (8.9ft)
3-8	
4-1	
4-2	
4-3	
4-4	
4-5	
4-6	
4-7	
4-8	

Figure C.87 shows the temperature of the SW corner of the EL. These thermocouple locations are listed with details in Table C.46.

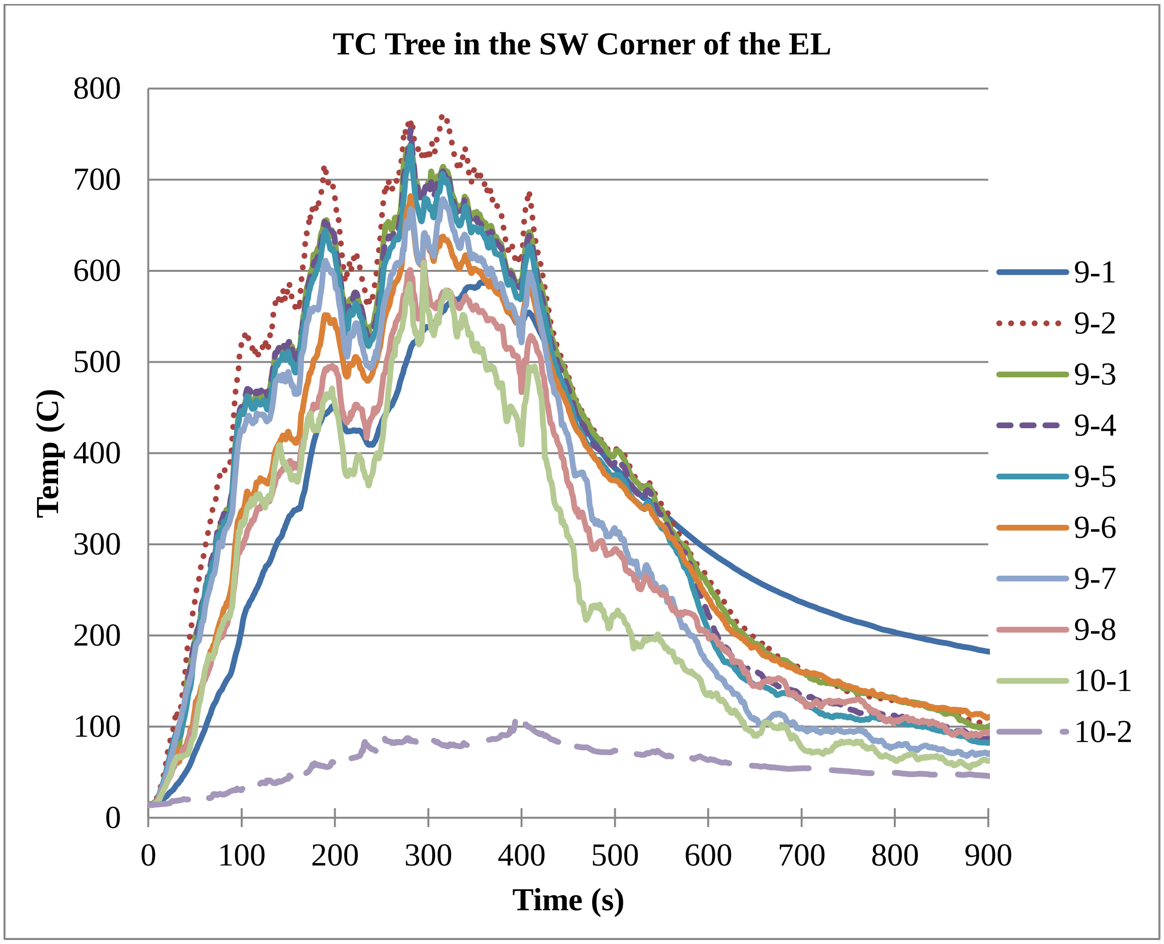

Figure C.87. Temperature in the SW corner of the EL

Table C.46. SW corner of EL TC tree list

9-1	TC tree in SW corner of EL below ceiling, starting with 10-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 9-1 on top at 2.7m (8.9ft)
9-2	
9-3	
9-4	
9-5	
9-6	
9-7	
9-8	
10-1	

C.5.2 TC Trees Above the EL Ceiling

Figure C.88 shows the two thermocouple trees located above the ceiling of the EL. One thermocouple tree was located on the NW corner and the other was located on the SE corner.

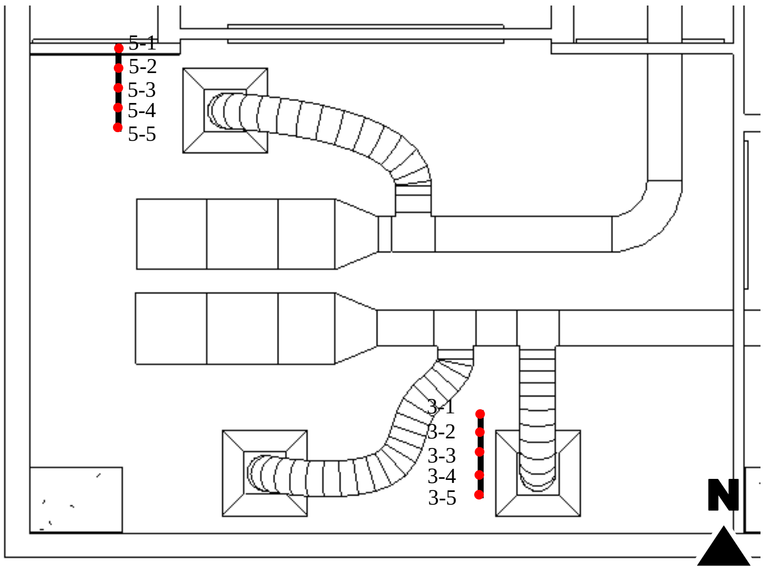

Figure C.88. TC trees above EL ceiling

Figure C.89 shows the SE corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table C.47.

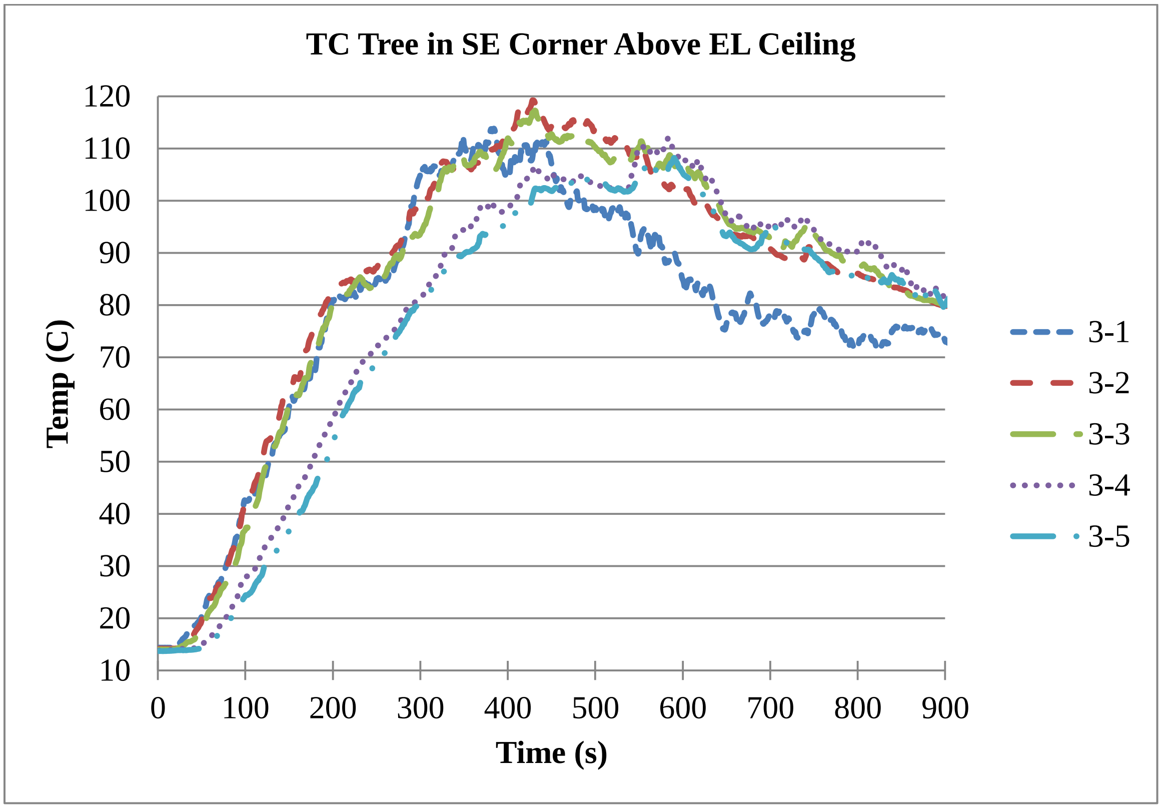

Figure C.89. Temperature of the SE corner space above the EL ceiling

Table C.47. EL SE corner above ceiling TC tree list

3-1	TC tree hanging from 4th floor slab above ceiling SE EL starting with 3-5 right above ceiling and increasing in 0.3m (1ft) increments to 3-1 being on top
3-2	
3-3	
3-4	
3-5	

Figure C.90 shows the NW corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table C.48.

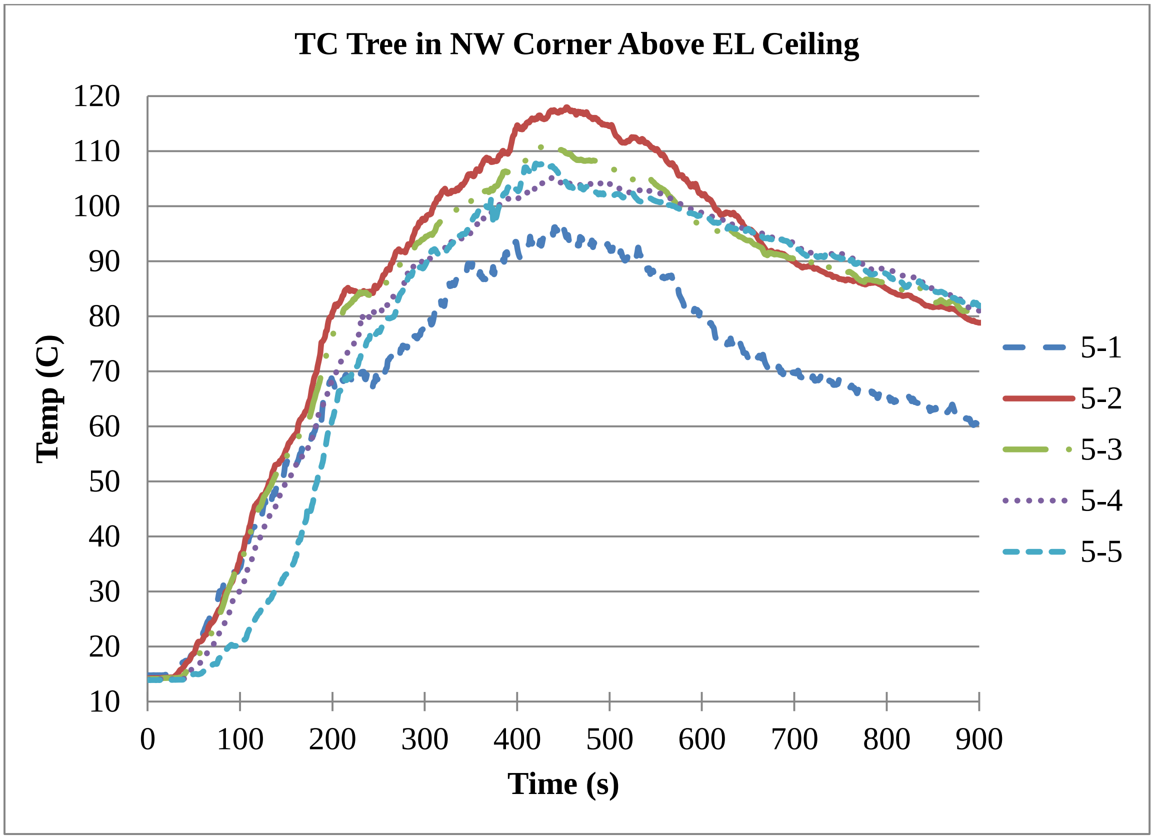

Figure C.90. Temperature of the NW corner space above the EL ceiling

Table C.48. EL NW corner above ceiling TC tree list

5-1	TC tree hanging from 4th floor slab above ceiling NW EL starting with 5-5 right above ceiling and increasing in 0.3m (1ft) increments to 5-1 being on top
5-2	
5-3	
5-4	
5-5	

C.5.4 Inside Elevator Shaft

Figure C.91 shows the thermocouple tree located inside the elevator shaft.

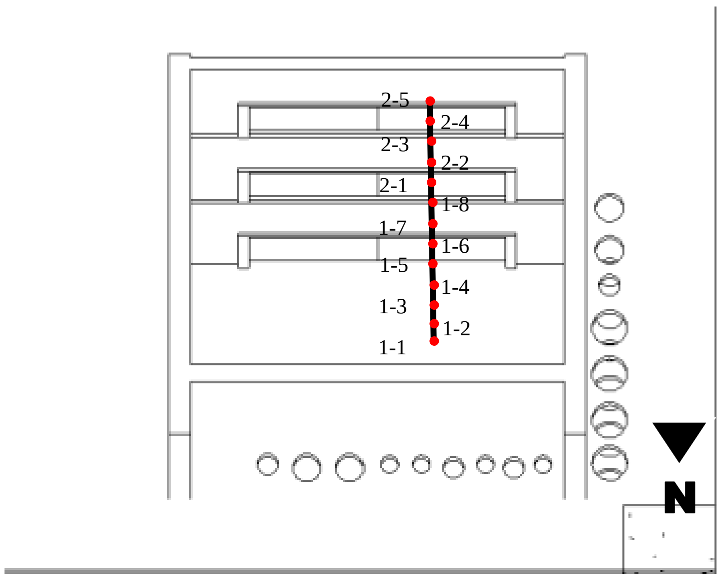

Figure C.91. TC inside elevator shaft from 5th to 3rd floor

Figure C.92 shows the temperature inside the elevator shaft from the 3rd floor up. These thermocouple locations are listed with details in Table C.49.

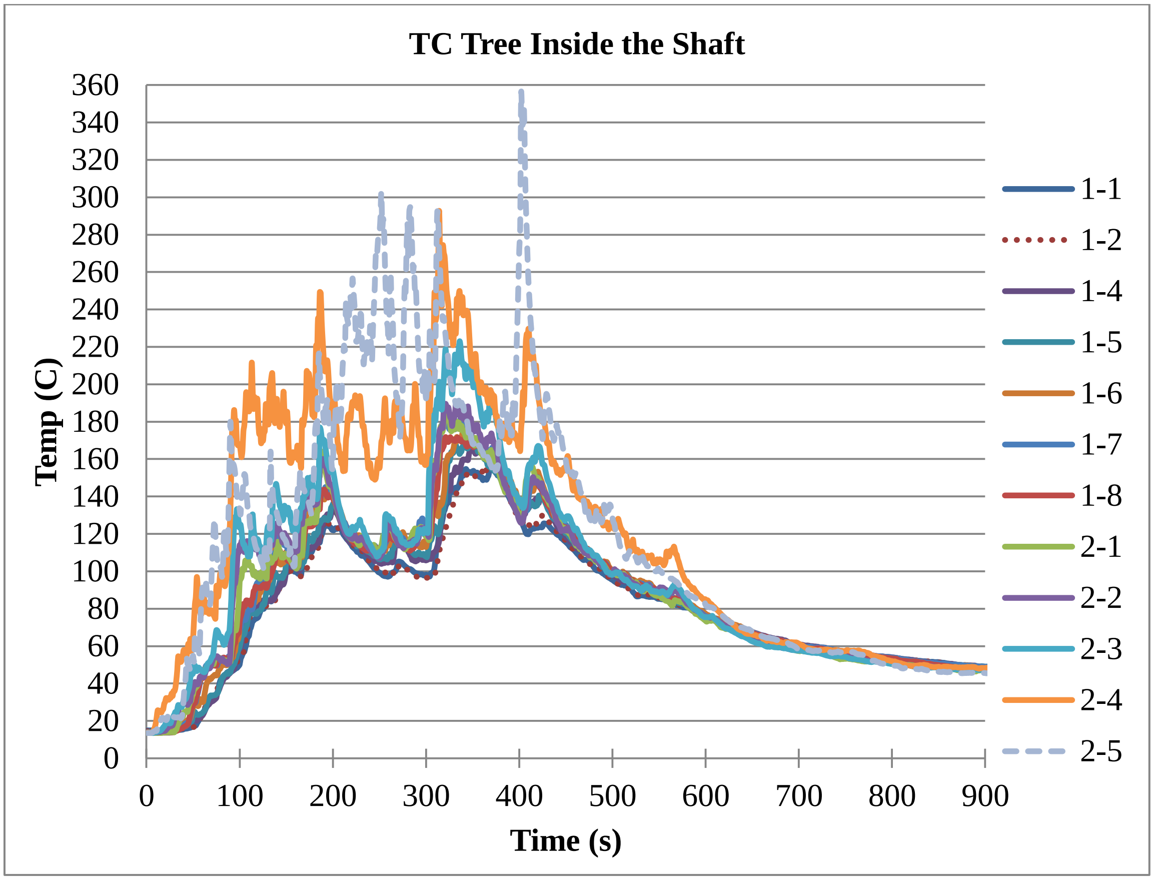

Figure C.92. Inside the shaft temperature

Table C.49. Inside elevator shaft from 5th to 3rd floor TC list

<table>
<tr><td>1-1</td><td rowspan="13">TC tree inside elevator shaft hanging down from the roof with 10-1 being 0.25m (10in) below the roof and decreasing at 0.9m (3ft) increments ending with 11-5 being 0.66m (2.2ft) above the 3rd floor slab</td></tr>
<tr><td>1-2</td></tr>
<tr><td>1-3</td></tr>
<tr><td>1-4</td></tr>
<tr><td>1-5</td></tr>
<tr><td>1-6</td></tr>
<tr><td>1-7</td></tr>
<tr><td>1-8</td></tr>
<tr><td>2-1</td></tr>
<tr><td>2-2</td></tr>
<tr><td>2-3</td></tr>
<tr><td>2-4</td></tr>
<tr><td>2-5</td></tr>
</table>

C.5.5 Exterior Gas Temperatures

Figure C.93 shows the thermocouples that were located on the south and west exterior balloon frames.

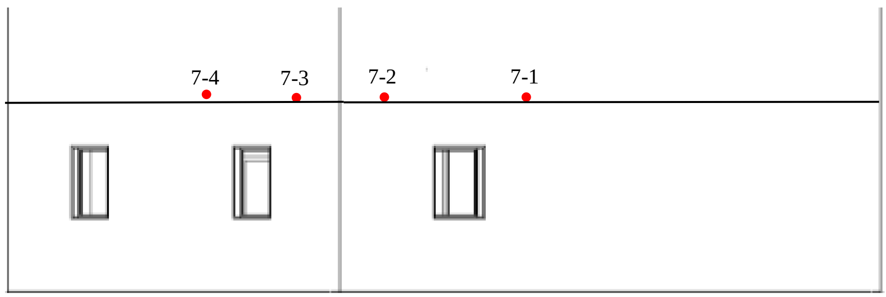

Figure C.93. TC on S and W exterior balloon framing walls

Figure C.94 shows the temperatures of the north and west exterior balloon frames. These thermocouple locations are listed with details in Table C.50.

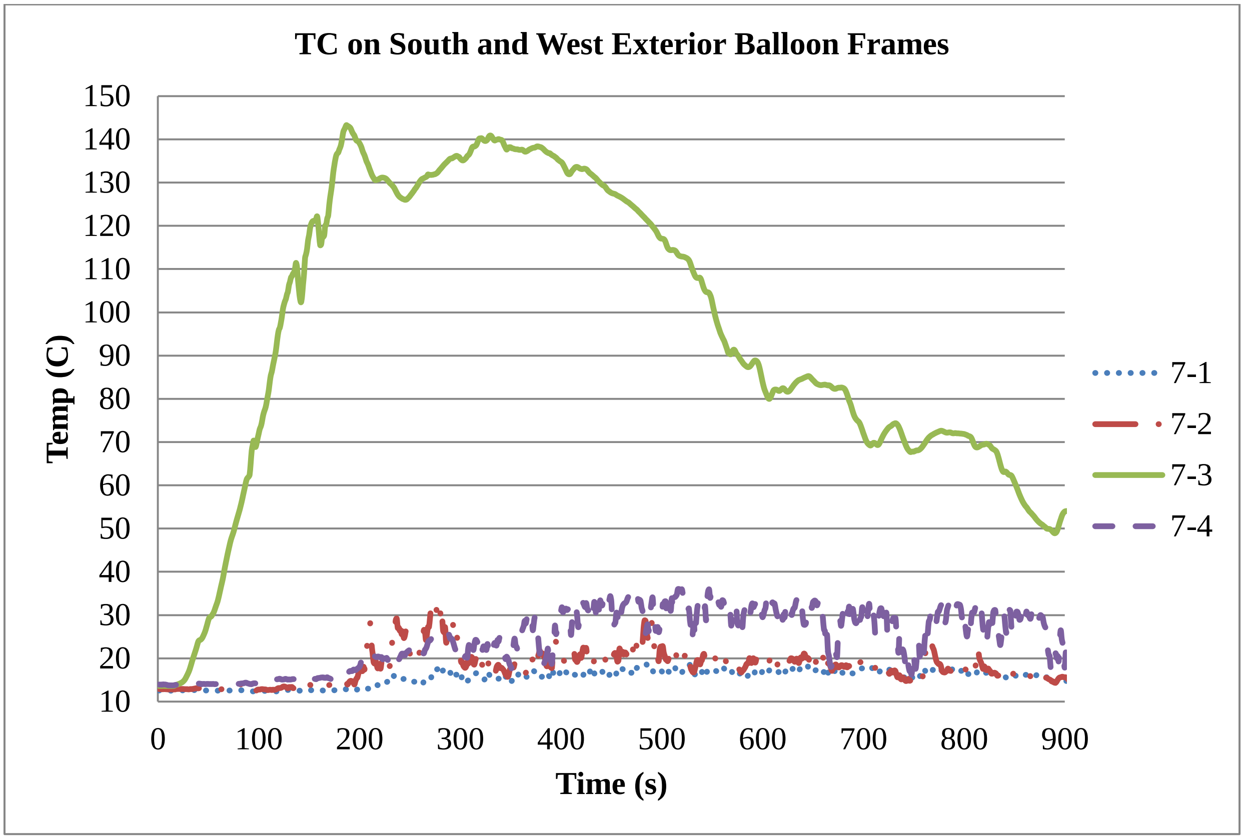

Figure C.94. TC on S and W exterior balloon framing walls

Table C.50. S and W exterior balloon framing walls TC list

7-1	Balloon framing south wall East
7-2	Balloon framing south wall west
7-3	Balloon framing west wall south
7-4	Balloon framing west wall north

C.5.7 HVAC Duct and Vent

Figure C.95 shows the thermocouples that were located in the HVAC duct behind the fire damper in the 3rd floor stair landing and the vent in the 4th floor.

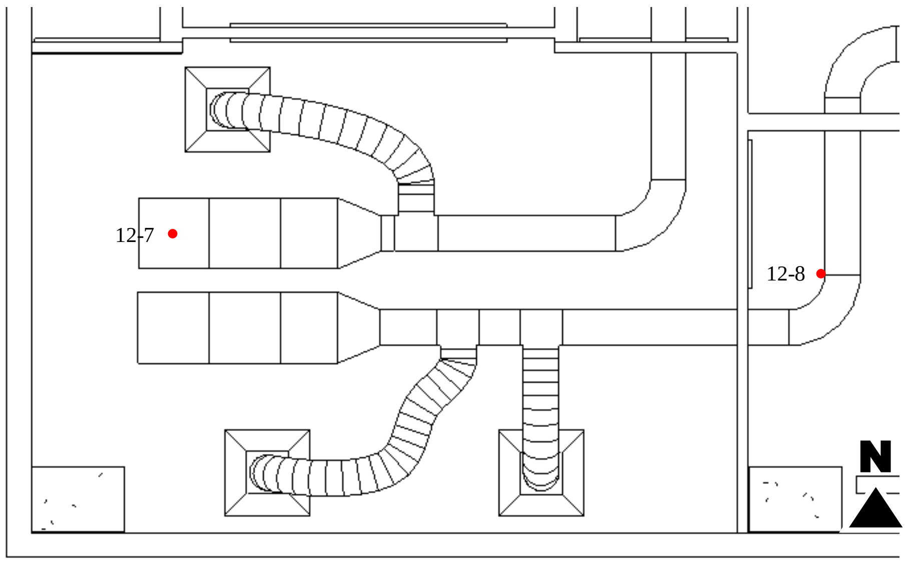

Figure C.95. TC in HVAC duct damper and 4th floor vent

Figure C.96 shows the HVAC duct and vent temperatures. These thermocouple locations are listed with details in Table C.51.

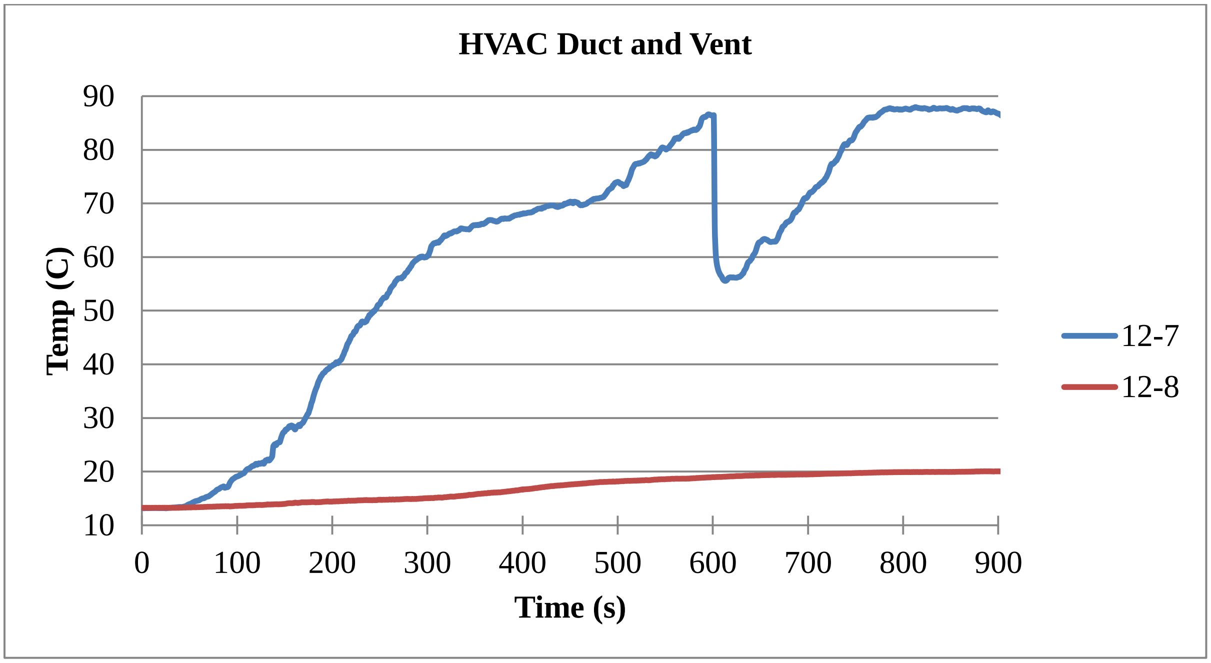

Figure C.96. HVAC duct and vent temperatures

Table C.51. HVAC duct damper and 4th floor vent TC list

12-7	Vent temperature in the fourth floor
12-8	TC in the duct of the stairwell landing

C.6 EL-2 FIRE TEST TEMPERATURES

C.6.1 TC Trees in the EL

Figure C.97 shows the two thermocouple trees placed in the EL area.

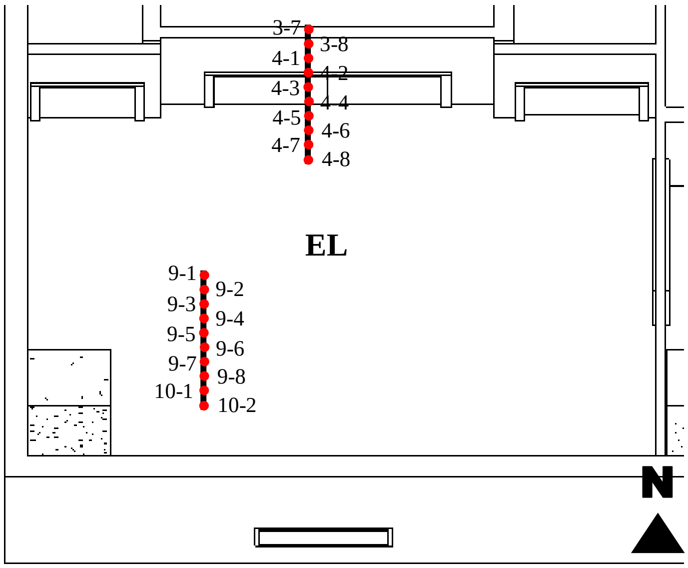

Figure C.97. TC trees in EL

Figure C.98 shows the temperature in front of the elevator door. These thermocouple locations are listed with details in Table C.52.

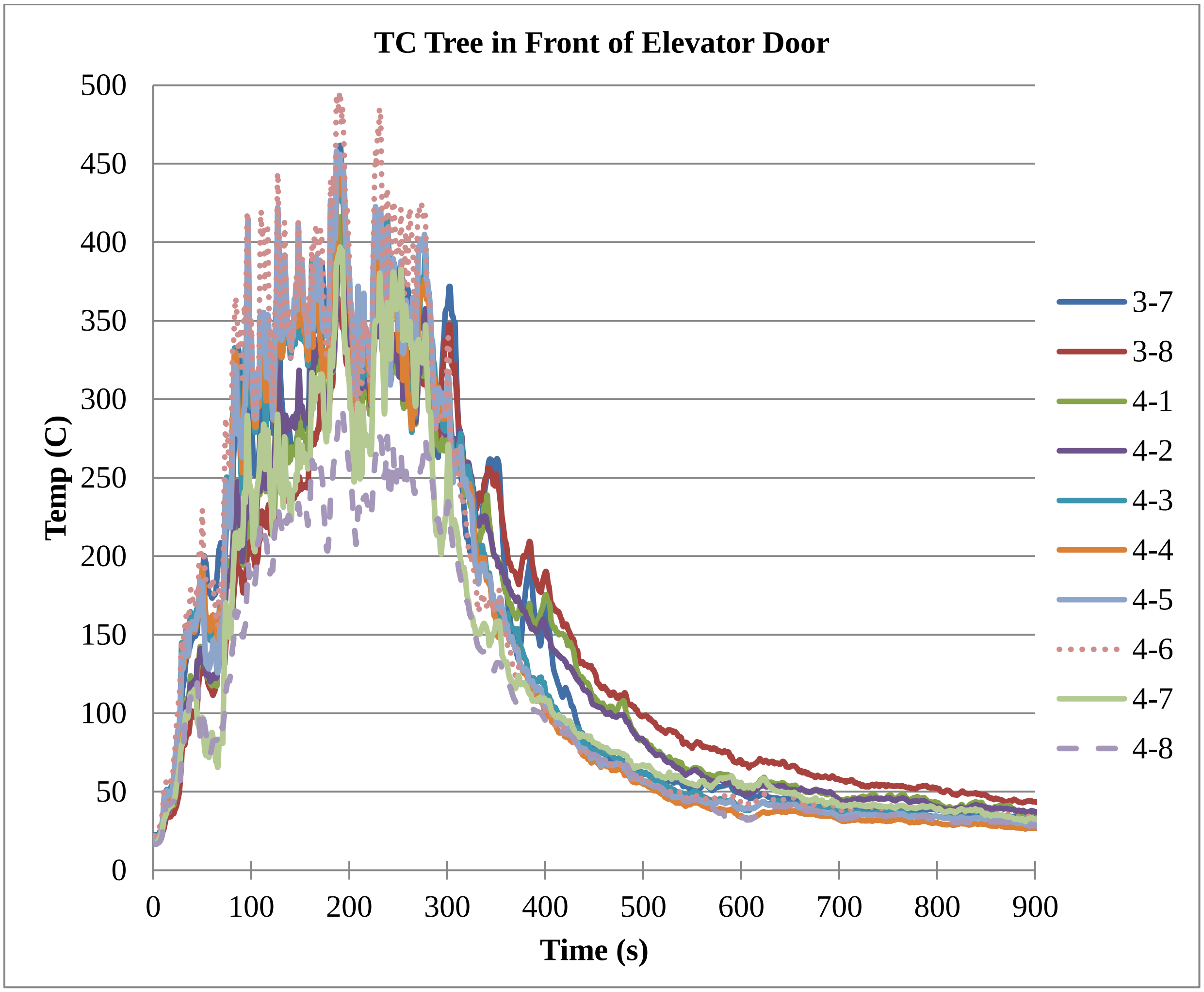

Figure C.98. Temperature in front of the elevator door

Table C.52. Front of elevator door TC tree list

<table>
<tr><td>3-7</td><td rowspan="10">TC tree in front of shaft door below ceiling of EL starting with 4-8 starting on the floor slab and increasing by 0.3m (1ft) increments to 3-7 on top at 2.7m (8.9ft)</td></tr>
<tr><td>3-8</td></tr>
<tr><td>4-1</td></tr>
<tr><td>4-2</td></tr>
<tr><td>4-3</td></tr>
<tr><td>4-4</td></tr>
<tr><td>4-5</td></tr>
<tr><td>4-6</td></tr>
<tr><td>4-7</td></tr>
<tr><td>4-8</td></tr>
</table>

Figure C.99 shows the temperature of the SW corner of the EL. These thermocouple locations are listed with details in Table C.53.

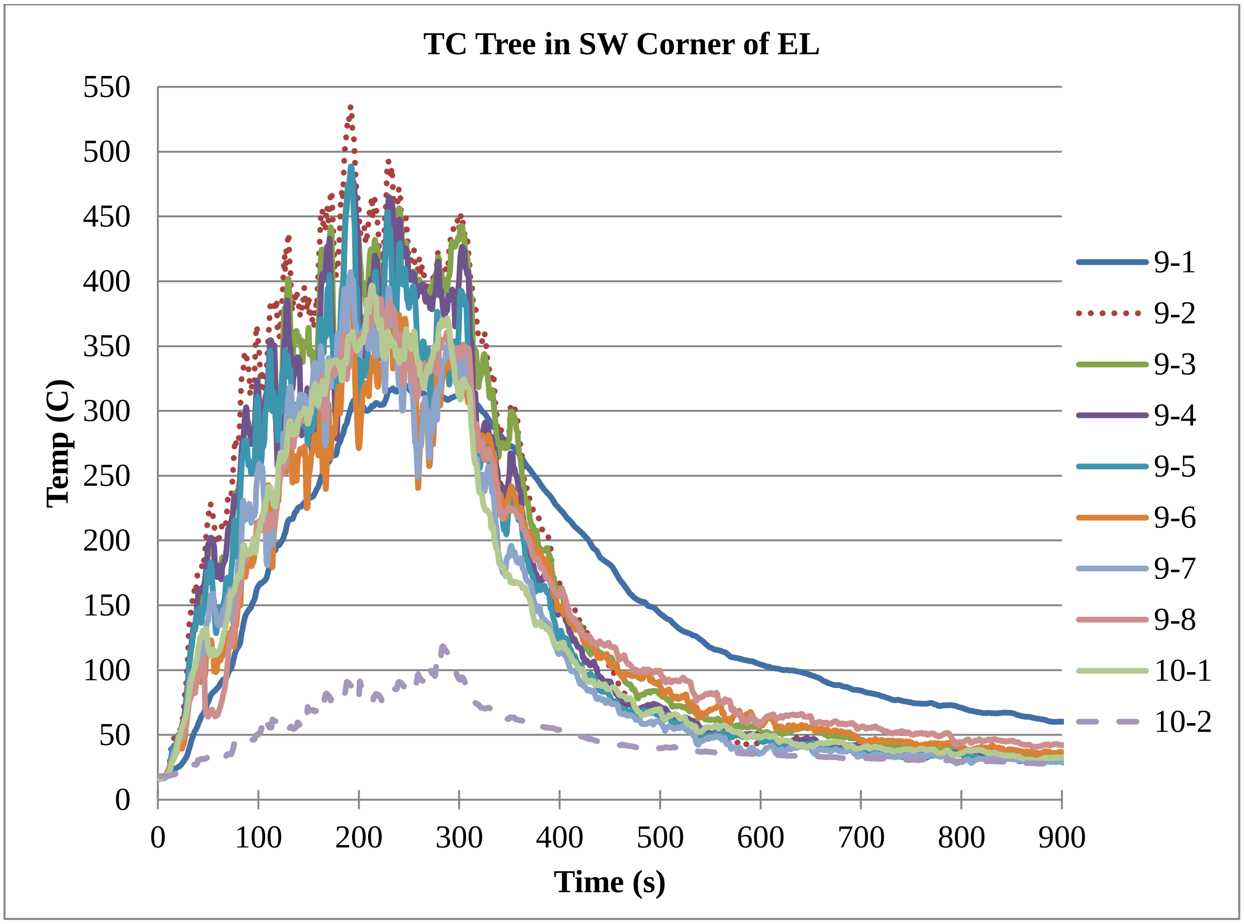

Figure C.99. Temperature in the SW corner of the EL

Table C.53. SW corner of EL TC tree list

9-1	TC tree in SW corner of EL below ceiling, starting with 10-2 starting on the floor slab and increasing by 0.3m (1ft) increments to 9-1 on top at 2.7m (8.9ft)
9-2	
9-3	
9-4	
9-5	
9-6	
9-7	
9-8	
10-1	

C.6.2 TC Trees Above the EL Ceiling

Figure 8.54 shows the two thermocouple trees located above the ceiling of the EL. One thermocouple tree was located on the NW corner and the other was located on the SE corner.

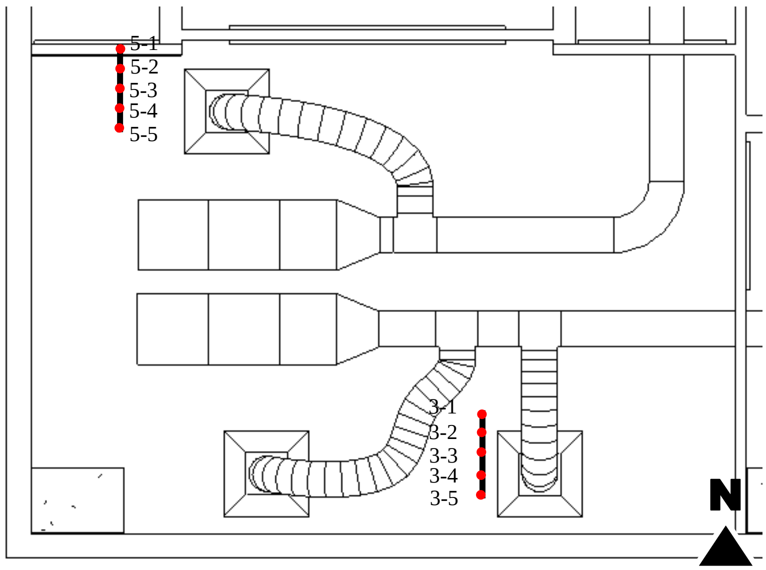

Figure C.100. TC trees above EL ceiling

Figure C.101 shows the SE corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table C.54.

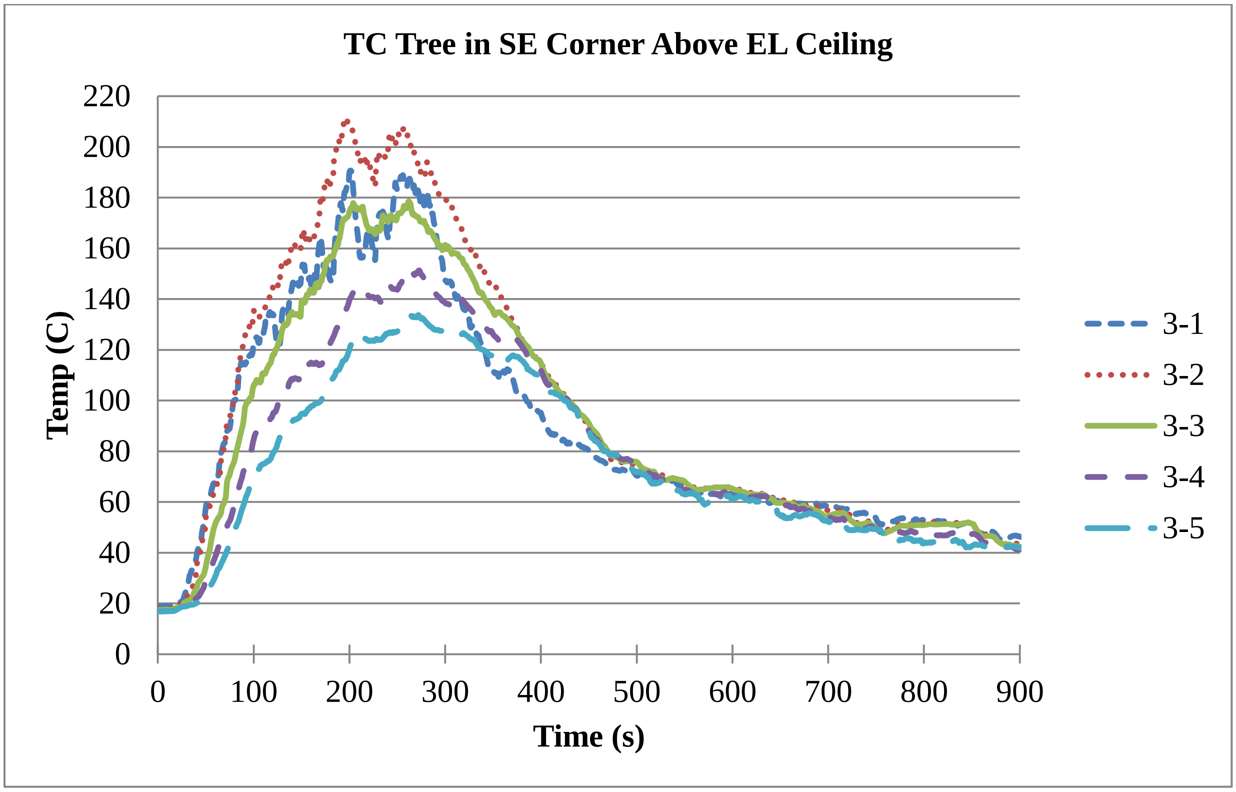

Figure C.101. Temperature of the SE corner space above the EL ceiling

Table C.54. EL SE corner above ceiling TC tree list

3-1	TC tree hanging from 4th floor slab above ceiling SE EL starting with 3-5 right above ceiling and increasing in 0.3m (1ft) increments to 3-1 being on top
3-2	
3-3	
3-4	
3-5	

Figure C.102 shows the NW corner temperature above the EL ceiling. These thermocouple locations are listed with details in Table C.55.

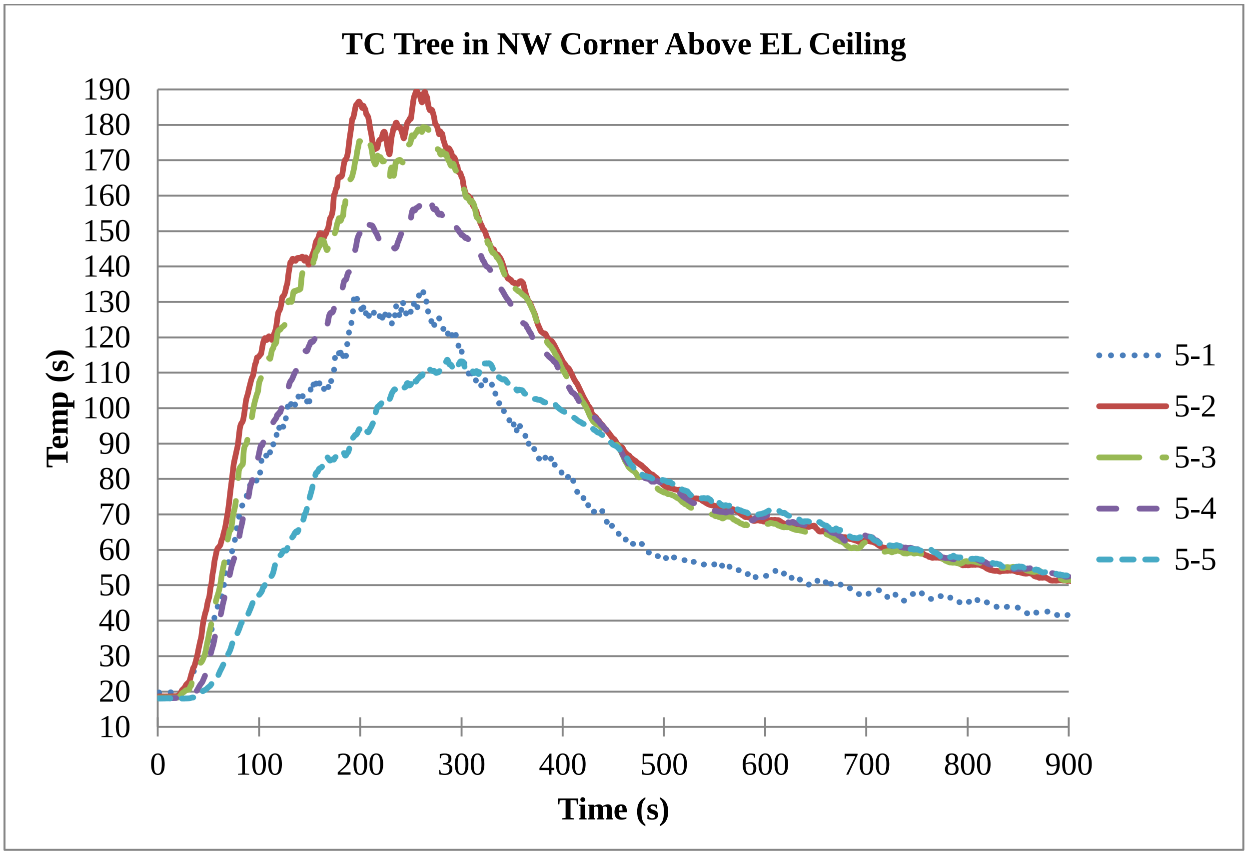

Figure C.102. Temperature of the NW corner space above the EL ceiling

Table C.55. EL NW corner above ceiling TC tree list

5-1	TC tree hanging from 4th floor slab above ceiling NW EL starting with 5-5 right above ceiling and increasing in 0.3m (1ft) increments to 5-1 being on top
5-2	
5-3	
5-4	
5-5	

C.6.4 Inside Elevator Shaft

Figure C.103 shows the thermocouple tree located inside the elevator shaft.

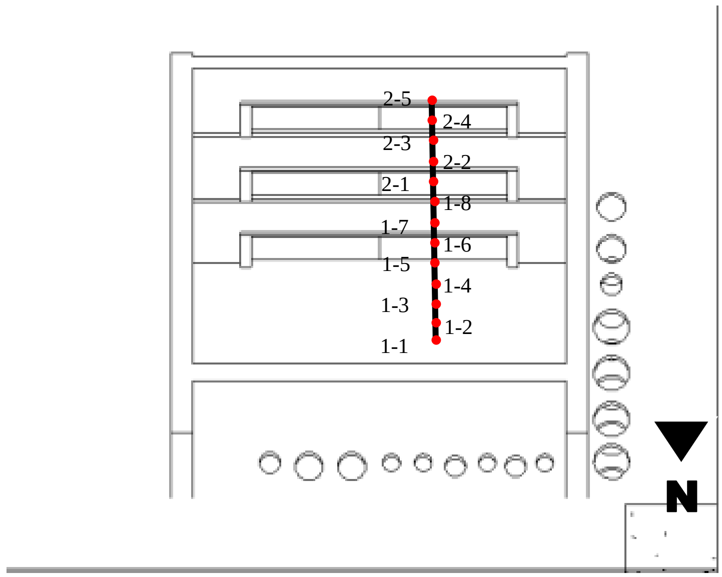

Figure C.103. TC inside elevator shaft from 5th to 3rd floor

Figure C.104 shows the temperature inside the elevator shaft from the 3rd floor up. These thermocouple locations are listed with details in Table C.56.

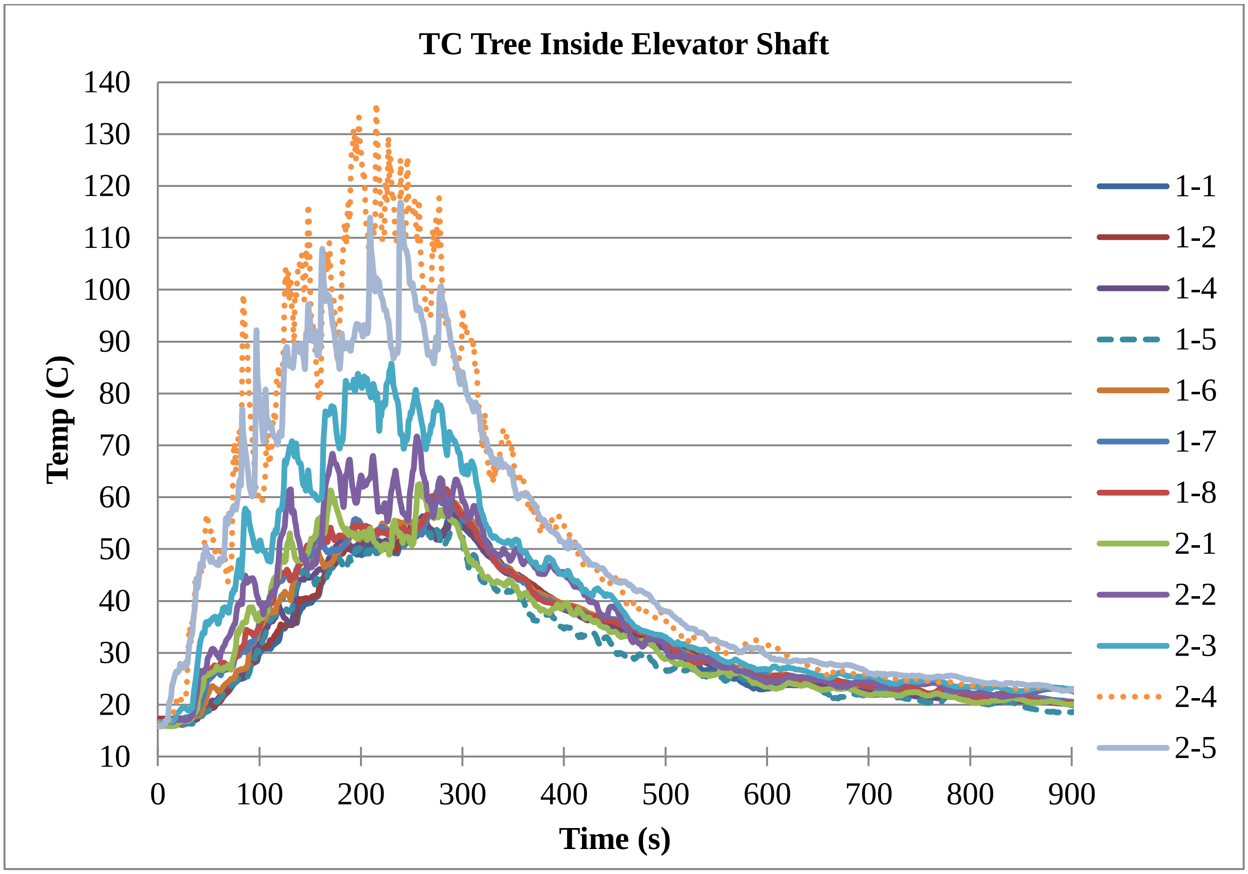

Figure C.104. Inside the shaft temperature

Table C.56. Inside elevator shaft from 5th to 3rd floor TC list

<table>
<tr><td>1-1</td><td rowspan="13">TC tree inside elevator shaft hanging down from the roof with 10-1 being 0.25m (10in) below the roof and decreasing at 0.9m (3ft) increments ending with 11-5 being 0.66m (2.2ft) above the 3rd floor slab</td></tr>
<tr><td>1-2</td></tr>
<tr><td>1-3</td></tr>
<tr><td>1-4</td></tr>
<tr><td>1-5</td></tr>
<tr><td>1-6</td></tr>
<tr><td>1-7</td></tr>
<tr><td>1-8</td></tr>
<tr><td>2-1</td></tr>
<tr><td>2-2</td></tr>
<tr><td>2-3</td></tr>
<tr><td>2-4</td></tr>
<tr><td>2-5</td></tr>
</table>

C.6.5 Exterior Gas Temperatures

Figure C.105 shows the thermocouples that were located on the south and west exterior balloon frames.

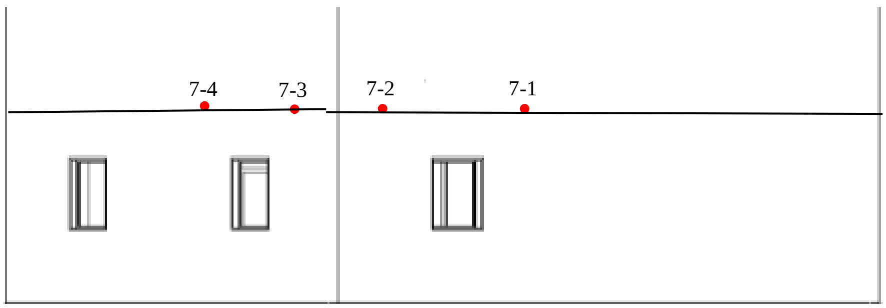

Figure C.105. TC on S and W exterior balloon framing walls

Figure C.106 shows the temperatures of the north and west exterior balloon frames. These thermocouple locations are listed with details in Table C.57.

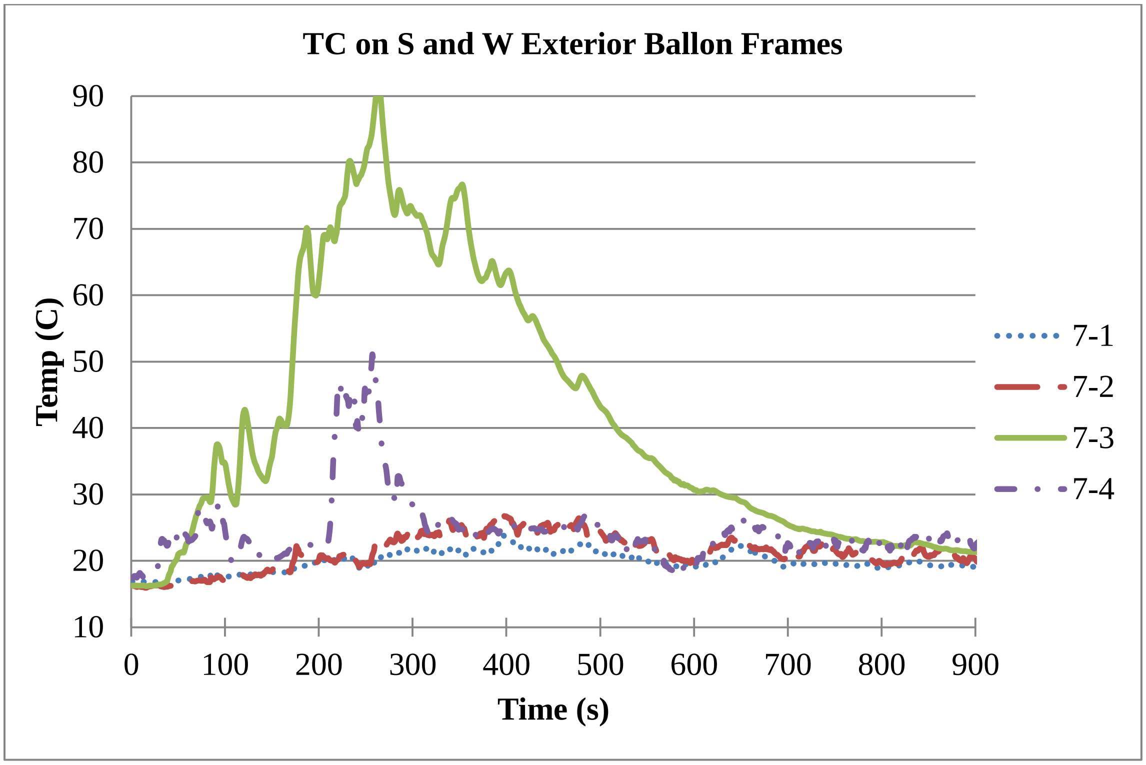

Figure C.106. TC on S and W exterior balloon framing walls

Table C.57. S and W exterior balloon framing walls TC list

7-1	Balloon framing south wall East
7-2	Balloon framing south wall west
7-3	Balloon framing west wall south
7-4	Balloon framing west wall north

C.6.6 HVAC Duct and Vent

Figure C.107 shows the thermocouples that were located in the HVAC duct behind the fire damper in the 3rd floor stair landing and the vent in the 4th floor.

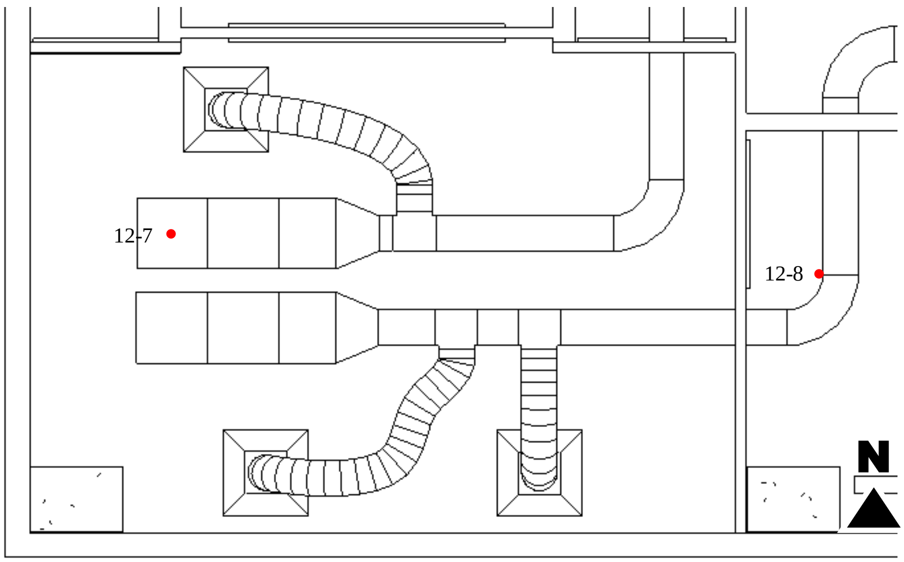

Figure C.107. TC in HVAC duct damper and 4th floor vent

Figure C.108 shows the HVAC duct and vent temperatures. These thermocouple locations are listed with details in Table C.58.

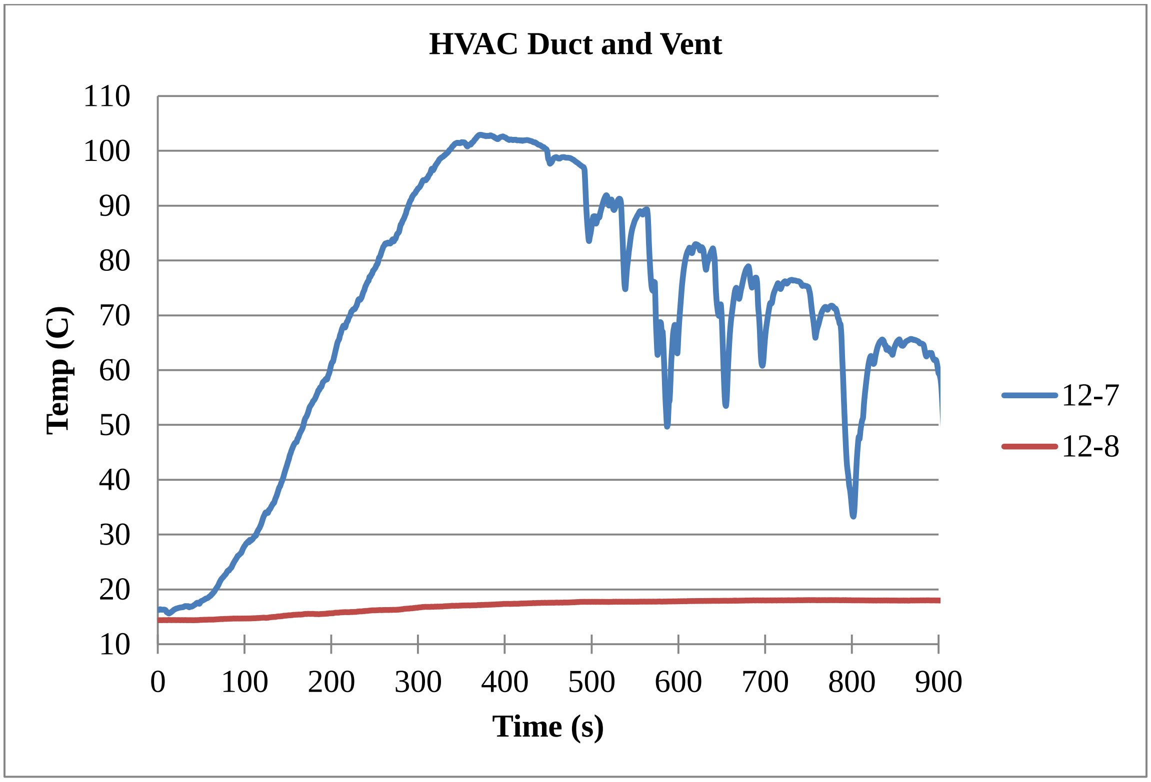

Figure C.108. HVAC duct and vent temperatures

Table C.58. HVAC duct damper and 4th floor vent TC list

12-7	Vent temperature in the fourth floor
12-8	TC in the duct of the stairwell landing

D FIRE RISK MANAGEMENT PLAN

D.1 SAFETY PROTOCOL DURING FIRE TESTS

Safety during fire tests generally follows the site safety protocol including the need for hard hats, safety glasses and closed-toed boots. In addition, at the request of the UCSD EH&S Department, no one was allowed to remain in the building during fire tests, and the San Diego Fire Department (SDFD) was required to be on site. Unlike the seismic motion tests, there was no alarming system as the pressurization of the pump was not involved. Therefore, before the fire tests, the fire test operators confirmed that the building was cleared out, and another safety observer in the ground level blocked any incoming person to the building at the same time. The readiness of the SDFD was also confirmed. Since the building was tall, and located in a windy environment, a remote personal communication device was required to control human flow at the time of ignition. Once accessible route of evacuation for the fire test operators was ready, the heptane pan fire was ignited by a designated test operator who wore fire protection jacket and face shield. Before each fire test, dress rehearsal was performed to make sure that test operators were ready and preparation of the fire test was completed.

It was confirmed that the SDFD would be present 4 hours per day to ensure the fire safety. It was planned to begin the fire test around 9 AM each day as test operators could prepare things not being in a hurry before the fire test, and this timing matched the schedule of SDFD availability (nominally 9AM – 1PM).

D.2 EMERGENCY CONDITION AND FIRE DEPARTMENT INVOLVEMENT

Since the building was in a damaged state by earthquake motion tests, and various unknown factors such as wind direction, and humidity were involved, it was very difficult to predict fire phenomena in advance. In addition, the fire was not directly watched by nearby fire test operators (i.e., from within the building) at the direction of UCSD EH&S. To compensate for lack of personnel within the building during testing, the internal compartment temperatures, and fire test scene were monitored by fire test operators in the ground level, and for any emergency situations, the SDFD were ready take action as they deemed appropriate. A request was \made to the SDFD, that if possible, any manual extinguishments would involve use of a fog nozzle to minimize physical damage to sensors from a high-pressure hose stream.

Expected phenomena during fire tests were as below.

- Light smoke can come out through window openings.
- Flame tip can be seen through window openings.
- The paper on the surface of the gypsum wall board (GWB) will ignite and burn, especially within the small burn room.
- Minor flame and smoke spread may occur to adjacent compartments in relation to the damage state of the building.

In the unlikely event of fire spread beyond the compartment of origin, fire department intervention would be requested:

- If there is a severe heptane leak which can be seen via the camera.
- If flame spread is observed on the surface of the exterior wall as ignited through the window openings.
- If structural components become weak due to high heat and the exterior balloon framing is detached from main body of the building
- If there is a request from the chief fire test operator based on real-time observations of the fire test.

D.3 OVERALL PROCEDURE FOR FIRE TESTS

A Ph.D. student at Worcester Polytechnic Institute (WPI), Haejun Park took the lead for instrumentation, and in running fire tests assigning missions to two Master students at WPI, AJ Campanella, and Jin Kyung Kim.

1. Check of building status and safety prior to fire testing
    a. Checked the building's structural integrity and for any possible falling items (conducted by seismic / structural engineers)
    b. Confirmed that pressure was bled out from fire sprinkler system on the third floor
    c. Confirmed that electricity was provided to the building
    d. Confirmed that no hazardous and combustible fuel gas existed in the building
2. Preparation of the room of fire test
    a. Removed unnecessary fuel items in the room of origin and clean the space
    b. Marked and drew necessary information such as ruler in the wall to check the smoke layer height or the area where care should be taken

3. Instrumentation
    a. Moved necessary equipment and tools to the fire test floor
    b. Located the DAQ system
    c. Installed TCs
    d. Connected DAQ system with TCs
    e. Checked the TC values with DAQ system in operation
    f. Installed video recording system
    g. Checked the video recording system's functionality
4. Preparation of fire tests
    a. Prepared the fire test room by closing (or opening) doors
    b. Located the heptane and retention pans
    c. Brought the proper amount of heptane fuel to the room of origin from the storage space
    d. Had emergency personnel ready in site
5. Initiation of fire tests
    a. Followed safety protocol as outlined above (clear building, check FD status)
    b. Started DAQ and ignited the fire
    c. Moved out from the room of the origin and monitor temperatures
    d. Watched for fire to terminate via camera link
    e. Lead fire test operator to reviewed building, with FD personnel at their discretion
    f. Lead fire test operator called 'all clear'
6. Finishing fire tests
    a. Finish the test and let the room be cooled down

Cleaned the fire space and prepared for the next test following the protocol above

D.4 MANAGEMENT OF FIREFIGHTING RUN-OFF WATER

D.4.1 Amount of Water Involved in Tests

An automatic sprinkler system was installed in the building, and was be exposed to seismic and fire tests. A common sprinkler system was connected to the city water main or pumps and often times, water damage can become an issue when sprinklers are activated. For the BNCS project tests, the automatic sprinkler system was charged with water by either using a pump or city main supply. Once sufficient volume of water was charged, the water supply was disconnected from the automatic sprinkler system. As a result, in the worst case scenarios such as pipe rupture, the amount of water released would be limited to only the amount stored in the sprinkler pipe system. The estimated amount of water was calculated by *Western Fire Protection*, who installed the sprinkler system in the building. About 15 gallons of water was stored per floor resulting in a total of 75 gallons of water in the entire building. Therefore, there would have been little or no possibility of water damage from the automatic sprinkler. In addition, during the fire tests, most the water in the sprinkler system was drained out just to test sprinkler activation.

D.4.2 Firefighting Method for Heptane Fuel

Heptane was used as a source of fuel in the fire tests. Heptane is considered a flammable liquid with density of 680kg/m^3 and immiscible with water. Therefore, water is not considered to be a good firefighting method for heptane pan fire. In the fire lab at Worcester Polytechnic Institute, a portable fire extinguisher, not a water based extinguishment mode, is used to put out a heptane pan fire in emergency conditions, although water spray is a more commonly used method and works well for most fires.

D.4.3 Firefighting Run-Off Water

The role of fire fighters during the fire tests included emergency management, where any extinguishing action would be required in cases if the fire became uncontrolled, additional fuel items would ignite, and the fire grows larger than the designed range of 1.5MW. Depending on the room size, and opening size, fire size can vary, but the design values were calculated to prohibit any flashover condition. Assuming that any emergency condition occurs and fire fighters are involved in firefighting activities, it was recommended that portable fire extinguisher be used instead of applying large amount of water.

To prevent water runoff to the concrete pad of the shake table from any emergency case of fire-fighting, a water containment dike material shown in Figure D.1 was installed around the building site. Figure D.2 shows the site including the shake table and the concrete pad and a layout of the dike installation plan. The dike, 208 feet in length and 2.25 inches in height, had the capacity to contain a total area of 1,665 feet squared and a volume of 2,333 gallons of water. In addition, separate dike containment was installed around a 2 feet by 2 feet storm drain. A detailed CAD drawing of dike installation plan is shown in Figure D.3. These measures ensured that all water runoff was prevented during the testing period.

Figure D.1. Dike containment (http://www.aztechsupplies.com/items_SD__Spill-Dikes-Berms.html)

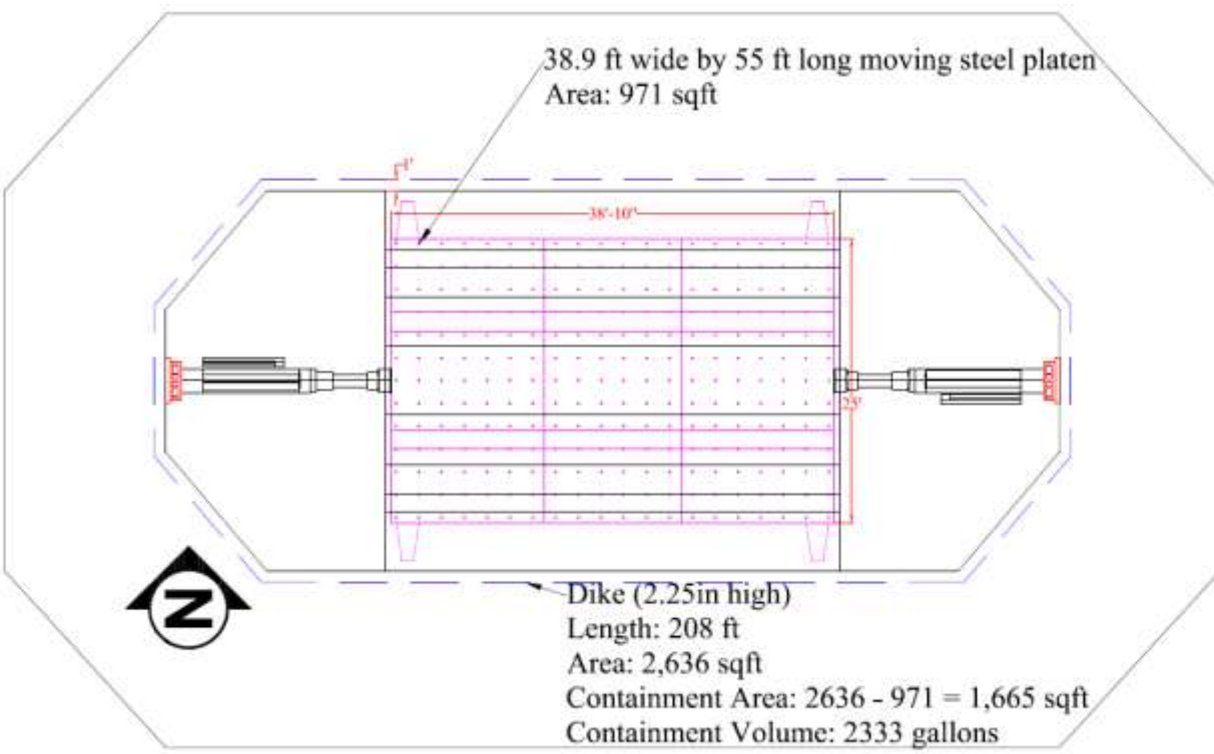

Figure D.2. Dike system layout

Figure D.3. Dike system layout