



Alternative Means and Methods Review:

Transformer Vault Exhaust Horizontal Ductwork

Project: 701 S. Jackson St., Seattle, WA

Client Name: Neiman Taber

Client Address: 1435 34th Avenue, Seattle, WA

Date: 4/14/2022

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1 OVERVIEW

Neiman Taber (Client) is serving as the architect for a new eight-story multifamily development to be located at 701 S. Jackson St., Seattle, WA (Project). The Project will consist of 202 residential units, retail, and a single level of underground parking. The Project will be under the jurisdictional review of the City of Seattle.

The Client has requested for Code Unlimited to review and advise on a fire-resistant assembly for a horizontal run of exhaust ductwork serving a transformer vault. This report reviews the applicable code requirements and recommends an alternative approach that achieves compliance with the intent of the Seattle Building Code and Seattle City Light standards.

2 CODE REQUIREMENTS

The review contained herein is based on the following relevant codes:

- 2018 Seattle Building Code (SBC)
- 2018 Seattle Mechanical Code (SMC)
- 2021 Seattle City Light Standard 0751.00 (SCLS)

Code requirements relevant to the subject fire-resistant assembly condition are summarized below.

SBC Table 509 references NFPA 70 (2017) Article 110 (Requirements for Electrical Installations) and Article 450 (Transformers and Transformer Vaults) for transformer vault fire separation requirements. Pursuant to NFPA 70 §110.31(A)(5), NFPA 70 §450.42 requires enclosure of transformer vaults in construction qualified to a 3-hr fire resistance rating. Furthermore, SCLS 9.8.1 states that transformer vault exhaust ductwork shall have a 3-hr fire resistance rating.

SBC §703.2.1 requires that nonsymmetrical fire barriers/partitions be fire tested per ASTM E119 from both sides, and the assigned fire resistance rating shall be the shortest duration obtained from the two tests.

SBC §713 provides requirements for fire resistance rated shaft enclosures. Per SBC §713.5, horizontal runs of shafts shall be protected by a fire resistance rated floor assembly.

SBC §717 provides requirements for ducts and air transfer openings. Per SBC §717.1.1, ducts transitioning horizontally between shafts shall not require a shaft enclosure provided that the duct penetration into each associated shaft is protected with fire dampers (Figure 1 and Figure 2). Per SBC §717.3.2.1, such fire dampers would be required to be 3-hr fire resistance rated.

SBC §717.2.2 requires that fire dampers for hazardous exhaust duct systems to comply with the SMC, which adopts/amends the 2018 International Mechanical Code. SMC §510.1 states that hazardous emissions include flammable vapors, gases, fumes, mists or dusts, and volatile or airborne materials posing a health hazard, such as toxic or corrosive materials. SMC 510.7.1 prohibits the use of fire dampers in hazardous exhaust ducts. However, transformer vault exhaust would not be considered hazardous exhaust per SMC 510.1. Notwithstanding, SCLS 9.8.4 states that fire dampers shall not be installed in transformer vault exhaust ductwork.

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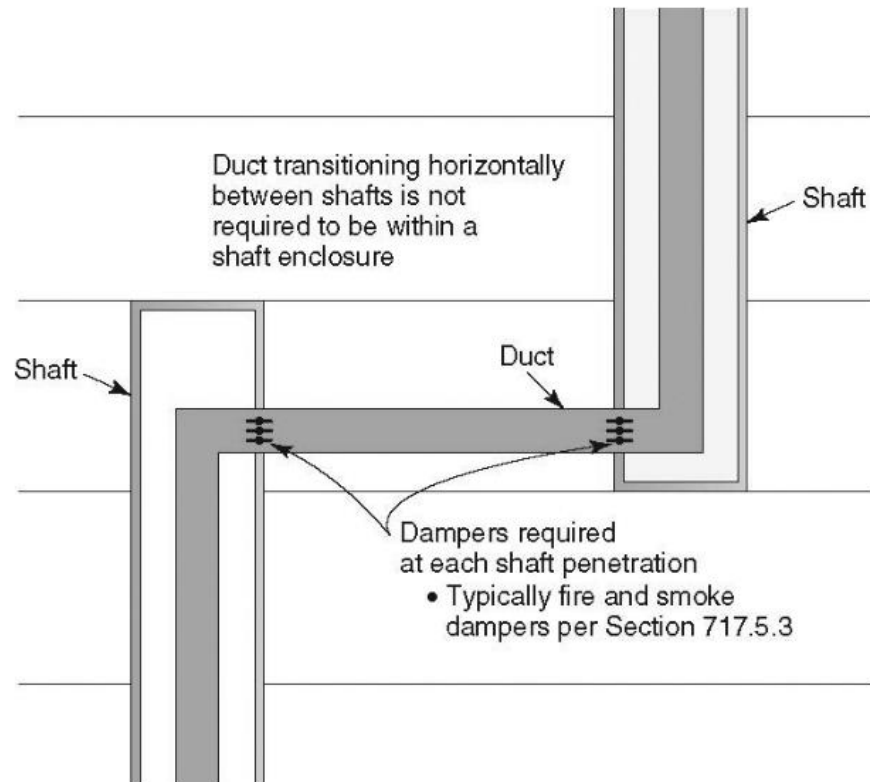


Figure 1: Horizontal Duct Between Two Shafts (2018 International Building Code Commentary)

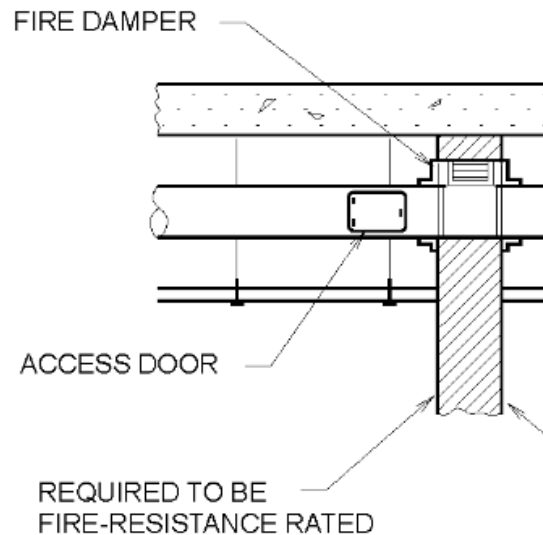


Figure 2: Fire Damper Installed in Fire Barrier (2018 International Building Code Commentary)

3 PROPOSED CONDITION

Figure 3 is a plan view sketch received from the Client on 28 February 2022. We understand a 2-ft x 2-ft section of exhaust ductwork will extend vertically through the Level 2 floor from a transformer vault located on Level 1. From this point, the exhaust duct (either 2-ft x 2-ft or 3-ft x 1-ft) will extend horizontally (without duct openings) with a 90-degree elbow along the underside of the Level 3 concrete floor slab for a total length of approximately 30 to 40-ft and then extend vertically through the Level 3 floor. We understand each vertical run of the exhaust ductwork will be enclosed within a qualified 3-hr fire resistance rated assembly. This review pertains exclusively to the horizontal run of the exhaust ductwork serving the transformer vault.

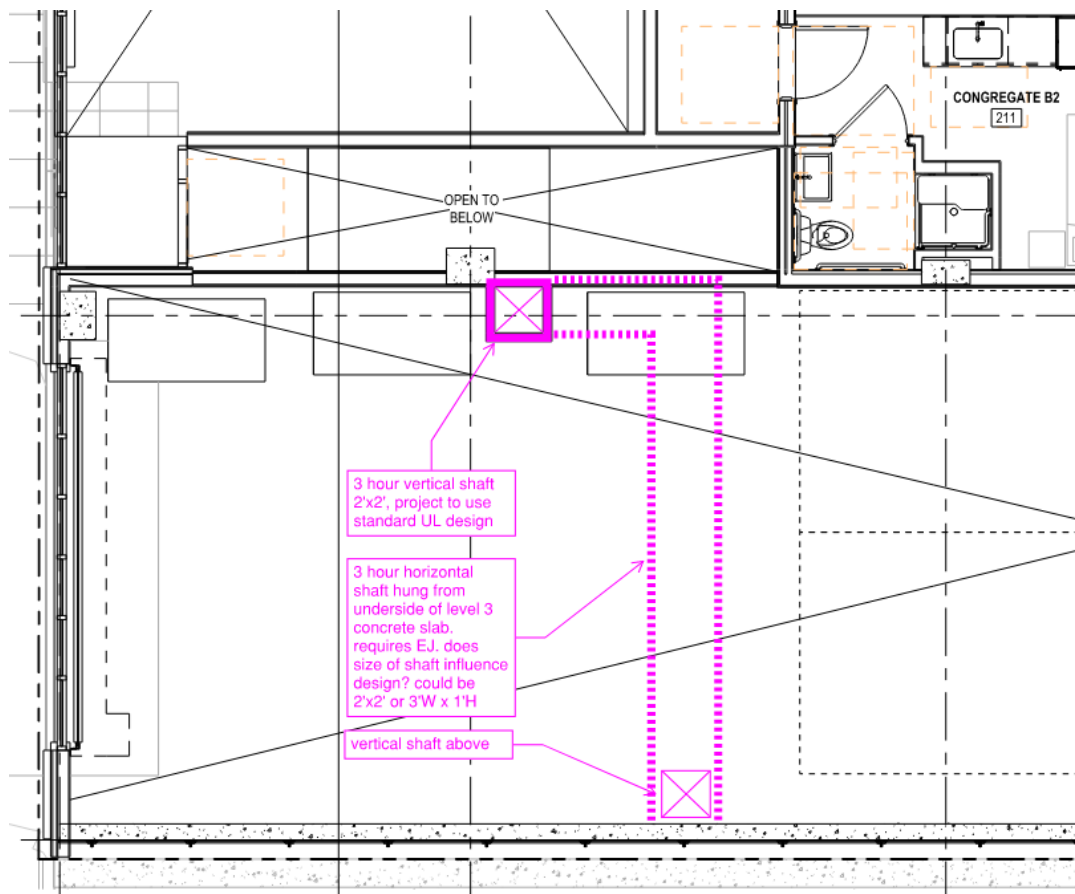


Figure 3: Transformer Vault Horizontal Exhaust Ductwork

Per Section 2 above, the SBC would allow this condition to be resolved using fire dampers. However, SCLS prohibits fire dampers in transformer vault exhaust ductwork. Consequently, the horizontal ductwork must achieve a level of performance comparable to that achieved if fire dampers were used (i.e., prevent fire spread via ductwork conveyance from Level 1 to Level 2 (and vice versa) as well as from Level 2 to Level 3 (and vice versa)).

Traditionally, duct shaft enclosures are constructed using a set of adjoining fire barrier walls, usually gypsum shaft walls tested to ASTM E119. However, ASTM E119 does not specifically evaluate horizontal runs of such

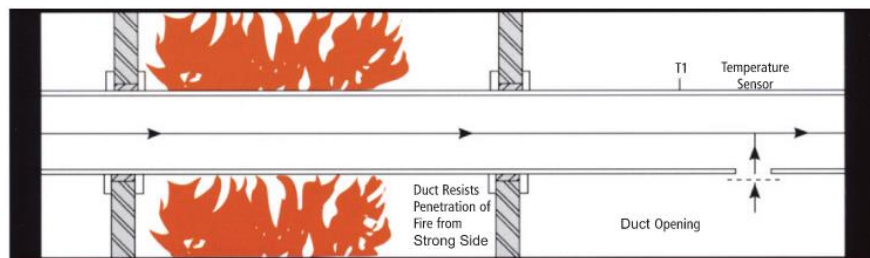
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assemblies. Notably, a gypsum board encasement assembly suspended in a horizontal orientation may not provide equivalent mechanical integrity performance as compared its counterpart qualified in the vertical (wall) orientation. Hence, the subject condition would either need to be protected with a fire resistance rated floor or an alternative means per SBC 104.5 (Alternative Materials, Methods of Construction and Design). Given the impracticability of protecting this ductwork with a fire resistance rated floor, a reasonable alternative means is proposed.

As referenced in the Underwriters Laboratories (UL) Fire Resistance Directory for “Fire Resistant Ducts,” ISO 6944:1985 (Fire Resistance Tests – Ventilation Ducts) specifies test methods and evaluation criteria for ventilation ductwork in terms of the ability to resist the spread of fire from one fire compartment to another without the aid of fire dampers. This test method is applicable to vertical and horizontal ductwork and accounts for joints, air supply/exhaust openings, suspension devices, and other ductwork assembly aspects. ASTM E2816 (Standard Test Methods for Fire Resistive Metallic HVAC Duct Systems), which was introduced more recently, is comparable to ISO 6944:1985. Specifically, the ISO 834 time-temperature fire curve used for testing per ISO 6944:1985 is very similar to the ASTM E119 fire curve used for testing per ASTM E2816.

As illustrated in Figure 4, ISO 6944:1985 (and similarly ASTM E2816) provides “Duct A” and “Duct B” qualifications for testing conducted with fire exposure from the exterior of the ductwork (Strong Side Test) and fire exposure entering the interior of the ductwork (Weak Side Test), respectively. According to the UL Directory, Duct A assemblies are intended for ductwork that passes through the fire environment without openings. Figure 5 shows a representative test assembly for Duct A qualification. Overall, ISO 6944:1985 (and similarly ASTM E2816) provides rigorous criteria for evaluating the fire resistance of ventilation ductwork assemblies as an alternative to prescribed shaft enclosures. Either standard is not directly equivalent to ASTM E119 testing. However, a qualification that achieves an equal hourly rating for each of the evaluation criteria (i.e., stability, integrity, and insulation) in either of these standards would meet the general intent of ASTM E119 in this context.

Fire Outside – Strong Side Test Specimen (Duct A)



Fire Inside – Weak Side Test Specimen (Duct B)

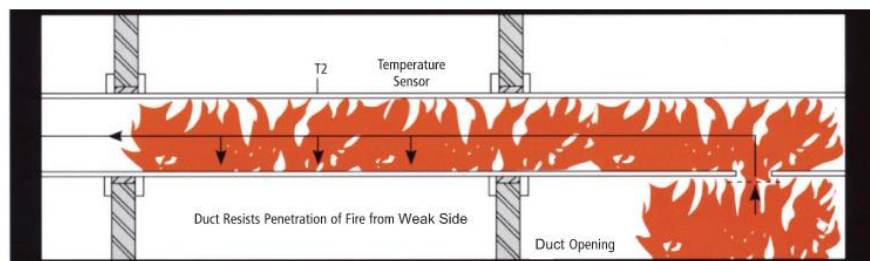


Figure 4: ISO 6944 Fire Test Conditions

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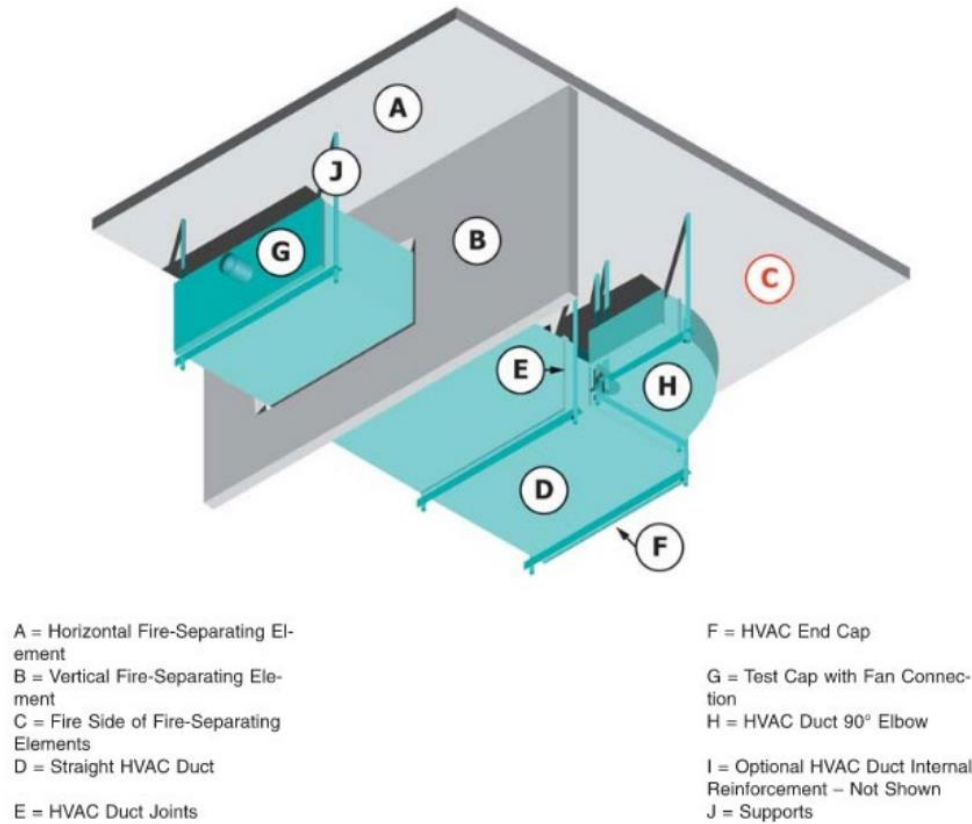


Figure 5: ISO 6944 Duct A Test Assembly

The **FyreWrap Elite 1.5** fire resistance duct assembly by Unifrax provides a 3-hr fire resistance rating for stability, insulation, and integrity per ISO 6944:1985 qualified using a Duct A test configuration. As shown in Figure 6, the assembly primarily consists of foil-encapsulated blankets (made of soluble amorphous wool fibers or calcium magnesium silica fibers) wrapped around the exterior of the ductwork. The manufacturer's specifications and installation instructions are attached for reference. Also, this assembly is similarly qualified for vertical ductwork applications.



Figure 6: FyreWrap Elite 1.5 Insulation

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The FyreWrap Elite 1.5 fire resistance duct assembly is not qualified using a Duct B test configuration per ISO 6944:1985. The Duct B test configuration primarily addresses the importance of testing nonsymmetrical fire resistive assemblies from both sides per SBC §703.2.1. However, the use of a Duct A qualification is reasonable for this case given the subject ductwork will not contain openings along its horizontal extension on Level 2. From an insulative perspective, the blanket wrap is expected (though not specifically qualified) to provide a similar thermal resistance from either of its sides. From a mechanical integrity perspective, the blanket wrap is expected (though not specifically qualified) to provide a similar level of reliability whether the fire exposure is from the exterior or interior given its light weight and wrapping around the ductwork. Notably, the mechanical integrity of the blanket wrap under fire conditions would be more predictably adequate as compared to a gypsum board encasement assembly suspended in a horizontal orientation which may suffer delamination due to failure of fasteners under tension forces. Also, the Duct B testing configuration primarily addresses the spread of fire through a fire barrier wall separating adjacent compartments. However, the subject horizontal ductwork does not pass through any fire barrier walls on Level 2. Lastly, we are not aware of any fire resistive duct assembly qualified per ISO 6944:1985 (or ASTM E2816) using a Duct B test configuration that achieves a 3-hr fire resistance rating for stability, insulation, and integrity. Hence, we judge that the FyreWrap Elite 1.5 fire resistance duct assembly is the most reasonable alternative available to the use of fire dampers for this specific application.

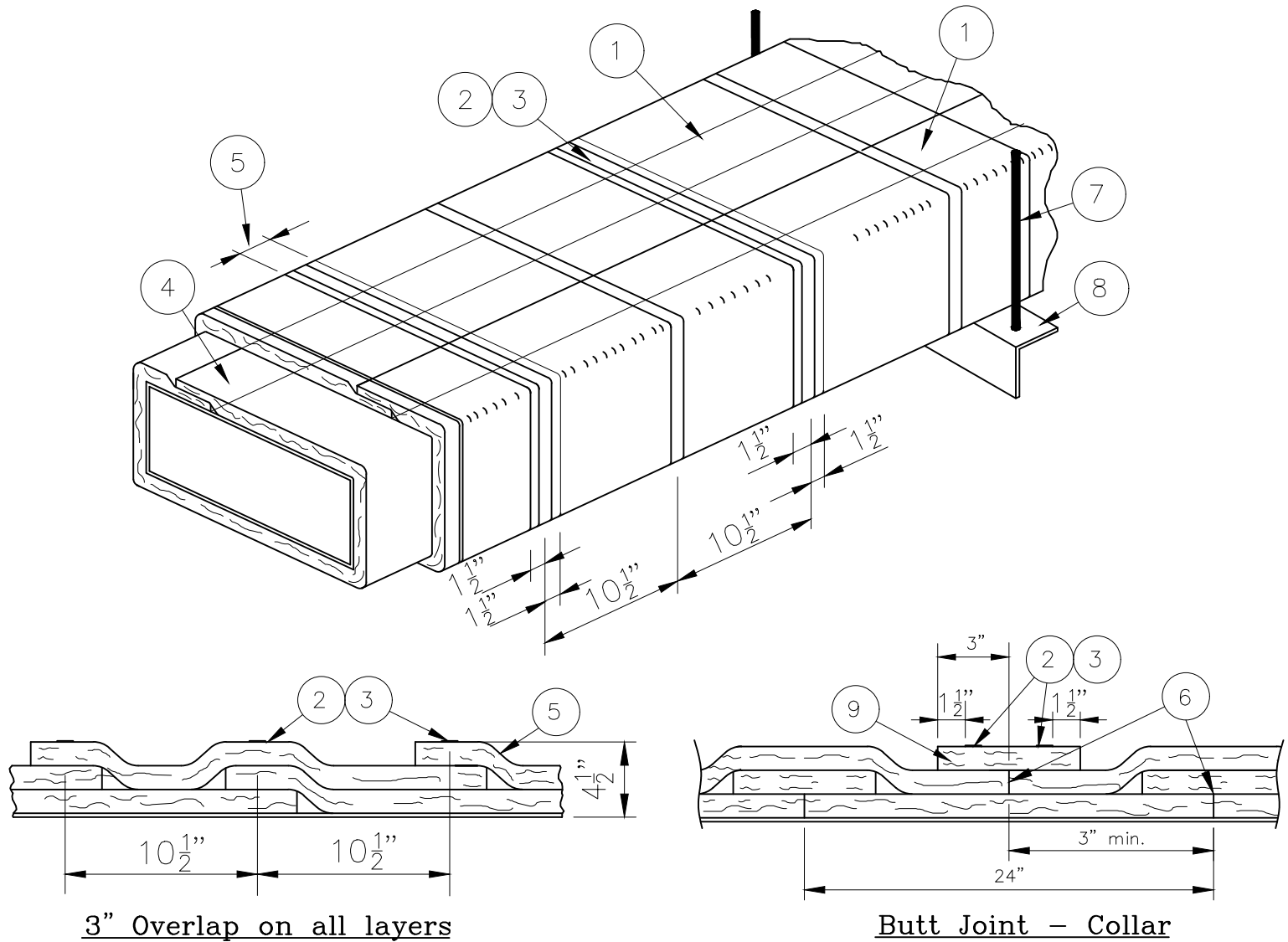
4 CONCLUSIONS

We have reviewed the transformer vault exhaust horizontal ductwork condition and relevant code requirements pertaining exclusively to its fire resistance. Given the prohibition of fire dampers by the SCLS, the impracticability of protecting this ductwork with a fire resistance rated floor, and the potential mechanical integrity issues posed by using a fire resistance rated vertical shaft enclosure in the horizontal orientation, a reasonable alternative means is proposed. The **FyreWrap Elite 1.5** fire resistive duct assembly by Unifrax (or any approved equivalent) provides a 3-hr fire resistance rating per ISO 6944:1985 for stability, insulation, and integrity. We judge that this fire resistance duct assembly is the most reasonable alternative available to the use of fire dampers for this specific application. This assembly must be installed in accordance with all manufacturer's specifications/instructions and is subject to review and approval by the City of Seattle.

Kevin LaMalva, P.E. (WA)
Code Unlimited LLC.



FyreWrap® Elite® 1.5 Duct Insulation
 ISO-6944 Duct A System (Horizontal)
 Stability=3 hrs, Integrity=3 hrs, Insulation=3 hrs
 Intertek Design UNI/DI 180-01



Legend:	
1	FyreWrap® Elite 1.5" Duct Insulation, Two Layers
2	Filament Tape (Temporary Hold)
3	Carbon or SS Banding Straps (Permanent Hold)
4	3" Minimum Longitudinal Overlap
5	3" Minimum Transverse Overlap
6	1" Compressed Butt Joint
7	Steel Hanger Rod
8	Steel Angle
9	6" wide FyreWrap® Elite 1.5" Collar

Wall Assembly – Use min. 3 hour rated wall assembly constructed of nom. 8 in. (203 mm) thick normal weight or min. 4.4 in. (112 mm) thick lightweight (100 to 150 pcf) reinforced concrete; or, use any Listed 3-hour gypsum wall assembly, min. 152 mm (6 in.) thick, with min. 22 GA (0.8 mm), 3 5/8 in. (92 mm) deep, steel studs covered with gypsum board on both sides. Create an opening in the wall assembly with an annular space between the penetrating item and the wall between 0.5 in. (12.7 mm) and 3 in. (76 mm) with a max. opening of 29 in. (736.5 mm) x 59 in. (1498.5 mm).

Steel Air Duct – Min. 0.029 in (22 gauge or 0.71 mm) thick galvanized-sheet steel* with max. cross sectional area of 1296 in.² (0.84 m²) and the max. width not exceeding 54 in. (1372 mm). Use min. reinforcement requirements for 500Pa (2 in. water GA) under pressure. Use max. spacing of 49 in. (1250mm) between joint/intermediate reinforcements. For transverse joint reinforcements other than bolted companion angles (rolled steel angle-flanged joints), use a min. of one (1) intermediate reinforcement spaced max. 3 in. from the joint. For circular ducts the max. cross sectional area is 1296 in.² (0.84 m²) and the max. diameter not exceeding 40.62 in. (1032 mm). Duct sections shall be assembled using bolted companion angles (rolled steel angle-flanged joints) for transverse joint/intermediate reinforcement angles.

*Note – increase steel gauge as needed to meet min. SMACNA or DW/144 requirements for pressure class and size

Firestop System – Install additional perimeter steel reinforcement (min. 1 in. (25.4 mm) x 1 in (25.4 mm.) x 1/8 in. (3 mm) RSA) required 3 in. (76 mm) from both sides of the wall assembly, and secured 12 in. (305 mm) on center (oc) with 0.25 in. (6.5 mm) hex head bolts, nuts, and washers, 4mm (0.157 in.) diameter steel pop rivets and/or #8, 0.5 in. long (M4 x .07, 12.7 mm long) self-drilling Phillips truss head screws spaced 152 mm (6 in.) oc. Use one of the following firestop system's methods:

- Intertek Design Number UNI/PF 180-01 as detailed in ASTM E814 Firestop System.
- Intertek Design Number UNI/BI 120-06 as detailed in ISO 6944 Firestop System.

Fire Resistive System – The fire resistive system shall consist of the following:

Insulation – Install two layers of fully encapsulated, nom. 6-pcf (96 kg/m³) density, nom. 1.5 in. (38 mm) thick, min. 24 in. (610 mm) wide blanket. Seal all cut edges with min. 3 in. (76 mm) wide aluminum foil tape. FyreWrap Elite 1.5 Duct Insulation

- **Overlap Joints:** Install the first layer with a min. 3 in. (76 mm) overlap and the second layer with a 3 in. (76 mm) overlap offset min. 10.5 in. (267 mm) from first layer joints
- **Butt Joints with collar:** Install all blankets compressed min. 1 in. (25.4 mm) butted together placing a 6 in. (152 mm) wide collar of blanket over the butt joint. Repeat for second layer offsetting joints min. 10.5 in. (267 mm)

Mechanical Attachments – Secure insulation to the duct using min. 12-gauge steel insulation pins welded on the bottom of the duct spaced 10.5 in. vertically x 12 in. wide x 6 in. from duct edge. Secure insulation on pins with 2 in. (50 mm) steel speed clips. If required, bend or cut the pins after installing speed clips for safety. In addition to the steel pins use min. 1/2 in. (12.7 mm) wide steel bands located 1 ½ in. (38 mm) from each blanket edge and max 10 ½ in. (267 mm) on center between.

Hanger System – Use steel angle as trapeze cross-member of size and composition specified in Table 1 with holes positioned a min. 1 in. (25.4 mm) to max. 3 in. (76 mm) distance from duct assembly hung on steel threaded rods secured with washers and nuts sized per Table 1

TABLE 1 – “Trapeze” Suspension System

Min. Threaded Rod Diameter	Max. Duct Perimeter	Min. Steel Angle* *Note – Or metric Equivalent	Max. Support Distance
1/2 in. (13 mm)	48 in. (1219 mm)	1.5 in. x 1.5 in. x 1/8 in. RSA	54 in. (1372 mm)
5/8 in. (16 mm)	96 in. (2438 mm)	2 in. x 2 in. x 1/4 in. RSA	54 in. (1372 mm)
3/4 in. (19 mm)	156 in. (3962 mm)	3 in. x 3 in. x 3/8 in. RSA	54 in. (1372 mm)