Providing a Smoke Refuge Area During a Fire

Doug Hartsock, P.E.

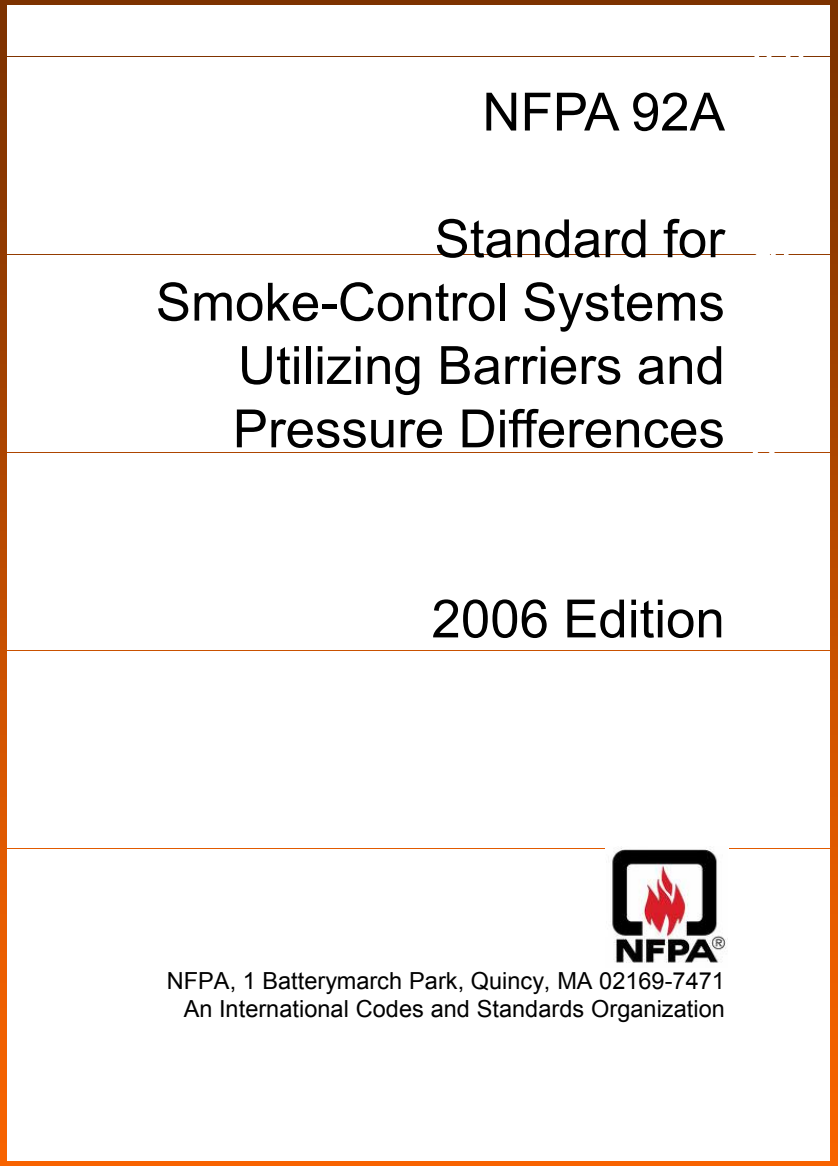
URS Washington Division

Why Be Concerned About Fire?

Where There's Fire, There's Smoke

- 75% of fire fatalities annually are due to toxic gas effects and oxygen deprivation [1]
- Hydrogen cyanide gas is formed by incomplete combustion of natural and synthetic fibers [1]

[1]U.S. Fire Administration, "Facts on Fire," 2003


NFPA 92A
Standard for
Smoke-Control Systems
Utilizing Barriers and
Pressure Differences
2006 Edition
NFPA®
NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

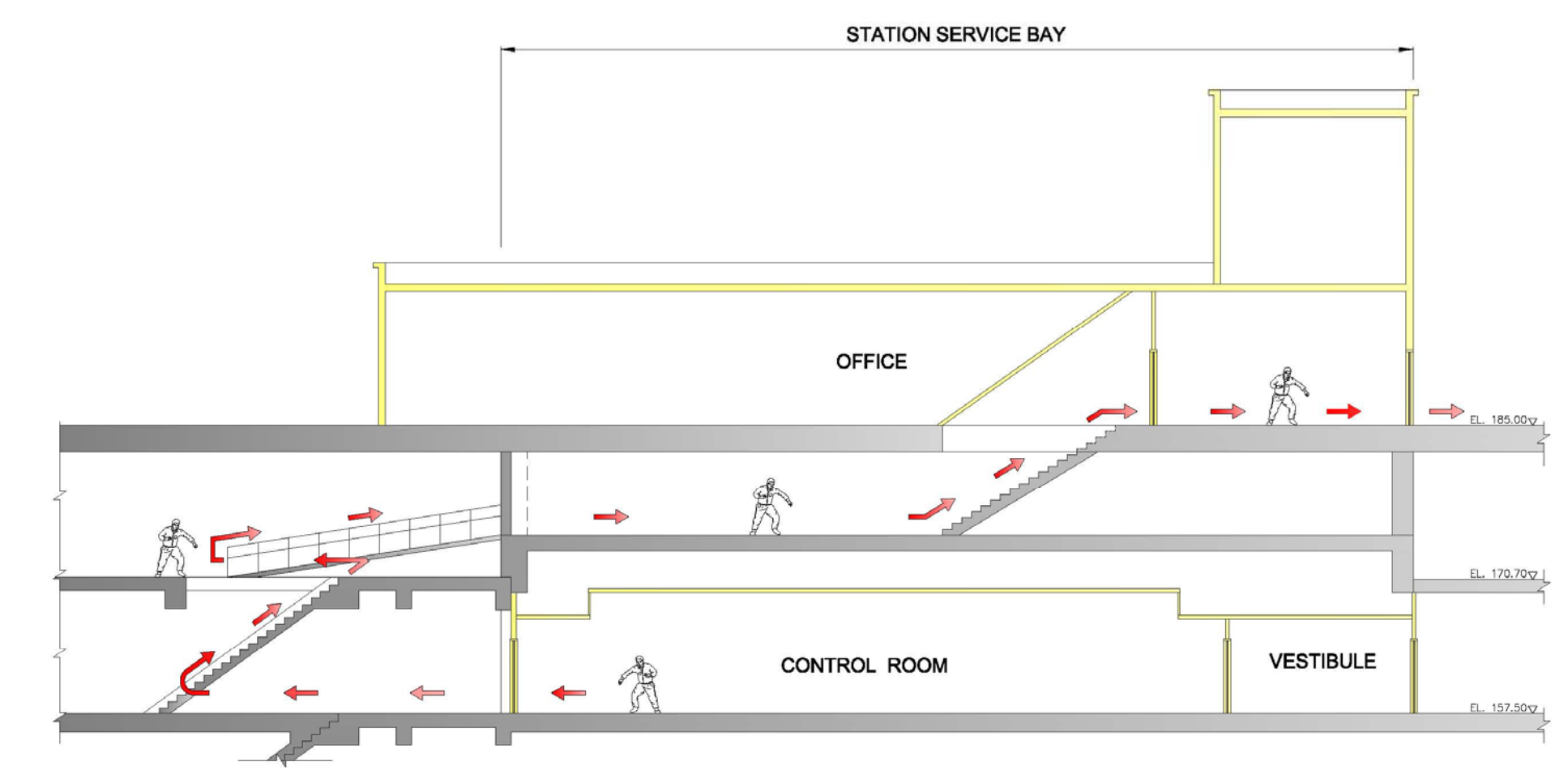
Definitions

- **Smoke Refuge Area**: An area of the building separated from other spaces by fire resistant rated smoke barriers in which a tenable environment is maintained for the period of time that such areas might be occupied at the time of fire.
- **Tenable Environment**: An environment in which smoke and heat are limited or otherwise restricted to maintain the impact on occupants to a level that is not life threatening.

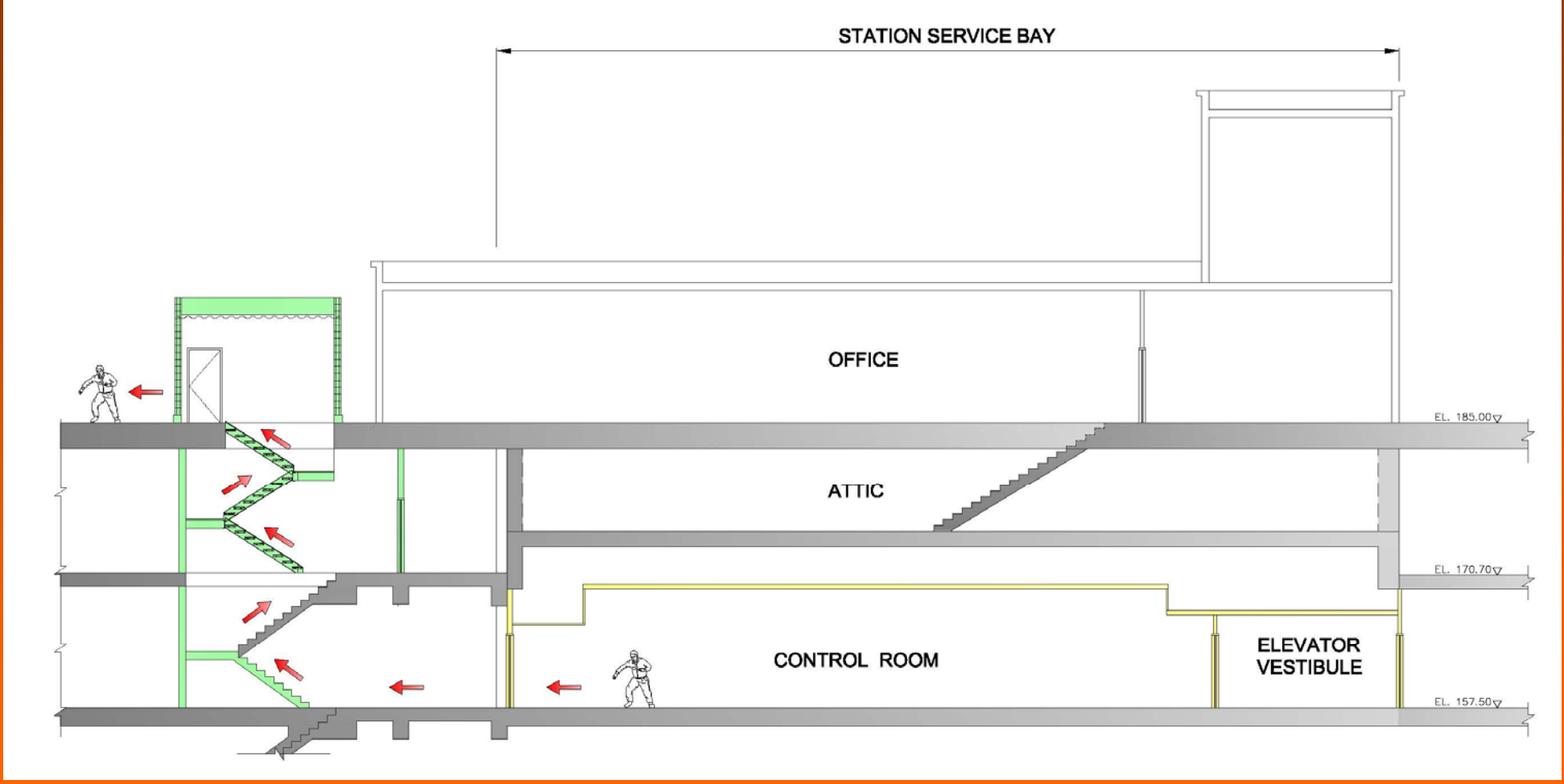
Step 1: Establish the Egress Route

- Easy to pressurize
- As direct as possible
- 2-hour fire separation

Existing Egress Route



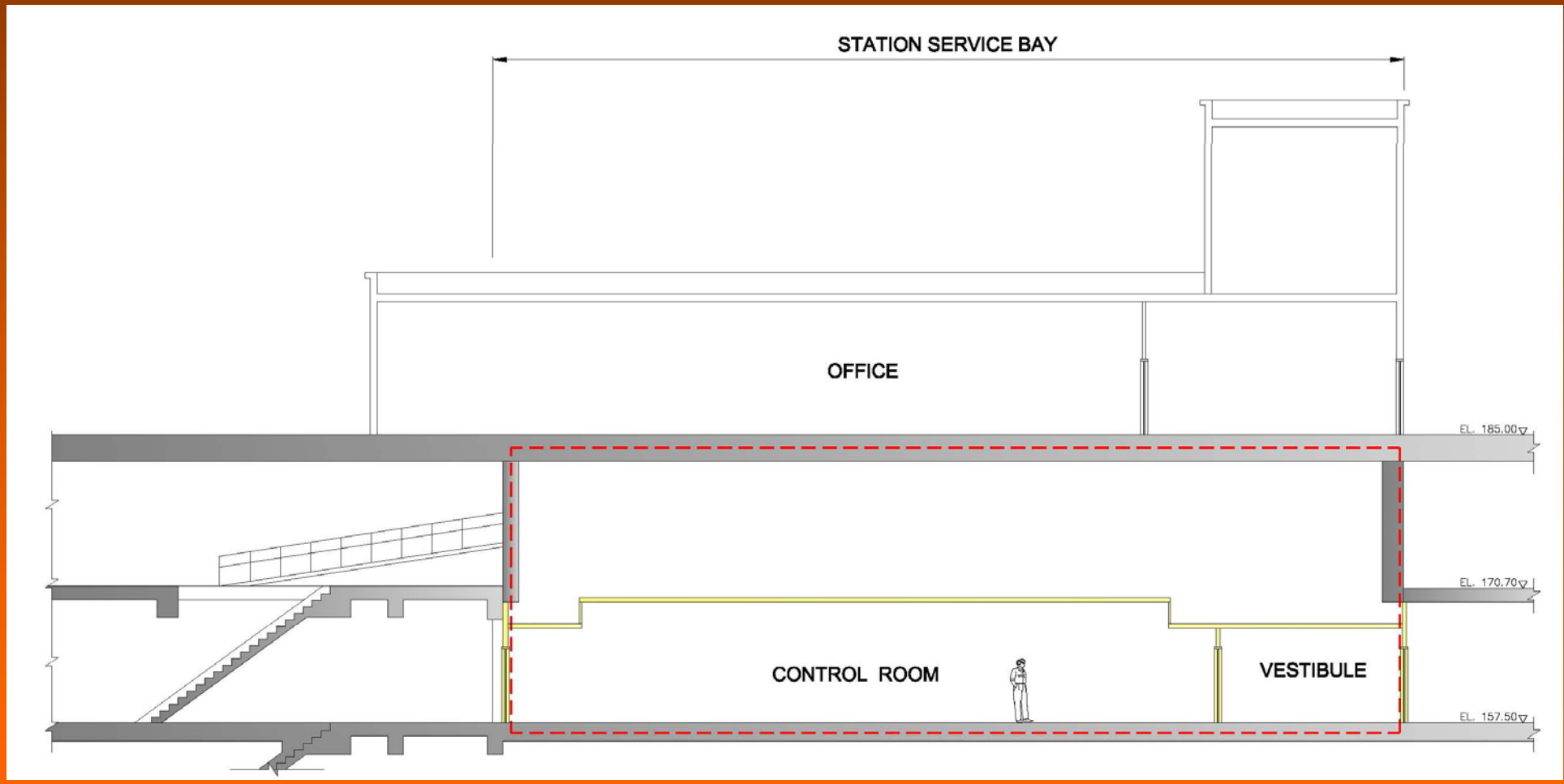
New Egress Route



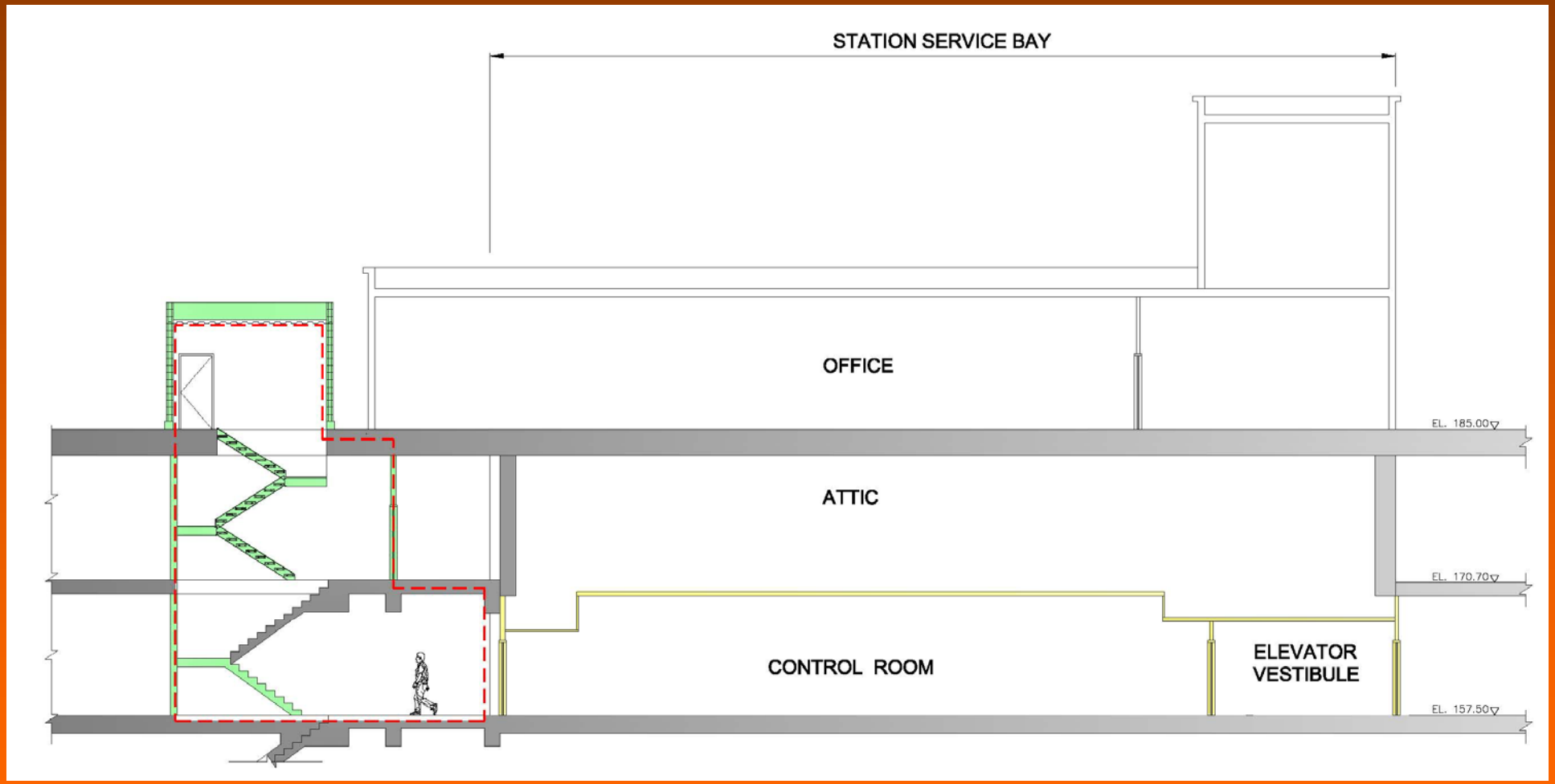
Step 2: Establish the Boundaries of the Smoke Refuge

- Easy to pressurize
- Reasonable volume
- 2-hour fire separation

Control Room Boundary



Egress Boundary



Step 3: Establish Egress Air Flow

- Air Leakage Method[1]
- Air Flow Through Open Doors[2]

[1] ASHRAE, Principles of Smoke Management

[2] IBC 2006

Air Leakage Method (ASHRAE)

$$Q = K*(N*A/\rho^{1/2})*(\Delta p_{max}^{3/2} - \Delta p_{min}^{3/2})/(\Delta p_{max} - \Delta p_{min})$$

where

Q = leakage rate, cfm
K = constant = 475
N = number of floors = 3
A = flow area between stairwell and building = 0.73 ft^2
ρ = density of air in stairwell = 0.075 lb/ft
Δp_{min} = min. pressure difference = 0.18 in wg (NFPA 92A, Table 5.2.1.1)
Δp_{max} = max. pressure difference = 0.37 in wg (IBC 2006, Section 909.7.2)

Q = <u>2,973 cfm</u>

Air Flow Through Open Doors (IBC)

$$Q = V_{max} \times A_{door}$$

where

Q = flow rate through one open door, cfm

V_{max} = max. air velocity through an open door = 200 ft/min (IBC 909.7.2)

A_{door} = area of door = 21 ft^2

Q = 4,200 cfm/door

Assume two doors open; Q = 8,400 cfm

Step 4: Establish Control Room Air Flow

- Air Leakage Method[1]
- Air Change Method[2]

[1] IBC 2006

[2] Industry Standard

Air Leakage Method (IBC)

Q = (Quantity or Area) * (Leakage Area or Factor) * (Leakage Velocity), cfm

Room Feature	Total Area or Quantity	Leakage Area or Factor	Leakage Velocity	Total Leakage
Walls Floor Ceiling	11,540 ft^2	0.001 ft^2/ft^2	200 ft/min	2,308 cfm
Closed Doors	1	0.33 ft^2	200 ft/min	66 cfm
Open Doors	1	21 ft^2	200 ft/min	4,200 cfm

Q = 6,574 cfm

Air Change Method

$$Q = V_{room} \times ACH / 60 \text{ min}$$

where

Q = Required flow rate to achieve room air change rate, cfm

V_{room} = Volume of room = 68,000 ft^3

ACH = Room air changes per hour = 10

$$Q = \underline{11{,}333 \text{ cfm}}$$

Step 5: Establish Design Pressures

0.18
Minimum
(NFPA 92A)

0.37
Maximum
(IBC 909.7.2)

Inches, water gauge

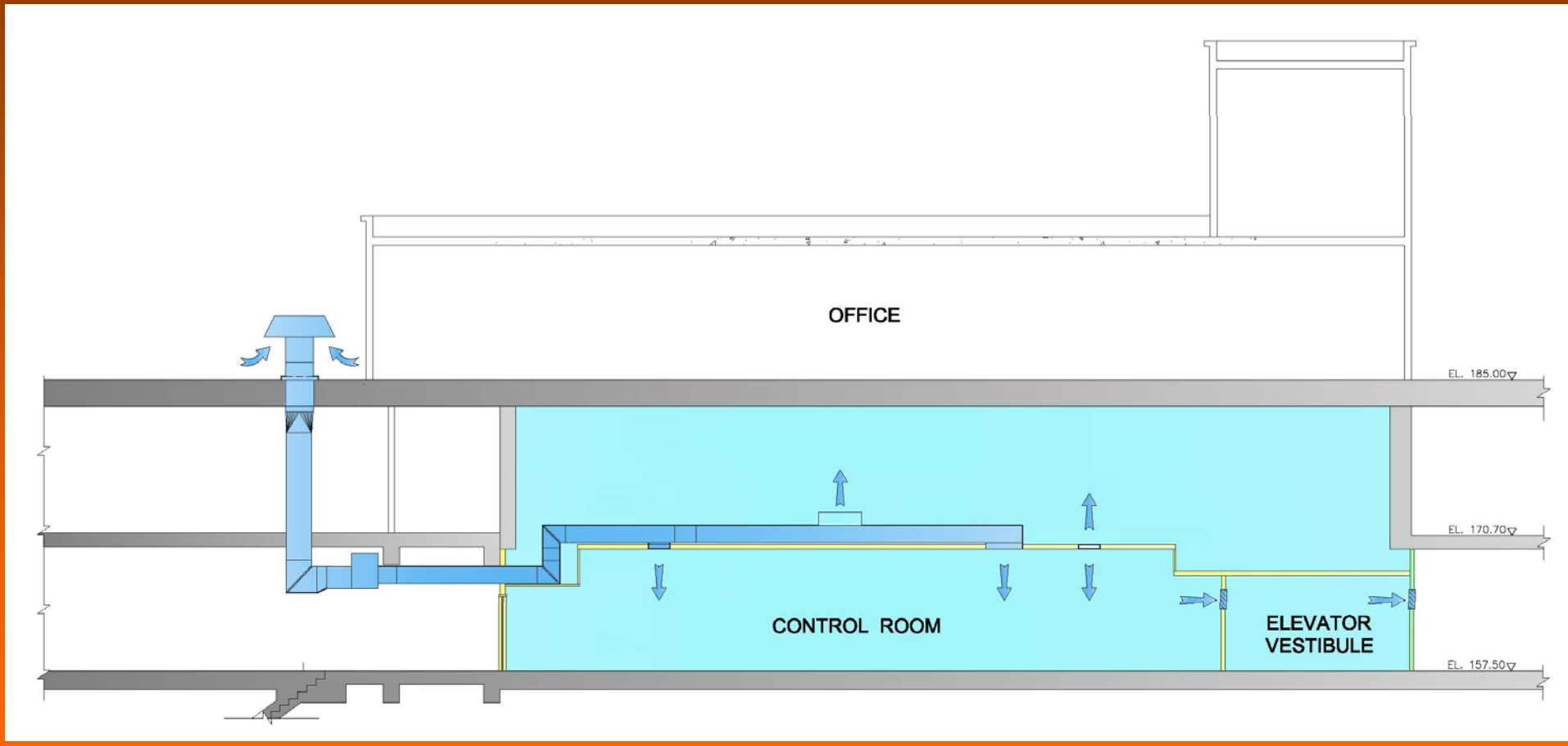
Step 6: Establish Type of Pressurization System

- Single vs. multiple point injection
- Dedicated vs. non-dedicated system
- Compensated vs. non-compensated system

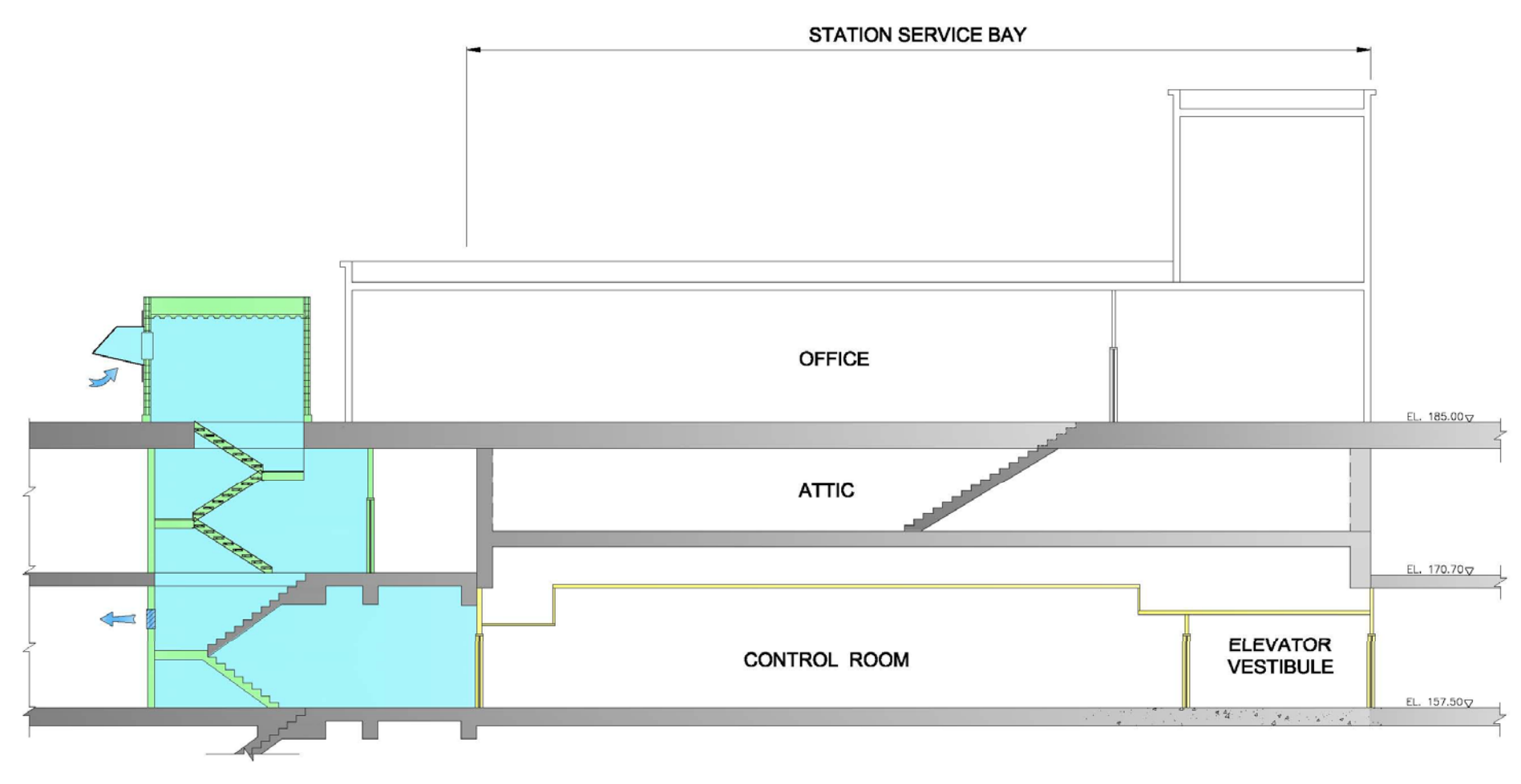
Step 7: Establish How to Supply Outside Air

- Intake location
- As direct as possible
- Ducted vs. non-ducted

Control Room Outside Air Supply



Egress Outside Air Supply



Step 8: Conduct Penetration Survey

- Removed Piping
- Cabling Blockouts
- HVAC Ducts

Step 9: Establish How to Power the System

- High reliability power for pressurization system required per the NEC (NFPA 70)
- Fan motors and smoke/fire dampers supplied by battery derived power

Step 10: Establish How to Control the System

- Automatic deployment initiated by fire detector
- Manual deployment initiated by control room operator
- Optional manual override of certain controls

Step 11: Reduce the Need to Ever Have to Use the System

- Control the fuel
- Compartmentalize
- Install automatic sprinklers

Questions?