

Section 909 Smoke Control Systems is replaced in its entirety as follows:

SECTION 909
SMOKE CONTROL SYSTEMS

909.1 Scope and purpose. This section applies to mechanical smoke control systems when they are required by other provisions of this code. The purpose of this section is to establish minimum requirements for the design, installation and acceptance testing of smoke control systems that are intended to provide a tenable environment for the evacuation or relocation of occupants. Smoke control systems regulated by this section serve a different purpose than the smoke- and heat-venting provisions found in Section 910. Mechanical smoke control systems shall not be considered exhaust systems under Chapter 5 of the *Denver Mechanical Code*.

Exceptions:

1. This provision does not preclude application of the performance-based design calculations.
2. Stairway and hoistway pressurization system designs in high rise buildings where the uppermost occupiable floor is more than 250 feet above the lowest level of fire department vehicle access, and all healthcare occupancy groups, shall be performed by an engineering analysis.

909.2 General design requirements. Buildings, structures or parts thereof required by this code to have a smoke control system or systems shall have such systems designed in accordance with the applicable requirements of Section 909 and the generally accepted and well-established principles of engineering relevant to the design. The construction documents shall include sufficient information and detail to adequately describe the elements of the design necessary for the proper implementation of the smoke control systems. These documents shall be accompanied by sufficient information and analysis to demonstrate compliance with these provisions.

909.3 Smoke control systems. As required by other sections of this code, smoke control system(s) shall be provided for high-rise buildings, atriums, covered malls, underground buildings, assembly occupancies with smoke-protected seating, stages and areas in accordance with Section 410 of the *Denver Commercial Building Code*, airport buildings in accordance with Appendix S of the *Denver Commercial Building Code*, and assembly occupancies with an aggregate of 1,000 or more occupants in high-rise buildings. This requirement shall be applicable to the Occupancy Groups as follows: A; B; E; M; R-1; R-2, and I-1 and I-3.

909.3.1 Unenclosed vertical openings. Where unenclosed vertical openings are provided as permitted by Section 712 of the *Denver Commercial Building Code*, buildings with a smoke control system shall have the floor openings between smoke zones protected by draft curtains and closely spaced sprinklers installed in accordance with NFPA 13 smoke detectors located at the floor side of the opening.

909.4 Construction document submittals. Construction documents for smoke control systems shall be submitted for permit application with the construction drawings for the project in accordance with Section 133. of the *International Building Code*, including the seal and signature of the design professional responsible for the coordination of the smoke control design package

909.5 Shop drawing submittals (deferred submittal). The deferred submittal shall be consistent with the *approved* construction document submittal and reviewed by the engineer of record prior to submission to the Denver Fire Department in accordance with Appendix O.

909.6 Smoke barrier construction. Smoke barriers shall comply with Section 709 of the *Denver Commercial Building Code*.

909.7 Power systems. The smoke control system shall be supplied with two sources of power. Primary power shall be from the normal building power system. Secondary power shall be from an *approved* emergency or standby source complying with NFPA 70 (NEC). The secondary power source and its transfer switches shall be in a separate room from the normal power transformers and switchgear and shall be enclosed in a room constructed of not less than 1-hour fire barriers ventilated directly to and from the exterior. Power distribution to the automatic transfer switch from the two sources shall be by independent routes. Transfer to secondary power shall be automatic and in compliance with NFPA 70 (NEC).

909.7.1 Power sources and power surges. Elements of the smoke control system relying on volatile memories or the like shall be supplied with uninterruptible power sources of sufficient duration to span a 15-minute primary power interruption. Elements of the smoke control system susceptible to power surges shall be suitably protected by conditioners, suppressors or other *approved* means.

909.7.2 Wiring. In addition to meeting requirements of NFPA 70 (NEC), all wiring, regardless of voltage, shall be fully enclosed within continuous raceways in mechanical rooms, electrical rooms, elevator equipment rooms and vertical risers. Wiring shall not be painted. The detection and control system wiring shall be clearly marked at all junctions, accesses and terminations.

909.8 Firefighter's smoke control panel. A firefighter's smoke control panel meeting the requirements of UL 864 and listed for smoke control under UL product category guide designation UUKL shall be provided and shall include manual control or override of automatic control for mechanical smoke control systems. Upon an alarm, the fire alarm system shall take direct control of all smoke control system components such as fans, dampers, activation of dedicated pressure control systems and status indication. The fire alarm system shall provide a signal to any temperature control or building automation systems for HVAC system enable/disable control and status. Where HVAC systems are utilized for smoke control the fire alarm system shall take direct control of those HVAC system components utilized for smoke control. Hard-wired interlock is acceptable. The fire alarm system shall provide automatic and manual override control and status. Terminal air distribution units may remain under their own normal building automation control. The panel shall be located in a fire command center complying with Section 509 in high rise buildings or buildings with smoke-protected assembly seating. In all other buildings, the firefighter's smoke control panel shall be installed in an *approved* location adjacent to the fire alarm control panel. The firefighter's smoke control panel shall comply with Appendix O.

909.8.1 Smoke control systems. The firefighter's control panel shall be provided for manual or override of automatic control of mechanical smoke control systems. This panel shall graphically depict the individual smoke control system fan and damper controls, their relative location within the building, stairwells, hoistways, building pressurization and exhaust airflow, refuge area pressurization and all other smoke control zones that apply. This panel shall clearly show the building arrangement and smoke control zones served by the systems. The graphic panel shall be oriented to the building and include a North reference compass point. A combination of vertical (section) and/or horizontal (plan) graphic arrangement may be necessary. The operating control and status indicators on the FSCP shall have a maximum height from the floor of 6 feet, 6 inches and a minimum of 2 feet, 0 inches, and may require more than one section to accommodate height limitations. Layout, labeling and location of the fire fighters control panel shall be reviewed and *approved* by the Fire Department prior to fabrication.

909.8.2. Verification. Control systems for mechanical smoke control systems shall include provisions for verification. Verification shall include positive confirmation of actuation, testing, manual override, and the presence of power downstream of all disconnects. A preprogrammed weekly test sequence shall report abnormal conditions audibly, visually, and by printed report. The preprogrammed weekly test shall operate all devices, equipment, and components used for smoke control. Monitoring for fault status for pressurization and smoke removal fans shall include the following:

1. Loss of power to the fan or VFD/motor starter.

2. Open electrical disconnect at pressurization and smoke removal fan, whether the *fire alarm system* is in alarm or not.
3. Fan fails to move air by program or switch on FSCP.
4. VFD/motor start failure.

909.9 System response time. Smoke control system activation shall be initiated immediately after receipt of an appropriate automatic or manual activation command. Smoke control systems shall activate individual components (such as dampers and fans) in the sequence necessary to prevent physical damage to the fans, dampers, ducts and other equipment. The total response time for individual smoke control systems to achieve their desired operating mode shall not exceed the following time periods:

Fan operating at desired state – 75 seconds

Damper position travel – 60 seconds

909.10 Testing of smoke control systems. Before the Fire Department accepts the smoke control systems and prior to initial occupancy, the smoke control systems shall be tested in their presence to confirm that the systems operate in compliance with this Section. In addition, all smoke control systems shall be tested annually and shall be maintained to perform its intended purpose under the code version with which it was built.

909.10.1 Acceptance testing. The requirements of acceptance testing defined hereinafter shall be the minimum requirements. All acceptance tests shall be witnessed by a Fire Department representative.

1. Furnish a testing procedure, reviewed by the smoke control system design professional engineer, to the Fire Department 72 hours in advance of the acceptance tests being performed. The procedure shall define how compliance with the code will be demonstrated. The procedure shall also identify what instrumentation including artificial smoke generating equipment, will be used during the testing.
2. Smoke control systems testing shall include the following subsystems to the extent that they affect the operation of the smoke-control system:
 - a. Fire alarm system (See NFPA 72)
 - b. Building automation and temperature control system
 - c. HVAC equipment
 - d. Electrical equipment
 - e. Power sources including emergency or standby power
 - f. Automatic suppression systems
 - g. Automatic operating doors and closers
 - h. Dedicated and non-dedicated smoke-control systems
 - i. Emergency elevator operation
3. Prior to witnessed acceptance testing of the smoke control systems, the design professional engineer shall confirm and advise the Fire Department in writing that the entire smoke control system has been installed, air balanced and tested in accordance with its design, plans, specifications and this code.
4. The following shall be notified so that they may witness the acceptance testing:
 - a. Design professional Engineer-of-Record

- b. Building contractor
 - c. Owner's representative
 - d. Denver Fire Department
 - e. Denver Building Department
5. Unless otherwise *approved* by the Fire Department, sufficient smoke shall be generated to produce at least the volume of the smoke zone being tested within approximately five minutes. All smoke-generating devices shall be supplied by the owner or his representative and *approved* by the *fire code official*.
 6. Acceptance testing shall demonstrate that the correct outputs are produced for a given input for each control sequence specified. The following control sequences shall demonstrate complete smoke-control sequence.
 - a. Normal mode
 - b. Automatic smoke-control mode for first alarm
 - c. Manual override of normal and automatic smoke-control modes
 - d. Return to normal
 7. After the smoke control system is activated, smoke shall not continue to migrate to other smoke zones of the building.
 8. Smoke control systems shall demonstrate the ability to inhibit smoke from migrating across smoke zone boundaries to other areas and containment within the active smoke zone. Smoke control systems shall also demonstrate the continual reduction of smoke concentration from within the active smoke zone by demonstrating exhaust rates of at least 40 percent during incident (sealed floor except one stairway door in open position) and at least 80 percent of the design rate in post fire conditions for salvage and overhaul operations. These system capabilities shall be measured and verified with anemometers or similar measurement tools during acceptance testing at the exhaust intake locations.

909.10.1.1 Testing requirements. Tests shall be performed in full automatic mode with the building operating under both normal power and emergency power. Test equipment shall include manometer (calibrated within last 12 months), spring scale and other equipment as necessary to adequately measure and record system performance. Communications shall be provided between the test locations and the fire command center.

1. For a building that is not a high rise, multiple tests on more than one floor or smoke zone shall be required to demonstrate proper operation.
2. For high rise buildings, tests shall be conducted at a minimum of three locations.
 - a. A floor in the lower third, a floor in the middle third and a floor in the upper third of the building.
 - b. With a floor in alarm, an additional automatic alarm shall be initiated on a floor immediately above or below the initial floor in alarm. All floors in alarm shall go to exhaust mode
 - c. With a floor in alarm, a manual pull station on another floor shall be activated. Smoke control operation shall not be affected.

- d. For atriums, more than one test may be required depending upon the atrium configuration, its relationship to adjacent spaces and if the atrium is located in a high-rise.
 - e. Activation of one smoke detector in each smoke control zone on each floor being tested.
 - f. Activation of at least one sprinkler flow switch.
 - g. Activation of at least one manual pull station.
3. For high rise buildings, pressure differentials shall be measured across stairway doors, across elevator/lobby/refuge corridor area doors and adjoining spaces, between atriums and areas immediately adjacent to atriums where atriums are part of a high-rise building. Door opening force into stair enclosures or refuge areas shall not exceed 30 pounds under any conditions.
 4. Upon activation of the fire alarm system for each test, confirm that the smoke control system fans and dampers have assumed the correct operating condition for the type of alarm initiating device and the location of the initiating device. This shall be confirmed also at the smoke control panel in the fire command center.
 5. Manually override the operation of a sampling of fans and dampers during each test, taking care not to damage system components. Return all override switches to their "auto" position after each test.
 6. Make-up air provisions may include:
 - a. Stairway doors on the fire floor may be opened and used as a source of make-up air during smoke exhaust system testing.
 - b. Variable frequency drives for smoke exhaust system fans may be controlled in response to duct static pressure settings.
 - c. Dedicated make-up air systems.
 - d. Other methods as documented in the design submittals and *approved by the fire code official*.

909.10.3 Annual tests. Annual tests shall be performed in accordance with Sections 909.10.3.1 and 909.10.3.2, on all smoke control systems including those installed prior to adoption of this code. It is recognized that smoke control systems installed prior to adoption of this code could have parameters that are different than those described in this section. In those cases, smoke control tests shall be adjusted accordingly to meet the intent of this section.

Denver Fire Department representatives shall have the authority to witness any regularly scheduled annual testing of smoke control systems.

909.10.3.1 Equipment operating tests. The following equipment operating tests shall be conducted annually on the smoke control system components:

1. Verify the proper control and status indication of smoke control dampers (i.e., "OPEN/CLOSED") and fans (i.e., "ON/OFF") by visual observation at each damper and fan location and at the smoke control status/control panel in the fire command center.
2. Verify that all smoke control dampers and fans assume the correct operating position under both normal and fire modes and when the manual override switches at the smoke control status/control panel are placed in the "auto" position.
3. Verify that the manual override switches function properly for smoke control dampers and fans.

4. Items 1, 2 and 3 above may be performed by qualified service technicians who are familiar with the proper operation of the smoke control systems and equipment. The engineer responsible for conducting the smoke control system performance tests shall develop the test procedures to be used and review the results obtained by the service technicians, including an actual sampling to confirm the accuracy of the test. A statement summarizing this review shall be included in the performance test report described in Section 909.10.4 that is required to be submitted by the engineer to the Fire Department.
5. A copy of the written test procedure and an accurate log of tests shall be maintained in the fire command center and at either the building management office or the maintenance office. A copy of the previous test report shall be submitted to the engineer responsible for the smoke control performance tests for the engineer's review and approval prior to the smoke control test. Any defects, system modifications and repairs shall be recorded in the log. Necessary corrections shall be made prior to the smoke control performance test.

909.10.3.2 Performance tests. Within 30 days after completion of annual equipment operating tests defined above, conduct the following smoke control system performance tests. The annual smoke control systems tests shall be conducted under the direct supervision of a professional engineer qualified in the testing of such smoke control systems.

1. Activate the smoke control systems automatically through the fire alarm system for tests used to confirm proper sequencing of the system components. Measure actual relative pressure differentials between areas in alarm and adjacent areas and actual door opening forces.
2. For high rise buildings, conduct smoke control tests, observations and measurements of all aspects of the smoke control system at a minimum of 15 percent of the smoke-controlled floors with a minimum of 3 floors, evenly spaced throughout the vertical sections of the building. Smoke control tests in subsequent years shall be conducted on previously untested floors, as may be practical so that all floors ultimately are tested.
3. For all other buildings, conduct smoke control tests, observations and measurements of all aspects of the smoke control system at a minimum number of locations to demonstrate proper performance as *approved* by the Fire Department. Each test shall attempt to involve as many different fan systems as practical. Smoke control tests in subsequent years shall be conducted on previously untested locations, as may be practical so that all locations ultimately are tested over a three-year period.
4. Tests of the smoke control system shall be conducted by activation of at least one smoke detector in each smoke control zone on each floor being tested. One test of at least one of the smoke control zones shall include activation of one sprinkler flow switch. In addition, the smoke control tests shall include activation of at least one manual fire alarm box. For high rise buildings, pressure differentials shall be measured across stairway doors, between floors in alarm and floors immediately above and below floors in alarm, across elevator/lobby/refuge corridor area doors and adjoining spaces in Group R-1, R-2 or I-1 occupancies, and between atriums and areas immediately adjacent to atriums where atriums are part of high rise buildings.
5. Upon activation of the fire alarm system for each test, confirm that the smoke control system fans and dampers have assumed the correct operating condition for the type of alarm initiating device and the location of the initiating device. This shall be confirmed also at the smoke control panel in the fire command center.
6. Manually override the operation of a sampling of fans and dampers during each test, taking care not to damage system components. Return all override switches to their "auto" position after each test.

909.10.4 Test reports. Within 30 days of completing any smoke control test, submit a test report to the Fire Department. A copy of the previous and current test reports shall be kept in the fire command center. The test report shall be written by the professional engineer who conducted the testing. The test report shall bear the seal and signature of the professional engineer. Any defects, modifications and repairs shall be recorded in a log kept in the fire command center and at either the building management office or the maintenance office. The test report shall include, but is not limited to the following:

1. Provide a brief description of the smoke control system installed in the building being tested and state the year the building received its construction permit for the smoke control system. Provide a sequence of operation for the smoke control system.
2. Describe in general terms the equipment operating test procedures. Include a list of the equipment operating and smoke control test deficiencies along with a schedule of the proposed corrective action.
3. Describe detailed procedures followed during the equipment operating tests. Describe detailed procedures followed during the smoke control tests.
4. List test equipment used and outside air temperature and wind conditions at the time the smoke control tests were conducted.
5. State sequences and timing of the system operations during all smoke control tests (e.g., smoke detector activation time, fan start times, time for dampers to assume the correct position, etc.).
6. List the location of test measurements and the measured values for pressure differentials and door-opening forces for each test location.
7. Record any operational defects and performance deficiencies with respect to the requirements of this section, and state recommendations for corrective action. Include a schedule to re-test each deficiency. Submit results of any subsequent tests performed after completion of the corrective action.
8. Engineer's assessment indicating that the smoke control system, as installed and tested, conforms to the requirements of Section 909.

909.10.5 Functional test requirements for smoke control system equipment. Testing of smoke control equipment shall be performed in accordance with this section to determine that the installed systems continue to operate in accordance with the *approved* design. Operational testing of the smoke control system shall include all equipment such as fans, dampers, controls, and doors. Testing shall include positive confirmation of actuation. System equipment and components shall be exercised for sufficient time to provide positive confirmation of proper operation or fault condition.

909.10.5.1 Written record. Results of the tests shall be documented in the building's life safety systems testing and maintenance log and printed reports generated during the automated testing. Testing documents must be maintained on-site in the fire command center or in a location *approved* by the *fire code official*.

909.10.5.2 Dedicated systems.

909.10.5.2.1 Dedicated systems shall be tested semiannually.

909.10.5.2.2 The smoke-control system shall be operationally tested as prescribed in Section 909.10.5. Dedicated smoke control systems shall be operated for each control sequence.

909.10.5.2.3 Operation of the correct outputs for each given input shall be verified and recorded.

909.10.5.3 Non-dedicated systems.

909.10.5.3.1 Non-dedicated systems shall be tested annually.

909.10.5.3.2 The smoke-control system shall be operationally tested as prescribed in Section 909.10.5. Nondedicated smoke control systems shall be operated on a representative sample of each type of equipment sufficient to verify proper operation for each control sequence. For high rise buildings, tests shall be conducted at a minimum of 15 percent of the smoke-controlled floors with a minimum of 3 floors, evenly spaced throughout the vertical sections of the building. Tests in subsequent years shall be conducted on previously untested floors, as may be practical so that all floors ultimately are tested. For all other buildings, tests shall be conducted at a minimum number of locations to demonstrate proper performance as *approved* by the Fire Department. Tests in subsequent years shall be conducted on previously untested locations, as may be practical, so that all locations ultimately are tested over a three-year period. Operation of the correct outputs for each given input shall be verified and recorded.

909.10.6 System repairs and maintenance. All deficiencies noted in the annual report shall be corrected within 30 days and, if required by the engineer, the smoke control system shall be re-tested. All smoke control systems will be maintained to perform its intended purpose under the code version with which it was built. With approval of the Denver Building Department and the Denver Fire Department smoke control systems may be remodeled to comply with current code.

909.11 System acceptance. Buildings, or portions thereof, required by this code to comply with this section shall not be issued a certificate of occupancy until the provisions of this section have been fully complied with and the fire department has received satisfactory instruction on the operation, both automatic and manual, of the system.

Exception: In buildings of phased construction, a temporary certificate of occupancy shall be allowed provided that those portions of the building to be occupied meet the requirements of this section and that the remainder does not pose a significant hazard to the safety of the proposed occupants or adjacent buildings.

909.12 Smokeproof enclosures. For buildings required to comply with Sections 403 or 405 of the *Denver Commercial Building Code*, a smokeproof enclosure shall consist of an enclosed, pressurized stairway or ramp conforming to Section 909.15.1 and 1023.11 of the *Denver Commercial Building Code* and this Section.

909.12.1 Ventilation systems. Smokeproof enclosure ventilation systems shall be independent of other building ventilation systems. The equipment and ductwork shall comply with one of the following:

1. Equipment and ductwork shall be located exterior to the building and directly connected to the smoke proof enclosure or connected to the smoke proof enclosure by ductwork enclosed by two-hour fire barriers.
2. Equipment and ductwork shall be located within the smoke proof enclosure with intake or exhaust directly from and to the outside or through ductwork enclosed by two-hour fire barriers.
3. Equipment and ductwork shall be located within the building if separated from the remainder of the building, including other mechanical equipment, by two-hour fire barriers.

909.13 Design criteria. All smoke control systems shall comply with the requirements of Sections 909.13.1 through 909.13.10. All equipment shall have local operating controls disabled when in smoke control mode. Equipment internal faults shall not cause shutdown of the smoke control equipment unless *approved* in writing by the *fire code official*. Equipment including, but not limited to, fans, current transducers (CT's), differential pressure transmitters, sail switches, ducts, duct protecting materials, automatic dampers, balance dampers, actuators, linkage, limit switches and motor controllers shall be suitable for their intended use. Equipment

functions and operating characteristics shall not detract from the smoke control systems' stable and reliable performance. Upon smoke control activation, VFD's shall operate in override or life safety mode where faceplate commands and non-smoke control commands are ignored. In addition, non-critical faults (safeties) shall be ignored to ensure the continued and stable performance of the smoke control fan.

909.13.1 Minimum pressure differential. The minimum pressure differential across stairway and hoistway smokeproof enclosures on fire floors, shall be +0.05-inch water gauge (0.0124 kPa) with pressurization fans turned on and fire floor in exhaust mode. Where elevator lobbies are provided, the pressure differential shall be measured between the pressurized lobby and fire floor with pressurization fans turned on and fire floor in exhaust mode. Minimum operating performance of pressurization fans shall not be less than 12 Hz for VFD's or the motor control's minimum manufacturer published rating.

909.13.2 Maximum door opening force. The maximum pressure difference across a smoke barrier or smoke zone and an opening into a stair enclosure shall be determined by the required door-opening forces. Door opening force shall not exceed 30 pounds applied horizontally at the latch side of the door on the door-opening device under any operating condition. Maximum door opening force shall not exceed 15 pounds at stairway entry doors during a non-fire mode of operation. Opening force at elevator lobby doors shall comply with *Denver Commercial Building Code* and be measured on the fire floor with the hoistway pressurization fans turned on and fire floor in exhaust mode.

909.13.3 Resistance to smoke recirculation. Locate outdoor air intakes for pressurization systems remote from points of discharge for smoke exhaust systems in order to minimize the potential for recirculation of smoke to the outdoor air intakes. The minimum separation distance shall be 10 feet in any direction.

909.13.4 Determination of the volume of a space. The volume of a given building element shall be defined as the space that is contained between the finished floor slab(s) of one level and the underside of the floor or roof element above, and the walls or partitions that form the boundaries of the space.

909.13.5 Fire/Smoke damper temperature rating. The temperature rating for the thermal element in fire and combination fire/smoke dampers, where they are applied in smoke exhaust systems, shall be no less than 250 degree ° F. For systems where the probable temperature rise to which the damper will be exposed may be higher than 250 degree ° F the temperature shall be computed by an *approved* method.

909.13.6 Fans. In addition to other requirements, belt-driven fans shall have 1.5 times the number of belts required for the design duty, with the minimum number of belts being two. Fans shall be selected for stable performance based on normal temperature and, where applicable, elevated temperature. Calculations and manufacturer's fan curves shall be part of the documentation procedures. Fans shall be supported in accordance with Chapter 16 of the *Denver Commercial Building Code*. Motors driving fans shall not be operated beyond their nameplate horsepower (kilowatts), as determined from measurement of actual current draw, and shall have a minimum service factor of 1.15.

909.13.7 Motor controllers and variable frequency drives (VFDs). Motor controllers and variable frequency drives (VFDs) provided to operate fans of smoke exhaust and pressurization systems shall be installed in secure, conditioned and protected locations. These devices shall be located in a room or space separated from the remainder of the building by a 1-hour fire-resistance rated fire barrier. Power wiring and control wiring between switchgear and /or panels, motor controllers, VFDs and smoke control system motors and control dampers shall be in non-flexible metallic raceway up to the component connection. VFDs for smoke control system fans shall not be equipped with a manual or automatic bypass switch except where fans are designed and set for 60 hertz, nominal.

Exception: The final connection to the component shall be made with the appropriate flexible conduit in accordance with NFPA 70 (NEC).

909.13.8 Ducts. Duct materials and joints shall be capable of withstanding the probable temperatures and pressures to which they are exposed during smoke control operating conditions. Ducts shall be constructed and supported in accordance with the *Denver Mechanical Code*. Ducts shall be leak tested to 1.5 times the maximum design pressure in accordance with nationally accepted practices. Measured leakage shall not exceed 5 percent of design flow. Results of such testing shall be a part of the documentation procedure. Ducts shall be supported directly from fire-resistance-rated structural elements of the building by substantial, noncombustible supports.

Exception: Flexible connections (for the purpose of vibration isolation) complying with the *Denver Mechanical Code*, that are constructed of *approved* fire-resistance-rated materials.

909.13.9 Equipment, inlets and outlets. Equipment shall be located so as to not expose uninvolved portions of the building to an additional fire hazard. Outside air inlets shall be located so as to minimize the potential for introducing smoke or flame into the building. Exhaust outlets shall be so located as to minimize reintroduction of smoke into the building and to limit exposure of the building or adjacent buildings to an additional fire hazard.

909.13.9.1 Vegetated roofs. Stairway and hoistway pressurization system intakes shall be separated by a minimum of 15 feet from vegetated areas.

909.13.10 Automatic dampers. Automatic dampers, regardless of the purpose for which they are installed within the smoke control system, shall be listed and conform to the requirements of *approved*, recognized standards.

909.14. Smoke control systems for atriums (where required by Section 404 of the Denver Commercial Building Code).

909.14.1 Requirements. The operation of the smoke control systems shall be controlled through the fire alarm system and shall comply with the requirements of this Section. The atrium volume shall include all spaces not separated from the atrium by the provisions of Section 404.6 of the *Denver Commercial Building Code*.

909.14.2 Operation. Where required by Section 907.2.14, activation of initiating devices shall cause the following sequence to occur:

1. Open atrium exhaust dampers.
2. Open supply dampers to atrium.
3. Close exhaust dampers on all adjacent smoke zones.
4. Start exhaust fans.

909.14.3 Atrium exhaust. The system shall exhaust a minimum of six air changes per hour. A minimum of 50 percent of the volume of supply air shall be sized and introduced via gravity supply or fan powered inlets within 10 feet of the lowest level of the atrium. The total volume of supply air shall be 75 percent of the required volume of exhaust air. A maximum velocity of 200 feet per minute shall be maintained across the net free area of the supply air openings.

909.14.4 Exhaust openings. Atrium exhaust openings shall be located in the ceiling or in a smoke trap area immediately adjacent to the ceiling at the top of the atrium. The lowest level of the exhaust openings shall be above the top of the highest elevation of door openings into the atrium.

909.15 Smoke control systems for high-rise buildings.

909.15.1 Stairway pressurization systems.

909.15.1.1 Requirements. Where the uppermost landing of an exit enclosure serves an occupiable floor located more than 75 feet above the lowest level of fire department vehicle access road, the stairway enclosure and associated exit passageway shall be mechanically pressurized with outdoor air, via one or more separate, dedicated pressurization systems. The operation of each stairway pressurization system shall be controlled through the fire alarm system. Fire, smoke, or fire/smoke dampers are prohibited in stairway pressurization systems. Isolation dampers are permitted in the outdoor air intake ductwork, where such dampers are provided with a hard-wired interlock with the drive or starter, that proves “damper open” position, and that the damper is configured to “fail” open from a control standpoint. Each stairway pressurization system shall be enclosed in an *approved* two-hour fire-resistive rated fire barrier and/or horizontal assembly from the outdoor air intake to the stairway enclosure penetration. Ductwork shall not be required within the stairway enclosure.

Exception: Where ductwork is not provided for stairway pressurization, stairway shaft leakage shall not exceed 10 percent of actual supply, exclusive of the door leakage.

909.15.1.2 Operation. Each fan discharge shall be provided with a duct smoke detector that shall annunciate a supervisory signal at the fire command center (graphic annunciator) and shall illuminate a lamp adjacent to the fan status indicator at the firefighter’s smoke control panel. The capability to manually override the operation of each fan shall be provided to the Fire Department personnel in the fire command center. Fans shall not shut off until manually overridden by Fire Department personnel or until the fire alarm system is reset. Each stairway pressurization system shall indicate that the system is moving air at the firefighter’s smoke control panel in accordance with Appendix O. Monitoring of air flow is permitted to be accomplished with torque indication on a variable frequency drive, differential pressure across the fan or current switches on the power feed to the fan. Variable frequency drives used for smoke control systems shall not be required to be UUKL listed. The drive shall not fail to a greater capacity than that associated with the control setpoint for the fan.

909.15.1.3 Design. The air volume introduced into the stairway shall be as follows: 15 floors or less, at least 800 cfm per floor; 16 floors or more, at least 10,000 cfm, plus 200 cfm per floor in excess of 15 floors with 0.5-inch water column static pressure minimum at the duct penetration into the stairway. In order to comply with the requirements of Section 909.13, dynamic static pressure control shall be provided for stairway pressurization fans. Either dynamic static pressure or fixed speed controls shall be provided. Dynamic static pressure controls are permitted to be tuned and set to a fixed value. Air for the stairways serving buildings where the uppermost occupied floor is more than 120 feet above the lowest level of fire department vehicle access shall be introduced into the stairway at a minimum of two injection points. One injection point shall be located not more than 50 feet above the grade plane. In buildings where the uppermost landing of an exit enclosure serves an occupiable floor located more than 250 feet above the lowest level of fire department vehicle access, an engineered design shall be required.

909.15.2 Hoistway pressurization systems.

909.15.2.1 Requirements. Each elevator hoistway with a total rise of 75 feet or more or any elevator hoistway serving any occupiable floor located more than 75 feet above the lowest level of fire department vehicle access shall be mechanically pressurized with outdoor air, via one or more separate, dedicated pressurization systems in accordance with Section 909.15.1.1. Where hoistway pressurization is provided in lieu of required enclosed elevator lobbies in any building as permitted by Section 3006.3 Item 4 of the *Denver Commercial Building Code*, design shall comply with provisions of Section 909.15.2.3

909.15.2.2 Operation. System operation shall comply with Section 909.15.1.2.

909.15.2.3 Design. The air volume introduced into the elevator hoistway shall be as follows: 15 floors or less, at least 900 cfm per floor, plus 270 CFM per door opening, with 0.5-inch water column static pressure minimum at the duct penetration into the hoistway; 16 floors or more, at least 13,500 cfm, plus 270 cfm per door opening, with 0.5-inch w.c. static pressure minimum at duct penetration into the hoistway. In order to comply with the requirements of Section 909.13, dynamic static pressure control shall be provided for hoistway pressurization fans. Dynamic static pressure or fixed speed controls shall be provided. Dynamic static pressure controls are permitted to be tuned and set for a fixed value. In buildings where the uppermost elevator landing serves an occupiable floor located more than 250 feet above the lowest level of fire department vehicle access, an engineered design shall be required. Hoistway pressurization system performance shall not interfere with the opening and closing of elevator doors. Refer to Chapter 30 of the *Denver Commercial Building Code* for door operation.

909.15.2.4 Smoke venting to exterior. Smoke venting of pressurized elevator hoistways to the exterior of the building shall not be required.

909.15.2.5 Elevator machine rooms. Elevator machine rooms may be pressurized indirectly via the elevator hoistway pressurization system through the cable slots in the machine room floor.

909.15.2.6 Lobby/ Areas of rescue assistance. Elevator lobbies designated as areas of rescue assistance are permitted to have the elevator lobby/area of rescue assistance pressurized using the elevator hoistway pressurization system by transferring air to the elevator lobby area of rescue assistance from the hoistway. The lobby/area of rescue assistance shall be pressurized by the transfer of air from the pressurized hoistway through the leakage at the elevator doors. Where *approved* by the *fire code official*, use of transfer openings protected with fire/smoke dampers between the hoistway and the lobby/area of rescue assistance is also acceptable.

909.15.3 Smoke exhaust systems.

909.15.3.1 Requirements. Smoke exhaust system(s) shall be provided in high-rise buildings system shall be controlled via the fire alarm system, to operate in conjunction with the other applicable smoke control systems for the building, in order to achieve the objectives as follows:

1. To maintain a zone of negative pressure in the fire floor (or smoke zone) relative to the other floors or adjacent smoke zones, means of egress stair enclosures and elevator lobby/refuge areas; and...
2. To maintain a maximum stair enclosure or smoke barrier door opening force on the fire floor or smoke zone in alarm. The prescriptive approach described herein is not intended to preclude the use of a performance-based smoke control approach, such as that defined by NFPA 92.
3. Maintenance of tenable environment is not required in the immediate area of fire origin.
4. Shall demonstrate the continual reduction of smoke concentrations from the smoke zone of origin per Section 909.10.1 Item 8.

909.15.3.2 Configuration. Smoke exhaust systems shall include motorized combination fire/smoke dampers or a motorized smoke and a fire damper on each floor of a multi-level building served by the system(s). The exhaust damper(s) in the fire floor smoke zone in alarm shall be commanded open, in order to exhaust that zone, and the smoke exhaust fan commanded to "ON". The exhaust dampers in other smoke zones shall be driven to, or shall remain in, the closed position. The use of smoke dampers shall not preclude the provision of fire dampers, where required by other sections of this code. Exhaust damper(s) shall be located within the upper third of the finish floor height.

909.15.3.3 Design criteria. The general building smoke exhaust system(s) for each floor/smoke zone shall be sized in accordance with the following:

1. The smoke exhaust system shall be sized to remove a minimum of 5 air changes per hour on the fire floor in Occupancy Groups A, B, E and M.
2. The smoke exhaust system shall be sized to remove a minimum of 15 air changes per hour in the typical floor corridors, the typical floor corridors/elevator lobbies, or the typical floor elevator lobbies in Occupancy Groups R-1, R-2, I-1 and I-3. Amenity spaces less than 3,000 square feet in Groups R-1 and R-2 occupancies are not required to be provided with a separate smoke exhaust system.
3. That appropriate consideration shall be made for damper leakage on non-fire floors connected to a central riser system, when selecting the smoke exhaust fan(s).
4. Smoke exhaust systems shall be in ducts constructed in accordance with Section 909.13.8.
5. The engineer shall design make-up air to be available to the smoke zone in alarm so exhaust rates satisfy 909.10.1 Item 8. Submittal documentation shall include analysis presenting methodology for achieving such.

909.15.3.4 Operation. Upon activation of an automatic alarm initiating device as described in Section 907, the following smoke control sequence shall occur:

1. Turn off all supply and make-up air fans, unless used to afford make-up air to the smoke exhaust zone.
2. Open exhaust dampers on the zone in alarm.
3. Close smoke exhaust dampers to all other smoke zones.
4. Close all supply air dampers, unless used to afford make-up air to the smoke exhaust zone.
5. Initiate stairway and elevator hoistway pressurization sequences in accordance with Sections 909.15.1 and 909.15.2.
6. Start exhaust fans.

909.15.4 Street level tenant exception. Smoke exhaust systems shall not be required to serve individual tenant areas or lobbies located on the level of building egress.

909.15.5 Small assembly areas or similar uses exception. Smoke exhaust for assembly areas or similar uses 3,000sf (278m²) or less in cumulative size for the floorplate shall not be required when these areas are separated by smoke partitions constructed in accordance with Section 710 of the *Denver Commercial Building Code*.

909.16 Smoke control systems for parking garages within high rise structures.

909.16.1 Requirements. Elevator lobbies designated as refuge areas on all floors within an enclosed parking structure shall have the elevator lobby/refuge area pressurized using the elevator hoistway pressurization system by transferring air to the elevator lobby/refuge area. Use of transfer openings protected with fire/smoke dampers between the hoistway and the lobby/refuge area is acceptable.

909.16.2 Open parking garages. A general building smoke control system shall not be required for elevator lobbies that are enclosed and that serve an open parking garage, if direct access without stairs or obstructions is available for people with special needs to exit from the elevator lobby to the open parking garage level or directly to a public way.

909.16.3 Enclosed garages. Exhaust fans associated with an enclosed parking structure shall be capable of manual operation from the smoke control panel. Such exhaust fans will not require a redundant source

of electrical power, and this shall be indicated at the smoke control panel with the words, “**Not on Emergency Power.**”

909.17 Smoke exhaust. Smoke exhaust for assembly occupancies with 1,000 occupants or more in high-rise buildings, stages and areas in accordance with Section 410 of the Denver Commercial Building Code, and underground buildings shall comply with Sections 909.17.1 through 909.17.3.1.

909.17.1 Requirements. Each area shall be separated into smoke zones not to exceed 52,000 square feet on a single floor. Smoke zones shall be separated from each other by walls that extend from the floor to the underside of the floor or roof above except for the following:

1. Openings into atriums.
2. Pedestrian bridges between two buildings.
3. Non-required stair enclosures between floors.
4. Open escalators between multiple floors.
5. Where draft stops as prescribed in Section 909.17.2.1 are provided.

909.17.2 Design criteria. Building construction shall be configured in order to support the performance of the smoke exhaust system, in accordance with the following:

1. Where wall separation is not provided between smoke zones, draft stops shall be provided. The configuration of the draft stops shall be as *approved* by the Building and Fire Departments.
2. A smoke zone in alarm shall actuate the respective smoke exhaust system, while smoke exhaust systems in adjacent smoke zones remains inactive.
3. Where smoke zones have wall separations, a positive static pressure differential shall be maintained between adjacent non-alarm zones, relative to the smoke zone in alarm.
4. Sprinkler and smoke detection zones shall coincide with smoke zones.
5. Products of combustion must be demonstrated to be contained within the zone of origin, for smoke zones without wall separations. Failure to restrict products of combustion to the floor or area of origin shall be considered non-compliant with the performance requirements for the smoke exhaust system.

909.17.2. Assembly area smoke zones shall be separated from adjacent zones by draft stops located immediately adjacent to each smoke zone. The draft stops shall be at least 18 inches deep. The draft stops shall be of non-combustible or limited combustible material that will stay in place before and during sprinkler operation.

Exception: Assembly areas smoke zone separation from adjacent smoke zones is not required for ceiling heights 18 feet and greater.

909.17.3 Design criteria. The smoke exhaust system shall exhaust a minimum of six air changes per hour.

909.17.3.1 Operation. Upon activation of a fire alarm initiating device in accordance with Section 907, smoke control operation shall comply with the following:

1. Open exhaust dampers for smoke zone in alarm
2. Start smoke zone exhaust fans
3. Close supply dampers to smoke zone in alarm

4. Adjacent zones go to 100 percent outside air
5. All other systems maintain normal operation

909.18 Reserved.

909.19 Smoke control systems for covered mall buildings. Where required by Section 402 of the *International Building Code*, smoke control systems shall comply with Section 909.14.

909.20 Alteration of smoke control systems in existing high-rise buildings. Smoke control systems shall be maintained in operational condition as required by the code under which the system was installed. The system alteration may be considered for application under this code with approval by the *fire code official*, provided that; the building is fully protected by automatic sprinklers complying with current NFPA 13 provisions for high rise buildings, the building has complying standpipes, and smoke detection is provided in accordance with Section 907.2.13.1.1. Upon approval, the altered configuration shall be considered the new requirement and documented as *approved* by the Denver Building Department and the Denver Fire Department. Future work shall not be allowed to adversely affect the performance of the system. Construction drawings and system sequence of operation shall be submitted for approval in accordance with Appendix O.

SECTION 910

SMOKE AND HEAT REMOVAL

Section 910.3.1 Listing and labeling is replaced in its entirety as follows:

910.3.1 Listing and labeling. Smoke and heat vents shall be *listed* and labeled to indicate compliance with UL 793 or FM 4430.

Exception: Gravity-operated drop out vents are not permitted.

Section 910.3.6 Smoke and heat vent fall protection and its subsection are added as follows:

910.3.6 Smoke and heat vent fall protection. In Group F, M, and S occupancies fall protection shall be provided meeting minimum requirements of Sections 910.3.6.1 and 1108 Items 1, 2 and 3.

910.3.6.1 Fall protection construction. Fall protection shall be of such construction and mounting that they are capable of withstanding a load of at least 400 pounds per square foot applied perpendicularly at any one area on the screen. Covers shall be secured in place to prevent accidental removal or displacement. Opening limitation shall be not more than 6 inches in diameter or of slatwork with openings not more than 2 inches wide with length unrestricted.

SECTION 912

FIRE DEPARTMENT CONNECTIONS

Section 912.2 Location is replaced in its entirety as follows:

912.2 Location. With respect to hydrants, driveways, buildings and landscaping, fire department connections shall be so located that fire apparatus and hose connected to supply the system will not obstruct access to the buildings for other fire apparatus. The location of fire department connections shall be field *approved* by the *fire code official* prior to installation. Fire department connections shall be a minimum of one 2½ x 2½ x 4-inch Siamese or single 2½-inch, as *approved* by the *fire code official*. In buildings with standpipes, an FDC shall be located within 100 ft. of a fire hydrant.