SMOKE CONTROL
HOW TO OBTAIN TENABLE CONDITIONS

Morrison Hershfield
Consulting Engineers and Managers
Smoke Management System

An engineered system that includes all methods that can be used singly or in combination to modify smoke movement.
Smoke Control System

An engineered system that uses mechanical fans to produce pressure differences across smoke barriers to inhibit smoke movement.
Design Basis  

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This edition of NFPA 101® Life Safety Code® was adopted by the National Fire Protection Association, Inc. at its November Association Technical Meeting held November 16–20, 2002, in Atlanta, GA. It was issued by the President Council on January 17, 2003, with an effective date of February 1, 2003, and supersedes all previous editions.

This edition of NFPA 101® was approved as an American National Standard on January 17, 2003.

Origin and Development of NFPA 101

The Life Safety Code had its origin in the work of the Committee on Safety to Life of the National Fire Protection Association, which was appointed in 1902. In 1912 a pamphlet titled Forts Drills in Factories, Schools, Department Stores and Theaters was published following in presentation by the late Committee member R. H. Newhall at the 1911 Annual Meeting of the Association. Although the pamphlet’s publication marked the beginning of the Committee, it was considered a Committee publication.

For the first few years of its existence, the Committee on Safety to Life devoted its attention to a study of the possible fire involving loss of life and to the reduction of that loss of life. This work led to the preparation of standards for the construction of structures, fire apparatus, and other means of fire protection and to the publication of several pamphlets and bulletins.

In 1911 the Committee on Safety to Life was reorganized to include representatives of certain interested groups not previously participating in the standard’s development. The Committee then began to further develop and integrate previous Committee publications to provide a

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Design Basis – NFPA 101 – NBCC – OBC –

- Atria
- Malls
- High rise smoke-proof enclosures
- Stages & Platforms
- Assembly Seating
- Underground Structures
- Performance Based Design
Smoke Control Methods

Figure 2: Sandwich smoke-control system.

FIGURE A.5.5.1.1.1 Arrangements of Smoke-Control Zones.
## Life Safety Mode Set Up Chart

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Life Safety Mode for AHU

- D1 Open
- D2 & D3 Closed
- D4 Closed
- D7 Closed

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Typical Life Safety Mode Set Up for Double Zone Air Handling Unit

(AHU-1, 2, 3, 4, 5, 6, 7, 8, 10)
## Smoke Control Matrix

### MORRISON HERSHFIELD

**New Equipment Tag No.:**

**Most Smoke Detection(s):**

**NORMAL MODE**

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* Supply & Return Fans: 3 x R, 1 x D, 1 x R, 1 x D

* School Assembly Level 2, Upper & Lower Bridge, Kitchen Exhaust, Orientation Level, Leach
International Building Code Specifies Design Parameters

- Pressurization method
- Airflow design method
- Exhaust method

NFPA 92A
Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences

NFPA 92B
Standard for Smoke Management Systems in Malls, Atria, and Large Spaces
Fire Modeling Specific Design Parameters

Spread of Fire & Smoke Through Mechanical Shafts

- Fire dampers are closed
- Fire damper is open
Fire Modeling Development of Smoke

Figure 6.1: A screenshot of the model showing the smoke spreading

Fire scenario 1: Fire starts in this bedroom

Smoke development
Fire Modeling Development of Smoke in Stairwell

Figure 6.16 A screenshot of the model showing the smoke spreading in the stairways (pressurizing fan is not working)
Figure 6.15: CO Concentration vs. Time in stairwell (Christmas tree fire)
Figure 6.17: Visibility level vs. Time in stairwell (Christmas tree fire with stairway pressurizing fan)

- Visibility level decreases in central core in fire floor but smoke does not penetrate to stairwell because of air pressure in stairwell.
- Stairwell (1st, 2nd, 6th and 16th floors)
- Central core 1st floor
- Visibility threshold = 2m

TIME

VISIBILITY LEVEL

stairwell (1st, 2nd, 6th and 16th floors)

Central core 1st floor

visibility threshold = 2m
Fire Modeling Visibility Versus Time

Figure 6.14: Visibility vs. Time in stairwell (Christmas tree fire)
Design Basis – NFPA 101 – NBCC – OBC –
3.2.8.4. Exits

• *Building* - 18 m in height,
• contains an *interconnected floor space*,
• limit the passage of smoke from a fire into *exit* stair shafts opening into an *interconnected floor space*
• 2 h period after the start of fire- 1% by volume of contaminated
Control the movement of smoke within a building containing an interconnected floor space.
Activation sprinkler system / 2 smoke detectors in a single zone
the system shall

- stop air moving fans
- activate *exit* stair shaft pressurization fan
- activate elevator Vestibules (door hold opens / press.)
- activate the vestibule air supply
Activate air handling equipment shall provide

6 air changes per hour

Supply air in sufficient quantities

Prevent smoke from passing out of such floor area into other portions of the interconnected floor space.
A mechanical exhaust shall remove air at the top of interconnected floor space - 6 air changes per hour,

If space exceeds 17,000 m³- only 4 air changes per hour.
Overriding manual controls for the smoke control system for fire department
Section 3  Venting of Floor Areas

(1) The requirements of Sentence 3.2.6.10.(1) of Division B and of Measures H or I are met by incorporating in a floor area windows or wall panels as described in Sentence (2), by smoke shafts as described in Sentences (3) to (7) or by the use of building exhaust systems as described in Sentence (8).

(2) Where windows or wall panels are used for venting as required in Sentence (1), they must
(a) be uniformly distributed along the exterior wall of each storey,
(b) have a total area of not less than one per cent of the exterior wall area of each storey,
(c) be readily openable from the interior without the use of wrenches or keys,
(d) be readily identified from the interior, and from the exterior where they are accessible to fire fighters, and
(e) be designed so that when opened they will not endanger persons outside the building during a fire.

(3) Where one or more smoke shafts or vertical service spaces are used for venting to meet the requirements of Sentence (1), they must
(a) have an opening or openings into each storey with an aggregate area not less than that obtained from Table 2 for the height of the shaft, the area of the largest floor area served by the smoke shaft and the leakage characteristics of the shaft wall and dampers obtained from Tables 3 and 4,
(b) have an aggregate unobstructed cross-sectional area equal to that provided in Clause (a), and
(c) be designed to comply with the requirements of Sentence (4).
Section 7.3. Inspections and Test Procedures for Smoke Control Measures

7.3.1.1. Application

1) The test procedures described in Subsections 7.3.2. to 7.3.15., as appropriate to the fire safety measure being used, shall be carried out in addition to those required by Sections 7.1. and 7.2., unless otherwise specified in the fire safety plan. (See Appendix A.)
NBC 2005- Part 7 Fire Emergency Systems in High Buildings

7.3.2. Measure A

7.3.2.1. Test Procedures

1) Where Measure A is used to limit smoke movement as provided in Commentary C of the User’s Guide – NBC 1995 (Part 3),
   a) switches at the central alarm and control facility shall be tested to ensure that
      i) closures to vent openings in vertical service spaces that are
         required by Sentence (6)* of Measure A open automatically
         and remain open, and
      ii) the mechanical air supply to below grade stairshafts is
         initiated as provided in Sentence (3)* of Measure A,
   b) closures in openings to the outdoors in vertical service spaces that are required
      by Sentence (6)* of Measure A shall be tested to ensure that they will
      operate as required,
   c) closures in vent openings to the outdoors in above grade stairshafts shall be
      tested to ensure that they can be opened manually and will remain open
      as provided in Sentence (2)* of Measure A, and
   d) closures in vent openings to the outdoors in below grade stairshafts shall be
      tested to ensure that they will open automatically, if such means is provided,
      and remain open when air is being injected into the stairshaft.
Smoke Control

NFPA 92A
Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences
2006 Edition
NFPA 92A
Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences

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This edition of NFPA 92A, Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences, was prepared by the Technical Committee on Smoke Control Systems and acted on by NFPA at its June Association Technical Meeting held June 6–10, 2003, in Las Vegas, NV. It was issued by the Standards Council on July 29, 2003, with an effective date of August 11, 2003, and supersedes all previous editions.

This edition of NFPA 92A was approved as an American National Standard on August 10, 2003.

Origin and Development of NFPA 92A

The NFPA Standards Council established the Technical Committee on Smoke Control Systems in October of 1968 and charged it with addressing the need for guidelines and materials on building fire smoke management. With the help of a steering committee, the smoke control of the Technical Committee on Air Conditioning members were appointed to the Smoke Control Systems Committee in 1968. As a first attempt at addressing smoke management, a draft was prepared of a new document, NFPA 92A, that addressed smoke control utilizing barriers, airflows, and pressure differences so as to confine the smoke of a fire to the zone of the origin and thus maintain a safe environment in other zones.

The 1983 edition helped to refine the science and art of smoke control by incorporating the latest in technology. The 1996 edition added guidelines on control system supervision and instrumentation, it also provided substantial appendix material on testing for leakage of smoke-control enclosures.

The 2000 edition was a complete revision and added information based on research on the design and testing of smoke-control systems for areas of refuge, elevator lobbies and hallways.

Copyright NFPA
Purpose of NFPA 92A

Inhibit smoke from entering stairwells, means of egress, smoke refuge areas, elevator shafts, or similar areas

Inhibit the migration of smoke from the smoke zone
Simple single-point injection systems can use roof or exterior wall-mounted propeller fans.

The use of propeller fans without windshields is not permitted because of the extreme effect wind can have on the performance of such fans.
Multiple-injection systems can be used to overcome the limitations of single-injection systems.

Pressurization fans can be located at ground level, roof level, or at any location in between.
ELEVATORS FOR FIRE EVACUATION

- The building stack effect causes smoke to move into and out of the loosely constructed elevator hoistways.

- Several methods of correcting this problem have been proposed and investigated:
  - (1) Exhaust of the fire floor
  - (2) Pressurization of enclosed elevator lobbies
  - (3) Construction of smoke-tight elevator lobbies
  - (4) Pressurization of the elevator hoistway
  - (5) Closing of elevator doors after automatic recall
NFPA 92B

Standard for Smoke Management Systems in Malls, Atria, and Large Spaces

2005 Edition

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This edition of NFPA 92B, Standard for Smoke Management Systems in Malls, Atria, and Large Spaces, was prepared by the Technical Committee on Smoke Management Systems and acted on by NFPA at its November Association Technical Meeting held November 1-4, 2004, in Miami Beach, FL. It was issued by the Standards Council on January 14, 2005, with an effective date of February 7, 2005, and supersedes all previous editions.

This edition of NFPA 92B was approved as an American National Standard on February 7, 2005.

Origins and Development of NFPA 92B

The NFPA Standards Council established the Technical Committee on Smoke Management Systems in 1983 and charged it with addressing the need for guidelines and materials on smoke management. The Committee's first document, NFPA 92A, Recommended Practice for Smoke Control Systems, was published in 1988 and addressed smoke control utilizing barriers, airflows, and pressure differentials as to confine the spread of a fire to the zone of fire origin to maintain a tolerable environment in other zones. The complex problem of maintaining tolerable conditions within large zones of fire origin, such as malls and shopping malls, presented a more difficult issue in terms of the physics involved and data was reserved for the document, NFPA 92B, Guide for Smoke Management Systems in Malls, Atria, and Large Areas. The first edition was published in 1991, the second edition was published in 1997.

The 2005 edition was a substantial rewrite of the document to reflect the best current information on smoke management in malls, atria, and other large spaces. Major changes included new and updated definitions, additional data on the impact of sprinklers on smoke management, extensive discussions on basic principles and limitations, additional information on estimating heat release rates of fires, and new criteria for system verification.

Copyright NFPA
Purpose of NFPA 92B

Maintain a tenable environment in the means of egress from large-volume building spaces during the time required for evacuation

Control and reduce the migration of smoke between the fire area and adjacent spaces

NFPA 92B
Standard for Smoke Management Systems in Malls, Atria, and Large Spaces
**Applicability**

Large Open Spaces  
Low fuel load relative to size of the space

**Goal**

Move the smoke out of the space and prevent it from exposing other areas of the building
Scope of Documents NFPA 92B

Protect Upper Spaces in Atrium
Scope of Documents NFPA 92B

Mechanical Exhaust Systems
Scope of Documents NFPA 92B

Mechanical Makeup Systems

AIR MAKE-UP UNIT

ROOF TOP AIR MAKE-UP UNIT

Morrison Hershfield
NFPA Standard- NFPA 92A & 92B – Similar but Different

92A Seeks to move outside air into enclosed spaces to keep out of them and provide exhaust relief to allow doors to operate.

92B Seeks to move smoke out of large open spaces and provide intake relief to allow smoke freely.
NFPA 92A

5.1* System Operation.

Tenability - effective for the time period

Smoke-control systems designed for other considerations shall remain effective for the time dictated by the application.
Reliability Issues

NFPA 92A

1. Reliability of power source(s)
2. Arrangement of power distribution
3. Method and protection of controls and system monitoring
4. Equipment materials and construction
5. Building occupancy
Reliability Issues

- HVAC Equipment
  - Fans operation
    » Electricity must be available
    » Verify fans are running
Reliability Issues

- Smoke Dampers - UL 555S Standard for smoke dampers
  - Need to open (or close)
  - Controls
Design Documentation

• Design Report

• Operation and Maintenance Manual
Inspections and Tests - NFPA 92A/92B

- Preliminary Building Inspection
- Operational Testing
- Acceptance Testing
- Modifications
- Periodic Testing
Inspections and Tests - NFPA 92A/92B

- Preliminary Building Inspection
  - Shaft integrity
  - Fire stopping
  - Doors/closers
  - Glazing
  - Partitions and ceilings
Inspections and Tests- NFPA 92A/92B

• Operational Testing

Each system component and subsystem prior to interconnection to the smoke control system
  • Fire alarm
  • Energy & building management
  • HVAC equipment
  • Electrical equipment
  • Normal power
  • Standby power
  • Automatic suppression
  • Automatic doors
  • Dedicated smoke-control
  • Non-dedicated smoke-control
  • Emergency elevator
Acceptance Testing

- General testing
  - Normal mode
  - Automatic smoke-control mode for fire alarm (if included in system design)
  - Manual override (if included in system design)
  - Return to normal
• Acceptance Testing

- Stairwell pressurization system

  Normal mode

  Automatic smoke-control mode for fire alarm
  (if included in the system design)

  Manual override
  (if included in the system design)

  Return to normal
• Modifications

  • All operational and acceptance testing shall be performed on the applicable part of the system whenever the system is changed or modified.

  • If the smoke–control system or the zone boundaries have been modified since the last test, acceptance testing shall be conducted on the portion modified.
Smokes control equipment - fully operational

Inspections & Tests

Section 7.3 in Div. B of NRC, NBC 2005
Inspections and tests for equipment

- procedures established by the designer of the system.
- Supplementary Standard SB-4, "Measures for Fire Safety in High Buildings".

Periodic inspections and tests

- signature and seal of a Professional Engineer or Architect
- other inspection and test procedures may be approved
Contact Us

David Sylvester  
Life Safety Systems Specialist  
Morrison Hershfield Limited  
235 Yorkland Boulevard, Suite 600  
Toronto, Ontario  M2J 1T1

Mahnaz Gharahdaghi  
Life Safety System Designer

Tel. 416-495-4286  
Fax. 416-499-9658  
Email dsylvester@morrisonhershfield.com
SMOKE CONTROL
HOW TO OBTAIN TENABLE CONDITIONS

Thank You