NEMA

GUIDE FOR PROPER USE OF SMOKE DETECTORS IN DUCT APPLICATIONS

Reproduced By GLOBAL
ENGINEERING DOCUMENTS
With The Permission Of NEMA
Under Royalty Agreement

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Guide for Proper Use of Smoke Detectors in Duct Applications

Published by the
National Electrical Manufacturers Association
Fire Alarm Group of the Signaling, Protection,
and Communication Section 3-SB
for the automatic fire detection and alarm industry



Setting Standards for Excellence

Revised June 2001

© Copyright 2001 by the National Electrical Manufacturers Association. All rights including translation into other languages, reserved under the Universal Copyright Convention, the Berne Convention for the Protection of Literary and Artistic Works, and the International and Pan American Copyright Conventions.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

TABLE OF CONTENTS

Foreword	ii
Section 1— Definitions	1
Section 2 — Application of Duct Smoke Detection	3 - 5
Section 3 — Characteristics of Smoke in HVAC Systems	6 - 8
Section 4 — Duct Smoke Detection Equipment	9 - 10
Section 5 — Typical Air Handling Systems	11 - 13
Section 6 — How Duct Detection Systems are Used to Control Smoke	14 - 15
Section 7 — Procedure for Duct Detector Application and Installation	16 - 23
Section 8 — Testing, Maintenance and Service of Detectors for Use in Ducts	24 - 27

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

FOREWORD

Proper Use of Smoke Detectors in Duct Applications

The purpose of this guide is to provide much needed information concerning the proper use of smoke detectors in duct applications. Duct mounted smoke detectors are designed to provide a specific type of protection that cannot be duplicated by any other type of system. However, there has been a tendency to misapply these devices — attempting to use them as a substitute for an early warning smoke detection system. This fact, coupled with new methods of detecting smoke in ducts, has prompted the writing of this industry guide.

Fire Protection Engineers, Mechanical and Electrical Engineers, Fire Alarm System designers and installers should find the contents both educational and informative.

This information is intended as a technical guide, and distinct from a listing of mandatory requirements.

This ***Guide for Proper Use of Smoke Detectors in Duct Applications*** has been published by the National Electrical Manufacturers Association Fire Alarm Group of the Signaling, Protection, and Communication Section 3-SB for the automatic fire detection and alarm industry.

About the National Electrical Manufacturers Association (NEMA):

For more than 70 years, the National Electrical Manufacturers Association has been developing standards for the electrical manufacturing industry and is today one of the leading standards development organizations in the world. NEMA contributes to an orderly marketplace and helps ensure the public safety.

NEMA, with headquarters in Rosslyn, Virginia, has nearly 500 member companies, including large, medium, and small businesses. The organization is divided into eight divisions: Industrial Automation, Lighting Systems, Electronics, Building Equipment, Insulating Materials, Wire and Cable, Power Equipment, and Diagnostic Imaging and Therapy Systems. Within these divisions are over 50 product-specific sections. The Signaling Section is one such Section in the Electronics Division.

About the NEMA Signaling, Protection, and Communication Section (3-SB):

The objective of the Section is to be the principal source of technical, training, and educational materials essential for the specification and manufacture of reliable life safety products, their installation, performance, and inspection.

The Section currently represents over 40 U.S., U.K., and Japanese manufacturers in support of the automatic fire detection and alarm industry and the health care communications industry. Fire detection and alarm products include: life safety/fire alarm systems and devices that provide early warning of an impending or actual fire or gaseous hazard. The products detect, notify and initiate control functions in case of hazard to life or property.

For more information on NEMA and the Signaling Section, go to http://www.nema.org and search for the "Signaling Section" or "Fire Alarm"

Copyright 2001 by National Electrical Manufacturers Association

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 1

DEFINITIONS

TERMS

Air Sampling An extremely sensitive smoke detection device that can sample, test and evaluate the amount of particle concentration within an air sample.

Area Smoke Detector: A device that will detect visible or invisible particles of combustion. Also called a spot type detector.

Coil: A cooling or heating element made of pipe or tubing.

Coil, direct expansion: Coil using the direct refrigeration method.

CFM: Unit volume of flow-cubic feet per minute.

Damper: A valve or plate regulating the flow of air or other fluid.

Damper, multiple, louver: A damper having a number of adjustable blades, used to vary the volume of air passing through a confined section by varying the cross sectional area.

Duct: A passageway made of sheet metal or other suitable material not necessarily leak-tight, used for conveying air or other gas at low pressures.

Duct Smoke Detector: A device located within the duct, protruding into the duct, or located outside the duct that will detect visible or invisible particles of combustion flowing within the duct. Actuation of the device may allow operation of certain control functions.

Exhaust Tube: Usually a round tube that provides a path for sampled air to return from the detection device to the duct.

Fan: An air moving device comprising a wheel or blade and a housing or orifice plate.

Humidifier: A device to add moisture to the air.

Inch of Water: A unit of pressure equal to the pressure exerted by a column of water at a temperature of 4.0°C. (39.2°F.).

Ionization Smoke Detector: An ionization smoke detector has a small amount of radioactive material that ionizes the air in the sensing chamber, thus rendering it conductive and permitting a current to flow between two charged electrodes. This gives the sensing chamber an effective electrical conductance. When smoke particles enter the ionization area, they decrease the conductance of the air attaching themselves to the ions, causing a reduction in mobility. When the conductance is less than a predetermined level, the detector responds.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Light Beam Detector: A smoke detection device that operates on a smoke obscuration principle.

Photoelectric Smoke Detector: In a photoelectric light scattering smoke detector, a light source and a photosensitive sensor are so arranged that the rays from the light source do not normally fall on the photosensitive sensor. When smoke particles enter the light path, some of the light is scattered by reflection and refraction onto the sensor, causing the detector to respond.

Pitot Tube: A device used to measure the total pressure of a fluid stream. It is essentially a tube attached to a manometer at one end and pointed upstream at the other.

Pressure: The normal force exerted by a homogenous liquid or gas per unit of area on the wall of a container.

Pressure Differential: A pressure difference (usually specified in inches of water) between two points in a duct.

Return Exhaust: The duct which is used to return the air to the HVAC processing center fo conditioning.

Sampling Tube: Usually a round tube with holes that collects air from the duct and brings it to a detection device mounted outside the duct.

Smoke Detectors: A device that detects the visible and invisible particles of combustion.

Stratification: A phenomenon where smoke or other gases travel in layers at different levels within the duct, rather than being evenly distributed throughout the duct.

Supply Duct: The duct which distributes conditioned air, i.e., cooled, heated, cleaned, humidified, etc.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 2

APPLICATION OF DUCT SMOKE DETECTION

2.1. PURPOSE OF DUCT SMOKE DETECTION

2.1.1 National and local safety standards and codes recognize the ability of air duct systems to transfer smoke, toxic gases, and flame from area to area. Sometimes smoke can be of such a quantity as to be a serious hazard to life safety unless blowers are shut down and dampers actuated. **The primary purpose of duct smoke detection, then, is to prevent injury, panic, and property damage by reducing the spread (recirculation) of smoke.** Duct smoke detection can also serve to protect the air conditioning system itself from fire and smoke damage, and can be used to assist in equipment protection applications, for example, in the ventilation/exhaust duct work of main-frame computers and tape drives.

2.2. APPLICATIONS

2.2.1 Section 4-4.2 of NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems,* specifies that "smoke detectors listed for use in air distribution systems shall be located:

(a) Downstream of the air filters and ahead of any branch connections in air supply systems having a capacity greater than 2000 CFM (944L/s).

(b) At each story prior to the connection to a common return and prior to any recirculation of fresh air inlet connection in air return systems having a capacity greater than 15,000 CFM (7080 L/s). and serving more than one story.

EXCEPTION No. 1: Return system smoke detectors shall not be required where the entire space served by the air distribution system is protected by a system of area smoke detectors.

EXCEPTION No. 2: Fan units whose sole function is to remove air from inside the building to outside of the building.

2.2.2 Perhaps more important is the identification of what duct smoke detection is **NOT** intended for rather than what it is.

- It is **NOT** a substitute for area smoke detection.
- It is **NOT** a substitute for early warning detection.
- It is **NOT** a replacement for a building's regular fire detection system.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

2.2.3 NFPA 72, 2-10.2 supports this by stating:

Detectors that are installed in the air duct system per 2-10.1(2) shall not be used as a substitute for open area protection. If open area protection is required, 2-3.4 shall apply.

2.2.4 NFPA 72, 2-3.5.2.2 states:

Detectors placed in environmental air ducts or plenums shall not be used as a substitute for open area detectors. (see Section 2-10, Table A-2-3.6.1.1., A-2-10.1, and A-2-10.2) If open area protection is required, 2-3.4 shall apply.

2.2.5 Area smoke detectors are the preferred means of controlling smoke spread since:

2.2.5.1 Duct smoke detectors can only detect smoke when laden air is circulating in the ductwork. Fans may not be running at all times, such as during cyclical operation or during temporary power failure.

2.2.5.2 Duct smoke detectors normally sample great volumes of air from large areas of coverage. They cannot be expected to match the detection ability of area detectors.

2.2.5.3 Dirt contaminated air filters can restrict air flow causing a reduction in the operating effectiveness of the duct smoke detectors.

2.3 APPLICABLE DOCUMENTS

2.3.1 There are several important documents that provide guidance concerning the performance, application, and installation of duct detectors:

- U.L. 268A, Standard for Smoke Detectors for Duct Applications
- NFPA 90A 1999 edition. Installation of Air Conditioning and Ventilating Systems
- NFPA 92A, Smoke Control Systems
- NFPA 72 1999 edition, National Fire Alarm Code, Chapter 2, Initiating Devices,
- NFPA 101, Life Safety Code
- ASHRAE Handbook and Product Directory, Chapter 38, "Fire and Smoke Control"

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

2.4 TYPICAL SCENARIOS

2.4.1 Duct smoke detection may be useful in preventing injury and property damage in instances such as the following:

2.4.1.1 A heating, ventilation, or air conditioning (HVAC) fan motor overheats and resulting smoke is sensed by the duct detector installed in the main supply duct. The duct detector is equipped with an auxiliary relay that immediately cuts power to the fan motor, before significant amounts of smoke can be distributed to the occupied areas.

2.4.1.2 A fire starts on the second floor of a building. The HVAC system serving the second floor also serves floors one through four; therefore, smoke is being spread to these floors as well. If area smoke detectors are not provided, the only means of automatic detection are the duct smoke detectors located in the return air ducts on each floor ahead of the main return plenum. The quantity of smoke in the duct eventually reaches proportions sufficient to alarm the second floor duct detector which transmits a signal to the building fire alarm system. Evacuation signaling and HVAC shut- down functions are then provided by the fire alarm control unit. Refer to Section 2-10 of NFPA 72 and NFPA 92A for control of smoke spread.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 3

CHARACTERISTICS OF SMOKE IN HVAC SYSTEMS

3.1 GENERAL

3.1.1 Since the primary purpose for detecting smoke in the HVAC system is to automatically initiate action to minimize the spread of smoke through the air handling system, it follows that the nature of the smoke to be expected in various parts of the system should be understood. **The following discussion is a theoretical description of smoke characteristics as they pertain to this application, as yet, not supported by fire test data.**

3.2 SMOKE

3.2.1 To begin with, smoke, is the totality of the airborne visible or invisible particles of combustion. Smoke detectors are designed to sense the presence of particles, but depending upon the sensing technology and other design factors, different detectors respond to different types of particles. Detectors based on ionization detection technology are most responsive to the smaller, invisible sub-micron sized particles.

Detectors based on light scattering technology, by contrast, are most responsive to the larger visible particles. Detectors based on light extinction technology respond to both visible and almost invisible particles. Multi-sensor detectors include two or more detection (sensor) technologies to combine the sensor output of all technologies into the alarm decision. Figure 3-1 shows the relative sensitivity of the three technologies as a function of particle diameter, assuming a constant mass of particles.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

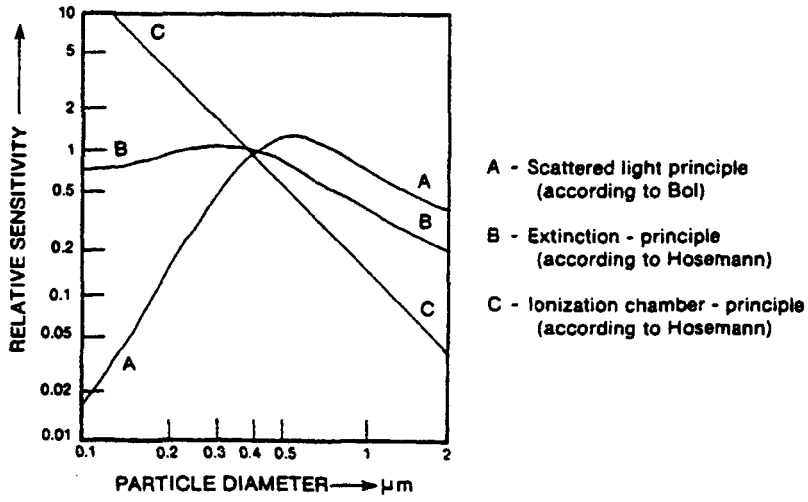

Figure 3–1: Relative Sensitivities of Three Technologies as a Function of Particle Diameter
(Source: NBS [NIST] IR78-1502, "Smoke Measurements in Large and Small Scale Fire Testing" by Richard Bukowski)

3.2.2 It is generally accepted that particle size distribution varies from sub-micron diameter particles predominant in the proximity of the flame of a flaming fire to particles one or more orders of magnitude larger, characteristic of smoke from a smoldering fire. The actual particle size distribution depends upon a host of other variables including the fuel and its physical make-up, the availability of oxygen including air supply and fire gas discharge, and other ambient conditions, especially humidity. Moreover, the particle size distribution is not constant, but as the fire gases cool, the sub-micron particles agglomerate and the vary large ones precipitate. In other words, as smoke travels away from the fire source, the particle size distribution shows a relative decrease in smaller particles. Water vapor, which is abundantly present in most fires, when cooled sufficiently will condense to form fog particles- an effect frequently seen above tall chimneys. Since water condensation is basically clear in color, with mixed particles, it can be expected to change the color of the mixture to a lighter one.

3.2.3 From the above discussion, one can begin to get an idea of what "smoke" is in the various parts of an air handling system. Specifically, the farther away the point of observation from the fire source, the cooler the smoke will be and the more visible because of the growth of sub-micron particles by agglomeration and recombination. There probably is some loss in quantity, i.e., the mass of the smoke particles at the point of entry to a duct system is probably greater than at some finite point down- downstream. However, at concentrations of concern, losses by precipitation are probably negligible.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

3.3 CHANGE IN CONCENTRATION

3.3.1 A much more important consideration is the change in concentration because of dilution by clean air from other return air ports in the duct system. A simple mathematical consideration will show that the original concentration is given by Q/V, where Q is the quantity of smoke particles and V the volume in which they are dispersed. If a return duct has four branches, each with equal air flow (cfm), then after they join, the concentration will be reduced to Q/4V.

3.3.2 The preceding assumes uniform dispersion of particles, which represents an ideal condition. In reality there is frequently non-uniform dispersion and concentration can and does vary from no smoke to very high in a cross-section area of a duct.

This is especially true just downstream from any point of entry. In a return air duct, for example, stratification can be expected immediately downstream from each return air grill. Text books teach that uniform dispersion is reasonably assured at a distance equal to 10 duct widths downstream for a duct with turbulent air flow. (In practical consideration, Chapter 2 of NFPA 72 accepts at least 6 ducts widths, but the 10 duct width distance should be used when possible.) In those cases where laminar flow is predominant, uniform dispersion might never be achieved.

3.3.3 Air velocity, per se, has no direct effect upon the characteristics of smoke. It does, however, affect the concentration because, as velocity is increased, the total volume in which smoke that is being produced at some rate is dispersed, Q/dt (quantity of smoke per given time period) increases proportionately. Stated differently, in a one-foot square duct an air flow of one hundred feet per minute would transport one hundred cubic feet of air each minute. Increasing the velocity to four hundred feet per minute would increase the volume of air transported to four hundred cubic feet per minute, thereby reducing the concentration of smoke particles by a factor of four, assuming that the rate of smoke generation was the same in both cases.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 4

DUCT SMOKE DETECTION EQUIPMENT

4.1 DUCT SMOKE DETECTORS

4.1.1 Definition:

A duct smoke detector is a device or group of devices used to detect the presence of smoke in the airstream of duct work sections of the HVAC air-handling systems.

4.1.2 Typical smoke detection devices used for duct application include area smoke detectors within an enclosure mounted outside the duct (utilizing sampling tubes), area smoke detectors listed for in-duct or partial in-duct mounting, a light beam detector consisting of projector and receiver mounted within the duct, and an air sampling type detector. In all cases, alarm contacts are available either in the detector or in the fire alarm control unit to initiate air movement control or to perform other control functions.

4.1.3 An externally mounted duct detector enclosure contains either an ionization, photo-electric or multi-sensor type smoke detector. Air stream sampling is accomplished by sampling tubes that penetrate and traverse either the supply or return air ducts. The sampling tubes are positioned so air may be drawn through the detector, sampled, and then returned to the air stream within the duct. (See Figure 4-1.)

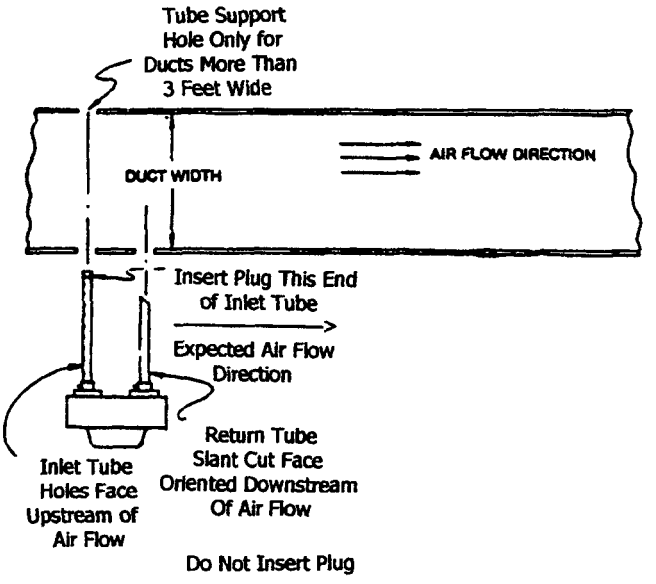

Figure 4–1 Typical Installation Using Air Sampling Tubes

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

4.1.4 An area smoke detector, listed for the application, may be mounted on an outlet box totally within the duct or they may be mounted on the exterior of the duct, with the sensing area of the detector protruding into the air stream. (See Figure 4-2.)

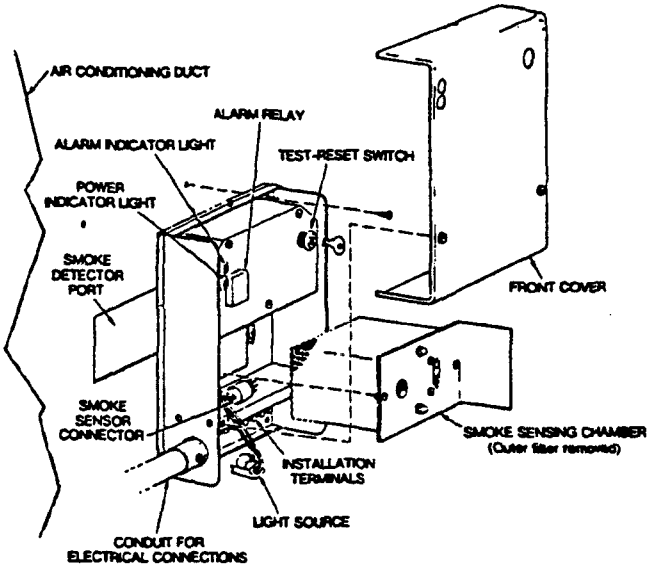

Figure 4–2: Typical Installation with Sensor Protruding into the Air Stream

4.1.5 Another duct detection device may be the light beam type detector. This unit performs best when utilizing long beam paths, e.g., in large plenums rather than small ducts.

4.1.6 Air sampling detection units are relatively new. Extremely sensitive, they can detect minute changes in air particle concentration. An air sampling detection tube or head is inserted in the air stream of the duct. Air is drawn out and through the detection device. The detection unit typically is set at an operating level of normal background particle concentration. An alarm will sound when concentration exceeds a preset alarm threshold value. (See Figure 4-3.)

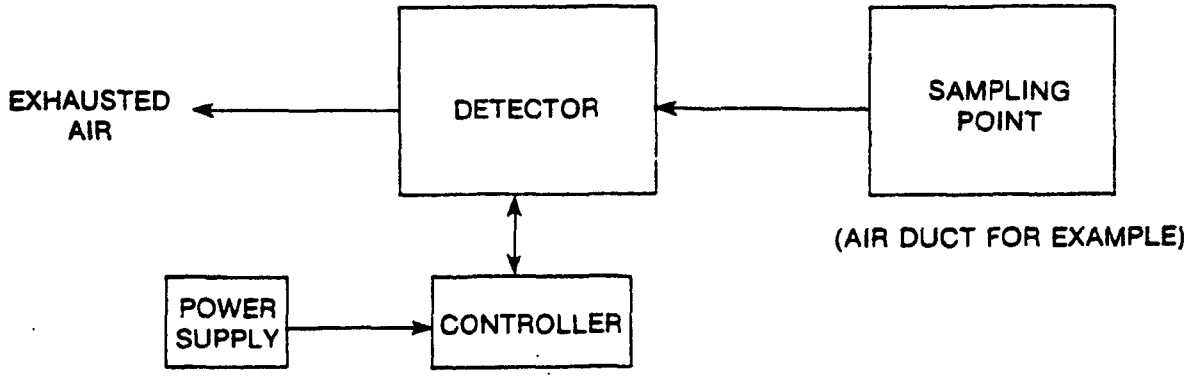

Figure 4–3: Typical Air Sampling Detector Installation

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 5

TYPICAL AIR HANDLING SYSTEMS

5.1 GENERAL

5.1.1 Heating, ventilating and air conditioning systems, as applied to commercial buildings, condition and distribute air usually through a network of ducts.

5.1.2 The air handling system can be divided into four basic segments. Figure 5-1 shows a simplified schematic view of a typical air handling system.

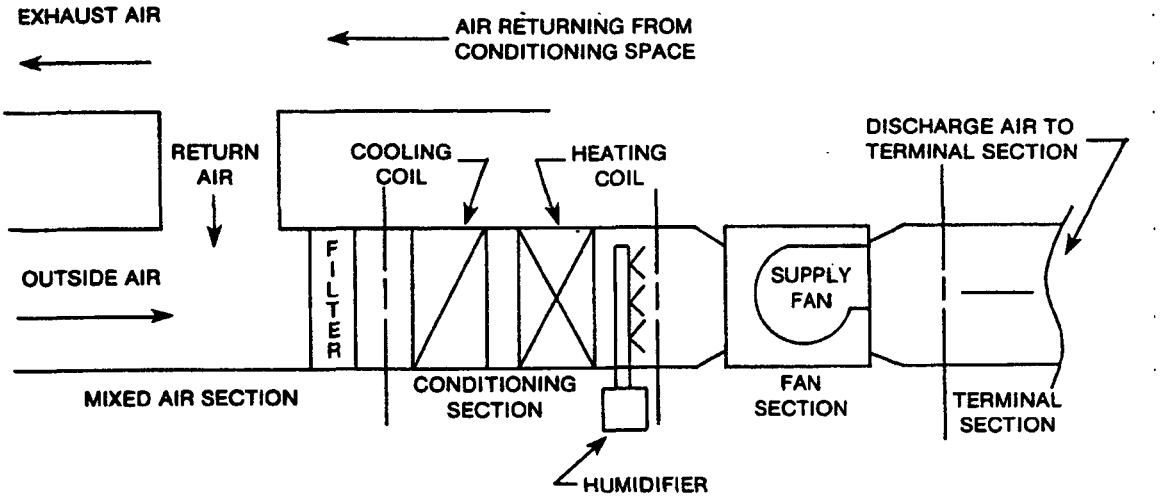

Figure 5–1: Typical Air Handling System

5.2 MIXED AIR SECTION

5.2.1 This section consists of a plenum where recirculated (return) air and fresh (outside) air are introduced and mixed. A filter removes dirt, dust and other airborne particles from the air before it enters the conditioning section.

5.3 CONDITIONING SECTION

5.3.1 The conditioning section generally consists of a heating coil, a cooling coil, a humidifier or any combination thereof. These coils may be arranged in series, in parallel or in a combination of series and parallel.

5.3.2 The cooling coil lowers the temperature of the air passing through it either by using chilled water or direct expansion of a refrigerant gas supplied from a remote refrigeration compressor.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

5.3.3 The heating coil raises the temperature of the air passing through it by means of steam, hot water, or electric heaters.

5.3.4 A humidifier is used to add moisture. A humidifier adds dry steam directly into the air stream. A humidifier will be shut off whenever the system supply fan is not running to avoid moisture damage to the duct system.

5.4 FAN SECTION

5.4.1 This section consists of one or more fans powered by a single electric motor. The fan section may be placed either before or after the conditioning coils.

5.4.2 The fan section may include a device to regulate the static pressure developed by the fan. The device might be an inlet vane (vortex) damper, discharge damper, suction damper, or a device to regulate the fan speed.

5.5 TERMINAL SECTION

5.5.1 This section controls the volume or the final conditioning of the air before it is supplied to the conditioned space. Sometimes terminal devices are located in the same mechanical equipment room that houses the air handler. More often, terminal devices are located remote from the individual spaces that they serve. These terminal devices can be reheat coils, mixing boxes, variable volume boxes and induction units.

5.6 KEY PARAMETERS

5.6.1 The capacity of air handling systems are typically rated in cfm (cubic feet per minute). This is determined by multiplying the cross sectional area of the duct in square feet times the velocity of the air in feet per minute. (Note for a metric system the capacity is rated in cubic meters per second.)

5.6.2 Air velocities used in the duct systems are typically 500 ft./min. (2.54 m/s) which is the rating for most of the heating and cooling coils used in the systems. Higher velocities may be encountered in applications where air must be moved through longer ducts. Maximum velocities encountered there can be as much as 4500 ft./min. (22.9 m/s). The air velocity in the supply (fan discharge) side will be larger than in the return side. Velocities in the return side may be as low as 200-300 ft./min. (1.02 - 1.52 m/s).

5.6.3 The range of sizes in duct work varies greatly. The smaller ducts are similar in size to the air ducts used in residential dwelling and may be less than 1' x 1' (.3m x .3m). The maximum duct sizes used in large air handling systems are:

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

System Type	Supply Side	Return Side
High Pressure	8' x 8' (2.78m x 2.78m)	Can be very large, '12 x12' (4.18m x 4.18m) or more.
Low Pressure	6' (2.09m) diameter	

5.6.4 The air pressure inside a duct with respect to the air pressure outside the duct is positive on the supply side of the fan and is negative on the return side.

PRESSURE IN INCHES H_20 (kPa)*

System Type	Supply Side		Return Side	
	Max In	Typical	Max In	Typical
High Pressure	+5 (1.24)	4.0 (.99)	-2 (.50)	-1 (.25)
Low Pressure	+2 (.50)	+1.5 (.37)	-2 (.50)	-1 (.25)

***(1" H_20 = .2486 kPa)**

5.6.5 The temperature inside the duct of an operating air handling system will be between 42°F and 180°F (5.6°C and 82.2°C). Cooling applications will have the lowest temperatures. For heating applications, the typical temperature will be about 100°F (37.8°C). The 180°F (82.2°C) is fairly unusual and will be encountered only in areas near a steam coil.

(a) When the fan is off, temperatures in the vicinity of a steam coil may reach 240°F (115.6°C). A device located here may be even warmer due to radiation from the steam coil.
(b) The temperature of the air in the mixed air and outside air sections are affected by the outdoor temperature. In very cold climates, the temperature in these sections can get as low as -40°F (-40°C).

5.6.6 The expected range of temperature surrounding the duct system is:

Indoor areas 45°F to 120°F (7.2°C to 48.9°C)
Outdoor areas -40°F to 160°F (-40°C to 71.1°C)

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 6

HOW DUCT DETECTION SYSTEMS ARE USED TO CONTROL SMOKE

6.1 GENERAL

6.1.1 An HVAC system supplies conditioned air to virtually every area of a building. Smoke introduced into this air duct system covers the entire building. Smoke detectors designed for use in air duct systems are used to sense presence of smoke in the duct.

6.2 NFPA 90A, 1999 edition

6.2.1 NFPA 90A Standard for the installation of Air Conditioning and Ventilating Systems, requires that smoke detectors listed for duct installations be installed:

(a) Downstream of the air filters and ahead of any branch connections in air supply systems having a capacity greater than 2000 cfm (944 L/s).

(b) At each story prior to the connection to a common return and prior to any recirculation or fresh air inlet connection in air return systems having a capacity greater than 15,000 cfm (7080 L/s) and serving more than one story.

Exception No. 1: Return system smoke detectors shall not be required where the entire space served by the air distribution system is protected by a system of area smoke detectors.

Exception No. 2: Fan units whose sole function is to remove air from the inside of the building to the outside of the building.

6.3 TYPICAL SINGLE-ZONE HVAC SYSTEM

6.3.1 Figure 6-1 shows a typical single zone HVAC system.

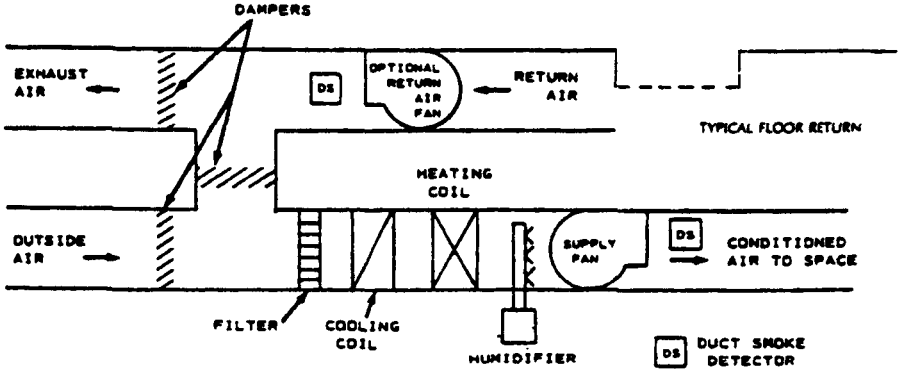

Figure 6–1: Typical Single Zone System

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

6.3.2 A return air fan is not used in all systems. Detectors may be placed in the outdoor air supply to sense if smoke is being drawn into the system from outside the building. It would then close the outdoor air damper allowing the rest of the HVAC system to continue operating.

6.3.3 In the typical fan system shown in Figure 6-1, when any duct smoke detector senses smoke, the fan system will be turned off and all the dampers shown will go to their closed positions. These actions are intended to prevent smoke from being distributed via the air handling system to unaffected areas of a building.

6.3.4 An alternate method that may be used is to only stop the supply fan and keep the return fan running. In this method, the outdoor air damper and the mixed air damper go closed and the (exhaust) air damper is opened. This technique will help exhaust smoke-laden air from the building.

6.3.5 In addition to the requirements of NFPA 90A 1999 edition, duct smoke detectors may also be used within the duct systems as detection devices in engineered smoke control systems. These systems are engineered for the specific building. They use the building construction and air handling systems to contain and reduce the spread of smoke.

6.3.6 NFPA 90A,4-4.4.2 requires that where an approved protective signaling system is installed in a building, the smoke detectors required by the provisions of Section 4-4 shall be connected to the protective signaling system in accordance with the requirements of NFPA 72, National Fire Alarm Code. Smoke detectors used solely for closing dampers or heating, ventilating, and air conditioning system shutdown shall not be required to activate the building evacuation alarm.

6.4 TYPICAL FAN CONTROL CIRCUIT

6.4.1 Figure 6-2 shows a typical fan control circuit.

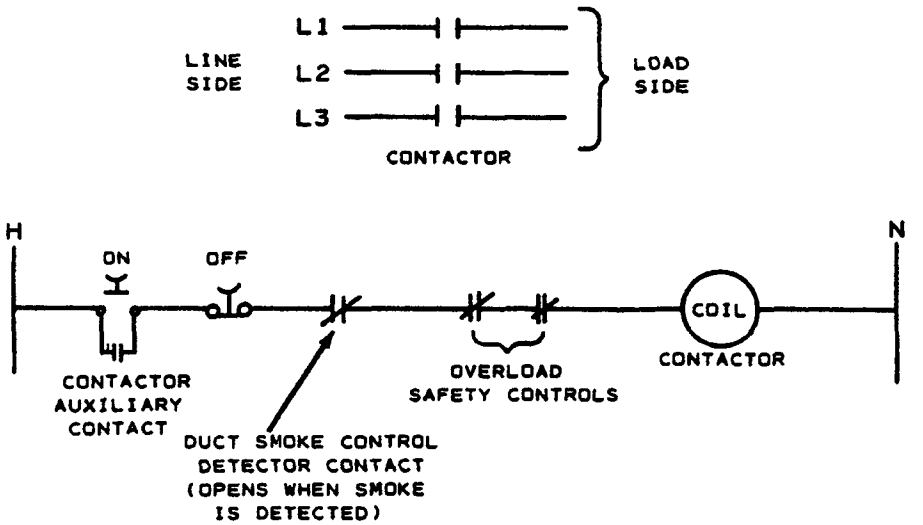

Figure 6–2: Typical Fan Control Shut Down Circuit

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 7

PROCEDURE FOR DUCT DETECTOR APPLICATION AND INSTALLATION

7.1 APPLICATION

7.1.1 Select supply and exhaust ducts to be smoke detector monitored.[1]

7.1.2 Locate supply or exhaust input/output ports, filters, diluters, dampers, chillers, heaters, humidifiers, dehumidifiers, air cleaners, control devices, deflectors, bends, and restrictors in engineering drawings and specifications.

7.1.3 Supply duct installation should be downstream of fan, filters, chillers, heaters, and humidifiers.

7.1.4 Duct detectors in the return air stream should be located at every return air opening within the smoke compartment, or where the air leaves each smoke compartment, or in the duct system before the air enters the return air system common to more than one compartment.

7.1.4.1 **EXCEPTION**: Additional smoke detectors are not required to be installed in ducts where the air duct system passes through other smoke compartments not served by the duct.

7.1.5 Location of detectors mounted in or on air ducts should be at least six duct widths downstream from any duct openings, deflection plates, sharp bends, or branch connections.

7.1.5.1 **EXCEPTION:** Where it is physically impossible to locate the detector accordingly, the detector can be positioned closer than six duct widths, but as far possible from the opening, bend, or deflection plates.

7.1.6 Upon selection of location for duct detector installation, drill hole into duct and measure duct air velocity, humidity, and temperature. Refer to duct instrumentation for instrument use in this manual.

7.1.7 Measure room temperature and humidity in area of intended duct detector installation.

7.1.8 Detectors should be listed by a third party testing laboratory for the environment measured in the duct and room at the installation location. The detector should be relocated if measurements fall outside of rated limits.

[1]See NFPA 90A 1999 edition for details of where duct smoke detectors can be eliminated in systems of less than 15,000 cfm capacity or in buildings equipped with a system of smoke detectors providing total area coverage.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

7.2 INSTALLATION OF IN-DUCT DETECTOR

7.2.1 Installation of duct detectors may be within the duct, protruding into the duct, or mounted in an enclosure with sampling tubes protruding into or traversing the duct.

7.2.2 Drill only required holes for duct installation. A template should be provided to locate mounting holes for detector enclosure, sampling tubes, access panels, or doors and to give specified hole diameters and/or duct entry dimensions.

7.2.3 Detector installation within the duct can be of the pendant or beam types.

7.2.3.1 The pendant duct detector should be mounted to an appropriate electrical box. The box pendant extension arrangement should be mounted from either the top or side walls extending to the center of the air duct stream.

7.2.3.2 Access panels or doors are incorporated in the duct side walls and are used during installation and for maintenance and test. They are required by NFPA 72, Section 2-10.5.3 and NFPA 90A, Section 2-3.4.1.

7.2.3.3 A "in-duct" detector arrangement should be mounted rigidly to withstand the pressure and resonant vibrations caused by the air velocity. (See Figure 7-1.)

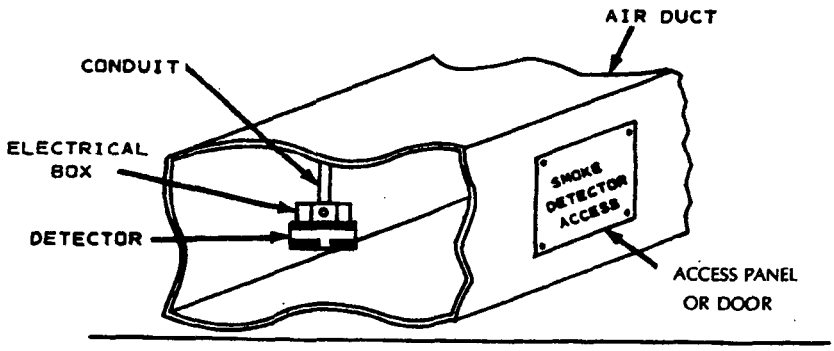

Figure 7-1: "In-Duct" Air Duct Installation

7.2.4 Following are procedures that will aid in properly installing smoke detectors that mount to the side of the duct and sample smoke via tubes that project into the duct.

7.2.4.1 A well placed duct detector monitors representative samples of air flowing through a duct. While any air sample may seem sufficient, there are several problems which should be dealt with:

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Dilution — Outside air, if mixed with circulated air, can dilute combustion particle concentration and can prevent a detector from sensing a fire condition. Remember that detectors will alarm only when combustion particles constitute a specified percentage of air being sampled. To avoid dilution, **detectors should be located ahead of fresh air intakes and ahead of the exhaust air output.**

Stratification — Detector placement should be such that there is uniform air flow in the cross section area. In practice, this ideal condition may not always be achievable. The distance from a bend or vent is usually given as a multiple of duct width or diameter. Within a duct, air and combustion particles may stratify in such a way that proper sampling cannot take place. The wider the duct, the greater the possibility of stratification taking place. **A method of getting a representative air sample is to locate a duct detector just after a bend in the duct or after an air inlet which creates turbulence.** (See Figure 7-2.) A distance of **six duct widths** should separate the duct housing from the bend or inlet. See 7.1.5.1. for exception.

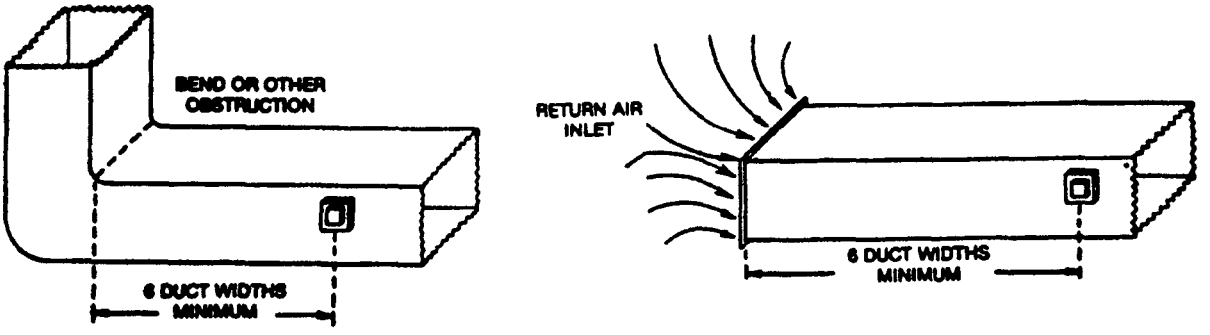

Figure 7–2: Typical Duct Detector Placement

Excess Humidity — As with open area detectors, high levels of humidity or condensation within the duct can cause nuisance alarm problems. Duct detectors should be located at a minimum of ten feet **downstream** from humidifiers.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Air Filters — Air filters within ducts tend to collect paper, lint and trash - and all flammable materials. For this reason, duct detectors should be located on the downstream side of filters.

Air Velocity — Duct smoke detectors are usually designed to be used in air handling systems having a certain range of air velocities. Be sure to check engineering specifications to make sure duct air velocity does not exceed or fall below these parameters.

Placement — Duct detector assemblies mounted within the duct should be located on the sides or suspended from the top of a duct. Detectors designed for use in open air applications should not be used inside a duct in place of a duct detector.

7.2.4.2 Duct detectors mounted in an enclosure with sampling tubes can be installed onto any wall of the duct unless otherwise restricted by the manufacturer's instructions.

7.2.4.3 Select sampling tube length for duct enclosure installation. If duct is more than three feet wide, drill an appropriate diameter hole directly opposite to support sampling tube of lengths longer than three feet.

7.2.4.4 Exhaust tube length is not usually a critical dimension. It may vary from a stub to the full width of the duct. Be sure to follow the recommendations of the manufacturer regarding the exhaust tube.

7.2.4.5 Install the sampling and exhaust tubes to the mounting holes on the duct enclosure.

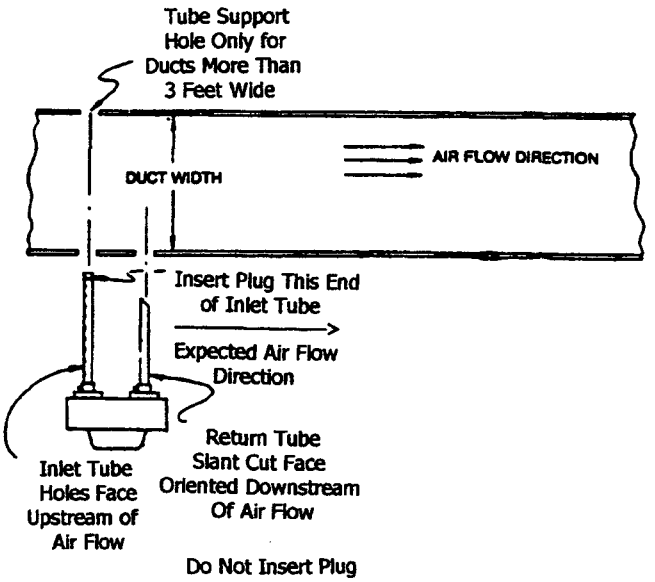

Figure 7–3: Inlet Tube Orientation

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

7.2.4.6 Tubes may be marked or, as indicated in manufacturer's installation instructions, provided with inhibitors to ensure that the tubes are installed in their proper duct input and output ports.

7.2.4.7 Position holes or openings along the length of the sampling tube in the direction of airflow. Secure the tube position with locking means provided. A tube visual indicator should be provided to indicate the tube hole location without dismantling the duct installation.

7.2.4.8 Position holes or openings along the length of exhaust tube in the downstream direction of airflow. Secure the tube position with locking means provided. A tube visual indicator should be provided to indicate the tube hole location without dismantling the duct installation.

7.2.4.9 Plug sampling tube end with air stopper.

7.2.4.10 The duct smoke detector enclosure and sampling tubes should be mounted rigidly to prevent noise chatter and mechanical fatigue.

7.2.4.11 Air leaks should be avoided. Air leaks in or out of the duct or detector will dilute or redirect smoke within the duct. Gaskets and duct seal can be used to avoid or seal any leaks.

7.2.4.12 If the duct sampling tube protrudes through opposite side of the duct, seal the opening around the tube on the outside of the duct with duct sealant.

7.2.4.13 After mounting the duct enclosure to the duct and installing the sampling and exhaust tubes, verify that there is air flow through the duct detector. This is accomplished by measuring the static pressure difference between the inlet and outlet tubes using a manometer as illustrated in the instrument section of this manual. If the pressure differential cannot be attained check for leaks, proper orientation of hole placement on exhaust and sample tubes, air velocity, and stratification of airflow in the duct. Relocate the duct detector installation if pressure differential specified by the manufacturer cannot be attained after checking all possible fault causing problems.

7.2.4.14 Prior to completing the installation, clean the duct enclosure, and check indicators for hole orientation.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

7.3 DUCT INSTRUMENTATION

7.3.1 Pressure Reading Instruments

7.3.1.1 Used for reading:

- Air velocities in ducts.
- Pressure drops across components.

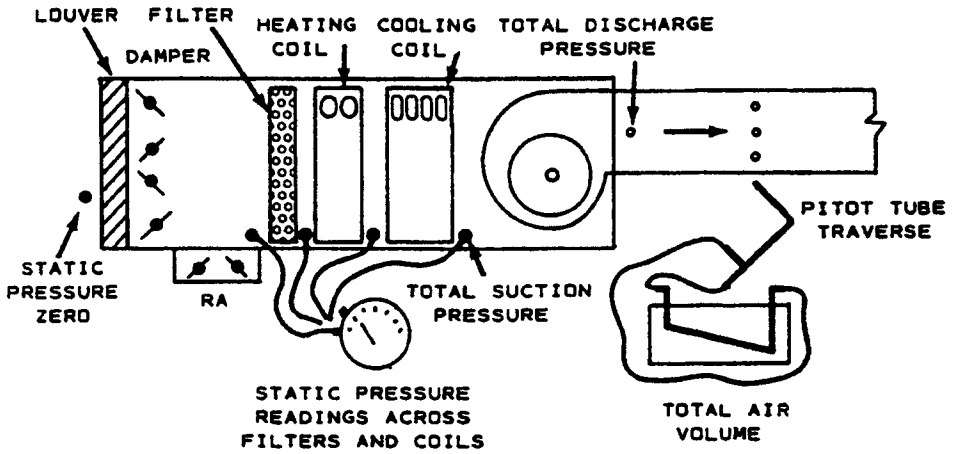

Figure 7–4: After electrical and rpm readings are taken the total volume of air, fan pressure and pressure drops are read.

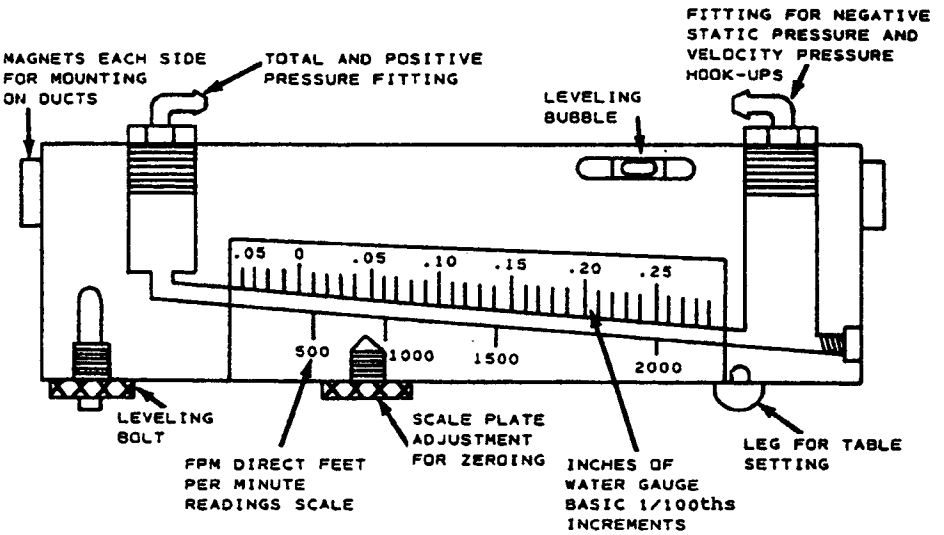

Figure 7–5: 115-AV inclined manometer for velocity pressure readings in low velocity ducts, 400 to 2000 fpm

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

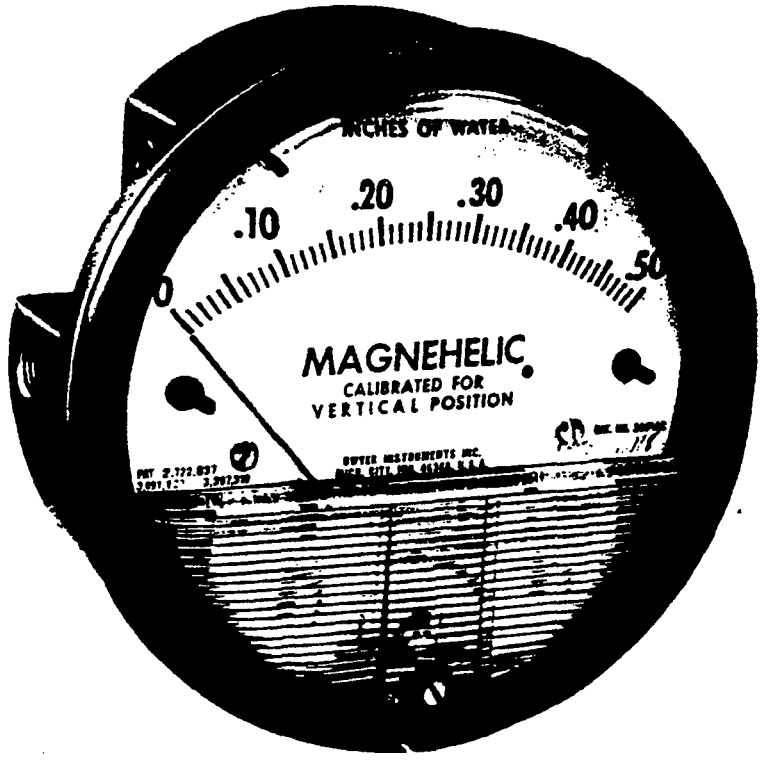

Figure 7–6: Magnehelic gauge for reading static pressures in air systems

7.3.1.2 Instrument readings taken by:

- Inclined liquid manometer.
- Vertical liquid manometer.
- Pressure differential gauges.
- Micrometer liquid hook gauge.

7.3.1.3 Manometer gauges are used in conjunction with pitot tubes, straight metal tubes and various static pressure sensors.

7.3.1.4 Pressure drops are best read with a magnehelic gauge. For lower velocity readings in the range between 400 and 2000 fpm a 1/4 inch manometer is the most accurate instrument to use along with the pitot tube. For higher velocity readings in ducts the 10 inch vertical or the one inch inclined manometer is required. See Figure 7-4 for example of manometer and gauge use. See Figure 7-5 for inclined manometer type, and Figure 7-6 for magnehelic gauge.

7.3.2 Air Velocity Reading Instruments:

7.3.2.1 Used for reading:

- Air flow through duct openings.
- Air flow through duct filters, coils, louvers.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

7.3.2.2 Instrument readings taken by:
- Velometer.
- Thermo-Anemometer.

7.3.2.3 The thermo-anemometer is illustrated in Figure 7-7.

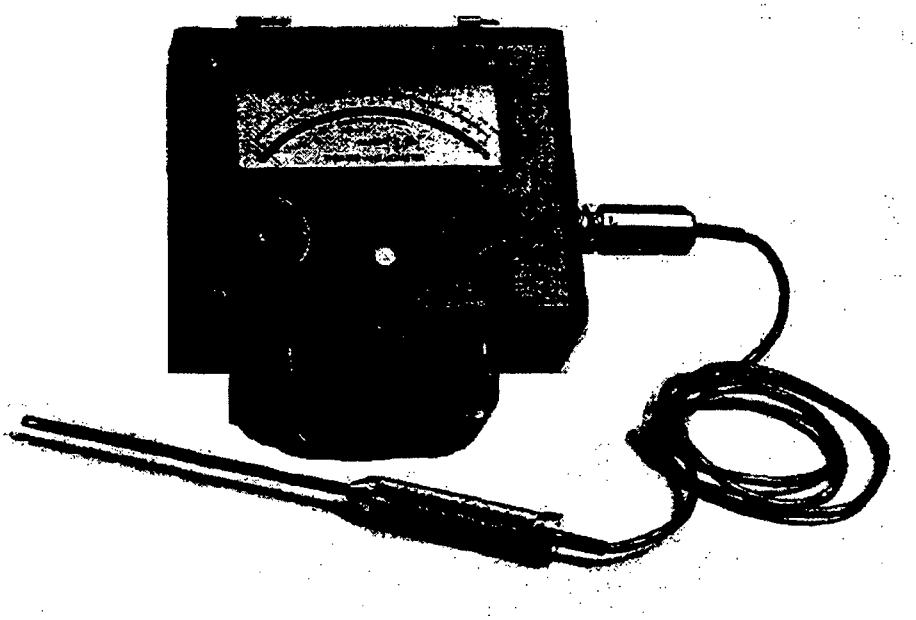

Figure 7–7: Thermo-Anemometer

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

SECTION 8

TESTING, MAINTENANCE AND SERVICE OF DETECTORS FOR USE IN DUCTS

8.1 GENERAL

8.1.1 Smoke detectors are designed to be as maintenance-free as possible. However, dust, dirt and other foreign matter can accumulate inside a detector and change its sensitivity; this is especially true with duct type smoke detectors. They can become either more sensitive, which may cause unwanted alarms, or less sensitive which may reduce the level of protection. Both are undesirable. Therefore, detectors should be tested periodically and maintained at regular intervals. Closely follow the manufacturer's specific recommended practices for maintenance and testing. Also refer to Section 4-4 and Appendix B of NFPA 90A and Chapter 7 of NFPA 72.

8.2 TYPICAL MAINTENANCE PRACTICES

8.2.1 Under normal conditions detectors should be given routine maintenance at least twice a year, more frequently in dirtier than normal environments.

8.2.2 Notify the proper authorities that the smoke detector system is undergoing maintenance, and therefore the system will temporarily be out of service. **CAUTION: Disable the zone or system undergoing maintenance to prevent unwanted alarms and possible dispatch of the fire department.**

8.2.3 Most duct smoke detectors have detector heads that can be accessed for cleaning. Use a vacuum cleaner and remove dust from the detector by placing the nozzle as close as possible to the openings in the outside housing. A nozzle with a brush attachment will assist in dust removal. Some detectors can be removed for more thorough cleaning; refer to manufacturer's recommended procedure for details. Also check the sampling tube holes to make sure they are not clogged.

8.2.4 Test each detector's sensitivity.

8.2.5 If a detector's sensitivity is within specifications, nothing further need be done to the detector. If the detector's sensitivity is outside specifications, replace the detector or follow the manufacturer's recommended procedure.

8.2.6 Restore zone or system at the completion of testing.

8.2.7 Notify the proper authorities that testing has been completed and that the system is again operational.

8.2.8 Other checks that should be made during maintenance procedures:

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

- Holes or cracks in duct work near vicinity of detector.
- Air leaks where detector housing or sampling tubes are attached to duct.
- Dust accumulations in or on sampling tubes, sampling tube filters, and detector head.
- Wiring terminal screws tightness.

8.3 TYPICAL TESTING PROCEDURES

8.3.1 All detectors should be:

(a) tested or inspected at least annually to ensure that they sample the air stream.
(b) tested at least annually, by causing them to initiate an alarm at their installed location to assure that they are operative and produce the intended response.
(c) sensitivity checked within one year after installation and every alternate year thereafter. (See NFPA 72,7-3.2.1).

8.3.2 It is not recommended that actual duct fires be used to test duct smoke detectors. This procedure does not provide a consistent, measurable method of determining if the detectors are performing properly. Using the test procedures and test equipment recommended by the detector manufacturer is the best way to test these detectors.

8.3.3 Most detectors are equipped with a built-in test mechanism, electronic metering equipment, or aerosol test apparatus; refer to manufacturer's specifications for details.

8.3.4 Notify the proper authorities that the smoke detector system is being tested. All persons who would automatically receive a real fire alarm signal should be notified to prevent an unnecessary response.

8.3.5 Follow the manufacturer's recommended test methods.

8.3.6 If a detector functions properly and its sensitivity is within specifications, nothing further need be done to the detector. However the Routine Maintenance Procedure (described in Section 8.2) is recommended. If a detector's sensitivity is not within specifications, it should be replaced, or refer to manufacturer's recommended procedure.

8.3.7 Restore the zone or system at the completion of testing.

8.3.8 Notify all the persons notified at the beginning of the test that testing has been completed and the system is again operational.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

8.4 RECOMMENDED TESTING AND MAINTENANCE LOG PROCEDURES

8.4.1 It is recommended that a permanent Detector Test Log be set up and maintained, with a record for each individual smoke detector in each building. Each detector should be clearly described, with information on the type of detector, the model number, the serial number (if any), the location, and the type of environment. Data entries should include test dates, type of test mode, test results, maintenance, and comments. A sample detector test log page is shown on the following page.

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

DETECTOR TEST LOG

Detector Identification Information

Manufacturer and Detector Model: _____ Serial Number:_____ Date Installed:_____

Description of Detector Location:

Example: 3rd Floor of west wing in elevator lobby

_____

_____

_____

Test Results and Maintenance Data

Date Tested	Test Mode	Test Results	Maintenance Performed	Comments
Example: 8/5/99	detector test button	passed	none	

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale

Copyright National Electrical Manufacturers Association
Provided by IHS under license with NEMA
No reproduction or networking permitted without license from IHS
Not for Resale