

HVAC DUCT SYSTEMS INSPECTION GUIDE



**SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.**

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THIRD EDITION – 2006



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**4201 Lafayette Center Drive
Chantilly, VA 20151-1209
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4201 Lafayette Center Drive
Chantilly, VA 20151-1209

Printed in the U.S.A.

FIRST EDITION – 1989
SECOND EDITION – JUNE 2000
2ND PRINTING – SEPTEMBER 2001
THIRD EDITION – 2006

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FOREWORD

One definition of inspect is “to view closely and critically.” In building construction the term “inspection” brings to mind many other terms: completeness, compliance, conformance, quality assurance, design deficiency, oversight, neglect, unauthorized substitution, defects and omissions, punch list, responsible party, call back, and payment retention. In any case the mechanical systems inspector plays an important role in contract compliance or code compliance verification. Knowledge and reasonableness are prerequisites for employment in this capacity. This guide is based on the assumption that SMACNA duct construction standards and installation recommendations are linked to contract or code compliance. It is an administrative guide to the inspection of duct systems. It can serve as a study guide for those needing an introduction to the functions of duct systems, to the nature of ductwork, and to the SMACNA documents it previews. Study of the complete texts of the excerpted editions is necessary and encouraged. Familiarity with all of the documents that regulate duct system installation will enable inspectors to develop their own checklists and to establish scales of importance that are consistent with their duties.

NOTE: The provisions herein are not intended to constitute contract requirements in and of themselves. The SMACNA manuals to which this guide refer contain many alternative constructions. They also contain many details that are obligatory. Other details are left to the prudent judgement of the contractor. Thus, this document is no substitute for familiarity with all of the provisions in the other manuals.

The following SMACNA manuals are excerpted within this guide:

- HVAC Duct Construction Standards, Third Edition, 2005
- Fibrous Glass Duct Construction Standards, Seventh Edition, 2003
- Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems, Fifth Edition, 2002

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CHAPTER 1

SCOPE

1.1 SCOPE

This document gives reasons for doing inspections of air handling systems, provides outlines that can be used to organize and conduct inspections, and sets forth checklists that call attention to the basic features of ductwork and items placed in duct systems.

It presumes that *SMACNA's construction standards are used as the basis of compliance*, whether they are explicitly invoked in contract documents or in codes. No attempt is made to segregate designer's inspection obligations from those of code officials.

It is primarily prepared for commercial HVAC systems; however, similar principles would apply for residential or industrial work inspection. Furthermore, it assumes that prescription specifications apply rather than performance specifications. Performance specifications typically call for HVAC systems to maintain control of the environment within certain tolerances. Whether the duct system has the specified airflow rate, maintains air temperature, humidity, degree of cleanliness, etc., or whether it controls room air motion and pressure differentials in relation to adjacent spaces are separate matters of design and testing and balancing that are already dealt with in numerous handbooks and standards. An overview of the functions of duct systems is given in Appendix A.

Finally, although this document covers some items that are safety related, this document is not a safety inspection guide. It is presumed that the applicable codes and system designs that are allowing use of the SMACNA standards and manuals address safety issues independently.

1.2 WHAT IS THE PURPOSE OF INSPECTION?

The purpose of inspection is to determine if the construction and installation comply with the documents for which the inspector is responsible.

1.3 WHAT IS THE VALUE OF INSPECTION?

The value of inspection is the assurance that the materials and assemblies purchased are either provided and available or that defects and omissions are documented.

1.4 WHAT IS THE COST OF INSPECTION?

The cost of inspection includes the expense for the manpower, travel, tools, tests, and report preparations necessary to conduct adequate investigations of construction that is in progress or presumably completed.

1.5 DOES THE TIMING OF INSPECTIONS AFFECT CONSTRUCTION COSTS?

The timing of inspections has a definitive impact on construction costs. The work that will be concealed or inaccessible for inspection after installation should be inspected while work is in progress. Delay in construction progress may occur if further work has to be suspended pending inspection. Correcting deficiencies after installations are complete is expensive and time consuming; it may affect the work of several trades; it may result in delays in payment or in contract close-out; it can even result in delayed occupancy or delayed use of the facilities.

1.6 WHAT RISKS ARE INVOLVED WHEN INSPECTIONS ARE NOT DONE OR ARE NOT DONE PROPERLY?

Some of the risks involved when inspections are not done or not done properly are:

- a. Less qualified or less scrupulous contractors will gamble that omissions and defects will go undetected and will under-price the work or make excessive profits
- b. Owner dissatisfaction will lead to litigation
- c. Occupant dissatisfaction with indoor air quality and safety can result
- d. Disruptive delays in occupancy and use can occur
- e. Expensive corrective work at a later date will be required
- f. Hazards that should be detected are not
- g. The inspector's employer will have liability for consequences of delay and damage or loss
- h. Adverse publicity can disrupt normal business practices
- i. Bonding companies may have to complete the project



- j. Different insurance will be needed than was anticipated.

1.7 WHAT QUALIFICATIONS ARE NEEDED BY INSPECTORS?

Some of the qualifications needed to inspect are:

- a. Knowledge
- b. Experience
- c. Respect for limits of authority
- d. Reasonableness.

1.8 HOW DO I USE THIS GUIDE?

This guide is intended to acquaint inspection officials, designers, and contractors with the basic features of duct construction, equipment connections to ducts and items inserted in ducts as they are found in the SMACNA manuals.

NOTE: The provisions herein are not intended to constitute contract requirements in and of themselves. The SMACNA manuals to which this guide refer contain many alternative constructions. They also contain many details that are obligatory. Other details are left to the prudent judgement of the contractor. Thus, this document is no substitute for familiarity with all of the provisions in the other manuals.

The following SMACNA manuals are excerpted within this guide:

- *HVAC Duct Construction Standards, Third Edition, 2005*
- *Fibrous Glass Duct Construction Standards, Seventh Edition, 2003*
- *Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems, Fifth Edition, 2002*

However, this guide does provide a framework of knowledge and perspective that should provide a “feel” for construction that complies with SMACNA standards. When something is found on a job site that doesn’t “look like” what is described herein, the inspector should examine a specific submittal, shop drawing, coordinated drawing, standard, or code to ascertain whether the installation is or is not in compliance. Otherwise, the checklists are useful in surveying the contract documents to find the subjects that are actually in a specific project. Edited versions of them

can be created in the office environment so that they, along with any necessary documents, can be taken to a construction site to perform inspections.

Inspection plays a vital role in contract compliance and it assures that quality and performance are consistent with the design. It has recognizable dollar value that owners and citizens can recognize and appreciate.

1.9 DUCT INSPECTIONS OVERVIEW

Some guidelines for a duct inspection are presented below:

- a. Prerequisites for conducting inspections:
 1. Possess *general knowledge* of the craftsmanship of ducts
 2. As applicable, conduct thorough examination of contract *plans, specifications, change orders, submittals, code requirements, and standards* invoked by these documents
 3. Identify *framing* requirements and *fire stopping* for ducted penetrations of building structures and review *clearances* to combustible materials
 4. Prepare *lists* of items to be inspected
 5. Anticipate *work progress schedules*, particularly for ductwork that will be inaccessible after concealment or invisible after insulation is applied
 6. Clarify *authority* to approve, inspect, reject, and suspend work and to withhold occupancy permits.
- b. Arrange a meeting when possible between Inspector(s) and Job Supervisors prior to beginning installation to review the complete requirements for ductwork.
 1. **Materials**
Review requirements
 2. **Duct Construction Schedules**
Review wall thickness, reinforcements, joints and seams, and pressure classification as applicable to each system
 3. **Duct System Supports**
Review support methods for ducts and apparatus to which they connect

4. **Flexible Duct/Connector**
Review length, type, configuration, support, and requirements for listing and labelling of flexible ducts and flexible connectors
 5. **Sealants**
Review types and required use of sealants, as needed, for ducts, fittings, connections, and casing
 6. **Barrier Penetrations**
Review methods of penetrating fire and smoke barriers
 7. **Access**
Review maintenance access requirements and size and location of access doors
 8. **Air Terminals**
Review provisions for locating and supporting grilles, diffusers, and registers
 9. **Volume Control Devices**
Examine methods of automatic or manual balancing of airflow in systems
 10. **Building Compartment Leakage**
Investigate the airtightness of building compartments to be pressurized under emergency mode situations
 11. **Plenums**
Review construction of field erected plenums and casings and clearances for maintenance and operation within these
 12. **Special Duty Systems**
Give due attention to special duty systems such as grease hood and fume hood exhausts, dishwasher and shower room exhausts, engineered smoke control systems, etc.
 13. **Insulation**
Review the types and methods of insulation
 14. **Tests**
Determine what tests are required, any concealment contingencies, what reports are to be filed, and what witnessing, if any, is required.
- c. Conduct appropriate periodic inspections using checklists.
1. Visually inspect the installation
 2. Witness qualification and operating tests as required
3. Look for labels and imprintings that are required for factory-made products
 - d. Give contractors appropriate and timely notice of deficiencies and omissions.
 - e. Special Notices:
 1. The designer of an air system is required to *show the locations and mounting arrangement* of all fire dampers, smoke dampers, through-penetration firestops, and similar protection means *on the contract drawings*. This is usually required in codes as a prerequisite for construction permit issuance. Likewise, he is required to show on the contract drawings all air volume regulating devices required to balance the system. SMACNA strongly endorses a contractor's right to an equitable contract adjustment for all such devices not shown on the contract drawings.
 2. The use of gypsum wallboard as duct material is relatively rare. Construction standards for such use, except as air shafts, do not exist. Temperature, humidity, leakage, and damage susceptibility are all factors that limit its use in applications other than ceiling plenums and air shafts. Limitations in the specific code should be checked.
 3. The duct may be only designated to be "reasonably airtight." This terminology is commonly found in mechanical codes and in fire protection related standards such as NFPA 90A. Since it has no quantitative evaluation criteria it means that whatever leakage results from using the prescribed duct construction methods and good workmanship is acceptable. Good workmanship would be that perceived to be such in the trade.

SMACNA manuals do not set allowable leakage rates or require leakage tests. It is the system designer's duty to prescribe these if needed. Comprehensive analysis of leakage, leakage rates expected in sealed and unsealed ducts, leakage classifications, and test procedures are in the SMACNA HVAC Air Duct Leakage Test Manual. SMACNA does not designate specific methods of sealing.



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CHAPTER 2

COMPLIANCE AND QUALITY CONTROL

.....

2.1 COMPLIANCE AND QUALITY CONTROL

Although knowledge of the details in the construction standards is the ultimate basis of quality control, installations should also be checked by routinely looking for the presence or absence of general features that reflect the level of quality.

2.2 CHECKLISTS

The following checklists provide information and compliance and quality control. Not all projects will have all items listed in the checklist.



SPECIAL CONDITIONS REVIEW CHECKLIST

- ☐ Duct pressure classes are clearly given on the drawings or in the specifications for each system.
- ☐ The amount of sealing is specified or an allowable leakage rate is given.
- ☐ Field tests other than testing and balancing are required.
- ☐ The configuration of duct fittings is specified. It is determined by:
 - ☐ design documents
 - ☐ clarification by submittals
 - ☐ contractor's choice of options in the SMACNA manuals.
- ☐ As-built ductwork deviates from the design documents. It was influenced by:
 - ☐ obstructions
 - ☐ crowded conditions
 - ☐ equipment that was relocated
 - ☐ approved submittals
 - ☐ change orders.
- ☐ Ducts are not penetrated by anything other than piping, wiring, or tubing that is a necessary part of the HVAC system.
- ☐ The project requires seismic restraints on mechanical systems.
- ☐ Ductwork is not supporting items that are not of the sheet metal trade.
- ☐ Air passageways in return air ceilings and in shafts are not blocked.
- ☐ There is sufficient space in and behind access doors or panels in ceilings, walls, and shafts to allow a person to perform maintenance on the HVAC system devices that require it.
- ☐ Maintenance access in ducts is provided. Its form is:
 - ☐ hinged panels
 - ☐ lift off panels
 - ☐ removable sections of ducts.
- ☐ Automatic monitoring devices to be mounted in or on ducts are present and operable:
 - ☐ fire stats
 - ☐ freeze stats
 - ☐ smoke detectors
 - ☐ fail-safe air flow switches
 - ☐ damper position indicators.
- ☐ Early occupancy and warranty period adjustments.
- ☐ Owner's operating and maintenance instructions:
 - ☐ by designers
 - ☐ by contractors.

DUCT SYSTEM INSPECTION CHECKLIST



ACCEPTABLE



DEFICIENT

REASON:

RIGID DUCTWORK

- ☐ Pressure Class
- ☐ Duct Wall
- ☐ Joints
- ☐ Seams
- ☐ Reinforcements
- ☐ Tie Rods
- ☐ Crossbreak/Bead
- ☐ Sealing
- ☐ Hanger/Support
- ☐ Insert/Anchors
- ☐ Duct Liner
- ☐ Liner Adhesive
- ☐ Liner Pins
- ☐ Hangers
- ☐ Elbows
- ☐ Turning Vanes
- ☐ Transitions
- ☐ Trunk-Branch Fitting
- ☐ Branch Connection
- ☐ Extractors

- ☐ Splitters
- ☐ Volume Dampers
- ☐ Tap Collars
- ☐ Terminal Connection
- ☐ Equipment Connection
- ☐ Access Doors
- ☐ Fan Inlet
- ☐ Fan Outlet
- ☐ Belt Guards
- ☐ Vibration Connection
- ☐ Air Intake
- ☐ Louvers
- ☐ Air Exhaust
- ☐ Curbs
- ☐ Flashing
- ☐ Casing
- ☐ Plenum
- ☐ In Slab
- ☐ Underground
- ☐ Paint/Coatings
- ☐ Weatherproofing

T = Type
A = Attachment
I = Incomplete
SP = Spacing
M = Material
R = Rating

S = Size
L = Location
C = Corrosion
U = Unclean
D = Damage

DEFECT LOCATION AND
COMMENT (write in)

FIRE/SMOKE DAMPERS

- ☐ Location
- ☐ Sleeves
- ☐ Connections
- ☐ Retaining Angles
- ☐ Clearances
- ☐ Control Means
- ☐ Access

MISCELLANEOUS

- ☐ Grease Duct
- ☐ Range Hood
- ☐ Breeching
- ☐ Furnace Vent
- ☐ Chimney
- ☐ Fume Hood
- ☐ Dishwasher Exhaust Duct
- ☐ Air Shaft
- ☐ Through-penetration Firestop
- ☐ Insulation
- ☐ Ceiling Plenum Contents
- ☐ Pressurized Exit
- ☐ PVC Duct
- ☐ FRP Duct
- ☐ Maintenance Access

FLEXIBLE DUCT

- ☐ Duct Grade/Class
- ☐ Connector Grade
- ☐ UL/Other Label
- ☐ Excess Tension
- ☐ Excess Sag
- ☐ Supports
- ☐ Bend Radius
- ☐ 2 in. (51 mm)
- ☐ Metal Collars
- ☐ Damage

JOB _____

CONTRACTOR _____

INSPECTOR _____

FOR _____ DATE _____



HVAC Duct Systems Inspection Guide • Third Edition



Documents

Document Sharing Hub

INSPECTION CHECKLIST FOR FIBROUS GLASS DUCT SYSTEM INSTALLATION

References

SMACNA Standards
North American Installation Manufacturers Association (NAIMA)
Board Manufacturer's Standards

General

	Yes	No
1. Is the duct used within its service limitations?	☐	☐
2. Is system operating within the design limitations for which it was built?	☐	☐
3. Are all sheet metal accessory items galvanized?	☐	☐
4. Is the EI rating printed on the board facing?	☐	☐
5. Is the UL label present on much of the duct surface?	☐	☐
6. Is the system free from visual signs of duct board facing delamination?	☐	☐

Fabrication and Installation

7. Are turning vanes installed in accordance with the Standards? (Pressing your hand into the cheek of the ell will reveal if specified vanes are being used.)	☐	☐
8. When metal parts are attached, are 2½ in. (63.5 mm) (minimum) square steel washers used on 16 in. (405 mm) (maximum) centers?	☐	☐
9. When staples can't be used, are 8 in. (203 mm) cross tabs of approved closure being used in place of staples? (Tab spacing requirements are 12 in. (305 mm) OC, minimum one per side)	☐	☐
10. Is the system completely free from tears or punctures in the facing?	☐	☐
11. Is the system free from areas where excessive amounts of closure materials, such as several wraps around a joint, may have been used to conceal potential problem areas?	☐	☐
12. Are all system joints tight, free from bulges, with taped joints showing good workmanship?	☐	☐
13. Are all fittings fabricated in accordance with the Standards and do they demonstrate good workmanship?	☐	☐
14. Have offsets been installed so duct sections aren't forced to bend around obstructions?	☐	☐
15. Are all panels in any fitting at least 4 in. (102 mm) long, including male or female joints?	☐	☐

Electric Heaters

16. Is interior sleeve present, properly attached with screws and washers 16 in. (405 mm) on centers?	☐	☐
17. Is heater separately supported?	☐	☐
18. Are all listed clearances to combustibles and radiation protections in place?	☐	☐

Dampers

19. If a motorized damper operator is being used, is the sheet metal sleeve extended so the operator is mounted on the same sleeve with the damper?	☐	☐
20. On a manual volume damper, does the quadrant move a full 90 degrees?	☐	☐

Fire Dampers

21. Is sheet metal sleeve present? (Fibrous duct stops at barrier)	☐	☐
22. Is duct properly attached to sleeve with screws and washers 16 in. (405 mm) on centers and sealed?	☐	☐

Access Doors

23. Is installation in accordance with the Standards?	☐	☐
---	--------------------------	--------------------------

Grilles, Diffusers, Registers

24. Is the extra weight of the item being separately supported and not dependent on the duct alone for support? (EXCEPTION: Registers not greater than 150 in ² (0.097 m ²) in area may be attached to the duct with metal channel without other support.)	☐	☐
--	--------------------------	--------------------------

Equipment Unit Connection

25. Are sheet metal screws and washers used to secure duct system to flange extensions?
(Mechanical fasteners must be used!)

Yes☐**No**☐**Closure**

26. Are all joints in the system properly sealed?
27. Are closure materials of a listed type as evidenced by presence of UL instruction sheet in duct board carton? Is tape imprinted?
28. Are there staples or cross tabs, properly spaced, on circumferential joints?
29. Are staples, if used, of the correct type and size, and spaced in proper intervals as recommended by the duct board manufacturer?
30. Are all pressure-sensitive tape closures rubbed down adequately, with staples or scrim in facing clearly visible through the tape?
31. If heat-sealable tape closure was used, was it applied correctly, as evidenced by dot color change?
32. If glass fabric and mastic are used, is the mesh of the glass fabric completely filled with mastic?

☐☐☐☐☐☐☐☐☐☐☐☐☐☐**Reinforcement**

33. Is reinforcement system of recommended type (formed metal, tie rod, or combination)?
34. Is tie rod wire 12 gage (0.18 mm) or heavier?
35. Is tie rod spacing correct according to duct span, board type, and static pressure?
36. Are tie rod washers 2½ in. (63.5 mm) square and proper gage by type?
37. Do tie rod washers have turned edges facing away from duct board so they won't cut into it?
38. If tie rods reinforce a butt joint, are rods used on both sides of butt joint?
39. Is wire termination one of those in the Standards?
40. Are anti-sag devices used on ducts 48 in. (1220 mm) span or greater, to support top panel of ducts?
41. Do tie rods run straight through ducts and not at angles?
42. Are heels of tees, elbows, and end caps reinforced (formed sheet metal channel, tie rod, or combination)?
43. When formed sheet metal channel reinforcement is used, are sheet metal gages, dimensions, and spacing correct?
44. On supply ducts, is reinforcing member on the female side of the shiplap?
45. On return ducts, are sheet metal channel reinforcements attached to ducts with screws and 2½ in. (63.5 mm) square washers or 2 × 6 in. (51 × 150 mm) clips?
46. On return ducts, is the reinforcing member attached to the male shiplap side of the joint?
47. For the heels of tees, elbows, end caps, and any other fittings where a panel faces an opening on the opposite side, is correct reinforcing member (type: sheet metal channel, tie rod, or combination) applied?

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐**Hangers and Supports**

48. Are hangers installed in accordance with the Standards?
49. Are hanger designs in accordance with the Standards?
50. Are accessories that add weight to the duct system separately supported so as not to stress the system? (consult the standards)
51. Are vertical risers limited to two stories and supported on 12 ft (3650 mm) (maximum) centers?
52. If formed sheet metal reinforcements are used as hangers, are attachments within 6 in. (150 mm) of duct sides?
53. Are all fittings supported by hangers in accordance with the standards?

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

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APPENDIX A

FUNCTIONS OF DUCTED AIR HANDLING SYSTEMS

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A.1 VENTILATION AND AIR CONDITIONING

Air is a gas that contains oxygen. It envelops the planet and fills all open spaces within buildings. The breathing function of human beings removes oxygen from air. Thus, a replacement supply of oxygen is needed to sustain life. Oxygen is also used up in burning fuels such as coal, oil, or gas to provide heat for human comfort. Replacement of oxygenated air is needed for the heating process as well.

The process of providing a fresh supply of air for human need in buildings and comfort is called ventilation. Sometimes the removal of odorous or contaminated air is called ventilation as well. Building codes prescribe minimum amounts of ventilation.

The process of treating air by filtering, cooling, and adding or removing moisture from it is called air conditioning.

Motor driven fans move air from one space to another (through ducts) to control it or to create desirable air motion within occupied spaces. Fans do this by creating enough pressure to overcome the resistance to flow that naturally occurs when air molecules bump into objects or have their direction changed.

A.2 CENTRAL AIR HANDLING SYSTEM

Central air handling systems are relatively large networks of air ducts that have fans located in an equipment room somewhere in a building or on the roof of the building. Air ducts on the outlet side of the fan unit are called supply air ducts. They convey outdoor or “treated” air to multiple rooms in selected zones. Zones may cover part of a floor or all of a floor. They may also cover parts of, or all of, several floors. Supply ducts operate with a positive pressure; that is, the pressure in them is higher than the atmospheric pressure in the spaces they pass through.

In a central supply-return system other ducts called return air ducts will collect air from the same rooms or zones that the associated supply ducts serve and bring it back to the heating, cooling, filtering, etc., apparatus, for reconditioning before being sent back through the supply fan. The supply fan may serve both functions (supply and return) or a separate return air will mix with outdoor air in a fresh air intake plenum located on the suction side of the supply limit. Alternatively, it may be exhausted to the outdoors. The system arrangement is diagrammed in Figure A-7. Several

forms of “central” systems can be used. In some of them, not all of the return air is sent back to the central station fan unit. Instead, it is returned to a satellite unit that is located in its own zone where it is mixed with air coming from a central station unit and is then sent back to occupied spaces.

Air handling systems may be of constant volume or variable volume type. These terms refer to the quantity of air that is being circulated by the central station fan unit. Varying the volume permits conserving energy spent in circulating and treating air since in many cases the demand for heating or cooling varies over day-night and occupancy-use cycles.

A.3 DEDICATED EXHAUST SYSTEMS

Air removal from toilet rooms, potentially contaminated areas of hospitals and laboratories, cooling range areas, dishwashers, and boiler furnaces is normally exhausted directly to the outdoors by systems dedicated for the specific service. The expense or difficulty of reconditioning air from such operations to make it acceptable for occupant exposure is not considered worthwhile. In some cases, the thermal energy in exhaust air is saved by using heat recovery apparatus in the exhaust ducts. In industrial plants, dedicated exhaust systems collect and transport vapors, fumes, and particles that would cause health problems or interfere with work activity.

Another form of dedicated exhaust is smoke control. For a fire emergency, a separate smoke removal system can be activated or systems that would normally be operating in return/recirculation mode can be converted to exhaust mode.

The term “local exhaust” usually refers to air extraction from a specific work operation site within a room. This contrasts with general exhaust which will apply to area wide or an entire room.

All exhaust systems require a source of replacement or makeup air. The source may be a supply system, cracks or pores in the enclosure of exhausted space, open doors or windows, undercut doors, or louvered or dampered openings. Fan powered makeup air units are common in industrial facilities.

A.4 ROOM AIR DISTRIBUTION

Air velocity level and the pattern of air movement from a supply point to an exhaust point in a room affect occupant health, occupant comfort, and the efficiency of temperature control. Velocities under 15 feet per minute (fpm)(0.08 m/s) seem stagnant. Those over 65



fpm (0.33 m/s) seem drafty. The term “throw” designates the horizontal distance a supply air terminal directs air before it reaches minimum velocity. “Drop” pertains to vertical fall before reaching low velocity. Air terminals that have volume dampers are called registers. Special forms of supply terminals are called diffusers.

A.5 ROOM PRESSURE CONTROL

Rooms are designed to have positive pressure or negative pressure. In general those that have more fan powered supply air than fan powered exhaust will have positive pressure. When the opposite situation exists, the room will have negative pressure. The intended balance can be upset by unplanned opening of doors or windows, the wrong position of dampers, failure of interacting controls, unanticipated wind pressure on the building exterior, and other circumstances. Pressure control is critical in a fire situation and in chemically or biologically contaminated zones. Normal and emergency states of operation of fan systems must be understood in order to preserve health and safety.

A.6 INFILTRATION AND EXFILTRATION

Infiltration is unintentional air leakage into buildings. Exfiltration is uncontrolled air leakage out of buildings. These terms may also be applied to specific compartments within buildings. Typical rates of leakage for building components are given in the ASHRAE *Fundamentals Handbook* chapter on infiltration and exfiltration. The temperature, humidity, and cleanliness of air from these sources can significantly affect energy consumption costs as well as affect the

control of indoor environment for health and safety reasons.

A.7 CENTRAL ALARM CONTROL STATIONS

Modern buildings often have central control/alarm stations that visually display and permit diagnosis of the operating condition of fire alarm, smoke detector, sprinkler, and air handling systems. They also have stop-start controls that allow change of the operating state of the air handling systems. The functions of these interdependent controls and systems are vital for the safety of building occupants and they must be understood by those responsible for verifying their condition.

A.8 TESTING AND BALANCING

The operations of measuring and adjusting the quantity of air at fans, in ducts and at air terminals are designated “testing and balancing.” The shorthand term for this is TAB. Testing often involves measuring air pressures in ducts. Static pressure is force exerted on a duct wall in a manner similar to that in an inflated balloon. Velocity pressure is a force acting in the direction of flowing air as in wind pressure. The sum of static pressure and velocity pressure is called total pressure. Standard procedures for TAB are published by several respected organizations, including SMACNA.

A.9 SYMBOLS

Standardized terminology and illustrations of duct system components are given in Figures A-1 and A-1M.

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SYMBOL MEANING	SYMBOL	SYMBOL MEANING	SYMBOL
POINT OF CHANGE IN DUCT CONSTRUCTION (BY STATIC PRESSURE CLASS)		SUPPLY GRILLE (SG)	
DUCT (1ST FIGURE, SIDE SHOWN 2ND FIGURE, SIDE NOT SHOWN)		RETURN (RG) OR EXHAUST (EG) GRILLE (NOTE AT FLR OR CLG)	
ACOUSTICAL LINING DUCT DIMENSIONS FOR NET FREE AREA		SUPPLY REGISTER (SR) (A GRILLE + INTEGRAL VOL. CONTROL)	
DIRECTION OF FLOW		EXHAUST OR RETURN AIR INLET CEILING (INDICATE TYPE)	
DUCT SECTION (SUPPLY)		SUPPLY OUTLET. CEILING, ROUND (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	
DUCT SECTION (EXHAUST OR RETURN)		SUPPLY OUTLET. CEILING, SQUARE (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	
INCLINED RISE (R) OR DROP (D) ARROW IN DIRECTION OF AIR FLOW		TERMINAL UNIT. (GIVE TYPE AND OR SCHEDULE)	
TRANSITIONS: GIVE SIZES. NOTE F.O.T. FLAT ON TOP OR F.O.B. FLAT ON BOTTOM IF APPLICABLE		COMBINATION DIFFUSER AND LIGHT FIXTURE	
STANDARD BRANCH FOR SUPPLY & RETURN (NO SPLITTER) 45° INLET		DOOR GRILLE	
WYE JUNCTION		SOUND TRAP	
VOLUME DAMPER MANUAL OPERATION		FAN & MOTOR WITH BELT GUARD & FLEXIBLE CONNECTIONS	
AUTOMATIC DAMPERS MOTOR OPERATED		VENTILATING UNIT (TYPE AS SPECIFIED)	
ACCESS DOOR (AD) ACCESS PANEL (AP)		UNIT HEATER (DOWNBLAST)	
FIRE DAMPER: SHOW — VERTICAL POS. SHOW — HORIZ. POS.		UNIT HEATER (HORIZONTAL)	
SMOKE DAMPER		UNIT HEATER (CENTRIFUGAL FAN) PLAN	
HEAT STOP – CEILING DAMPER – RADIATION DAMPER –		THERMOSTAT	
TURNING VANES (TYPE AS SPECIFIED)		POWER OR GRAVITY ROOF VENTILATOR – EXHAUST (ERV)	
FLEXIBLE DUCT FLEXIBLE CONNECTION		POWER OR GRAVITY ROOF VENTILATOR – INTAKE (SRV)	
GOOSENECK HOOD (COWL)		POWER OR GRAVITY ROOF VENTILATOR – LOUVERED	
BACK DRAFT DAMPER		LOUVERS & SCREEN	

FIGURE A-1 SYMBOLS FOR HVAC SYSTEMS

SYMBOL MEANING	SYMBOL	SYMBOL MEANING	SYMBOL
POINT OF CHANGE IN DUCT CONSTRUCTION (BY STATIC PRESSURE CLASS)		SUPPLY GRILLE (SG)	
DUCT (1ST FIGURE, SIDE SHOWN 2ND FIGURE, SIDE NOT SHOWN)		RETURN (RG) OR EXHAUST (EG) GRILLE (NOTE AT FLR OR CLG)	
ACOUSTICAL LINING DUCT DIMENSIONS FOR NET FREE AREA		SUPPLY REGISTER (SR) (A GRILLE + INTEGRAL VOL. CONTROL)	
DIRECTION OF FLOW		EXHAUST OR RETURN AIR INLET CEILING (INDICATE TYPE)	
DUCT SECTION (SUPPLY)		SUPPLY OUTLET, CEILING, ROUND (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	
DUCT SECTION (EXHAUST OR RETURN)		SUPPLY OUTLET, CEILING, SQUARE (TYPE AS SPECIFIED) INDICATE FLOW DIRECTION	
INCLINED RISE (R) OR DROP (D) ARROW IN DIRECTION OF AIR FLOW		TERMINAL UNIT. (GIVE TYPE AND OR SCHEDULE)	
TRANSITIONS: GIVE SIZES. NOTE F.O.T. FLAT ON TOP OR F.O.B. FLAT ON BOTTOM IF APPLICABLE		COMBINATION DIFFUSER AND LIGHT FIXTURE	
STANDARD BRANCH FOR SUPPLY & RETURN (NO SPLITTER) 45° INLET		DOOR GRILLE	
WYE JUNCTION		SOUND TRAP	
VOLUME DAMPER MANUAL OPERATION		FAN & MOTOR WITH BELT GUARD & FLEXIBLE CONNECTIONS	
AUTOMATIC DAMPERS MOTOR OPERATED		VENTILATING UNIT (TYPE AS SPECIFIED)	
ACCESS DOOR (AD) ACCESS PANEL (AP)		UNIT HEATER (DOWNBLAST)	
FIRE DAMPER: SHOW —▲— VERTICAL POS. SHOW —◆— HORIZ. POS.		UNIT HEATER (HORIZONTAL)	
SMOKE DAMPER		UNIT HEATER (CENTRIFUGAL FAN) PLAN	
HEAT STOP – CEILING DAMPER – RADIATION DAMPER –		THERMOSTAT	
TURNING VANES (TYPE AS SPECIFIED)		POWER OR GRAVITY ROOF VENTILATOR – EXHAUST (ERV)	
FLEXIBLE DUCT FLEXIBLE CONNECTION		POWER OR GRAVITY ROOF VENTILATOR – INTAKE (SRV)	
GOOSENECK HOOD (COWL)		POWER OR GRAVITY ROOF VENTILATOR – LOUVERED	
BACK DRAFT DAMPER		LOUVERS & SCREEN	

FIGURE A-1M SYMBOLS FOR HVAC SYSTEMS (METRIC)

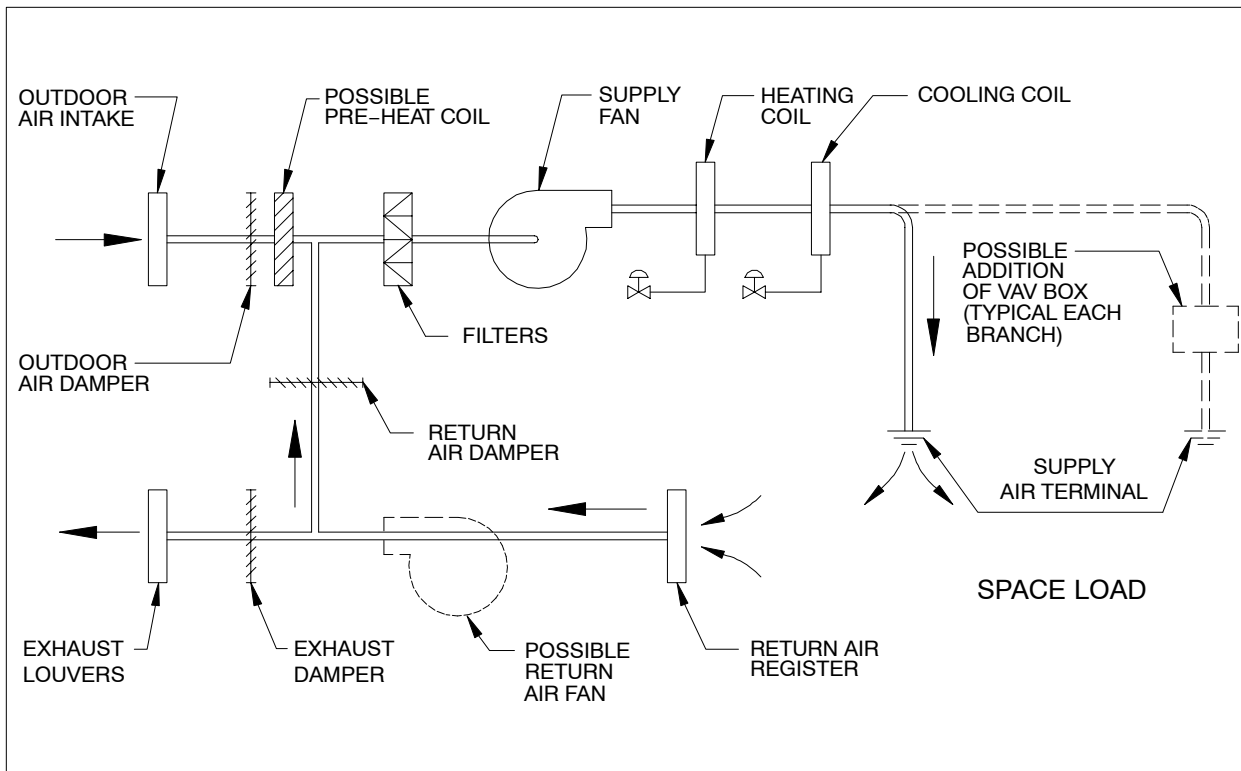


FIGURE A-2 SINGLE DUCT SYSTEM

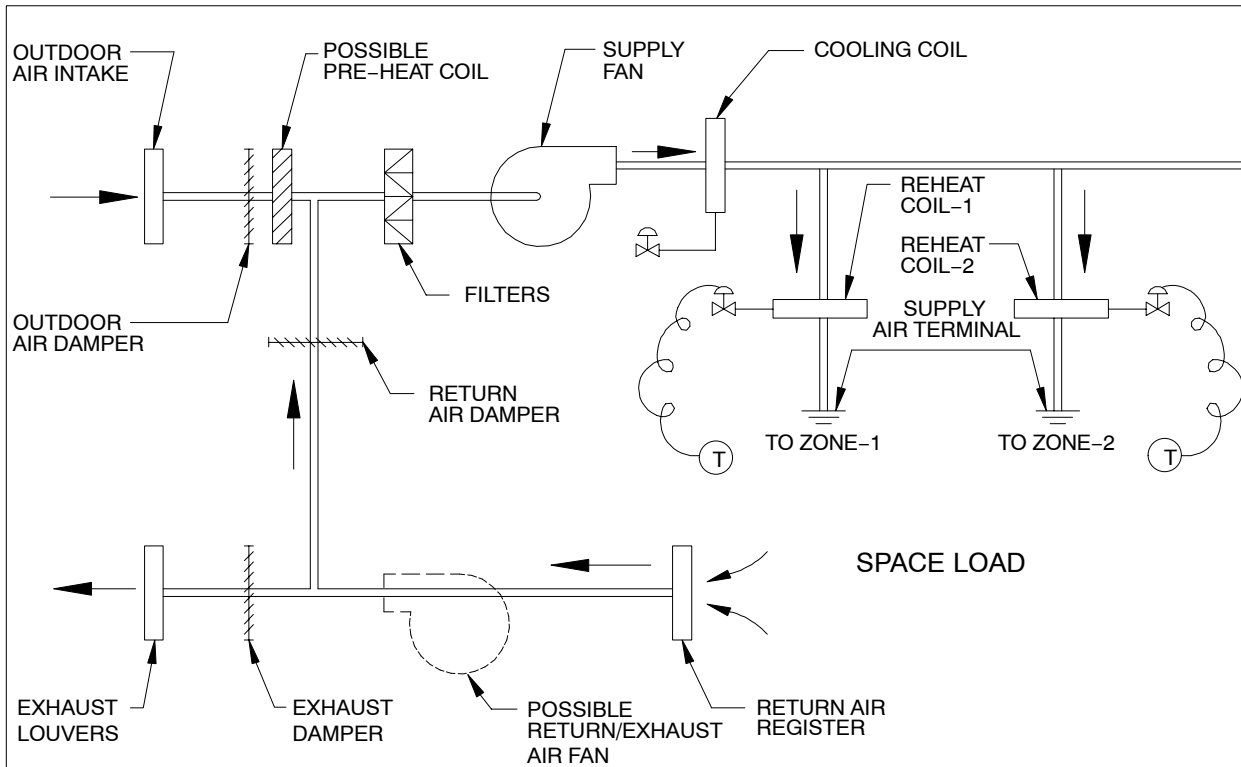


FIGURE A-3 TERMINAL REHEAT SYSTEM

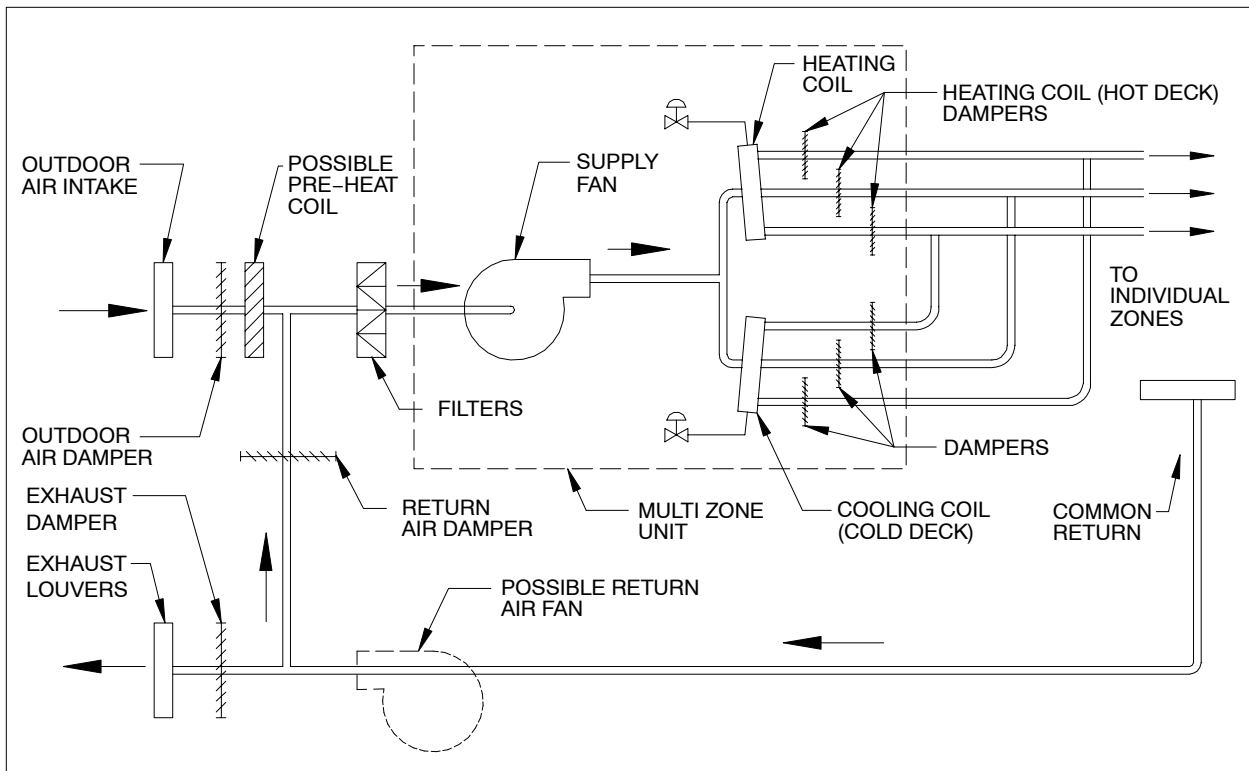


FIGURE A-4 MULTI-ZONE SYSTEM

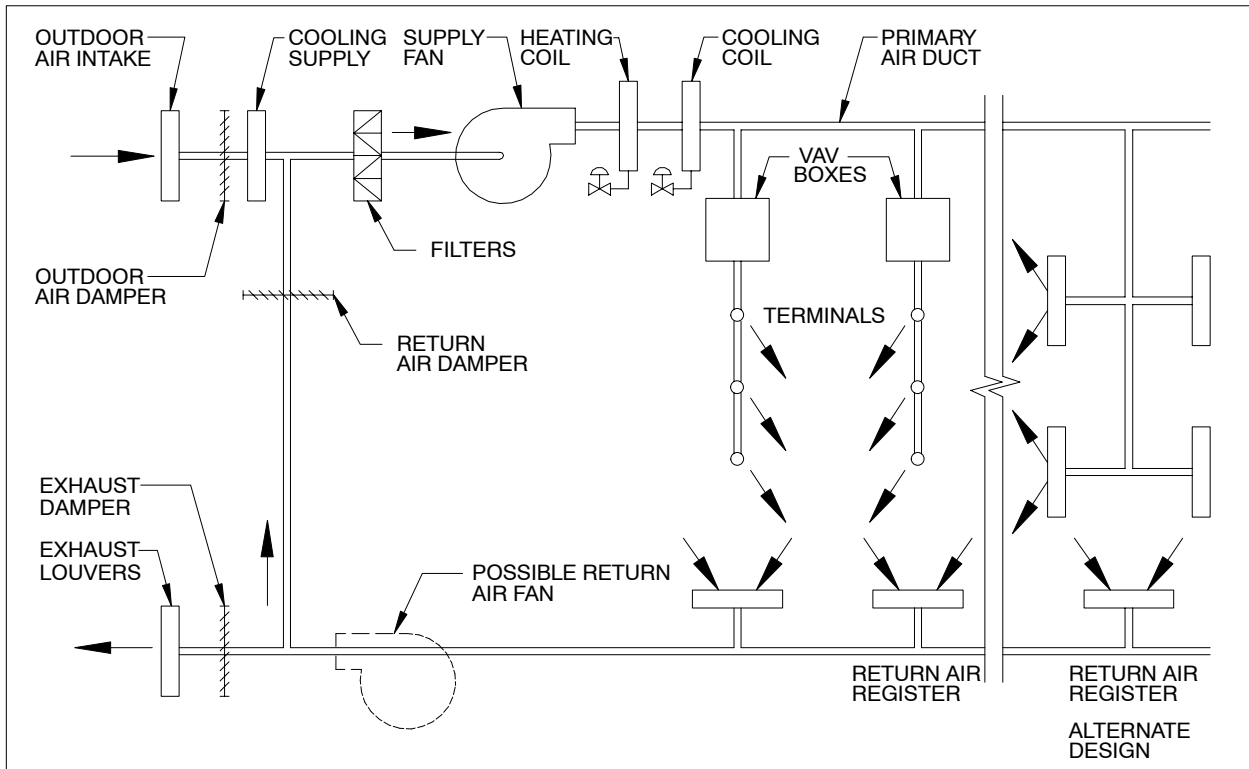


FIGURE A-5 VARIABLE VOLUME SYSTEM

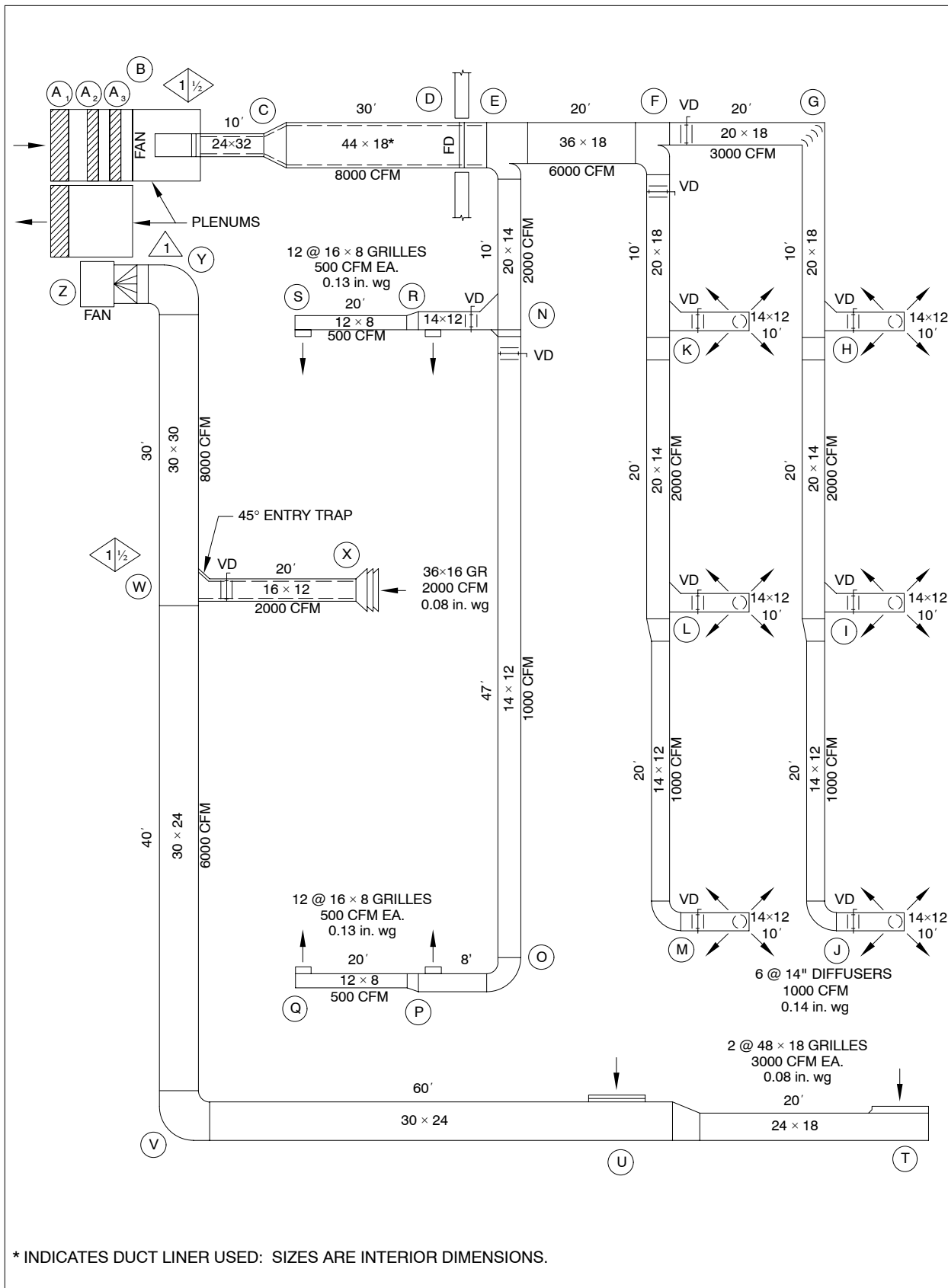


FIGURE A-6 DUCT SYSTEM EXAMPLE

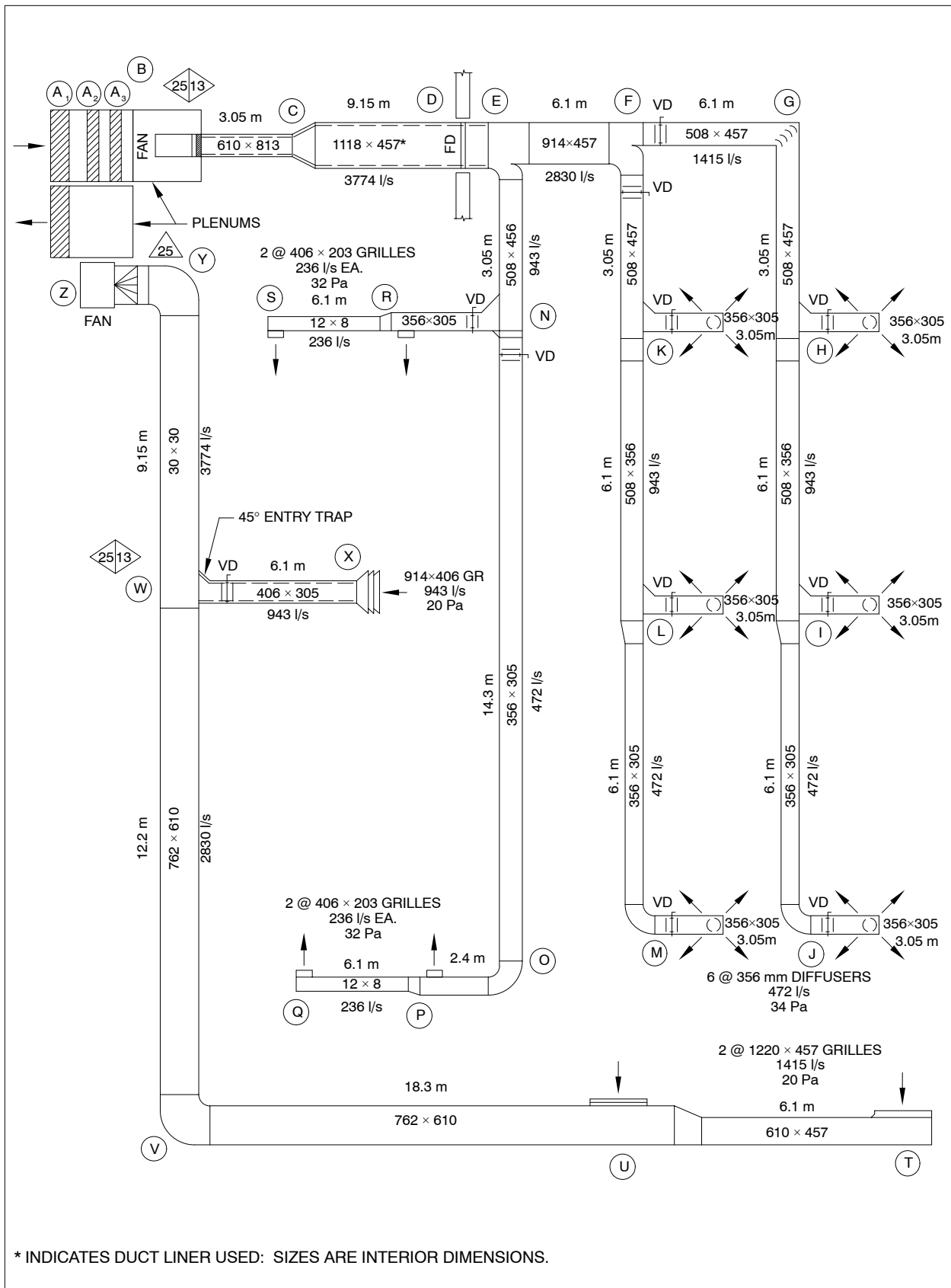
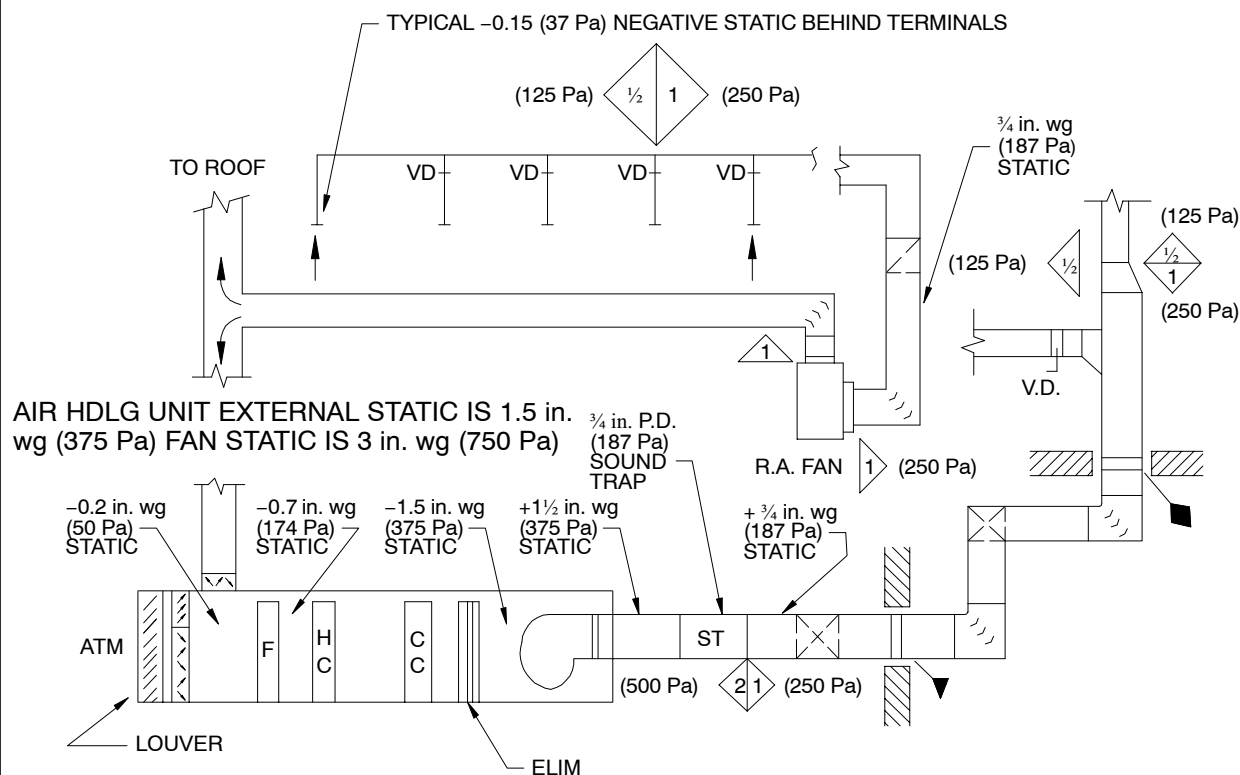


FIGURE A-6M DUCT SYSTEM EXAMPLE (METRIC)



SAMPLE SITUATION WITH A TERMINAL REQUIRING 0.15 in. wg (37 Pa) STATIC, A BRANCH DAMPER REQUIRING 0.15 in. wg (37 Pa) STATIC, DUCT DESIGNED FOR 0.1 in. wg LOSS/100 ft (25 Pa/30 m) AND FITTING LOSSES EQUAL TO STRAIGHT DUCT LOSS THE CIRCUIT CAN BE 100 L.F. (30 m) LONG BEFORE ½ in. wg (125 Pa) LOSS IS EXCEEDED.



THE NUMBER ASSIGNS PRESSURE CLASS WHICH WILL ACCOMMODATE MAXIMUM OPERATING PRESSURE IN THE DUCT SUBSECTION. THE SYMBOL CONTINUES THE ASSIGNMENT UNTIL THE DUCT TERMINATES OR ANOTHER SYMBOL APPEARS.

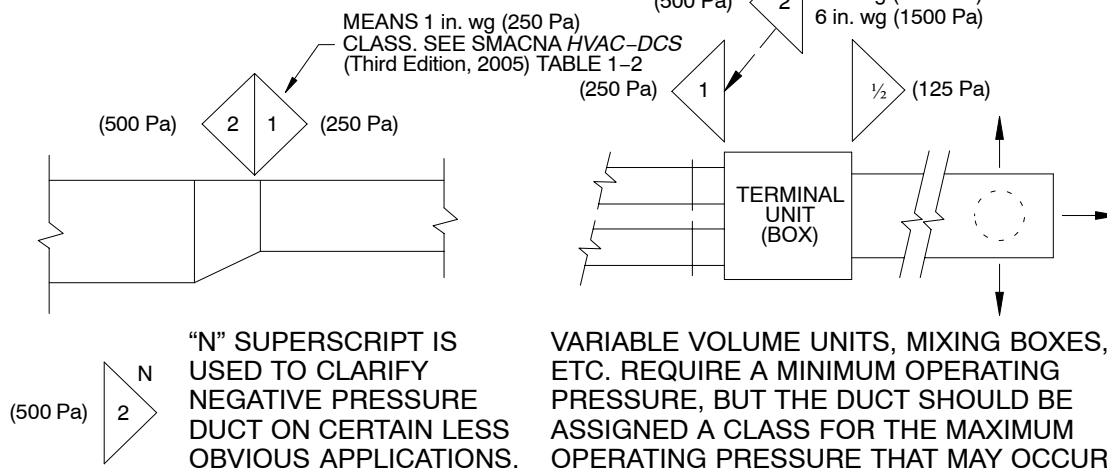


FIGURE A-7 DUCT PRESSURE CLASS DESIGNATION

APPENDIX B

DUCT CONSTRUCTION MATERIALS

Materials used for rigid ducts include: galvanized steel, black carbon steel, aluminum, stainless steel, copper, fiberglass reinforced plastic (FRP), polyvinyl chloride (PVC), polyvinyl steel (PVS), concrete, fibrous glass (duct board), and gypsum board. Codes, construction standards, and the design documents governing air handling systems define acceptable limits of use of each material. This Appendix contains a brief review of materials application.

B.1 GALVANIZED STEEL

APPLICATIONS—Widely used as a duct material for most air handling systems; not recommended for corrosive product handling or temperatures above 400°F (204°C).

ADVANTAGES—High strength, rigidity, durability, rust resistance, availability, non-porous, workability, and weldability.

REMARKS—Galvanized steel sheet is customarily available in commercial and lock forming quality. *See* additional characteristics in Table B-1.

B.2 CARBON STEEL (BLACK IRON)

APPLICATIONS—Breechings, flues, stacks, hoods, other high temperature duct systems, kitchen exhaust systems, ducts requiring paint, or special coating.

ADVANTAGES—High strength, rigidity, durability, availability, paintability, weldability, non-porous.

REMARKS—Hot-rolled sheet is manufactured by hot-rolling slabs in a continuous mill. Cold-rolled sheet is manufactured from hot-rolled, descaled coils by cold reducing to the desired thickness, generally followed by annealing. Hot-rolled carbon steel is generally softer, less precisely rolled, less expensive, and is used more frequently than cold-rolled steel. *See* the specifications in Table B-2.

B.3 STAINLESS STEEL

APPLICATIONS—Duct systems for kitchen exhaust, moisture laden air, fume exhaust.

ADVANTAGES—High resistance to corrosion from moisture and most chemicals, ability to take a high polish.

REMARKS—Available in many different alloy combinations. Types 304 and 316 are most commonly used. Stainless is usually available in the finishes listed in Table B-3.

B.4 ALUMINUM

APPLICATIONS—Duct systems for moisture laden air, louvers, special exhaust systems, ornamental duct systems.

ADVANTAGES—Light weight, resistance to moisture, corrosion (salt free), availability.

REMARKS—Various alloys are available in sheet form with the 3000-H14 temper series being the most commonly specified for duct systems. A “utility grade” sheet is also available. Sheets can also be obtained with embossed or anodized surfaces. The commonly used grade has about one half of the tensile strength and one third of the rigidity of steel. It also has high thermal expansion. *See* additional characteristics in Table B-4.

B.5 COPPER

APPLICATIONS—Duct systems for exposure to outside elements and moisture laden air, certain chemical exhaust, ornamental ductwork, hoods.

ADVANTAGES—Accepts solder readily, durable, resists corrosion, non-magnetic.

REMARKS—Its connection to other metals can result in galvanic corrosion. Its use is limited to pressure below 2 in. wg (500 Pa).

B.6 FIBERGLASS REINFORCED PLASTIC (FRP)

APPLICATIONS—Chemical fume exhaust, scrubbers, underground duct systems.

ADVANTAGES—Resistance to corrosion, strength.

REMARKS—Codes usually limit its application. Although NFPA Standard 91 covers FRP, provisions therein relate more to pipe than to duct.



B.7 POLYVINYL CHLORIDE (PVC)

APPLICATIONS—Exhaust systems for chemical fumes and hospitals, underground duct systems.

ADVANTAGES—Resistance to corrosion, weight, weldability, ease of modification.

REMARKS—Use is restricted by codes and its combustibility and toxicity ratings.

B.8 POLYVINYL STEEL (PVS)

APPLICATIONS—Underground duct systems, moisture laden air, and corrosive air systems.

ADVANTAGES—Resistance to corrosion, availability.

REMARKS—Polyvinyl steel is a polyvinyl chloride plastic coating heat-fused to galvanized steel. 2 mil (0.05 mm) and 4 mil (0.10 mm) coating thicknesses usually are standard, with steel gages (US standard) available from 26 ga (0.55 mm) through, and including, 14 ga (2.0 mm). This product is most popular in spiral seam pipe and is available in flat sheets and coil stock of lockforming quality. It is susceptible to coating damage and temperature limits.

REMARKS—Due to high smoke generation rating, sprinklers may also be required by codes.

B.9 CONCRETE

APPLICATIONS—Underground ducts, air shafts.

ADVANTAGES—Compression strength, corrosion resistance.

B.10 ASBESTOS CEMENT

APPLICATIONS (FORMER)—Underground duct systems, kitchen exhaust, chemical exhaust, high temperature duct systems, flues, and vents.

ADVANTAGES—Resistance to most chemicals, can be used up to 2000°F (1093°C).

REMARKS—Asbestos products are now subject to many government regulations.

B.11 RIGID FIBROUS GLASS

APPLICATIONS—Interior HVAC low pressure duct systems.

ADVANTAGES—Lightweight, thermal insulation and vapor barrier, acoustical qualities, ease of modification, inexpensive tooling for fabrication.

REMARKS—Construction standards and code related provisions must be strictly followed.

B.12 GYPSUM BOARD

APPLICATIONS—Ceiling plenums, corridor air passageways, airshafts.

ADVANTAGES—Cost, availability.

REMARKS—Must be sealed. There are no construction standards for ducts of this material. Its temperature, moisture susceptibility, and damage potential are factors that affect its use. Codes regulate its application.

Gage	Thickness in Inches			Weight				Thickness in Millimeters		
	Min.	Max.	Nom.	Min lb/ft ²	Nom. lb/ft ²	Max. lb/ft ²	Nom. kg/m ²	Min.	Max.	Nom.
33	0.0060	0.0120	0.0090	0.2409	0.376	0.486		0.1524	0.3048	0.2286
32	0.0104	0.0164	0.0134	0.4204	0.563	0.665		0.2642	0.4166	0.3404
31	0.0112	0.0172	0.0142	0.4531	0.594	0.698		0.2845	0.4369	0.3607
30	0.0127	0.0187	0.0157	0.5143	0.656	0.759	3.20	0.3188	0.4783	0.3988
29	0.0142	0.0200	0.0172	0.5755	0.719	0.820		0.3569	0.5169	0.4369
28	0.0157	0.0217	0.0187	0.6367	0.781	0.881	3.81	0.3950	0.5550	0.4750
27	0.0172	0.0232	0.0202	0.6979	0.844	0.943		0.4331	0.5931	0.5131
26	0.0187	0.0247	0.0217	0.7591	0.906	1.004	4.42	0.4712	0.6312	0.5512
25	0.0217	0.0287	0.0247	0.8407		1.167		0.5274	0.7274	0.6274
24	0.0236	0.0316	0.0276	0.9590	1.156	1.285	5.64	0.6010	0.8010	0.7010
23	0.0266	0.0346	0.0306	1.0814		1.408		0.6772	0.8772	0.7772
22	0.0296	0.0376	0.0336	1.2038	1.406	1.530	6.86	0.7534	0.9534	0.8534
21	0.0326	0.0406	0.0366	1.3263		1.653		0.8296	1.0296	0.9296
20	0.0356	0.0436	0.0396	1.4486	1.656	1.775	8.08	0.9060	1.106	1.006
19	0.0406	0.0506	0.0456	1.6526		2.061		1.028	1.288	1.158
18	0.0466	0.0566	0.0516	1.8974	2.156	2.305	10.52	1.181	1.441	1.311
17	0.0525	0.0625	0.0575	2.1381		2.546		1.331	1.591	1.461
16	0.0575	0.0695	0.0635	2.3420	2.656	2.832	12.96	1.463	1.763	1.613
15	0.0650	0.0770	0.0710	2.6481		3.138		1.653	1.953	1.803
14	0.0705	0.0865	0.0785	2.8725	3.281	3.525	16.01	1.784	2.204	1.994
12	0.0854	0.1014	0.0934	3.4804		4.133		2.162	2.5823	2.372
12	0.0994	0.1174	0.1084	4.0516	4.531	4.786	22.11	2.523	2.983	2.753
11	0.1143	0.1323	0.1233	4.6505		5.394		2.902	3.362	3.132
10	0.1292	0.1472	0.1382	5.2675	5.781	6.002	28.21	3.280	3.740	3.510
9	0.1442	0.1622	0.1532	5.8795		6.614		3.661	4.121	3.891
8	0.1591	0.1771	0.1681	6.4874	6.875	7.222		4.040	4.500	4.270

Table B-1 Galvanized Sheet Thickness Tolerances

NOTES:

- Based on ASTM A924/A924M-94, Standard Specification for General Requirements for Sheet Steel, Metallic Coated by the Hot-Dip Process (formerly ASTM A525); and ASTM A653/A653M-94, Standard Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvanized) by the Hot-Dip Process.
- Tolerances are valid for 48 in. (1220 mm) and 60 in. (1524 mm) wide coil and cut length stock - other dimensions apply to other sheet widths and to strip.
- The lock forming grade of steel will conform to ASTM A653 (formerly ASTM A527).
- The steel producing industry recommends that steel be ordered by decimal thickness only. Thickness and zinc coating class can be stenciled on the sheet. The gage designation is retained for residual familiarity reference only.
- Minimum weight in this table is based on the following computation:
 Min. sheet thickness (t) minus 0.001 in. of G60 coating times 40.8 lb per sf per inch plus 0.0369 lb per sf of zinc. G90 stock would be comparably calculated from:

$$\text{minimum weight} = (t - 0.00153 \text{ in.}) 40.8 + 0.0564.$$
 However, scale weight may run 2% (or more) greater than theoretical weight. Actual weight may be near 40.82 lb per sf per inch.
- G60 coating, per ASTM A653 and ASTM A90, has 0.60 oz/sf (triple spot test) total for two sides. 0.59 oz/sf of zinc equals 0.001 in. 1 oz is 0.0017 in. and is 305.15 g/m². G90 coating is 0.90 oz/sf (triple spot test), or 0.00153 in. Magnetic gage measurement of zinc coating may have 15% error.
- ASTM A2092, Practices for Preparation of Zinc-Coated Galvanized Steel Surfaces for Paint, includes mill phosphatizing.
- ASTM A755 is the Specification for Sheet Steel, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Building Products. Other information is available from the National Coil Coaters Association, Philadelphia, PA.
- Much chemical and atmospheric corrosion information is available from ASM International in Metals Park, Ohio and from NACE International in Houston, TX.
- A principle international standard is ISO 3575, Continuous Hot-Dip Process, Zinc-Coated Carbon Steel Sheet of Commercial, Lock Forming, and Drawing Qualities.



M.S. Gage	Weight lb/sf (kg/m ²)	Thickness					ANSI STANDARD B32.3 Preferred in Thickness Millimeters	
		Nominal in. (mm)	Hot-rolled		Cold-rolled			
			Min.	Max.	Min.	Max.	First	Second
28	0.625 (3.051)	0.0149 (0.378)			0.0129 (0.328)	0.0169 (0.429)	0.30	0.35
26	0.750 (3.661)	0.0179 (0.455)			0.0159 (0.404)	0.0199 (0.505)	0.40	0.45
24	1.000 (4.882)	0.0239 (0.607)			0.0209 (0.531)	0.0269 (0.683)	0.50	0.65
22	1.250 (6.102)	0.0299 (0.759)			0.0269 (0.683)	0.0329 (0.836)	0.75	0.85
20	1.500 (7.232)	0.0359 (0.912)			0.0329 (0.836)	0.0389 (0.988)	1.0	0.90
18	2.000 (9.764)	0.0478 (1.214)	0.0428 (1.087)	0.0528 (1.341)	0.0438 (1.113)	0.0518 (1.316)	1.2	1.0
16	2.500 (12.205)	0.0598 (1.519)	0.0538 (1.367)	0.0658 (1.671)	0.0548 (1.392)	0.0649 (1.649)	1.6	1.4
14	3.125 (15.256)	0.0747 (1.897)	0.0677 (1.720)	0.0817 (2.075)	0.0697 (1.770)	0.0797 (2.024)	2.0	1.9
12	4.375 (21.359)	0.1046 (2.657)	0.0966 (2.454)	0.1120 (2.860)	0.0986 (2.504)	0.1106 (2.809)	2.5	2.8
10	5.625 (27.461)	0.1345 (3.416)	0.1265 (3.213)	0.1425 (3.619)	0.1285 (3.264)	0.1405 (3.569)	3.5	3.4
8	6.875 (33.564)	0.1644 (4.176)	0.1564 (3.973)	0.1724 (4.379)			3.8	

Table B-2 Manufacturers Standard Gage-Thickness (Uncoated Steel)

NOTES:

- Manufacturers Standard Gage* is based on a theoretical steel density of 489.6 lb/cf, or 40.80 lb/sf per inch of thickness plus 2.5% normally experienced increase in delivery weight. Thus, the weight basis associated with thickness specifications is 41.82 lb/sf per inch.
- U.S. Standard Gage*, the legal gage since 1893, although based on the density of wrought iron 480 lb/cf, used 40.00 lb/sf/in. for both iron and steel. Thus, U.S. gage thicknesses are derived from weights 2% lighter than steel.
- The table is based on 48 in. (1220 mm) width coil and sheet stock. 60 in. (1524 mm) stock has the same tolerance for gages listed except for 16 gage which has ± 0.007 in. in hot-rolled sheet.
- See ASTM Standards A366 (cold-rolled order form), A568 (properties of hot-rolled and cold-rolled sheet of commercial quality), and A569 (hot-rolled order form).
- Thickness and weight in customary units are based on data in the *AISI Carbon Sheet Steel Products Manual*. Metric conversions listed here are straight multiplications for comparison purposes. Individual manufacturers may quote other tolerances.
- ANSI is the American National Standards Institute. Standards B32.3 actually covers a wider range of thickness than listed here.

Gage	Thickness in Inches				Weight				Thickness in Millimeters		
	Min.	Max.	Tolerance	Nom.	lb/ft ²		kg/m ²		Nom.	Min.	Max.
					300	400	300	400			
31	0.0089	0.0129	0.002	0.0109	0.459	0.451	2.239	2.200	0.2769	0.2269	0.3269
30	0.0105	0.0145	0.002	0.0125	0.525	0.515	2.562	2.512	0.3175	0.2675	0.3675
29	0.0121	0.0161	0.002	0.0141	0.591	0.579	2.883	2.825	0.3581	0.3081	0.4081
28	0.0136	0.0176	0.002	0.0156	0.656	0.644	3.200	3.142	0.3962	0.3462	0.4462
27	0.0142	0.0202	0.003	0.0172	0.722	0.708	3.522	3.454	0.4369	0.3569	0.5169
26	0.0158	0.0218	0.003	0.0188	0.788	0.773	3.844	3.771	0.4775	0.3975	0.5575
25	0.0189	0.0249	0.003	0.0219	0.919	0.901	4.483	4.395	0.5562	0.4762	0.6362
24	0.0220	0.0280	0.003	0.0250	1.050	1.030	5.122	5.025	0.6350	0.5550	0.7150
23	0.0241	0.0321	0.004	0.0281	1.181	1.159	5.761	5.654	0.7137	0.6137	0.8137
22	0.0273	0.0353	0.004	0.0313	1.313	1.288	6.405	6.283	0.7950	0.6950	0.8950
21	0.0304	0.0384	0.004	0.0344	1.444	1.416	7.044	6.908	0.8738	0.7738	0.9738
20	0.0335	0.0415	0.004	0.0375	1.575	1.545	7.683	7.537	0.9525	0.8525	1.0525
19	0.0388	0.0488	0.005	0.0438	1.838	1.803	8.966	8.796	1.1125	0.9835	1.2425
18	0.0450	0.0550	0.005	0.0500	2.100	2.060	10.245	10.050	1.2700	1.1400	1.4000
17	0.0513	0.0613	0.005	0.0563	2.363	2.318	11.528	11.308	1.4300	1.3000	1.5600
16	0.0565	0.0685	0.006	0.0625	2.625	2.575	12.806	12.562	1.5875	1.4375	1.7375
15	0.0643	0.0763	0.006	0.0703	2.953	2.897	14.406	14.133	1.7856	1.6356	1.9356
14	0.0711	0.0851	0.007	0.0781	3.281	3.219	16.006	15.704	1.9837	1.8037	2.1637
13	0.0858	0.1018	0.008	0.0938	3.938	3.863	19.211	18.845	2.3825	2.1825	2.5825
12	0.1000	0.1184	0.009	0.1094	4.594	4.506	22.411	21.982	2.7788	2.5488	2.9788
11	0.1150	0.1350	0.010	0.1250	5.250	5.150	25.612	25.124	3.1750	2.9250	3.4250
10	0.1286	0.1526	0.012	0.1406	5.906	5.794	28.812	28.265	3.5712	3.2712	3.8712
9	0.1423	0.1703	0.014	0.1563	6.563	6.438	32.017	31.407	3.9700	3.6100	4.3300
8	0.1579	0.1859	0.014	0.1719	7.219	7.081	35.217	34.544	4.3663	4.0063	4.7263

Table B-3 Stainless Steel Sheet Thickness

NOTES:

- a. ASTM A167 — “Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip” (Properties of the 300 series)
- b. ASTM A480 — “Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip”
- c. Finishes:
 - No. 1 Finish — Hot-rolled, annealed, and descaled.
 - No. 2 D Finish — Cold-rolled, dull finish.
 - No. 3 B Finish — Cold-rolled, bright finish.
 - Bright Annealed Finish — A bright cold-rolled finish retained by annealing in a controlled atmosphere furnace.
 - No. 3 Finish — Intermediate polished finish, one or both sides.
 - No. 4 Finish — General purpose polished finish, one or both sides.
 - No. 6 Finish — Dull satin finish, Tampico brushed, one or both sides.
 - No. 7 Finish — High luster finish.
 - No. 8 Finish — Mirror finish.
- d. The 300 series weight is based on 41.99 lb per square foot per inch of thickness (or 504 lb/cf).
- e. The 400 series weight is based on 41.20 lb per square foot per inch of thickness (or 494 lb/cf).
- f. ASTM A666 covers the structural grade of stainless steel (not used for ducts). For design criteria, generally, consult the *AISI Stainless Steel Cold-Formed Structural Design Manual*. For general application and corrosion data consult the *AISI Design Guidelines for the Selection and Use of Stainless Steels* and the Specialty Steel Industry of the United States in Washington, D.C.



Thickness in Inches				Weight		Thickness in Millimeters		
Nom.	Tolerance 48 in. and (60 in.) Width	Min.	Max.	lb/ft ²	kg/m ²	Nom.	Min.	Max.
0.016	0.0015	0.0145	0.0175	0.228	1.114	0.4068	0.3683	0.4445
0.020	0.0020 (0.0030)	0.0180	0.0220	0.285	1.393	0.5080	0.4572	0.5588
0.024	0.0020 (0.0030)	0.0220	0.0260	0.342	1.671	0.6096	0.5588	0.6604
0.025	0.0020 (0.0030)	0.0230	0.0270	0.356	1.7398	0.6350	0.5842	0.6858
0.032	0.0025 (0.0035)	0.0295	0.0345	0.456	2.228	0.8128	0.7493	0.8763
0.040	0.0035 (0.0045)	0.0365	0.0435	0.570	2.786	1.0160	0.9271	1.1049
0.050	0.0035 (0.0050)	0.0465	0.0535	0.713	3.484	1.2700	1.1811	1.3589
0.063	0.0035 (0.0050)	0.0595	0.0665	0.898	4.389	1.6000	1.5113	1.6891
0.080	0.0045 (0.0060)	0.0755	0.0845	1.140	5.571	2.0320	1.9117	2.1463
0.090	0.0045 (0.0060)	0.0855	0.0945	1.283	6.270	2.2860	2.1717	2.4003
0.100	0.0055 (0.0070)	0.0945	0.1055	1.426	6.969	2.5400	2.4003	2.6797
0.125	0.0055 (0.0070)	0.1195	0.1305	1.782	8.709	3.1750	3.0353	3.3147

Table B-4 Aluminum Sheet Thickness (Alloy 3003-H14)

NOTES:

- Weight is based on 14.256 lb per square foot per inch of thickness (or 171.1 lb/cf). Alloy 1100 is of slightly lower density.
- Specification references: ASTM B209 Standard Specification of Aluminum Alloy Sheet and Plate which references ANSI *Standard H-35.2 Dimensional Tolerances for Aluminum Mill Products*.
- Other useful references are published by the Aluminum Association: *Specification for Aluminum Structures*; *Engineering Data for Aluminum Structures*; *Aluminum Standards and Data*.

APPENDIX C

HVAC DUCT CONSTRUCTION STANDARDS