HVAC Air Duct Leakage

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HVAC Air Duct Leakage

- Variables Affecting Duct Leakage
- Duct Leakage vs. Duct Surface Area
- Definitions
- Duct Sealing
- Duct Leakage Tests & Procedures

HVAC Air Duct Leakage Test Manual

- SMACNA HVAC Duct Construction Standard, 2005 3rd Edition
- International Energy Conservation Code (Chapter 8)
- ASHRAE Fundamentals Handbook (Chapter 35)

Key Variables that Affect the Amount of Leakage

- Static Pressure
- Amount of Duct
- Openings in the Duct Surface
  - Seams, Joints, Access Doors, Rod and Fastener Penetrations, Equipment
- Workmanship

ASHRAE SPC 193P

- Method of Testing For Determining the Air-Leakage Rate of HVAC Equipment
- Furnaces, Heat Pumps, A/C Units, Coil Boxes, Filter Boxes and Associated Components

Duct Leakage is Related to Duct Surface Area

- Research in Europe and in the U.S. has led to the Conclusion that a Duct Surface Leakage Factor can be Identified by the Following Relationship:

$$F = C_L P^N$$

Duct Leakage is Related to Duct Surface Area

$F = C_L P^N$ **Where:**

- **F is a leak rate per unit of duct surface area (typically CFM/100SF)**
- **C_L is a constant**
- **P is static pressure (typically in in. W.G.)**
- **N is an exponent (most typically 0.65)**

Duct Construction Standards

- Ductwork be Constructed for the Specific Pressure Classifications shown on the contract Drawings (1/2", 1", 2", 3", 4", 6", 10")
- Duct Construction per SMACNA HVAC Duct Construction Standards
- Ducts Sealed in accordance with Table 1-2 – SMACNA HVAC Air Duct Leakage Test Manual, HVAC-DCS 2005

Table 1-2		
Standard Duct Sealing Requirements		
SEAL CLASS	Sealing Requirements	Applicable Static Pressure Construction Class
A	Class A: All Transverse joints, longitudinal seams, and duct wall penetrations	4” w.g. and up (1000 Pa)
B	Class B: All Transverse joints and longitudinal seams only	3” w.g. (75-0 Pa)
C	Class C: Transverse joints only	2” w.g. (500 Pa)
In addition to the above, any variable air volume system duct of 1” (250 Pa) and 1/2” w.g. (125 Pa) construction class that is upstream of the VAV boxes shall meet Seal Class C.		

Definitions

- **Seam:**

  Joining two longitudinally (in the direction of airflow) oriented edges of duct surface between two joints. Helical (spiral) lock seams are exempt from sealing requirements.

Definitions

- **Joints: All other duct surface connections made on the perimeter are deemed to be joints including:**
  - **Girth Joints**
  - **Branch & Sub-Branch Intersections**
  - **Duct Collar Tap-ins**
  - **Fitting Subsections**

Definitions

- **Joints: (Continued)**
  - **Louver and Air Terminal Connections to Ducts**
  - **Duct, Plenum and Casing Abutments to Building Structures**

Definitions

- **Duct Wall Penetrations**
  - **Control Rods/Levers**
  - **Pressure Taps**

Duct System Designer

- Match Fan to System Pressure Losses
- Account for Equipment Leakage (Fans, Coils, VAV, etc.)
- Specify Duct Pressure Class
- Specify Amount & Manner of Leakage Testing

Duct Sealing

- Leakage is a Function of Static Pressure and System Size
- Designer Must Specify the Duct Pressure Class or Classes Required for Duct Construction
- Duct Construction at 1" & ½" Pressure Class Meet Seal Class C – Recommended

Sealants

- Liquids
  - Consistency of Heavy Syrup
  - Can be Applied by Brush, Cartridge Gun or Powered Pump
  - Contain 30-60 percent Volatile Solvents – Shrinkage when Drying
  - Water Based vs. Oil Based

Sealants

- Liquids
  - Recommended for Slip Type Joints where the Sealant Fills a Small Space Between Overlapping Pieces of Metal
  - Where Clearances Exceed 1/16" Several Applications may be Necessary

Sealants

- Mastics
  - More Suitable for Application as Fillet, in Groves or Between Flanges
  - Have Excellent Adhesion and Elasticity
- Gaskets
  - Durable, Soft Elastomer Butyl or Extruded Forms
  - Used in Flange Joints
  - Should Have Adhesive Backing for Ease of Application

Sealants

- Tapes
  - Such Closures are Listed as Components of Systems Complying with UL 181
  - No Recognized Industry Performance Standards that set forth:
    - » Peel Adhesion, Shear Adhesion
    - » Tensile Strength
    - » Temperature Limits
    - » Accelerated Aging

Sealants

- Tapes
  - Some test results are published in the product directories of the Pressure Sensitive Tape Council located in Glenview, Illinois.
  - Shelf Life Difficult to Identify (6 mos.-1 yr.)
  - Aging Characteristics Questionable
  - Compatibility of the Adhesive with the Duct Material (Flexible, Non-metallic Ducts)

Sealants

- Heat-Applied Materials
  - Hot Melts – normally Shop Applied
  - Thermally Activated – Uses Heat to either Shrink Fit Closures or to Expand Compounds within Joint Systems
- Mastic and Embedded Fabric
  - Woven Fabrics (Fibrous Glass Mesh, Gauze, Canvas, etc.)
  - Sealing Compounds including Lagging Adhesive

Sealants

- Shelf Life may be one year or less – often only 6 months. Installer should verify that shelf life has not been exceeded.
- Safety Considerations
  - Sealants may be flammable in wet or partially cured state
  - Use liquids & mastics in well-ventilated areas
  - Observe printed precautions of manufacturers

Leakage Tests

- **Need to verify leakage control by field testing is not present when adequate methods of assembly and sealing are used.**

- **Leakage tests for duct systems constructed to 3" w.g. or lower are typically not recommended.**

Duct Sealing

- **Unsealed Ducts may leak at the following Rates:**

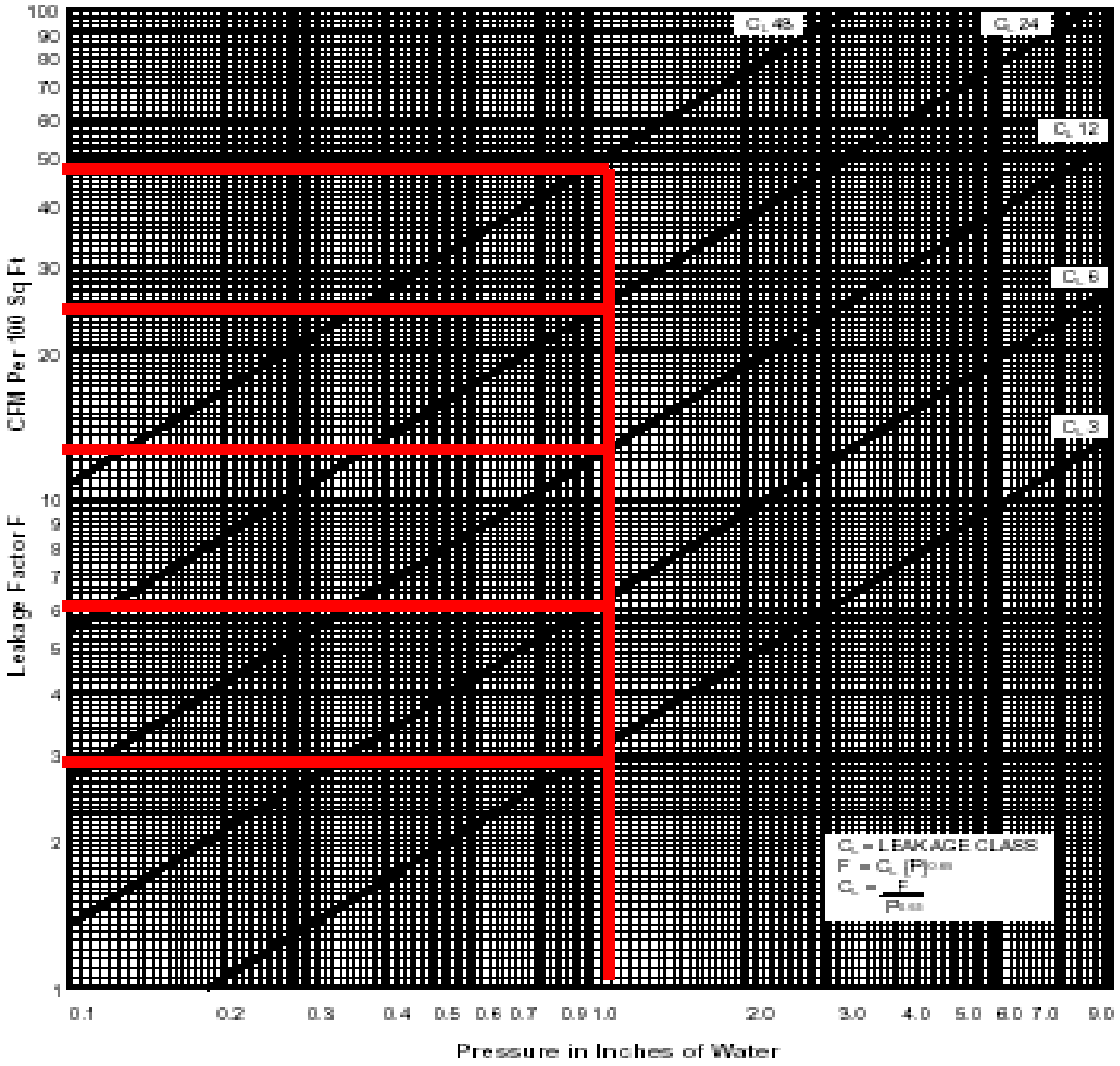
Duct Pressure in Inches w.g.	CFM/100 S.F.
0.1	11
0.25	20
0.50	31
1.0	48

Leakage Tests

- For Systems of 4" w.g. Class and higher:
  - The designer must determine if any justification for testing exists.
  - If so, he must clearly designate in the contract documents the portions of the system(s) to be tested and must specify the appropriate test methods.

Table 4-1 Applicable Leakage Classes

DUCT CLASS	½", 1", 2' W.G.	3" W.G.	4", 6", 10" W.G.
SEAL CLASS	C	B	A
SEALING APPLICABLE	TRANSVERSE JOINTS ONLY	TRANSVERSE JOINTS & SEAMS	JOINTS, SEAMS & ALL WALL PENETRATIONS
LEAKAGE CLASS			
RECTANGULAR METAL	24	12	6
ROUND METAL	12	6	3



DUCT LEAKAGE CLASSIFICATION – FIGURE 4-1

Test Procedures

1. Select a section of duct to be tested.
2. Select a test pressure not in excess of the pressure class rating of the duct. (Usually the actual operating pressure.)
3. Calculate the allowable leakage using leakage factors for the duct surface area.

Test Procedures

4. Select the blower and orifice suitable for the test airflow requirements.
5. Connect the blower and flowmeter to the duct section.
6. Provide temporary seals at all ends of the ductwork.

Test Procedures

7. Start the blower at a low airflow capacity, increasing the airflow until the test pressure is reached.

8. Adjust blower capacity until steady-state conditions at the test pressure are achieved.

Test Procedures

9. **Record the airflow (across the orifice) at the steady state condition.**

10. **This airflow is the CFM leakage of the tested section of the duct.**

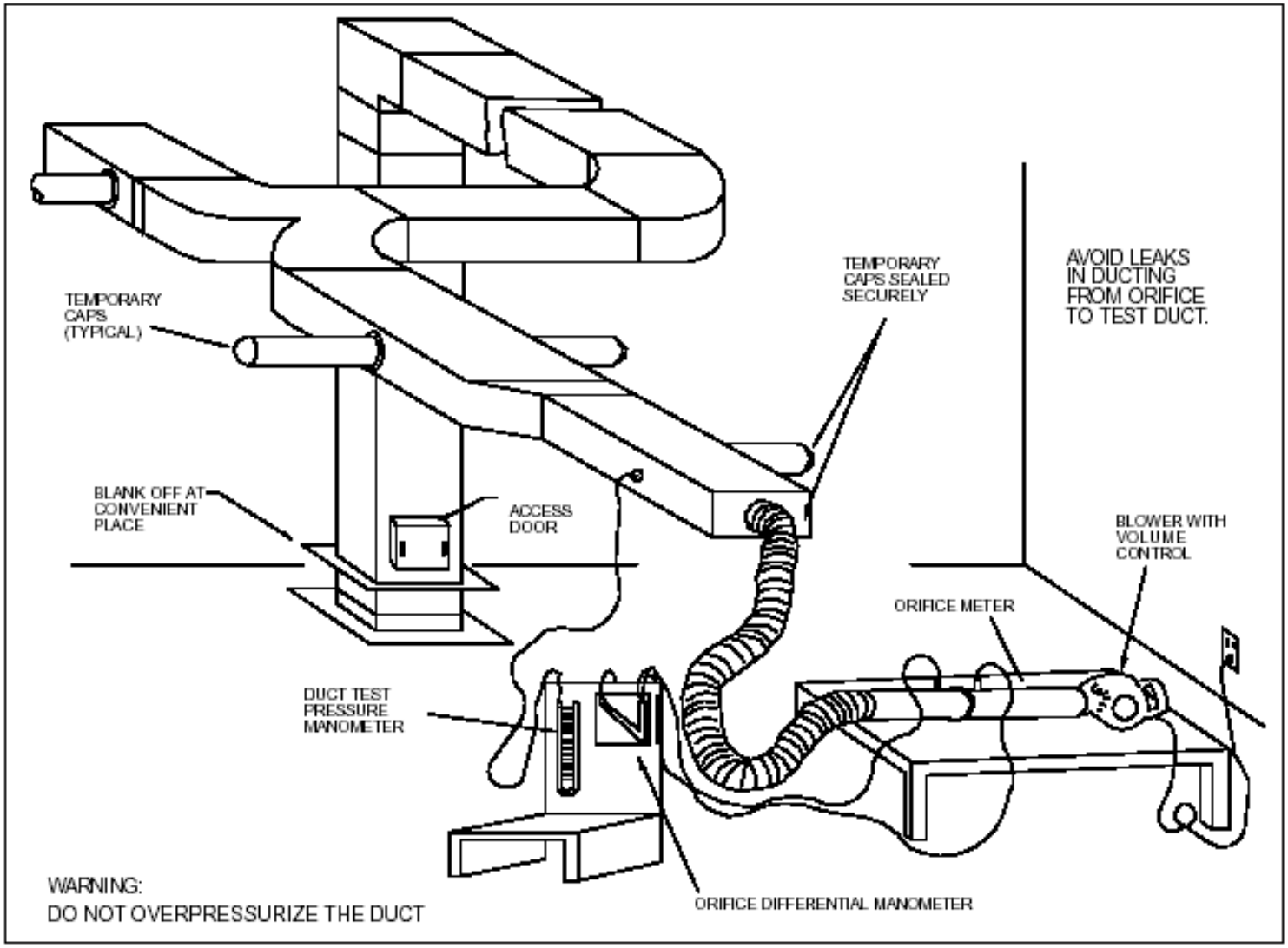
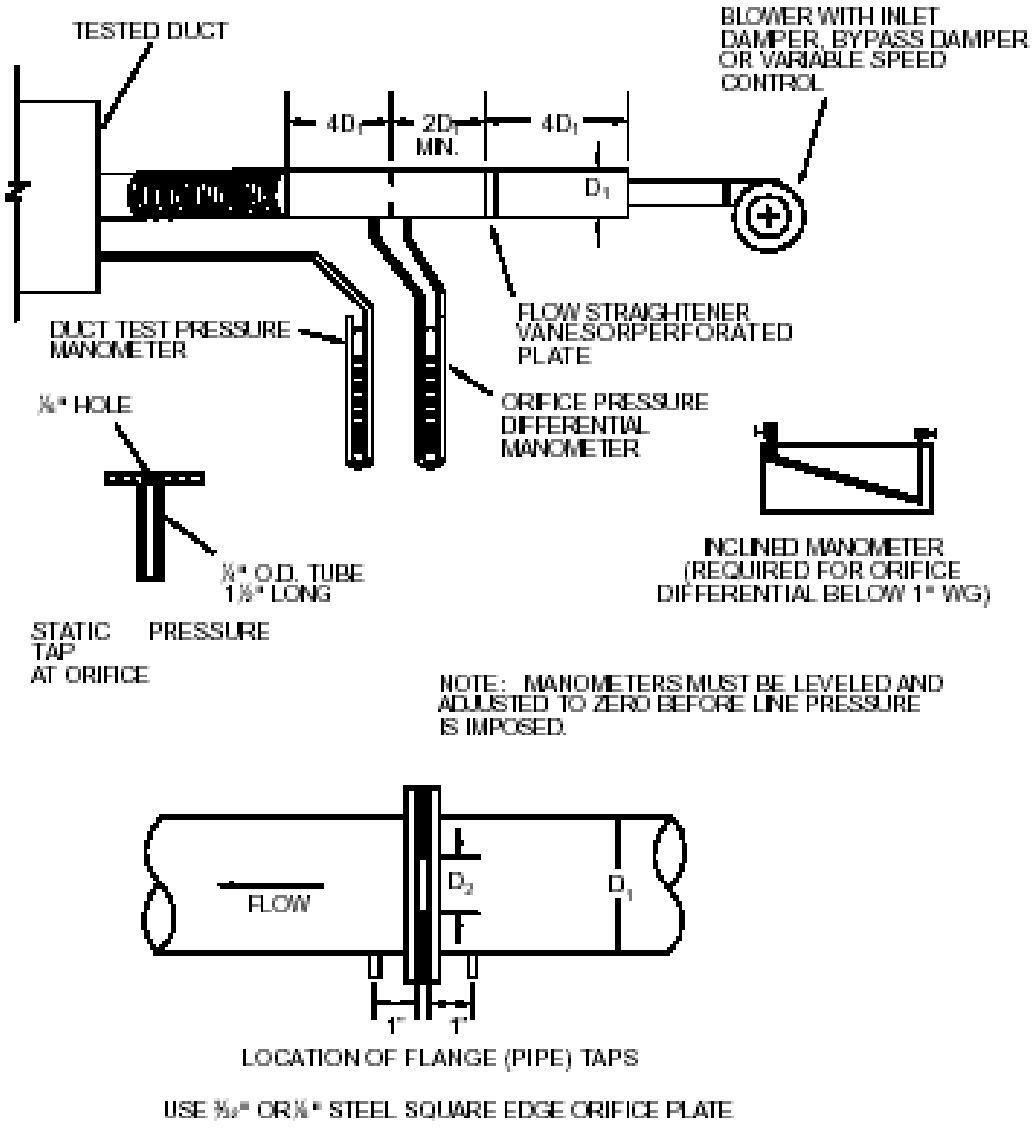
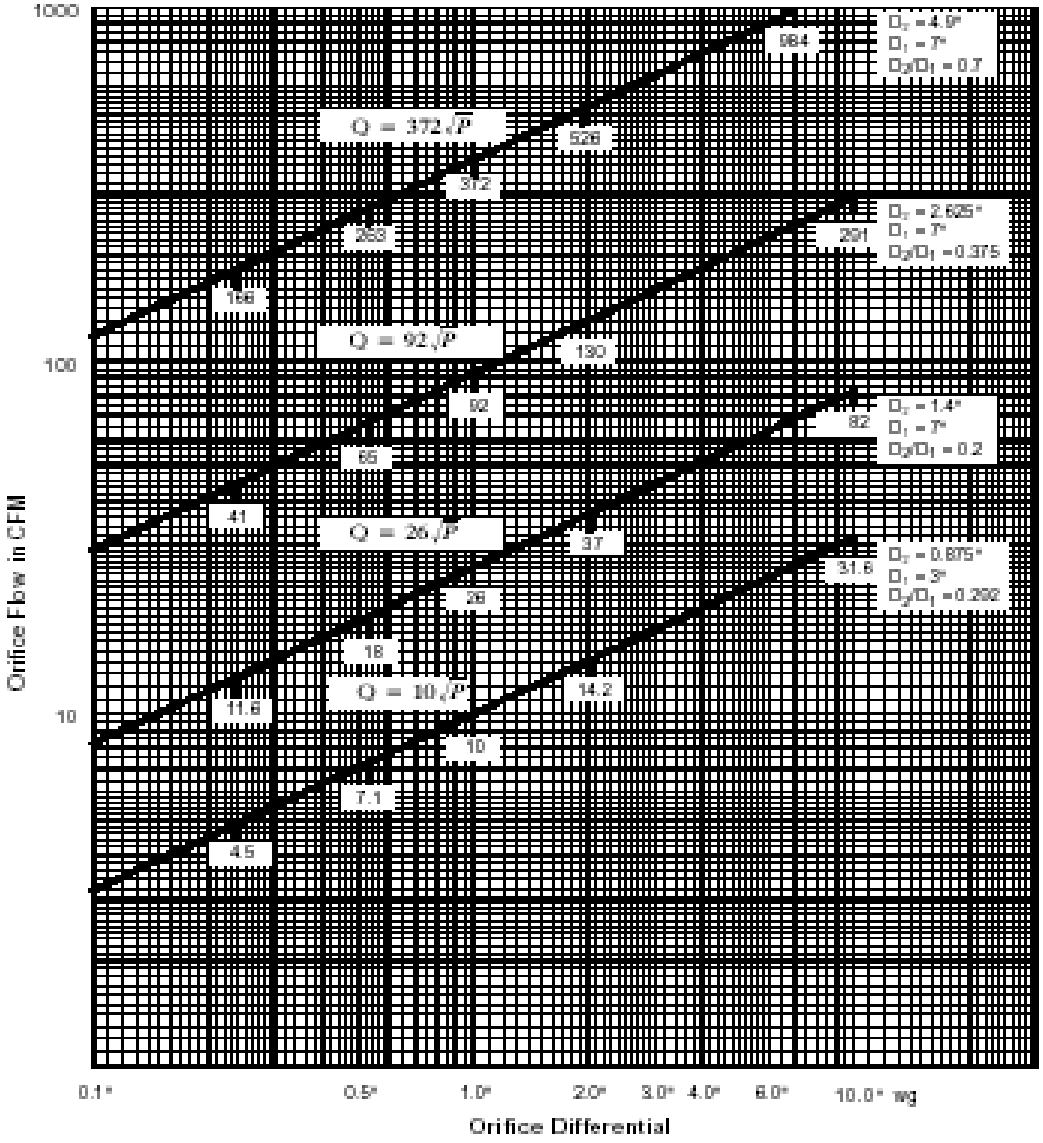


ILLUSTRATION OF TESTING FIGURE 3-1



LEAKAGE TEST METER APPARATUS – FLANGE TAPS FIG. 5-1



TYPICAL ORIFICE FLOW CURVES – FIGURE 5-3

ΔP in. w.g.	Orifice Size			ΔP in. w.g.	Orifice Size			ΔP in. w.g.	Orifice Size		
	1.4"	2.625"	4.90"		1.4"	2.625"	4.90"		1.4"	2.625"	4.90"
0.02			57.1	1.22	28.7	101.4	410.3	4.10	52.3	185.3	746
0.04		18.7	78.8	1.24	28.9	102.3	413.6	4.20	52.9	187.5	755
0.06		22.8	95.3	1.26	29.2	103.1	416.9	4.30	53.5	189.7	763
0.08		26.2	109.2	1.28	29.4	103.9	420.1	4.40	54.1	191.9	772
0.10		29.3	121.5	1.30	29.6	104.7	423.4	4.50	54.7	194.0	781
0.12		32.1	132.6	1.32	29.8	105.5	426.5	4.60	55.3	196.2	789
0.14		34.6	142.8	1.34	30.1	106.3	429.7	4.70	55.9	198.3	797
0.16		37.0	152.3	1.36	30.3	107.1	432.9	4.80	56.5	200.4	806
0.18		39.2	161.2	1.38	30.5	107.9	436.0	4.90	57.1	202.4	814
0.20		41.3	169.6	1.40	30.7	108.6	439.1	5.00	57.6	204.4	822
0.22		43.3	177.6	1.42	30.9	109.4	442.2	5.10	58.2	206.5	830
0.24		45.2	185.2	1.44	31.2	110.2	445.2	5.20	58.8	208.5	838
0.26		47.0	192.6	1.46	31.4	110.9	448.3	5.30	59.3	210.4	846
0.28		48.8	199.6	1.48	31.6	111.7	451.3	5.40	59.9	212.4	854
0.30		50.5	206.5	1.50	31.8	112.4	454.3	5.50	60.4	214.3	862
0.32		52.1	213.0	1.52	32.0	113.2	457.2	5.60	61.0	216.3	869
0.34		53.7	219.4	1.54	32.2	113.9	460.2	5.70	61.5	218.2	877
0.36		55.3	225.6	1.56	32.4	114.6	463.1	5.80	62.0	220.0	884
0.38		56.8	231.6	1.58	32.6	115.4	466.0	5.90	62.6	221.9	892
0.40		58.3	237.5	1.60	32.8	116.1	468.9	6.00	63.1	223.8	899
0.42		59.7	243.2	1.62	33.0	116.8	471.8	6.10	63.6	225.6	907
0.44		61.1	248.8	1.64	33.2	117.5	474.7	6.20	64.1	227.4	914
0.46		62.4	254.3	1.66	33.4	118.2	477.5	6.30	64.6	229.2	921
0.48		63.8	259.6	1.68	33.6	118.9	480.3	6.40	65.1	231.0	928
0.50	18.5	65.1	264.9	1.70	33.8	119.6	483.1	6.50	65.6	232.8	935
0.52	18.8	66.4	270.0	1.72	34.0	120.3	485.9	6.60	66.1	234.6	942
0.54	19.2	67.6	275.0	1.74	34.2	121.0	488.7	6.70	66.6	236.3	949
0.56	19.5	68.9	280.0	1.76	34.4	121.7	491.5	6.80	67.1	238.1	956
0.58	19.9	70.1	284.8	1.78	34.6	122.4	494.2	6.90	67.6	239.8	963
0.60	20.2	71.3	289.6	1.80	34.8	123.1	496.9	7.00	68.1	241.4	970

TABLE 5-2 ORIFICE FLOW RATE (SCFM) VS. PRESSURE DIFFERENTIAL (in. of Water)

PROJECT NAME _____ PROJECT NO. _____ PAGE _____ OF _____

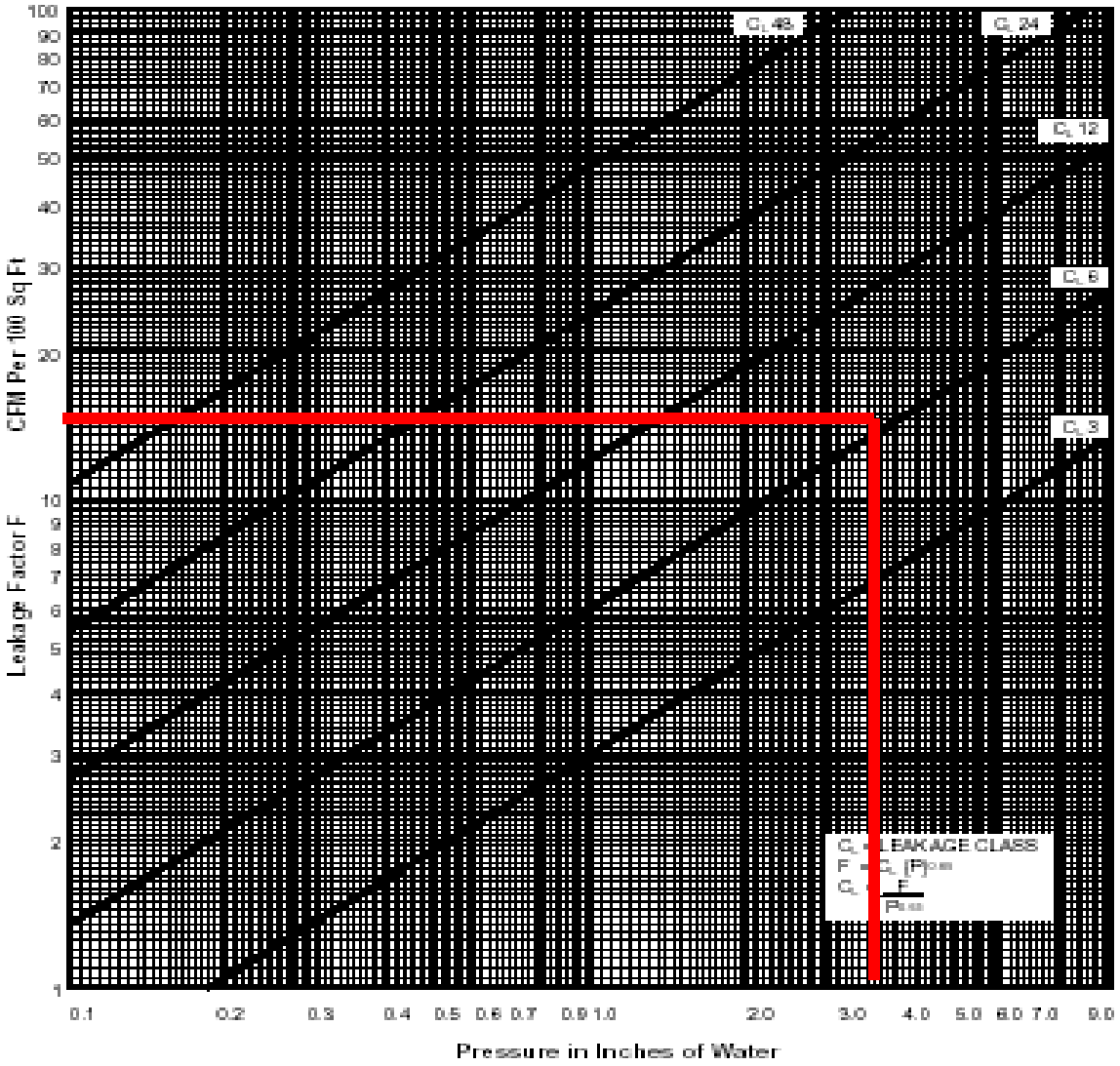
AIR DUCT LEAKAGE TEST SUMMARY

AIR SYSTEM _____
FAN CFM (Q) _____

LEAKAGE CLASS _____
SPECIFIED TEST PRESSURE (P_t) _____
DUCT CONSTRUCTION PRESSURE CLASS (P_c) _____

DESIGN DATA				FIELD TEST DATA RECORD							
SUBJECT DUCT	SURFAC AREA IN FT^2	ALLOWABLE LEAKAGE		DIAMETER		PRESSURE '' W.G.		DATE	PERFORMED BY	WITNESSED BY	ACTUAL CFM
		FACTOR CFM/100 FT^2	CFM (TEST SECTION)	ORIFICE	TUBE	DUCT	ACROSS ORIFICE				
TOTAL SYSTEM				****	***	**	*****	****	****	****	
TEST SECTION(S)											

13.6



4" w.g. Construction Class – operating at 3.5" w.g. = Leakage Class 6

DUCT LEAKAGE CLASSIFICATION – FIGURE 4-1

LEAKAGE CLASS	FAN CFM PRORATED* PER S.F.	STATIC PRESSURE (IN WG) ½	1	2	3	4	6
48	2	15	24	38			
	2½	12	19	30			
	3	10	16	25			
	4	7.7	12	19			
	5	6.1	9.6	15			
24	2	7.7	12	19			
	2½	6.1	9.6	15			
	3	5.1	8.0	13			
	4	3.8	6.0	9.4			
	5	3.1	4.8	7.5			
12	2	3.8	6	9.4	12		
	2½	3.1	4.8	7.5	9.8		
	3	2.6	4.0	6.3	8.2		
	4	1.9	3.0	4.7	6.1		
	5	1.5	2.4	3.8	4.9		
6	2	1.9	3	4.7	6.1	7.4	9.6
	2½	1.5	2.4	3.8	4.9	5.9	7.7
	3	1.3	2.0	3.1	4.1	4.9	6.4
	4	1.0	1.5	2.4	3.1	**3.4** 3.7	4.8
	5	0.8	1.2	1.9	2.4	3.0	3.8
3	2	1.0	1.5	2.4	3.1	3.7	4.8
	2½	0.8	1.2	1.9	2.4	3.0	3.8
	3	0.6	1.0	1.6	2.0	2.5	3.2
	4	0.5	0.8	1.3	1.6	2.0	2.6
	5	0.4	0.6	0.9	1.2	1.5	1.9

TABLE A-1 LEAKAGE AS PERCENT OF FLOW IN SYSTEM

NOTES – TABLE A-1 LEAKAGE AS PERCENT OF FLOW IN SYSTEM

*TYPICALLY $\frac{\text{FAN CFM}}{\text{DUCT SURFACE AREA}}$ WILL BE 2 TO 5 CFM/SQUARE FOOT.

% OF FLOW = LEAKAGE FACTOR (IN CFM/100 AT THE PRESSURE)

DIVIDED BY $\frac{\text{FAN } CFM}{S.F. \text{ SURFACE}} = \frac{CFM_A}{100\ S.F.} \times \frac{S.F}{CFM_F}$

CLASS 48 IS AVERAGE UNSEALED RECTANGULAR DUCT. CLASS 24 AND LOWER ARE ANTICIPATED RESULTS FOR SEALED DUCTS.

GIVEN:	**ASSUME:**
From Fig. 4-1	Fan CFM = 16000
Leakage Class = C_L6	Duct Area = 4000 sf.
Operating Pressure = 3.5" w.g.	$\frac{\text{Fan CFM}}{\text{Duct Area}} = \frac{16000}{4000} = 4$
Leakage Factor = 13.6 CFM/100 sf.	
CALCULATION:	
% of flow $= \frac{\text{Leakage Factor}}{\frac{\text{Fan CFM}}{\text{Duct Area}}}$	$= \frac{13.6}{4} = 3.40$

Questions

&

Answers