APPENDIX -D-

METHODS FOR
ESTIMATING AND MEASURING AIRFLOW

CONTENTS

METHODS FOR ESTIMATING AND MEASURING AIRFLOW

PART I – METHODS FOR *ESTIMATING* AIRFLOW

1. **METHODS**
   - **The following methods are outlined in this Appendix:**
     - Air Conditioning Capacity (Tons)
       - The Preston Guide or Carrier Blue Book
       - Model Number Nomenclature
     - Heating System Capacity (kBtuh Output)
       - Btuh Output of Gas Furnace
       - Wattage of Electric Furnace
   - **Air Conditioner or Heat Pump**
     - AC/HP unit capacity may be determined by the following methods using information obtained from the condenser nameplate:
       - A-1: The Preston Guide or Carrier Blue Book
       - A-2: Model Number Nomenclature
   - **Gas or Electric Furnace**
     - Furnace capacity may be determined by using the unit's Btuh <u>Output</u>.
       - Gas: Directly from the nameplate
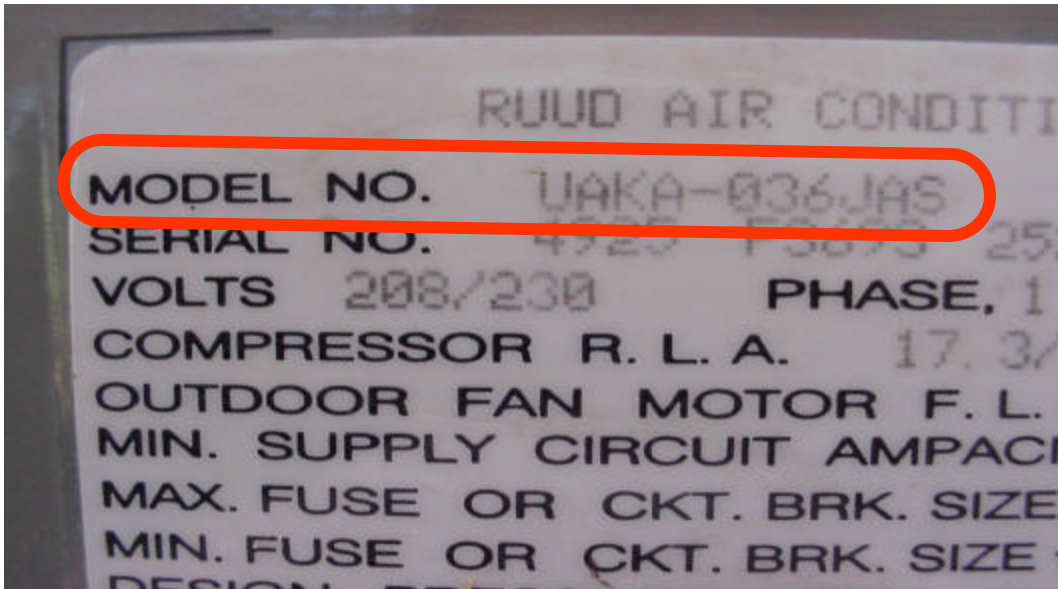   - Electric: Wattage converted to Btuh Output
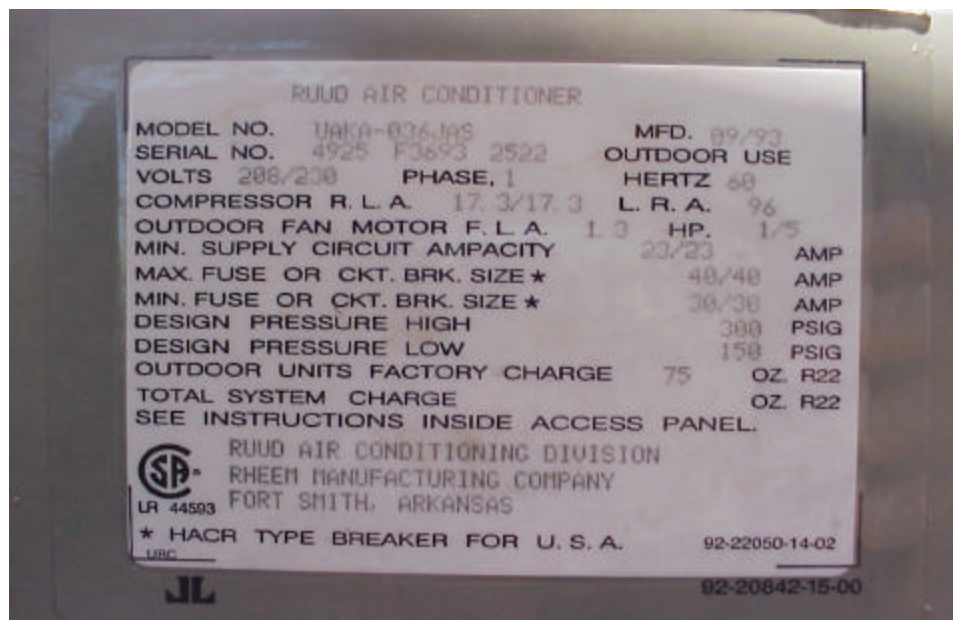
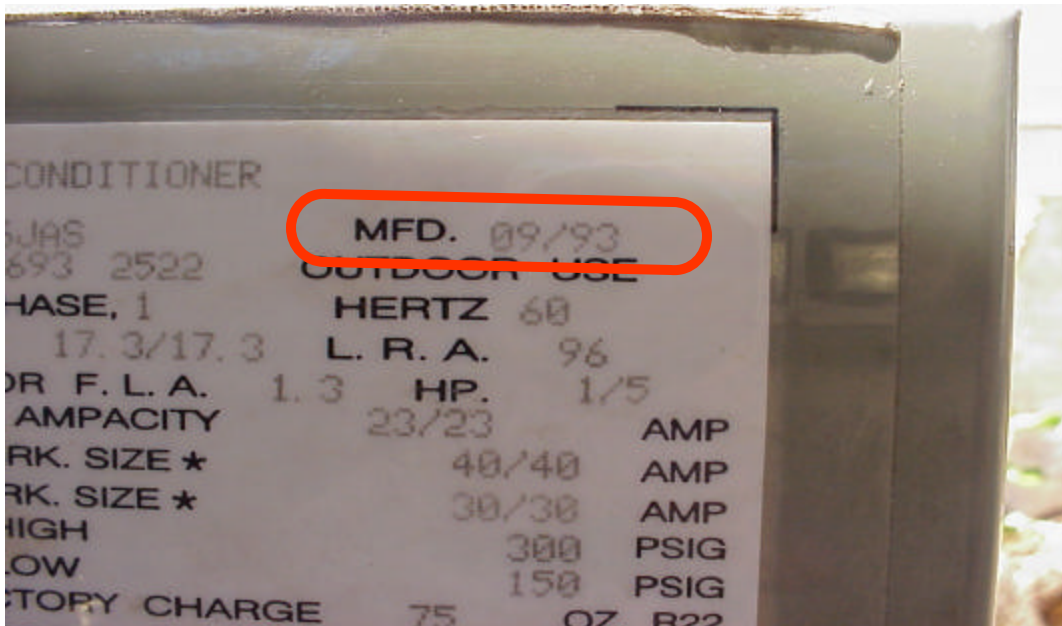EXAMPLE OF A CONDENSER NAMEPLATE

D-2

2. AIR CONDITIONER AND HEAT PUMP UNITS

- **Method A—Preston Guide or Carrier Bluebook**
  - **Step A-1:** Determine the model number and date of manufacture from the condenser nameplate.

NAMEPLATE SHOWS MODEL NUMBER TO BE "UAKA-036JAS"

NAMEPLATE SHOWS DATE OF MANUFACTURE TO BE "09/93"

2. AIR CONDITIONER AND HEAT PUMP UNITS (continued)

- ### Method A—Preston Guide or Carrier Bluebook (continued)
  - **Step A-2:** Check the Preston Guide (or Carrier Bluebook) to determine cooling capacity of the unit, based on model number and date of manufacture.
    - Find model number UAKA-036JA manufactured in 1993.
    - Find cooling capacity, which in this example is 34,400 Btu.

Preston Guide

RUUD

The 1994 BlueBook™ • 381

DATA FROM THE PRESTON GUIDE SHOWS
UNIT'S COOLING CAPACITY TO BE 34,000 BTU

UAKA-036DA
1993   34,400   10.5
UAKA-036JA
1993   34,400   10.5
UAKA-042CA
1993   42,000   10.5

D-4

2. AIR CONDITIONER AND HEAT PUMP UNITS (continued)

- **Method A—Preston Guide or Carrier Bluebook (continued)**
  - **Step A-3:** Calculate cooling capacity in tons based on KBtu.
    - Per the Preston Guide, unit cooling capacity = 34,400 Btu
    - Divide Unit Capacity by 12,000 Btu/ton to convert Btu to tons: [34,400 Btu ÷ 12,000 Btu/ton = 2.87 tons]
    - Establish tons of cooling capacity:
      - Round up to 3 tons, <u>or</u>
      - Find "Nominal Tons" using the chart in Figure D-1.
- **Method B—Model Number Nomenclature**
  - This method may be used when KBtu can be determined from the model number.
  - **Step B-1:** Locate model number on the condenser name plate.
    - Refer to the nameplate pictured on page D-3.
    - In this example, the model number is "UAKA-0**36**JAS".
  - **Step B-2:** Establish cooling capacity in Btu.
    - **36** is the capacity of the unit, and
    - That is equivalent to 36,000 Btu.
  - **Step B-3:** Divide unit capacity in Btu by 12,000 Btu/ton to determine cooling capacity in tons:
    - [36,000 Btu ÷ 12,000 Btu/ton = 3 tons]
    - Cooling capacity is 3 tons.

FIGURE D-1: NOMINAL TONS BASED ON UNIT CAPACITY IN BTU

UNIT CAPACITY (BTU)	CALCULATED TONS	NOMINAL TONS
14,000 – 21,999	1.17 – 1.82	1.5
22,000 – 26,999	1.83 – 2.24	2.0
27,000 – 32,999	2.25 – 2.74	2.5
33,000 – 38,999	2.75 – 3.24	3.0
39,000 – 44,999	3.25 – 3.74	3.5
45,000 – 53,999	3.75 – 4.49	4.0
54,000 – 62,999	4.50 – 5.24	5.0

3. FURNACES

- **System G: Determining Estimated Airflow for Gas Furnaces**
  - **Step G-1:** Determine Btuh <u>output</u> from unit name plate.
    - Locate Btuh output on the nameplate (see picture below).
      - Output is 80,000 Btuh in this example.
    - If only Input is listed, Output = Input x (% efficiency).
      - Example: (100 kBtuh Input) x (0.80 AFUE) = 80 kBtuh.
  - **Step G-2:** Convert Btuh output to estimated airflow in cfm.
    - Assume 21.7 cfm per kBtuh.
    - Use the following equation to determine estimated airflow:
      [Output kBtuh x 21.7 cfm/kBtuh = cfm system airflow]
    - Example:
      [80 (kBtuh) x 21.7 (cfm/KBtu) = 1,736 cfm system airflow]
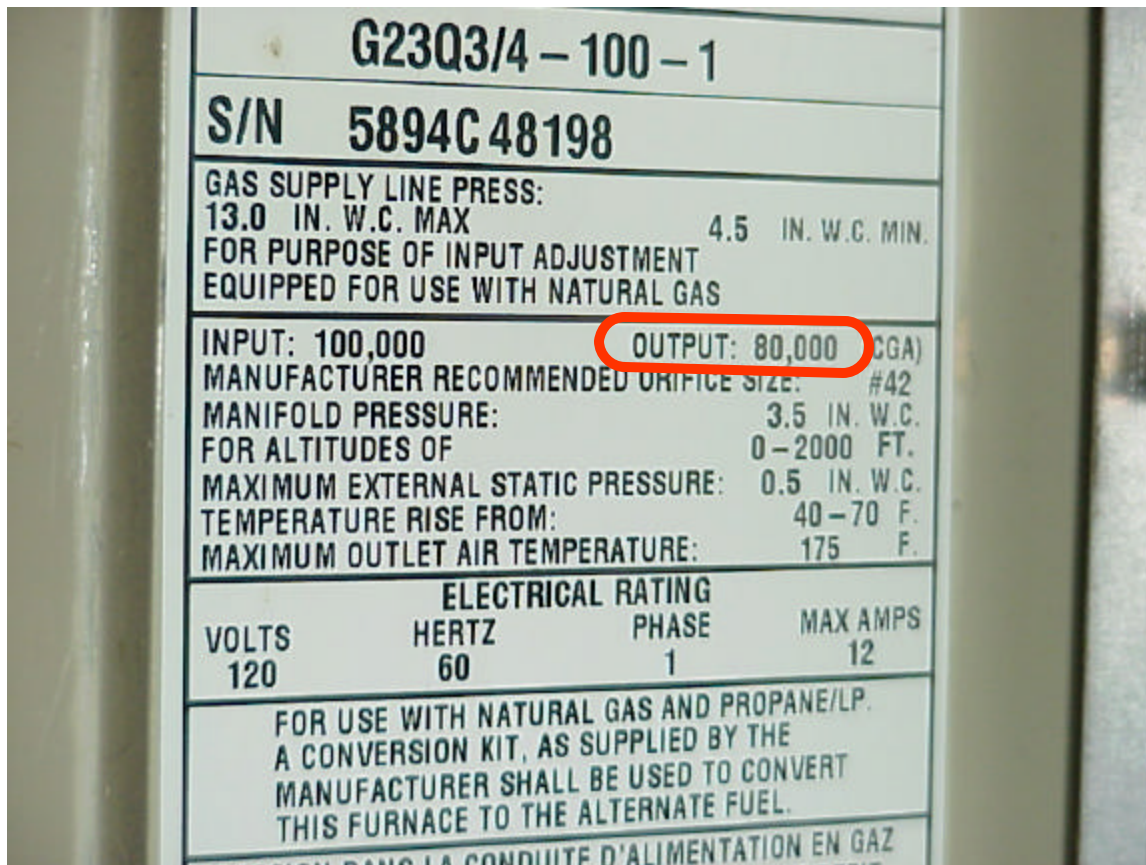
EXAMPLE OF A GAS FURNACE NAMEPLATE SHOWING
HEATING CAPACITY (OUTPUT) OF 80,000 BTUH

D-6

3.   FURNACES **(continued)**

- **System E: Determining Estimated Airflow for Electric Furnaces**
  - **Step E-1:** Determine wattage from unit name plate.
    - Locate ~~wattage~~ heating capacity (in kilowatts) on the nameplate (see graphic below).
    - Heating Capacity (output) is ~~6,900~~ 20 kilowatts in this example ~~(230 volts x 30.0 amps = 6990 watts)~~.
    - **Step E-2:** Convert kilowatts to kBtuh output to estimated airflow in cfm, assuming 3.413 kBtuh per kilowatt and 95% efficiency.
    - Use the following formula to convert wattage to kBtuh output:
      - [(watts x 3.413 x 0.95) ~~÷ 1,000~~ = kBtuh output] <u>or</u>
      - [(kilowatts x 3.242) ~~÷ 1,000~~ = kBtuh output]
      - In this example: ~~[6990 (watts) x 3.242 ÷ 1,000 = 22.66 KBtu]~~ [20 (kW) x 3.242 = 64.84 kBtuh output].
  - **Step E-3:** Convert kBtuh output to estimated airflow in cfm.
    - Assume 21.7 cfm per kBtuh.*
    - Use the following equation to determine estimated airflow: [kBtuh x 21.7 cfm/kBtuh = cfm system airflow]
    - Example: [~~22.66~~64.84 (kBtuh) x 21.7 (cfm/KBtu) = ~~492~~1407 cfm system airflow]

ELECTRIC FURNACE
SIMULATED NAMEPLATE

MANUFACTURED BY XYZ FURNACE CORP.

MODEL # 000000000   SERIAL # 00000000

~~Voltage: 230 Volts Amperage: 30 Amps~~
HEATING CAPACITY: 20 KILOWATTS
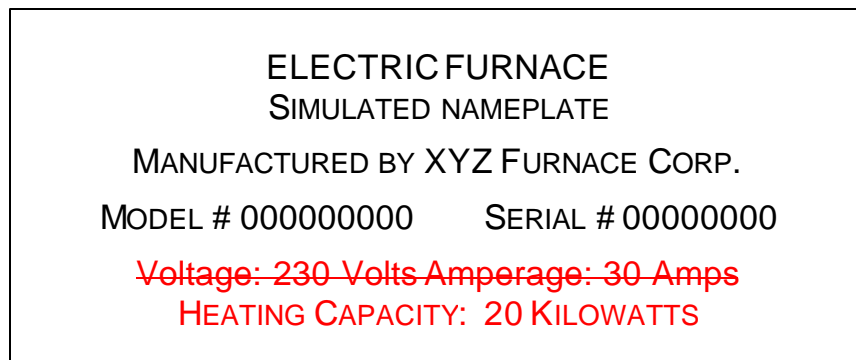
EXAMPLE OF AN ELECTRIC FURNACE NAMEPLATE
SHOWING HEATING CAPACITY OF 6,900 WATTS

(TEMPORARY GRAPHIC)

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*May be used until CEC determines cfm/kBtuh default for electric furnaces.

PART II – METHODS FOR *MEASURING* AIRFLOW

Methods for measuring HVAC system airflow (fan flow) presented in this appendix are methods approved by the California Energy Commission and described in Appendix RE-2005 of the Title 24 "Residential Alternative Calculation Method (ACM) Approval Manual for the 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings" — Publication 400-03-003F, available online at: http://www.energy.ca.gov/title24/2005standards/index.html

1. FLOW GRID MEASUREMENT

- **Overview**
  - This method uses a "metering plate" containing "pressure sensing grids", which are directed toward the air handler.
  - The metering plate temporarily replaces the filter in a typical air handler system during the air flow measurement procedure.
    - If the filter location is directly adjacent to the air handler, the metering plate will measure the total air handler flow.
    - If the filter is located remotely at a single central return, the metering plate will measure the air flow through the central return. Airflow measurement through the central return will be very close to the total air handler air flow only if the return duct is very tight.

FLOW GRID (METERING PLATE) WITH PRESSURE SENSING GRIDS DIRECTED TOWARD AIR HANDLER

TUBING TO GAUGE

RETURN OPENING

RETURN GRILLE

D-8
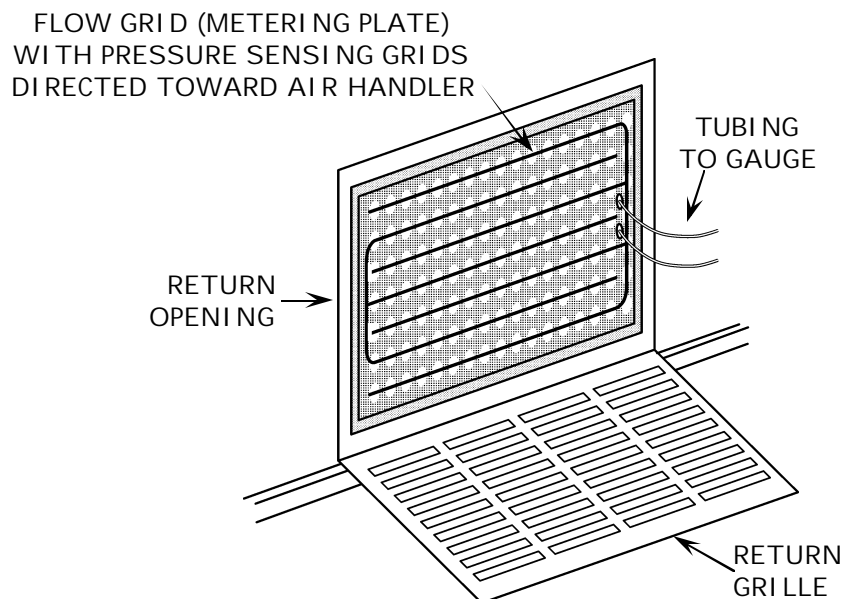
1. FLOW GRID MEASUREMENT (continued)

- **Protocol**
  - Equipment used for measurements shall meet the requirements specified in ACM Residential Manual Appendix RE-2005, §RE.3.1.3, "Flow Grid Measurement."
  - The following general guidelines are for reference only; measurement shall be:
    - Performed in accordance with test equipment manufacturer's instructions, <u>and</u>
    - In harmony with ACM Residential Manual Appendix RE-2005, §RE.4.1.3, "Diagnostic Fan Flow Using Flow Grid Measurement".

- **General Guidelines**
  - **Step 1:** System operating pressure shall be measured with the air handler operating at maximum speed used in the system.
    - Using a digital pressure gauge, pressure difference in Pa shall be measured between the supply plenum and the conditioned space (**P**sp) using a static pressure probe pointing into the air stream.
    - Probe may be placed in the nearest supply duct when access to the supply plenum is unavailable.
    - Probe shall be adjusted to achieve the highest pressure and then secured in place during the fan flow test.

SUPPLY PLENUM

STATIC PRESSURE PROBE DIRECTED INTO SUPPLY AIRFLOW

D-9
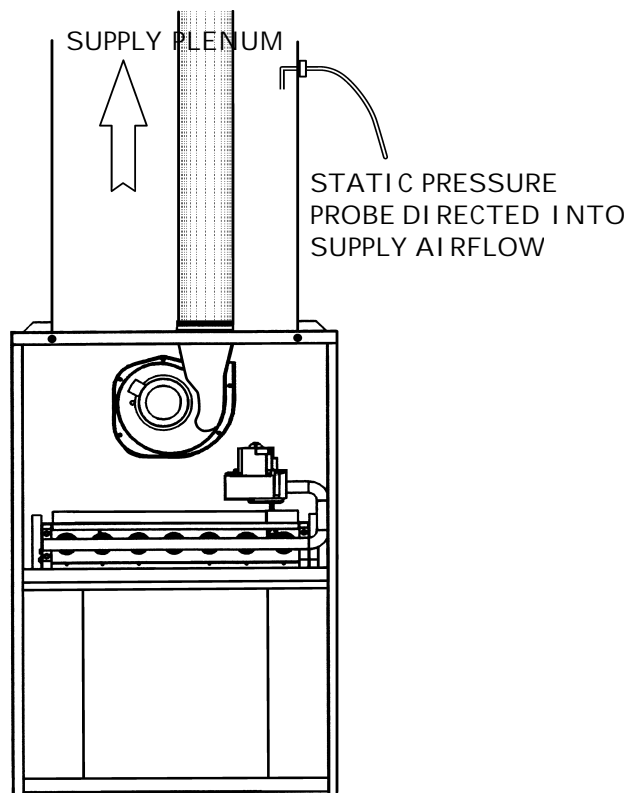
1~~0~~. FLOW GRID MEASUREMENT (continued)
- General Guidelines (continued)

- **Step 2:** With the air handler off, the flow grid measurement sensor (metering plate) shall be installed, with the pressure sensing grids directed toward the air handler, and with no obstructions within 6" upstream or 2" downstream of the metering plates, in the best available location (filter slot or filter grille) where all system airflow passes through the flow grid:
  - In a filter slot as close to the air handler as possible, <u>or</u>
  - In the filter grille of a single-return duct system, <u>or</u>
  - In each filter grille of a multiple-return duct system simultaneously.

(A) When Using DG-700 Fully-Automated Digital Gauge

- **Step A-3:** Air handler shall be operated again at the same speed as used in Step 1, and time averaging shall be lengthened as needed to maximize accuracy when readings are fluctuating.
- **Step A-4:** Measured system airflow (Qah) shall be obtained from the digital pressure gauge and recorded.
- **Step A-5:** When the flow grid is installed in a remote filter grille, manufacturer's correction factor shall be used to increase accuracy.

METERING PLATE INSTALLED IN FILTER SLOT, WITH FRONT SIDE FACING INTO THE AIRFLOW

AIRFLOW

D-10
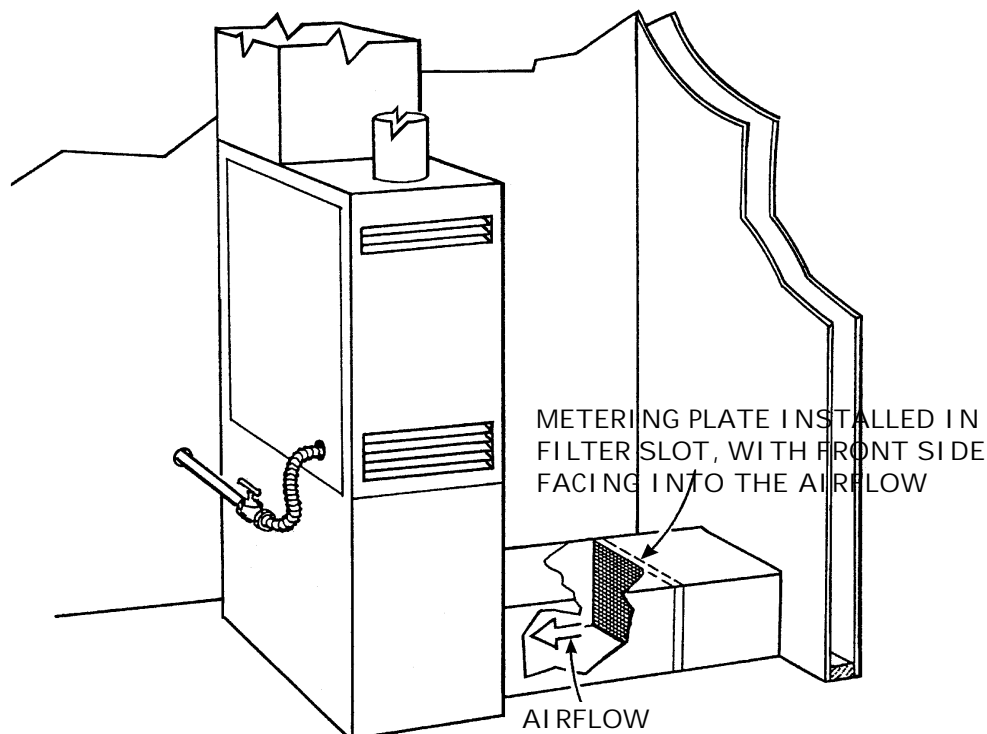
1<s>0</s>. FLOW GRID MEASUREMENT (continued)
- General Guidelines (continued)
(B) When Using DG-3 Digital Gauge

- **Step B-3:** With air handler operating again at the same speed as in Step 1, measurements shall be made with the flow grid in place:
  - System operating pressure re-measured (Ptest).
  - Airflow through the flow grid measured (Qgrid).
- **Step B-4:** System Airflow (Qah) shall be calculated by:
  - Multiplying Qgrid by equipment manufacturer's Flow Resistance Correction Factors (sample shown below), <u>or</u>
  - Applying the following equation to readings obtained in Steps 1 and B-3:

  System Airflow (Air Handler Flow) = Qah = Qgrid x (Psp/Ptest)$^{0.5}$

- **Step B-5:** When the flow grid is installed in a remote filter grille, manufacturer's correction factor shall be used to increase accuracy.

All Gauges

- **Step 6:** Adjusted Airflow shall be calculated (to correct for differences in system operating pressures measured in Steps 1 and 3) using manufacturer's flow resistance correction procedure.

Appendix B **Flow Resistance Correction Factors**

Table B.1 Flow Resistance Correction Factors (using Pascals)

Normal System Operating Pressure in Pascals (NSOP)

		10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50
	10	1.00	1.10	1.18	1.26	1.34	1.41	1.48	1.55	1.61	1.67	1.73	1.79	1.84	1.90	1.95	2.00	2.05	2.10	2.14	2.19	2.24
	12	0.91	1.00	1.08	1.15	1.22	1.29	1.35	1.41	1.47	1.53	1.58	1.63	1.68	1.73	1.78	1.83	1.87	1.91	1.96	2.00	2.04
	14	0.85	0.93	1.00	1.07	1.13	1.20	1.25	1.31	1.36	1.41	1.46	1.51	1.56	1.60	1.65	1.69	1.73	1.77	1.81	1.85	1.89
	16	0.79	0.87	0.94	1.00	1.06	1.12	1.17	1.22	1.27	1.32	1.37	1.41	1.46	1.50	1.54	1.58	1.62	1.66	1.70	1.73	1.77
	18	0.75	0.82	0.88	0.94	1.00	1.05	1.11	1.15	1.20	1.25	1.29	1.33	1.37	1.41	1.45	1.49	1.53	1.56	1.60	1.63	1.67
	20	0.71	0.77	0.84	0.89	0.95	1.00	1.05	1.10	1.14	1.18	1.22	1.26	1.30	1.34	1.38	1.41	1.45	1.48	1.52	1.55	1.58
TrueFlow	22	0.67	0.74	0.80	0.85	0.90	0.95	1.00	1.04	1.09	1.13	1.17	1.21	1.24	1.28	1.31	1.35	1.38	1.41	1.45	1.48	1.51
System	24	0.65	0.71	0.76	0.82	0.87	0.91	0.96	1.00	1.04	1.08	1.12	1.15	1.19	1.22	1.26	1.29	1.32	1.35	1.38	1.41	1.44
Operating	26	0.62	0.68	0.73	0.78	0.83	0.88	0.92	0.96	1.00	1.04	1.07	1.11	1.14	1.18	1.21	1.24	1.27	1.30	1.33	1.36	1.39
Pressure	28	0.60	0.65	0.71	0.76	0.80	0.85	0.89	0.93	0.96	1.00	1.04	1.07	1.10	1.13	1.16	1.20	1.22	1.25	1.28	1.31	1.34
in	30	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00	1.03	1.06	1.10	1.13	1.15	1.18	1.21	1.24	1.26	1.29
Pascals	32	0.56	0.61	0.66	0.71	0.75	0.79	0.83	0.87	0.90	0.94	0.97	1.00	1.03	1.06	1.09	1.12	1.15	1.17	1.20	1.22	1.25
(TFSOP)	34	0.54	0.59	0.64	0.69	0.73	0.77	0.80	0.84	0.87	0.91	0.94	0.97	1.00	1.03	1.06	1.08	1.11	1.14	1.16	1.19	1.21
	36	0.53	0.58	0.62	0.67	0.71	0.75	0.78	0.82	0.85	0.88	0.91	0.94	0.97	1.00	1.03	1.05	1.08	1.11	1.13	1.15	1.18
	38	0.51	0.56	0.61	0.65	0.69	0.73	0.76	0.79	0.83	0.86	0.89	0.92	0.95	0.97	1.00	1.03	1.05	1.08	1.10	1.12	1.15
	40	0.50	0.55	0.59	0.63	0.67	0.71	0.74	0.77	0.81	0.84	0.87	0.89	0.92	0.95	0.97	1.00	1.02	1.05	1.07	1.10	1.12
	42	0.49	0.53	0.58	0.62	0.65	0.69	0.72	0.76	0.79	0.82		87	0.90	0.93	0.95	0.98	1.00	1.02	1.05	1.07	1.09
	44	0.48	0.52	0.56	0.60	0.64	0.67	0.71	0.74	0.77				0.88	0.90	0.93	0.95	0.98	1.00	1.02	1.04	1.07
	46	0.		55	0.59	0.63	0.66	0.69	0.7					86	0.88	0.91	0.93	0.96	0.9	1.00	1.02	1.0
					0.61	0.65	0.							0.87	0.89	0.91	0.9		1.00		
						0.								5	0.87	0.8					

EXAMPLE OF FLOW RESISTANCE CORRECTION FACTORS
USED TO CALCULATE ADJUSTED AIRFLOW

2. PLENUM PRESSURE MATCHING MEASUREMENT

- **Overview**
  - This procedure is also known as "Duct Tester Used as a Powered Capture Hood."
  - The duct tester is used to pressurize the system to equal the pressure created by the air handler, so that airflow through the duct tester represents system airflow (fan flow).

- **Protocol**
  - Equipment used for measurements shall meet the requirements specified in ACM Residential Manual Appendix RE-2005, §RE.3.1.1, "Plenum Pressure Matching Measurement."
  - The following general guidelines are for reference only; measurement shall be:
    - Performed in accordance with test equipment manufacturer's instructions, <u>and</u>
    - In harmony with ACM Residential Manual Appendix RE-2005, §RE.4.1.2, "Diagnostic Fan Flow Using Plenum Pressure Matching".

D-12
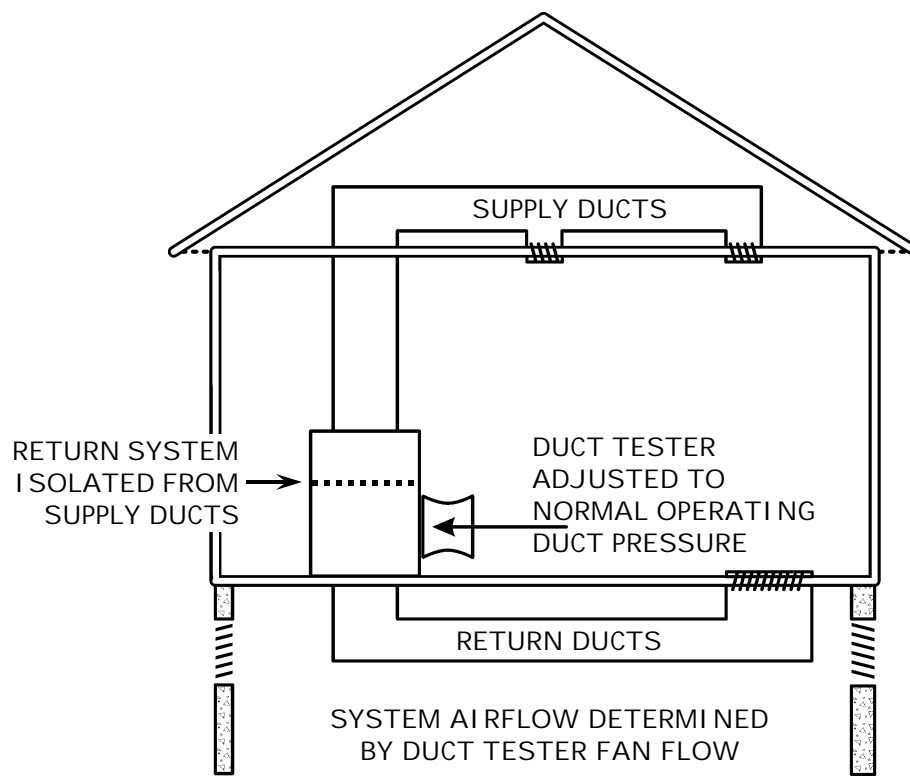
2. PLENUM PRESSURE MATCHING MEASUREMENT (continued)

- **General Guidelines**
  - **Step 1:** Supply plenum pressure test set-up:
    - Air handler shall be off.
    - Doors, windows, etc. shall be open to prevent pressure changes in the space containing the handler (e.g., outside door/window for air handler in conditioned space; or access doors, vents, etc. for air handler in garage, attic, etc.).
    - All supply and return registers shall be open, and filter(s) clean.
    - Static pressure probe, directed into the airflow, shall be inserted into the supply plenum or in a supply trunk nearby. It shall be adjusted (rotated) to achieve the highest pressure and securely attached.
    - Tubing from the probe shall be attached to **Channel A Input** tap of the digital pressure gauge, and the **Reference** tap shall be open to the conditioned space.
  - **Step 2:** With the air handler fan operating at the maximum speed used in the system (e.g., cooling speed when air conditioning is present), the pressure difference in Pa between the supply plenum and the conditioned space (**P**sp) shall be measured. **P**sp, the normal operating duct pressure, is the target pressure to be maintained during the system airflow (fan flow) tests.

SUPPLY PLENUM

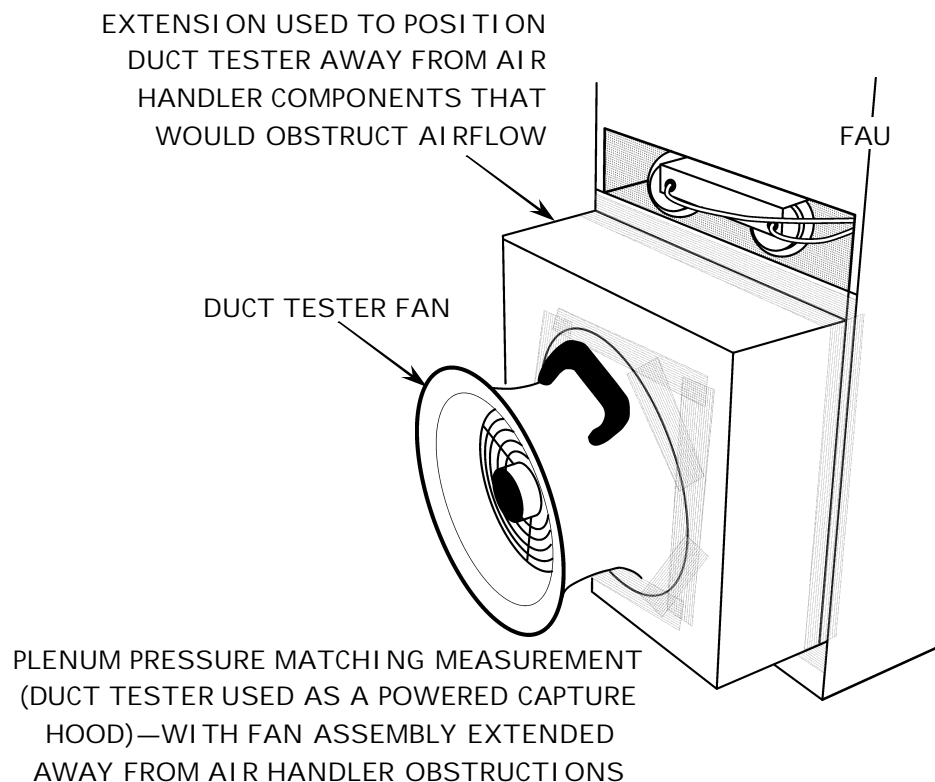STATIC PRESSURE PROBE DIRECTED INTO SUPPLY AIRFLOW

D-13
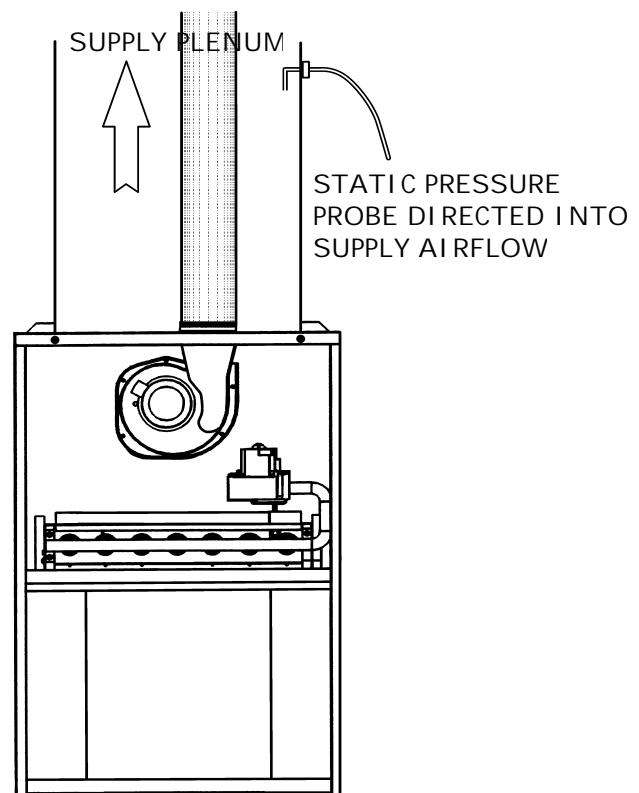
2. PLENUM PRESSURE MATCHING MEASUREMENT (continued)
- **General Guidelines**
  - **Step 3:** Duct Tester set-up at air handler cabinet:*
    - With the air handler access panel removed, the return air opening inside the air handler cabinet shall be sealed (e.g., with cardboard and tape) to isolate the return system from the supply system.
    - The Duct Tester shall be installed in place of the air handler access panel. If air handler components will obstruct airflow, the Duct Tester shall be mounted on an extension/box (illustrated below) that holds it away from the furnace cabinet.
    - Tubing shall connect the Duct Tester to the **Channel B Input** tap on the digital pressure gauge, and the **Reference** tap shall be open to space where the Duct Tester is located.

*Attachment to the return grille of a single-return system (pictured on page D-15) is possible. However, if the return duct is not substantially airtight, leaks will cause the airflow measurement to be inaccurate.

EXTENSION USED TO POSITION DUCT TESTER AWAY FROM AIR HANDLER COMPONENTS THAT WOULD OBSTRUCT AIRFLOW

FAU

DUCT TESTER FAN

PLENUM PRESSURE MATCHING MEASUREMENT (DUCT TESTER USED AS A POWERED CAPTURE HOOD)—WITH FAN ASSEMBLY EXTENDED AWAY FROM AIR HANDLER OBSTRUCTIONS

D-14

112. PLENUM PRESSURE MATCHING MEASUREMENT (continued)

- **General Guidelines (continued)**
  - **Step 4:** With the air handler operating,
    - Duct Tester shall be turned on and adjusted until the duct pressure on **Channel A** equals the normal operating duct pressure (Psp) measured in Step 2.
    - Airflow through the Duct Tester shall be determined (calculated or measured using the digital gauge fan flow feature), which is the estimated cfm system airflow through the air handler (Qah).
  - **Step 5:** Correction shall be made when Duct Tester cannot adequately pressurize the system to equal the normal operating duct pressure (Psp) recorded in Step 2:
    - With the Duct Tester producing the maximum attainable duct pressure on **Channel A** (Pmax), the airflow through the Duct Tester (Qmax) shall be determined.
    - System airflow at normal operating duct pressure (Psp) shall be estimated using the following equation:
    - System (Air Handler) Airflow = Qah = Qmax x (Psp/Pmax)$^{0.5}$

SINGLE CENTRAL RETURN

DUCT TESTER FAN

OPTIONAL DUCT TESTER LOCATION
AT A SINGLE-RETURN SYSTEM INLET (WHEN
RETURN DUCTWORK IS SUBSTANTIALLY AIRTIGHT)

D-15
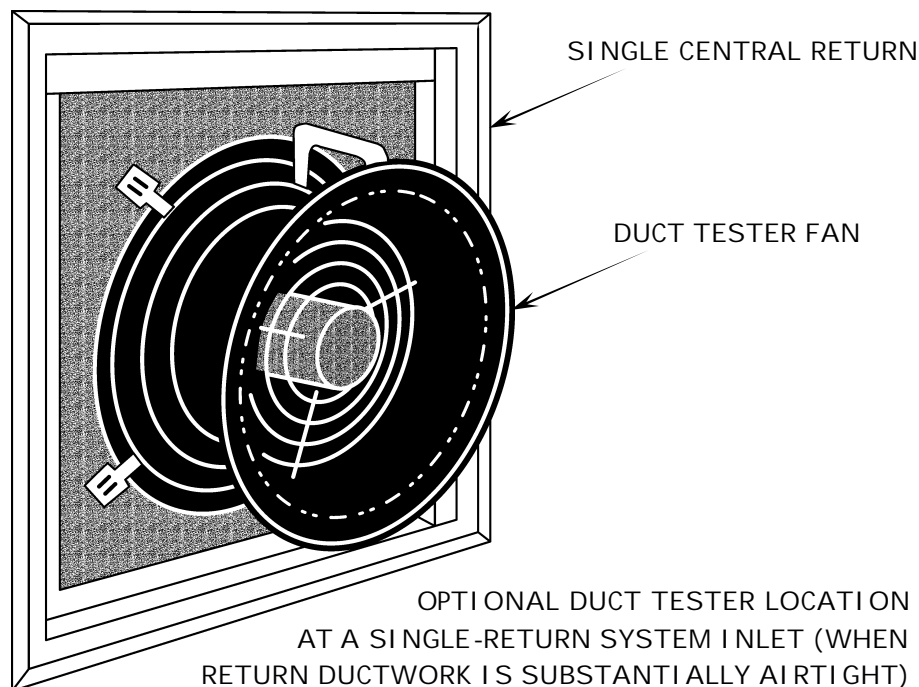
3. USING A FLOW CAPTURE HOOD

- **Overview**
 - The procedure utilizes a "capture flow hood" to directly measure airflow through the return or supply system.
  - The flow hood covers the entire register/grille and captures the airflow going into it.

- **Protocol**
  - Equipment used for measurements shall meet the requirements specified in ACM Residential Manual Appendix RE-2005, §RE.3.1.2, "Flow Capture Hood Measurement."
  - The following general guidelines are for reference only; measurement shall be:
    - Performed in accordance with test equipment manufacturer's instructions, and
    - In harmony with ACM Residential Manual Appendix RE-2005, §RE.4.1.1, "Diagnostic Fan Flow Using Flow Capture Hood."

- **General Guidelines**
  - **Step 1:** Fan switch shall be set to "On" position with system air handler operating on maximum speed for the unit. To get highest speed in systems without a fan "On" switch, unit must be run in:
    - Cooling mode for heating and air conditioning systems.
    - Heating mode for heating-only systems.
  - **Step 2:** System airflow (fan flow) shall be measured at the return grille(s) with a calibrated Flow Capture Hood. When multiple return grilles are present, airflow at each shall be measured.
  - **Step 3:** The Total System Airflow in cfm (Q_{ah}) shall be the sum of the measured return flows.
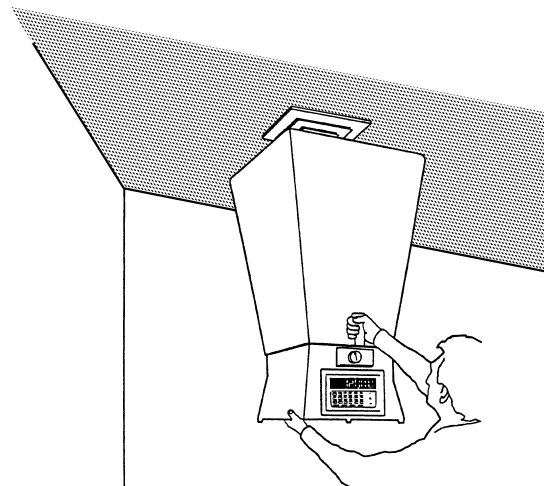
MEASURING AIRFLOW WITH
A FLOW CAPTURE HOOD