Table 14 .... Determination of Free Area and Total Pressure Loss of Register for No Deflection of Air[a, b, c, d, e]

Register Free Air in Square Inches (Upper value in each group)
Pressure Loss in Inches of Water Column (Lower value in each group)

CFM	Distance from Register to Opposite Wall									CFM	Distance from Register to Opposite Wall						
	19–21	22–24	25–27	28–30	31–34	35–39	40–49	50–59	60–69		35–39	40–49	50–59	60–69	70–79	80–89
					A	B							A′	B′		
190[f]–209	62 0.02	47 0.03	37 0.04	30 0.06	24 0.09	18 0.15				660–699	210 0.02	143 0.03	95 0.07	69 0.12	49 0.22	
210[f]–229	76 0.02	58 0.02	45 0.04	36 0.05	29 0.08	22 0.12				700–739	236 0.02	160 0.03	107 0.06	77 0.11	54 0.21	
230[f]–249		69 0.02	53 0.03	43 0.04	34 0.07	26 0.11				740–779	262 0.02	179 0.03	119 0.06	86 0.10	61 0.18	
250[f]–269		81 0.02	63 0.03	50 0.04	40 0.06	31 0.09	21 0.18			780–819	291 0.02	198 0.03	132 0.05	95 0.09	67 0.17	
270[f]–299		93 0.02	73 0.02	59 0.03	47 0.05	36 0.08	24 0.16			820–859	320 0.02	218 0.03	145 0.05	105 0.08	74 0.15	
300[f]–339			95 0.02	77 0.03	61 0.04	46 0.06	32 0.12			860–899	352 0.02	240 0.02	160 0.04	115 0.08	81 0.14	
340[f]–379			120 0.02	97 0.02	77 0.03	59 0.05	40 0.10			900–939	385 0.01	262 0.02	175 0.04	126 0.07	89 0.13	
380[f]–419				119 0.02	95 0.03	73 0.04	50 0.08			940–979	419 0.01	285 0.02	190 0.04	137 0.07	97 0.12	
420[f]–459				149 0.02	114 0.03	88 0.04	60 0.07			980–1019	455 0.01	309 0.02	206 0.04	148 0.06	105 0.11	
460[f]–499				171 0.02	136 0.02	105 0.03	71 0.06			1020–1059	493 0.01	335 0.02	223 0.03	161 0.06	113 0.11	
500[f]–539					160 0.02	123 0.03	84 0.05			1060–1099	530 0.01	361 0.02	241 0.03	173 0.06	123 0.10	
540[f]–579					186 0.02	143 0.02	97 0.05	65 0.09	47 0.17	1100–1139	571 0.01	388 0.02	258 0.03	186 0.05	132 0.09	93 0.17
580[f]–619					213 0.02	164 0.02	111 0.04	74 0.08	54 0.15	1140–1179		416 0.02	277 0.03	199 0.05	141 0.08	100 0.16
620[f]–659						180 0.02	127 0.04	85 0.07	61 0.14	1180–1219		446 0.02	297 0.03	214 0.04	151 0.08	107 0.15
								A	B	1220–1259		476 0.02	317 0.03	228 0.04	161 0.07	116 0.14
										1260–1299		507 0.01	338 0.02	243 0.04	172 0.07	122 0.13
										1300–1339		539 0.01	359 0.02	258 0.04	183 0.07	130 0.12
										1340–1379			382 0.02	274 0.04	195 0.07	138 0.12
										1380–1419			403 0.02	290 0.03	206 0.06	146 0.12
										1420–1459				308 0.03	218 0.06	155 0.10
										1460–1500				324 0.03	230 0.06	163 0.10
															A′	B′	

Footnotes for Table 14

[a] If register selected based on distance from register to opposite wall is unsatisfactory on account of size or pressure loss, it is permissible to shift one or more spaces left or right in the tables to obtain a more suitable register. If requirements fall in blank space, select two registers in place of one and divide CFM capacity between the two registers.

[b] Total pressure (static plus velocity) loss is based on FLAT FACE ADJUSTABLE BAR TYPE and does NOT include stackhead.

[c] Values on the right of line A and A′ should not be used in applications such as churches, auditoriums, and concert halls.

[d] Values on right of line B and B′ should not be used in applications such as residential work, motion picture theaters, court rooms, and schools.

[e] For floor and baseboard registers where a velocity of approximately 300 FPM is used, the free area = $\frac{\text{CFM} \times 144}{300}$ or approximately, $\frac{\text{CFM}}{2}$. Assume a pressure loss of 0.01.

[f] For any volume under 190 CFM use Table 13.

Table 15 .... Suggested Bonnet Pressure
Inches of Water

Total CFM Through Any One Duct	Suggested Bonnet Pressure In. Water	Total CFM Through Any One Duct	Suggested Bonnet Pressure In. Water
800–1000	0.10	3500 to 5000	0.15
1000–1200	0.10	5000 to 7500	0.25
1200–1800	0.10	7500 to 10,000	0.375
1800–2400	0.13	10,000 to 12,000	0.500
2400 to 3500	0.14	12,000 to 14,000	0.750

the ducts. Hence, ducts need not be insulated except as follows:

1. Supply ducts:
   A. Located in enclosed, *unheated* spaces—1 in. of insulation.
   B. Located in spaces exposed to outdoor temperature—2 in. of insulation.
2. Return ducts—1 in. of insulation when *not* located in heated space.

The procedure for larger systems may also be used to design perimeter systems in which the trunk duct is embedded in the concrete slab floor, usually just inside the foundation wall.[19] In such systems the branch ducts are usually very short and consist only of the take-off fitting, the diffuser boot or stackhead, and a short length of riser. The *trunk* is installed in the same manner as the loop duct in a smaller installation, and is often insulated to reduce heat loss and prevent overheated floors above the duct. Perimeter insulation must be used between the foundation wall and duct.

AUTOMATIC CONTROLS

Air stratification, high bonnet temperatures, excessive flue gas temperatures, and heat overrun or lag in a properly designed system, can be largely eliminated through proper care in the planning and installation of the control system.[20] Best results are obtained when the fan is operated as continuously as possible, coupled with frequent, short cycles of burner operation. Controls usually employed are:

1. A *room thermostat* located in the occupied space at a point where there is good air circulation and where the temperature is representative of the area being controlled. It is the operating control which initiates the starting and stopping of the burner. It is frequently of the timed, two-position type. Refer to Chapter 43 for more information on types of room thermostats.

2. A *fan thermostat* located in the bonnet of the furnace to start the fan at a bonnet temperature 10 to 15 deg above room temperature and stop the fan at about 15 deg below the cut-in point. The lower settings are used for high side-wall register installations and the higher settings for baseboard register installations. For most satisfactory performance these settings should be as low as is feasible without resulting in drafts.

3. A *high limit control*, also in the bonnet of the furnace, to stop the burner independently of the room thermostat if the air temperature exceeds 200 F. The fan thermostat and high limit control are sometimes combined into a single unit.

4. A *humidistat* to regulate the moisture supplied to the rooms on systems which are equipped with humidifying means. This may be of the room type, usually located adjacent to the room thermostat, or it may be of the insertion type located in the main return air duct.

5. Primary and limit controls for the various types of gas burners, oil burners and coal burners (stokers) should be provided as required, and are discussed in Chapter 34.

ADJUSTMENT OF SYSTEM

More even room temperatures will result if the controls are adjusted to produce long period fan operation. This is accomplished in automatically-fired forced warm air heating systems when the control arrangement is of the type where the room thermostat controls the fire, and the blower control (fan switch) controls the blower operation. This procedure as outlined in detail in Manual 6 of the National Warm Air Heating and Air Conditioning Association, is as follows:[3]

1. Adjust the fuel input in proper relation to the heat loss of the structure.
2. Determine the temperature rise through the furnace.
3. Adjust the air volume to produce a temperature rise through the furnace of about 90 deg.
4. If adjustable, set the fan switch differential to a minimum of about 15 deg.
5. Adjust the fan switch cut-out point as low as practicable.
6. Balance the system by adjusting dampers to produce even temperature distribution between rooms.
7. Set the room thermostat at the desired room temperature.

Close control of room temperature is facilitated by the use of a room thermostat having a narrow operating differential. The heat anticipating thermostat is such a device.

WARM AIR CEILING PANEL SYSTEMS

Warm air ceiling panel heating systems utilize a false ceiling suspended 3¼ in. from the ceiling joists which have previously been covered on the bottom with sheets of plasterboard. Special hangers are used to suspend the false ceiling or heating panel from the joists. Steel supporting rods are installed through these hangers and metal lath is attached to the rods. The lath is then plastered to a thickness of ¾ in., making a completely sealed air space above the ceiling. Warm air is delivered to this sealed space through a standard warm air duct, installed in the usual manner. The air is then circulated over the entire ceiling being guided by sheet-metal baffles. After the air has passed over the ceiling, it is returned to the furnace through a return air duct for reheating. The system is closed, and no air is introduced into the heated space from the panel. (See also Chapter 30, Panel Heating.)

Because a warm air ceiling panel system involves a different type of ceiling construction, its installation is practically limited to new construction. Only automatically-fired and thermostatically-controlled furnace-blower units may be used with this system. The standard automatic heating controls consisting of a room thermostat, temperature limit control, blower control (fan switch), and primary control are all that are required. While warm air ceiling panel heating has particular advantages in one-story utility room houses, it can be just as effectively installed in one- and two-story houses with basements.

Complete design and installation procedure is given in Manual 7-A of the National Warm Air Heating and Air Conditioning Association.[18]

SUMMER OPERATION

During hot summer periods a slight cooling effect may sometimes be obtained by the circulation of basement air through the system. This beneficial effect is due to both the increased air movement in the occupied spaces and the small reduction in dry-bulb temperature brought about by