

## North American Orifice Metering System

Bulletin 8697

Ref: Sheets 8697-3 and -5, Bulletin 8736

**8697 and M8697** Metering Orifices accurately measure gas flows to industrial burners. They are compact, inexpensive, and can be installed in individual burner gas lines to expedite adjustment of air/fuel ratio. They allow easy checking of operation while burners are firing.

Individual metering orifices are a great convenience on multi-burner furnaces, facilitating setting all burners the same or in desired gradients. Some installations add a larger 8697 Metering Orifice (upstream of the individual units) for continuous metering of total gas consumption in a zone or for the whole furnace.

Many plants also use 8697 Metering Orifices in burner air lines to enable precise matching flows of combustion air and gas.

### FEATURES

8697 Sizes: ½" through 4" pipe size  
M8697 Sizes: ½" through 2" in ISO 7-Rp

Nominal flows: 90 cfh to 15,700 cfh natural gas  
(2.5 m³/h to 444.6 m³/h)

Flexibility: Each orifice holder offers a choice of seven or eight plates that can be exchanged without removing holder from pipe. This allows convenient on the job tailoring of the meter to fit its requirements.

### INSTALLATION

10 Straight clean pipe diameters upstream, 4 diameters downstream, without valves or fittings.

For maximum accuracy, readings must be corrected for:

- gas (or air) line pressure
  - gas (or air) temperature
  - barometric pressure
- Sheets 8697-3 and 8697-5 deal with correction factors

Observe straight pipe run requirements.

Pressure taps should be on top or side of pipe to reduce problems with dirt or condensate collecting in taps or manometer hose.

When pressure is over 3 psi (207 mbar), remove hose barbs and install tube fittings to use metal tubing, rather than hose, between metering orifice and manometer.

When metering oxygen, use specially cleaned pipe and oxygen approved differential-pressure gauges and equipment.

#### Models:

**8697--A:** Standard meter for air and fuel gases up to 25 psi (1.7bar)\* pressure.

**8697--C:** Meter specially cleaned for oxygen service up to 25 psi (1.7bar)pressure.



**8697 Orifice Holder with interchangeable orifice plates.**

### SELECTING AN ORIFICE

1. Determine high fire air flow rate at the burner.
2. Determine corresponding gas flow rate: (For typical natural gas, divide air flow by 11 to determine gas flow.) See table below for other air/gas volume ratios.
3. Select next smaller orifice plate capacity from Table B1 (realize that the plate capacity is offered in a number of different pipe size holders).

\* Maximum allowable pressure is 3 psig on all 8697A series orifice holders manufactured prior to October 2011.

Fuel Gases	Air/gas volume ratios (10% XSAir and typical fuels)
natural	11
propane	26.2
butane	33.6
coke oven	5.3

#### Example:

1. A 4422-7-A Burner passes 27,000 cfh air at 16 psi (assuming 16 psi represents "high fire" for this example).
2. Corresponding natural gas flow is 2455 cfh.
3. A #2000 plate is preferred because its higher required pressure drop--approximately 5.3"wc--means **low fire** readings will be easier and more accurate.

The 4422-7-A Burner has a 2½" gas connection; a #2000 plate is offered in the 8697-5 (2½") holder (as well as in the -3 [1½"] and -4 [2"] units), so an 8697-5-A2000 Metering Orifice may be the most convenient for this job.

Flow Capacities and ID's of 8697 Metering Orifices

TABLE B1. Flow Capacities, cfm (m<sup>3</sup>/h) with 3.5"wc (8.72 mbar) drop

14.397 psia inlet pressure; 80 F inlet temperature  
(993 mbar inlet pressure; 27 C inlet temperature)

Plate No.*	Coke Oven Gas				Natural Gas				Gas Pipe Size Code, 8697-						
	Natural Gas O (0.6 sg)	Propane (1.5 sg)	Butane (2.0 sg)	Air (1.0 sg)	Oxygen Δ (1.1 sg)	Natural Gas (4"wc drop)	-01 (1/2")	-0 (3/4")	-1 (1")	-2 (1 1/4")	-3 (1 1/2")	-4 (2")	-5 (2 1/2")	-6 (3")	-7 (4")
90	90(2.5)	57(1.6)	49(1.4)	70(2.0)	66(1.9)	96(2.7)	0.223(5.66)								
108	108(3.1)	68(1.9)	59(1.7)	84(2.4)	79(2.2)	115(3.3)	0.243(6.17)								
130	130(3.7)	82(2.3)	71(2.0)	101(2.9)	96(2.7)	139(3.9)	0.266(6.76)								
156	156(4.4)	99(2.8)	85(2.4)	121(3.4)	115(3.3)	167(4.7)	0.297(7.37)	0.289(7.34)							
186	186(5.3)	118(3.3)	102(2.9)	144(4.1)	137(3.9)	199(5.6)	0.314(7.98)	0.315(8.00)							
225	225(6.4)	142(4.0)	123(3.5)	174(4.9)	166(4.7)	241(6.8)	0.342(8.69)	0.344(8.74)							
270	270(7.6)	171(4.8)	148(4.2)	209(5.9)	199(5.6)	289(8.2)	0.371(9.42)	0.374(9.5)	0.383(9.73)						
324	324(9.2)	205(5.8)	177(5.0)	251(7.1)	240(6.8)	346(9.8)	0.408(10.36)	0.419(10.64)	0.419(10.64)						
387	387(11.0)	245(6.9)	212(6.0)	300(8.5)	285(8.1)	414(11.7)	0.438(11.13)	0.455(11.56)	0.455(11.56)						
468	468(13.3)	296(8.4)	256(7.3)	362(10.3)	344(9.7)	500(14.2)	0.476(12.09)	0.496(12.60)	0.503(12.78)						
558	558(15.8)	353(10.0)	305(8.6)	432(12.2)	410(11.6)	597(16.9)	0.539(13.69)	0.547(13.89)	0.547(13.89)						
675	675(19.1)	427(12.1)	370(10.5)	522(14.8)	496(14.0)	722(20.4)	0.586(14.88)	0.615(15.24)	0.615(15.24)	0.604(15.34)					
810	810(22.9)	512(14.5)	443(12.5)	627(17.8)	595(16.9)	864(24.5)	0.634(16.10)	0.651(16.54)	0.651(16.54)	0.661(16.76)					
915#	915(25.9)#	615(17.4)	532(15.1)	752(21.3)	715(20.2)	1040(29.5)	0.707(17.96)	0.718(18.24)	0.722(18.34)	0.722(18.34)					
972	972(27.5)	734(20.8)	635(18.0)	897(25.4)	853(24.2)	1240(35.1)	0.769(19.53)	0.781(19.84)	0.790(20.07)	0.790(20.07)					
1160	1160(32.9)	887(25.1)	766(21.7)	1083(30.7)	1030(29.2)	1500(42.5)	0.853(21.16)	0.851(21.16)	0.851(21.16)	0.851(21.16)	0.862(21.90)	0.872			
1400	1400(39.6)	1056(29.9)	913(25.9)	1292(36.6)	1230(34.8)	1790(50.7)	0.918(23.32)	0.918(23.32)	0.918(23.32)	0.918(23.32)	0.940(23.88)	0.948			
1670	1670(47.3)	1266(49.8)	1095(31.0)	1465(41.5)#	1472(41.7)	2140(60.6)	0.937(23.80)#	0.937(23.80)#	0.937(23.80)#	0.937(23.80)#	1.02(25.91)	1.032			
1890#	1890(53.5)#	1518	1313	1858	1766	2570					1.110 (28.19)	1.121	1.136		
2000	2000(56.6)	1823	1578	2230	2120	3080					1.204 (30.58)	1.221	1.236		
2400	2400	2190	1890	2300(65.1)#	2540	3690					1.156(29.36)#	1.320	1.346		
2880	2880	2630	2270	3220	3050	4440						1.433	1.468	1.468	
2970#	2970(84.1)#	3140	2730	3730(105.6)#	3660	5310					1.475(37.47)#				
3450	3450	3790	3290	4650	4410	6410								1.594	1.604
4150	4150	4550	3940	5580	5290	7700								1.732	1.755
4810#	4810(136.2)#	5460	4730	6690	6350	9240								1.872	1.914
4970	4970	5660	5660	8010	7620	11100								1.844#	
6000	6000	6540	6810	9250#	9160	13300								2.080	
7200	7200	7870	7870	12175#	12175#									2.272	2.280#
7286#	7286#													2.460	2.718#
8640	8640														
10350	10350														
11950#	11950#														
12450	12450														
15700#	15700#														

(Identical capacity plates do not interchange among different size orifice holders because of physical differences.)

TABLE C. Gas Data

Kind of Gas	Gas Gravity	Btu per cu ft	Correct Air/Gas Ratio	Flow Factor <sup>§</sup>
Natural <sup>○</sup>	0.6	1060	10	1.00
Coke Oven <sup>□</sup>	0.4	570	5.45	1.22
Propane	1.5	2500	23.8	0.63
Butane	2.0	3210	30	0.55
Air	1.0	—	—	0.77
Oxygen <sup>△</sup>	1.1	—	—	0.74

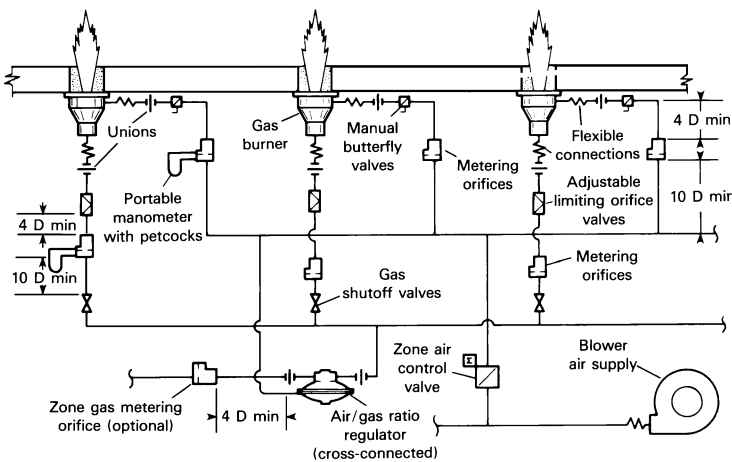
- \* 00 is a blank plate without orifice
- † For pressure and temperature conditions other than 14.397 psia and 80 F, see Sheets 8697-3 and -5.
- Natural gas capacity at 3½"wc dp is the plate number.
- ‡ High Beta ratio; normally used for air to prove flow only.
- △ For oxygen, specify 8697- -C-plate #. Use oxygen-cleaned metal tubing and pipe to an oxygen-approved differential-pressure gauge. Use only for line pressure at or below 25 psig.
- § Capacity factor of a given orifice relative to same orifice with natural gas.
- Corrosive to brass.

TABLE D. Average Recovery % of Tap Differential

ID	Average Recovery	Permanent Pressure Loss
1st	15	85
2nd	17	83
3rd	20	80
4th	23	77
5th	27	73
6th	32	68
7th	36	64

The pressure recovery for any specific orifice/holder combination depends on its position in the group of seven standard ID's available for its pipe size.

EXAMPLE: 36% pressure recovery is possible with an 8697-1-810 or with an 8697-7-12450 (as well as the 7th ID in all other pipe sizes). This means that when the pressure taps show a 3.5"wc pressure differential, the permanent pressure loss is (100 - 36) or 64% of 3.5 or 2¼"wc.



Piping for metering orifices with nozzle-mix burners (with premix burners, install orifice holder between atmospheric regulator and mixer). One portable manometer can be used for all orifice differential readings.

## CHANGING ORIFICES

1. Turn off gas supply.
2. Remove orifice plate size tag.
3. Remove cover screws and cover.
4. Loosen internal spring holding screw.
5. Remove orifice plate.
6. Install new orifice plate.
7. Tighten internal spring holding screw.
8. Replace cover and cover screws.
9. Attach new orifice plate size tag.
10. Perform leak test to verify no leakage.

## FIELD SETUP

1. Light burner. Adjust regulator and limiting orifice valve per their instructions.
2. Attach a manometer or quality air pressure gauge to burner air connection. Set burner air valve for desired pressure.
3. Open each orifice holder pressure tap momentarily to flush out condensate and dirt.
4. Connect a manometer, with its equalizing valve open, to orifice holder taps. Slowly open these taps; then slowly close the equalizing valve, taking care not to "blow" the manometer.
5. Adjust limiting orifice valve for proper gas flow reading.

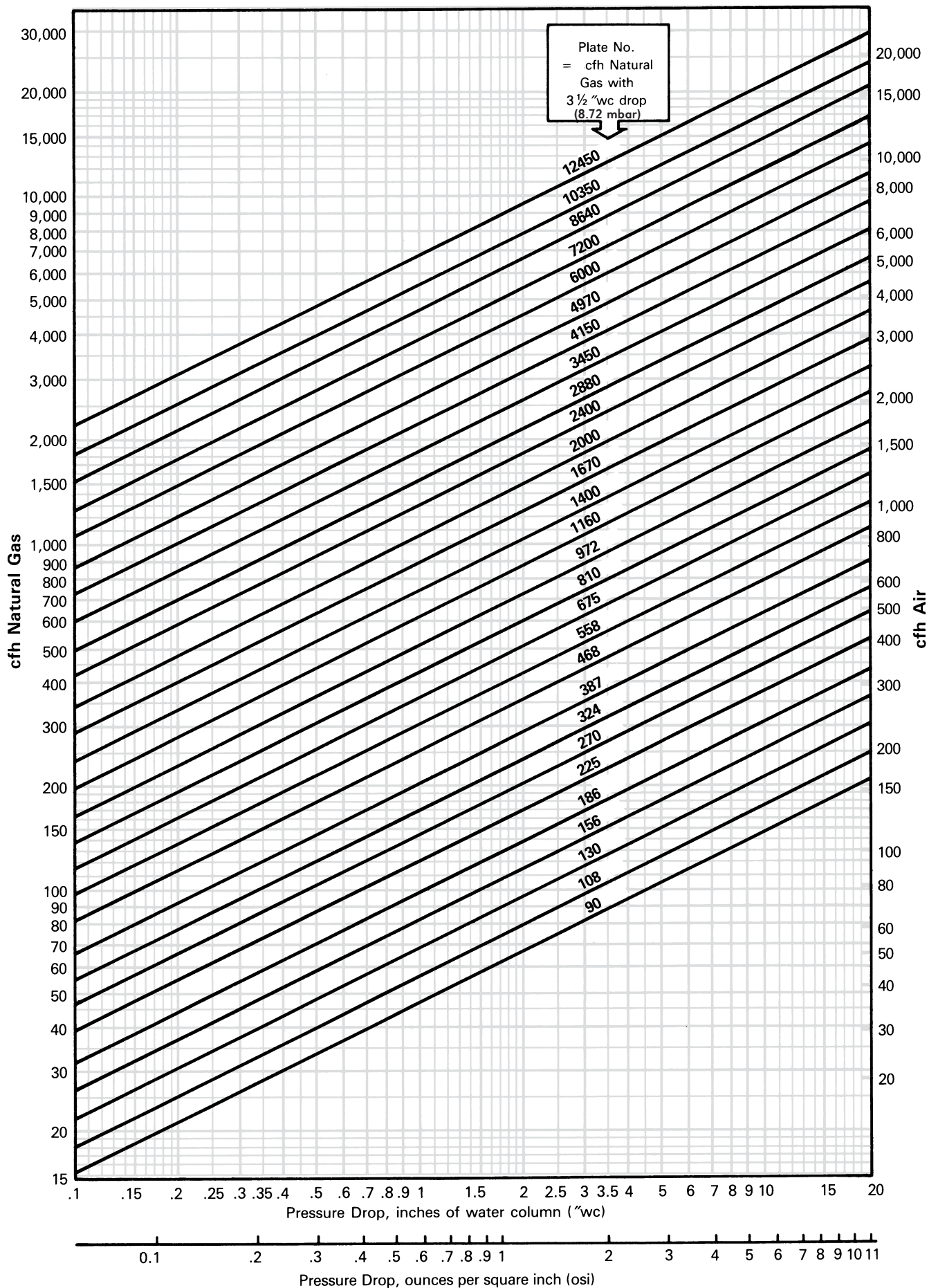
Using example (from "Selection," page 1):

If actual high fire air pressure on gauge is 14 osi, air flow is  $27,000 \times \sqrt{14/16} = 25,260$  cfh and corresponding natural gas flow should be 2526 cfh.

Adjust limiting orifice gas valve until manometer across the #2400 plate shows 3.88"wc:  $(2526/2400)^2 \times 3.5$ . (If using an 8736-A Manometer, its right hand scale [specifically for 8697 Metering Orifices] could be used--in this case  $2526/2400 = 1.05$  scale factor.)

**WARNING:** Situations dangerous to personnel and property may exist with the operation and maintenance of any combustion equipment. The presence of fuels, oxidants, hot and cold combustion products, hot surfaces, electrical power in control and ignition circuits, etc., is inherent with any combustion application. Parts of this product may exceed 160F in operation and present a contact hazard. Fives North American Combustion, Inc. urges compliance with National Safety Standards and Insurance Underwriters' recommendations, and care in operation.

### Capacities of 8697 Metering Orifice Plates



**8697-7 Orifice Holder** is identical in operation to smaller sizes, but it is mounted between flanges instead of being threaded onto pipe. Standard ANSI 125 psi flanges and full faced gaskets must be supplied separately.

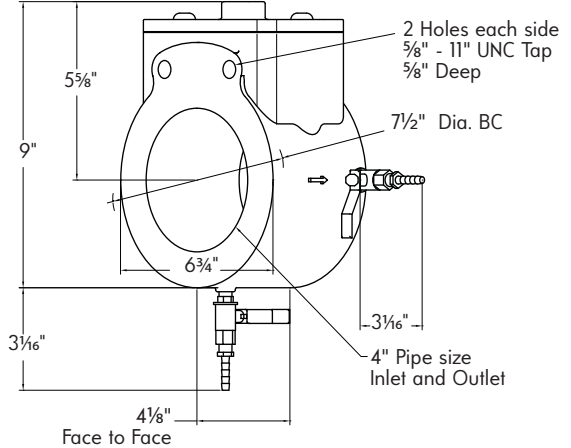
Holder fits within bolt circle of flanges: Two top bolts on each side screw into the holder to assure correct alignment.

Weight: 25 pounds

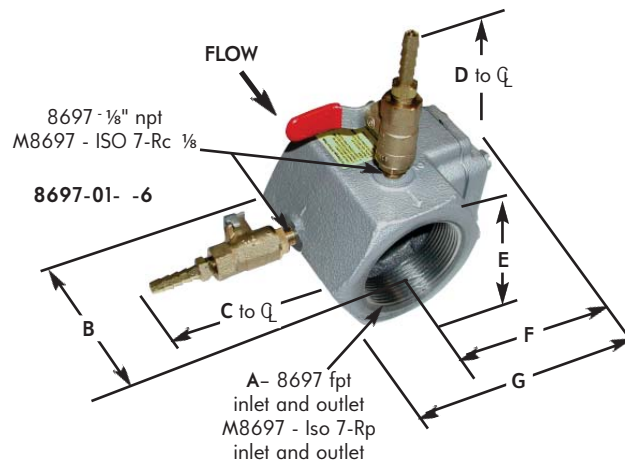
## CONSTRUCTION

Orifice plates: stainless steel. Accurately manufactured with a square edge orifice. Plate is stamped with its number, which is its capacity in cfh of 0.6 s.g. gas at 3.5"wc (8.72 mbar) pressure drop. Orifice holders: cast iron. Stainless steel springs, neoprene gaskets, brass hose cocks--alternate cocks available for gases corrosive to brass.

Allow screwdriver clearance for changing orifice plate



## DIMENSIONS



Orifice Holder designation	dimensions in inches (mm)							wt in lb (kg)
	A	B	C	D	E	F	G	
<b>8697-01/M8697-01</b>	1/2 (13)	2 13/16 (71)	3 7/8 (98)	3 5/8 (92)	1 3/8 (35)	1 13/16 (46)	2 21/32 (67)	1 3/4 (0.8)
<b>8697-0/M8697-0</b>	3/4 (19)	2 7/8 (73)	3 7/8 (98)	3 3/4 (95)	1 5/8 (41)	1 13/16 (46)	2 3/4 (70)	1 3/4 (0.8)
<b>8697-1/M8697-1</b>	1 (25)	3 1/8 (79)	4 (102)	3 7/8 (98)	1 7/8 (48)	1 15/16 (49)	3 (76)	2 1/2 (1.1)
<b>8697-2/M8697-2</b>	1 1/4 (32)	3 1/8 (79)	4 5/16 (110)	4 1/8 (105)	2 3/8 (60)	2 3/16 (56)	3 1/2 (89)	2 3/4 (1.2)
<b>8697-3/M8697-3</b>	1 1/2 (38)	3 1/8 (79)	4 7/16 (113)	4 1/4 (108)	2 5/8 (67)	2 5/16 (59)	3 3/4 (95)	4 (1.8)
<b>8697-4/M8697-4</b>	2 (51)	3 1/4 (83)	4 3/4 (121)	4 1/2 (114)	3 1/8 (79)	2 1/2 (64)	4 1/4 (108)	5 1/2 (2.5)
<b>8697-5</b>	2 1/2 (64)	3 3/4 (95)	5 1/8 (130)	4 13/16 (122)	3 3/4 (95)	3 1/4 (83)	5 3/8 (137)	9 1/2 (4.3)
<b>8697-6</b>	3 (76)	3 7/8 (98)	5 9/16 (141)	4 7/8 (124)	4 1/2 (114)	3 3/4 (95)	6 5/16 (160)	12 1/4 (5.6)

DIMENSIONS SHOWN ARE SUBJECT TO CHANGE. PLEASE OBTAIN CERTIFIED PRINTS FROM FIVES NORTH AMERICAN COMBUSTION, INC. IF SPACE LIMITATIONS OR OTHER CONSIDERATIONS MAKE EXACT DIMENSION(S) CRITICAL.



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