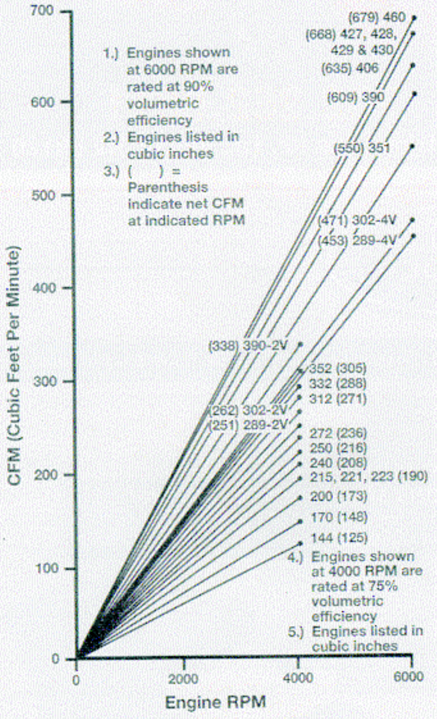
CFM REQUIREMENTS AND CARBURETOR SIZING

One of the most common misunderstandings that many people have about carburetion is CFM (cubic feet per minute). This is because over the years some very effective marketing has been done to get people to be concerned about CFM without any real explanation. When carburetor orders are placed at Pony Carburetors many individuals refer to a 600 (CFM) or a 735 (CFM) etc. It is not uncommon to get a call for someone wanting a 750 (CFM) for a 289 cubic inch engine. This article will hopefully show our readers why a request like this doesn't make any sense and clarify any misinformation and misconceptions. Please note that the principles touched on here are presented in a simplified approach and are general concepts.

Ford Engine Size/CFM Chart

CFM Ratings Indicated are at 75%, 85%, or 90% Volumetric Efficiency



VOLUMETRIC EFFICIENCY

This is the amount of air (air/fuel mixture) that is actually taken into the engine versus what the theoretical amount that COULD be taken in. Remember that we are working with 4-cycle engines - meaning that there is an intake stroke on every other revolution. The theoretical amount of volume in a 302 cubic inch engine is 302 cubic inches of air. That would mean for EVERY OTHER revolution of the crankshaft, the engine would take in a full "gulp" of air filling each cylinder with a full charge of air/fuel mixture. This would mean that 302 cubic inches of air would be taken in. Expressed another way - 151 cubic inches of air would be "gulped" for every revolution.

Theoretically, that is a great concept but in reality almost never happens. Restrictions such as carburetors, sharp turns in intake manifolds, heads, exhaust manifolds, and quiet mufflers do not allow the engine to "breathe" 100%. In addition, valves are only open for micro seconds and this further reduces the breathing capability. The reality is that a standard performance engine will have a volumetric efficiency of around 75%. That means the example 302 is only capable of "gulping" approximately 225 cubic inches of air for every other revolution (302 X .75 = 226.5). A high performance engine has a volumetric efficiency of about 85% and an all out racing engine about 90-95%. (These figures are at high speed and vary through the RPM range.)

In mathematical terms the equation looks like this:

$$\frac{\text{Actual Air / Fuel Mixture Intake}}{\text{Theoretical Air/Fuel Mixture}} = \text{Volumetric Efficiency}$$

ENGINE/CARBURETOR SIZING RELATIONSHIP

By reading the previous discussion one can quickly follow that the larger the engine, the more air it is capable of "gulping." Now in order to be able to figure out how much CFM your particular engine can use we use the following equation:

$$\frac{\text{Cubic In. Displacement}}{2} \times \frac{\text{Maximum RPM}}{1728} = \frac{\text{Maximum}}{\text{CFM}}$$

First, we divide the cubic inch displacement of our engine by 2 (because there is only one intake stroke per cylinder every OTHER revolution). Next, we take the anticipated maximum RPM of the engine and divide by 1728 (12 x 12 x 12 = 1728, converting cubic inches to cubic feet). Most Ford V8's (Chrysler and GM too) are out of camshaft efficiency and valve spring pressure at 5500 RPM and Y-blocks redline at 4500 RPM. The product of the equation is the maximum CFM that the particular engine can use.

EXAMPLE:

$$\frac{\text{289 Cu. In.}}{2} \times \frac{\text{8000 RPM}}{1728} = \frac{669}{\text{CFM}}$$

Unfortunately, this is still not the final answer for sizing a carburetor. The volumetric efficiency must be taken into consideration. In our example a 289 @ 8000 RPM can use 669 CFM.

However:

669 CFM X .90 volumetric efficiency = 602 CFM

669 CFM X .85 volumetric efficiency = 568 CFM

Our example is based on a Hi-Po 289. Ford installed a 600 CFM Autolite 4100 on this engine. Did Ford engineers know what they were doing? You bet! A standard "A" code 289 4 barrel with the factory valve train will not run much above 6000 RPM. 6000 RPM requires 501 CFM X .85 volumetric efficiency = 426 CFM. Ford installed a 480 CFM carburetor! Refer to the Ford Engine Size/ CFM Chart for some actual engine requirements. These values are realistic engine RPM operating ranges with an appropriate volumetric efficiency applied. After studying the chart, compare that to the CFM rating of the carburetors Ford installed on these engines (see CFM Ratings chart).

CARBURETOR RATINGS

Carburetor CFM's are not exactly what they appear to be. As extreme examples consider the following:

1. A 200 cubic inch 6 cylinder in stock condition - but we're going to "hop it up" and put a Holley 735 (CFM) on it. Will the carburetor magically flow that much? Not hardly - when the theoretical maximum a 200 could use @ 6000 RPM is 347 CFM. The secondaries would not even begin to open.

CFM RATINGS

1 BARREL		CFM
Holley	1904	170
	1908	130/150
	1909	125/150
Ford/Autolite		
1100 –	1.00"	130
1100 –	1.10"	156
1100 –	1.20"	185
1101 –	1.29"	210
Carter		
YF		150/187
RBS		215

2 BARREL		CFM
Holley		
2100/2110		165
2300 Small (#103 Throttle Plates)		205
2300 Large (#107 Throttle Plates)		240
Ford (Autolite/Motorcraft) All 2100's		
Venturi Size	.98	190
	1.02	245
	1.01	240
	1.08	287
	1.14	300
	1.21	351
	1.23	356
	1.33	424
Carter		
ABD		345

4 BARRELS		
4100 Ford (Autolite)		
	1.06	450
	1.08	480
	1.12	600
	1.19	669

4 BARRELS (con't.)		
4300 Autolite/Motorcraft		
Small	1.00	441/470
Large	1.25	600
4300-D Spreadbore		
	715	
Carter		
AFB		625
Rochester Q-Jet		715

HOLLEY 4-V	
4000 "Teapot"	374
4000 Supercharged & 56 Lincoln	453

By engine size/application Advertised Ratings

Shelby	289	715
Shelby	302	600
	390	600
1965-66	427	780
1968	427	600
	428	735
Boss	429	735
Boss	302	780 (Not Possible)

Turn a Holley upside down and look at the throttle plate numbers: A lot of "marketing" has been done concerning CFM. Look at the throttle plate number and the chart.

T/P #	Advertised
107/116	500-550
109/118	600
172 (or 173)	715, 735, 750, 780
180	800

2. Let's now be absurd in the other direction. Let's put an Autolite 1100 one barrel on a 460 cubic inch engine. Above about 2200 RPM, the 460 is going to run out of steam. Why? Because you're only going to force so much air through a 186 CFM carburetor and about 200 would be the absolute maximum at atmospheric pressure. One and two barrels are rated in theory at .3 of an inch pressure drop through the carburetor. Four barrels are rated at .15 of an inch pressure drop through the carburetor.

A Quick Quiz:

Which is better, a 500 CFM racing two barrel or a 480 CFM four barrel? You should know the answer ¬because of different conditions at which they were rated, the 480 CFM 4V will significantly out perform the 2V. If the 500 CFM 2V were rated at 4V conditions, it would flow approximately 380 CFM on an appropriately sized engine.

SUMMARY ON CARBURETOR SIZING

There are a few wives tales about sizing:

1. More is better.
2. Changing jets will change the CFM of the carburetor.
3. A 750 means it flows 750 CFM.
4. Over carbureting means it'll run too rich.

The reality is:

1. A carburetor needs to be appropriately sized for the engine size and the related components (cam, exhaust, intake, rear-end ratio, valve train, etc.). Just "throwing" a larger carburetor on and leaving everything else alone will be a big disappointment - in fact usually the engine overall runs worse.
2. Changing jets changes the air fuel ratio, not the CFM. The only way to change CFM in a carburetor is to physically grind and enlarge the venturi, which destroys the ability of the carburetor to create venturi vacuum and therefore meter fuel.
3. A 750 will flow 750 CFM if the engine is capable of utilizing that much air.
4. Too large a carburetor leans out mixtures at lower RPMs (not idle) destroying performance, and then usually overfuels (poor fuel economy) at higher RPMs.

BIGGER IS NOT BETTER

With any luck the information provided in this article will have cleared up any misunderstandings that many people have regarding carburetion. Contrary to popular opinion, it is clear that BIGGER IS NOT BETTER, at least in terms of carburetors. As always, we welcome your comments and questions about any of our Good Carbs articles or any carburetor related questions in general.

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