ngm turbochargers
AEROSPACE-AUTOMOTIVE
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TURBOSYSTEM TURBOCHARGER

This Specification Sheet is designed to enable the custom selection of Garrett TO4B turbochargers for engines ranging from 75 – 575 B.H.P., with a single unit, and in excess of 1200 B.H.P. when employing dual units.

There are three general classifications of Garrett turbochargers, each of which has distinct size and operating characteristics.

Turbocharger	Output	Inducer diameter		Exducer diameter	
Y-4	75 – 275 B.H.P.	Y-4	1.750	N	2.109
M-2	125 – 375 B.H.P.	M-2	1.984	O	2.339
V-2	175 – 575 B.H.P.	V-2	2.218	P	2.581

It is essential to remember that once you add a turbocharger to an internal combustion engine, that together they become a compound unit. This means that horsepower output is no longer the result of the basic engine's design, but rather that of the turbocharger's compressor ability to flow air. (C.F.M. or lbs./min.)

The same turbocharger would therefore be used on a five litre V-8, as a two litre four cylinder, if both were required to produce 500 B.H.P. The difference would only be in the fact that the five litre engine would probably achieve target horsepower at 5,000 R.P.M. while the two litre engine would need to turn 8,500 R.P.M. while indicating a higher inlet manifold pressure to achieve the same target. Nevertheless, both compound units would be flowing the same amount of air, and require similar turbochargers. The following table, while accurate, is only a general guide, and makes many assumptions.

Should you have any specific queries, do not hesitate to contact your nearest Normalair-Garrett AiResearch Turbo-system dealer.

TURBOSYSTEM TURBOCHARGER
TO4B TURBOCHARGER SELECTION

Engine Displacement	Boost Requirement 0-10 P.S.I.G.		10-20 P.S.I.G.	20 P.S.I.G.
1250-1500 c.c	Y-4/.30-N	6,500 R.P.M. Max.	Y-4/.30-N	M-2/.30-0
1500-1750 c.c	Y-4/.40-N		Y-4/.30-N	M-2/.40-0
1750-2000 c.c	Y-4/.50-N		Y-4/.40-N	M-2/.50-0
2000-2250 c.c	Y-4/.58-N		Y-4/.50-N	M-2/.58-0
2250-2500 c.c	Y-4/.69-N		Y-4/.58-N	M-2/.69-0
2500-2800 c.c	M-2/.50-0	5,500 R.P.M. Max.	M-2/.40-0	M-2/.96-0
2800-3100 c.c	M-2/.58-0		M-2/.50-0	V-2/.50-P
3100-3400 c.c	M-2/.69-0		M-2/.58-0	V-2/.58-P
3400-3700 c.c	M-2/.81-0		M-2/.69.0	V-2/.69-P
3700-4000 c.c	M-2/.96-0		M-2/.81-0	V-2/.81-P
4000-4300 c.c	V-2/.58-P	4,500 R.P.M. Max.	V-2/.50-P	V-2/.96.P
4300-4600 c.c	V-2/.69-P		V-2/.58-P	V-2/1.14-P
4600-4900 c.c	V-2/.81-P		V-2/.69-P	2x M-2/.50-0
4900-5200 c.c	V-2/.96-P		V-2/.81-P	2x M-2/.58-0
5200-5500 c.c *	V-2/1.14-P		V-2/.96-P	2x M-2/.69-0
5500-5800 c.c *	V-2/1.30-P		V-2/1.14-P	2x M-2/.81-0
5800-6100 c.c *	V-2/1.49-P		V-2/1.30-P	2x M-2/.96-0

TURBOCHARGER DETAILS

Turbocharger Unit P/No.	C.H.R.A.	Compressor Trim	Compressor P/No.	Compressor Housing P/N	Turbine Housing A/R	Turbine P/No.	Turbine Trim	Turbine P/No.
5- 9800	408316-9	Y-4	409179-26	409995-9	.30	201500-10	N	407276-4
5- 9810	408316-9	Y-4	409179-26	409995-9	.40	201500-9	N	407276-4
5- 9820	408316-9	Y-4	409179-26	409995-9	.50	201500-8	N	407276-4
5- 9830	408316-9	Y-4	409179-26	409995-9	.58	201500-7	N	407276-4
5- 9840	408316-9	Y-4	409179-26	409995-9	.68	201500-6	N	407276-4
5- 9850	408316-10	M-2	409179-22	409995-5	.30	201500-20	O	407276-5
5- 9860	408316-10	M-2	409179-22	409995-5	.40	201500-29	O	407276-5
5- 9870	408316-10	M-2	409179-22	409995-5	.50	201500-28	O	407276-5
5- 9880	408316-10	M-2	409179-22	409995-5	.58	201500-27	O	407276-5
5- 9890	408316-10	M-2	409179-22	409995-5	.68	201500-26	O	407276-5
5- 9900	408316-10	M-2	409179-22	409995-5	.81	201500-21	O	407276-5
5- 9910	408316-10	M-2	409179-22	409995-5	.96	201500-22	O	407276-5
5- 9920	408316-11	V-2	409179-25	409995-8	.50	201500-38	P	407276-6
5- 9930	408316-11	V-2	409179-25	409995-8	.58	201500-37	P	407276-6
5- 9940	408316-11	V-2	409179-25	409995-8	.68	201500-36	P	407276-6
5- 9950	408316-11	V-2	409179-25	409995-8	.81	201500-31	P	407276-6
5- 9960	408316-11	V-2	409179-25	409995-8	.96	201500-32	P	407276-6
5- 9970	408316-11	V-2	409179-25	409995-8	1.14	201500-33	P	407276-6
5- 9980	408316-11	V-2	409179-25	409995-8	1.32	201500-34	P	407276-6
5- 9990	408316-11	V-2	409179-25	409995-8	1.49	201500-35	P	407276-6

CUSTOM SELECTING YOUR TURBOCHARGER COMPRESSOR

In order to re-check the match of a turbocharger compressor for a custom application, or to *find the best compressor match for custom applications with specifications other than those provided for on the preceding Turbocharger Selection Charts*, it is first necessary to calculate. (1) the correct Pressure Ratio, and (2) Turbocharged Air Flow (in C.F.M.). Once these factors have been derived they can be plotted on the Compressor Maps (next page) to determine which compressor to use.

Pressure Ratio Before calculating the compressor Pressure Ratio, you must decide what maximum boost pressure will be utilized (7 lbs. P.S.I. is recommended for general applications and will be used for our examples). Then, follow this formula:

Pressure Ratio =

$$\frac{\text{Boost Pressure} + \text{Atmospheric Pressure*}}{\text{Atmospheric Pressure*}}$$

Example:

$$\frac{\text{7 lbs. p.s.i. Boost Press.} + \text{14.7 p.s.i. Atm. Press.}}{\text{14.7 Atm. Press.}}$$

= 1.5 Pressure Ratio

**Note: Subtract .5 p.s.i. from 14.7 p.s.i. for each 1,000 ft. above sea-level to determine approximate atmospheric pressure at altitudes.*

Turbocharged Air Flow Next, it is necessary to determine the volume of air or "Air Flow" (C.F.M.) which the turbocharged engine will require. The following formula is used to calculate the required C.F.M. for 4-cycle engines.

$$\frac{\text{½ C.I.D.} \times \text{Maximum R.P.M.}}{1728} \times \text{V.E.} \times \text{D.R.} = \text{C.F.M.}$$

The abbreviations above stand for:

- C.I.D. = Cubic Inch Displacement
- R.P.M. = Revolutions Per Minute
- V.E. = Volumetric Efficiency
- D.R. = Density Ratio
- C.F.M. = Cubic Feet per Minute

EXAMPLE: 100 C.I.D. engine operating up to 6,000 R.P.M. and 7 lbs. p.s.i. boost pressure (at sea level):

$$\frac{½ \times 100 \times 6000}{1728} \times .80 \times 1.25 = 173.61 \text{ C.F.M.}$$

EXPLANATION: 100 C.I.D. is the engine size (divide c.c. by 16.387 to get C.I.D.). This displacement is divided by 2 (or, multiplied by ½) because the cylinders in a 4-cycle engine take in air on every other revolution.

We then multiply ½ C.I.D. by the engine's maximum R.P.M. to get cubic inches (of air) per minute.

Now we divide this figure by 1728 to convert *cubic inches* per minute to *cubic feet* of air per minute (C.F.M.).

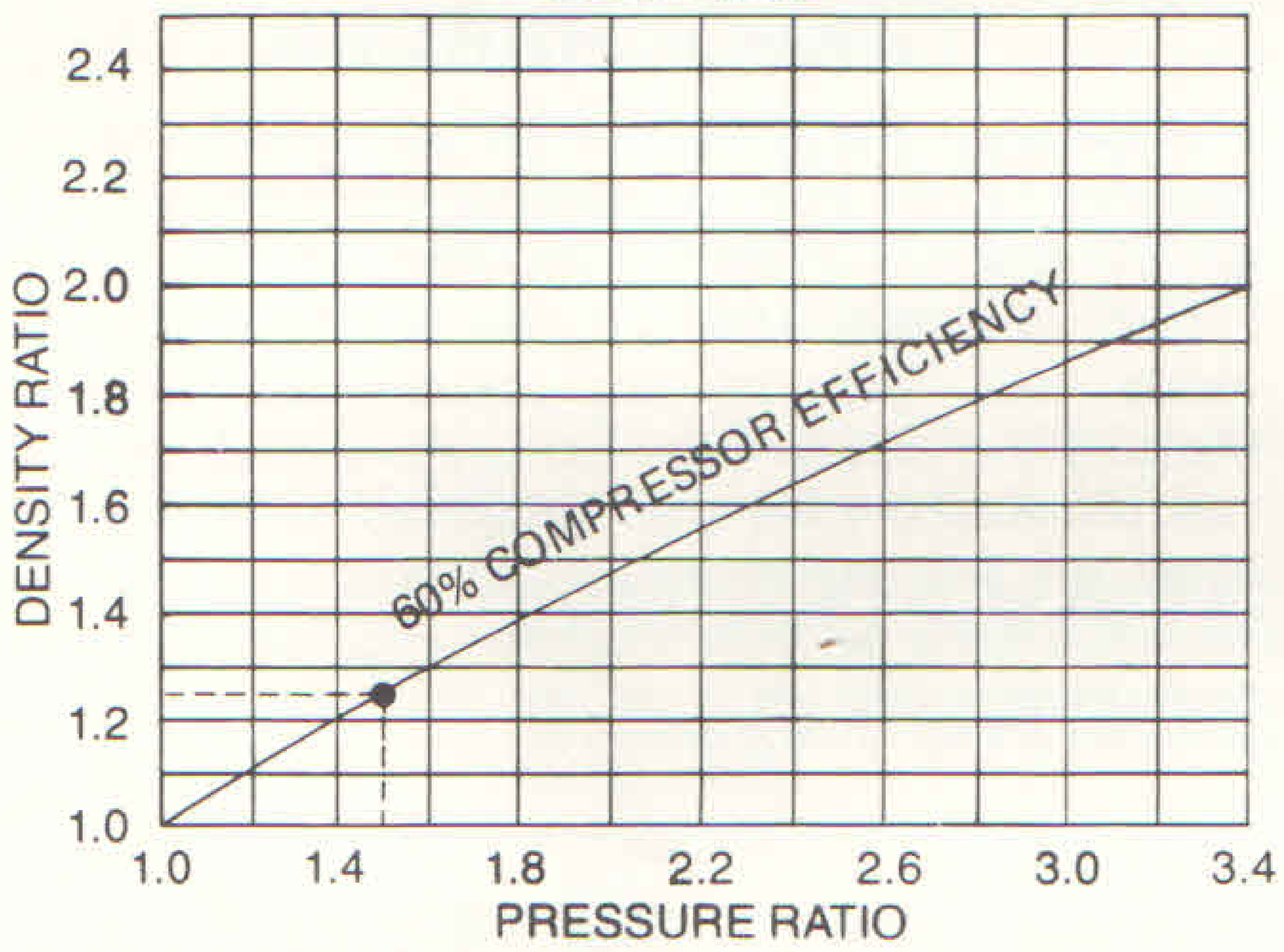
However, average engines only fill the cylinders approximately 80%, so we must multiply the cubic inches of air per minute by .80 (V.E.).*

We now have the figure which represents the "naturally aspirated" Air Flow. It must be multiplied by D.R. (Density Ratio) to find the *turbocharged* volume of air.**

To find the D.R., first locate the 1.5 Pressure Ratio (as determined earlier) on the "Pressure Ratio vs. Density Ratio" chart. Now move up to the 60% Compressor Efficiency point (which is the minimum desirable efficiency); then move left to the Density Ratio, which is 1.25 in this case.

Now we can complete the formula, by multiplying the D.R. times the "naturally aspirated" Air Flow to find the *turbocharged* air requirements in C.F.M.

COMPRESSOR DENSITY RATIO VERSUS PRESSURE RATIO FOR AIR



Using the Compressor Map On the 3 Compressor Maps (next page) locate the 1.5 Pressure Ratio line and move across to the appropriate C.F.M. point. If the point falls *between* the Surge line and the Efficiency line, the compressor is a good match. If the C.F.M. point falls to the *left* of the Surge line, the compressor could be damaged if used for your application. If the point falls to the *right* of the efficiency line, the compressor will be less efficient than desired for your application.

Dual Turbocharger Applications If two turbochargers are to be used on an application; first divide the previously calculated turbocharged air requirements (in c.f.m.) by 2. Next follow the instructions under "Using the Compressor Map." Use two turbochargers with the compressors of the proper match.

See the "Custom Selecting Your Turbocharger Turbine" to complete your turbocharger match.

CUSTOM SELECTING YOUR TURBOCHARGER TURBINE

Due to the numerous factors involved in selecting the correct turbine housing for a *custom application*, suggested turbocharger configurations (which include the turbine housing) are listed on page 1. The turbine trim is matched to the compressor trim on the chart to facilitate the selection of the custom turbine. ("Trim" refers to the size and contour of the machining on the wheel and housing.) The other factor which you must determine is the correct A/R.

"A/R" represents the relative area of the air (exhaust) passage, or "nozzle" in the turbine housing. *The smaller the A/R*, the smaller (or more constricted) the passage, and *the faster the turbocharger runs. The larger the A/R,* the larger the passage and the *slower the turbocharger runs.* The A/R number is cast on the turbine housing for identification.

The correct A/R turbine housing is necessary for the most efficient engine operation. Too small a turbine housing A/R causes excessive back pressure and heat. Too large a turbine housing A/R does not provide boost at lower R.P.M.. Under most average conditions with a boost controlled system, boost pressure should start between 1,500 and 2,000 engine R.P.M. (under full load).

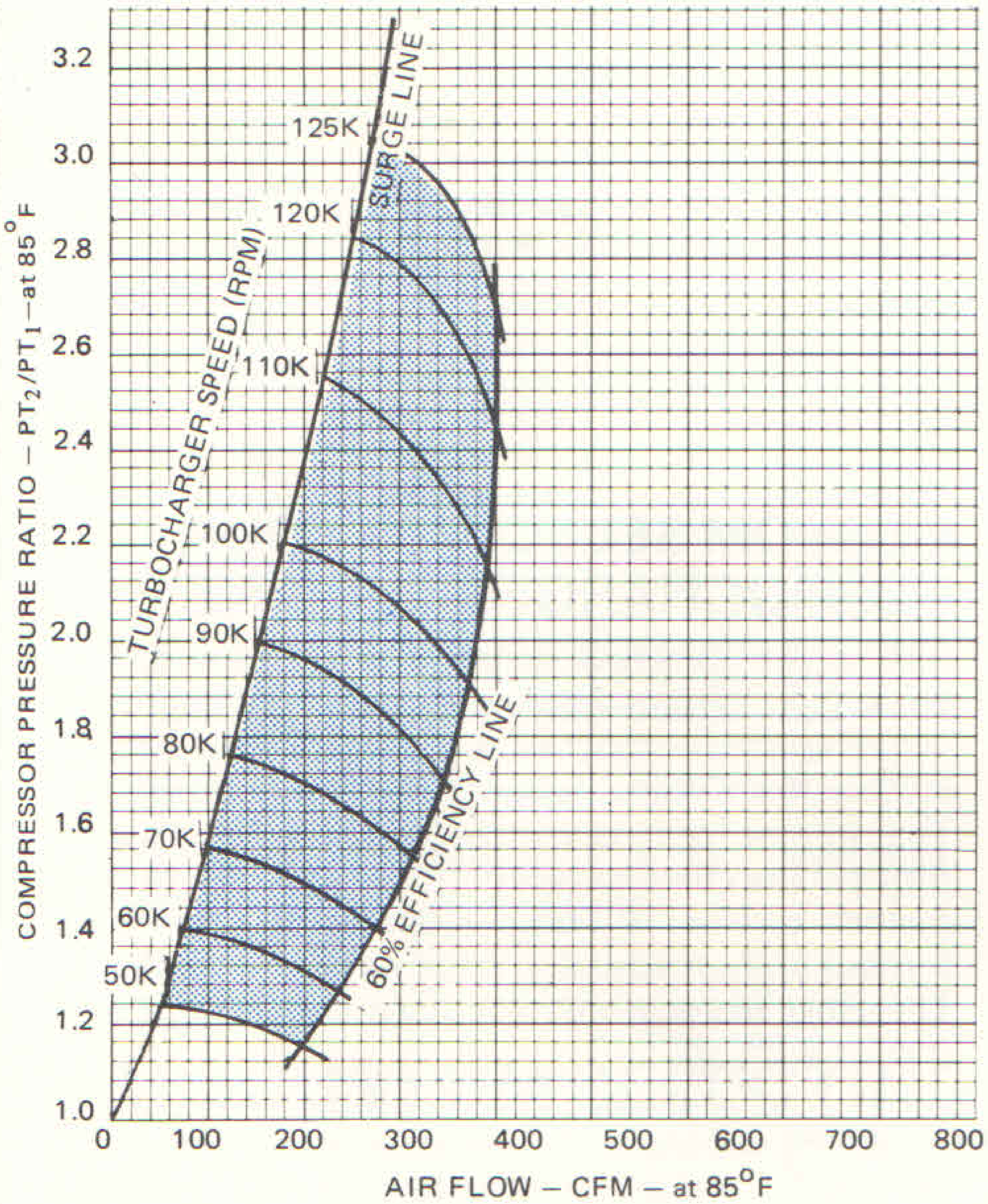
Exhaust system back pressure *before* the turbocharger is one of the best ways to determine the correct A/R turbine has been selected. For gasoline engines the back pressure should be less than 3 times the boost pressure gauge reading at full load. The less the back pressure, the more efficient the engine will run.

WARNING:
All recommended turbocharger to engine matches assume some form of boost control.

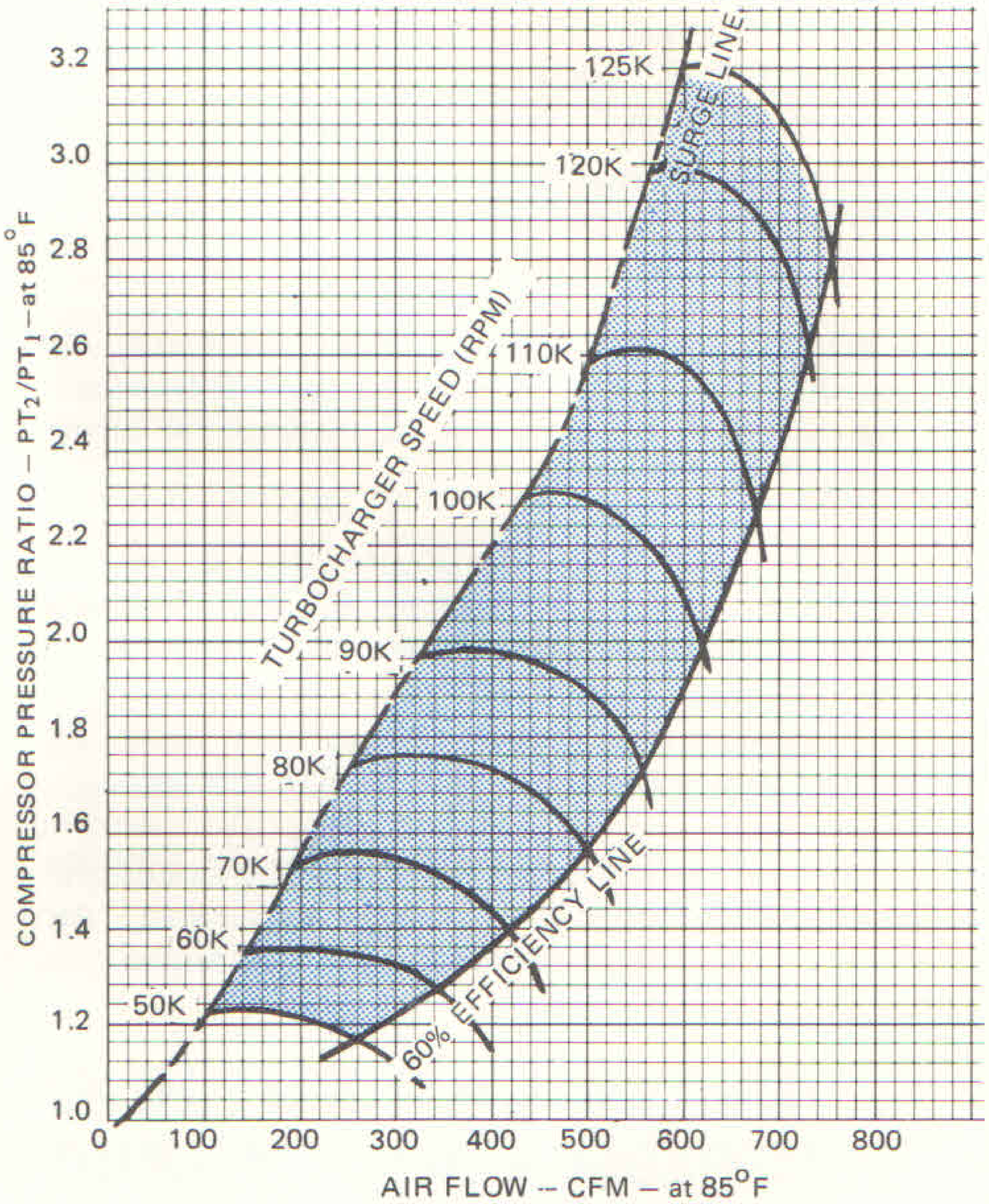
**Modified engines may have a better V.E.*

***It is necessary to find the D.R. in order to use the Compressor Map to check the match of your compressor selection. This is because compressor maps are made using inlet air flow, and a greater volume of air exists the compressor than enters the compressor (the air which enters becomes heated, thus is less dense but of greater volume when it exits).*

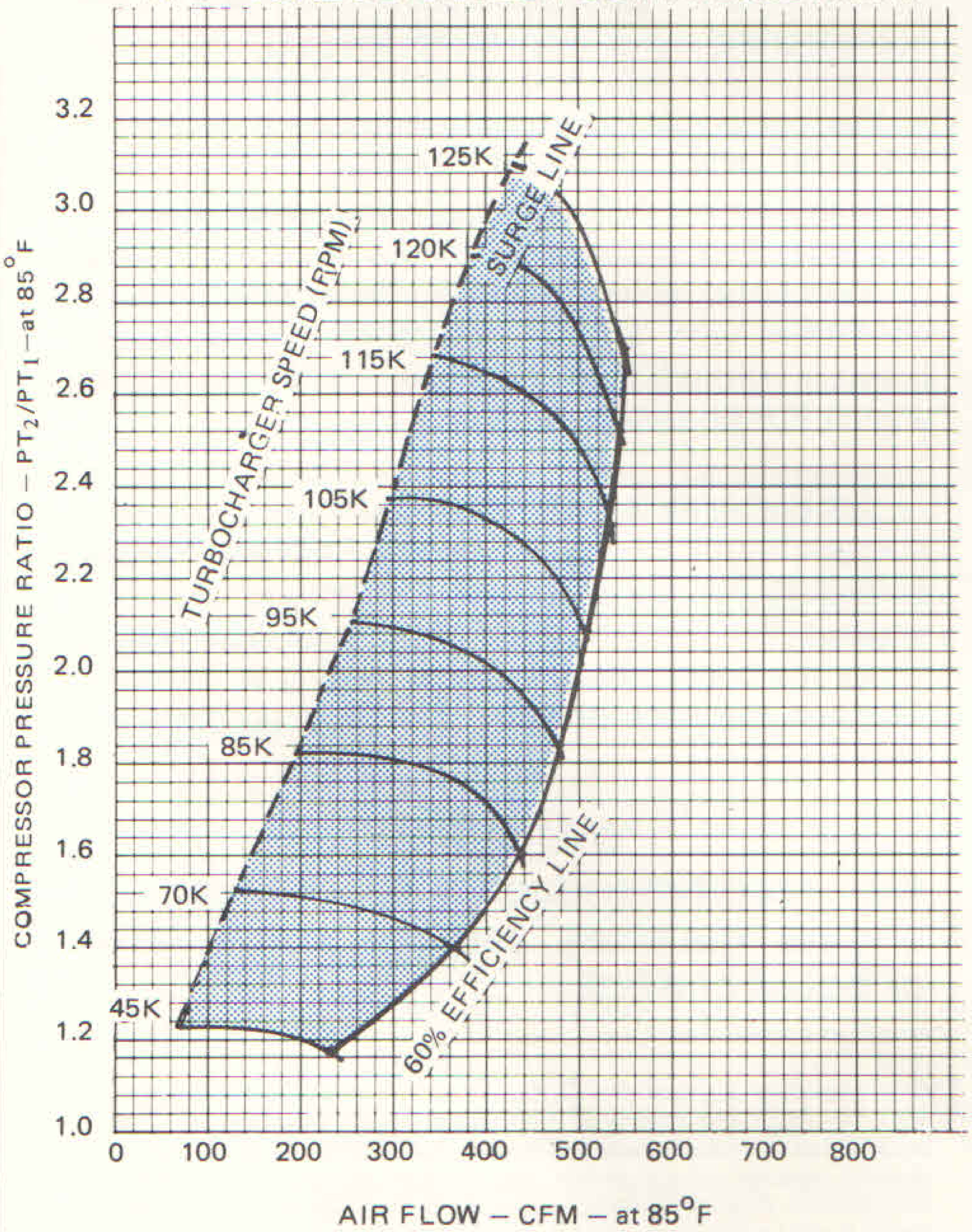
"Y-4" TURBOCHARGER COMPRESSOR MAP



"V-2" TURBOCHARGER COMPRESSOR MAP



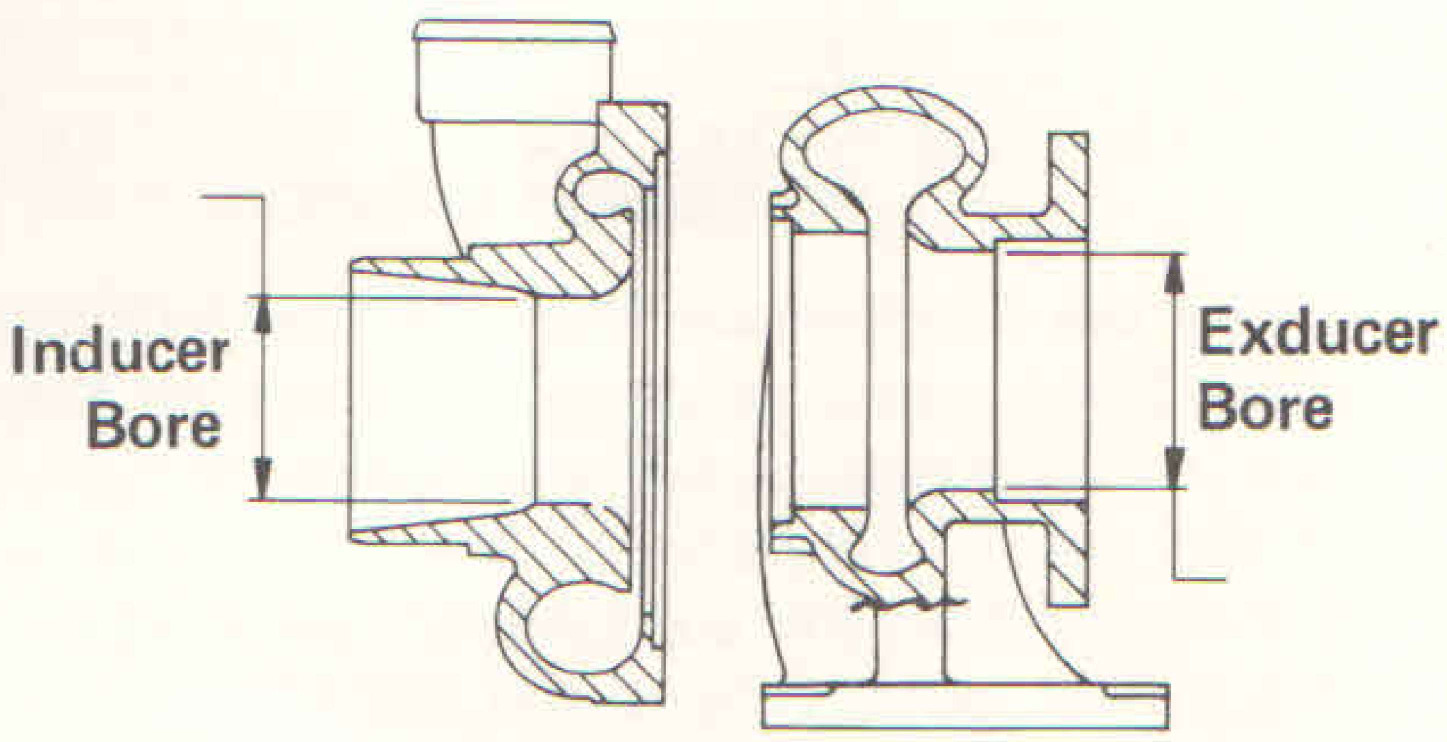
"M-2" TURBOCHARGER COMPRESSOR MAP



IDENTIFYING A TURBOSYSTEM TURBOCHARGER

Turbosystem turbochargers are easily identified by knowing (1) the inducer bore, (2) the exducer bore, and (3) the A/R of the turbine housing.

The "inducer bore" is the smallest diameter inside the inlet of the compressor housing. Measure the inducer bore (accurately) and compare this dimension with the "suggested turbocharger" chart on the corresponding turbocharger Specification Sheet. In this manner you can find the compressor trim.



Next, measure accurately the exducer bore, which is the smallest, inside diameter in the outlet of the turbine housing. This dimension can then be checked on the appropriate Specification Sheet chart to find the corresponding turbine trim.

Finally, locate the A/R number, which is cast on the turbine housing. The exact turbocharger number can be determined by comparing this information to the appropriate Turbocharger Selection Chart.