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**Turbocharger
Nomenclature
and Terminology**

SAE Recommended Practice
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Ø TURBOCHARGER NOMENCLATURE AND TERMINOLOGY

1. SCOPE:

This recommended practice applies to nomenclature of turbocharger parts and terminology of performance.

2. NOMENCLATURE:

- 2.1 Turbocharger: A device used for increasing the pressure and density of the fluid entering an internal combustion engine using a compressor driven by a turbine which extracts energy from the exhaust gas.
- 2.2 Compressor: The component of the turbocharger that raises the pressure and density of the inlet fluid.
- 2.3 Compressor Impeller (Rotor, Wheel): The principle rotating component of the compressor which imparts energy to the fluid.
- 2.4 Compressor Diffuser: A component of the compressor in which the kinetic energy of the fluid leaving the impeller is partially converted to a rise in static pressure.
- 2.5 Compressor Housing: The housing that encloses the impeller(s) and diffuser(s), forms an inlet flow path to the impeller and collects the fluid leaving the diffuser for delivery to the engine.
- 2.6 Turbine: The component of the turbocharger that extracts energy from the exhaust gas of the engine and converts it to shaft work to drive the compressor impeller(s).
- 2.7 Turbine Rotor (Wheel): The principle rotating component of the turbine which extracts energy from the exhaust gas.
- 2.8 Vaned Nozzle: An arrangement of stationary or moveable vanes for controlling the velocity of the exhaust gas relative to the turbine rotor.

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- 2.9 Vaneless Nozzle: An arrangement in which the internal flow passage geometry of the turbine housing controls the velocity of the exhaust gas relative to the turbine rotor without the use of vanes.
- 2.10 Turbine Housing: The housing that encloses the rotor(s) and nozzle(s), directs exhaust gas into the nozzle(s) and forms an exit flow path from the rotor(s).
- 2.11 Wastegate: A valve that, when open, allows some of the exhaust gas to bypass the turbine rotor.
- 2.12 Clockwise and Counterclockwise Rotation: Direction of shaft rotation when viewed looking into the compressor inlet.
- 2.13 Variable Geometry Turbocharger: A turbocharger in which moving parts are used to alter the gas velocities and hence the performance of the turbine or the compressor, or both.
- 2.14 Turbocompounding: A method of increasing the power or efficiency, or both, of an internal combustion engine by means of a turbine which converts exhaust gas energy into shaft power and delivers it to the engine.
- 2.15 Series Turbocharging: An arrangement of two or more turbochargers with the compressors and turbines installed in series to increase the pressure and density of the fluid entering the engine.
- 2.16 Actuator: A device incorporated into a turbocharger assembly which controls the movement of the variable geometry component(s) or wastegate.
- 2.17 Bearing Housing: The housing that encloses and supports the bearing(s) and seals and makes provision for lubrication and cooling.

3. PERFORMANCE TERMINOLOGY:

3.1 Fixed Geometry Compressor:

$$\text{Compressor pressure ratio} = \frac{\text{Outlet air static absolute pressure (kPa)}}{\text{Inlet air total absolute pressure (kPa)}}$$

$$\text{Compressor air mass flow} = \text{kg/s of air mass flow through the compressor}$$

$$\text{Corrected compressor air mass flow} =$$

$$\text{Compressor air mass flow} \times \sqrt{\frac{\text{Compressor inlet total absolute temperature (K)}}{298 \text{ K}}}$$

$$(\text{Compressor inlet total absolute pressure (kPa)} / 100 \text{ kPa})$$

$$\text{Corrected compressor speed} =$$

$$\frac{\text{Compressor impeller speed (rpm)}}{\sqrt{\frac{\text{Compressor inlet total absolute temperature (K)}}{298 \text{ K}}}}$$

3.1 (Continued):

$$\text{Compressor efficiency (\%)} = \frac{\text{Isentropic enthalpy rise across compressor stage through compressor pressure ratio}}{\text{Actual enthalpy rise across compressor stage}}$$

Surge is indicated by a line on the left hand side of a compressor graph as determined on a steady flow test stand. Surge is severe flow reversal combined with audible coughing and banging. The onset of surge may vary from one installation to another and the graph surge line should only be used as a guide.

3.2 Variable Geometry Compressor: Terminology the same as for fixed geometry compressor.3.3 Fixed Geometry Turbine:

$$\text{Turbine expansion ratio} = \frac{\text{Inlet gas total absolute pressure (kPa)}}{\text{Outlet gas static absolute pressure (kPa)}}$$

Turbine gas flow = kg/s of gas flow through the turbine

Turbine gas flow parameter =

$$\frac{\text{Turbine gas flow} \times \sqrt{\text{Turbine inlet total absolute temperature (K)}}}{\text{Turbine inlet total absolute pressure (kPa)}}$$

$$\text{Turbine speed parameter} = \frac{\text{Turbine rotor speed (rpm)}}{\sqrt{\text{Turbine inlet total absolute temperature (K)}}}$$

Combined turbine x mechanical efficiency (%) =

$$\frac{\text{Actual Total enthalpy rise across compressor stage}}{\text{Isentropic total enthalpy drop across turbine stage through turbine expansion ratio}}$$

If users require the use of total-to-total turbine x mechanical efficiencies and expansion ratios, the user and the turbocharger manufacturer should agree upon a method of obtaining, whether it be through calculation (knowing turbine exit state conditions and geometry) or through gas stand data.

3.4 Variable Geometry Turbine: Terminology same as fixed geometry turbine.3.5 Bearing Mechanical Losses:

Bearing power loss = kW at a given turbocharger shaft speed and expansion ratio

4. PERFORMANCE GRAPH FORMAT:4.1 Fixed Geometry Compressor:

INLET DIA. _____ (mm)*

OUTLET DIA. _____ (mm)*

INLET TYPE: _____

OUTLET TYPE: _____

IMPELLER INERTIA: _____ (N-m-sec²)* = AT PRESSURE
MEASURING STATIONS

COMPRESSOR PRESSURE RATIO (TOTAL-TO-STATIC)

DATA OBTAINED WITH
COMPRESSOR HOUSING
AND OUTLET INSULATEDCORRECTED
COMPRESSOR
SPEED (rpm)

SURGE

COMPRESSOR
EFFICIENCY

CORRECTED COMPRESSOR AIR MASS FLOW (kg/sec)

FIGURE 1 - Typical Turbocharger Compressor Performance Graph

4.2 Variable Geometry Compressor: The performance graph format would be the same as for the fixed geometry compressor. Unless otherwise agreed to by the user and the turbocharger manufacturer, three graphs should typically be supplied as follows:

- Optimized for minimum surge.
- Optimized for peak efficiency.
- Optimized for maximum flow.

4.3 Fixed Geometry Turbine:

COMPRESSOR DESCRIPTION: _____
 TURBINE HOUSING TYPE: _____
 IF LIQUID COOLED:
 LIQUID DESCRIPTION: _____
 LIQUID TEMP. INTO HSG: _____ (°C)
 LIQUID PRESS. INTO HSG: _____ (kPa)
 DISCHARGE CONNECTION DESCRIPTION: _____
 $T_{1T}/T_{1C} = \text{_____}$ OR $T_{1T} = \text{_____}$ (°C) $T_{1T} = 600 \pm 20^\circ\text{C}$ FOR DIESEL ENG.
 $T_{1T} = 900 \pm 20^\circ\text{C}$ FOR S.I. ENG.
 OIL TYPE: _____ $T_{1C} = \text{COMPRESSOR INLET TEMP. (}^\circ\text{C)}$
 OIL SUPPLY TEMP. = _____ (°C) 100°C RECOMMENDED
 ROTOR AND SHAFT INERTIA = _____ (N-m-sec²)

$D_1/D_2 = \text{_____}$ } TURBOCHARGER
 $L/D_2 = \text{_____}$ } REF. TEST CODE

DATA APPLY ONLY WITH
NOTED COMPRESSOR

SYMBOL	TURBINE SPEED PARAMETER
○	
□	
◇	
△	
●	

COMBINED TURBINE x MECHANICAL EFFICIENCY (TOTAL-TO-STATIC)
 AND TURBINE GAS FLOW PARAMETER $\left(\frac{\text{kg} - \sqrt{\text{K}}}{\text{sec} \cdot \text{kPa}} \right)$

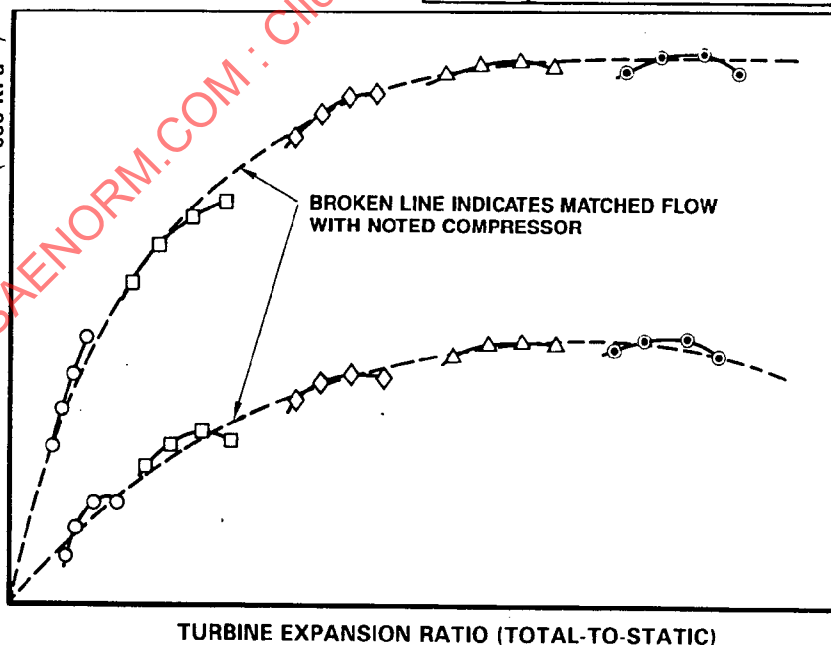


FIGURE 2 - Typical Turbocharger Turbine Performance Graph

4.4 Variable Geometry Turbine: The performance graph format would be the same as for the fixed geometry turbine. The number of graphs to be supplied to the user to adequately describe the performance range should be agreed to with the turbocharger manufacturer. Three graphs should typically be supplied as follows:

- a) Optimized for minimum flow.
- b) Optimized for mid-point flow.
- c) Optimized for maximum flow.

4.5 Wastegate: If users require the use of wastegate data (for example, flow versus lift and lift versus pressure), the user and the manufacturer should agree on a format.

BEARING SYSTEM DESCRIPTION:

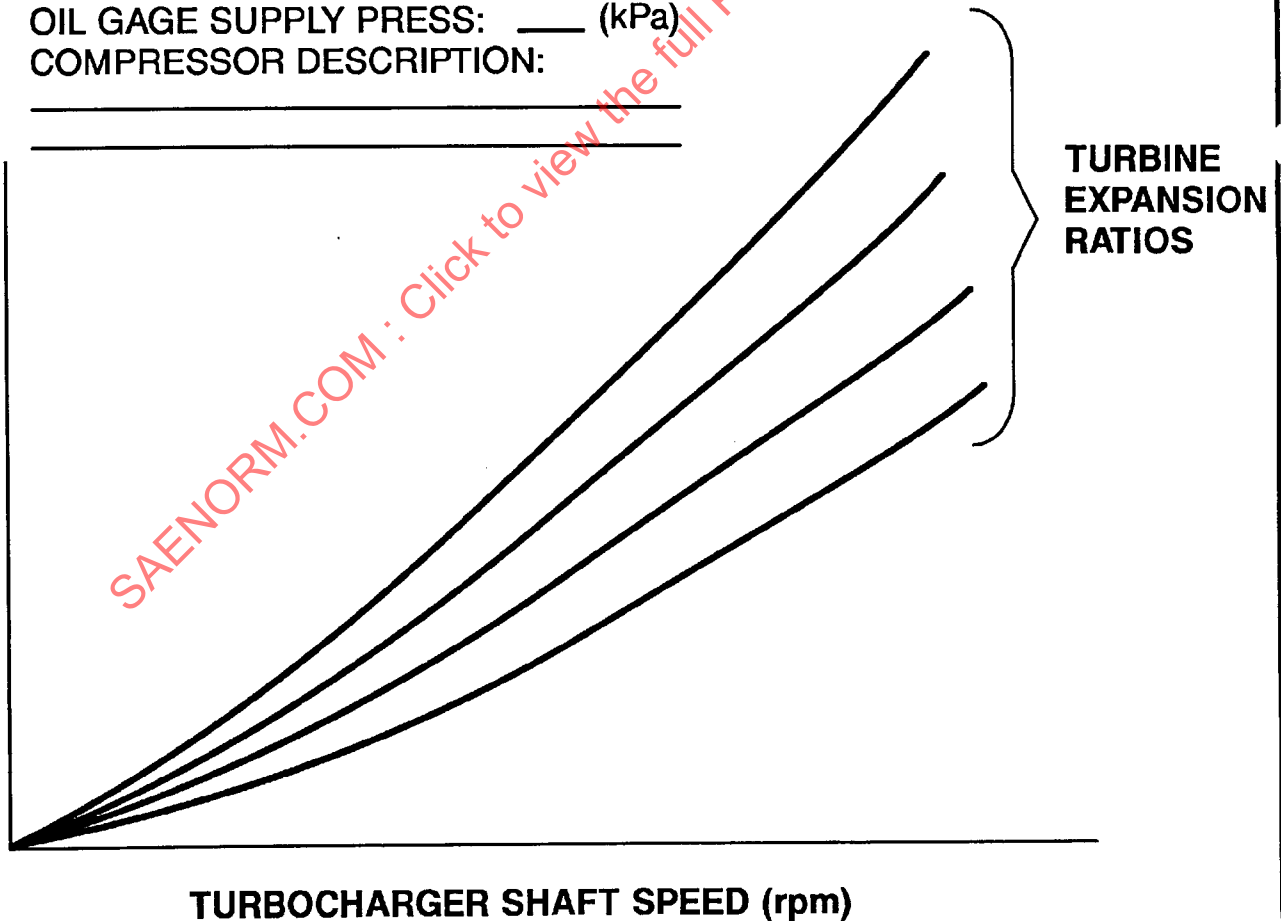
OIL TYPE: _____

OIL SUPPLY TEMP: _____ (°C)

OIL GAGE SUPPLY PRESS: _____ (kPa)

COMPRESSOR DESCRIPTION:

BEARING POWER LOSS (kw)



TURBOCHARGER SHAFT SPEED (rpm)

FIGURE 3 - Bearing Power Loss Graph

4.7 Oil Flow:BEARING SYSTEM DESCRIPTION:

OIL TYPE: _____

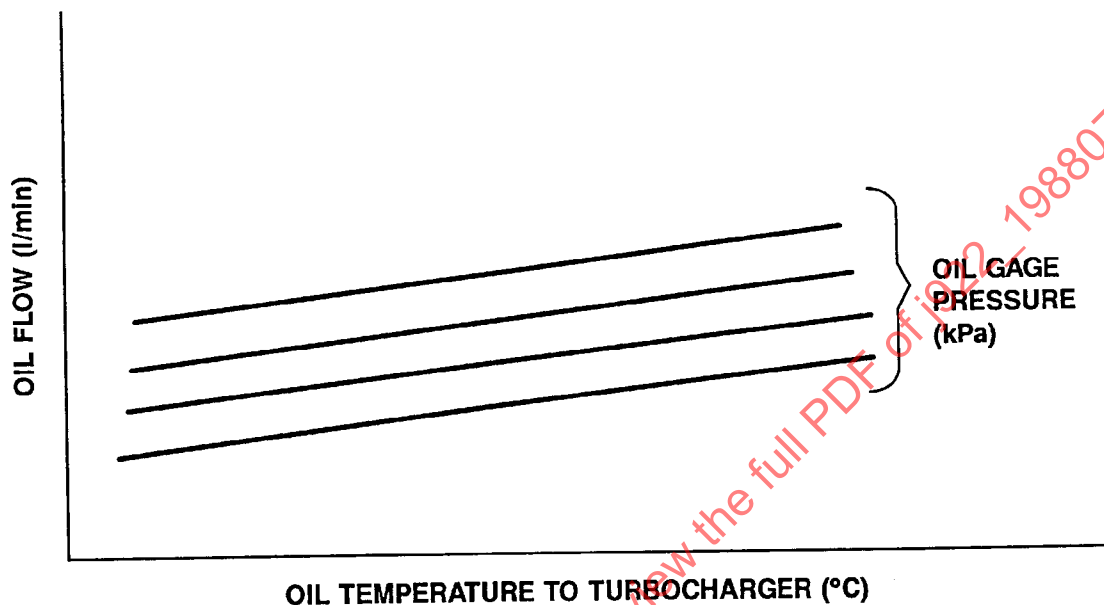


FIGURE 4 - Turbocharger Oil Flow Graph

- 4.8 Liquid Flow: If users require the use of liquid flow data (for example, pressure drop, temperature rise, surface temperature, etc.) for cooled bearing or turbine housings, the user and the manufacturer should agree upon a format.

5. REFERENCES:

SAE J916 JUN82

SAE J1349 JUN83

"Principles of Turbomachinery," D. G. Shepherd, Macmillan, 1956.

"Thermodynamics of Turbomachinery," S. L. Dixon, Pergamon, 1978.

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