SURFACE VEHICLE STANDARD

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(R) Turbocharger Gas Stand Test Code

RATIONALE

SAE J1826 provides a standard for establishing the performance of turbocharger components. The standard has been expanded to contain deifinitions of surge and soft surge, choke line, added requirements for data points per speed line and number of speed lines, added definition of the measurement section geometries, and updates of the data reporting formats and improved illustrations.

1. SCOPE

The test procedures outlined in this SAE Standard are applicable to turbocharging systems having either fixed- or variable-geometry.

1.1 Purpose

The purpose of this document is to provide a laboratory test procedure and presentation format for establishing the component performance for a turbocharger. It is intended that this test procedure be used to determine turbocharger compressor and turbine performance characteristics for passenger cars, off-highway, and commercial vehicle. The resulting data are intended for use in turbocharger component performance assessment and development and for engine/turbocharger matching. In particular, the intent is to provide well defined data in a consistent format for engine simulation programs.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J922 Turbocharger Nomenclature and Terminology

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J244 Measurement of Intake Air or Exhaust Gas Flow of Diesel Engines

SAE J1349 Engine Power Test Code - Spark Ignition and Compression Ignition - As Installed Net Power Rating

TSB003 Rules for SAE Use of SI (Metric) Units

2.2.2 Other Publications

Shepard, D.G., "Principles of Turbomachinery," MacMillan.

Keenan and Kaye, "Gas Properties," John Wiley & Sons.

Holman, J.P., "Experimental Methods for Engineers," McGraw-Hill.

3. DEFINITIONS AND TERMINOLOGY

Also refer to SAE J922, Section 2.

3.1 Turbocharger Hardware

3.1.1 FIXED-GEOMETRY TURBOCHARGER

Turbocharger having no moving parts in the aerodynamic flowpath other than the compressor impeller and turbine rotor.

3.1.2 VARIABLE-GEOMETRY TURBOCHARGER

Turbocharger incorporating moving parts such as, but not limited to, compressor inlet guide vanes, variable-geometry compressor diffuser, moveable turbine inlet nozzle vanes (VNT), and/or a wastegate.

3.2 Turbocharger Performance

Also refer to SAE J922, Section 3.

3.2.1 FLOW

Compressor air mass flow = kg/s of air mass flow through the compressor.

Corrected compressor air mass flow =

$$\text{Compressor air mass flow x } \frac{\sqrt{(\text{T1(Compressor inlet total absolute temperature (K))}/298\text{K})}}{(\text{P1(Compressor inlet total absolute pressure (kPa))}/100\text{kPa})} \quad \text{(Eq. 1)}$$

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

$$\text{Turbine gas flow parameter} = \frac{\text{Turbine gas flow x}\sqrt{\text{T3(Turbine inlet total absolute temperature (K))}}}{\text{P3(Turbine inlet total absolute pressure (kPa))}} \quad \text{(Eq. 2)}$$

3.2.2 PRESSURE RATIO (EXPANSION RATIO)

$$\text{Compressor pressure ratio} = \frac{\text{P2(Outlet air total absolute pressure (kPa))}}{\text{P1(Inlet air total absolute pressure (kPa))}} \quad \text{(Eq. 3)}$$

$$\text{Turbine expansion ratio} = \frac{\text{P3(Inlet gas total absolute pressure (kPa))}}{\text{P4(Outlet gas static absolute pressure (kPa))}} \quad \text{(Eq. 4)}$$

3.2.3 EFFICIENCY

$$\text{Compressor efficiency} = \frac{\text{Isentropic total enthalpy rise across compressor stage calculated using compressor pressure ratio}}{\text{Actual total enthalpy rise across compressor stage}} \quad \text{(Eq. 5)}$$

$$\text{Combined turbine x mech. efficiency} = \frac{\text{Actual total enthalpy rise across compressor stage}}{\text{Isentropic total enthalpy drop across turbine stage calculated using turbine expansion ratio}} \quad \text{(Eq. 6)}$$

3.2.4 SPEED PARAMETER

$$\text{Corrected compressor speed} = \frac{\text{Compressor impeller speed}\left(\frac{\text{r}}{\text{min}}\right)}{\sqrt{\frac{\text{T1(Compressor inlet total absolute temperature (K))}}{\text{298K}}}} \quad \text{(Eq. 7)}$$

$$\text{Turbine speed parameter} = \frac{\text{Turbine rotor speed }\left(\frac{\text{r}}{\text{min}}\right)}{\sqrt{\text{T3(Turbine inlet total absolute temperature (K))}}} \quad \text{(Eq. 8)}$$

3.2.5 SURGE

Surge is indicated as a line on the left-hand side of a compressor map as determined on a steady-flow test stand. Surge is the boundary of an area of severe flow reversal combined with audible coughing and banging. The position of the surge line is influenced by the characteristics of the full compressor-test stand system. Additionally, the practical definition of the surge line has typically been imprecise, making it difficult to compare data from different sources. From a consistency perspective, surge is defined by this standard as the onset of increased fluctuations in compressor outlet pressure. This is recognized as a very conservative approach. A hard surge line at which flow reversal occurs may also be indicated. A more detailed definition is provided below.

3.2.5.1 SOFT SURGE

Complete flow reversal is not present, but there is some degree of separation and flow reversal in the compressor. To provide the most complete information on this, a map of coefficient of variation of pressure, along with the rate at which the pressure is sampled (see 4.2 regarding minimum sampling rate), taken at the compressor inlet (P1) should be provided as a function of corrected mass flow and compressor pressure ratio. See Figure 1. It is hard to completely differentiate soft surge, because the condition has a gradual onset—as compared to full surge, which is an absolute condition. Industry definitions of soft surge could vary considerably, based on the definition and detection method.