



Induction Subsystem Air Flow Pressure Loss Bench Test

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To provide a common method of quantifying airflow pressure loss for the induction systems of internal combustion engines.

1.2 Applicability. For all passenger cars and trucks

1.3 Remarks. This procedure does not encompass pressure loss caused by vehicle sheet metal prior to air entering the dirty air snorkel.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- GM Air Induction Subsystem Technical Specification (SSTS)
- Kiel Probes, available through United Sensor Corporation, Amherst, New Hampshire, www.unitedsensorcorp.com
- Kiel Specification Pages
- Mensor Company, San Marcos, Texas, www.mensor.com
- Subsystem Technical Specification (SSTS)
- United Sensor Corporation, Amherst, New Hampshire

3 Resources

3.1 Facilities. Must be able to maintain an ambient room temperature of $21\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Vacuum source capable of maintaining a flow rate of 25 g/s greater than rate listed on SSTS.

3.2.2 Barometer.

3.2.3 Thermometer.

3.2.4 Relative humidity indicator.

3.2.5 Airflow measuring device transducer with accuracy of 0.5% full scale flow rate and 0.05% full scale pressure drop. Recommended pressure transducer (Mensor 6100 pressure transducer, 40 in-H₂O full scale, $\pm 0.01\%$ full scale uncertainty).

3.2.6 Kiel probe with 3.1 mm ($\frac{1}{8}$ in) sensing head (see Appendix A, Section A1 for Kiel probe specifications).

3.3 Test Vehicle/Test Piece. Air Induction System (air box, filter, Mass Air Flow (MAF) sensor, ducts, and resonators).

3.4 Test Time.

Calendar time: 1 day

Test hours: 1 hour

Coordination hours: 4 hours

3.5 Test Required Information.

- Maximum mass airflow and pressure loss target for specific application (SSTS).
- Unigraphics (UG) data of throttle body to clean air duct interface.

3.6 Personnel/Skills. Capability to use basic tools and flow bench operation.

4 Procedure

4.1 Preparation. If the component being tested is not designed for air entry (such as a clean air duct without the airbox attached), form a radius at the air entry point. Use SAE International Ideal Orifice. See Appendix D, Figure D1 for Ideal Orifice.

Note: If not available, default to:

$$r/d \geq 0.15$$

Where:

r = Radius of flare

d = Duct/tube diameter

Insert a length of straight pipe that is of the same inside diameter as the outlet of the throttle body/turbo inlet and is a total of six (6) diameters in length. This pipe should be installed between the outlet of the test piece and the inlet of the flow bench. Install Kiel probe (for total pressure) in the middle of the straight pipe (three diameters from either end) ensuring that the sensing head is facing upstream and is in the cross sectional center of the pipe.

Refer to Appendix A, Section A1, for Kiel probe type and orientation.

Refer to Appendix D, Figure D2 for an example of a GM flow bench adaptor.

4.1.1 The test must be conducted using a fixture where all the air induction system components are arranged in vehicle position relative to each other. However, the entire system does not have to be positioned in vehicle orientation. The air induction supplier is responsible to build any fixtures necessary to accomplish this. The air induction supplier will collaborate with the MAF sensor supplier while designing the fixture to insure the fixture is compatible with MAF supplier flow bench room.

4.2 Conditions.

4.2.1 Environmental Conditions. Record barometer, temperature, and relative humidity of test facility.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions.

4.3.1 Attach subsystem to flow bench, making sure the system is oriented as it would be in net vehicle position using a fixture. (Refer to 4.1.2)

4.3.2 Starting at a flow rate that is 5% of the SSTS target, increase the flow rate incrementally. Specifically include points at the target and 5% beyond the target (see Table 1 and Appendix C, Data Sheet C1 for example). Label this data as **Pressure Loss** for Kiel probe readings. A minimum of six (6) test points are required. See Appendix C, Data Sheet C1, for flow rate profile example.

**Table 1: Examples for Starting and Last Flow Rates for Pressure Loss (PL) Data Collection
(Given the SSTS Target Flow Rate)**

Examples of SSTS Target Flow Rates (grams/second)	Starting Flow Rate for Data Collection = 5% of the SSTS Target	Last Data Collection Flow Point = 5% Beyond SSTS Flow Rate Target
50	2.50	52.50
100	5.00	105.00
150	7.50	157.50
200	10.00	210.00
250	12.50	262.50
300	15.00	315.00
350	17.50	367.50
400	20.00	420.00
450	22.50	472.50
500	25.00	525.00
550	27.50	577.50
600	30.00	630.00
650	32.50	682.50
700	35.00	735.00

5 Data

5.1 Calculations. Volumetric flow rates should be corrected to a mass air flow rate in units of grams/second. Using data from 4.2.1, static pressure can be calculated from the total pressure measurement (Appendix B, Sections B1 and B2).

5.2 Interpretation of Results. Data must be presented as tested. Do **not** correct the data.

5.3 Test Documentation. An Engineering Report should be generated following completion of this procedure. Data should be recorded on Appendix C, Data Sheet C1 and presented as a plot.

x axis = grams/second

y axis = kilopascals

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Induction System: The induction system consists of all components from the dirty air snorkel to throttle body or base engine inlet.

7.2 Acronyms, Abbreviations, and Symbols.

AIS	Air Induction System
Deg	Degrees
Dia	Diameter
DRE	Design Release Engineer
GSSLT	Global Subsystem Leadership Team
I.D.	Inside Diameter
MAF	Mass Air Flow
O.D.	Outside Diameter
PL	Pressure Loss
Sec	Seconds
SSTS	Subsystem Technical Specification
UG	Unigraphics

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW14908

9 Release and Revisions

This standard was originated in December 2005. It was first approved by the Chassis Center Group in January 2006. It was first published in January 2006.

Issue	Publication Date	Description (Organization)
1	JAN 2006	Initial publication.
2	JAN 2007	Section 7.2: Updated Acronyms (Chassis Center Group)
3	JUN 2009	Removed reference to “flow restriction” and changed to “pressure loss”. Removed all reference to Piezo ring. 2.3 Updated text. 4.1 Updated text. 4.3.3 Updated text. 4.3.4 Added. 4.3.4 thru 4.3.7 deleted. 5.1 thru 5.3 updated text. Appendix A, B, and C Added. (Powertrain Integration)
4	OCT 2014	Revised to current template, 3.2.5 Updated text, 4.1.2 Added, 4.3.2 Updated text. (Chassis Induction Global Subsystem Leadership Team (GSSLT))

Appendix A: Kiel Probes

A1 General Information.

Note: The following information has been provided by United Sensor Corporation, based out of Amherst, New Hampshire.

A1.1 Aerodynamic Properties. Kiel probes are used to measure total pressure in fluid stream where the direction of flow is unknown or varies with operating conditions. Their correction factor is zero (0) when used within the ranges outlined in A1.1.1 and A1.1.2.

A1.1.1 Mach Number Range True total pressure is indicated up to a Mach Number of Mach 1. There is a slight drop in yaw in sensing range above Mach 0.3. This decreases averages of approximately 4% for all types at Mach 1.

A1.1.2 Reynolds Number Range. Insensitive to Reynolds Number except at extremely low velocities for Pitot-Static probes. For air, this limiting velocity is about 1.2 m/s (4 ft/s) for the smallest size Kiel probes listed.

A1.2 Time Constant. This depends on the complete installation, probe, pressure lines, and manometer. With 3.1 mm ($1/8$ in) diameter connecting hose up to 6 m (20 ft) long and a liquid manometer of 6.35 mm ($1/4$ in) inside diameter (ID), the Type B probe will reach equilibrium reading in approximately 15 s. Using this time t as a standard, the other time constants for average stem lengths will be as shown in Table A1.

Table A1: Time Constants

Type	Constant (t in seconds)
A	2.4 t
C, D, H	0.04 t
E, F	0.02 t

A1.3 Turbulence Errors. Negligible, especially since the probe is yaw insensitive. However, very high turbulence may cut down the yaw and pitch insensitive ranges.

A1.4 Yaw and Pitch Angle Range. The outstanding advantage of Kiel probes compared with other total pressure probes is complete insensitivity to direction of flow within certain limits. Their yaw and pitch characteristics are generally the same although stem interference on some designs will change one from the other. Figure A1 shows these flow angles and Figure A2 is a typical calibration curve of a Type A probe. It can be seen that the correction factor equals zero (0) up to the limits of the yaw range and then drops very sharply. The range is arbitrarily defined as the point where the error equals 1% of velocity pressure. Symbols used in these figures are:

Pt: Total Pressure

Ps: Static Pressure

Ptp: Indicated Total Pressure

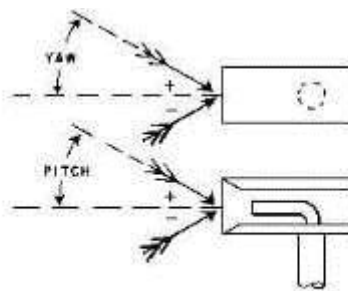


Figure A1: Flow Angles