AIRFLOW REFERENCE STANDARDS

Foreword—This reaffirmed document has been changed only to reflect the new SAE Technical Standards Board format.

1. **Scope**—The purpose of this SAE Recommended Practice is to establish reference standards for airflow measurements in the ranges required for testing automotive engine induction systems and to describe equipment that will facilitate the use of such standards to check the accuracy of various equipment and methods.

2. **References**—There are no referenced publications specified herein.

3. **Airflow Nozzle Definition**—The airflow reference system consists of a series of 10 nozzles called Calibration Transfer Nozzles, which are designed for operation at sonic flow velocities. Each nozzle is identified by a particular serial number and its nominal airflow, expressed in grams per second, at standard flow conditions. For this document, standard conditions are defined as:

   a. Air Pressure—100 kPa ABS
   b. Exit Pressure—less than 45 kPa ABS
   c. Air Temperature—25 °C
   d. Ambient Relative Humidity—35%

3.1 The nominal flow values established for the series of nozzles that should be used are: 1, 5, 10, 15, 20, 25, 50, 100, 150, and 200 g/s.

Typical outline dimensions and nozzle shape of an approved calibration transfer nozzle are shown in Figure 1. Nozzles produced for use in accordance with this document must be calibrated by a procedure which establishes an overall uncertainty (possible bias plus three standard errors) with 0.2% of a primary standard traceable to the National Institute of Standards and Technology (NIST).

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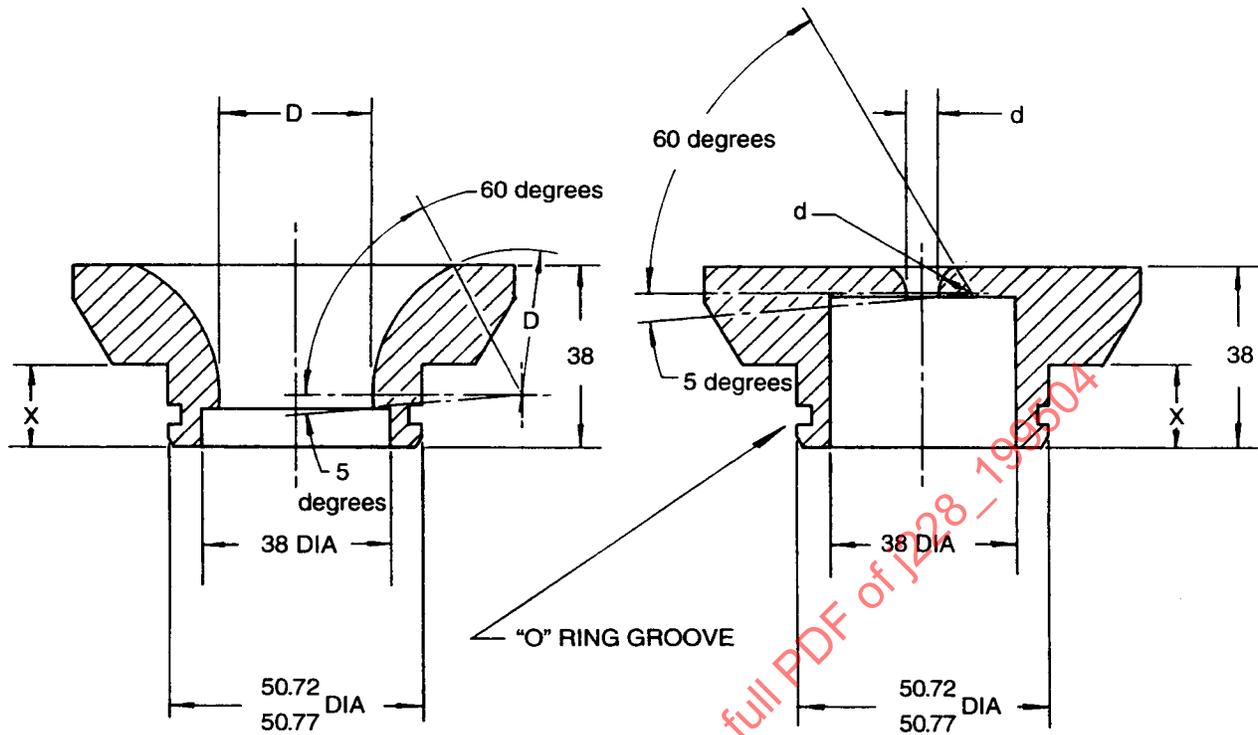
FIGURE 1—TYPICAL OUTLINES OF AIRFLOW CALIBRATION TRANSFER NOZZLE

4. ***Accessory Hardware and Instrumentation***—Figure 2 shows the nozzle holder which provides the adaptation necessary to fit the user's test equipment. The construction details of the holder are optional, but the dimensions of the air section must be retained. During use, there shall be no obstruction upstream of the nozzle inlet face for a distance of 5 D_{max} in a direction parallel to the flow and for a distance of 3 D_{max} in a direction perpendicular to the flow, where D_{max} is the throat diameter of the largest nozzle. Although the kind of temperature and pressure measuring instruments are not specified in this document, their accuracy must be traceable to the NIST and the overall uncertainty of their readings must be within 0.1% of actual. These instruments should be placed upstream of the nozzle entrance, preferably at a distance equal to the obstruction limits (see Figure 3). When calibration transfer nozzles are used for correlation between flow locations, a single set of temperature and pressure measuring instruments shall be used.
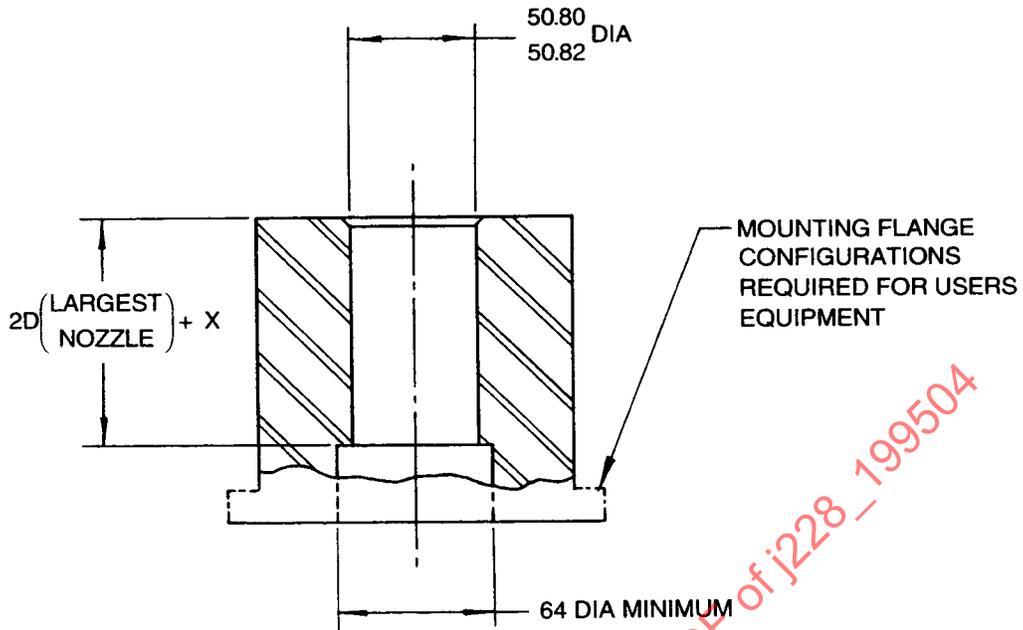
$$2D \begin{pmatrix} \text{LARGEST} \\ \text{NOZZLE} \end{pmatrix} + X$$

50.80
────── DIA
50.82

MOUNTING FLANGE
CONFIGURATIONS
REQUIRED FOR USERS
EQUIPMENT

64 DIA MINIMUM

FIGURE 2—NOZZLE HOLDER

RECOMMENDED LOCATION FOR
TEMPERATURE AND PRESSURE SENSORS

3D (LARGEST NOZZLE)

NO OBSTRUCTIONS WITHIN
THIS CYLINDRICAL VOLUME
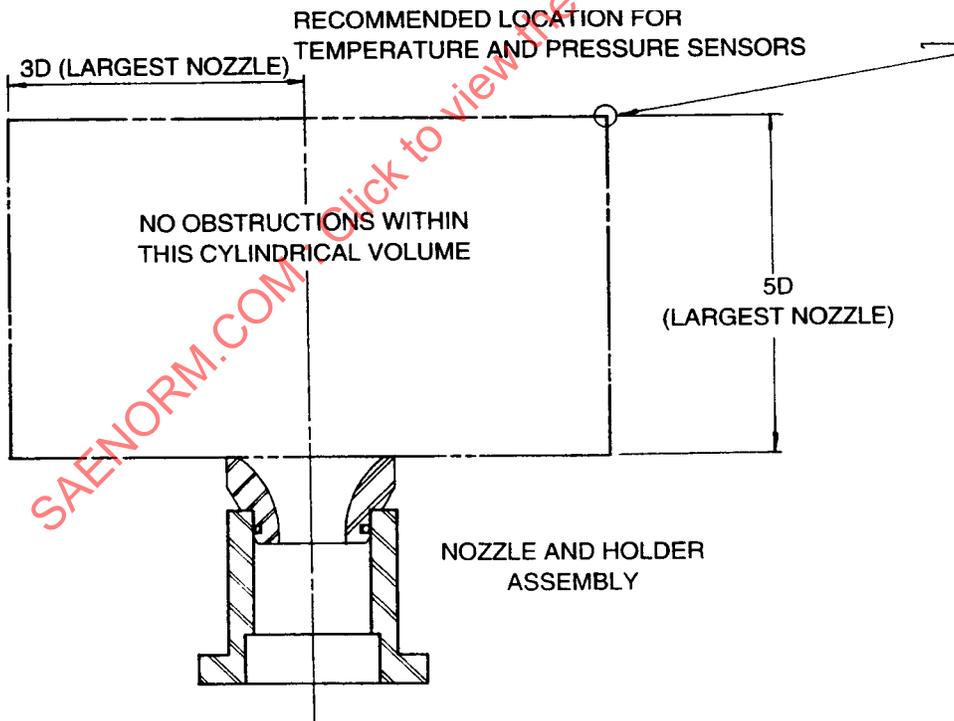
5D
(LARGEST NOZZLE)

NOZZLE AND HOLDER
ASSEMBLY

FIGURE 3—NOZZLE ENTRANCE OBSTRUCTION LIMITS

5. **Airflow Correction Factors—**When the actual inlet conditions existing during use of calibration of a nozzle are not identical to the standard conditions, the calibrated mass flow rate, W_s, may be corrected to actual flow rate, W, at actual flowing conditions by Equation 1:

$$W = W_s \sqrt{\frac{T_s}{T}} \left(\frac{P}{P_s}\right)\left[\frac{F(\tau, R)}{F(\tau_s, R_s)}\right]$$ (Eq. 1)

where:

$$F(\tau, R) = \sqrt{\frac{\tau}{R}\left(\frac{2}{\tau + 1}\right)^{\frac{\tau + 1}{\tau - 1}}}$$

Subscript s refers to standard conditions
W = Mass flow rate
P = Absolute pressure at inlet
T = Absolute stagnation temperature at inlet
R = Gas constant for moist air
τ = Specific heat ratio for moist air

Values of $F(\tau,R)/(F(\tau_s,R_s)$ may be obtained from Figure 4 and are valid for actual operating conditions over the following ranges:

   a.   Inlet Pressure, P—96 to 103 kPa ABS
   b.   Inlet Temperature, T—293 to 303 K
   c.   Ambient Relative Humidity—0 to 50%
   d.   Nozzle Exit Pressure—less than 45 kPa ABS

When the use conditions are not within the limits given previously, special nozzle calculations or calibrations must be obtained from the nozzle manufacturer.