

Issued 1970-05
Revised 1997-10
Stabilized 2011-07

Superseding ARP1179C

Aircraft Gas Turbine Engine Exhaust Smoke Measurement

RATIONALE

ARP1179 was originally developed in 1970 (with subsequent updates) as the measurement technique for Smoke Number (SN) that has been used as the basis of regulatory standards for ensuring that the exhaust plumes from aircraft engines are essentially non-visible. It has, and still does, serve this purpose.

More recent concerns relate to the health and climate impacts of particulate matter emitted by aircraft engines. Particle size, number and mass are all seen as relevant parameters as is the issue of "volatility".

The SAE E-31 Committee is currently using all its resources in developing a new ARP on the mass and number measurement of non-volatile particles at the exhaust of aircraft engines.

Hence the Committee recommends keeping ARP1179 as it still serves its purpose of quantifying the visibility at the exhaust of aircraft engines; it does not recommend any revision of it.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) standardizes test equipment and procedures for the measurement of smoke emission from aircraft gas turbine engines. The procedures included are for determining and reporting the amount of smoke emission. Tests have indicated that the practically achievable precision of the smoke number is within ± 3 when the system is properly used as outlined herein. This procedure is not intended for in-flight testing, nor does it apply to engines operating in the afterburning mode.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP1256 Procedure for the Continuous Sampling and Measurement of Gaseous Emissions
from Aircraft Turbine Engines

2.2 ANSI Publications:

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI PH 2.17

3. SECTIONS:

This document is divided into the following sections

4. Definitions and Terminology
5. Equipment
6. Test Procedures
7. Information and Data to be Recorded
8. Data Reduction and Analysis
9. Presentation of Results
10. Comments
11. Key Words

4. DEFINITIONS AND TERMINOLOGY:

The following apply to the terms indicated as they are used in this document.

A: Area of the smoke filter spot.

AIRCRAFT GAS TURBINE ENGINE: Any gas turbine engine used for aircraft propulsion or power generation, including those commonly called turbojet, turboprop, or turboshaft type engines.

FILTER MATERIAL: Filter material shall be Whatman No. 4 filter paper.

POWER SETTING: A value of the quantity used to rate the power output of an engine. The power setting of turbojet and similar engines should generally be expressed in terms of net thrust (corrected). For turboprop and similar engines, power setting should generally be in terms of shaft horsepower.

PRECISION: The closeness with which a measurement upon a given, invariant sample can be reproduced in short-term repetitions of the measurement with no intervening instrument adjustment.

SN: Smoke Number, the dimensionless term quantifying smoke emission. SN increases with smoke density and is rated on a scale from 0 to 100. SN is evaluated for a sample size of 16.2 kg of exhaust gas/m² (0.0230 lb/in²) of filter area.

SN': Smoke number obtained from an individual smoke sample. SN' is defined in 8.2, and is evaluated from the spot reflectance irrespective of the sample size.

SAMPLING: The collection of an exhaust sample under controlled conditions for the purpose of analysis.

SMOKE: Small gas-borne solid particles, including but not limited to black carbonaceous material from the burning of fuel, which in sufficient concentration create visible opacity.

4. (Continued):

STANDARD VOLUME: A standard volume of gas defined as the volume at 288 K (15 °C, 59 °F) and 101.32 kPa (29.921 in Hg absolute).

V: The measured sample size (volume).

W: The calculated mass of the measured sample volume.

5. EQUIPMENT:

5.1 System Scheme:

Figure 1 is a schematic diagram of a proper system. An optional bypass around the volume meter may be installed to facilitate meter reading. It simplifies automation of the smoke meter to acquire a preset sample volume.

5.2 Sampling Probe:

The probe shall be made of stainless steel. If a mixing probe is used, all sampling holes shall be of equal diameter and total probe orifice area shall be such that at least 80% of the pressure drop through the probe assembly (from free stream to probe outlet) shall be taken at the orifices. Probe orientation and sampling locations shall be as follows:

- a. A minimum of 12 sampling points shall be used. Either mixing or individual probes are acceptable.
- b. The axial location of the sampling plane shall be as close to the plane of the exit nozzle as engine performance parameters permit but in any case shall be held within 0.5 exit nozzle diameter of the exit plane.
- c. The sampling points shall be arranged over the exhaust nozzle exit area for straight turbojet, turboprop, turboshaft, and mixed flow (or confluent flow) fan engines, and over the core nozzle exit area for nonmixed fan engines.
- d. In order to promote uniformity of smoke measurements, a specific probe design should be standardized for use with a given type or series of engines. It must be demonstrated, by means of detailed traverse measurements in the sampling plane, that this probe design provides a representative smoke sample.
- e. If it is desired to draw a higher sample flow rate through the probe than through the filter holder, an optional flow splitter may be located between the probe and Valve A (Figure 1), to dump the excess flow. The dump line should be as close as possible to probe off take and should not affect the ability of the sampling system to maintain the required 80% pressure drop across the probe assembly. The dump flow may also be sent to the CO₂ analyzer or complete emissions analysis system thus eliminating the need for Valve E.

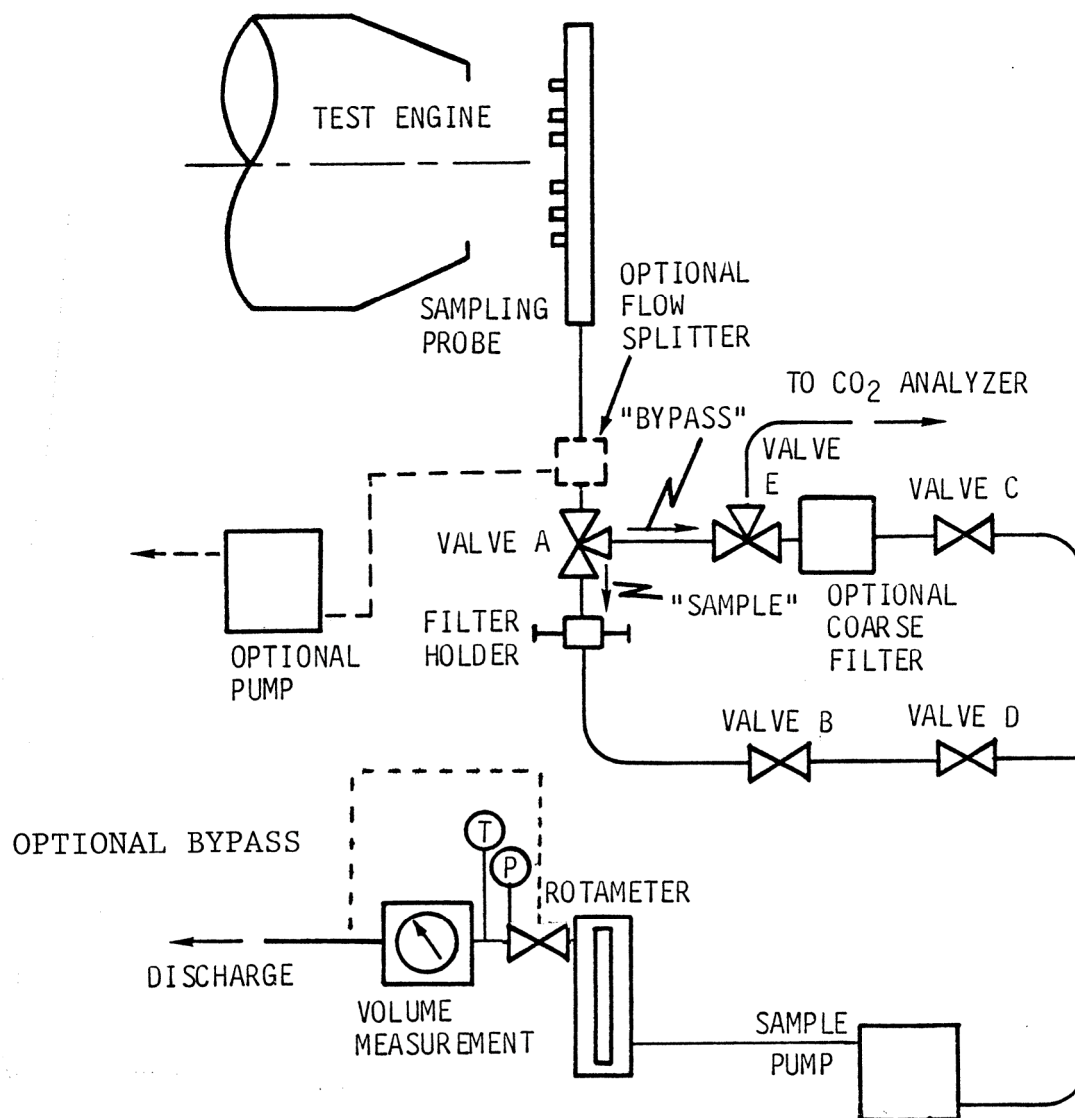


FIGURE 1 - Sampling System Schematic Diagram