

Issued 1970-06
Cancelled 2002-10

Superseding J177 JUN1995

**Measurement of Carbon Dioxide, Carbon Monoxide, and Oxides
of Nitrogen in Diesel Exhaust**

1. **Scope**—The method presented applies to the analysis of the indicated constituents in diesel engine exhaust, or vehicles using diesel engines, when operating at steady-state conditions.

The measurements of carbon monoxide, carbon dioxide, and nitric oxide are based on continuous sampling and analysis by nondispersive infrared (NDIR) methods. Measurements of total oxides of nitrogen by chemiluminescence and NDIR methods is discussed.

- 1.1 **Purpose**—This SAE Recommended Practice provides for the measurement of carbon dioxide, carbon monoxide, and oxides of nitrogen in diesel exhaust.

2. **References**

- 2.1 **Applicable Publications**—The following publications form a part of this specification to the extent specified herein.

- 2.1.1 “Cooperative Evaluation of Techniques for Measuring NO and CO in Diesel Exhaust,” CRC Report No. 443, March 1971 (SAE Paper 720104).
- 2.1.2 “Effect of Humidity of Air Intake on Nitric Oxide Formation in Diesel Exhaust,” CRC Report No. 447.
- 2.1.3 “Cooperative Evaluation of Techniques for Measuring NO and CO in Diesel Exhaust—Phase IV,” CRC Report No. 472, Aug. 1974 (SAE Paper 750204).
- 2.1.4 “Cooperative Study of Some Heavy Duty Diesel Emission Measurement Methods,” CRC Report No. 487, July 1976.
- 2.1.5 “Effect of Intake-Air Humidity and Temperature on Diesel Emission with Correlation Studies,” Ethyl Report ER442 (SAE Paper 730213).
- 2.1.6 NIST Standard Reference Materials, Office of SRM, B311 Chemistry, National Institute of Standards and Technology, Washington, DC 20234.
- 2.1.7 Federal Register, Vol. 42, No. 174, Thursday, Sept. 8, 1977, “EPA—Heavy Duty Engines for 1979 and Later Model Years—Certification and Test Procedures.”

SAE Technical Standards Board Rules provide that: “This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user.”

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright ©2002 Society of Automotive Engineers, Inc.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER:

Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

SAE J177 Cancelled OCT2002

- 2.1.8 Atkins Psychrometer #ZO2B-3, Atkins Technical Inc., P.O. Box 14405, Univ. of Florida.
- 2.1.9 EG&G Environmental Equipment Model 911 Humidity Analyzer, 151 Bear Hill Rd., Waltham, MA 02154.
- 2.1.10 K. M. Cole and J. A. Reger, "Humidity Calibration Techniques," Instruments and Control Systems, Jan. 1970, p. 77.
- 2.1.11 A. Wexler and W. G. Brombacher, "Methods of Measuring Humidity and Testing Hygrometers," NBS Circular 512, Washington, DC, 1951.
- 2.1.12 A. Wexler (Editor), "Humidity and Moisture: Measurement and Control in Science and Industry," Reinhold Pub. Corp., NY, 1965, (Vol. 1-4), Vol. 1, R. E. Ruskin, "Principles and Methods in Measuring Humidity in Gases."
- 2.1.13 ASTM E 337-72, "Standard Method for Determining Relative Humidity by Wet and Dry-Bulb Psychrometer," American Society for Testing Materials, 1916 Race St., Philadelphia, PA 19103-1187.
- 2.1.14 Keenan and Keyes, "Steam Tables."
- 2.1.15 R. L. Beatty, L. B. Berger, and H. H. Schenk, "Determinations of the Oxides of Nitrogen by the Phenoldisulphonic Acid Method," U.S. Bureau of Mines Report of Investigations, No. 3687, Feb. 1943.
- 2.1.16 "Research Technique for the Determination of Oxides of Nitrogen in Gaseous Combustion Products," CRC Designation A-2-857.
- 2.1.17 B. E. Saltzman, *Anal. Chem.*, Vol. 26 (1954), p. 1949.
- 2.1.18 *Ibid*, Vol. 32 (1960), p. 135.
- 2.1.19 R. F. Davis and W. E. O'Neill, "Determination of Oxides of Nitrogen in Diesel Exhaust by a Modified Saltzman Technique," U.S. Bureau of Mines Report of Investigations, No. 6790, 1966.
- 2.1.20 SAE Recommended Practice, "Measurement of Carbon Dioxide, Carbon Monoxide and Oxides of Nitrogen in Diesel Exhaust," SAE J177a, SAE Handbook.
- 2.1.21 D. B. Kittelson, et al, SAE Paper 770720, "Sampling and Physical Characterization of Diesel Exhaust Aerosols," and SAE Paper 780110, "Diesel Exhaust Aerosol Particle Size Distributions—Comparison of Theory and Experiments."
- 2.1.22 W. H. Lipkea, J. H. Johnson, and C. T. Vuk, "The Physical and Chemical Character of Diesel Particulate Emissions," SAE SP-430, Feb. 1978.
- 2.1.23 J. M. Perez, et al, "Cooperative Study of Heavy Duty Diesel Emission Measurement Methods," SAE Paper 780112, Feb. 1978.
- 2.1.24 Balston Filter Assembly Type 33, with Filter Element Type D. H., Balston Filter Corp.
- 2.1.25 Lipson and Sheth, "Statistical Design and Analysis of Engineering Experiments," McGraw-Hill, 1973, p. 80.

3. Definitions of Terms and Abbreviations

3.1 Terms Used

- 3.1.1 EXHAUST EMISSION—Any substance (but normally limited to pollutants) emitted to the atmosphere from any opening downstream from the exhaust port of the combustion chamber of an engine.
- 3.1.2 DIESEL ENGINE—Any compression ignition internal combustion engine using the basic diesel cycle, that is, combustion results from the spraying of fuel into air heated by compression.
- 3.1.3 STEADY-STATE CONDITION—An engine operating condition at a constant speed and load and at stabilized temperatures and pressures.
- 3.1.4 KILOWATTS—Observed kilowatts unless otherwise indicated (brake power x 0.7457).
- 3.1.5 NIST—National Institute of Standards and Technology
- 3.1.6 RATED KW OUTPUT—The maximum brake power output of an engine in kilowatts (kW) as stated by the manufacturer.
- 3.1.7 RATED SPEED—The engine speed at which the rated kW is obtained.
- 3.1.8 TOTAL OXIDES OF NITROGEN—The sum total of the measured ppm of nitric oxide (NO) plus the measured ppm of nitrogen dioxide (NO₂) expressed as an equivalent mass of NO₂.
- 3.1.9 CALIBRATION GAS—A gas used to establish instrument response. Concentration known to ±2%, traceable to National Institute of Standards and Technology Standard Reference Materials (Reference 2.1.6).
- 3.1.10 SPAN GAS—A gas used routinely to check instrument response. Concentration traceable to calibration gas.

3.2 Abbreviations Used

C—Degrees Celsius
CHEMI—Chemiluminescence
cm—Centimeters
CO₂—Carbon dioxide
CO—Carbon monoxide
conc—Concentration
DI—Direct injection
dia—Diameter
DIR—Dispersive Infrared
DUV—Dispersive Ultraviolet
EXH—Exhaust
F/A—Fuel/Air ratio
g—Gram(s)
h—Hour
kg—Kilogram
kPa—Kilopascals
kW—Kilowatt
L—Liter(s)
m—Meter(s)
max—Maximum
min—Minimum, minute(s)
mL—Milliliter(s)