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ASTM STANDARD D-2624-95: "STANDARD TEST METHODS FOR ELECTRICAL CONDUCTIVITY OF AVIATION AND DISTILLATE FUELS."

by

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Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels[1]

This standard is issued under the fixed designation D 2624; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval. This is also a Standard of the Institute of Petroleum issued under the fixed designation IP 274. The final number indicates the year of last revision.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 These test methods cover the determination of the electrical conductivity of aviation and distillate fuels with and without a static dissipator additive. The test methods normally give a measurement of the conductivity when the fuel is uncharged, that is, electrically at rest (known as the rest conductivity).

1.2 Two test methods are available for field tests of fuel conductivity. These are: (*a*) portable meters for the direct measurement in tanks or the field or laboratory measurement of fuel samples, and (*b*) in-line meters for the continuous measurement of fuel conductivities in a fuel distribution system. In using either type of instrument, care must be taken in allowing the relaxation of residual electrical charges before measurement and in preventing fuel contamination. For specification purposes, conductivity measurements should be made with the portable meters.

1.3 The values stated in SI units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, 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.* For specific precautionary statements, see Notes 1, 2, and 5.

2. Referenced Documents

2.1 *ASTM Standards:*

D 4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination[2]

D 4308 Test Method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *picosiemens per metre, n*—the unit of electrical conductivity is also called a conductivity unit (CU). A siemen is the SI definition of reciprocal ohm sometimes called mho.

$$1 \text{ pS/m} = 1 \times 10^{-12}\,\Omega^{-1}\,\text{m}^{-1} = 1 \text{ cu} = 1 \text{ picomho/m} \qquad (1)$$

3.1.2 *rest conductivity, n*—the reciprocal of the resistivity of uncharged fuel in the absence of ionic depletion or polarization.

DISCUSSION—It is the electrical conductivity at the initial instant of current measurement after a d-c voltage is impressed between electrodes.

4. Summary of Test Methods

4.1 A voltage is applied across two electrodes in the fuel and the resulting current expressed as a conductivity value. With portable meters, the current measurement is made almost instantaneously upon application of the voltage to avoid errors due to ion depletion. Ion depletion or polarisation is eliminated in dynamic monitoring systems by continuous replacement of the sample in the measuring cell. The procedure, with the correct selection of electrode size and current measurement apparatus, can be used to measure conductivities from 1 pS/m or greater. The commercially available equipment referred to in these methods covers a conductivity range up to 2000 pS/m with good precision (see Section 11), although some meters can only read to 500 or 1000 pS/m.

4.1.1 The EMCEE Model 1152 Meter is available with expanded ranges but the precision of the extended range meters has not been determined. If it is necessary to measure conductivities below 1 pS/m, for example in the case of clay treated fuels or refined hydrocarbon solvents, Test Method D 4308 should be used.

5. Significance and Use

5.1 The ability of a fuel to dissipate charge that has been generated during pumping and filtering operations is controlled by its electrical conductivity, which depends upon its content of ion species. If the conductivity is sufficiently high, charges dissipate fast enough to prevent their accumulation and dangerously high potentials in a receiving tank are avoided.

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[1] These test methods are under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and are the direct responsibility of Subcommittee D02.J on Aviation Fuels.

In the IP, these test methods are under the jurisdiction of the Standardization Committee.

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[2] *Annual Book of ASTM Standards*, Vol 05.02.

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PORTABLE METER METHOD

6. Apparatus

6.1 *Conductivity Cell and Current-Measuring Apparatus*—Any equipment capable of giving a conductivity reading almost instantaneously with the application of the voltage.[3]

6.2 *Thermometer*, having a suitable range for measuring fuel temperature in the field. A thermometer holder should be available so that the temperature can be directly determined for fuel in bulk storage, rail tank cars, and trucks.

6.3 *Measuring Vessel*—Any suitable cylindrical vessel capable of holding sufficient fuel to cover the electrodes of the conductivity cell. For the equipment referred to in Footnote 3, a minimum volume of 1 L is required.

7. Reagents and Materials

7.1 *Cleaning Solvents*—Use isopropyl alcohol if water is suspected (**Warning**—See Note 1.) followed by analytical grade toluene. (**Warning**—See Note 2.)

NOTE 1: **Warning**—Flammable.

NOTE 2: **Warning**—Flammable. Vapor harmful.

7.1.1 A mixture of 50 % volume analytical grade isopropanol and 50 % volume analytical grade heptane (**Warning**—See Note 2) is a satisfactory substitute for toluene.

8. Calibration

8.1 The calibration procedure will be dependent upon the equipment used. The procedures for the instruments listed in Footnote 3 are described in Annexes A1 and A2.

9. Sampling

9.1 Fuel conductivity measurements should be made *in situ* to avoid changes during sample shipment. If it is necessary to take samples for subsequent analysis, the following precautions should be taken:

9.1.1 If the cell is in contact with water and the instrument is switched on, an immediate offscale reading will be obtained. If the cell has been in contact with water, it shall be thoroughly rinsed with cleaning solvent, preferably isopropyl alcohol, and dried with a stream of air. In hot, humid conditions, condensation on the cell can occur, which can cause abnormally high zero, calibration and sample readings. This can be avoided by storing the cell at a temperature 2 to 5°C in excess of the maximum ambient temperature where this is practicable.

9.1.2 The sample size should be as large as p
and not less than 1 L.

NOTE 3—Test method results are known to be sensit
contamination from sampling containers. For recommend
containers refer to Practice D 4306.

9.1.3 All sample containers should be thorough
with cleaning solvent and dried with a stream of ai
taking the samples, all containers, including caps,
rinsed at least three times with the fuel under test.

9.1.4 Conductivity measurements should be ma
as possible after sampling and preferably within 2

10. Procedure

10.1 The specific instrument calibration proce
tailed in Annexes A1 and A2 are an essential p
following generalized procedures. The appropriat
tion steps for the instrument used should be follow
commencing the subsequent procedures.

10.2 *In Situ Field Measurement on Tanks, T*
Tank Trucks, etc.—For field measurements the co
meters referred to in Footnote 3 are considered sui
use of these meters in hazardous locations may be
by the regulatory agency having jurisdiction. Ea
extension cable or can be equipped with one to lo
into the tank. High impedance hand held m
susceptible to electrical transients caused by exten
flexing during measurements. Failure to hold the
steady during measurement can result in significan
precision than shown in Table 1. The following in
apply to the meters referenced in Footnote 3.

10.2.1 Check meter calibration as detailed in An
A2, depending on the meter used. Bond the me
tank and lower the conductivity cell into the ta
desired level taking care to avoid partial imm
contact with tank water bottoms, if present.
conductivity cell in an up-and-down motion t
previous fuel residues.

NOTE 4: **Caution**—To prevent static discharge betwee
fuel and a conductive probe inserted into a tank, the appro
precautions of bonding and waiting for charge dissipatio
observed. For example, the American Petroleum Institute
recommends that a 30-min interval be allowed after pum
storage tank before an operator mounts a tank to insert
device. This will also ensure that the fuel is electrically at r

10.2.2 After flushing the cell, hold it steady

TABLE 1 Precision[A]

Conductivity, pS/m	Repeatability	Reprod
1	1	
15	1	
20	1	
30	2	
50	3	
70	4	
100	5	
200	10	
300	14	
500	21	
700	29	
1000	39	1
1500	55	1

[A] The precision limits in Table 1 are applicable at room tempe
cantly higher precision (×2) may be applicable at temperatures nea

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[3] The following portable equipment has been found satisfactory for this purpose:

(*a*) Maihak MLA Conductivity Indicator, manufactured by H. Maihak, 2000 Hamburg 60, Postfach 601709. W. Germany; the U. S. agent is Ampower Corp., 7700 Marene Rd., North Bergen, NJ 07047; the U. K. agent, Smail Sons & Co. Ltd., 129 Whitefield Road, Glasgow SWI. Scotland.

(*b*) Ethyl Distillate Conductivity Meter, Models 8150 and 8151 manufactured by Ethyl Corp., 19 Roszel Rd, Princeton, NJ 08540. These meters are no longer available. However, calibration procedures for the existing meters can be obtained from the manufacturer.

(*c*) Emcee Conductivity Meter, Models 1151A and 1152, manufactured by Emcee Electronics, Inc., 520 Cypress Ave., Venice, FL 34292. The Model 1151A is no longer available. However, calibration for the existing meters can be obtained from the manufacturer.

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activating the instrument record the highest reading after initial stabilization. This should occur within 3 s. On instruments with more than one scale range, select the scale that gives the greatest sensitivity for the conductivity value being determined. Ensure that the appropriate scale multiplying factor (or scale range) is used. Record the fuel temperature.

10.3 *Laboratory and Field Measurements on Sampled Fuels:*

10.3.1 *Preparation of Containers (Metal or Glass)*—Prior to taking samples, take extreme care to ensure that all containers and measuring vessels have been thoroughly cleaned. It is preferable that containers are laboratory cleaned prior to shipment to the field for sampling (see Section 9).

10.3.2 *Measurement*—Rinse the conductivity cell thoroughly with the fuel under test to remove fuel residues remaining on the cell from previous tests. Transfer the fuel to the measuring vessel and record the conductivity of the fuel using the procedure applicable to the particular apparatus. If one of the conductivity meters referenced in Footnote 3 is used, follow these instructions: Rinse the cell concurrently with the rinsing of the measuring vessel. Then transfer the sample to be tested to the clean, rinsed measuring vessel. Check meter calibration as detailed in Annex A1 or A2, depending on the meter used. Fully immerse the conductivity cell into the test fuel and measure the conductivity following the procedure in 10.2.2 and the appropriate Annex. Record the fuel temperature.

NOTE 5—In order to avoid erroneous readings, it is important to ensure that the bottom of the conductivity cell does not touch the sample container. This is applicable to all containers, whatever the material of construction.

11. Report

11.1 Report the electrical conductivity of the fuel and the fuel temperature at which measurement was made. If the electrical conductivity reads zero on the meter, report less than 1 pS/M.

NOTE 6—It is recognized that the electrical conductivity of a fuel varies significantly with temperature and that the relationship differs for various types of aviation and distillate fuel. If it is necessary to correct conductivity readings to a particular temperature, each laboratory would have to establish this relationship for the fuels and temperature range of interest. Refer to Appendix X2 for additional information of the effect temperature has on the electrical conductivity of fuels.

12. Precision and Bias[4]

12.1 The precision of this test method as determined by statistical analysis of test results obtained by operator–instrument pairs at a common test site is as follows. The precision data generated for Table 1 did not include any gasolines or solvents.

12.1.1 *Repeatability*—The difference between successive measured conductivity values obtained by the same operator with the same apparatus under constant operating conditions on identical test material at the same fuel temperature would, in the long run, in the normal and correct operation of the test method, exceed the values in Table 1 only in one case in twenty.

12.1.2 *Reproducibility*—The difference between two single and independent measurements of conductivity obtained by different operators working at the same location (12.2) on identical test material at the same fuel temperature would, in the long run, in the normal and correct operation of the test method, exceed the values in Table 1 only in one case in twenty.

12.2 In 1987, a test program was carried out to investigate reproducibility of results when samples are shipped between laboratories. (See Appendix X1.)[5] While repeatability values were similar to those in Table 1, it was concluded that adequate reproducibility values were not obtained due to changes in conductivity of samples during shipment and storage. In the event of dispute or concern regarding shipped sample conductivity, it is recommended that operators come to the bulk fuel storage site to measure conductivity on bulk fuel or on freshly obtained samples according to cited procedures. This assures that a sample identical to the bulk supply is tested by either or both parties and the precision data shown in Table 1 shall apply.

12.3 *Bias*—Since there is no accepted reference material or test method for determining the bias of the procedure in Test Methods D 2624 for measuring electrical conductivity, bias cannot be determined.

CONTINUOUS IN-LINE CONDUCTIVITY MONITOR METHOD

13. Apparatus[6]

13.1 Continuous measurements can be made where suitable precautions have been taken to remove static charges before the representative fuel stream is passed through the in-line measuring cell. A controlled, continuous flow through the cell prevents ion depletion, thereby providing the equivalent of rest conductivity as a continuous measurement.

14. Installation

14.1 In general, the equipment is designed for permanent installation in the fuel distribution system. Follow the manufacturer's recommendations concerning installation and flow control, particularly with respect to the provision of adequate relaxation time. Install the sample tapping point at least 30 m downstream of any additive injection system, unless a mixing device is used which has been shown to give adequate mixing of the additive concerned prior to sampling. A thermometer having a suitable range for measuring fuel temperature in the field should be installed downstream of the test cell.

15. Procedure

15.1 Flush the cell thoroughly by initiating a controlled flow of the fuel to be measured. Purging of air from the cell and adequate flushing is normally achieved in a few minutes

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[4] Supporting data can be obtained from ASTM Headquarters. Request RR:D02-1013 and RR:D02-1161. The second report is details of data by the IP which resulted in the data in Table 1.

[5] Refer to Appendix X1 for a summary of the data and conclusions from this program on file at ASTM Headquarters. Request RR:D02-1235.

[6] The following continuous measuring equipment has been found satisfactory for this purpose: Staticon Conductivity Monitor, Manufactured by Emcee Electronics, 520 Cypress Avenue, Venice, FL 34292.

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but a longer flush is recommended when calibrating the instrument. The controlled flow must conform to the manufacturer's recommendation. Too fast or too slow a flow will result in inaccuracies in the conductivity measurement.

16. Calibration

16.1 The specific calibration procedure detailed in Annex A4 is an essential part of the general procedure and should be completed prior to initiating automatic monitoring and control of continuous fuel streams. If fitted, the high- and low-level alarm circuits should be calibrated as recommended by the manufacturer.

17. Measurement

17.1 After calibration, select the instrument scale of the approximate range anticipated for the fuel stream and initiate continuous measurements of fuel conductivity. Make measurements at the test cell temperature (indicated by the installed thermometer), which should approximate the temperature of the fuel in the system.

18. Report

18.1 Report the electrical conductivity of the fuel an fuel temperature at which measurement was made (sec 7).

19. Precision and Bias

19.1 *Repeatability* of the continuous meter has established to be within the range given for the po instruments (see 12.1.1).[4]

19.2 *Reproducibility* has not been established.

19.3 *Bias*—Since there is no accepted reference m or test method for determining the bias of the proced this test method, bias cannot be determined.

20. Keywords

20.1 aviation fuels; conductivity meter; conductivit distillate fuels; electrical conductivity; picosiemen meter; rest conductivity; static dissipator additives; electricity

ANNEXES

(Mandatory Information)

A1. CALIBRATION OF THE MAIHAK METER (Analog Type)

A1.1 Before carrying out the calibration procedure the conductivity cell must be clean and dry (Note 4 in Test Method D 2624).

A1.2 The Maihak meter has been built in four models or series with different characteristics. The corresponding instrument numbers are as follows:

Series	Instrument Number
1	64001 to 64068, 64070
2	64069, 64071 to 64171
3	Prefix 2-
4	Prefix 3-

Series 2 and 3 instruments should have been subsequently modified with parts supplied by the manufacturer; in this case, the instrument numbers bear the suffix "M."

A1.3 *Checking the Calibration*—To check the calibration reading, press the green READ button with the conductivity cell in the rest position against the calibration resistor in the housing. A meter reading of 465 ± 10 pS/m should be obtained. For confirmation press the red *2X* button and then also the green READ button, as above. The meter should read 232 ± 10 pS/m.

A1.3.1 To check the live zero reading, lift the conductivity cell slightly in the housing to break contact with the calibration resistor. Press the green READ button. Repeat while pressing the red *2X* button. For Series 3 a instruments a reading of zero should be obtained. For 1 and 2 instruments a positive reading of about 10 pS/m should be obtained. This value must be subt from all measured conductivity readings. If readings these limits are not obtained, the instrument require vicing.

NOTE A1.1—If the pointer of the meter oscillates during m ment, it is likely that the battery needs replacing.

A1.4 *Verifying Performance of the Meter*—Fully im the conductivity cell into the test fuel, hold it stead then press the green READ button and record the h reading after the needle has recovered from the overswing caused by inertia. The initial recovery shou exceed 20 pS/m and will be completed in less than 1 conductivities in the range from 500 to 1000 pS/m th *2X* button should be pressed and kept pressed whi READ button is pressed. Multiply the resultant scale re by 2 to obtain the correct conductivity reading. technique is also applicable for conductivities less tha as a check on the direct reading.)

NOTE A1.2—It has been found that the early series instrum not work properly at very low ambient temperatures. However, and 4 instruments operate satisfactorily at temperatures down to provided that the exposure time is limited to 30 min maximum

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A2. CALIBRATION OF THE EMCEE CONDUCTIVITY METER (Digital Type)

Model 1152

A2.1 Connect the probe to the connector on the Emcee Digital Conductivity Meter and depress the MEASURE switch (M) with the probe out of the fuel sample. Zero reading should be 000 ± 001 (in approximately 3 s).

A2.2 If the instrument does not meet the specification, remove the probe and depress MEASURE switch (M). If the instrument meets the specification without the probe attached, the probe should be thoroughly rinsed with isopropyl alcohol and allowed to air dry before retesting for zero. If the instrument does not meet the specification without the probe attached, then the adjustment procedure of A3.4 should be performed.

A2.3 Note the calibration number stamped on the probe. Depress the CALIBRATION switch (C) with the probe out of the fuel sample. The reading should be ten times the number stamped on the probe ±0.005 (after approximately 3 s). For example: Probe number equals 40, meter reading must be 400 ± 005 (395 to 405). If instrument does not meet specification, proceed to A2.5.

A2.4 Zero adjustment is performed without the probe attached and the MEASURE switch (M) depressed. Insert a screwdriver in the hole marked "Zero" and adjust the control until the DISPLAY reads 000 ± 001.

A2.5 Calibration is performed without the probe attached and with the CALIBRATION switch depressed. Insert a screwdriver in the hole marked "CALIBRATE" and adjust to within ±002 of ten times the number stamped on the probe.

A3. CALIBRATION OF THE STATICON CONDUCTIVITY MONITOR

Model 1150 (In-Line)

A3.1 Before carrying out the calibration procedure, flush the installed conductivity cell and adjust the fuel flow to the recommended level.

A3.2 Before calibrating, turn the power switch to ON and adjust the meter to zero as directed. Turn the function switch to CALIBRATE. Press the meter button and read. The meter should indicate 100 pS/m on each of three scales. If not, adjust as instructed. Turn the function switch to LOW ALARM, adjust the alarm level as required. The optional high-level alarm may be calibrated in a similar manner on monitors fitted with this equipment. Turn the function switch to OPERATE and lift the reset switch. (The alarm light will go out.) The recorder will then indicate the conductivity of the fuel stream. The alarm will be activated and the pumping circuits disabled if the conductivity drops below (or above) the preset level.

APPENDIXES

(Nonmandatory Information)

X1. DISCUSSION OF PRECISION STATEMENTS—TESTS CONDUCTED AT A COMMON SITE VERSUS DIFFERENT LOCATIONS (RR:D02-1235)

X1.1 *Purpose of Test Program*—A round-robin test program[5] was conducted to determine if the precision of the test method is affected when samples are shipped to different laboratories for testing.

X1.2 *Background:*

X1.2.1 From past test programs such as the one documented in RR:D02-1013 (9/11/75), it was determined samples may change as a function of time. Therefore, the precision statement in Test Methods D 2624 – 89 was calculated from data obtained at a common test site. The basis for the precision data was developed in a cooperative test program carried out on October 28, 1981, at the Mobil Paulsboro laboratory. These data are reported in RR:D02-1161, dated June 1982, and were further analyzed by the IP to result in the precision statement data for repeatability and reproducibility shown in Test Methods D 2624 – 89.

X1.2.2 The question still remained, however, of whether the judgment that samples shipped to various laboratories would not be "identical" was substantially correct. A cooperative test program was therefore organized to evaluate the precision of Test Methods D 2624 when samples were shipped between laboratories. The test program was conducted in 1987, and documented in RR:D02-1235.

X1.3 *Test Program:*

X1.3.1 In the 1987 program, ten fuels of various types were prepared with a planned conductivity range of 0 to 1000 pS/m. Details of the fuel types and additives are given in Appendix I of the research report. Samples included Jet A, Jet A-1, Diesel, JP-4, JP-8, and Jet-B fuels (the military specification fuels contained the fuel FSII/corrosion inhib-

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itor package). Conductivity additives included Stadis 450 and ASA-3 in aviation fuels and Petrolite T-511 and Mobil Conductivity Improver in the nonaviation fuels.

X1.3.2 The protocol for testing as provided to participants is given in Appendix II of the research report. Tests were carried out with Emcee Model 1152 Digital Conductivity Meter only; participants were asked to measure conductivity directly in the containers.

X1.4 *Data:*

X1.4.1 Data were obtained at typical laboratory (20°C) and reduced temperatures. Data obtained at typical laboratory temperatures outside 19 to 21°C were temperature-compensated to 20°C.

X1.4.2 The data obtained from the test program as well as the temperature-compensated data are in Appendix III, Tables 1, 2, and 3 of the research report.

X1.5 *Statistical Analyses*—The reduced temperature data were not used to calculate precision. Details of the statistical analysis are in Appendix IV of the research report. The results from Appendix III, Table 3, temperature-compensated data, are given in Table X1.1. Information for the table was extracted from the April 7, 1988, minutes of the Test Methods D 2624 Conductivity Round Robin Task Force of Section J-11 on Electrical Characteristics.

X1.6 *Conclusions:*

X1.6.1 The task force recommended that results of this program (RR:D02-1235) be referenced in Test Methods D 2624 and D 4308, with the recommendation that samples should not be shipped between laboratories for th
The basis for this recommendation is that adequat
ducibility is not obtained for shipped samples.

**TABLE X1.1 Comparison of Precision Data from Comm
Different Sites**

Conductivity, pS/m	Repeatability		Reproducibi	
	Common Site	Different Sites	Common Site	Diffe
30	2	4	6	
100	5	7	17	
300	14	13	45	
500	21	22	69	

X1.6.2 It is not possible to decide on the basi
study that any one fuel or additive type presents a p
problem with respect to shipment of samples
laboratories, or that any one fuel type is less vuln
change in transit/storage.

X1.6.3 It might be possible to define a narrow
conditions under which many samples could be tra
to other laboratories and tested with acceptable r
ibility of data. However, one reason for change i
conductivity is interaction of the conductivity addi
other trace materials in the fuel, unrelated to the
type or other conditions. Because type and amoun
materials vary, there is no way of predicting w
specific fuel sample will or will not be affected. This
has been observed with all fuel and additive types.

X2. TEMPERATURE–CONDUCTIVITY RELATIONSHIPS

X2.1 *Introduction:*

X2.1.1 The conductivity of hydrocarbon fuels and solvents generally changes with temperature, primarily due to changes in the mobility of the conducting species related to fuel viscosity effects. The possibility of dramatic temperature changes during the handling of hydrocarbons should especially be considered when the fuel or solvent is treated with static dissipator (conductivity improving) additives. The temperature-conductivity relationship of jet fuels and No. 2 heating and diesel fuels has been studied extensively,[7] although much data are not in the open literature. Extensive data are not available for other hydrocarbons.

X2.1.2 This appendix provides some guidance on how to evaluate low temperature needs and on the examination of fuel or solvent behavior.

X2.2 *Fundamental Relationships:*

X2.2.1 Conductivity has a semi-log relationship to temperature, but with some restrictions, as shown in Eq (1).

$$\mathrm{Log}_{10} K_{t1} = n(t1 - t2) + \mathrm{Log}_{10} K_{t2} \qquad (1)$$

where K_{t1} and K_{t2} are the conductivities at temperatures $t1$ and $t2$, and n is the temperature-conductivity coefficient and has units of $°F^{-1}$ or $°C^{-1}$. It is important to show these units to avoid confusion. This equation can be rearranged to give the following:

$$n = \frac{\mathrm{Log}_{10} K_{t1} - \mathrm{Log}_{10} K_{t2}}{t1 - t2}$$

Thus after measuring the conductivity of a fue
different temperatures the value of n can be calcul
then, using Eq (1), the conductivity of that fue
estimated at other temperatures.

X2.2.2 There are, however, some limitations
approach. Studies with jet fuels[7] have shown
temperature-conductivity coefficients grows larger a
atures below about −10°C. In other words, the
relationship is not always linear over a broad
conductivity at very low or high temperatures is of
separate coefficient should be calculated based
measurements at the lowest temperatures likely
countered.

X2.3 *Practical Considerations:*

X2.3.1 Unfortunately, only very clean hyd
show reproducible conductivity-temperature rela
Most fuels contain trace contaminants or co-additi
strongly affect the behavior of conductivity as te
varies. In exceptional circumstances fuels have sho
conductivity at −20°C than at +25°C. Evaluation
dissipator additives in clay-treated versus nontr
have demonstrated that trace impurities play an
role.

X2.3.2 Either the temperature-conductivity
can be assumed to vary over a wide range, or se
from a specific source can be evaluated to see if a
range applies.

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[7] Gardner, L., and Moon, F. G., "The Relationship Between Electrical Conductivity and Temperature of Aviation Fuels Containing Static Dissipator Additives," *NRC Report No. 22648*, 1983.

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X2.3.3 Temperatures likely to be encountered can be determined based on expected ambient temperatures during the lifetime of the hydrocarbon, bulk storage temperatures, and line-fill volume and temperatures.

X2.4 *Typical Temperature-Conductivity Coefficients*—Temperature-conductivity coefficients likely to be encountered are cited in the following table. These data are not represented, or expected, to include the extremes of behavior which can be encountered and are only for guidance purposes.

Fuel Type	n, Typical, °C^{-1}
Jet B (JP-4)	0.007 to 0.015
Jet A-1 (Jet A)	0.013 to 0.018
No. 2, 2D	0.015 to 0.022

X2.5 *Determination of Temperature-Conductivity Coefficients:*

X2.5.1 Measurements to determine coefficients are easily carried out and require only a few simple precautions. In general, these simply assure that other variables are controlled so that temperature effects only are measured.

X2.5.2 Test containers should be as specified in Practice D 4306.

X2.5.3 Before varying temperature, fuel should be stored in the test container for a time until a stable conductivity value is obtained at room temperature; one or two weeks may be required.

X2.5.4 Conductivity should then be measured at room temperature, then after storage for 24 h at each test temperature. Temperatures should include the complete range of interest.

X2.5.5 The container should then be stored for 24 h at room temperature and conductivity remeasured; a value close to that obtained originally should be obtained.

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