SAE International™ SURFACE VEHICLE STANDARD

SAE J2302

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Thermal Effectiveness of Sleeve Insulation

1. ***Scope***—This procedure measures the resistance to radiant heat flow of insulating materials in sleeve form. The sleeve's effectiveness (S_E) is determined by measuring the difference in surface temperature of a flat black, single-diameter ceramic cylinder with and without the standard diameter sleeve at the specified temperature, position, and distance from the radiant heat source.

1.1 **Safety**—This method may involve hazardous materials, operations, and equipment. This SAE Standard does not address the safety problems associated with its use. It is the responsibility of the user of this document to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.2 **Limitations**—The temperature measurement range of this procedure is 121 °C to 482 °C. Sleeve size is limited to 19 mm nominal ID and 30 cm ± 2 cm long. The test distance is the shortest measured span from the surface of the radiant heat source to the surface of the ceramic cylinder. Unless otherwise specified, the standard distance is 25 mm ± 2 mm with the cylinder position parallel to and directly above the heat source. This procedure is performed under static (passive) air flow with no vibration. Do not adapt the temperature sequencing as a thermal cycle.

1.3 This test method is based on SI units.

1.4 **Note to Users**—Use the appropriate alphanumeric codes to specify temperature condition (Table 1), sequence (Table 2), smoke generation option (see 6.3.2) and sample position (see 6.3.3) when referencing this document. For example, a line code of B(2)S(25)P(3)D(20) after the SAE document number means: Heating to a two-step sequence (B2), first at 121 °C, then 260 °C measuring smoke generation (S) at a level not exceeding 25 s. The sample position (P) is at 3 o'clock, 20 mm (D) from the heat source. Bracket numbers in parentheses.

2. References

2.1 **Applicable Publication**—The following publication forms a part of this specification to the extent specified herein.

2.1.1 NIST PUBLICATION—Available from the National Institute of Standards and Technology, U.S. Department of Commerce, Gaithersburg, MD 20899. (Formerly NBS)

NIST (NBS) Circular 590—Methods of Testing Thermocouples and Thermocouple Materials

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3. ***Summary*—**This method describes the procedure and equipment for measuring the thermal effectiveness of sleeves. The test also contains the option of monitoring smoke generation time at the conditions specified. A base line is established first by exposing a 16 mm OD, flat black ceramic cylinder to the specified radiant heat source. Normally, the ceramic cylinder is parallel to and directly above the heat source at the specified distance. Other ceramic cylinder positions are possible. During the test, both facing surface temperatures of the radiant heat source and cylinder are recorded. After establishing the base line surface temperature, the ceramic cylinder is sleeved with the protective material and tested again. The surface temperatures of the heat source, sleeve, and cylinder are recorded. In both test sequences, measuring the radiant source temperature and sleeve surface temperatures ensures consistent and fair measure of the sleeve's effectiveness. A significant variation in these values requires a repetition of the test sequence.

4. *Significance and Use*

4.1 Data obtained by this method are applicable to the material under conditions of this test and are not necessarily the same as those obtained in end use applications. The information permits comparison, selection, or qualification of commercially available sleeves where a level of proficiency is desired beyond short time quality control tests.

4.2 The test set-up (see Figure 1) can be modified to reduce the effects of convective heat transfer by aligning the sleeve horizontal (3 o'clock position) to the heat source. Indicate other positions and distances from the heat source using item 6.3.3 protocol.

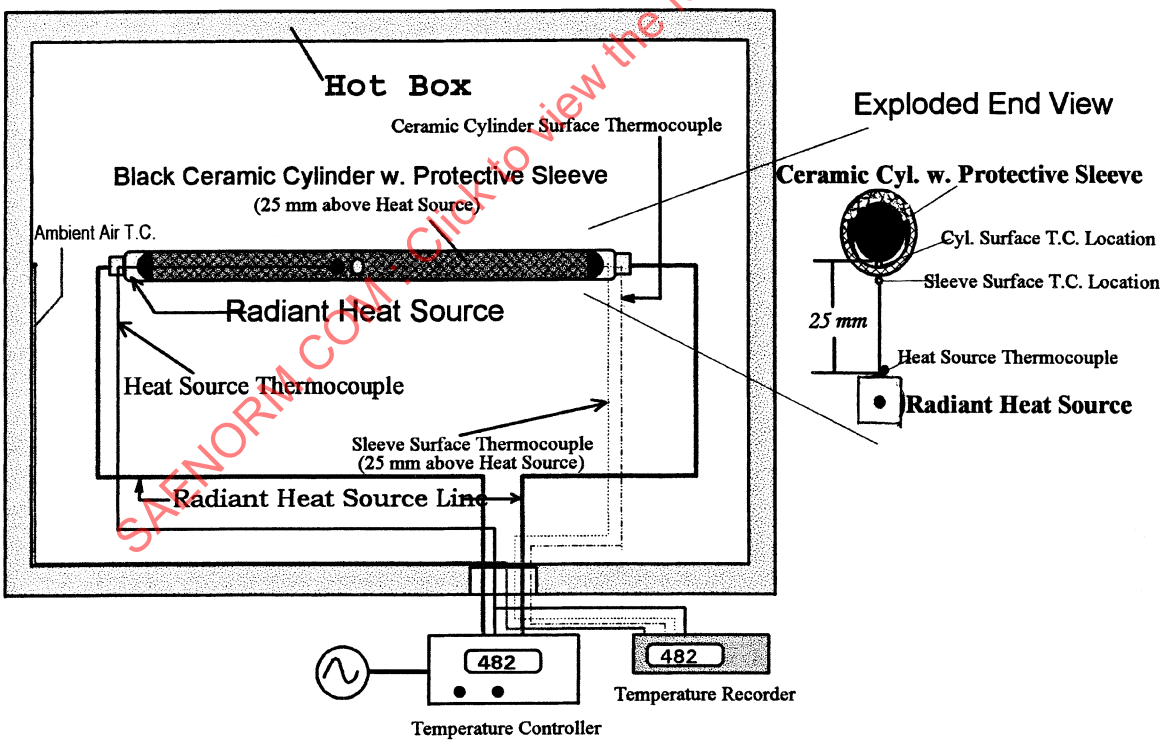


FIGURE 1—TEST SET-UP TOP VIEW

4.3 Test conditions and requirements using a line code must follow the order of temperature, sequence, smoke generation (optional), position by the clock, and distance from the heat source. See 1.4. Bracket all numbers in parentheses.

4.3.1 TEMPERATURE AND SEQUENCE PROTOCOL—List single or multiple test temperatures using the appropriate Table 1 condition letter. Condition A cannot use the sequence number 2 or 3 because it is the lowest specified temperature. If a step sequence is desired with Condition A as the upper temperature, use the Z suffix. Using a 2 or 3 test sequence after a B or C condition means the sequence follows the lower temperatures in Table 1. Always use the Z suffix to indicate a departure from the Table 1 temperature sequence. When using the Z suffix, indicate the preferred temperatures in degrees celsius in parentheses, separating the temperatures with a slash mark (/) - for example, Z2 (100 °C/121 °C).

4.3.2 POSITION AND DISTANCE PROTOCOL—The letter P followed by the appropriate number in parentheses indicates the circumferential clock position of the ceramic cylinder to the heat source. The radial distance D from the surface of the heat source to the surface of the ceramic cylinder is specified in mm bracketed by parentheses. If no position or distance is specified, the standard conditions apply.

5. Equipment[1]

5.1 Hot Box—Fabricated from non-conductive, fire-resistant, thermal-insulation board material (see detail drawing Figures 2A and 2B), open at the top with nominal internal dimensions of 50 cm x 50 cm x 50 cm. Angle iron 50 mm x 50 mm x 4 mm supports the box panels.

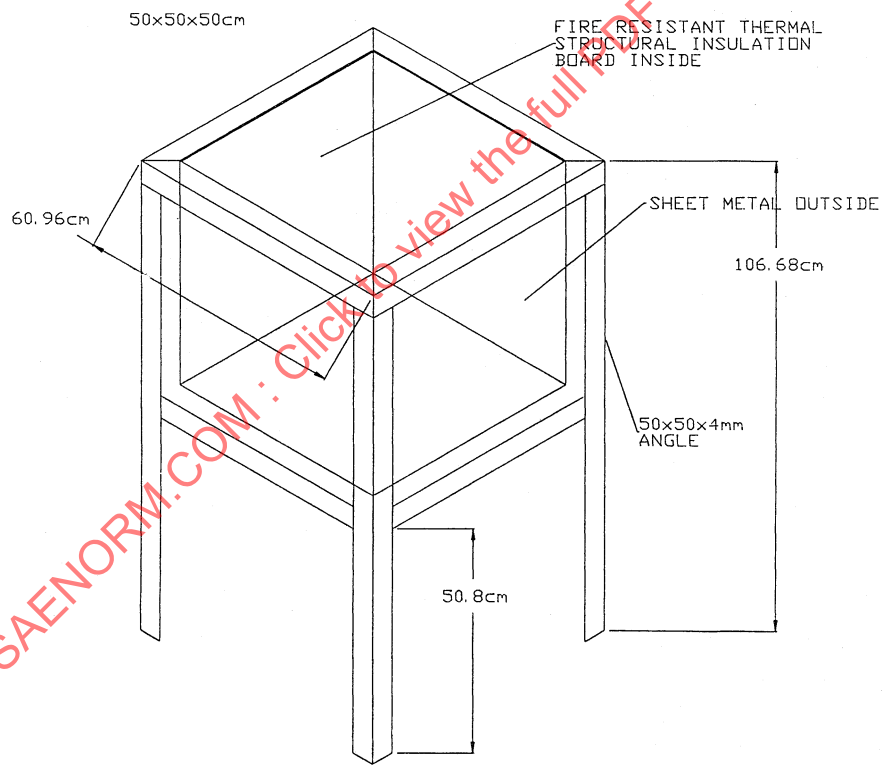


FIGURE 2A—HOT BOX

1. A complete parts list is available from SAE.

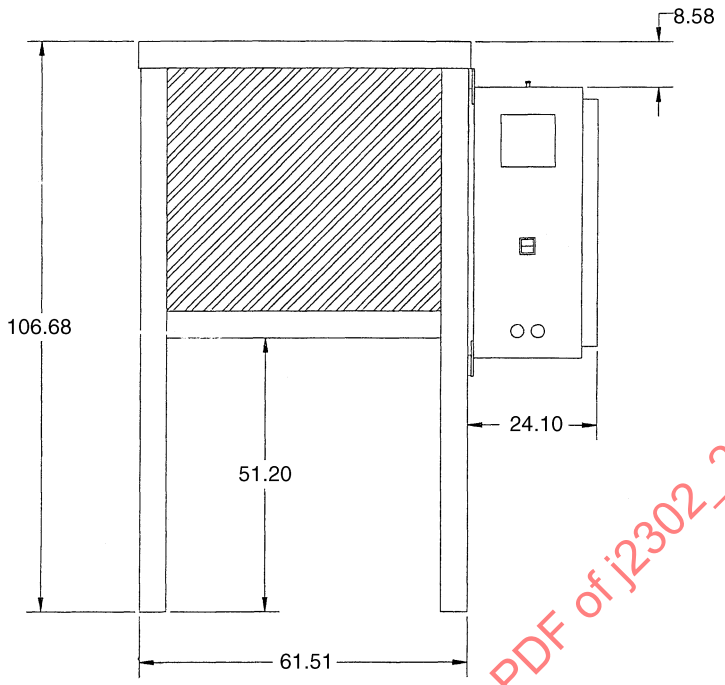


FIGURE 2B—HOT BOX SIDE VIEW WITH CONTROLLER

5.2 Fume Hood—Per appropriate industry-approved construction and performance.

5.3 Radiant Heat Source—Unit 320 mm long x 16 mm OD, capable of reaching 540 °C. Black-coated stainless steel emitter sheath. The sheath is backed with 2.5 cm high-density thermal insulation. The thermal heater output is 1100 W, 240 V, 4.6 A, with surface self-cleaning capability for most applications.[2]

5.4 Temperature Controller—1/4 DIN, digital indicating controller with an accuracy of ±3 °C up to 540 °C. Autotuning based microprocessor for primary output. Four to 20 mA output. Operating environment 0 °C to 65 °C. Sensor input must accept type K thermocouple.[3]

5.5 Temperature Recorder—Computer-controlled data analyzer.[4] Optional manual data recorder with a digital indicator. Ten-channel sensor input selector. Will accept type K thermocouple. Operating environment 0 °C to 55 °C. Accuracy of ±3 °C up to 540 °C.[5]

5.6 Type K Thermocouple—American National Standards Institute (ANSI) code K (yellow) with chromel/alumel base metals. Choose solid bare wire diameter (gauge) at 0.5 mm (AWG 24). Insulation, glass braided over glass wrap or other that meets or exceeds 500 °C capability.

5.7 Ceramic Cylinder—A flat black (not painted) solid black ceramic mandrel rod, 16 mm OD x 320 mm long, composition: 92% Al_2O_3, 8-10% SiO_2 and 0.5-1% Fe_2O_3.[6]

2. (Raymax 1330 radiant heater meets the requirements.)
3. (Watlow Series 945-1FA1-A000 meets the requirements.)
4. (Fluke Hydra Data Logger meets the requirements.)
5. (Watlow #8D45-0080-0-600 meets the requirements.)
6. (National Ceramic Co. meets the requirements.)

5.8 Enclosure Panel Box—A unit, 51 cm x 41 cm x 20 cm, with a subpanel 43 cm x 33 cm for mounting the temperature controller, temperature indicator, circuit breaker, transformer, lights, and switches. See Figure 2B.

6. Test Requirements

6.1 Specimen—The test sleeve length must be 28 cm to 32 cm long with a 19 mm nominal ID. Measure the sleeve ID using a plug gauge. The sleeve may or may not incorporate a seam. Seamed sleeves are tested with the seam at the top of the ceramic cylinder. The air space between the test sleeve around the ceramic cylinder (drape gap) will not be uniform. Try to be consistent in placement of repetitive test samples.

6.2 Unless otherwise specified, testing shall be conducted following a specimen conditioning period of 24 h minimum at 23 °C ± 2 °C and 50% R.H. ± 5% R.H.

6.3 Temperatures—For standardization purposes, select one or more of the following test temperature conditions in Table 1:

TABLE 1—TEMPERATURE CONDITIONS

Condition	Temperature °C	Available Sequence Numbers
A	121	1
B	260	1,2
C	482	1,2,3
Z	As specified within the limits of this document.	As specified within the limits of this document.

6.3.1 SEQUENCE—For standardization purposes, select one of the following test sequences in Table 2.

TABLE 2—SEQUENCE

Sequence	Condition
1	Dedicated test at specified isothermal temperature.
2	Two-step sequence using specified temperatures.
3	Three-step sequence using specified temperatures.
9	As specified within the limits of this document.

6.3.2 Use the letter 'S' after the temperature condition letter in Table 1 to designate smoke generation and time in seconds in parentheses. See item 4.3.1.

6.3.3 POSITION AND DISTANCE—Indicate the circumferential position of your ceramic cylinder relative to the heat source (at the center) using the positions of the clock. The 12 o'clock position is standard, with the cylinder 25 mm directly over the heat source. Other positions (P) and distances (D) must be indicated on individual part or component drawings per item 4.3.2.

6.4 Do not use the sequence conditions to specify a repetitive cycle test.

6.5 The specimen must be free of any visible defects that would affect the test results.

6.6 Test in a "passive" hood environment. Air flow must not influence test measurements.

6.7 Thermocouple Mounting

6.7.1 CERAMIC CYLINDER—Position the thermocouple touching the outside surface of the cylinder, at the midpoint of the length (15 cm), and facing down at the lowest point toward the heat source. Cover (pot) the thermocouple junction using black aluminum oxide and ceramic base potting adhesive.[7]

Follow the manufacturer's requirements for handling and cure of the adhesive. Don't wrap or twist the thermocouple wires around the rod and risk breaking the integrity of the contact junction.

6.7.2 TEST SLEEVE—Position the thermocouple at the mid-point (15 cm) and lowest point of the test sleeve facing the radiant heat source. Sewn sleeves should be positioned on the ceramic rod with the seam 180 degrees away from the heat source. The junction point must be in direct contact with the surface of the material. Secure the thermocouple to the sleeve using a fine copper magnet wire wrap or fiberglass thermal tape capable of surviving the test temperatures. Make sure the wire or tape doesn't touch the end of the thermocouple.

6.7.3 HEAT SOURCE—As purchased the heat source thermocouple may not be in the proper position. Re-position the thermocouple at the mid-point (15 cm) of the heat source shown in Figure 1. Secure the thermocouple by brazing or using black aluminum oxide and ceramic base potting adhesive.[8]

7. Calibration

7.1 The instrument manufacturer or certified agent should calibrate all recorders to the appropriate National Institute of Standards and Technology (NIST) document for accuracy claimed and the appropriate label displayed on the instrument. Calibration by the test facility is appropriate if substantiated by data measured by calibrated instruments traceable to NIST (formerly NBS).

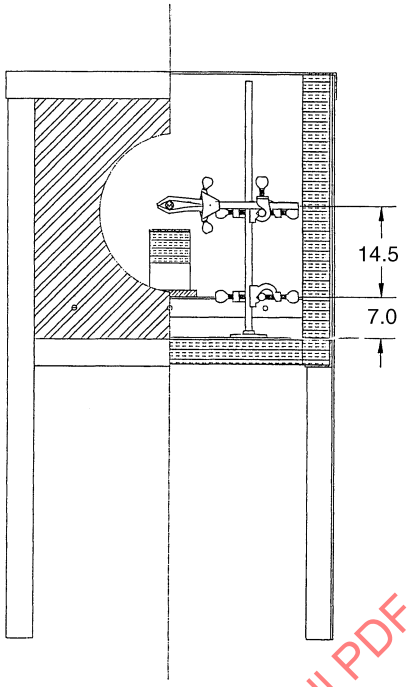
7.2 Calibrate thermocouples by the comparison method utilizing procedures based upon those described in NBS Circular 590, *Methods of Testing Thermocouples and Thermocouple Materials*. Pre-calibrated thermocouples are available from the manufacturers.

8. Procedure

8.1 Establish the base line (no sleeve) measurements by placing the ceramic cylinder in the Hot Box. Position and secure the thermocouples using the techniques described in 6.7. The ceramic rod is supported on clamps attached to a self-supporting lattice frame work using metal rods found in most lab equipment catalogs. Position the parts in the hot box according to Figures 3A and 3B. Unless otherwise specified, the cylinder must be 25 mm above the heat source (see 6.3.3). Connect the thermocouple to the temperature recorder.

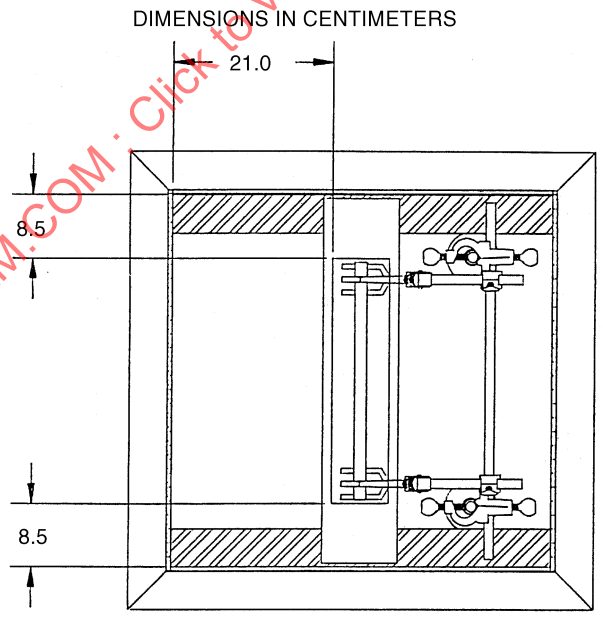
8.2 Check for ground loops, reversed connections and the integrity of all connections. Recalibrate if required. Begin a test sequence at 23 °C ± 2 °C air temperature as indicated by the thermocouple recording the temperature inside the hot box. Cracking of the ceramic bonding agent occurs after five or more heats, resulting in potential loss of surface contact of the thermocouple to the rod. If cracks occur, remove the excess bonding agent, rotate the rod, and remount the thermocouple contact to the new site with fresh bonding agent.

7. CERAMABOND 503 Blk., or its equivalent, has been found satisfactory for this purpose. This is obtainable from AERMCO, Ossining, NY.
8. Same as 7.



CUTAWAY

FIGURE 3A—CUTAWAY VIEW SHOWING SAMPLE MOUNTING



TOP VIEW

FIGURE 3B—TOP VIEW SHOWING SAMPLE POSITION

8.3 Turn on the power to the controller and recorder. Set the controller to the required temperature (see Table 1, 6.3). Allow the apparatus sufficient time to stabilize at the selected isothermal temperature. Steady-state is defined as three consecutive readings within ±2 °C of the set temperature. The starting point for determining the initial reaching of steady-state is when the continuous readout (temperature recorder) shows the first indication of the temperature to be measured. As the temperature increases to each set point, there may be a slight overshoot of the setting. Record the first steady-state set value as it is reached and ignore the slight rise (Figure 4). From early lab experience, initial runs of sleeves at all three temperatures took from 18 to 24 min to reach steady-state. Continue to record the air temperature inside the hot box. Do not use steady-state measurements as part of the ten data points.

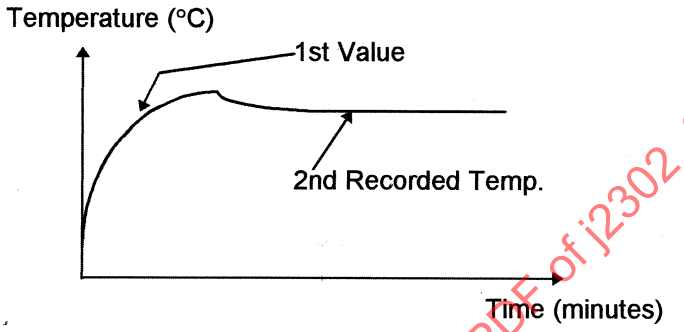


FIGURE 4—INITIAL TEMPERATURE MEASUREMENT POINTS FOR ESTABLISHING STEADY-STATE

8.4 After stabilizing the temperature set by the controller, start recording the heat source and cylinder surface temperatures. Record at 3-min intervals for 30 min *after* reaching steady-state. Continue to record the air temperature inside the hot box.

8.4.1 At the end of this period, if additional steps are required (see Table 2, 6.3.1), adjust the controller to the specified sequence condition in Table 2 and repeat the data acquisition steps. After establishing the baseline performance, end the test. Continue to record the air temperature inside the hot box.

8.5 After the test set-up has cooled, remove the set-up from the Hot Box and slide the protective sleeve on the cylinder. Don't move the thermocouple on the cylinder or the cylinder's position to the heat source. Place a second thermocouple on the outer surface of the sleeve, directly above the cylinder thermocouple. To prevent dislodging of the thermocouples, mount them on the test sleeve positioned on a second rod whose height is the same as the test. Carefully slide the sample onto the bare rod after butting the rod ends together to ease the transfer to the test rod. Place the sleeved cylinder back in the Hot Box and locate it 25 mm above the heat source. If applicable, position the sleeve seam away from the heat source.

8.6 Repeat the sequence described in 8.3. Begin the test sequence at ≤26 °C of the ceramic rod as indicated by the thermocouple on the rod. During the warm-up phase, be prepared to record the smoking time of the sample. Start the timer as soon as smoking is visually observed. Record the temperature that smoking started. Do not wait for the set temperature to be reached before starting smoke timing. Stop timing when no more smoke is observed. Report the time with a stop watch, in minutes and seconds.

8.7 After reaching the stable isothermal setting per 8.3, repeat steps 8.4 and if applicable, 8.4.1.

8.8 Reliable repeat measurements can be made only on the same sleeve at the lowest test temperature (condition A).