



400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J381

REV.
SEP2000

Issued 1968-02
Revised 2000-09
Superseding J381 APR1994
& SAE J382

Submitted for recognition as an American National Standard

(R) Windshield Defrosting Systems Test Procedure and Performance Requirements—Trucks, Buses, and Multipurpose Vehicles

1. **Scope**—This SAE Recommended Practice establishes uniform test procedures and performance requirements for the defrosting system of enclosed cab trucks, buses, and multipurpose vehicles. It is limited to a test that can be conducted on uniform test equipment in commercially available laboratory facilities. Current engineering practice prescribes that for laboratory evaluation of defroster systems, an ice coating of known thickness be applied to the windshield and left- and right-hand side windows to provide more uniform and repeatable test results, even though under actual conditions such a coating would necessarily be scraped off before driving. The test condition, therefore, represents a more severe condition than the actual condition, where the defroster system must merely be capable of maintaining a cleared viewing area.

Because of the special nature of the operation of most of these vehicles (where vehicles are generally warmed up before or garaged in preparation for road operations) and since defrosting under steady-state, over-the-road operations is the main concern, test conditions have been adopted which eliminate the engine warm-up phase of vehicle operation.

This document will be reviewed and revised as technological progress in vehicle defroster test procedure requires.

2. References

- 2.1 **Applicable Publications**—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

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

SAE J688—Truck Ability Prediction Procedure

SAE J826—Devices for use in Defining and Measuring Vehicle Seating Accommodation

SAE J941—Motor Vehicle Drivers Eye Locations

3. Definitions

- 3.1 **Defrost**—Melt frost on inside or test coating on the outside surface of the glass with the defroster system.
- 3.2 **Windshield Defroster System**—Means intended to defrost the windshield and specified portions of the right- and left-hand side windows.

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SAE J381 Revised SEP2000

3.3 Defrosted Area—That area of the windshield and right- and left-hand side windows composed of dry, cleared surface and melted or partially melted (wet) test coating and excluding that area of the windshield covered with dry test coating.

3.4 Coolant—Liquid used for heat transfer composed of 50% ethylene glycol/50% water or other liquids specified by vehicle manufacturer for use in the heat transfer system.

3.5 Daylight Opening (DLO)—The term “daylight opening” (DLO) refers to the maximum opening of any glass aperture which is unobstructed by moldings, masking, or framing.

4. *Defrosting/Demisting Test*

4.1 General Purpose Requirements—The windshield area to be defrosted was developed to be compatible with vision requirements necessary to operate trucks, buses, and multipurpose vehicles. The area is based on SAE J941 and SAE J826, with certain modifications to accommodate the wide variety of conditions encountered in these vehicles. For the purpose of this document, the head turn consideration in SAE J941 will not be used.

4.2 Test Equipment

4.2.1 Environmental chamber sufficiently large to contain the basic vehicle or basic vehicle body or partial body with provision for circulating air. If the road load test condition option is selected, a chassis dynamometer is required.

4.2.2 Means for recording the boundaries of the windshield areas defrosted. It is optional to use wax pencil and/or digital camera(s) for outlining defrosted areas. A digital camera with tripod should be used for each glass surface to picture windshield and side windows, i.e., one camera for windshield, one for each side of vehicle, and one for any rear glass, if applicable.

4.2.2.1 If digital camera(s) is using, camera's timing device has to have ability to set at least 1-min intervals.

4.2.3 Engine tachometer with an accuracy of 2% of observed values.

4.2.4 Stopwatch or other timing device.

4.2.5 Thermometers, thermocouples, or other temperature measuring devices with an accuracy of ± 0.5 °C.

4.2.6 Throttle control device (if desired).

4.2.7 Spray gun for applying distilled water to the windshield and side windows with the following characteristics:

- a. Fluid—Water
- b. Liquid nozzle size diameter—1.7 mm (0.070 in)
- c. Operating gun gauge pressure—345 kPa (50 psig)
- d. Airflow rate— $0.34 \text{ m}^3/\text{min} \pm 0.03 \text{ m}^3/\text{min}$ ($12 \text{ ft}^3/\text{min} \pm 1 \text{ ft}^3/\text{min}$)
- e. Pattern at 200 mm (8 in) from surface— $250 \text{ mm} \pm 50 \text{ mm}$ (10 in \pm 2 in) wide

4.2.8 Device for measuring quantity of water applied to windshield/side windows.

4.2.9 Auxiliary power supply for blower motor.

4.2.10 Anemometer to measure air velocity (with a measuring accuracy of 2% of observed values).

SAE J381 Revised SEP2000

4.2.11 Independent coolant supply may be used to provide coolant flow to the heater-defroster/demister system under test.

4.2.12 Instrument for measuring voltage and amperage.

4.3 Test Conditions—Either the engine in the test vehicle or an independent coolant supply may be used to provide coolant flow to the heater-defroster/demister system under test.

4.3.1 COLD CHAMBER TEMPERATURE— $-18^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ($0^{\circ}\text{F} \pm 2^{\circ}\text{F}$).

4.3.2 ENGINE LOAD AND SPEED (WHEN APPLICABLE)—Gasoline engines—1500 rpm \pm 50 rpm in neutral gear or any load not to exceed 40 km/h (25 mph) road load. Diesel engines—governed or rated speed either in neutral gear or at any load not to exceed 40 km/h (25 mph) road load.

Load on the chassis dynamometer shall not exceed the calculated as follows:

The sum of one half the *rolling resistance horsepower* plus the *air resistance horsepower* as established according to the procedure specified in SAE J688, using Tables 3 to 6. A value equal to the minimum of the rated gwv applicable to that defrosting system under test shall be used for the total gross vehicle weight and all calculated values will be for a speed of 40 km/h (25 mph) and an altitude of 0.30 km (1000 ft).

A sample calculation is provided in Figure 1.

At road load, the vehicle shall be run in that transmission gear which will permit running the engine at its governed or rated speed at the closest possible speed to, but not to exceed, 40 km/h (25 mph).

Truck model XXX
Minimum gwv rating - 12 250 kg (27 000 lb)

Area factor from Table 4 of SAE J688—0.145

Velocity factor from Table 5 of SAE J688—31.3

Altitude factor from Table 6 of SAE J688—0.97

Rolling factor from Table 3 of SAE J688—0.657

Air resistance hp = Area factor X Velocity factor X Altitude factor
= $0.145 \times 31.3 \times 0.97$
= 4.4

1/2 Rolling resistance hp = (1/2 Rolling factor X Gross weight in 1000 lb)
= $1/2 (0.657 \times 27)$
= 8.9

Road load = $4.4 + 8.9 = 13.3$ hp (9.9 kW)

NOTE—Data based on SAE J688 JUN63.

FIGURE 1—SAMPLE CALCULATION FOR ROAD LOAD

4.3.3 HEATER DEFROSTER SYSTEM COOLANT FLOW—With engine—That flow resulting from engine operation as prescribed in 4.3.2.

With independent coolant supply—Flow of coolant to be either 11.4 kg/min \pm 2.3 kg/min (25 lb/min \pm 5 lb/min) or the flow produced by the engine at 1500 rpm for the gasoline type and at governed speed for the diesel type, both for a closed engine thermostat condition.

SAE J381 Revised SEP2000

4.3.4 HEATER DEFROSTER SYSTEM COOLANT TEMPERATURES

- a. With engine—To be at $65\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($150\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) at the start of the test, or at the level of temperature of the coolant if below $65\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($150\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$). Coolant temperature after the start of the test is to be a function of the engine control temperature characteristics at the test conditions.
- b. With independent coolant supply—To be maintained at $65\text{ }^{\circ}\text{C} + 3\text{ }^{\circ}\text{C}/-0\text{ }^{\circ}\text{C}$ ($150\text{ }^{\circ}\text{F} + 5\text{ }^{\circ}\text{F}/-0\text{ }^{\circ}\text{F}$) for the entire test period.

4.3.5 AIR VELOCITY—The maximum wind velocity shall not exceed 3.2 km/h (2 mph).

4.3.6 SOAK TIME—Soak time in the environmental chamber is 4 h.

NOTE—If instrumentation is available to assure that the windshield, cab, and HVAC system with ductwork are stabilized at test temperature, a shorter soak time may be used.

4.3.7 NUMBER OF VEHICLE OCCUPANTS DURING TEST—Two maximum.

4.3.8 WINDSHIELD WIPERS—Wiper blades and arms are to be off the windshield glazing surface during the ice application. Windshield wipers may be used during the test.

4.3.9 DEFROSTER AND/OR HEATER SYSTEM AIR—On full, blower(s) on high speed, defrost mode, and fresh air mode, where applicable.

4.3.10 TEST VOLTAGE—To be 15% over nominal system rating at the blower motor (for example, 13.8 on 12 V system) or the supply end of motor dropping resistor.

NOTE—Blower motor voltage and current are to be measured as close to the motor as possible and the distance documented.

4.3.11 TEMPERATURE CONTROL—Maximum position.

4.3.12 All engine, heater, and defroster units shall be standard production parts or equivalent, adjusted to the manufacturer's specified limits.

4.3.13 Engine hood, doors, windows, and controllable vents shall be closed. Operation of the side windows is not permitted during the test. Use of the bunk curtain should be consistent, whether closed or open, throughout the test series. Bunk blower off, if applicable.

4.3.14 If an auxiliary heater (or heaters) is part of the standard heater and defroster system, it may be operated.

4.3.15 If the engine is used for supplying coolant, auxiliary means for preheating the engine, etc., is permissible to provide easier engine starting. Temperatures described in 4.5.5 must stay within specified limits.

4.3.16 For systems using an electrically conductive heating media integral with glazing material and if a coolant heater defroster means is not used, the following may not be necessary:

- 4.3.2
- 4.3.3
- 4.3.4
- 4.3.9
- 4.3.13
- 4.3.15

SAE J381 Revised SEP2000

- 4.3.17 Switch for activating electrically conductive media integral with the glazing material to be activated to its maximum setting.

4.4 Test Instrumentation

- 4.4.1 The temperature of the engine coolant or the independent supply coolant shall be measured as near to the inlet pipe of the heater unit as possible, but not farther than 6 in from the heater inlet and outlet tubes. For those systems using more than one heater, it shall be measured at the inlet pipe of the heater unit getting the first coolant flow. The coolant flow may be measured at any convenient point in the independent coolant supply system.
- 4.4.2 The ambient air temperature shall be measured at a point that is located at the midpoint of the windshield 300 mm (1 ft) ahead of the windshield surface. The air velocity at the windshield shall be measured at a point that is located at the midpoint of the windshield 25 mm (1 in) ahead of the windshield surface.
- 4.4.3 The windshield's interior surface temperature(s) shall be measured at a point located on the vertical and horizontal centerline(s) of the windshield(s).

4.5 Test Procedure

- 4.5.1 The cold chamber shall have been maintained at or below the specified test temperature for not less than 24 h preceding the vehicle soak period.

NOTE—If instrumentation is available to assure that windshield, cab, and HVAC system with ductwork are stabilized at test temperature, a shorter soak time may be used.

- 4.5.2 VEHICLE SOAK PERIOD—The vehicle shall stand inoperative at the specified test temperature to soak for a period of not less than 4 h. Vehicle doors/windows should be open during soak time.

NOTE—If instrumentation is available to assure that windshield, cab, and HVAC system with ductwork are stabilized at test temperature, a shorter soak time may be used.

- 4.5.3 ICE APPLICATION—Following the vehicle soak period, a coating of ice shall be formed on the windshield(s) as follows: The windshield(s) shall be sprayed with 0.05 mL of water per square centimeter of glass area ($0.05 \text{ mL/cm}^2 = 0.01 \text{ oz/in}^2$) applied by means of a spray gun with $345 \text{ kPa} \pm 35 \text{ kPa}$ ($50 \text{ psi} \pm 5 \text{ psi}$) air pressure at the device, measured while spraying to form an even coating of ice over the entire glass surface. The spray nozzle (adjusted to full fan pattern and maximum flow) is held perpendicular to and 200 to 250 mm (8 to 10 in) from the glass, and stroked back and forth evenly in horizontal overlapping layers until the specified quantity of liquid is applied. Upon completion of the icing process, an additional soak period of not less than 30 min and not more than 40 min shall have elapsed before start of the test.

- 4.5.4 If digital camera(s) is using, then during the spray freeze period position and secure the digital cameras to the tripods at the front and sides of the vehicle. Complete the electrical power and signal connections between cameras and the power/signal boxes that have to be connected to electrical outlet and placed at each tripod location. Adjust the camera height and angle for maximum coverage of the windows. Close the camera lens covers. Set the camera timing device to the required interval (it is recommended to use 1-min as a time interval, as this gives the best amount of data, and allows for the auto timer to become a non-issue.)

- 4.5.5 The test period begins when the engine coolant reaches $65 \text{ }^\circ\text{C} \pm 3 \text{ }^\circ\text{C}$ ($150 \text{ }^\circ\text{F} \pm 5 \text{ }^\circ\text{F}$). Test conditions described in 4.3 are to be maintained throughout the duration of the test. Prior to the start of the test period, while the engine or independent coolant supply is being warmed up, the temperature at thermocouple locations specified in 4.4.2 and 4.4.3 shall not exceed $-12 \text{ }^\circ\text{C}$ ($+10 \text{ }^\circ\text{F}$). As the test proceeds, the temperature at the thermocouple location specified in 4.4.2 shall not exceed $-12 \text{ }^\circ\text{C}$ ($+10 \text{ }^\circ\text{F}$). Open the camera(s) lens cover.

SAE J381 Revised SEP2000

- 4.5.6 When coolant inlet temperature indicates $65\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($150\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$), depress the camera timer override button and take the "time 0 or 0 min" picture. Turn on the camera(s) timing device. Turn on the blower power supply and test timer.
- 4.5.7 The observer(s) shall outline the defrosted areas on the inner surface of the windshield and left- and right-hand side windows at intervals of 5 min as the test proceeds. All in-cab temperatures are also to be recorded at the same 5-min intervals.
- NOTE—Defrost marking is to be made on the outer edge of the wet ice (Figure 2).
- 4.5.8 At the completion of the 30 min test initiated per 4.5.5, the defrosted pattern shall be recorded. It is suggested that the pattern be transferred to a transparent material by tracing. This record shall be marked to identify the driver's side of the windshield and the left- and right-hand side windows. Record the position of the bunk curtain.
- 4.5.9 After completion of the test, each digital camera is removed from the chamber and the images are downloaded from each individual camera onto a PC equipped with the appropriate software for the digital cameras used in the test. These images are in the standard *.jpg file formats and can be printed out on any color printer, or sent electronically to any other PC. These images can also be stored permanently in any fashion for further evaluation. Once the pictures are printed, a planimeter may be used to calculate given ice area. This allows for paying attention to the specifications requirements relating to where to trace (edge of white ice, edge of gray ice, edge of wet ice, see Figure 2.)

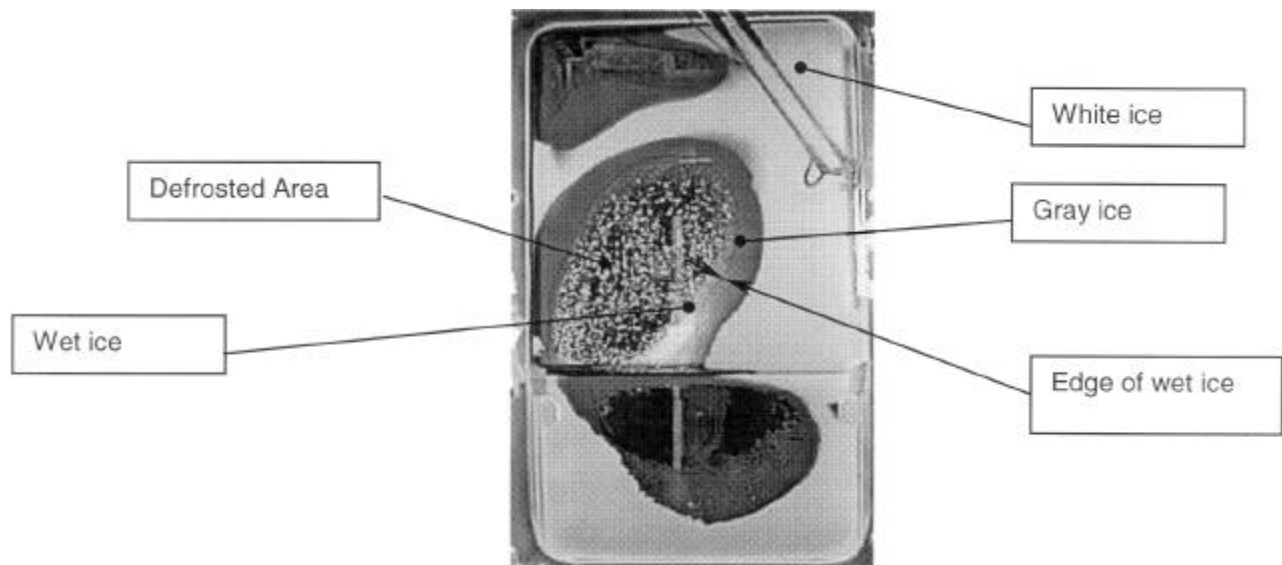


FIGURE 2—DIGITAL PICTURE OF DEFROSTING WINDOW

SAE J381 Revised SEP2000

4.5.11 AREA TO BE DEFROSTED—The windshield area that shall be defrosted is described by the use of Area A and C in Table 1. Each area has been established using the angles of Table 2 applied as shown in Figure 4.

TABLE 1—MINIMUM PERCENT OF WINDSHIELD TO BE DEFROSTED

| | Area A | Area C |
|------------|--------|--------|
| One Piece | 80 | 99 |
| Multipiece | 65 | 84 |

TABLE 2—WIPE AREA VIEWING REQUIREMENT

| Classification | F Dimension Mm | F Dimension in | Area | Center Angle Up, deg | Center Angle Down, deg | Center Angle Left, deg | Center Angle Right, deg |
|---|-------------------|-------------------|------|-------------------------|---------------------------|---------------------------|----------------------------|
| Truck, CBE and CAE ⁽¹⁾ | 0-1020 | 0-40 | A | 10 | 5 | 18 | 56 |
| | | | C | 5 | 1 | 10 | 15 |
| | 1020-1270 | 40-50 | A | 8 | 7 | 18 | 56 |
| | | | C | 3 | 3 | 10 | 15 |
| | | | A | 6 | 9 | 18 | 56 |
| 1270-Up | 50-Up | C | 1 | 5 | 10 | 15 | |
| | | A | 6 | 9 | 18 | 56 | |
| Buses, CBE School and Commercial ⁽²⁾ | 1270-1520 | 50-60 | A | 7.5 | 22 | 22 | 62 |
| | | | C | 1 | 16 | 22 | 15 |
| Buses, Forward Control School and Commercial | 1270-1520 | 50-60 | A | 7 | 14 | 18 | 65 |
| | | | C | 1 | 11 | 18 | 25 |
| Forward Control or Multipurpose | All | All | A | 9 | 7 | 18 | 56 |
| | | | C | 2 | 2 | 18 | 15 |
| Light-Duty Utility Vehicle (1) | All | All | A | 7 | 5 | 16 | 49 |
| | | | C | 4 | 2 | 8 | 13 |
| Van, Multistop(1) | Open | Open | A | 7 | 12 | 18 | 58 |
| | | | C | 1 | 6 | 10 | 15 |
| Trucks, COE | 1020-Up | 40-Up | A | 6 | 9 | 18 | 56 |
| | | | C | 1 | 5 | 10 | 15 |

1. Specifications also cover passenger carrying derivatives
2. Geometric center of eyellipse located 457 mm (18 in) from centerline of vehicle.

- a. Side View—The upper and lower boundary of the area is established by the intersection of two planes, which are seen as lines in the side view tangent to the upper and lower edges of the eyellipse, with the windshield glazing surface. The planes are fixed by angles above and below the XX line.
- b. Plan View—The left and right boundary of the area is established by the intersection of two vertical planes tangent to the left and right edges of the eyellipse with the windshield glazing surface. The planes are fixed by angles to the left and right of the XX line.
 The areas used in determining the percentage of defrosted area are those areas on the exterior glazing surface which are not within 25 mm (1 in) of the edge of the daylight opening (pillars, division bar, header, etc.) The percentage is the ratio of defrosted area within the defined area to the defined area.

SAE J381 Revised SEP2000

The left- and right-hand side window area that shall be defrosted is defined as 70% of that glass surface forward of line Y-Y. The defined 70% area must permit full visibility of the minimum size rear vision device specified by FMVSS 111.

Figure 5 illustrates all of the areas on a typical windshield.

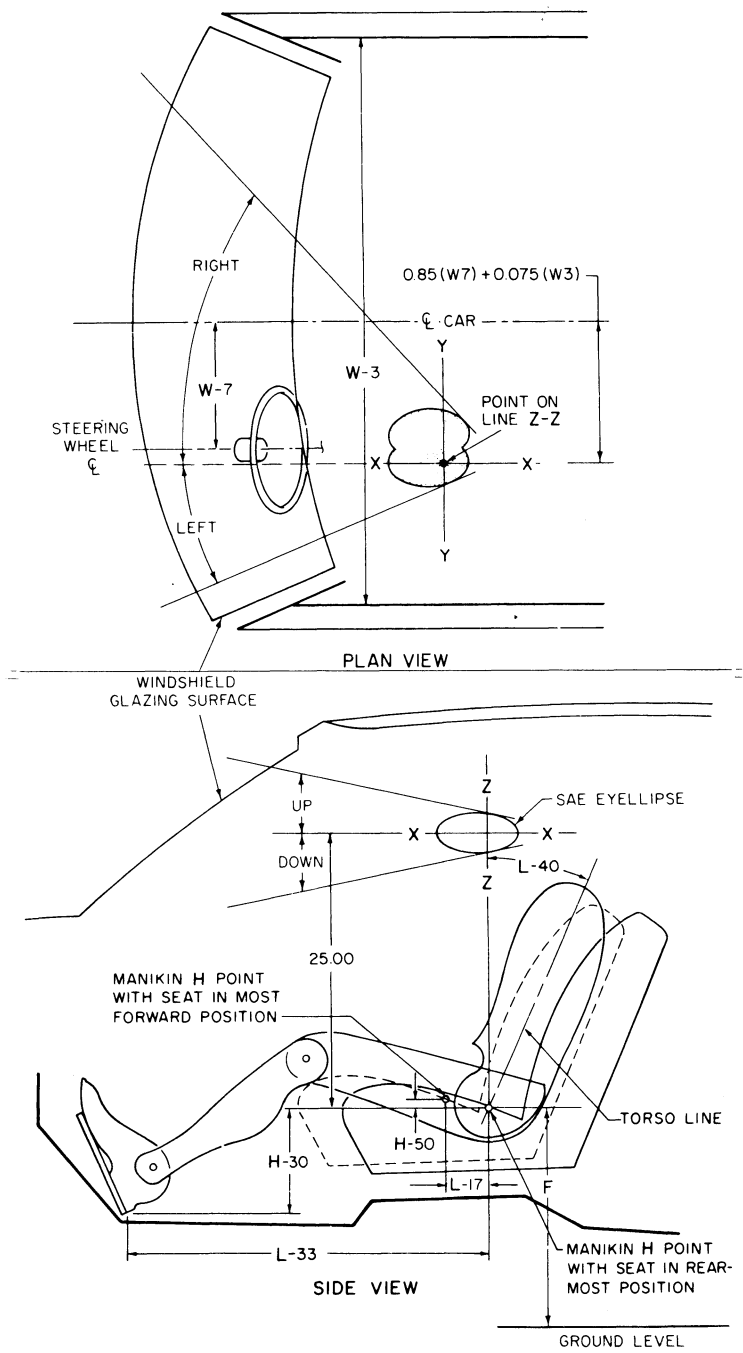


FIGURE 4—EYELLIPSE TEMPLATE LOCATION

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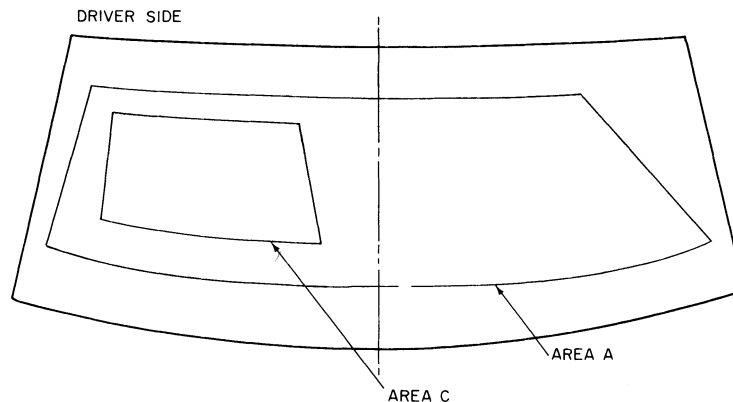


FIGURE 5—TYPICAL LOCATIONS OF AREAS A AND C AS VIEWED FROM INSIDE VEHICLE

4.5.12 After completion of the 30 min test initiated per 4.5.5 and recorded the defrosted data per 4.5.8, the defroster areas must meet the minimum requirements shown in Table 1.

4.6 Methods Comparison

4.6.1 TRACING METHOD DISADVANTAGES

- The time consuming task of warming up a room to allow for the removal of the trace itself.
- The associated time getting the traces into a usable format, as well as issues relating to iteration testing. This becomes significant when attempting to get two or three potential concepts tests as quickly as possible.
- Manual tracing of cleared areas are time consuming and difficult at best.

4.6.2 DIGITAL PHOTOGRAPHIC METHOD—The benefits of the digital photographic method can be classified into visible and non-visible advantages.

The visible advantages are:

- Digital photographic method allows for understanding of performance from any person, regardless of knowledge of the test procedure. This is due to the clear, visible picture of what is defrosted and what is not.
- Results are simply and quickly calculable, within minutes of the conclusion of the test, as the area cleared is a simple calculation. This allows for determination of effectiveness of the tested parameter immediately.
- Results are comparable to every-and-any test run in the same manner, as the camera tripod never moves, and there is no variable relating to the occupant of the cab and any interference they may have caused. This test procedure can be run with a single lab technician.
- The procedure removes the human element from the tracing portion the test, thus reducing error due to bias, interpretation, or heat source given off by different sized technicians.

The non-visible advantages are:

- Due to the soak time required to run multiple tests in a short time frame, the digital images can be down loaded and areas computed with a planometer using the guidelines established for that test (edge of white ice, edge of gray ice, edge of wet ice, Figure 2) before any subsequent test would be ready to run. This allows the next test to be run with results from the previous test already printed and ready to use as a guideline for performance on the next test. The digital photographic method gives repeatable results every time of testing.

SAE J381 Revised SEP2000

- b. The same cannot be said about the tracing method. Since most testing facilities do not have an image reducer, let alone an image reducer that can handle paper 36 in wide by 96 in long, these traces must be sent to an outside reduction lab. This process can take several hours, if not days. The reduction is usually still larger than desired, and needs further manipulation to allow it to be utilized in a report, where as with a single print, the digital method is ready for analysis, or inclusion in a report.

4.7 Digital Photographic Method Hardware Observations and Recommendations

- 4.7.1 Care must be taken when evaluating the type of digital photographic equipment to be used. Some cameras do not lend themselves to function well in the cold temperatures observed during a normal defrost test. In addition, cameras that do not have AC adapter capabilities make for a poor choice, as the sheer number of pictures taken will drain even the best batteries in a short period.
- 4.7.2 Programmable auto shut off, each camera may be off for a long period. If each picture sequence time exceeds the highest auto shut off value, the camera will shut down, and not be ready to take a picture when needed.
- 4.7.3 Cameras that store the image on an insertable 3.5 in disk are also poor choices, as the disk is subject to moisture and cold temperatures, and may malfunction. Most cameras have the ability to be remote operated, but attempting to network a multiple camera set up is difficult at best with current technology.
- 4.7.4 It is better to create a mechanical means to trigger the shutter at the desired times. A simple electronic timer operating a mechanical solenoid used to trigger the camera shutter button is the most cost effective, reliable way to interface with the camera(s).

5. Notes

- 5.1 **Marginal Indicia**—The change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE TRUCK AND BUS DEFROST, DEFOG, AND
WINDSHIELD WIPER SUBCOMMITTEE OF THE
SAE TRUCK AND BUS CAB AND OCCUPANT ENVIRONMENT COMMITTEE

SAE J381 Revised SEP2000

Rationale—Not applicable.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—This SAE Recommended Practice establishes uniform test procedures and performance requirements for the defrosting system of enclosed cab trucks, buses, and multipurpose vehicles. It is limited to a test that can be conducted on uniform test equipment in commercially available laboratory facilities. Current engineering practice prescribes that for laboratory evaluation of defroster systems, an ice coating of known thickness be applied to the windshield and left- and right-hand side windows to provide more uniform and repeatable test results, even though under actual conditions such a coating would necessarily be scraped off before driving. The test condition, therefore, represents a more severe condition than the actual condition, where the defroster system must merely be capable of maintaining a cleared viewing area.

Because of the special nature of the operation of most of these vehicles (where vehicles are generally warmed up before or garaged in preparation for road operations) and since defrosting under steady-state, over-the-road operations is the main concern, test conditions have been adopted which eliminate the engine warm-up phase of vehicle operation.

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SAE J941—Motor Vehicle Drivers Eye Locations

Developed by the SAE Truck and Bus Defrost, Defog, and Windshield Wiper Subcommittee

Sponsored by the SAE Truck and Bus Cab and Occupant Environment Committee