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400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J638

REAF. NOV1998

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Superseding J638 APR93

Submitted for recognition as an American National Standard

Motor Vehicle Heater Test Procedure

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***Foreword*—**This reaffirmed document has been changed only to reflect the new SAE Technical Standards Board format. Definitions has been changed to Section 3. All other section numbers have changed accordingly.

***1. Scope*—**This SAE Recommended Practice, limited to liquid coolant systems, establishes uniform vehicle heater test procedures. Both laboratory and complete vehicle tests are specified in this document. Required test equipment, facilities, and definitions are included.

NOTE— Defrosting and defogging procedures and requirements can be found in SAE J902, J381, J382, and J953.

2. References

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

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

SAE J381—Windshield Defrosting Systems Test Procedure—Trucks, Buses, and Multipurpose Vehicles
SAE J382—Windshield Defrosting Systems Performance Guidelines—Trucks, Buses, and Multipurpose Vehicles
SAE J902—Passenger Car Windshield Defrosting Systems
SAE J953—Passenger Car Backlight Defogging System

3. Definitions

3.1 Heater System—Means will exist for providing heating and windshield defrosting or defogging capability in a vehicle. The system shall consist of an integral assembly having a core assembly or assemblies, blower or blowers, and necessary duct systems and controls to provide heating, defrosting, and defogging functions. If vehicle body structure makes up some portion of the duct system, this structure or simulation of this structure must be included as part of the system.

3.2 Heater Core Assembly—The core assembly shall consist of a liquid-to-air heat transfer surface, liquid distributing header tanks, and liquid inlet and discharge tubes or pipes.

3.3 Heater-Defroster Blower—An air-moving device compatible with the energies available on the vehicle.

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3.4 **Coolant—**A 50:50 solution of ethylene glycol and water used to transfer heat from one point to another.

3.5 **Heater-Defroster Duct System—**Passages that conduct inlet and discharge air throughout the heater system. The discharge outlet louvers shall be included as part of the duct system.

3.6 **Heater System Test Buck—**Heater system installed on those body structures necessary to provide for the system as defined in 3.1.

3.7 **Heater Test Vehicle—**The completed vehicle as designed by the manufacturer, including the defined heater system.

3.8 **Body Leakage—**The static air flow leakage rate of the test vehicle at both +250 and –250 Pa.

4. Equipment

4.1 **Cold Room—**A facility capable of maintaining a temperature of –18 °C ± 2.5 °C and of sufficient size to contain the test set-up.

4.2 **Air Measuring Device—**A device capable of supplying and measuring total heater system air flow of a range of 32 to 240 L/s. On some commercial type vehicles, a greater range may be required. See Figure 1.

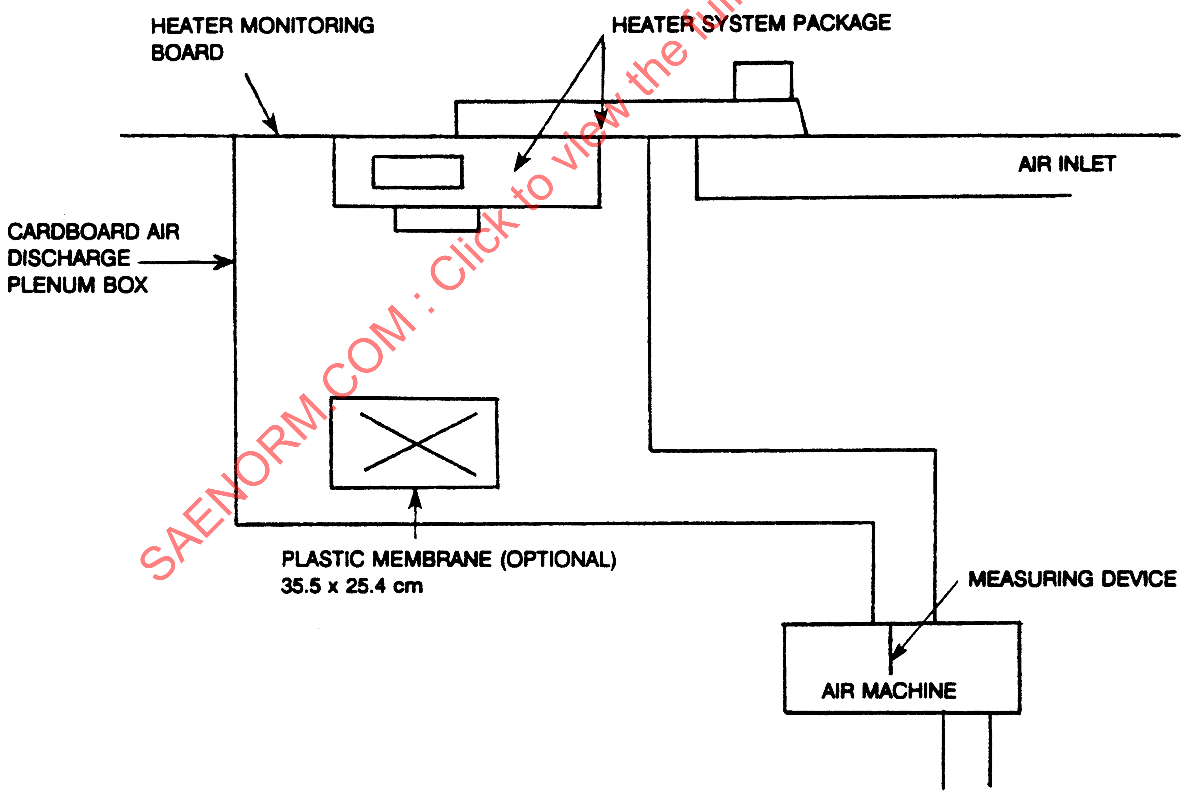

FIGURE 1—BENCH TEST SET-UP

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4.3 Coolant Supply—A closed loop system of 50:50 (by volume) solution of glycol-water at 82 °C temperature and 9 kg per minute flow.

4.4 Power Equipment Supply—A source capable of providing the required test voltage and current for the heater system.

5. Instrumentation

5.1 Air Temperature

5.1.1 DISCHARGE—Recommended air temperature measuring instrumentation is a grid of thermocouples at the appropriate outlets to obtain an accurate average temperature. Thermometers are not recommended because of their slow response to rapid temperature changes. The number of thermocouples depends on the ability to obtain an average temperature even though stratification may be present in the flow.

5.1.2 INTERIOR—In all outboard seating positions, thermocouples should be placed at appropriate locations to measure ankle, knee, and breath level temperatures with the seat in the rearmost and lowest position.

1. Ankle Level—Place on the floor at each outboard seating position, a thermocouple grid (minimum of 4 couples located in the corners of a 25 x 25 cm square area). The couples shall be located 7.5 cm ± 1.3 cm above the floor surface. The grid being located in the geometric center of each floor position.
2. Knee Level—Place a minimum of one thermocouple at seat height 10 cm ± 2.5 cm in front of the center of each outboard seating position. This measurement shall be from the extreme front edge of the seat and parallel to the floor.
3. Breath Level—Place a minimum of one thermocouple above each outboard seating position located approximately at breath level. Location as defined in Figure 2.
4. Whenever thermocouples are installed in a grid it is recommended that they be electrically averaged.

5.2 Coolant Temperature—The temperature of the coolant entering and leaving the unit shall be measured as close to the core assembly as possible with an immersion thermocouple device which can be read within ±0.3 °C.

5.3 Air Flow—Optional methods for determining air flow for BTU (J) rating of heater system.

5.3.1 BENCH TEST—Fabricate a plenum around the heater system discharge nozzle (including defroster nozzles). The air inlet should be representative of the design intent to simulate air flow restriction and should not be affected by the heater discharge plenum. The plenum must include an air pressure indicator (pitot tubes or other accepted device[1]) which is readable to 1.0 Pa. The plenum shall be of sufficient size that the inside surfaces shall be a minimum of 15 cm from the air discharge outlets in the direction of flow. This is to insure that there is no effect on air flow due to the proximity of plenum. See Figure 1.

5.3.2 VEHICLE TEST—For complete vehicle testing, the body can be used for the heater discharge plenum, however, the body leakage must not exceed 165 L/s at 250 Pa with all doors, windows, and design exhaust outlets closed. If the manufacturer's specified requirement is greater than 165 L/s at 250 Pa, the body should be sealed to achieve the 165 L/s leakage rate. The body must include a pressure indicator (pitot tube or other devices) which is sensitive to pressure differences of 1.0 Pa. A cardboard panel in place of glass in window opening with an air hose to the air measuring device and/or some optional air pressure indicator[1] may be used.

1. A plastic film membrane of 36 x 26 cm minimum taped to hole in plenum, not taut, to allow for visible response to establish interior pressure. When the membrane is in a neutral position, pressure is essentially zero.

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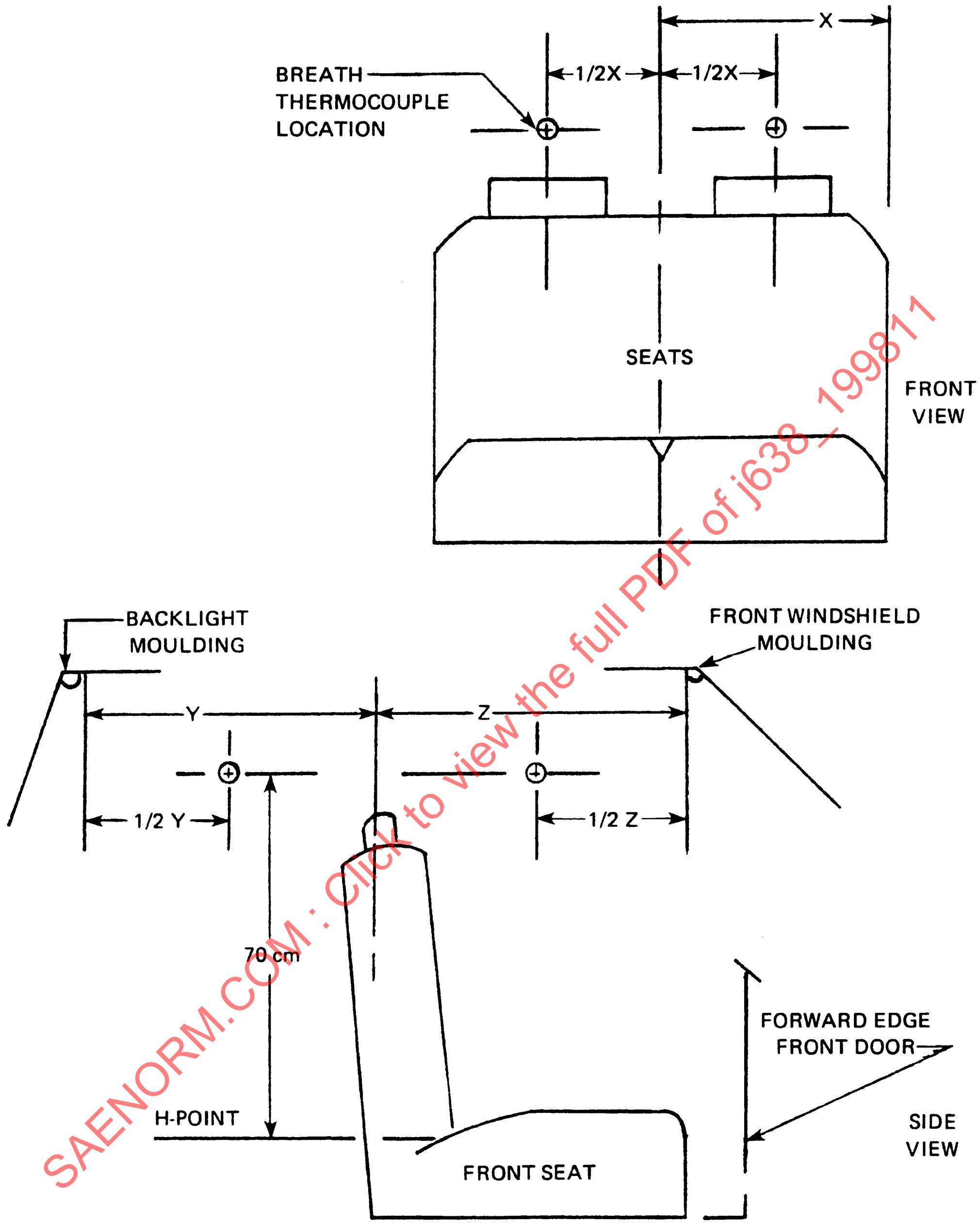

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Note 1: If rear window design allows direct overhead sunload to impinge on thermocouples, tilt couples forward as necessary to avoid direct impingement.

Note 2: Front seat to be in rearmost position (manual and power actuation); power actuated seats to be in no tilt full-down position.

Note 3: If front seat has back rest tilt feature, place in the full upright position.

FIGURE 2—BREATH LEVEL THERMOCOUPLE PLACEMENT

5.4 Coolant Flow—The quantity of coolant flowing shall be measured by means of a calibrated flow meter or a weighing tank to an accuracy of at least 2%.

5.5 Coolant Pressure—If the heater core assembly has a water valve as an integral part, it shall be included as a part of the core and set at its maximum flow rate. The coolant pressure drop across the heat exchanger and valve assembly shall be measured by means of suitable pressure connections as close as possible to the inlet and discharge pipes with a differential manometer that can be read within 300 Pa.

5.6 Additional Instrumentation—Additional instrumentation required for heater unit tests is a voltmeter and a shunt type ammeter to read the voltage and current at the heater motor. A means of measuring blower motor rpm is optional.

6. Test Procedures

6.1 Bench Test—Using the previously described equipment and instrumentation, install test heater system (see Figure 1). All capacity ratings are to be based on a calculated 100 °C temperature differential between inlet air and inlet coolant at a coolant flow rate of 9 kg per min. Other flow rates can be optionally recorded for comparison if desired. Test voltage should be the difference produced by the entire circuit loss between the appliance and the battery. (Reference 7.1) Maintain the air discharge plenum at zero pressure (neutral plastic membrane position) by suitable adjustment of the air machine. Take the following readings:

a. Dry bulb temperature (entering the nozzle)
b. Barometric pressure for density of test air
c. Discharge coolant temperature
d. Inlet coolant temperature
e. Coolant flow rate
f. Coolant pressure drop through heater core assembly
g. Inlet air temperature (average)
h. Discharge air temperature (average)
i. Air temperature at nozzle (average)
j. Chamber static pressure
k. Static pressure drop across nozzle
l. Current consumption in amperes at test voltage

The heat balance (air versus coolant) must be within 5% to be considered a satisfactory test.

6.2 Body Leakage Test—Measure static air flow leakage rate of the test vehicle to determine that the rate is within the manufacturer's design specification. Pressurize or evacuate the test vehicle up to 250 Pa through a window opening with an appropriate air-moving device with a capability of 45 to 240 L/s air flow.

6.3 Complete Vehicle Test in a Test Facility—Install instrumented vehicle in test facility equipped with a dynamometer to obtain a 48 km/h road load. (See SAE J902 for road load calculations). The test facility, including side walls and floors shall be stabilized at –18 °C ± 2.5 °C prior to installation of vehicle. Instrumentation is required to obtain the following readings:

a. Barometric pressure
b. Dry bulb temperature at heater air inlet
c. Inlet coolant temperature at heater core
d. Discharge coolant temperature at heater core
e. Dry bulb temperature at heater air discharge (average)
f. Voltage and current at blower motor
g. Thermocouple grid readouts
h. Vehicle coolant temperature at the thermostat housing
i. Engine rpm

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j. Elapsed time (stop watch)
k. Dynamometer load and speed

Soak vehicle with doors open and heater controls off for the necessary length of time to stabilize engine oil and coolant at –18 °C ± 2.5 °C. Record stabilized temperatures. Start the engine and set throttle device mechanism for 48 km/h road load in high gear (or manufacturer's recommended gear) and record time when the thermostat temperature reaches 38 °C. At this time, set heater controls and blower speed at maximum setting in heater mode, close all doors. At 5 min intervals record all instrumentation readings until interior vehicle air temperature stabilization occurs or a maximum of 1 h.

It must be noted that a means of circulating air at a maximum wind speed of 8 km/h directed into the windshield in the cold room is required to maintain the environmental temperature. In those rooms that do not have built in circulation, a portable fan may be used to provide a maximum of 8 km/h velocity into the windshield.

7. Basis of Rating

7.1 Heating BTU (J) Rating Buck or Bench—All capacity ratings are to be based on an 100 °C temperature differential between inlet air and inlet coolant at a coolant flow rate of 9 kg per minute.

The electrical system should be operated at the manufacturer's recommended nominal voltage as measured at the battery. The appliance tested should be with the normal vehicle wiring. If the test appliance is operated with an external voltage source, the test voltage should be the difference produced by the entire circuit loss between the appliance and the battery. The ratings shall include:

7.1.1 Heat transfer in BTU (J) per hour.

7.1.2 Air flow in L/s standard air.[2]

7.1.3 Air static pressure drop across unit in Pa.[2]

7.1.4 Coolant static pressure drop across unit in Pa.

7.1.5 Motor current.

7.2 In-Vehicle—Using the data according to 6.3, the manufacturer can determine relative merits of various heater designs. A final jury-road evaluation is recommended before finalizing design.

8. Computations

8.1 Body Leakage—Plot leakage rates as specified previously on log-log paper. (Plot leakage rate, L/s, on x-axis; pressure drop, Pa, on y-axis straight line drawn through two points results in body leakage for any pressure drop.)

8.2 Chart and Computations—Metric Units—See Figure 3.

2. 0 Pa static pressure shall be maintained at inlet and outlet of both outside air and recirculating air.

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Description of Unit ____________________

Purpose of Test ____________________

Nozzle Coefficient ____________________

Date __________ Location ____________________ Observers ____________________

Readings/Computations	Test Time (Minutes)												
	0	5	10	15	20	25	30	35	40	45	50	55	60
1. Flow-Coolant—kg/min													
2. ΔP_w thru core—Pa													
3. T_{in}—°C													
4. T_{out}—°C													
5. Heat Transfer—J/h													
AIR: 6. T dry bulb—°C													
7. Corrected Barometer—Pa													
8. Density—Inlet Air—kg/m^3													
9. Density—Chamber Air—kg/m^3													
10. T_n (Nozzle)—°C													
11. ΔP_n—At nozzle—Pa													
12. Air Flow (actual) Outlet—$m^3/s \times 10^3$ = L/s													
13. Air Flow (actual) Outlet—kg/h													
14. Air Flow (standard)—$m^3/s \times 10^3$ = L/s													
15. T_{in} (average) of Core—°C													
16. T_{out} (average) of Core—°C													
17. Heat Gained (actual)—J/h													
18. Heat Dissipation J/h/100 °C Δ T													
19. ΔP_a—across core—Pa													
ADD: 20. Fan—volts													
21. Fan—amps													
22. Fan—rpm													

NOTE 1: All pressure measurements in Pascals, accurate to within 1.0 Pa (0.005 in H_2O).
NOTE 2: All temperature measurements accurate to within 0.25 °C (0.5 °F) for air and coolant.
NOTE 3: 1 Pa = 10 dyne/cm^2.

Figure 3—CHART—METRIC UNITS

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8.2.1 COOLANT

a. Flow of Coolant (W_W)—kg/min—measured to within 2%.
b. Pressure Drop Through Unit (ΔP_W)—Pa—measured.
c. Temperature of Coolant Into Unit (T_{in})—°C—measured.
d. Temperature of Coolant Out of Unit (T_{out})—°C measured.
e. Heat Removed From Coolant (Q_W)—J/h—calculated.

$$Q_w = C_p W_w (T_{in} - T_{out}) \times 60 \quad \text{(Eq. 1)}$$

$$C_p = \text{Specific heat of coolant} \left(\text{approx.} \frac{3538\ J}{kg/c}\right) \quad \text{(Eq. 2)}$$

W_w = No. 1
T_{in} = No. 3
T_{out} = No. 4

8.2.2 AIR

a. Temperature of Air (Dry Bulb) – (T_{db}) – °C – measured.
b. Corrected Barometer (P_b) – Pa – measured.
c. Density of Inlet Air (D_a) – kg/m^3 – calculated.

$$D_a = \frac{P_b}{287.4\ T_a} \quad \text{(Eq. 3)}$$

P_b = No. 7

$T_a = 273.2 + T_{db}$

d. Density of Nozzle Air (D_n) – kg/m^3 – calculated.

$$D_n = D_a \times \frac{T_a}{T_{n_c}} \quad \text{(Eq. 4)}$$

$T_{n_c} = T_n + 273.2$

D_a = No. 8

e. Temperature of Air at Nozzle (T_n) – °C – measured.
f. Static Pressure Drop Across Nozzle (ΔP_n) – Pa – measured.
g. Actual Air Flow (V_{act}) – m^3/s – measured by means of a calibrated nozzle.
h. Actual Air Flow (W_a) – kg/h – calculated.

$$W_a = V_{act} D_n (3600) \quad \text{(Eq. 5)}$$

V_{act} = No. 12
D_n = No. 9

i. Air Flow Corrected to Standard Air Conditions (V_{std}) – m^3/s.

$$V_{std} = V_{act} \frac{D_n}{1.20} \quad \text{(Eq. 6)}$$

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j. Average Temperature of Air Into Unit (T_{in}) – °C – measured.
k. Average Temperature of Air Out of Unit (T_{out}) – °C – measured.
l. Actual Heat Gained by Air (Q_{act}) – J/h – calculated.

$$Q_{act} = W_a C_p (T_{out} - T_{in}) \quad \text{(Eq. 7)}$$

C_p = specific heat of air

m. Heat Dissipation – J/h/100 °CΔT

$$\text{Heat Dissipation} = \frac{Q_{act} \times 100}{\Delta T} \quad \text{(Eq. 8)}$$

ΔT = Temperature difference between inlet air and inlet coolant – °C (Item 8.2.1e minus Item 8.2.2j.)

n. Pressure Drop Across Unit (ΔP_a) – Pa – measured.
o. Fan – volts – measured.
p. Fan – amps – measured.
q. Fan speed – rpm – measured.

8.3 Chart and Computations – English Units—See Figure 4.

8.3.1 COOLANT

a. Flow of coolant (W_W) – lb/min – measured to within 2%.
b. Pressure Drop Through Unit (ΔP_W) – in Hg – measured.
c. Temperature of Coolant Into Unit (T_{in}) – °F – measured.
d. Temperature of Coolant Out of Unit (T_{out}) – °F – measured.
e. Heat Removed From Coolant (Q_W) – Btu/h – calculated.

$$Q_w = C_p W_w (T_{in} - T_{out}) \times 60 \quad \text{(Eq. 9)}$$

C_p = Specific heat of coolant
W_w = No. 1
T_{in} = No. 3
T_{out} = No. 4

8.3.2 AIR

a. Temperature of Air (Dry Bulb) – (T_{db}) – °F – measured.
b. Corrected Barometer (P_b) – in Hg – measured.
c. Density of Inlet Air (D_a) – lb/ft^3 – calculated.

$$D_a = \frac{P_b}{0.754\ T_a} \quad \text{(Eq. 10)}$$

P_b = No. 7

$T_a = 459.6 + T_{db}$

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