



Air Conditioning Evaporator Core Condensate Freeze Test Procedure

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. Determine if the control of the compressor (clutch control, variable displacement mechanism, or compressor speed) adequately protects the system from condensate freeze. An evaporator core freeze result in reduced compressor oil circulation and can result in compressor damage. Customer comfort will be reduced when airflow is reduced by icing. A secondary purpose of this test is to demonstrate refrigerant superheat control under prescribed of conditions. This procedure has the required instrumentation and test sequence for a subcool and superheat analysis without additional testing.

Note: The refrigerant charge variation included in this test is not sufficient to evaluate condensate freeze below Operational refrigerant charge. (i.e., GMW15775 is not a low refrigerant charge evaluation test).

Note: A change in the refrigerant used in a vehicle HVAC system has a significant impact on system performance and will require revalidation of evaporator freeze testing. A change to the Thermal Expansion Valve can impact condensate freeze performance and require an audit of the identified worst case conditions.

1.2 Applicability. This test procedure is for use on a full vehicle in a climate wind tunnel.

1.3 Remarks. This test procedure is to collect data during Heating Ventilation and Air Conditioning (HVAC) system validation.

1.3.1 GMW15775 is a vehicle-level test to perform final system verification of evaporator condensate freeze with production intent designs, controller, software and calibrations under a set of vehicle operating conditions. Steady state velocity conditions do not exercise Proportional, Integral and Differential (PID) compressor control logic used in variable displacement (pneumatic, electrically controlled, and electrically driven variable) Compressor Control systems. The GMW17775 vehicle speed profile or alternately the protocol from 4.3.2.3.4 assess the risk of dynamic evaporator local icing.

1.3.2 GMW16571 shall be used as a test technique to determine the optimal location of the refrigerant control sensors (Evaporator Air or Fin Temperatures, refrigerant temperature probes or refrigerant pressure transducers).

1.3.3 GMW16571 shall be used to develop initial calibrations with a proposed sensor placement and production intent control design that will provide robust protection from evaporator condensate.

Note: Engineering consideration should be applied where the production intent control points vary with ambient temperature. The matrix included in this procedure does not comprehend the impact of variable control points in terms of the effective evaporator loading and in regards to determining worst case frosting conditions. Using a fixed control point regarding ambient change during system frost control development may enable a more robust frost control data collection for the initial evaluation of the 12 test points.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW7022

GMW16571

GMW17775

GMW15845

GMW17738

2.3 Additional References.

CG2311 Climate Comfort Data Sheet and Appendix Tables (ID)

(ID) = This document is limited to internal use within General Motors and shall not be accessed outside this company. Contact the GM Lead Engineer for further instructions.

3 Resources

3.1 Facilities. Test to be run at a Climatic Tunnel capable of simulating defined conditions.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.3 Air temperature (8 to +40) °C. **Humidity control** (5 to 95)% Relative Humidity (RH). Note humidity control at the condenser is not required.

3.2 Equipment. The following minimum instrumentation shall be used per procedure GMW15845 (Test Vehicle Instrumentation Procedure).

3.2.1 Pressure Measurement.

3.2.1.1 Front Before Expansion Device (BXD) Refrigerant Pressure. Choose one of the three options.

3.2.1.1.1 Option 1. Direct mount of a production vehicle Air Conditioner (AC) pressure at the location defined in GMW15845. This method reduces the possible error caused by the remote high side transducer line refrigerant storage mass in instrumentation tubing. Direct mounting removes the need to correct test vehicle refrigerant charge values.

3.2.1.1.2 Option 2. Remote under hood transducer with common 1 m long instrumentation tubing (per GMW15845) for the front BXD and other desired component location. This method does not require the user to correct refrigerant charge mass for each 1 m high side tube employed provided the high side includes no more than the Compressor outlet and BXD measurements.

3.2.1.1.3 Option 3. Remote mount an instrumentation grade transducer for high side measurement. Usage of option three presents a need to correct the test vehicle refrigerant charge to account for the refrigerant stored in the high side instrumentation hose.

3.2.1.2 Evaporator outlet refrigerant pressure.

3.2.1.3 Compressor inlet refrigerant pressure.

3.2.1.4 Compressor outlet refrigerant pressure. Choose a method from 3.2.1.1 or capture the production vehicle AC High Side Transducer.

3.2.1.5 Rear Before Expansion Device Pressure (if equipped). Choose a method from 3.2.1.1.

3.2.1.6 Compressor crankcase refrigerant pressure (if applicable for variable displacement compressor).

3.2.1.7 Before evaporator core air static pressure (internal to HVAC module).

3.2.1.8 Cabin interior body air static pressure.

3.2.2 Thermocouples.

3.2.2.1 Evaporator outlet refrigerant temperature (at or within 10 mm of pressure measurement).

3.2.2.2 Evaporator inlet refrigerant temperature.

3.2.2.3 BXD Refrigerant Temperature (at or within 10 mm of pressure measurement).

3.2.2.4 Compressor inlet refrigerant temperature (at or within 10 mm of pressure measurement).

3.2.2.5 Compressor outlet refrigerant temperature (at or within 10 mm of pressure measurement).

3.2.2.6 Thermocouple near (within 5 mm of thermistor element of) **Evaporator Air Temperature (EAT) sensor** (if applicable) or **tube Thermocouple near** (within 5 mm of thermistor element in contact with fins of) **evaporator fin temperature sensor** (if applicable).

3.2.2.7 A thermocouple grid at evaporator air exit as described in GMW15845. Optionally, a similar or subset grid measuring the evaporator metal tube temperature at critical locations may be desired. In all cases, avoid a situation where a thermocouple wire modifies or blocks the flow of air to the evaporator air grid and or the refrigerant capacity control sensor.

Note: Additional metal tube contact temperature grid identifies the differential or “delta” temperature (the temperature difference) in thermocouple pairs increasing during an evaluation point, the higher delta provides a clear identification of local ice formation. This is most useful when local ice is a concern as opposed to traditional “large scale” core icing that reduces system airflow.

3.2.2.8 Three thermocouples distributed across the evaporator lower or bottom metal surface (outboard left, outboard right and central). The purpose is to evaluate icing of condensate draining onto the bottom tank, which has resulted in evaporator damage on the 2017 Chevrolet Impala V6.

3.2.3 Climate Control Commands.

3.2.3.1 Blower voltage and current draw.

3.2.3.2 For cycling compressor systems, compressor clutch voltage.

3.2.3.3 For electrically controlled pneumatic systems (EVDC) Pulse Width Modulated (PWM) duty cycle (%) and control valve current

3.2.3.4 For electrical compressor, compressor speed command (rpm).

Note: 3.2.3.3 and 3.2.3.4 will be recorded from control diagnostics. Optionally, a shunt can be used to record the EVDC compressor control current.

3.2.3.5 If available and/or applicable, record all refrigerant control sensor readings from control diagnostics (e.g., High-side and/or Low-side refrigerant pressure transducer(s), High-side and/or Low-side refrigerant temperature probes, Evaporator Air or Fin Temperature sensors).

3.2.4 Photographic Capture.

3.2.4.1 Condensate freezing local on the evaporator requires graphic documentation. A waterproof lighted USB or Wireless Borescope/Endoscope (suitable for dark environments) shall be engineered to capture local icing that might produce frost balls or other evaporator damaging local ice. Alternately, when usage of a borescope is not practical, a window installed on the HVAC module and suitable camera may be used.

Note: The photographic equipment may be intrusive to evaporator airflow. Where engineering evaluation suggests concern with local airflow blockage, the borescope shall be inserted then removed at each photographic capture. Photographic capture does not follow the 1 Hz data requirement.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Vehicle. Vehicle representative of production intent and equipped as described in GMW15845 – (Test Vehicle Instrumentation Procedure).

3.3.2 Components. Prepare compressor with minimum set control valve or pressure switch/thermal switch and EAT at their maximum tolerance for use in the tests (largest positive error).

3.4 Test Time.

Calendar time: 3 d

Test time: 16 h

Coordination time: 4 h

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Test technician familiar with test facilities and equipment.

4 Procedure

4.1 Preparation.

4.1.1 All applicable instrumentation shall be checked for certification to the International Organization for Standardization (ISO) calibration procedures. Submit this data sheet with other data sheets when the certification data is not otherwise preserved in the test laboratory records.

4.1.2 Prepare vehicle instrumentation as described in GMW15845 (Test Vehicle Instrumentation Procedure).

4.1.3 Climate control temperature setting adjusted to full cold unless evaluating the sensitivity of the temperature door position on the EAT sensor temperature.

4.1.4 Intake door shall be in the production intent fresh air position (Production Outside Air (P/OSA)) unless specifically indicated as recirculation position. (For automatic systems, consider fabrication of a removable lock for intake door in the fresh air position unless this is not representative of a customer selectable intake position.)

Note: This procedure typically applies to the primary evaporator in dual evaporator or evaporator/chiller applications. A chiller application typically uses a glycol heat transfer media and is not subjected to freeze. A secondary evaporator typically has both dryer airflow (operates in a recirculation airflow mode) and a larger refrigerant pressure drop (resulting in a warmer second evaporator refrigerant) resulting in reduced risk for frost formation. Where these typical conditions do not apply, then frost control measures and validation shall be executed.

4.1.5 Air Conditioner (AC) compressor is to operate in all data conditions unless otherwise stated.

4.1.6 The calibration used for compressor control logic shall represent a production variation worst case temperature on the evaporator core.

For example: A production intent calibration cycles the compressor off at +2.5 °C and on at +4.0 °C. The control error from the nominal test vehicle to the worst case variation control components (conditions which meet drawing requirements) is +0.5 °C, where the test vehicle is known to be centered in the variation band. A freeze test using a nominal test vehicle, requires a calibration robust to meeting frost requirements at the calibration of +2.0 °C off and +3.5 °C on. Variation in sensor thermal response (thermal lag) shall also be understood.

4.1.7 Multiple evaporator systems shall be tested with only the primary evaporator transferring heat. Additional evaporators are to be connected to the refrigeration circuit but not transferring heat (water pumps or airflow blowers off). This situation enables the non-operational evaporators or chillers to naturally sequester system refrigerant mass during operation, as this represents a typical customer environment.

4.2 Conditions.

4.2.1 Environmental Conditions. Thermal conditions (Ambient Air Temperature and Relative Humidity) are specified in Table 2 as part of the total test matrix.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 Road Load Coefficients. Test weight shall be set to curb weight plus 1 passenger.

4.2.2.2 Solar Load. Solar lamps shall not be used during this test. Ambient tunnel lighting is permitted.

4.2.3 Refrigerant Charge Conditions. The test conditions of Table 2 shall be tested at:

4.2.3.1 Cycle 1. Critical Charge (Orifice Tube Systems) or Operational Charge (Thermostatic eXpansion Valve (TXV) and Electronic eXpansion Valve (EXV) systems) as defined by GMW7022 (Refrigerant Charge Determination) to represent the refrigerant charge at the end of the vehicle service life.

4.2.3.2 Cycle 2. Production Refrigerant Charge (Operational or Critical Charge plus reserve charge) as defined by GMW7022 (Refrigerant Charge Determination).

4.2.3.3 Gear Step or Drive Positions.

Table 1: Gear Step or Drive Positions

Transmission	Speed			
	50 km/h	80 km/h	Speeds > 80 km/h	Idle
Manual Transmission – 5 speed	4 or 5. ^{Note 1}	5.	5.	Neutral
Manual Transmission – 6 speed.	4 or 5. ^{Note 1}	5 or 6. ^{Note 2}	6.	Neutral
Automatic Transmission.	D (Highest Drive Gear)			

Note 1: Use 5th Gear (exception: use 4th Gear when engine displacement is < 2.3 l and engine speed in 4th gear is < 1900 min⁻¹ (1900 rpm)).

Note 2: Use 6th Gear (exception: use 5th Gear when engine displacement is < 2.3 l and engine speed in 6th gear is < 1800 min⁻¹ (1800 rpm)).