



Discharge (DAT) and Evaporator (EAT) Air Temperature Sensors

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.

Deviations from this specification are permissible only with the express authorization of the responsible BOM Family Owner at GM.

Discrepancies or deviations within this specification or between this specification and country-specific regulations in the customer countries shall be indicated without delay by the supplier; possible solutions shall be discussed directly with the responsible BOM Family Owner at GM.

1.1 Purpose. This standard specifies the DAT (Discharge Air Temperature) Sensor and EAT (Evaporator Air Temperature) Sensor requirements. The functions, performance, design constraints, and validation required for these Sensors are defined in this document.

1.2 Applicability. The DAT Sensor is designed and engineered to provide the CCA (Climate Control Application) within the HVAC-Controller with, depending on variant, information about the air temperature at a point located along the HVAC air path slightly downstream of the HVAC-Module air distribution assembly to a point located along the HVAC air path slightly upstream of a HVAC outlet. Typically these sensors are located specific to the air distribution mode, such that there are vent (panel) mode DAT Sensors (upper duct) and heater (floor) mode DAT Sensors (lower duct) designed to measure the air temperature best for specific air distribution modes chosen by the user or control system.

The EAT Sensor is designed and engineered to provide the CCA within the HVAC or Body Controller with, depending on variant, information about the air temperature at a point location slightly downstream of the evaporator in the HVAC-Module. The EAT Sensor shall not measure fin type temperature.

1.3 Remarks. The Sensors will be available in following variants depending on vehicle and HVAC system specification/requirements:

1.3.1 Sensor Application Type.

1.3.1.1 DAT Sensor. DAT Sensors shall require a unique resistance tolerance specification of the NTC (Negative Temperature Coefficient) thermistor element (see paragraph 3.2.1.1).

1.3.1.2 EAT Sensor. EAT Sensors shall require a unique resistance tolerance specification of the NTC thermistor element (see paragraph 3.2.1.2).

1.3.2 Sensor Probe Type.

1.3.2.1 Point Temperature Probe. This Sensor type shall measure the temperature of air at a single point local to the NTC thermistor element.

- **Bent shaft design:** Sensor end-shaft shall be bent at a 45° angle from the sensor main shaft, which is attached to the Mounting/Connector end form.
- **Straight shaft design:** Sensor end-shaft shall be in alignment with the sensor main shaft, which is attached to the Mounting/Connector end form.

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1.3.2.2 Averaging Temperature Probe. This Sensor type shall measure (integrate) the average temperature of a cross section of airflow to which the probe is exposed. The design shall be cable of measuring a cross-section as small as 4 mm x 15 mm, to cross-sections as large as 7 mm x 50 mm. The accuracy of the air temperature averaging and the dynamic temperature measurement response for this style of sensor is defined in paragraph 3.2.1.5. Two cross sectional variants will be available depending on vehicle and HVAC system specification/requirements:

- **4x20** - a 4 mm x 20 mm measurement area, and
- **4x35** - a 4 mm x 35 mm measurement area.

1.3.3 Sensor Mounting Type.

1.3.3.1 Oriented Mount – Injection Molded Interface. The Sensor mounting end-form shall be designed to be aligned and subsequently "pushed and secured" into a mating "hole" geometry of a uniform thickness injection-molded plastic part of the HVAC-Module or HVAC duct work. The thickness of the injection-molded material can vary between (1.0 to 3.5) mm. The push and secure mounting features of the sensor mount geometry shall provide retention of the sensor per the requirements in paragraph 3.2.1.8.

1.3.3.2 Non-oriented Mount- Injection Molded Interface. Designed consistent to the "Oriented Mount – Injection Molded Interface" described above. The mating hole will be implemented without the alignment tab in these applications.

1.3.4 Sensor Probe Length. Each Sensor probe type shall have customizable probe shaft geometries.

Figure 1 is provided as a general reference for comprehension of the sensor variants referenced above. The supplier of the sensors shall provide the exact geometrical features of the Sensor variants such that the sensors meet all the requirements of this specification.

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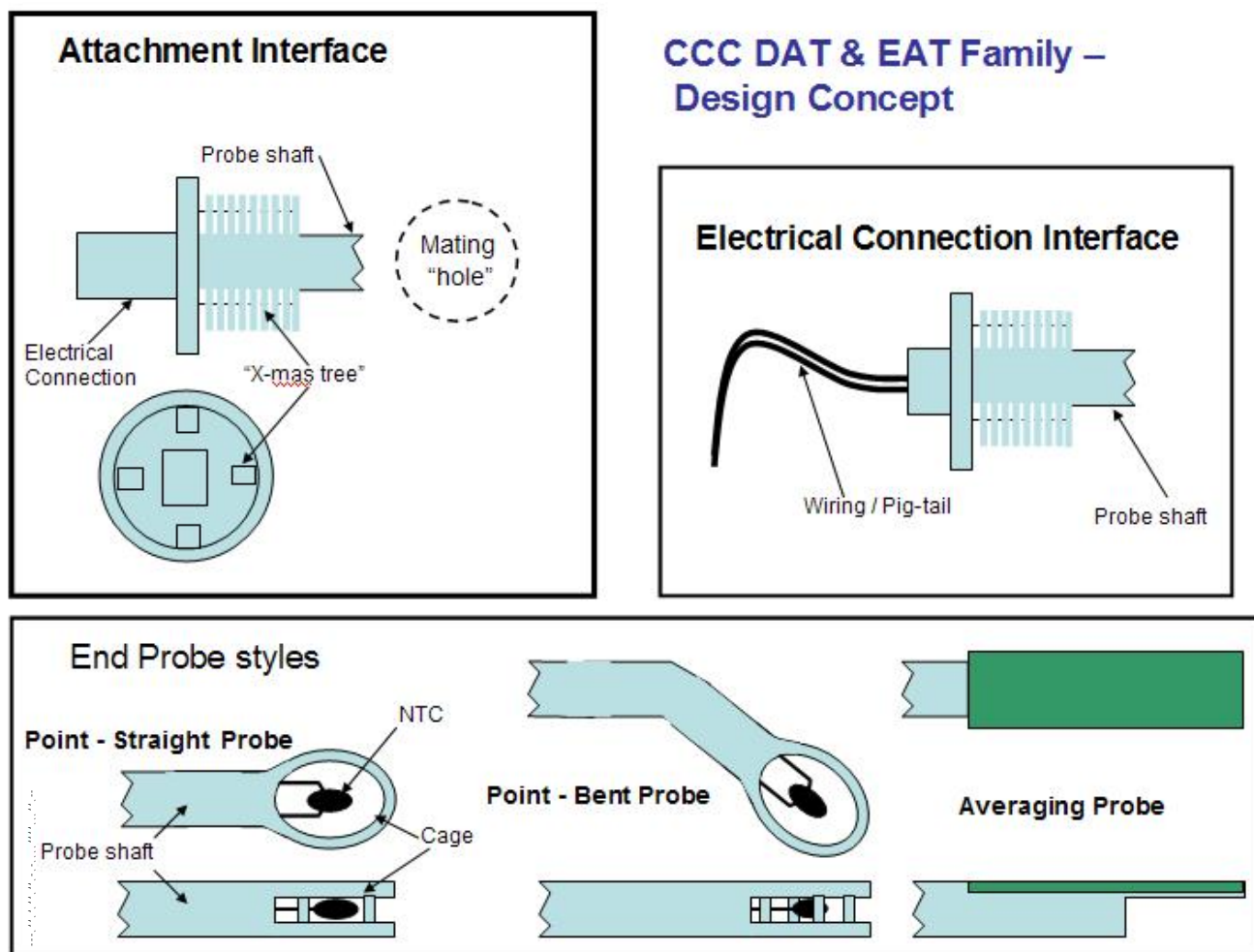
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Figure 1: Sensor Geometry Design Parameters for General Reference



2 References

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

2.1 External Standards/Specifications.

CMVSS 302	ISO 1043-2	ISO 1629	ISO/DIS 18064
FMVSS 302	ISO 11469	ISO 3795	SAE/USCAR-25

2.2 GM Standards/Specifications.

GME14090	GMW15626	GMW16331	GMW3191
GMW14082	GMW15760	GMW3097	GMW3232
GMW14234	GMW15760	GMW3172	GMW3600

2.3 Additional References.

ELEC86-S5148 (Best Practice 323_321 PSDS_K-PAC Set)
 GM1829 - ADV P&R - Analysis/Development/Validation Plan & Report
 GM3660 - Product Validation Complete Letter
 TLE-050046

3 Requirements

3.1 System/Subsystem/Component/Part Definition. GMW14082 and TLE-050046 shall apply.

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3.1.1 Appearance. The mechanical appearance of each Sensor variant shall be determined by the supplier. The math file shall be provided by the supplier to GM and filed under VAS (Vehicle Assembly Structure).

3.1.2 Content.

3.1.2.1 Physical Content. The Sensor assembly shall consist of a plastic sensor housing with an integrated NTC thermistor probe. The NTC thermistor probe and its leads shall be epoxy coated. The Sensor housing shall have a NTC protection 'Cage' that will prevent damage and/or deformation to the NTC element during handling, shipping (as part of a bundled harness) and insertion/assembly to the mating air handling part. This cage shall be designed to allow the sensor to meet paragraph 3.2.1.5 of sensed air temperature as a function of sensor orientation airflow velocity direction.

The Sensor housing shall be electrically connected via a two-wire pigtail which will be supplied with the sensor assembly. The length of the pigtail shall vary per sensor application on its associated HVAC-Module. The length of the pigtail will vary from (250 to 2000) mm. The required length of the pigtail shall be communicated by either the HVAC-Module supplier or the HVAC-Module supplier's wiring harness (Tier I) supplier.

The Sensor housing shall be equipped with either a snap-in/snap-fit geometry or a "X-mas tree"-style deformation geometry at the air-handling mount-end of the Sensor assembly.

3.1.2.2 Functional Content. The Sensor, depending on variant as described in paragraph 1.3 shall provide the following information:

- a) Discharge air temperature via local temperature measurement of the DAT NTC thermistor element, or
- b) Evaporator air temperature via local temperature measurement of the EAT NTC thermistor element

3.1.3 Ambient Environment. All environmental and electrical general requirements are referred to in GMW3172.

The DAT and EAT Sensors will be located in either the HVAC-Module or its attached duct work. These components are packaged under the IP (Instrument Panel) in the passenger compartment. The HVAC-Module is designed to produce and transport moist air at temperatures ranging from (-40 to +85) °C. Air velocities at the sensor range from (0 to 12) m/s. The air moisture content of the air can be anywhere from (0 to 100) % relative humidity. The DAT and EAT Sensors can be exposed to droplets of moisture which result from "spitting" of moisture off of the evaporator core and/or evaporator sump. The air transported in the HVAC-Module can contain dirt, pollutants and chemicals consistent with the air exposure outside and inside of the vehicle.

The Sensor shall pass environmental and durability validation when subjected to loads according to GMW3172 (Test legs for DV and Test legs for PV). Table 1 shows the applicable environmental load code letter for DAT and EAT Sensors.

Table 1: Environmental Load Code Letters

Electrical Load Code Letter	Mechanical Load Code Letter	Operating Temperature Code Letter	Climatic Code Letter	Chemical Load Code Letter	Dust and Water Protection Code Letter
Z	G	C	D	B	IP5K2

Note: Where Z = (0 to 5) V

3.1.4 Interfaces.

3.1.4.1 Mechanical/Mounting. The DAT Sensor shall be mounted downstream of the air distribution mode valving of the HVAC-Module. Exact location will vary depending on DAT application type (e.g. floor mode DAT, panel mode DAT), HVAC-Module design and duct work design.

The EAT Sensor shall be mounted downstream of the Evaporator Face. Exact location will vary depending on HVAC-Module design.

3.1.4.1.1 DAT/EAT Sensor Mounting Hole Design. If equipped (most likely DUCT located), the hole design shall look shown in Figure 2.

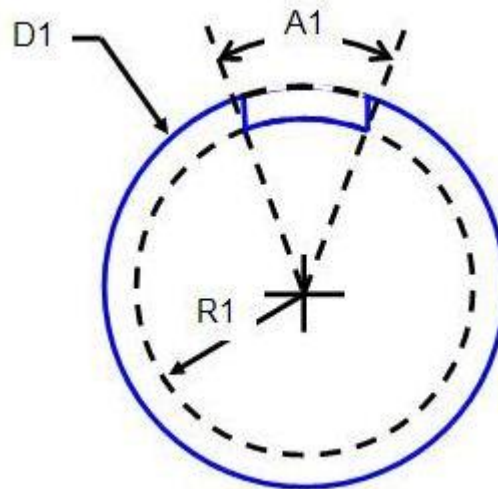
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Figure 2: Mounting Hole Geometry



Note: Drawing not to scale

Table 2 "Parameters for Mounting Hole Geometry" shows the applicable parameter to be used for Figure 2 "Mounting Hole Geometry".

Table 2: Parameters for Mounting Hole Geometry

Design Parameter	Value
A1: Angle to define width of tab	$(30 \pm 0.25)^\circ$
D1: Outer diameter	$(13.0 +0.02/-0.0) \text{ mm}$
R1: Radius for depth of tab into hole	$(4.5 +0.01/-0.0) \text{ mm}$

For HVAC-Module mounted DAT/EAT a snap-in interface is the preferred solution.

3.1.4.2 Electrical Connection. Depending on usage of the DAT/EAT Sensor, different electrical connection variants might be required:

- a) Pig-tail styled sensors are preferred inside the HVAC-Module, if there is an Module wiring harness available
- b) Connector styled sensors are preferred for integration into ducts (e.g. rear duct solutions for 3rd / 4th zone) and preferred for HVAC-Module if no Module wiring harness available or connector will be plugged-in at GM manufacturing plant

3.1.4.2.1 Pig-tail Wiring Harness Style. The Sensor shall be molded with wiring/"pig-tail" coming out of the rear housing of the sensor (in place of a connector). For most applications there will likely be the need for several lengths of wiring required depending on the location of the DAT/EAT Sensor in the HVAC-Module. The wires shall be terminated by stripping the insulation 12 mm. The wire shall have a conductor gauge of 0.35 mm², design (wire setup, insulation, temperature range, etc.) according to GMW15626 and ELEC86-S5148 (Best Practice 323_321 PSDS_K-PAC Set).

Note: For the purpose of quoting the wiring length shall be assumed to be 1200 mm. At award of business a cost-model will be developed for handling varying lengths of wiring. Final length will be approved by GM Engineering.

Table 3 shows the wire numeration and function for pig-tail wiring harness style.

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Table 3: Wire Numeration

Sensor Variant	Wire Number	Function
DAT Sensor	1	NTC analog signal
	2	NTC return
EAT Sensor	1	NTC analog signal
	2	NTC return

3.1.4.2.2 Connector Style. Connector shall be GM approved and USCAR released and needs to fulfill validation requirements of GMW3191 and paragraph 4.2.

The Sensor shall be molded with an integrated 2-pos. detail connector. The supplier shall provide information according to Table 4.

Table 4: Connector Style

Interface	Cavity	Supplier Drawing Number	Supplier P/N	GM P/N
Sensor (female)	1x2	13588641	tbd	13588641
Vehicle harness (male)	1x2	13588640	tbd	13588640

Table 5 shows the terminal numeration and function for connector style.

Table 5: Connector Terminal Numeration

Sensor variant	Connector Terminal Pin Number	Function
DAT Sensor	1	NTC analog signal
	2	NTC return
EAT Sensor	1	NTC analog signal
	2	NTC return

3.1.4.3 Component to Subsystem. The DAT and EAT Sensors are mechanically attached to the HVAC-Module and associated ductwork and electrically directly connected to an ECU (Electronic Control Unit) (e.g. ECC, CCP, HVAC-Silverbox, BCM, HIOE) according to Figure 3.

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Figure 3: Electrical Circuit

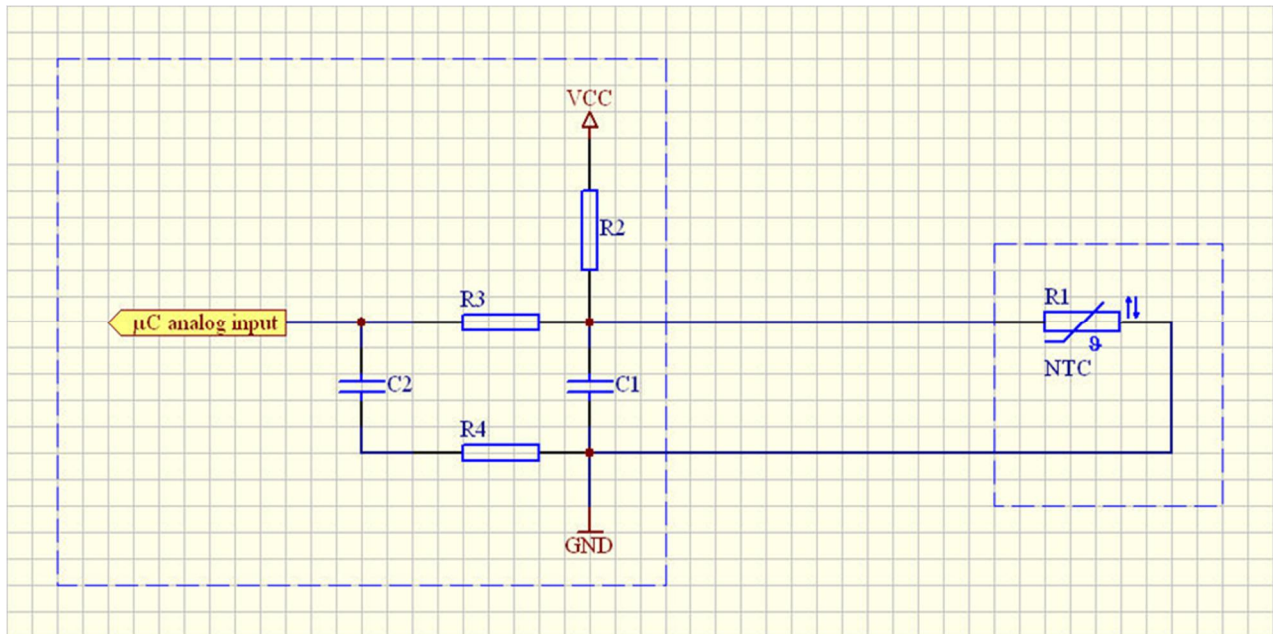


Table 6 shows the applicable parameter to be used for Figure 3.

Table 6: BOM (Bill of Material) of Electrical Circuit

Component / Label	Description
R1	NTC (DAT/EAT Sensor)
R2	Pull-up resistor (3 kΩ/5 kΩ/8 kΩ)
R3	ECU protection ^{Note 1}
R4	Low side resistor ^{Note 1}
C1	ECU / EMC protection ^{Note 1}
C2	ECU / EMC protection ^{Note 1}
C3	NTC / EMC protection ^{Note 2}
VCC	5 V DC supply voltage
GND	Ground reference
µC analog input	Input Signal to microcontroller of ECU

Note 1: Optional content, depends on ECU design requirements

Note 2: See requirements in GMW3097 for NTC component design requirements

3.1.5 Usage Definition. The estimated usage of the Sensor by a severe customer during 241 400 km of usage is 54 300 ignition on/off cycles with a total duration time of 11 500 h.

3.2 Product Characteristics. The required product characteristics for the DAT and EAT Sensors are identified in several different categories in the following paragraphs.

3.2.1 Performance Requirements. The functional performance requirements for the DAT and EAT Sensors are specified in the following paragraphs. All requirements apply for the conditions specified in paragraph 3.1.3, except where noted otherwise. Special vehicle, operational, or ambient conditions may be identified in some performance requirements paragraphs.

3.2.1.1 Temperature Transfer Function (DAT). The DAT Sensor shall consist of an NTC thermistor element with following R/T (Resistance vs. Temperature) characteristics according to Table 7.

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Table 7: Parameters for DAT Transfer Function

Design Parameter	Value
Temperature range	(-50 to +100) °C
Nominal resistance at +25°C	3 kΩ
Nominal Resistance tolerance at +25°C	±1.0 %
Nominal Resistance at +55 °C	900 Ω
Nominal Resistance at 0 °C	9.8 kΩ
Max Beta Tolerance from (-40 to +85) °C	±1.0 %

3.2.1.2 Temperature Transfer Function (EAT). The EAT Sensor shall consist of an NTC thermistor element with following R/T characteristics according to Table 8.

Table 8: Parameters for EAT Transfer Function

Design Parameter	Value
Temperature range	(-50 to +100) °C
Nominal resistance at +25 °C	3 kΩ
Nominal Resistance at +55 °C	900 Ω
Nominal Resistance at 0 °C	9.8 kΩ
Nominal Resistance tolerance at 0 °C	±1.0 %
Max Beta Tolerance from (-40 to +85) °C	±1.0 %

3.2.1.3 Sensor Error Limit. For a given Sensor sample, the change in resistance ΔR (delta R) shall be $\leq \pm 2 \%$ at the completion of the validation/ durability testing.

This requirement shall apply for the temperature range from (-40 to +85) °C.

Report in the test data at R(-40 °C), R(0 °C), R(+25 °C), R(+55 °C) and R(+85 °C).

3.2.1.4 Temperature Dynamic Response (EAT and DAT). The Sensor assembly shall exhibit the following normalized dynamic response when stabilized at a uniform environment (oil bath or quiescent air) at $(+40 \pm 2) ^\circ\text{C}$ and subsequently quenched in a uniform temperature air stream of $(1 \text{ m/s} \pm 0.2) \text{ m/s}$ at $(+80 \pm 2) ^\circ\text{C}$. The time to transition the sensor from the uniform environment to the air stream shall be $< 2 \text{ s}$.

The voltage of the sensor shall be measured at a frequency $> 5 \text{ Hz}$ per the sensor test circuit of paragraph 4.1.1.

The Sensor shall remain in the $+80 ^\circ\text{C}$ air stream until the voltage is stable within $\pm 10 \text{ mV}$.

The nominal time required for the sensor to reach 63.2 % of its final stabilized voltage after entering the $+40 ^\circ\text{C}$ air stream shall be:

- For Point temperature DAT Sensor variant: 8 s maximum
- For averaging temperature DAT Sensor variant: 8 s maximum
- For EAT Sensor variant: 8 s maximum

The tolerance around the average time constant (63.2 %) of a sample of at least 8 sensor assemblies shall be $\pm 1.2 \text{ s}$ (at 3σ).

Examples:

a) Nominal time to reach 63.2 % is 4 s:

$$t_{\min} = 4 \text{ s} - 1.2 \text{ s} = 2.8 \text{ s}$$

$$t_{\max} = 4 \text{ s} + 1.2 \text{ s} = 5.2 \text{ s}$$

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