



**WORLDWIDE
ENGINEERING
STANDARDS**

General Specification

GMW17055

Air Ducts for Hybrid Energy Storage Systems and Power Electronics Thermal Management

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. This component specification defines the design requirements for the ducts that carry air for thermal management of Energy Storage Systems (ESS) and/or Power Electronics associated with ESS. This specification applies to all duct material: plastic blow molded, injection molded and/or breathable, porous material that may be used in ESS Thermal Management Systems.

1.2 Applicability. This specification defines the general requirements and test procedures for the ESS ducts.

1.3 Remarks. Not applicable.

2 References

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

2.1 External Standards/Specifications.

FMVSS 302 SAE J1344

2.2 GM Standards/Specifications.

GMW3059	GMW8758	GMW14234	GMW15758
GMW3070	GMW14093	GMW14325	GMW15760
GMW3116	GMW14156 (ID)	GMW14334	GMW16443
GMW3172	GMW14157 (ID)	GMW14444	GMW17408
GMW3205	GMW14196	GMW14573	
GMW3232	GMW14226	GMW14729	

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

2.3 Additional References. The supplier shall work with the GM Responsible Engineer to comprehend the following requirements.

- Best Practices for Air Cooled ESS; HVACPTC-228 and HVACPTC-235.
- Design Guidelines applicable for Heating Ventilation and Air Conditioning (HVAC) ducts, ESS Thermal Management Systems.
- GM1829 Analysis Development Validation Plan and Report (ADVP&R).
- HVAC Duct Design Guidelines.
- Hybrid Thermal ESS Duct Statement of Requirements (SOR), Appendices C2, J1 and J2.
- Hybrid Thermal ESS Interface Control Documents (ICD).
- Squeak and Rattle (S&R) Noise Glossary.
- Subsystem Technical Specifications (SSTS).

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3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. Not applicable.

3.1.2 Content.

3.1.2.1 Physical Content. The duct(s) assembly includes:

- Air duct(s) which may be blow molded, injection molded, porous and/or other non-porous material(s).
- Clamps, adaptors, seals.
- Duct attachments.

3.1.2.2 Functional Content. Duct(s) may be required to provide some or all of the following functions:

- Transfer air for thermal conditioning of ESS or Power Electronics.
- Attenuate noise.
- Transfer air when inlet is blocked, duct has accidentally collapsed.
- Partially absorb accidental spill of liquid.

The duct requirements that apply to individual programs/applications/systems are detailed in the Hybrid Thermal ESS Duct SOR Appendix C2.

Note: Porous duct material should not be considered for the battery outlet to blower inlet duct.

3.1.3 Ambient Environment. Ducts used in these systems are packaged inside the vehicle, exposed to ambient temperatures in the range of -40 °C to 85 °C. All interior trim standards in GMW14444 apply.

3.1.4 Interfaces. In general, the ducts will interface with the ESS, Power Electronics for ESS, ESS blower, other ventilation ducts in the vehicle, trim inlet grilles and outlets such as the vehicle Pressure Relief Valve (PRV). Consult with related Subsystem Technical Specifications (SSTS), Best Practices for Air Cooled ESS (HVACPTC-228 and HVACPTC-235), GM internal Hybrid Thermal ESS ICD and Hybrid Thermal ESS Duct SOR Appendix C2 for specific interfaces for individual applications. The supplier shall work with the GM Design Responsible Engineer to comprehend the preceding requirement(s).

3.1.5 Usage Definition. The ducts referenced in this system are used for air cooled thermal management of ESS and Power Electronics systems.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Fixed-Value Performance Requirements.

3.2.1.1.1 Airflow Distribution and Pressure Drop.

3.2.1.1.1.1 Normal Operation. The design of the duct assembly shall enable evenly distributed airflow with minimal pressure drop. If the system has a dual inlet configuration, airflow shall be evenly balanced between the two openings. If the system has a dual outlet, the airflow shall be evenly balanced between the two openings. See Hybrid Thermal ESS Duct SOR Appendix C2 for the maximum pressure drop at maximum operating conditions.

For porous ducts, the maximum airflow across the porous duct wall in this condition shall not exceed the target listed in Hybrid Thermal ESS Duct SOR Appendix C2.

3.2.1.1.1.2 Blocked Inlet Duct. In some applications, inlet air ducts may be required to allow a minimum amount of airflow to the ESS in the event that the inlet grille is blocked. In this condition, the resultant air path should be unconditioned air flowing to the system. See Hybrid Thermal ESS Duct SOR Appendix C2 for applicability of this requirement.

3.2.1.1.2 Flammability. The duct assembly shall fulfill the flammability requirements of GMW14444. Testing shall be performed according to GMW3232 and meet requirements of FMVSS 302. Supplier letters of compliance shall be submitted eight weeks prior to Validation Test Complete (VTC).

3.2.1.1.3 Odor Characteristics. The ducts shall have an odor rating of 6 or greater when tested according to GMW14444 and GMW3205.

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3.2.1.1.4 Condensation. The duct assembly shall meet the requirements of GMW14729 for the formation of condensed water.

3.2.1.1.5 Liquid Management. In some applications, inlet air ducts may be required to drain water away from the system before it can reach the ESS, power electronics or blower. If required, this function may be achieved through appropriate duct design, use of porous material, or a trap, drain or valve mechanism. See Hybrid Thermal ESS Duct SOR Appendix C2 for applicability of this requirement.

3.2.1.1.6 Leakage. The ducts shall be airtight except where openings are shown. In general, the maximum air leakage through the internal seals (welds), flanges or duct joints shall not exceed 0.25 L/s when the duct is pressurized to 500 Pa static pressure. See Hybrid Thermal ESS Duct SOR Appendix C2 for specific program targets.

Seals may be required at certain duct interfaces, see Hybrid Thermal ESS Duct SOR Appendix C2. In general, foam seals are to be used to seal against the mating ducts and should be designed for 50% compression of the seal when installed. Adapters may be part of the inlet or outlet, as required. Adapters can be molded as part of the enclosures. The size and shapes of adapters shall be developed jointly between supplier and GM.

For foam seals, GM recommends:

1. Open Cell Foam per GMW14196, or
2. Closed Cell Ethylene Propylene Diene Monomer (EPDM) foam per GMW17408, Class 1, Type 1 for interior applications.

Foam seals must be attached using GM approved adhesives, such as GMW16443.

3.2.1.1.7 Squeaks, Rattles, Noise and Vibration. This system shall have no customer annoyance due to squeaks and rattles. The final authority for the determination of whether a noise is objectionable lies with the GM Lead Engineer and/or the GM Squeak and Rattle (S&R) Engineer. Squeaks and rattles include, but are not limited to all the noises described in the Squeak and Rattle Noise Glossary.

The Supplier is to accept full responsibility to produce S&R free, subsystems and/or components. The Supplier shall cooperate with GM and/or other suppliers to assure that no S&R annoyances occur at the interface of their components to other system and/or components. If an objectionable noise is found during any phase of the program, it will be the supplier's responsibility, with Buyer cooperation, to eliminate the noise and demonstrate resolution in a vehicle prior to exiting the program phase. If the noise is found in pilot or production, the supplier will be responsible to develop a containment plan and fix, as well as short and long-term solutions, as appropriate. Any issue raised during these processes, which is demonstrated to be the responsibility of the supplier, shall be corrected with urgency at no additional cost to GM. The Supplier will be responsible for the S&R performance of their subsystem.

3.2.1.1.8 Sound Transmission Loss (STL). Noise characteristics of the duct assembly shall be such that air rush and blower noise reaching the occupants in the vehicle is minimized and held to acceptable levels. Testing shall be performed per GMW14226. See Hybrid Thermal ESS Duct SOR Appendix C2 for the STL requirements for individual programs.

3.2.1.1.9 Vacuum Collapse. In some applications, the duct(s) may need to withstand collapse when subjected to vacuum. See Hybrid Thermal ESS Duct Appendix C2 for applicability.

3.2.1.1.10 Interconnection Assembly Forces. The connection points of the duct assembly to the ESS or any other vehicle component shall be designed in such a way that the duct is easily fitted to form a firm, leak free joint and perfect connection. Assembly forces shall meet GM ergonomic guidelines in GMW14234.

3.2.1.1.11 Dimensional Stability. No sagging may occur at connection points. The permissible die pitch burrs and molding offsets shall be no more than 0.5 mm. Dimensional stability shall be maintained over life of duct. The dimensional stability shall be verified following endurance tests.

3.2.1.1.12 Particle Ingestion. In some applications, the inlet air ducts may be required to prevent particle ingestion into the system. In this case, an inlet screen, mesh or filter shall be included in the inlet of the inlet duct and in general, will be designed to prevent spheres that are approximately one half the size of the battery cell spacing, from passing through. See Hybrid Thermal ESS Duct SOR Appendix C2 for applicability of this requirement.

3.2.1.2 Endurance Requirements. Sample sizes shall be defined for good confidence on the Weibull model and to demonstrate that the reliability target is achieved at the Reliability Evaluation Point (REP).

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3.2.1.2.1 Impact Resistance. All ducts are required to withstand, at a minimum, the impact of a 510 g steel ball dropped from a height of 1.0 m at a right angle to the duct. Depending on the location of the duct in the system, additional loading may be required, see Hybrid Thermal ESS Duct SOR Appendix C2 for specific requirements. The ducts shall withstand changes in appearance and functions when subjected to the minimum load and any additional loads described in Hybrid Thermal ESS Duct SOR Appendix C2.

3.2.1.2.2 Vibration Resistance. The duct(s) may be required to withstand vibration testing. See Hybrid Thermal ESS Duct SOR Appendix C2 for applicability. If required, the ducts shall be tested according to GMW3172, Random Vibration – Mounting Location Sprung Mass. Test duration shall be per vehicle application as defined in Hybrid Thermal ESS Duct SOR Appendix C2 in the X, Y, and Z axis with $T_{\text{minimum}} = -40\text{ }^{\circ}\text{C}$ and $T_{\text{maximum}} = 85\text{ }^{\circ}\text{C}$. For this test, the duct assembly, including seals, shall be supported in a fixture, in vehicle position and secured only at the vehicle attachment points.

3.2.1.2.3 Thermal Resistance. The ducts shall withstand changes in appearance and function when subjected to $95\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ for 168 h and $-30\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ for 24 h.

3.2.1.2.4 Oxidation Stability. The ducts shall withstand changes in material when subjected to temperatures of $150\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ for 168 h.

3.2.1.2.5 Resistance to Automotive Fluids. The ducts shall meet the requirements of GMW14334, Test Method – Materials, Chemical Resistance to Fluids, Code A, Rating 1.

3.2.1.2.6 Resistance to Humidity. The ducts shall withstand changes in appearance and function when subjected to a temperature of $38\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}$ with a dew point of $37\text{ }^{\circ}\text{C} +1\text{ }^{\circ}\text{C}/-2\text{ }^{\circ}\text{C}$ for 168 h.

3.2.2 Physical Characteristics.

3.2.2.1 Dimensions and Capacity. The duct designs are shown in Hybrid Thermal ESS Duct SOR Appendix C2.

3.2.2.2 Mass Properties. The mass targets are summarized in Hybrid Thermal ESS Duct SOR Appendix C2.

3.2.3 Reliability. This section contains the reliability requirements for the duct assembly. Reliability is defined as the probability of a product performing its intended function(s) in a manner which meets customer expectations, for a given period of time and or miles, under stated conditions.

3.2.3.1 Reliability Evaluation Point (REP). This specification, as written, provides a test exposure representing a REP of 15 years of corrosion and 241 350 km (150 000 miles) of severe customer usage at the vehicle level. Deviations from this requirement will be specified in Hybrid Thermal ESS Duct SOR Appendix C2. If the subject vehicle program has higher or different REP, it will be necessary to work with GM Validation Engineer to modify the test procedure to represent the new REP.

3.2.3.2 Reliability Requirements. This specification, as written, supports the demonstration of the required reliability of 99% or greater at a 50% confidence (R99C50), at the REP for the ducts. The supplier shall utilize “vehicle equivalent” laboratory test setups to simulate “in vehicle” orientations. If the orientation may be different from one vehicle to another, use the orientation which will provide the worst-case loads for all physical level Reliability Demonstration testing.

The Reliability Demonstration is provided by the Design Validation (DV) Endurance Tests specified in 3.7.1.3. In contrast to DV, the Endurance Tests specified for Product Validation (PV) in 3.7.2.3, are intended to confirm the reliability demonstrated during DV.

Note: Test to Failure (TTF) is always the preferred method. Failure is defined as, but not limited to, the loss of function, unacceptable performance degradation and non-conformance of the component as stated in this specification.

Note: The required number of test samples may be negotiable if it is not practical to run, for example, 23 samples. The negotiation of sample size should consider test equipment limitations, physical size of test samples, test duration, etc. However, reduction of the sample size may require inclusion/use of longer test durations or other test methods such as Highly Accelerated Stress Screening (HASS), Highly Accelerated Stress Testing (HAST), Calibrated Accelerated Life Testing (CALT), Highly Accelerated Life Testing (HALT), etc. Weibull slope values available from previous failure testing may be considered as a way to reduce the sample size and/or test duration. For detail refer to GMW14156, and GMW14157.

3.2.3.3 Accelerated Test Methods. GM encourages the use of appropriate Accelerated Test Methods, wherever possible; for example, the use of accelerated stress testing to reduce test time (e.g., GMW8758).

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