



Brake Electric Vacuum Pump Assembly Technical Specification

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 specification establishes the quantitative requirements for an Electric Vacuum Pump (EVP) assembly for future GM vehicles. It was created to support the GM advance purchasing activity for the EVP assembly and is derived from the Brake Subsystem Technical Specification (SSTS).

This document must only be used when invoked by a program specific technical specification. References to the program specific technical specification are included in this document where program specific requirements are expected to exist.

Note: The program specific technical specification may include additional program specific requirements that are not referenced in this document and may supercede any requirements included in this document. In the case of any conflicts between this document and the program-specific technical specification, the program specific technical specification takes precedence.

1.2 Applicability. The vacuum pump will be applied to passenger cars and light trucks up to 3500 kg Gross Vehicle Weight Rating (GVWR).

1.3 Remarks. The EVP assembly is designed to provide supplemental vacuum to support the hydraulic brake system.

The brake apply system works in conjunction with the foundation brakes to provide the vehicle with smooth, safe deceleration, retardation and retention performance under all driving conditions.

The apply system family is intended to provide world class performance from right sized components with interfaces flexible enough to support the diverse packaging and processing requirements of the company.

Consideration shall be given to the selection of recyclable materials.

2 References

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

2.1 External Standards/Specifications.

ISO 7637-2 SAE J2044

2.2 GM Standards/Specifications.

GMW3059	GMW3191	GMW14573	GMW15841
GMW3097	GMW14089	GMW14635	GMW15862
GMW3103	GMW14387	GMW14872	
GMW3172	GMW14558	GMW15272	

2.3 Additional References.

- Brake Electric Vacuum Pump Assembly Program Specific Technical Specification.
- Brake Subsystem Technical Specification (SSTS)
- Chassis Bracket Test and Analysis Procedure Analysis

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3 Requirements

3.1 Subsystem Definition. The EVP assembly shall provide supplemental vacuum to the brake system during powertrain periods of low vacuum output.

3.1.1 Appearance.

3.1.1.1 All EVP assembly components shall have identification tags/labels, supplier logos, and marking indicated on the outline drawing and shall be approved by GM.

3.1.1.2 All EVP assembly components that are visible to the customer shall be in black, gray, and/or silver. The supplier shall receive GM approval for production intent component appearance. This approval, or other appropriate agreement, is required prior to supplier commencing any activity related to component appearance that would force GM to incur cost penalties if a change is subsequently required.

3.1.1.3 Any components with painted, coated, and plated surfaces shall exceed a fifteen (15) year life without loss of function due to corrosion when mounted in their production intent environment.

3.1.2 Content.

3.1.2.1 Physical Content.

3.1.2.1.1 The EVP assembly includes the following major components:

- EVP Pump.
- Assembly (1).
- Isolation grommets (minimum of two (2)).
- Pump fasteners (minimum of two (2)).
- Electrical wiring harness connection.
- Vacuum hose connection for Quick Fittings according to SAE J2044.
- The EVP Assembly must not include an Inline Relay Box as it will be powered by a Relay within the Vehicle Fuse Box.

Note: None of the physical content shall require calibration prior to use in the GM vehicles.

3.1.2.1.2 All of the fittings shall be covered to prevent contamination and provide protection during shipping. The air intake port and electrical wiring harness shall be covered by conduit.

3.1.2.2 Functional Content. Not applicable.

3.1.3 Ambient Environment.

3.1.3.1 Mechanical. The EVP assembly shall be capable of enduring the environment when mounted anywhere in the engine compartment or other closed suitable areas close to brake booster.

3.1.3.2 Electrical. The EVP assembly components shall be capable of enduring the environment found in an automotive mounting location in the engine bay. Fusing will be applied to vehicle architecture for protection of the vacuum pump assembly as needed.

3.1.3.3 Atmospheric Pressure. The vacuum pump shall be designed to be exposed to between 45 kPa and 115 kPa during storage.

3.1.3.4 Shipment. EVP assembly shall withstand shipment by air. The vacuum pump shall not degrade when exposed to a temperature of -50 °C and to a pressure of 15 kPa.

3.1.3.5 Component Drop. The EVP assembly must not be dropped from any height. Components that are dropped from any height are to be considered scrap and not shipped to the customer.

3.1.4 Interfaces. The EVP assembly shall be designed to interface with the subsystems and components described in 3.1.4.1. The desire is for an architecture that will allow assembly plant processing flexibility. The exact details of the interfaces will be developed with the supplier. The packaging emphasis is on reducing the overall packaging size. See the program technical specification.

3.1.4.1 Vacuum Pump Mounting. According to the Global Noise, Vibration, and Harshness (NVH) Contenting Strategy Tool. The EVP Assembly shall be mounted to the cockpit module, body, or engine.

The priority for pump location is:

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- On the vehicle frame or powertrain cradle.
- On the body rails.
- Other closed suitable areas close to the brake booster.

All locations must be negotiated with manufacturing engineering; Splash Water- and NVH- engineering as well as Global Subsystem Leadership Team (GSSLT)/Bill of Materials (BOM) Family Owner (BFO).

3.1.5 Usage Definition. The passenger car customer usage data given in this section is for high levels of usage in 150 000 miles/240 000 km of retail customer driving. The heavy duty truck customer usage data given in this section is for high levels of usage in 200 000 miles/320 000 km of retail customer driving.

Note: Low levels of usage may be more appropriate for certain failure mechanisms, such as corrosion.

3.1.5.1 Maximum Continuous Run Time. Maximum pump continuous run time equals 4 h at 60 °C ambient temperature with 350 mBar throttle to allow air flow.

3.1.5.2 Number of Vacuum Pump Cycles. The EVP Assembly shall be capable of enduring a minimum of 600 h accumulated run time, segmented into 450 000 cycles, as described in Table 1, and still fulfill performance levels specified in 3.2.1.3.2 and 3.2.1.3.3. One (1) cycle of the vacuum pump equals pressure of 500 mbar to 300 mbar and back to 500 mbar (absolute Pressure). The vacuum pump running time per cycle is approximately 4.8 s.

Table 1: Vacuum Pump Cycles

Number of Cycles	Test Temperature
180 000	100 °C
240 000	60 °C
30 000	-30 °C

3.1.5.3 Cumulative Vacuum Pump Run Time. The EVP assembly shall be capable of operating for 600 h minimum.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Electrical Characteristics. Paragraphs 3.2.1.1.1 thru 3.2.1.1.11 define the electrical performance of the EVP assembly.

3.2.1.1.1 Operating Voltage Range. The normal operating voltage range for the compressor motor is 9 V to 16 V.

3.2.1.1.2 Operating Temperature for the Electronics. The operating temperatures for the mounting location of the EVP assembly are -40 °C to 125 °C with excursion to 140 °C.

3.2.1.1.3 Startup Current. The startup current for the compressor motor shall not exceed 60 A with 16 V applied at -40 °C. The duration of the startup current shall not exceed 500 ms.

3.2.1.1.4 Steady State Current. The steady state current shall be ≤ 9 A at 13.5 V at 23 °C.

3.2.1.1.5 Short Circuits. The EVP assembly shall be protected against short circuits to operating battery voltage and ground.

3.2.1.1.6 Electrostatic Discharge. The EVP assembly shall be capable of surviving without damage electrostatic discharge voltages between -25 kV and 25 kV for an energy storage representative of the human body.

3.2.1.1.7 Conducted Transients. The EVP assembly components shall be capable of surviving without damage, sinusoidal and transient conducted bursts representative of actual amplitudes, durations, and waveforms experienced on motor vehicles due to inductive and capacitive disturbances. Reference GMW3097 and GMW3103.

3.2.1.1.8 Voltage Overstress. The EVP assembly components shall be capable of surviving voltage overstress without damage.

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3.2.1.1.9 Reverse Battery. The EVP assembly components shall be protected to reverse polarity.

3.2.1.1.10 Sealing. EVP assembly shall be completely sealed and be capable of preventing water ingestion through the case, the connection system, the wiring/header connector, and the exhaust vent. The pump shall be capable of being cycled on and off for a minimum of 20 times, under 300 mm of water. Exceptions to this requirement may be granted at the sole discretion of GM, based on the final mounting location.

3.2.1.1.11 Voltage Transient Suppression. The Brake Vacuum Pump shall have voltage transient suppression built-in in order to prevent damage to the devices controlling the pump.

Using ISO 7637-2 Figure 1a, slow pulses test method, the device shall pass the Voltage Transient Emissions Test with a Severity level II as specified in Table C.2.

3.2.1.2 Mechanical Characteristics.

3.2.1.2.1 Mechanical Vibration. The EVP assembly shall encounter vibration inputs per Appendix A, Figure A1 and Table A1, using the sprung mass data, for body or chassis mounted pumps, and the engine data, for engine or transmission mounted pumps. Reference: Chassis Bracket Test and Analysis Procedure Analysis, Heewook Lee et.al.

3.2.1.2.2 Mechanical Shock. The EVP assembly shall be exposed to 40 half sine wave mechanical shocks in the upward, rearward, and both lateral directions based on Table 2.

Table 2: Mechanical Shock

Component Location	Maximum G Level (Zero-to-Peak)		Total Duration in ms
	Upward, Rearward	Left, Right	
Under Hood	14	7	10

3.2.1.2.3 Bracket Natural Frequency. The EVP mounting bracket, if used, should have a first mode natural frequency of ≥ 30 Hz if mounted on the chassis. If mounted on the powertrain, the first mode natural frequency should exceed the firing frequency of the engine at maximum engine speed. See example below in Table 3.

Table 3: Example of Bracket Natural Frequency for Powertrain Mounted Pump

Engine Maximum Rotational Speed in minutes ⁻¹	Engine Firing Frequency in Hz		
	4 Cylinder Engine	6 Cylinder Engine	8 Cylinder Engine
5000	167	250	333

3.2.1.2.4 Splash Water- and Suck- Back- Effect- Protection. The EVP Assembly shall be capable to pass Splash Water Tests according IPX6, mounted on a 360° rotating table, with the EVP air outlet 25° angled towards the water nozzle.

3.2.1.2.4.1 Voltage = 13 V $\pm$ 0.1 V.

3.2.1.2.4.2 Ambient temperature = 23 °C $\pm$ 2 °C.

3.2.1.2.4.3 Operating Conditions. Operate EVP with a 35 kPa throttle and a Vacuum Pipe (ID min. 10 mm) with a check valve 200 mm ahead of the EVP inlet. Apply a duty cycle of 20% (3 s ON; 12 s OFF). Ensure that rotation frequency of the mounting table is not equal to EVP duty cycle to allow water exposure to air outlet from random positions as EVP stops.

3.2.1.2.4.4 Test duration: Perform test for 10 minutes with intermitted pump operations acc. Duty cycle.

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3.2.1.3 Pump Operation.

3.2.1.3.1 Pressure Range. The vacuum pump shall operate between $P_{abs} = 500$ mbar (On) to 200 mbar (Off), unless otherwise specified. See the program technical specification.

3.2.1.3.2 Electro Pneumatic Ratings. The EVP shall be capable of pumping a test volume, according to Table 4, through a 10 mm inside diameter tube 100 cm long as listed in 3.2.1.3.2.1 thru 3.2.1.3.2.3.

3.2.1.3.2.1 Voltage = $13 \text{ V} \pm 0.1 \text{ V}$.

3.2.1.3.2.2 Ambient temperature = $23 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$.

3.2.1.3.2.3 Pressure generation time at 100 kPa (1 bar):

- $P_{abs} = 50$ kPa in 5.0 s maximum.
- $P_{abs} = 30$ kPa in 11 s maximum.
- $P_{abs} = 20$ kPa in 40 s maximum.

Table 4: Pumping Volume

Pump Version	1	2
Maximum weight target (in kg)	1.0	1.5
Test volume (in dm^3)	3.2 ± 0.1	4.5 ± 0.1

3.2.1.3.3 Electro Pneumatic Ratings at $-40 \text{ }^{\circ}\text{C}$ and $120 \text{ }^{\circ}\text{C}$. The EVP shall be capable of pumping a test volume, according to Table 4, through a 10 mm inside diameter tube 100 cm long as listed below at $-40 \text{ }^{\circ}\text{C}$ and at $100 \text{ }^{\circ}\text{C}$.

3.2.1.3.3.1 Voltage = $13 \text{ V} \pm 0.1 \text{ V}$.

3.2.1.3.3.2 Ambient temperature = $-40 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ and $100 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$.

3.2.1.3.3.3 Pressure generation time at 100 kPa (1 bar):

- $P_{abs} = 50$ kPa in 5 s maximum.
- $P_{abs} = 30$ kPa in 11 s maximum.
- $P_{abs} = 20$ kPa in 40 s maximum.

3.2.1.3.4 Electric Vacuum Pump Assembly Noise and Vibration.

3.2.1.3.4.1 Disturbance. The vibration level and noise level produced by the EVP assembly shall not be discernible in the passenger compartment under engine idling, window closed, and normal driving condition.

3.2.1.3.4.2 Isolation. The EVP assembly shall provide a means of vibration isolation, such as rubber mounts.

3.2.1.3.4.3 Manage Vacuum Pump Noise and Vibrations. The vacuum pump shall support compliance with the program vehicle level powertrain noise and vibration requirements found in the current GM program Vehicle Technical Specification (VTS). The supplier shall cooperate with GM in determining the root cause and resolution of any vacuum pump generated vehicle level noise and vibration deviations from the program VTS paragraphs for Powertrain Noise and Vibration.

3.2.1.3.4.3.1 Vacuum Pump Radiated Sound Power. The vacuum pump sound power levels shall not exceed the 1/3 octave levels specified in Table 5 when tested according to GMW14387.

Table 5: Radiated Sound Power

1/3 Octave Center Frequency in Hz	Sound Power Level in dB [Re: 10^{-12} W]
250	62.4
315	59.6
400	60.2

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