



Pressure Relieve Devices for Low and High Pressure Side

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 Scope. Pressure relieve device is for use in all passenger car and light commercial vehicle air conditioning (A/C).

1.2 Mission/Theme. This standard defines the minimum requirements for pressure relieve devices of the passenger car air conditioning system (not valid with/for R744 heating system) which are operated with refrigerant R744.

The pressure relive devices cause a refrigerant blow-off from the car air conditioning system in any event of a system over pressure.

1.3 Classification. Not applicable.

2 References

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

2.1 External Standards/Specifications.

DIN 8964	ISO 9001	ISO 9227	SAE J639
DIN 50014			

2.2 GM Standards/Specifications.

GMW3059	GMW3116	GMW15786
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2.3 Additional References.

 None.

3 Requirements

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance. All exterior and interior surfaces shall be clean and free of manufacturing lubricants, flux, soluble flux residue, metal chips, scale, and other contaminants that are not associated with the function. Flux residue shall not be considered a contaminant if it is insoluble in water, R744 or PAG/POE oil and does not contribute to corrosion in the system.

Appearance and finish of parts shall be free of weld and/or braze splatter, flash, ridges, roughness and of tool lubricants and other contamination according to DIN 8964.

3.1.2 Content. The major function of the pressure relieve device in the R744 A/C system is to protect the components and the A/C system from exceeding the maximum pressure. While current R134a refrigeration systems have mostly one pressure relieve device on the high pressure side in the compressor, two pressure relieve devices shall be provided on both the high pressure and low pressure sides of R744 refrigeration systems respectively, per SAE J639 and German Vehicle Development Authority (VDA) safety concept.

The main reasons for exceeding the maximum pressures are due to either refrigerant overfill of the refrigerant circuit, or malfunctions of the compressor control or blocking of a component, e.g., evaporator.

3.1.2.1 Physical Content. The pressure relieve device shall provide sealing to refrigerant R744. Sealing and function shall be designed for vehicle life time. Refrigerant flow out from the pressure relieve device shall be planned and executed carefully to assure that the refrigerant can escape from the system with the lowest possible risk.

3.1.2.2 Functional Content. Two fundamental functional types of pressure relieve devices are possible for the refrigerant circuit with R744:

- The self-closing reversible relief valve which closes itself and, consequently, the refrigerant circuit automatically and tightly after each overpressure incident, and
- The irreversible burst device which responds once. The entire refrigerant inside the A/C system with part of the lubricant is discharged to the environment and the A/C circuit remains open to the environment.

The probability that the pressure relieve device on the low pressure side responds is much lower than a response of the high pressure side. Usually the excessive operating pressure on the low pressure side is caused by a significant overfill or blocking behind the burst device, e.g., evaporator. On the high pressure side excessive operating pressure is caused by malfunction of high pressure limitation of the compressor.

Each pressure relieve device shall operate automatically. No other methods by mechanical, thermostatically and electrical control are allowed to use for the activation of the pressure relieve device.

The most important differences between the relief valve and the burst device are:

- Lower component strain than by explosive decompression because normally the system is not completely emptied to ambient pressure level.
- Because the relief valve closes at a certain pressure, the system normally never runs without refrigerant.
- The noise level in case of relief valve response relative to burst device response is lower.
- The function of the relief valve shall be tested without damaging the relief valve.

3.1.3 Ambient Environment and Operating Conditions. This defines the ambient temperatures and refrigerant temperatures which the components are exposed to. As orientation, the following values are defined for operating and non-operating A/C system. If the A/C system is switched off, the ambient conditions are equal to environment temperatures which are relevant for the design and construction of the pressure relieve devices.

3.1.3.1 High Pressure Side. The pressure relieve device shall be mounted directly in the compressor as part of the compressor assembly. Due to the typical location of the compressor near the hot engine, the environmental temperatures are in the range of:

- -40 °C in switched off condition and/or,
- -12 °C during refrigeration system operation to
- +130 °C permanent to
- +150 °C short term (5 minutes maximum each for a total of 168 h).

For special application - extremely hot – that shall be defined by GM:

- -40 °C in switched off condition and/or
- -12 °C during refrigeration system operation to
- +150 °C permanent to
- +180 °C short term (5 minutes maximum each for a total of 168 h).

The refrigerant temperature during operation is between -12 °C to +165 °C and +180 °C short term (5 minutes maximum each for a total of 168 h).

3.1.3.2 Low Pressure Side. The pressure relieve device shall not be located near the hot engine or other heat source underhood, therefore, the environmental temperatures are in the range of

- -40 °C in switched off condition and/or
- -12 °C during refrigeration system operation to
- +120 °C permanent to
- +135 °C short term (5 minutes maximum each for a total of 168 h).

The refrigerant temperature during operation is between -12 °C and +80 °C.

3.1.4 Interfaces.

3.1.4.1 High Pressure Side. Pressure relieve devices shall in principle be integrated in the system directly or close to the pressure source. The relief valve and/or the burst device on the high pressure side are, therefore, part of the compressor.

3.1.4.2 Low Pressure Side. Additionally, another pressure relieve device shall be provided on the low pressure side because of the maximum operating pressure on the low pressure side.

In compliance with SAE J639, overpressure by overcharging and also by blocking shall be avoided. Therefore, the relief valve or burst device on the low pressure side shall be located upstream directly after the expansion device and before the evaporator.

3.1.4.3 Non-interchangeability. The pressure control devices for high and low pressure side are not allowed to interchange one another. Therefore, the outside design of the pressure control elements shall be so different that mismatch is impossible. A metric fine left thread shall be used for high pressure side with size M12x1, and for low pressure side with size M14x1. A hexagonal bolt head without thread marking is required.

3.1.4.4 No Cross Section Reduction. When installing the pressure relieve devices in the respective A/C pipe and compressor, the detail dimensions of the interface shall be reviewed carefully to ensure that the end plugged into the line and the housing of the compressor does not negatively influence the flow cross section of the medium. The reduced cross section of the flow path will cause pressure losses. Such pressure losses are not allowed for the normal function of the pressure relieve device.

3.1.5 Safety and Usage Definition. The installation location of both pressure relieve devices shall be selected to assure that refrigerant blow-off is outside the passenger compartment including A/C unit, air intake and luggage compartment.

Additionally, the installation locations and blow-off directions of the pressure relieve devices shall be such that personal injury of persons near the vehicle and the system is not possible in case of refrigerant blow-off. The burst sound level shall be such that no personal injury of persons near the vehicle and the system is possible.

The integration of the pressure relieve devices into a third component, e.g., expansion device or connector block, shall be in such a way that the pressure relieve devices are from the outside of the component removable. To avoid the pressure relieve device being opened replaced inappropriately, e.g., through a screw, a warning is required on the pressure relieve device. The warning shall say for example "Do Not Remove", or the corresponding ISO symbol shall be used.

3.2 Product Characteristics. The test temperature for the following physical tests is $+23\text{ °C} \pm 5\text{ °C}$ according to DIN 50014 unless otherwise specified.

A minimum of five test samples are required for each test.

The test results shall be documented as part of Production Part Approval Process (PPAP) documents to GM.

3.2.1 Performance Requirements. The minimum pressures at which the pressure relieve devices shall respond at the earliest are:

- 15 MPa on the high pressure side (HD).
- 11 MPa on the low pressure side (ND).
- Pressure relief devices shall open completely and prevent the pressure in the refrigerant circuit from increasing further.
- 17 MPa on the high pressure side (HD).
- 13 MPa on the low pressure side (ND).

The response pressure (RP) intervals of the pressure relieve devices are:

- 15 MPa < RP for HD side < 17 MPa.
- 11 MPa < RP for ND side < 13 MPa.

Especially for relief valves: The relief valve shall close at a pressure which is 1.2 MPa below the response pressure. After ten responses, the response pressure shall still be within the specified response interval. After each response, the relief valve shall return to a safe condition, i.e., the change of response pressure shall be in the direction of lower pressures, whereby complete resealing shall further be assured. The emptying of the system shall be 250 kg/h.

Especially for burst device: The emptying of the A/C system to closely ambient pressure level depends on drain diameter and design. The initial emptying speed of the A/C system shall be 5 MPa/s. As initial pressure, the response pressure of the burst device may be used.

3.2.1.1 Leak Rate. The R744 leak rates of the pressure relieve devices are limited to a value of 1 g/year maximum.

These leak rates are determined according to the load collectives shown in Appendix A, Table A1 for the low pressure side and in Table A2 for the high pressure side.

The pressure relieve devices shall be installed as follows:

- **HD: High Pressure** side in test block, e.g., compressor block without further leakage points such as tube connections and shaft seal on it.
- **ND: Low Pressure** side in test block, e.g., refrigerant pipes or expansion device without further leakage points.

The measurement is made with a mixture of R744 and the refrigerant oil specified. The ratio of the mixture of R744 and the oil shall be same as the specified value of the A/C system of the vehicle. After filling the test block, compressor block, etc., the test unit shall be shacked to allow the oil being on the entire internal surface.

Each load condition shall be maintained until a steady-state condition of the leakage is reached, but at least 48 h. Leakage shall be determined in a system evacuated as required. CO₂ leakage is determined with a mass spectrometer and/or an equivalent leak detector. The average leak rate shall be determined as follows:

$$VR_m = \sum_{i=1}^n VR_i \cdot Gew_i$$

Where:

VR_m $\triangleq$ Average leak rate of the sample

VR_i $\triangleq$ Leak rate in the load condition i

Gew_i $\triangleq$ Weighting factor for the load condition i

Compliance with these requirements shall be assured after all function tests and for the entire vehicle life cycle.

Especially for Relief Valve: After five responses, the leak rate may increase to 1.5 g/year. After >10 actuations, the leak rate may increase to 2 g/year maximum.

Repeated leak rate test: The repeated leak rate test is made under the load condition No.3 and shall be used for the single and series tests which will be defined later.

The leak rate determined according to Appendix A, Table A1 and Table A2 (at a standstill +30 °C and a system pressure of 7 MPa) is defined as the base leakage for the pressure relieve device. This value shall not be exceeded during all repeated leak rate tests. The tolerance is set to 20%. The load condition shall be maintained for 48 h according to this paragraph.

3.2.1.2 Resistance to Under Pressure/Vacuum. The pressure relieve devices shall be installed according to paragraph 3.2.1.1 in test blocks which are completely sealed to the environment by soldering. A vacuum of 0.5 kPa absolute shall be applied to the pressure relieve devices and maintained constant for 5 minutes. The allowed pressure increase shall not exceed 0.5 kPa within 30 minutes and with pump switched off.

The pressure relief device shall function properly after this test.

After this test, the leak rate test, according to paragraph 3.2.1.1, shall be repeated.

The under pressure resistance test with leak rate test shall be performed subsequently 3 times.

3.2.1.3 Response Pressure Test. The response pressure for high pressure side shall be tested at:

- 15 MPa at +200 °C < RP < 17 MPa at +80 °C.

The response pressure for low pressure side shall be tested at:

- 11 MPa at +120 °C < RP < 13 MPa at +30 °C.

A separate burst pressure test for pressure relieve valve and burst element is not required.

3.2.1.4 Pressure Cycling Test. The pressure relieve devices shall be installed according to paragraph 3.2.1.1 in test blocks which are completely sealed to the environment by soldering.

Test conditions for low pressure side:

- Pressure cycles: 150 000.
- Test duration: 292 h, 150 000 cycles x 7 s.

- Test pressures: 2.5 MPa to 9 MPa absolute.
- Test medium: hydraulic or refrigerator oil.
- Temperature of test oil: $+80\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

Test conditions for high pressure side without creeping:

- Pressure cycles: 150 000.
- Test duration: 292 h, 150 000 cycles x 7 s.
- Test pressures: 5 MPa to 14.5 MPa absolute.
- Test medium: hydraulic or refrigerator oil.
- Temperature of test oil: $+155\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$.

The timing of the pressure cycles for high and low pressure side is shown in Figure 1. The duration of the pressure ramp is 0.5 s and the holding pressure is 3 s.

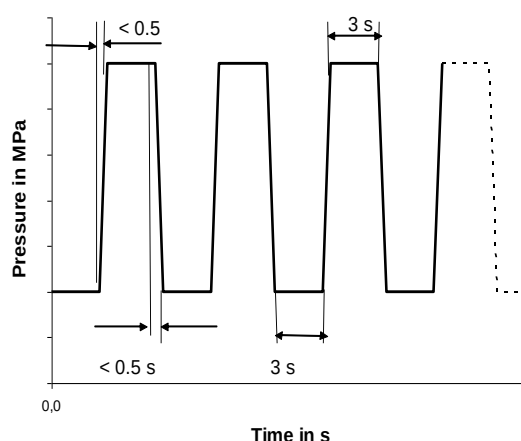


Figure 1: Pressure Cycles for High and Low Pressure Side Without Creeping

Creeping test for high pressure side only.

For each new technology, it is mandatory to verify at least once that no creeping appears. If the proof was performed, it is not necessary to repeat it for small design changes, but the supplier has to inform GM. Test conditions for creeping on high pressure side are shown in Table 1.

Table 1: Test Conditions for Creeping on High Pressure Side

Pressure in MPa	Cycles	Temperature in $^{\circ}\text{C}$	Period (HD-ramp-ND-ramp) in s	Time in h
$5 \leq P \leq 14.5$	5500	165	315 (300 - 5 - 5 - 5)	481
$5 \leq P \leq 14.5$	11 000	135	315 (300 - 5 - 5 - 5)	962
$5 \leq P \leq 14.5$	38 500	105	7 (3 - 0.5 - 3 - 0.5)	75

During the creeping test function, the pressure relieve valve shall not be impaired nor the form malleable changed.

After this test, the leak rate test, according to paragraph 3.2.1.1, shall be repeated and the response pressure, according to paragraph 3.2.1.3, shall be repeated.

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3.2.1.5 Temperature Cycling Test. The pressure relieve devices shall be tested in the condition assembled with the pipe, expansion device and/or the compressor as follows:

Fill the test sample with test medium hydraulic or refrigerator oil and apply the following pressure:

- ND: low pressure side 10.5 MPa.
- HD: high pressure side 14.5 MPa.

The temperature cycle intervals are:

- ND: from -40 °C to +120 °C $\pm$ 2 °C.
- HD: from -40 °C + 160 °C $\pm$ 2 °C.

The soak and/or cooling speed is ± 1 °C/minute.

The holding time at the minimum/maximum values is 30 minutes each. The total cycle duration:

- HD: 460 minutes (30 – 200 – 30 – 200).
- ND: 380 minutes (30 – 160 – 30 – 160).

Total test duration:

- HD: 77 h $\approx$ 10 cycles.
- ND: 63 h $\approx$ 10 cycles.

After this test, the leak rate test, according to paragraph 3.2.1.1, shall be repeated and the response pressure, according to paragraph 3.2.1.3, shall be repeated.

3.2.1.6 Vibration Test. For the vibration test, the pressure relieve devices shall be installed, according to paragraph 3.2.1.1, in test blocks which are completely sealed to the environment by soldering.

The test sample shall be filled internally with water or refrigerant oil to a level of 30% and after with nitrogen in the space above. The average pressures are 14 MPa for the high pressure side and 10 MPa for the low pressure side. The test shall be performed at room temperature.

The test sample is exposed to a sinusoidal vibration in vertical direction as follows:

- Frequency $\approx$ 20 Hz sinusoidal.
- Number of cycles: 3.6×10^6 (duration 50 h)
- Acceleration: $\pm 31.4 \text{ m/s}^2$ (this shall be the result to an amplitude: $\pm 2 \text{ mm}$).

After this test, the leak rate test, according to paragraph 3.2.1.1, shall be repeated and the response pressure, according to paragraph 3.2.1.3, shall be repeated.

If functional component parts are made from plastic: Subsequently, this test shall be made in the cold chamber at -20 °C and a pressure 2 MPa with the other conditions remaining the same.

After this test, the leak rate test, according to paragraph 3.2.1.1, shall be repeated and the response pressure, according to paragraph 3.2.1.3, shall be repeated.

3.2.1.7 Corrosion Test. The salt spray tests are accelerated corrosion test of the pressure relieve devices using a cyclically sprayed aqueous, acetic sodium chloride solution as corrosion agent.

The corrosion test shall be performed 20 days according to:

- Sea Water Acetic Acid Test (SWAAT), ISO 9227.

and 24 weeks according to:

- Alternating Climatic Corrosion Test to ISO 9227.

Both tests are described in Appendix A, Table A3 and Table A4.

The pressure relieve devices shall be leak tight over the total test. After the test, no functional failure shall be occur due to corrosion.

After this test, the leak rate test, according to paragraph 3.2.1.1, shall be repeated and the response pressure, according to paragraph 3.2.1.3, shall be repeated.

If aluminum parts are used, an even surface corrosion and/or shallow pitting corrosion is permitted with a wall thickness up to 30%. Pitting corrosion and other corrosion mechanisms, e.g., inter-crystalline corrosion, are not allowed.