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Road vehicles — Compressed natural gas (CNG) fuel system components —

Part 13: Pressure relief device (PRD)

Véhicules routiers — Composants des systèmes de combustible gaz naturel comprimé (GNC) —

Partie 13: Dispositifs de limitation de pression

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 41, *Specific aspects for gaseous fuels*.

This third edition cancels and replaces the second edition (ISO 15500-13:2012), which has been technically revised. It also incorporates the Amendment ISO 15500-13:2012/Amd.1:2016.

The main changes are as follows:

— Clause 4, the type of gas and service pressure value have been added;

— Clause 6, new tests for "high-pressure activation and flow rate", "water jet protection" and "impact due to drop" have been added.

A list of all parts in the ISO 15500 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

For the purposes of this document, all fuel system components in contact with natural gas have been considered suitable for natural gas as defined in ISO 15403-1. However, it is recognized that miscellaneous components not specifically covered herein can be examined to meet the criteria of this document and tested according to the appropriate functional tests.

All references to pressure in this document are considered to be gauge pressures unless otherwise specified.

This document is based on a service pressure for natural gas used as fuel of 20 MPa [200 bar[1)]] settled at 15 °C. Other service pressures can be accommodated by adjusting the pressure by the appropriate factor (ratio). For example, a 25 MPa (250 bar) service pressure system requires that pressures be multiplied by 1,25.

1) 1 bar = 0,1 MPa = 10^5 Pa 1 MPa = 1 N/mm^2.

Road vehicles — Compressed natural gas (CNG) fuel system components —

Part 13: Pressure relief device (PRD)

1 Scope

This document specifies tests and requirements for the pressure relief device (PRD), a compressed natural gas (CNG) fuel system component intended for use on the types of motor vehicles defined in ISO 3833.

This document is applicable to vehicles (mono-fuel, bi-fuel or dual-fuel applications) using natural gas in accordance with ISO 15403-1.

It is not applicable to the following:

a) liquefied natural gas (LNG) fuel system components located upstream of, and including, the vaporizer;

b) fuel containers;

c) stationary gas engines;

d) container-mounting hardware;

e) electronic fuel management;

f) refuelling receptacles.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15403-1, *Natural gas — Natural gas for use as a compressed fuel for vehicles — Part 1: Designation of the quality*

ISO 15500-1, *Road vehicles — Compressed natural gas (CNG) fuel system components — Part 1: General requirements and definitions*

ISO 15500-2, *Road vehicles — Compressed natural gas (CNG) fuel system components — Part 2: Performance and general test methods*

ISO 20653, *Road vehicles — Degrees of protection (IP code) — Protection of electrical equipment against foreign objects, water and access*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 15500-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
activation pressure
rupture disc pressure rating
pressure, as specified by the pressure relief device (PRD) manufacturer, at which a PRD is designed to activate in order to allow the discharge of the cylinder

3.2
activation temperature
temperature, as specified by the pressure relief device (PRD) manufacturer, at which a PRD is designed to activate in order to allow the discharge of the cylinder

3.3
fusible material
metal, alloy or other material capable of being melted where the melting is integral to the function of the pressure relief device (PRD)

3.4
parallel-combination relief device
pressure relief device (PRD) activated by high temperature or pressure acting separately

Note 1 to entry: This device may be integrated into one device that has independent pressure-activated and thermally-activated parts. It may also be formed by two independent devices (one pressure-activated and one thermally-activated) that act independently.

3.5
pressure-activated relief device
pressure relief device (PRD) activated by pressure

3.6
burst disc
rupture disc
operating part of a *pressure-activated relief device* (3.5) which, when installed in the device, is designed to burst at a predetermined pressure to permit discharge of the cylinder

3.7
series-combination relief device
pressure relief device (PRD) activated by a combination of high temperature and pressure acting together

3.8
thermally-activated relief device
pressure relief device (PRD) activated by high temperature

3.9
yield temperature
temperature at which the *fusible material* (3.3) becomes sufficiently soft to activate the device and to permit discharge of the cylinder

Note 1 to entry: There are several possible scenarios for a vehicle involved in a fire. The pressure relief device (PRD) is intended to reduce the risk of cylinder rupture under most of these scenarios while keeping a low risk of accidental activation. Experience shows that the best solution depends on the type of cylinder the PRD is mounted on.

3.10
flow capacity
capacity in volume per unit time at specified conditions, for a pressure relief device (PRD)

3.11
long trigger PRD
pressure relief device (PRD) having a heat reactive element (portion of a PRD that reacts to heat to activate the PRD) that is more than 10 times longer than the longest dimension of the PRD body

3.12
remote trigger PRD
pressure relief device (PRD) having the heat reactive element (portion of a PRD that reacts to heat to activate the PRD) that is separate from the gas handling portion of the PRD, such that it is possible for the heat reactive element to be heated separately from the main body or gas control portion of the PRD

3.13
K_v
valve flow coefficient
number equal to the flow rate in cubic meters per hour [m^3/h] of water at a temperature of 16 °C with a pressure drop across the valve of 0,1 MPa

4 Marking

If the PRD is a stand-alone component, marking shall provide sufficient information to allow the following to be traced:

a) the manufacturer's or agent's name, trademark or symbol;

b) the type of gas (CNG);

c) the service pressure;

d) the fusible material yield temperature or PRD activation temperature (as per Annex A), and the rupture disc pressure rating or activation pressure, as appropriate;

e) the type of relief device (e.g. thermally-activated, series-combination, parallel-combination).

If there is a possibility that the PRD could be installed with the flow in the wrong direction, the PRD shall be marked with an arrow to show the direction of flow.

NOTE This information can be provided by a suitable identification code on at least one part of the component when it consists of more than one part.

5 Construction and assembly

The PRD shall conform to the applicable provisions of ISO 15500-1 and ISO 15500-2, and with the tests specified in Clause 6. Tolerances should follow the specifications of ISO 15500-2.

Each part of the device shall not interfere with the operation/activation of the other part. The device shall be able to vent the content of the cylinder through any one of the parts of the PRD independently. The device shall be able to vent the content of the cylinder if the pressure- and thermally-activated parts open simultaneously.

The suggested configuration for PRDs is a parallel-combination or thermally-activated relief device for every type of cylinder. Series PRDs may only be used in type 1 steel cylinders and shall not be used in type 2, type 3 and type 4 cylinders.

PRDs designed to conform to this document shall be used with natural gas that conforms to the natural gas specifications from ISO 15403-1.

6 Tests

6.1 Applicability

The tests required to be carried out are indicated in Table 1.

Table 1 — Applicable tests

Test	Applicable	Test procedure as required by ISO 15500-2	Specific test requirements of this document
Hydrostatic strength	X	X	X (see 6.2)
Leakage	X	X	X (see 6.3)
Excess torque resistance	X	X	
Bending moment	X[a]	X	X (see 6.4)
Continued operation	X	X	X (see 6.5)
Corrosion resistance	X	X	
Oxygen ageing	X	X	
Ozone ageing	X	X	
Heat ageing	X	X	
Automotive fluids	X	X	
Electrical over-voltages	X	X	
Non-metallic material immersion	X	X	
Vibration resistance	X	X	
Brass material compatibility	X	X	
Accelerated life	X	X	X (see 6.6)
Benchtop activation	X	X	X (see 6.7)
Thermal cycling	X	X	X (see 6.8)
Condensate-corrosion resistance	X	X	X (see 6.9)
Flow capacity	X	X	X (see 6.10)
High-pressure activation and flow rate	X		X (see 6.11)
Water jet protection	X		X (see 6.12)
Impact due to drop	X		X (see 6.13)

[a] This test is to confirm proper design and construction of stand-alone, externally-threaded PRD designs and is not required if the PRD is internally imbedded in the valve body.

Unless otherwise noted, while testing long trigger PRDs, or remote trigger PRDs, the tests performed shall use lengths or configurations that represent the worst conditions for that test, or shall use samples at each limit of the lengths to be approved.

6.2 Hydrostatic strength

6.2.1 Housing

The manufacturer shall either physically test the housing or prove its strength by calculation.

6.2.1.1 Test procedure

6.2.1.1.1 Inlet passage strength

One piece shall be tested with pressure applied to the inlet, with the internal releasing components in the normally closed position. Pressure-activated elements such as burst discs may be modified,

replaced with a plug or removed for the purpose of this test. The test shall be performed according to the procedure given in ISO 15500-2 using a pressure of 2,5 times the working pressure at 20 °C ± 5 °C.

6.2.1.1.2 Outlet passage strength

The outlets or venting orifices shall be plugged in a suitable way, without affecting the housing resistance. The internal triggering components such as fusible material or rupture discs shall be removed or otherwise opened or activated. Pressure shall be applied to the inlet of the device. The test shall be performed according to the procedure given in ISO 15500-2 using a pressure of 1,25 times the working pressure or the working pressure upstream of the outlet passage, whichever is greatest.

6.2.2 Fusible material

6.2.2.1 Test procedure

Test the fusible material in the PRD (thermally-activated or combination) hydraulically at 20 °C ± 5 °C using the following procedure.

a) Subject three randomly selected test specimens to a constant pressure of 1,2 times the working pressure for 30 min. For series-combination relief devices, the burst disc shall not be removed. For parallel-combination relief devices, only the thermally-activated part of the device shall be tested.

   During the test, the fusible material shall not begin to extrude out of the PRD.

b) Increase the pressure at a rate of less than or equal to 0,5 MPa/s to 2,3 times the working pressure or to the pressure at which the fusible material starts to extrude.

6.2.2.2 Requirement

If the extrusion of the fusible material begins at less than 1,7 times the working pressure, the device is considered to have failed the test.

6.3 Leakage

Follow the procedure for testing leakage given in ISO 15500-2, using the test temperatures and pressures given in Table 2. The PRD shall be either bubble-free or have a leakage rate <2 Ncm^3/h.

Table 2 — Test temperatures and pressures

Temperature [°C]	Pressure [MPa]
−40 or −20	75 % and 2,5 % of the working pressure
room temperature	2,5 % and 100 % of the working pressure
85 or higher	5 % and 100 % of the working pressure

6.4 Bending moment

The purpose of this test is to confirm proper design and construction of stand-alone, externally-threaded PRD designs. Test the PRD according to the corresponding procedure given in ISO 15500-2.

6.5 Continued operation

6.5.1 Test procedure

a) Randomly select five test specimens.

b) Cycle the PRD according to Table 3, with water or CNG or dry air or inert gas at between 10 % and 100 % of the working pressure, at a maximum cyclic rate of 10 cycles per minute.

Table 3 — Test temperatures and cycles

Temperature [°C]	Cycles
85 or higher	2 000
57 ± 2	18 000

6.5.2 Requirements

Following the test, there shall be no extrusion of the fusible material from the PRD.

At the completion of the test, the PRD shall conform to the requirements of 6.3 and 6.7.

6.6 Accelerated life

6.6.1 General

Fusible materials can creep and flow within the operating temperature range of natural gas vehicle PRDs.

Accelerated-life testing is performed to verify that the rate of creep is sufficiently low in order that the device can perform reliably for at least one year at 85 °C and for at least 20 years at 57 °C. Accelerated-life testing shall be performed on new PRD designs or designs in which the fusible material melt temperature or device activation mechanism is modified. For devices not using activation materials that can creep, testing and analysis shall be performed to verify that the device performs reliably for at least one year at 85 °C and at least 20 years at 57 °C.

6.6.2 Test procedure

a) Place the test specimens in an oven or liquid bath, holding the specimens' temperature to within ±1 °C throughout the test.

b) Elevate the pressure on the PRD inlet to 100 % of the working pressure and hold this constant to within ±0,7 MPa until activation. The pressure supply may be located outside the controlled temperature oven or bath. Limit the volume of liquid or gas to prevent damage to the test apparatus upon activation and venting.

Each device may be pressurized individually or through a manifold system.

6.6.3 Accelerated-life test temperature

The accelerated-life test temperature, T_L, is given in Celsius by the following formula:

$$T_L = 12{,}88 \cdot T_f^{\,0{,}420}$$

where T_f is the manufacturer's specified activation temperature, in Celsius.

6.6.4 Requirements

6.6.4.1 Three PRDs shall be tested at the manufacturer's specified activation temperature to verify that they activate in less than 10 h.

6.6.4.2 Five PRDs shall be tested at their accelerated-life test temperature. The time-to-activation for accelerated-life test devices shall exceed 500 h.

6.7 Benchtop activation

6.7.1 General

6.7.1.1 The purpose of the benchtop-activation test is to demonstrate that a PRD activates consistently throughout its life.

6.7.1.2 Test two PRDs without subjecting them to other tests in order to establish a baseline time for activation. The PRDs that have undergone the tests of 6.5 and 6.9 shall be tested according to 6.7 and meet the requirements of 6.7.2 or 6.7.3, as applicable.

6.7.1.3 Test thermally-activated relief devices in accordance with 6.7.2. Series-combination relief devices, activated by a combination of high pressures and temperatures acting together, shall be tested in accordance with 6.7.3. Parallel-combination relief devices, activated by high pressure and temperatures acting separately, shall be tested in accordance with 6.7.4.

6.7.2 Thermally-activated relief devices

6.7.2.1 Test setup

The test setup shall consist of either an oven or chimney capable of maintaining a gas temperature at 600 °C ± 10 °C in the area of the oven or chimney into which the PRD is inserted for testing. The PRD shall not be exposed directly to flame.

6.7.2.2 Test procedure

a) Pressurize the PRD to 25 % of the working pressure or 2 MPa, whichever is less.

b) The temperature shall remain within the acceptable range for 2 min prior to running the test.

c) Insert the PRD in the oven or chimney and record the time-to-activation, *t*.

6.7.2.3 Requirements

The PRDs subjected to the tests of 6.5, 6.8, 6.9, 6.13 and the tests from ISO 15500-2:2016, Clauses 10 and 18 shall activate no more than two minutes longer than the baseline activation time of the PRDs not subjected to those tests.

6.7.3 Series-combination relief devices

6.7.3.1 Test procedure

a) Place the PRD in an oven heated to a temperature 11 °C ± 1 °C above the yield temperature of the fusible material, until the temperature of the PRD is stabilized.

b) Pressurize the PRD until it activates.

6.7.3.2 Requirements

The PRDs subjected to the tests of 6.5, 6.8, 6.9, 6.13 and the tests from ISO 15500-2:2016, Clauses 10 and 18 shall activate at a pressure >75 % and <105 % of the activation pressure of a PRD not subjected to any previous testing.

6.7.4 Parallel-combination relief devices

6.7.4.1 Test procedure

a) Test the thermally-activated part of the PRD following the tests of 6.7.2.

b) Activate the pressure-activated part of the PRD by pressurizing until the rupture disc bursts.

6.7.4.2 Requirements

The PRDs subjected to the tests of 6.5, 6.8, 6.9, 6.13 and the tests from ISO 15500-2:2016, Clauses 10 and 18 shall be subjected to the test procedure in 6.7.2.2 and meet the following requirements:

a) the thermal part of the PRDs shall meet the requirements of 6.7.2.3;

b) the pressure-activated part shall activate at a pressure >75 % and <105 % of the activation pressure of a PRD not subjected to any previous testing.

This test shall be conducted at ambient temperature. The PRD shall be activated by pressurizing rapidly to 85 % of the rated burst pressure, held there for at least 30 s, and thereafter shall be raised at a rate not in excess of 0,69 MPa per minute, until the disk bursts or until the device relieves pressure.

The PRDs subjected to pressure cycling, thermal cycling, salt corrosion resistance, gas condensate corrosion resistance and impact due to drop and vibration, shall activate at a pressure which is at least 140 % of the manufacturer's specified service pressure but is not more than 105 % of the activation pressure, of the PRD which had not been subjected to previous design qualification tests.

6.8 Thermal cycling

6.8.1 Test procedure

Thermally cycle the PRD between −40 °C or −20 °C as applicable and 85 °C or higher, as follows.

a) Place a depressurized PRD in a fluid bath maintained at −40 °C or −20 °C as applicable or lower for a period of 2 h or more. Then transfer the device to a fluid bath maintained at 85 °C or higher within 5 min of having removed it from the cold bath.

b) Leave the depressurized PRD in the fluid bath maintained at 85 °C or higher for a period of 2 h or more. Then transfer the device to the fluid bath maintained at −40 °C or −20 °C as applicable or lower within 5 min of having removed it from the hot bath.

c) Repeat steps a) and b) until a total of 15 thermal cycles have been achieved.

d) With the PRD conditioned for a period of 2 h or more in the fluid bath of −40 °C or −20 °C as applicable, cycle the PRD between no more than 10 % and no less than 100 % of the service pressure for a total of 100 cycles.

When testing long trigger or remote devices, the longest length permitted by the design shall be used for this test.

6.8.2 Requirements

At the completion of the test, the PRD shall meet all the requirements of 6.3 and 6.7.

6.9 Condensate-corrosion resistance

6.9.1 Test procedure

a) Seal the outlet port of the PRD.

b) Fill the pressure side of the PRD with the test solution given in 6.9.2 and soak the device for 100 h at 20 °C ± 5 °C.

c) Empty the solution from the PRD and reseal the outlet port, then heat the device for an additional 100 h at 85 °C or higher.

At the end of this test, the PRD shall meet all the requirements of 6.3 and 6.7.

6.9.2 Test solution

The test solution, by volume percentage, shall consist of:

— Stoddard solvent, 84,8 %,

— benzene, 10,0 %,

— phosphate ester compressor oil, 2,5 %,

— water, 1,5 %,

— methanol 1,0 %, and

— mercaptan, 0,2 %.

6.10 Flow capacity

6.10.1 General

6.10.1.1 Three virgin random samples of the PRD and one of each of the PRDs subjected to the tests of 6.5, 6.8, 6.9, 6.13 and the tests from ISO 15500-2:2016, Clauses 10 and 18, shall be tested for flow capacity. Each device tested shall be made to operate by temperature, by pressure or a combination of temperature and pressure.

6.10.1.2 After activation per 6.7, and without cleaning, removal of parts or reconditioning, each PRD shall be subjected to an actual flow test wherein the amount of gas released by the device is measured. The individual flow capacities of each of tested PRDs shall fall within 10 % of the highest flow capacity recorded.

6.10.1.3 The rated flow capacity of the device shall be the average flow capacity of the nine tested samples and in line with the manufacturer specified flow capacity.

6.10.2 Test procedure

a) Conduct flow testing with air, inert gas or natural gas at 1,0 MPa ± 10 %.

b) Measure the temperature.

c) Correct the calculation of flow rate to 0,1 MPa absolute and 15 °C.

6.11 High-pressure activation and flow rate

6.11.1 General

Three devices shall be tested to determine the flow performance when activated at high pressure with a large volume of gas.

Since minimum gas volume in the setup of the test depends in part on the final results, more devices may be required to determine the correct initial setup.

6.11.2 Test setup

The test setup shall consist of either an oven or chimney which is capable of controlling air temperature and flow to achieve a consistent temperature of 600 °C ± 10 °C in the air surrounding the pressure relief device (PRD). The PRD shall not be exposed directly to flame. The PRD shall be mounted in a fixture that shall be documented. A volume of gas shall be installed ahead of the PRD, in accordance with the manufacturer's installation instructions. The volume of gas shall be sufficient that the PRD vents down to 10 % of the start pressure in no less than 10 s, and shall be enough that the PRD reaches a stable K_v before reaching 25 % of starting pressure. The testing conditions for the new and aged PRD comparison samples should be the same.

6.11.3 Test procedure

Pressurize the PRD to the manufacturer's specified service pressure ±2 %. In the case of multiple rated service pressures of a single design, the highest may be used as acceptable test conditions for all pressures. The gas temperature shall be below 40 °C. The pressure of the stored gas shall be measured in such a way that it is not affected by flow past the pressure measurement device. Place a thermocouple in the oven or chimney to monitor the temperature. The temperature shall remain within the acceptable range for two minutes prior to running the test. Insert the PRD into the oven or chimney. Record the pressure over time from the point of insertion into the oven until venting is complete.

6.11.4 Acceptable results

The flow of the devices shall not stop until the tank is below 10 % of initial pressure.

6.11.5 Data analysis and availability

The graph of the pressure data for all devices shall be made available to fuel container and/or vehicle manufacturers or integrator on request. Verification of the existence of these documents satisfies the intent of this provision.

6.12 Water jet protection

6.12.1 General

This test is intended for components that can be exposed to the exterior of a vehicle, particularly where pressure washing or road spray can be experienced, and having external openings or seals when installed per the manufacturers component literature.

6.12.2 Method of test

The part shall be tested in accordance with ISO 20653 for IPX9K adding 120° and 150°.

6.12.3 Acceptance criteria

The part shall not be damaged or otherwise rendered inoperable. Water shall not penetrate any external seals.

6.13 Impact due to drop

When subjected to a vertical drop of 2 m ± 5 % onto a smooth concrete floor or pad, PRDs in the final assembled form shall meet all operational performance requirements without loss of function or degradation of service life, or shall exhibit obvious exterior (physical) damage which indicates the part unsuitable for use. This requirement shall be demonstrated as follows.

a) PRD sample(s) selected at random shall be subjected to impact by being dropped from a height of 2 m ± 5 %, from the lowest point on the device without restricting its motion as a result of gravity, at room ambient temperature, onto a smooth concrete pad or floor. For devices having extended flexible elements such as hoses, these shall be dropped with the flexible element in the pre-installation condition, with no packaging material. Each sample shall be allowed to bounce on the concrete pad or floor after the initial impact. One sample shall be dropped in all six of the major axes (opposing directions of three orthogonal axes; vertical, lateral and longitudinal) of orientation. Alternatively, up to six samples may be used such that all six of the major axes are covered. After each drop, the sample shall be examined for visible damage. If any of the six dropped orientations do not show visible exterior damage that indicates that the part is unsuitable for use, then it shall meet the requirements of the vibration test in ISO 15500-2. At the manufacturer's discretion, one sample may be used for all directions.

b) If one or more of the dropped orientations exhibits visible exterior damage which indicates that the part is unsuitable for use, the damage signature(s) shall be graphically documented and provided to the container manufacturer as the relative measure for rejection of visibly damaged parts, that orientation shall not require functional testing.

7 Production batch inspection and acceptance testing

7.1 The PRD manufacturer shall institute a production batch inspection and acceptance testing programme that ensures consistent safety performance of the product.

7.2 Required batch testing

7.2.1 Benchtop activation

A PRD from each batch shall be subject to the appropriate benchtop activation test per 6.7. Virgin components may be used for the test.

Thermally activated PRDs shall activate within 2 min of the baseline activation time as established with the design qualification benchtop activation test.

7.2.2 The batch size is limited to what can be produced from a single batch of system critical components, or 1 000 units, whichever is less.