BRITISH STANDARD

BS EN 15611:2008
+A1:2010

Railway applications — Braking — Relay valves

ICS 45.060.01

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 15611:2008+A1:2010. It supersedes BS EN 15611:2008, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by [A1] 〈A1〉.

The UK participation in its preparation was entrusted to Technical Committee RAE/4, Braking.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN 15611:2008+A1:2010) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2011, and conflicting national standards shall be withdrawn at the latest by April 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document includes Amendment 1, approved by CEN on 2010-08-30.

This document supersedes EN 15611:2008.

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[A1] This document has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document. 〈A1〉

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard is applicable to relay valves designed to control the brake cylinder pressure of compressed air brakes fitted to railway vehicles, in association with an air brake distributor valve or other control device, and in response to a change in vehicle load that is either continuously variable or in two stages i.e. empty - loaded.

Relay valves operating with other pressures, in particular the brake pipe pressure, are not included.

This European Standard specifies the requirements for the design, manufacture and testing of relay valves.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 14478:2005, *Railway applications — Braking — Generic vocabulary*

EN 15355, *Railway applications — Braking — Distributor valves and distributor-isolating devices*

EN 15625, *Railway applications — Braking — Automatic variable load sensing devices*

EN 50125-1, *Railway applications — Environmental conditions for equipment — Part 1: Equipment on board rolling stock*

EN 60721-3-5:1997, *Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities — Section 5: Ground vehicle installations (IEC 60721-3-5:1997)*

EN 61373:1999, *Railway applications — Rolling stock equipment — Shock and vibration tests (IEC 61373:1999)*

EN ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation (ISO 228-1:2000)*

ISO 8573-1:2001, *Compressed air — Part 1: Contaminants and purity classes*

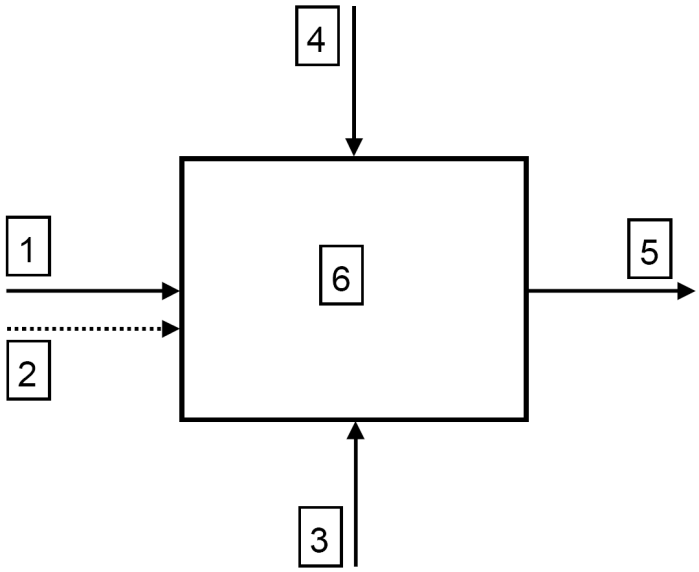
3 Terms and definitions, symbols and abbreviations

For the purposes of this document, the terms and definitions, symbols and abbreviations given in EN 14478:2005 and the following apply.

3.1 Terms and definitions

3.1.1
relay valve
device, the main function of which is to control a pneumatic output pressure as a function of the variation of one or more input pressures

NOTE 1 See Figure 1.



Key

1 first input pressure

2 second input pressure

3 control signal - continuous load sensing pressure (Lcp), or control signal - empty/load signal pressure (Lsp), or mechanical input (lever) or electrical input

4 auxiliary reservoir pressure, supply pressure (AR)

5 output pressure

6 relay valve

Figure 1 — Relay valve, pressures and control signals

NOTE 2 The definition of “relay valve” in EN 14478 is specific to a load dependant relay valve. This EN standard considers one or more input pressures in accordance with the diagram in Figure 1.

3.1.2
input pressure
control pressure received by the relay valve

NOTE Pressure generally considered as being the output pressure from a distributor or a brake control unit; sometimes referred to as pilot pressure or dummy brake cylinder pressure.

3.1.3
output pressure
pressure output from the relay valve

NOTE Pressure generally considered as being the brake cylinder pressure when the relay valve is used in a variable load braking system. This pressure can also be used as the input pressure to another relay valve. The output pressure can obtain one, two or three fixed levels or it can be changed continuously between a minimum and a maximum or vice versa.

3.1.4
relay valve ratio
ratio of the output pressure to input pressure

3.1.5
control signal
signal received from the continuous load sensing device (Lcp) or empty - loaded changeover device (Lsp) or a mechanical input (lever) or an electrical input that varies the relay valve ratio dependant on vehicle load

NOTE This can also be a speed signal or other parameter, dependant on the relay valve application.

3.1.6 Relay valve types

3.1.6.1
single stage relay valve
relay valve type A
relay valve with one fixed relay valve ratio, where the ratio can be less (step-down), equal or greater (step-up) than 1

3.1.6.2
multi stage relay valve
relay valve type B
relay valve with more than one fixed relay valve ratio, where the ratios can be less (step-down), equal or greater (step-up) than 1

3.1.6.2.1
relay valve type B1
multi stage relay valve that can change relay valve ratio during a brake application

NOTE Typically used on vehicles normally operated in empty or fully loaded condition.

3.1.6.2.2
relay valve type B2
multi stage relay valve where a change of relay valve ratio cannot take place during a brake application

NOTE Blocking the relay valve ratio during brake application is typically used to avoid frequent changeovers taking place on vehicles operated near the changeover weight.

3.1.6.2.3
empty/load relay valve
specific type of multi stage relay valve (type B1 or B2) with only two stages, giving an empty (tare) or a loaded output pressure proportional to input pressure dependant on the load signal input

3.1.6.3
variable load relay valve
relay valve type C
relay valve with a continuously changeable relay valve ratio, where a load signal is used to change the ratio

3.1.6.4
multi stage variable load relay valve
relay valve type C1
relay valve with a continuously changeable relay valve ratio, where a load signal is used to change the ratio and with a multi stage feature added

NOTE Typically a load signal is used to change the relay valve ratio and a control signal (automatic or manual) is used to change the stage(s). The typical result is that at the same load and input pressure, in the lower stage (e.g. P-mode, passenger train) results a lower output pressure and in a higher stage (e.g. R-mode, rapid passenger train) this results in a higher output pressure.

3.1.6.5
two (multi) input relay valve
relay valve type D
relay valve (type A, B or C) with two (or more) input pressures, controlling a single output pressure

3.1.6.6
variable load relay valve with kinked characteristic
relay valve type E
variable load relay valve (Type C) with a special, non-linear characteristic, which automatically comes into operation when the vehicle has more than a certain load

NOTE This function reduces (in comparison with a linear characteristic) the output pressure for low input pressures to a certain level to limit the heat impact to the wheels during continuous braking.

3.1.7
sensitivity
change of input pressure causing a variation of output pressure, when the change of input pressure is in the same direction, with no overshoot or reversal

3.1.8
initial sensitivity
change of input pressure, starting at 0 bar which causes the output pressure to start increasing

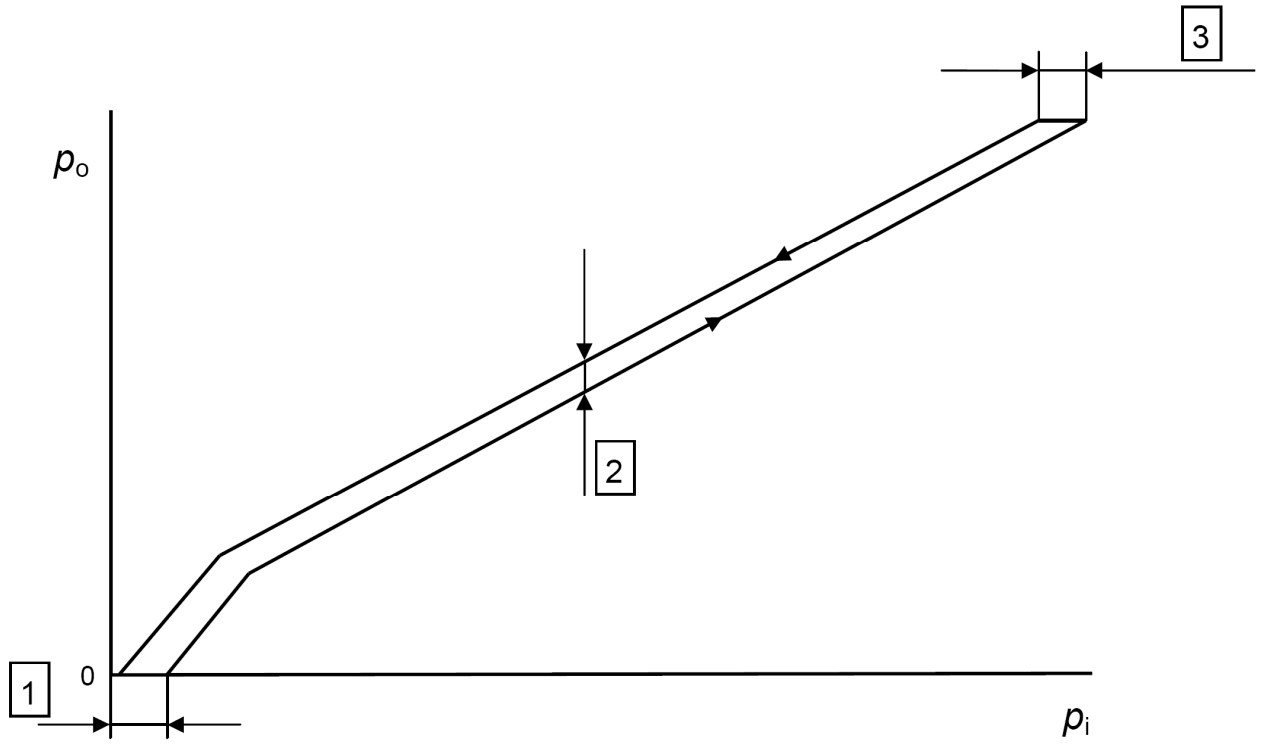
NOTE See Figure 2.

3.1.9
sensitivity at reversal
change of input pressure causing a variation of output pressure, when the change of input pressure is changing its direction from increasing to decreasing

NOTE See Figure 2.

3.1.10
hysteresis
difference in output pressure with the same input pressure, where the input pressure is first rising to a value and then, having been taken past that value, subsequently falls to the same value

NOTE See Figure 2.



Key

1 initial sensitivity

2 hysteresis

3 sensitivity at reversal

NOTE The figure is simplified for illustrative purposes, e.g. the real pressure development is not shown.

Figure 2 — Hysteresis and sensitivity

3.1.11
initial braking position
first braking step corresponding to a reduction of the brake pipe pressure of 0,4 bar to 0,5 bar, which results in an input pressure to the relay valve of (0,7 ± 0,1) bar

3.1.12
normal litre
Nl
unit of mass for gases equal to the mass of 1 l at a pressure of 1,013 2 bar (1 atmosphere) and at a standard temperature, often 0 °C or 20 °C

NOTE Airflow is often stated in normal litres per minute (Nl/min).

3.2 Symbols

p pressure

p_i input pressure

p_o output pressure

t time

3.3 Abbreviations

BCP brake cylinder pressure

Lcp Control signal - continuous load sensing pressure

Lsp Control signal - empty/load signal pressure

AR Auxiliary reservoir pressure, supply pressure

4 Design and manufacture

4.1 General

4.1.1 A relay valve shall enable a distributor valve to be used without any vehicle specific modification to the distributor, related to the brake cylinder volume. This includes the independence of the brake application and release times, the inshot feature and the output pressure development for any output (brake cylinder and piping) volume.

4.1.2 The use of a relay valve shall not alter any of the characteristics of the distributor and/or a brake control unit that are not specified in this standard.

4.1.3 The use of a relay valve shall enable the vehicle to maintain a nominally constant brake application or release time.

4.1.4 The use of a relay valve shall enable the brake cylinder pressure to be maintained between prescribed limits (e.g. interoperable or national). These limits may be defined by different brake modes or speed-dependent requirements or where there is a requirement to maintain a nominal constant brake mass percentage irrespective of load.

4.1.5 Table 1 below provides a description of relay valve types described in this standard with the relevant clause references.

Table 1 — Relay valve types and corresponding clauses

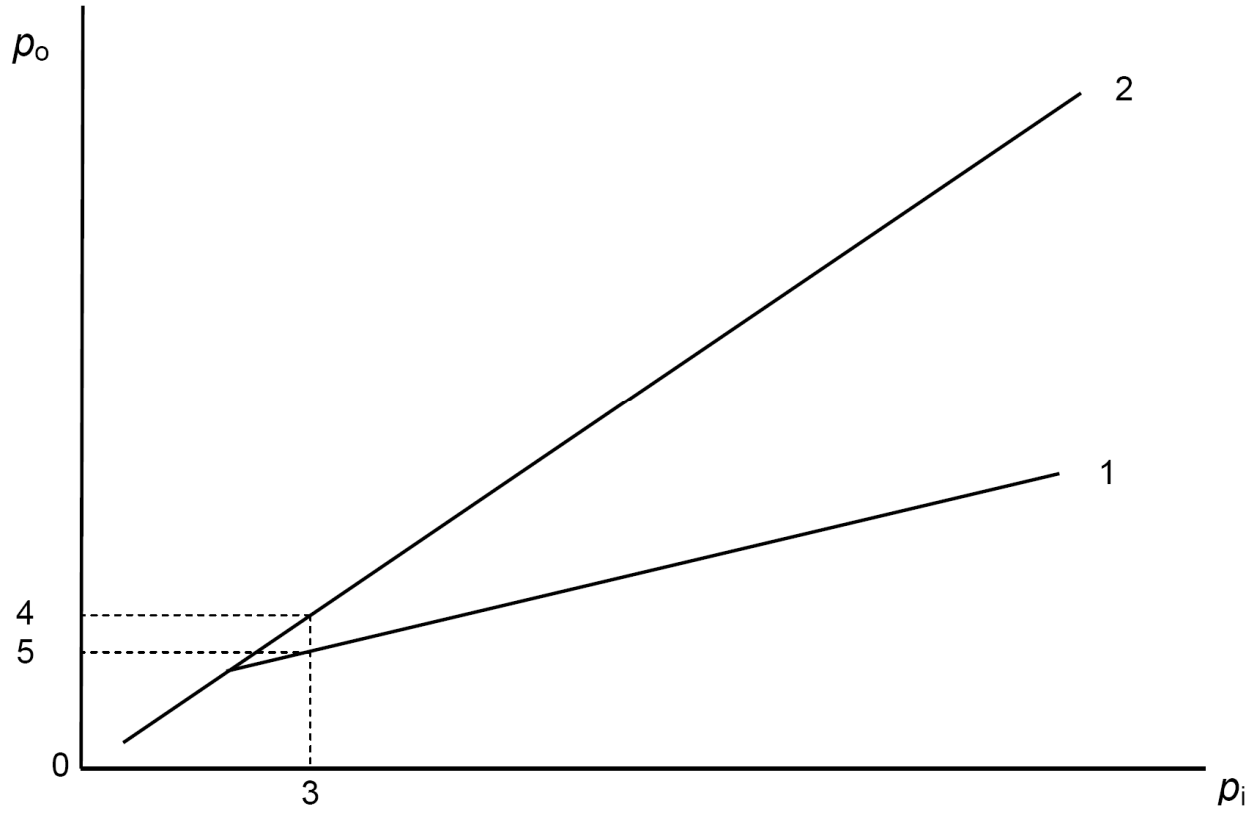
Type Symbol	Description	Comment	Definitions Clause Reference	Functional Requirement Clauses	Testing Clauses
A	One fixed relay valve ratio		3.1.6.1 Single stage relay valve	4.2.1 4.2.2.1 4.2.3 4.2.7 4.2.8 4.2.9 4.2.10 4.2.11 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 5	6.2.4.2 6.2.4.3 6.2.4.11 6.2.4.12 6.2.4.14 6.2.4.15 6.2.4.16 6.2.4.17
B – Basis of either B1 or B2 Types below	Two or more fixed relay valve ratios	Empty/loaded or low/high	3.1.6.2 Multi stage relay valve	4.2.1 4.2.2.1 4.2.2.2 4.2.3 4.2.7 4.2.8 4.2.9 4.2.10 4.2.11 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 5	6.2.4.2 6.2.4.3 6.2.4.4 6.2.4.11 6.2.4.12 6.2.4.14 6.2.4.15 6.2.4.16 6.2.4.17
B1		Change of relay valve ratios required/allowed during brake application	3.1.6.2.1	As for Type B plus 4.2.4	As for type B plus 6.2.4.5
B2		Change of relay valve ratio not allowed during brake application	3.1.6.2.2	As for Type B plus 4.2.5	As for Type B plus 6.2.4.6
C	Continuously changing relay valve ratio		3.1.6.3 Variable load relay valve	4.2.1 4.2.2.1 4.2.3 4.2.5 4.2.7 4.2.8 4.2.9 4.2.10 4.2.11 4.3 4.4 4.5 4.6 4.7 4.8 4.9 4.10 5	6.2.4.2 6.2.4.3 6.2.4.6 6.2.4.7 6.2.4.8 6.2.4.12 6.2.4.14 6.2.4.15 6.2.4.16 6.2.4.17
C1		Continuously changing relay valve ratio, with a multi stage feature added	3.1.6.4 Multi stage variable load relay valve	As for Type C plus 4.2.2.3	As for Type C plus 6.2.4.10
D	Two or more input pressures with „select high“ feature	overlay function to type A – C	3.1.6.5 Two (multi) input relay valve	As for Type A, B or C plus 4.2.2.4	As for Type A, B or C plus 6.2.4.13
E	Kinked characteristic	additional overlay function to type C	3.1.6.6 Variable load relay valve with kinked characteristic	As for Type C plus 4.2.6	As for Type C plus 6.2.4.9

4.2 Functional requirements

4.2.1 Minimum output pressure

The minimum output pressure of the relay valve (brake cylinder pressure) shall be such that a minimum brake force of 10 % of the maximum brake force in all conditions of vehicle load, is achieved in response to a nominal input pressure of 0,7 bar (Initial braking position). Figure 3 gives an example of the output pressure of a relay valve for different conditions of vehicle load.

NOTE The relay valve design may provide means to make the minimum output pressure changeable according to the requirements of different applications.



Key

1 empty condition

2 loaded condition

3 initial input pressure (0,7 ± 0,1) bar

4 initial output pressure loaded

5 initial output pressure unloaded

Figure 3 — Example of the output pressure p_o of a relay valve (brake cylinder pressure) in relation to the input pressure p_i for different conditions of vehicle load

4.2.2 Accuracy of the output pressure and changeover

4.2.2.1 General (type A, B1, B2, C, C1, E)

The output pressure of the relay valve shall be within the following tolerances, related to the minimum (empty)/maximum (loaded) figures, given by the type plate and the installation drawing of the relay valve:

— ± 0,1 bar for nominal output pressures ≤ 3,8 bar at an input pressure of (3,8 ± 0,02) bar;

— ± 0,15 bar for nominal output pressures > 3,8 bar at an input pressure of (3,8 ± 0,02) bar.

This requirement shall be tested in accordance with 6.2.4.4 (type B1 and B2), 6.2.4.7 (type C and C1), 6.2.4.9 (type E) and 6.2.4.11 (type A, B1 and B2).

4.2.2.2 Accuracy of the changeover of a two, or more, stage relay valve (type B, B1 and B2)

The relay valve shall be designed to changeover from the empty (low), to intermediate (if applicable), and to the loaded (high) condition and reverse, as defined in 4.2.3, at nominal values of the load signal pressures (Lsp).

The accuracy of the changeover shall be tested in accordance with 6.2.4.4.

4.2.2.3 Accuracy of the change of a variable load relay valve with a two stage function overlaid to the variable load brake function (type C1)

It shall be possible at any input pressure and any load control pressure (Lcp) to change from a lower to a higher level of the output pressure or vice versa.

The ratio of the gradient of the output to the input pressures between the higher value of the output pressure to the lower value shall be constant between initial and full service and within a tolerance of ± 10 % for any load condition; this condition is related to a nominal input pressure of 3,8 bar and shall be initiated by a pneumatic or electric control signal.

This requirement shall be tested in accordance with 6.2.4.10.

4.2.2.4 Accuracy of the output pressure of a relay valve designed for two or more input pressures (type D)

The output pressure of the relay valve shall correspond to the highest of the input pressures. The tolerance of the maximum output pressure nominal values shall be ± 0,1 bar, if the nominal value is ≤ 3,8 bar and ± 0,15 bar, if the nominal value is > 3,8 bar. In the case where two or more input pressures are acting simultaneously, the output pressure tolerance shall be a maximum of ± 0,20 bar, if the nominal value is ≤ 3,8 bar and ± 0,30 bar, if the nominal value is > 3,8 bar.

This requirement shall be tested in accordance with 6.2.4.13.

4.2.3 Load signal characteristics

The design of the relay valve shall allow interaction with at least one of the following load signal types:

a) manual empty-loaded signal, where this signal is provided by a lever, either mounted directly on the relay valve, or remotely operated on the vehicle to manually change from the low to the high output pressure, or vice versa;

b) pneumatic empty/load signal, where the relay valve shall be designed to operate on receipt of the relevant signal pressure dependant on the brake system design, as follows:

1) Where the changeover device is supplied from the AR, and Lsp/Lcp pressure is ≤ 0,5 bar this indicates a load that is less than the switching point and shall cause the relay valve to output its lower ratio. If Lsp/Lcp pressure is ≥ 3,0 bar this indicates a load greater than the switching point and shall cause the relay valve to output its higher ratio.

2) Where the changeover device is supplied from the BCP, the Lsp/Lcp indicating the loaded condition can either be 0 bar or equivalent to the brake cylinder pressure and shall cause relay valve to output its higher ratio.

NOTE The signal pressure is typically supplied as a load control signal pressure (Lsp) from a manually operated pneumatic device e.g. a changeover cock, or an automatic empty-loaded changeover device. Alternatively it is supplied as a continuous load sensing pressure (Lcp).

c) variable load signal, i.e. where the load sensing pressure (Lcp) comes from an automatic continuously variable load sensing device (weighing valve) giving continuous load information. See EN 15625.

4.2.4 Enabling of a change of relay valve ratio during brake application of a relay valve of type B1

Whilst the brakes are applied with a brake cylinder pressure > 1 bar, changes of the load sensing pressure (Lcp or Lsp) outside the limits of ≤ 0,5 bar and ≥ 3 bar shall initiate the change of the relay valve ratio.

For relay valves designated for a changeover during brake application (for speed dependent braking) the relay valve shall not prevent the changeover. See 4.2.5.

This requirement shall be tested in accordance with 6.2.4.5.

Higher values of the load sensing pressure may be required to achieve a change of relay valve ratio for other than freight applications e.g. for locomotives or multiple units. In this case the values of the load sensing pressure will be higher than the values contained in this requirement and the test in 6.2.4.5 shall be amended to meet the requirements of the specific relay valve application.

4.2.5 Prevention of a change of relay valve ratio during brake application of a relay valve of type B2 and a variable load relay valve, types C, C1, D, E

Whilst the brakes are applied with an output pressure ≥ 1 bar, changes of the load sensing pressure (Lcp or Lsp) of ± 0,5 bar shall not initiate a change of the relay valve ratio.

NOTE For specific applications, where the load is either fully loaded or tare, this requirement need not apply (for example tank wagons).

This requirement shall be tested in accordance with 6.2.4.6.

4.2.6 Kinked characteristic of a variable load relay valve (type E)

A variable load relay valve with kinked characteristic may be specified for use on SS-Wagons with tread brakes.

A relay valve with a kinked characteristic shall be designed to operate in association with distributor valves compliant with EN 15355, for use on tread braked wagons of greater than 14,5 t axle loads. The required characteristic shall reduce the output pressure (BCP) at lower brake demands whilst raising the output pressure (BCP), at moderate to high brake demands, to the equivalent value required to achieve the maximum braking rate at full load.

The relay valve characteristic shall be designed such that a change of characteristic is achieved at input pressures A and B, see Figure 11, established for equivalent brake pipe reductions of 0,8 bar and 1,2 bar respectively as sensed by the distributor. The values of input pressures A and B shall be in the range of 1,8 bar to 2,0 bar and 2,9 bar to 3,15 bar respectively. The increase in output pressure (BCP) achieved between the input pressure values A and B shall increase in relation to the increase in input pressure.

The output pressure achieved for input pressure values below input pressure A shall be lower than the equivalent straight line characteristic for the maximum axle load. The output pressure achieved for input pressure values above input pressure B shall return to the equivalent straight line characteristic for the maximum axle load.

The relay valve shall also be designed for defined output pressures which correspond to 33 %, 67 %, 80 % and 100 % of the equivalent fully loaded condition signal (see Figure 11).

These requirements shall be tested in accordance with 6.2.4.9.

4.2.7 Interaction of a relay valve and a distributor valve

Any combination of a distributor and a relay valve (either integral or separate) shall be approved according to this standard and the relevant distributor valve standard.

The following accuracy shall be achieved when the pair is fitted to a vehicle if necessary by adjustment of the relay valve output. The design of the relay valve shall allow for this adjustment to be made. In combination with a distributor valve of a defined type the relay valve shall ensure the following characteristics.

a) For brake application:

   1) For all distributor valve/relay valve combinations, except matched pairs of interoperable distributor valves and relay valves:

      i) For a test conducted using an actual distributor in combination with a relay valve for an input pressure to the distributor of 0 bar (emergency brake application) and with the distributor output pressure of (3,8 ± 0,1) bar, which forms the input to the relay valve, the accuracy of the relay valve output pressure shall be ± 0,2 bar. This applies to the empty and loaded conditions.

      ii) The output pressure rise time (brake application time measured using an emergency brake application from the start of the rise of the output pressure to 95 % of its maximum value) of the relay valve shall be 3 s to 6 s with an input pressure rise time to the relay valve of 3 s to 5 s.

   2) For matched pairs of interoperable distributor valves and relay valves, if specifically required by the customer:

      i) For a test conducted using an actual distributor in combination with a relay valve for an input pressure to the distributor of 0 bar (emergency brake application) and with the distributor output pressure of (3,8 ± 0,1) bar, which forms the input to the relay valve, the accuracy of the relay valve output pressure shall be ± 0,1 bar, when achieved by adjustment of the matched pair. This applies to the empty and loaded conditions.

      ii) The output pressure rise time (brake application time measured using an emergency brake application from the start of the rise of the output pressure to 95 % of its maximum value) of the relay valve shall be 3 s to 6 s with an input pressure rise time to the relay valve of 3 s to 5 s.

      iii) For relay valves of type C, C1, D and E when used in a matched pair, this combination shall have a performance at intermediate load conditions Lcp3 and Lcp5 (see Table 6), providing an output pressure accuracy of ± 0,15 bar. At load condition Lcp4 the output pressure accuracy shall be ± 0,1 bar. This shall be tested with the load sensing pressure increasing from Lcp3.

b) For brake release, all distributor valve/relay valve combinations:

   1) The output pressure shall continuously follow the drop of the input pressure from its maximum to 0,1 bar. The time delay for the start of the drop of the output pressure shall be ≤ 10 % of the total allowed release time for the distributor valve;

2) When the input pressure has fallen to 0,05 bar, the output pressure shall fall to ≤ 0,05 bar not more than 15 s later.

These requirements shall be tested in accordance with 6.2.4.14 and 6.2.4.17.

4.2.8 Hysteresis

The maximum hysteresis of any relay valve shall be ≤ 0,15 bar, at a relay valve ratio of 1.

For single stage relay valves (type A) the maximum hysteresis shall be ≤ 0,10 bar.

This requirement shall be tested in accordance with 6.2.4.8 to 6.2.4.11.

4.2.9 Sensitivity

The sensitivity of a relay valve with a relay valve ratio of 1 or greater at 20 °C shall be ≤ 0,1 bar.

The sensitivity of a relay valve with a relay valve ratio less than 1 shall be such that a minimum of 5 steps of output pressure can be achieved between the initial input pressure and maximum input pressure.

The initial sensitivity of any relay valve at 20 °C shall be ≤ 0,3 bar. An input pressure of 0,3 bar shall cause an output pressure of ≥ 0,1 bar in any load situation.

The sensitivity at reversal of a relay valve with a relay valve ratio of 1 or greater, shall be ≤ 0,2 bar.

The sensitivity at reversal of a relay valve with a relay valve ratio greater than 0,5 and less than 1 shall be ≤ 0,4 bar.

There is no requirement for the sensitivity at reversal of a relay valve with a relay valve ratio less than 0,5.

These requirements shall be tested in accordance with 6.2.4.12.

4.2.10 Flow

The relay valve shall be capable of operating within the requirements of this standard with the possibility of a wide variation in the volume attached to the output. Any volume limitations of a specific relay valve shall be identified by the manufacturer in the relevant technical documents and the operating capability confirmed as part of the vehicle test.

4.2.11 Leakage

The sealing arrangement within the relay valve shall prevent any unacceptable loss of air.

At an environmental temperature of (20 ± 5) °C, the relay valve shall not have a leakage rate of greater than 0,005 Nl/min for the AR, 0,001 Nl/min for the input pressure and 0,003 Nl/min for the output pressure and Lcp/Lsp, at normal working pressures. This requirement shall be tested in accordance with 6.2.4.3.

At an environmental temperature of – 25 °C, also at + 70 °C the relay valve shall not have a leakage rate of greater than 0,01 Nl/min at the normal working pressures. This shall be tested in accordance with 6.2.4.16.

At – 40 °C ≤ environmental temperature < – 25 °C the relay valve shall not have a leakage rate of greater than 0,1 Nl/min at normal working pressures. This shall be tested in accordance with 6.2.4.16.

4.2.12 Change of relay valve ratio

The design shall enable the relay valve ratio to be controlled by one or more of the following means:

a) a mechanical means e.g. a screw for adjusting the relay valve ratio (fixed setting, unchangeable during operation);

b) mechanical means e.g. a lever or electrical means e.g. a magnet valve to switch the relay valve ratio during operation;

c) signal pressure(s) to switch the relay valve ratio from a first to a second (third) level of output pressure or to change the relay valve ratio continuously.

4.3 Shock and vibration

The relay valve shall be able to operate without restriction under shock and vibration conditions as specified by EN 61373:1999, Category 1, Class A or B.

The relay valve shall fulfil the specified requirements during a random vibration test in accordance with EN 61373:1999, Clause 8.

The relay valve shall withstand a simulated long life test at increased random vibration levels in accordance with EN 61373:1999, Clause 9 without any loss of performance.

The relay valve shall withstand shock testing in accordance with EN 61373:1999, Clause 10 without any loss of performance.

These requirements shall be tested in accordance with 6.2.4.15.

4.4 Environment requirements

4.4.1 General

The design shall take into account that the relay valve shall be able to be put into service and operate normally in the conditions and climatic zones for which it is designed and in which it is likely to run, as specified in this standard.

NOTE 1 The environmental conditions are expressed in classes for temperature, humidity, etc., thereby giving the vehicle designer the choice of a relay valve suitable for operation on a vehicle all over Europe, or have a restricted use.

NOTE 2 The environment range limits specified are those that have a low probability of being exceeded. All specified values are maximum or limit values. These values may be reached, but do not occur permanently. Depending on the situation there may be different frequencies of occurrence related to a certain period of time.

NOTE 3 The environment requirements of this document cover the environment requirements of the HS RST TSI which only refers to EN 50125-1.

The relay valve shall be tested in accordance with requirements given in Clause 6 of this standard including where required environmental/climatic testing.

4.4.2 Temperature

The relay valves covered by this standard shall be able to operate:

— at – 25 °C ≤ environmental temperature ≤ 70 °C without any deviation from the technical requirements specified in Clause 4 in this standard;

— at – 40 °C ≤ environmental temperature < – 25 °C with allowed deviation from the technical requirements specified in this standard but without affecting the function of the relay valve.

In the range from – 40 °C ≤ environmental temperature < – 25 °C the values of sensitivity and hysteresis shall be not more than two times higher than at normal temperatures. The tolerances of the pressures shall be not more than four times higher than at normal temperatures.

The leakage rate from – 40 °C ≤ environmental temperature < – 25 °C and at + 70 °C is defined in 4.2.11.

These requirements shall be tested in accordance with 6.2.4.16.

The purchaser can specify higher or lower extreme temperature limit values if operational constraints demand it. In this case the temperature limit values used in the extreme temperature tests 6.2.4.16 shall be changed accordingly.

4.4.3 Other environmental conditions

4.4.3.1 General

The following environmental conditions shall be considered in the design of the relay valve.

It shall be demonstrated that these environmental conditions have been taken into account in the design of the relay valve. It is sufficient for the supplier to make a declaration of conformity stating how the environmental conditions in the following clauses have been taken into account.

If not specifically required to be tested as part of the type testing requirements in Clause 6 of this standard, suitable tests and/or design assessments considering the effect of the following environmental conditions on the relay valve, shall be used in the development/design proving of the relay valve, prior to type testing.

4.4.3.2 Altitude

The relay valve shall be able to operate without restrictions up to an altitude of 2 000 m.

4.4.3.3 Humidity

The following external humidity levels shall be considered:

— yearly average: ≤ 75 % relative humidity;

— on 30 days in the year continuously: between 75 % and 95 % relative humidity;

— on the other days occasionally: between 95 % and 100 % relative humidity;

— maximum absolute humidity: 30 g/m^3 occurring in tunnels.

An operationally caused infrequent and slight moisture condensation shall not lead to any malfunction or failure.

The psychometric charts contained in EN 50125-1 shall be used to establish the range of variation of the relative humidity for the different temperature classes that it is considered will not be exceeded for more than 30 days per year.

At cooled surfaces, 100 % relative humidity can occur causing condensation on parts of equipment; this shall not lead to any malfunction or failure.

Sudden changes of the air temperature local to the vehicle can cause condensation of water on parts of equipment with rate of 3 K/s and maximum variation of 40 K; these conditions particularly occurring when entering or leaving a tunnel shall not lead to any malfunction or failure of the equipment.

4.4.3.4 Rain

Rain rate of 6 mm/min shall be taken into account. The effect of rain shall be considered depending on the possible equipment installation together with wind and vehicle movement.

4.4.3.5 Snow, ice and hail

Consideration shall be given to the effect of all kinds of snow, ice and/or hail. The maximum diameter of hailstones shall be taken as 15 mm, larger diameter can occur exceptionally. The effect of snow, ice and hail shall be considered depending on the equipment installation together with wind and vehicle movement.

4.4.3.6 Solar radiation

Equipment design shall allow for direct exposure to solar radiation at the rate of 1 120 W/m^2 for a maximum duration of 8 h.

4.4.3.7 Resistance to pollution

The effects of pollution shall be considered in the design of equipment and components. Means may be provided to reduce pollution by the effective use of protection of the relay valve. The severity of pollution can depend upon the location of the equipment, therefore the effects of the kinds of pollution indicated in Table 2 shall be considered as a minimum.

Table 2 — Pollution

Pollution	Class to be considered
Chemically active substances	Class 5C2 of EN 60721-3-5:1997
Contaminating fluids	Class 5F2 (electrical engine) of EN 60721-3-5:1997 Class 5F3 (thermal engine) of EN 60721-3-5:1997
Biologically active substances	Class 5B2 of EN 60721-3-5:1997
Dust	Class 5S2 of EN 60721-3-5:1997
Stones and other objects	Ballast and other objects of maximum 15 mm diameter
Sand	Class 5S2 of EN 60721-3-5:1997
Sea spray	Class 5C2 of EN 60721-3-5:1997

4.5 Compressed air quality

It shall be possible to operate the relay valve without restrictions with at least the compressed air quality according to the following classes defined by ISO 8573-1:2001:

— Class 4 – for the maximum particle size and the maximum concentration of solid contaminants;

— Class 4 – for the water dew point;

— Class 4 – for the maximum total (droplets, aerosols and vapours) oil concentration.

The relay valve shall be capable of operating in an air supply system that is not fitted with an air dryer, or when the air dryer is out of order. The air system should therefore include some means of preventing water collecting within the relay valve and hence freezing of the water in conditions below 0 °C.

4.6 Service life

No specific requirements for the relay valve to attain a particular service life are contained in this standard.

Any testing to establish the service life of a relay valve shall be conducted as part of the product development.

NOTE The service life of the relay valve is a function of the environment/operating conditions in which the relay valve will function, and the requirements for the relay valve to achieve a serviceable life in accordance with the maintenance requirements of the vehicle to which it is fitted.

4.7 Fire behaviour

The materials used in the manufacture of the relay valve shall prevent the emission of fumes or gases that are harmful and dangerous to the environment, particularly in the event of fire.

The assembled relay valve shall limit fire ignition, propagation and the production of smoke in the event of fire on primary ignition from a source of 7 kW for 3 min.

4.8 External appearance

The dimensions and the co-ordinates and threads of the ports and fixing points of the relay valve shall comply with the detail given by the relevant drawings.

The design of the relay valve shall ensure that the exterior surfaces of the relay valve are free of sharp edges and corners that could be dangerous to those people handling the relay valve or, when installed on a vehicle, working on adjacent equipment.

This requirement shall be checked in accordance with 6.2.4.2.

4.9 Design requirements regarding pressure stress

The design of the relay valve shall allow safe required performance with a maximum supply pressure of 10 bar. It shall be taken into consideration that maximum supply pressure can be reached in other pneumatic circuits of the relay valve when the standard requires such a function.

4.10 Interface

4.10.1 General

A relay valve shall be capable of being installed on the vehicle in accordance with 4.10.2 and 4.10.3 or directly mounted to a distributor valve.

4.10.2 Mechanical

The interface of the relay valve to the vehicle shall be via a mounting bracket or manifold. The connectors shall be suitably sized to meet the physical loadings identified in this standard. The interface of the relay valve with manifold or bracket is dependant on the individual design of the relay valve.

4.10.3 Pneumatic

The relay valve shall be mountable to a pipe bracket or a manifold which itself is connected to the vehicle body.

The pipe connection threads of a pipe bracket or manifold for the input pressure, the supply reservoir and the output pressure shall be either G1/2 or G3/4. For the load sensing pressure the connection threads shall be G1/4 or G1/2. The load sensing pressure connection may be on the body of the relay valve. All threads shall be in accordance with EN ISO 228-1.

5 Materials

The selection of the material and the manufacturing process shall comply with the requirements of this standard, technical specification and/or the relevant manufacturing drawings.

6 Type tests

6.1 General

The following type tests shall be carried out in order to assess the performance of the relay valve against the requirements of this standard.

All the test requirements shall be achieved to obtain type test compliance. The type tests shall be conducted and the records shall be kept as evidence of the compliance with this standard.

The tests shall be conducted on individual relay valves.

The figures used representing test results are given for clarity and are not conforming in all required details (for example the scale) with the actual performance required.

Prior to type testing the applicable values of all relevant pressures shall be established from the relevant design documentation for the particular type of relay valve to be tested.

6.2 Individual relay valve tests

6.2.1 Test bench for individual relay valves

The type tests shall be performed on a test bench specifically designed such that all the requirements given by this standard for the testing of the relay valve can be performed.

A diagram of the test bench that shall be used to show conformity of the relay valve with the requirements of 4.2 is shown in Figure 4. This test bench arrangement or an equivalent may be used for both ambient and extreme temperature testing when used in association with a thermostatic enclosure. The dimensions and other characteristics of the test bench components shall be provided to ensure the performance of the test bench is in accordance with the requirements of this specification. This shall be verified to ensure that constructional elements of the test bench have not affected that performance.

A test bench shall include:

a) measuring instruments for the following pressures:

   1) input pressure(s);

   2) output pressure(s) BCP;

   3) control pressure (Lsp/Lcp);

   4) auxiliary reservoir pressure (AR);

b) a device to create the input pressure and the load signal pressure with an accuracy of at least ± 0,02 bar.

The measuring instrumentation used on the test bench shall be calibrated and have a maximum deviation of 0,02 bar for the pressure measurement. Pressure tolerances are stated as applicable in the following subclauses of 6.2.

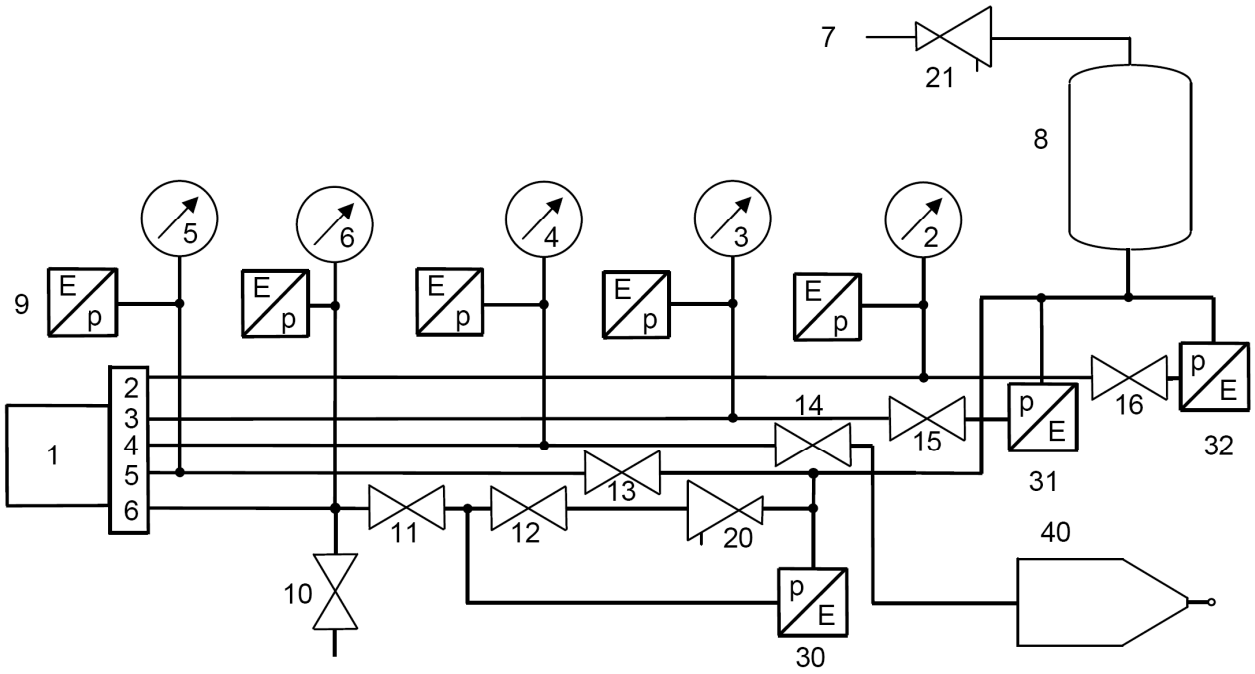
The test bench shall be capable of simulating a brake cylinder volume in the complete range that the relay valve is capable of supplying.

The isolating cocks shall be situated at a place, that the pipe volume between isolating cocks and the relay valve is ≤ 200 cm³ including the pipework to and the measuring instrument itself.

The pipe volume between isolating cock and relay valve, including the pipework to, and the measuring instruments itself, shall be known to allow the calculation of the leakage rates.

The auxiliary reservoirs shall be of a suitable size to the output volume (brake cylinder), with means to pressurize them to a range from 5 bar to 10 bar.

The test bench leakage shall not be greater than 0,001 Nl/min in any separated pipe or reservoir volume.



Key

1	relay valve
2	pressure gauge/pressure to electrical signal transducer - first input pressure
3	pressure gauge/pressure to electrical signal transducer - second input pressure
4	pressure gauge/pressure to electrical signal transducer - output pressure (BCP)
5	pressure gauge/pressure to electrical signal transducer - auxiliary reservoir pressure (AR)
6	pressure gauge/pressure to electrical signal transducer - control pressure (Lsp/Lcp)
7	air supply
8	auxiliary reservoir
9	pressure to electric signal transducer
10,11,12,13,14,15,16	isolating cock
20,21	pressure reducer
30,31,32	electric to pressure controller
40	brake cylinder (variable)

NOTE Recommended pipe sizes are for 2 and 3: 10 mm diameter and 1,0 mm wall thickness; for 4 and 5: 19 mm diameter and 1,5 mm wall thickness; for 6: 6 mm diameter and 1,0 mm wall thickness.

Figure 4 — Test bench for individual relay valves

The pressure controller to generate the input pressure and the Lsp or Lcp pressure shall work smoothly and continuously, with controlled gradients. The overshoot shall not exceed 0,02 bar, see Figure 5.

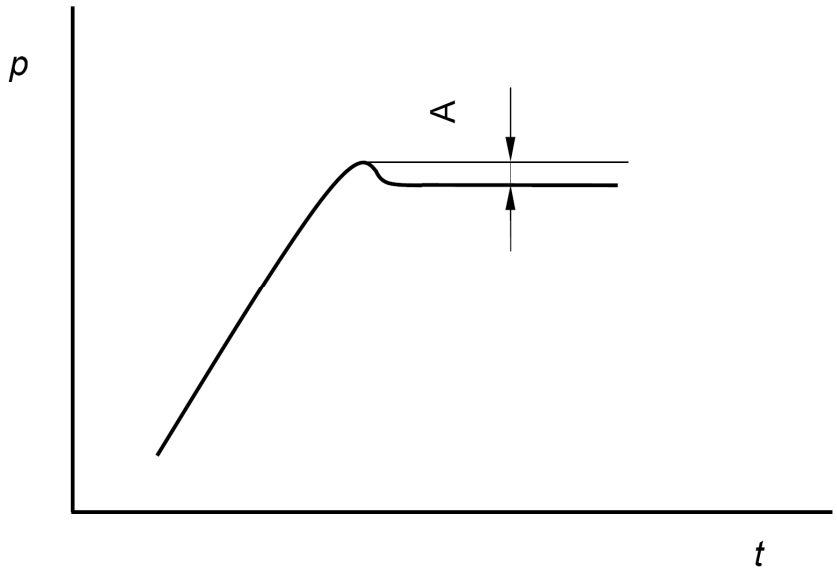


Figure 5 — Allowed overshoot "A" ≤ 0,02 bar in adjusting the input pressure and the load control pressure in relation to time

6.2.2 Sampling for type tests

A sample of ten relay valves shall be taken from the production.

6.2.3 Test temperature and air quality

The tests described in the following except the type tests of 6.2.4.16 shall be performed at (20 ± 5) °C. The tests shall be performed with an air quality of the compressed air of at least class 4-4-4 as specified in ISO 8573-1:2001.

6.2.4 Procedure for type tests

6.2.4.1 Principle

The tests on the sample of ten (10) relay valves shall be carried out in the order shown in Table 3. The tests shall be applied to the different relay valve types as shown in Table 4.

Table 3 — Sample testing

Subclause	Test	Test valve number									
		1	2	3	4	5	6	7	8	9	10
6.2.4.2	Check of physical and geometrical characteristics	x	x	x	x	x	x	x	x	x	x
6.2.4.3	Leakage	x		x		x		x			x
6.2.4.4	Characteristics of the output pressure in relation to the load sensing pressure of a two, or more, stage relay valve	x				x			x		
6.2.4.5	Additional test of the change of the relay valve ratio for two stage relay valves whilst brake is applied	x				x			x		
6.2.4.6	Additional test of the prevention of the change of the relay valve ratio during brake application	x				x			x		
6.2.4.7	Characteristics of the output pressure in relation to the control signal Lsp of variable load relay valve	x				x			x		
6.2.4.8	Characteristics of the output pressure in relation to the input pressure of a variable load relay valve without kinked characteristic (type C, C1, D)	x				x			x		
6.2.4.9	Characteristics of the output pressure in relation to the input pressure of a variable load brake valve with kinked characteristic (Type E)	x				x			x		
6.2.4.10	Characteristic of a variable load relay valve with a two stage function overlaid to the variable load brake function	x				x			x		
6.2.4.11	Characteristics of the output pressure in relation to the input pressure of a relay valve with one or more fixed ratios	x				x			x		
6.2.4.12	Sensitivity	x				x			x		
6.2.4.13	Additional test for relay valves with two, or more, input pressures	x				x			x		
6.2.4.14	Interaction of a relay valve and a distributor valve – simulated test	x				x			x		
6.2.4.15	Shock and vibration		x								
6.2.4.16	Operation at extreme temperature			x				x			
6.2.4.17	Interaction of a relay valve and a distributor valve – combination test	x									

Table 4 — Table of tests to be conducted on each relay valve type

Test subclause	Technical requirement	Test	Applicable to relay valve types (see 3.1.6)
6.2.4.2	4.8	Check of physical and geometrical characteristics	all
6.2.4.3	4.2.11	Leakage	all
6.2.4.4	4.2.2.2	Characteristics of the output pressure in relation to the load sensing pressure of a two, or more, stage relay valve	B1, B2
6.2.4.5	4.2.3	Additional test of the change of the relay valve ratio for two stage relay valves whilst brake is applied	B1
6.2.4.6	4.2.5	Additional test of the prevention of the change of the relay valve ratio during brake application	B2, C, C1, D, E
6.2.4.7	4.2.2	Characteristics of the output pressure in relation to the control signal Lcp of variable load brake relay valve	C, C1
6.2.4.8	4.2.2	Characteristics of the output pressure in relation to the input pressure of a variable load relay valve without kinked characteristic	C, C1, D
6.2.4.9	4.2.6	Characteristics of the output pressure in relation to the input pressure of a variable load relay valve with kinked characteristic	E
6.2.4.10	4.2.2	Characteristic of a variable load relay valve with a two stage function overlaid to the variable load brake function	C1
6.2.4.11	4.2.2	Characteristics of the output pressure in relation to the input pressure of a relay valve with one or more fixed ratios	A, B1, B2
6.2.4.12	4.2.9	Sensitivity	all
6.2.4.13	4.2.2.4	Additional test for relay valves with two, or more, input pressures	D
6.2.4.14	4.2.7	Interaction of a relay valve and a distributor valve – simulated test	all
6.2.4.15	4.3	Shock and vibration	all
6.2.4.16	4.4.2	Operation at extreme temperatures	all
6.2.4.17	4.2.7	Interaction of a relay valve and a distributor valve – combination test	all

6.2.4.2 Check of physical and geometrical characteristics

6.2.4.2.1 Test procedure

In accordance with the particular order documentation and approval drawings, dimensional accuracy shall be verified by means of appropriate measuring instruments and form gauges e.g. threaded connections may be

checked using GO/NOT GO gauges in accordance with EN ISO 228-2. The external surfaces shall be checked for sharp edges and corners.

6.2.4.2.2 Pass/fail criteria

The result is satisfactory if all the specified characteristics are met and no sharp edges and corners are present on the external surfaces.

6.2.4.3 Leakage

6.2.4.3.1 Test procedure

The following tests shall be carried out on the test bench shown in 6.2.1. Leakage rates shall be stated in Nl/min. The leakage rate shall be calculated from a measured pressure drop and a known volume inside the relay valve and the pipe of the test bench up to the stop cock.

With the air supply regulated to give an auxiliary reservoir pressure of (9,9 ± 0,1) bar and an Lsp (as applicable) pressure of (4,5 ± 0,1) bar increase the input pressure to (3,8 ± 0,1) bar. Close cocks 10 to 16 and wait 30 s.

Record the pressures of the input, auxiliary reservoir, output and Lsp/Lcp. After 60 s record all pressures again.

6.2.4.3.2 Pass/fail criteria

Input pressure leakage shall be < 0,001 Nl/min, AR leakage shall be < 0,005 Nl/min; output pressure leakage and Lsp/Lcp leakage shall be < 0,003 Nl/min.

NOTE The following table shows pressure change values occurring in a volume of 0,1 l with a leakage rate quoted in Nl/min (Normal Litres at 0 bar, 20 °C).

Table 5 — Leakage air volume in relation to pressure drop (e.g. for a volume of 0,1 l)

Pressure drop in a volume of 0,1 l, within 1 min	Leaking air volume, Nl/min
0,01	0,001
0,03	0,003
0,05	0,005

6.2.4.4 Characteristics of the output pressure in relation to the load sensing pressure of a two, or more, stage relay valve (type B1 and B2)

6.2.4.4.1 Test procedure

The test shall establish the accuracy of the output pressure and the changeover in accordance with 4.2.2.2.

The nominal values of the output pressure for the empty (low), the loaded (high) and intermediate levels (if applicable), conditions shall be tested using a nominal input pressure of (3,8 ± 0,02) bar.

Nominal values of the Lcp, causing the changeover from the empty (low), intermediate (if applicable) and to the loaded (high) condition and vice versa, shall be established from the relevant design documentation (if applicable). These may vary dependant on whether an applied or released brake is being simulated.

Figure 6 below shows in principle the performance of an empty/load relay valve having an internal changeover mechanism operating in response to an analogue Lcp signal.

The following tests apply to relay valves with an internal changeover mechanism using an Lcp signal or which use an input pressure signal (Lsp).

For relay valves which utilise the relay valve output pressure as the source of the Lsp signal, the following tests are applicable if the Lsp signal is reversed (i.e. connected (high) to the relay valve input pressure to produce the empty condition and vented (0 bar) to produce the loaded condition). The resultant output pressures will therefore be reversed accordingly.

6.2.4.4.2 Test sequence for type B1 and B2

Using the test bench of 6.2.1, charge the auxiliary reservoir pressure (AR) to (9 ± 0,5) bar and set the input pressure to 0 bar (gauge 2). Then follow the step sequence as below.

1) Adjust the Lsp/Lcp to 0 bar, using cocks 10, 11, 12 and electric to pressure controller 30.

2) Increase the input pressure (gauge 2) to (3,8 ± 0,02) bar within 3 s to 5 s, using electric to pressure controller 31.

3) Wait 10 s, then measure and record the output pressure for the empty (low) condition.

4) Decrease the input pressure to 0 bar (gauge 2).

5) Increase the Lcp to the upper tolerance of the changeover value or Lsp to its high value for the empty to loaded (low to high) changeover condition.

6) Increase the input pressure to (3,8 ± 0,02) bar within 3 s to 5 s, using electric to pressure controller 31.

7) Wait 10 s, then measure and record the output pressure (gauge 4) for loaded (high) condition.

8) Decrease the input pressure to 0 bar.

9) Decrease the Lcp to the lower tolerance of the nominal changeover point, or Lsp to 0 bar, for the loaded to empty (high to low) changeover condition.

10) Increase the input pressure to (3,8 ± 0,02) bar within 3 s to 5 s, using electric to pressure controller 31.

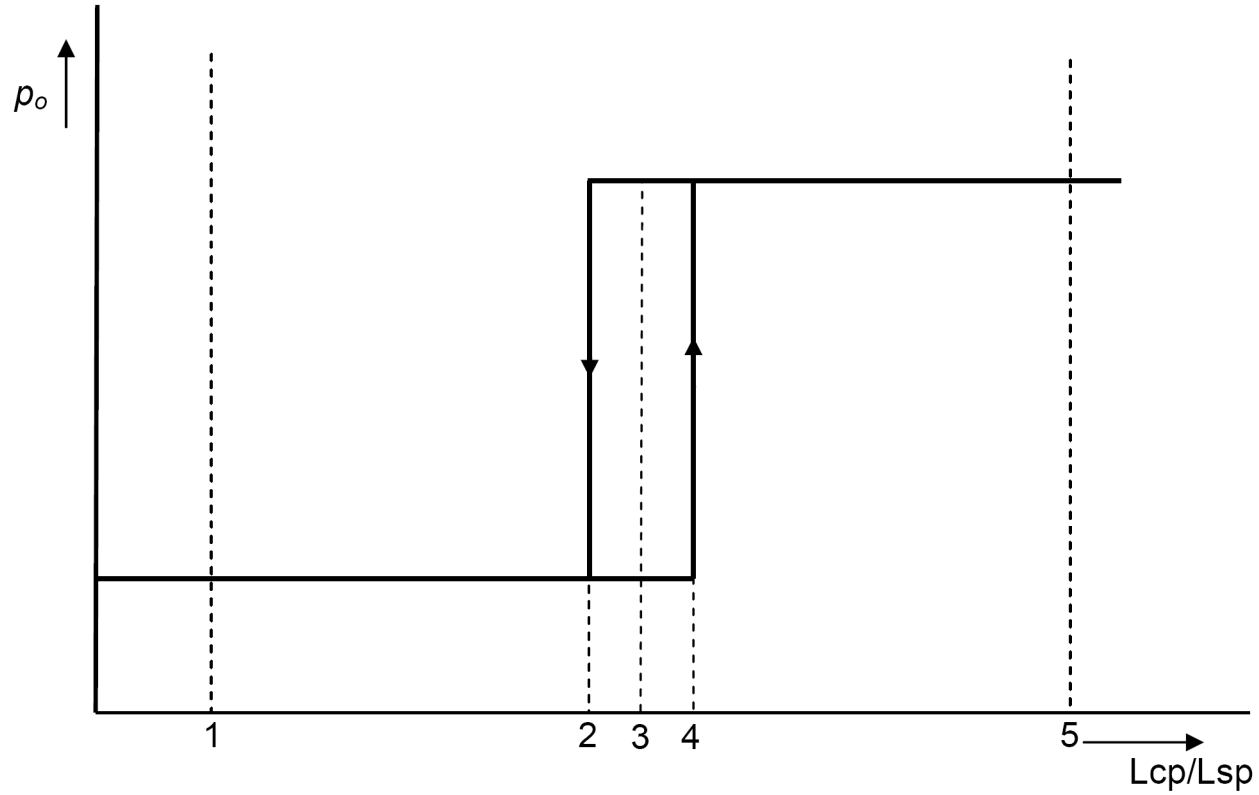
11) Wait 10 s, then measure and record the output pressure for empty (low) condition.

12) Produce a diagram such as in Figure 6 from the test results by connecting the measured values.

6.2.4.4.3 Pass/fail criteria

The measured values of output pressure shall correspond to the nominal empty, (low), loaded (high) and empty (low) figures respectively, within a tolerance of ± 0,1 bar if the ratio is ≤ 1 and ± 0,15 bar if the ratio is > 1.

For relay valves of Type B2 it is acceptable, to get the higher output pressure at a Lcp less than the nominal changeover point, and the lower output pressure at a Lsp greater than the nominal changeover point. This shall be established from the relevant design documentation.



Key

1 empty (low) condition

2 tolerance for the changeover point from loaded to empty (high to low) condition

3 nominal changeover point from empty to loaded (low to high) condition

4 tolerance for the changeover point from empty to loaded (low to high) condition

5 loaded (high) condition

Figure 6 — Characteristics of the output pressure p_o in relation on the load sensing pressure Lcp/Lsp of an empty/load relay valve

6.2.4.5 Additional test of the change of the relay valve ratio for two stage relay valves whilst brake is applied (type B1)

6.2.4.5.1 Test procedure

This clause is applicable only when a change of relay valve ratio is required during brake application (e.g. speed dependent braking) as per the technical requirement of 4.2.4.

The test procedure corresponds to 6.2.4.4.1, but the Lsp shall be changed whilst the input pressure stays at (3,8 ± 0,02) bar.

Higher values of the load sensing pressure may be required to achieve a change of relay valve ratio for other than freight applications e.g. for locomotives or multiple units. In this case the values of the load sensing pressure will be higher than the values contained in this test and shall be amended to meet the requirements of the specific relay valve application.

6.2.4.5.2 Test sequence

Using the test bench of 6.2.1, charge the auxiliary reservoir pressure to (5 ± 0,5) bar, set the input pressure to 0 bar (gauge 2), and follow the step sequence as below.

1) Start with an input pressure to 0 bar.

2) Adjust the Lsp to (0,40 ± 0,05) bar, using cocks 10, 11, 12 and electric to pressure controller 30.

3) Increase the input pressure to (3,8 ± 0,02) bar within 3 s to 5 s, using electric to pressure controller 31.

4) Wait 10 s, then measure the output pressure for empty (low) condition.

5) Increase the Lsp to a value of (3,10 ± 0,05) bar, i.e. higher than the minimum nominal changeover point from empty to loaded (low to high) condition.

6) Wait 10 s, then measure the output pressure for loaded (high) condition.

7) Decrease the Lsp to 0 bar.

8) Wait 10 s, then measure the output pressure for empty (low) condition.

6.2.4.5.3 Pass/fail criteria

The output pressures measured in steps 4, 6 and 8 shall correspond to the nominal loaded (high) respectively empty (low) figures within a tolerance of ± 0,1 bar.

6.2.4.6 Additional test of the prevention of the change of the relay valve ratio during brake application (type B2, C, C1, D and E)

6.2.4.6.1 Test procedure

This clause is applicable only when a change of relay valve ratio is forbidden during brake application (e.g. variable load braking), corresponding to the technical requirement of 4.2.5.

This test procedure corresponds to 6.2.4.4.1, but the Lsp/Lcp is changed whilst the output pressure stays at (1,1 ± 0,1) bar .

6.2.4.6.2 Test sequence

Using the test bench of 6.2.1, charge the auxiliary reservoir pressure to (5 ± 0,5) bar, set the input pressure to 0 bar (gauge 2), and follow the step sequence as below.

1) Adjust the Lsp to 0 bar, or Lcp to to its empty value, using cocks 10, 11, 12 and electric to pressure controller 30.

2) Increase the input pressure (gauge 2) at a rate of (3,8 ± 0,02) bar within 3 s to 5 s, up to an output pressure of (1,1 ± 0,1) bar using electric to pressure controller 31.

3) Wait 10 s, then measure the output pressure.

NOTE If the output pressure is less than 1 bar when Lcp is in the empty condition, the Lcp should be increased so that (1,1 ± 0,1) bar output pressure can be achieved and the test sequence re-started.

4) Increase the Lsp to a value 0,5 bar higher than the nominal changeover point from empty to loaded (low to high) condition or the Lcp to a value 0,5 bar higher than its empty value.

5) Wait 10 s, then measure the output pressure.

6) Decrease the Lsp to a value 0,5 bar lower than the nominal changeover point from loaded to empty (high to low) condition or reduce the Lcp pressure by 0,5 bar.

7) Wait 10 s, then measure the output pressure.

8) Decrease the input pressure to 0 bar.

9) Adjust Lsp/Lcp to the loaded condition.

10) Increase the input pressure to 1 bar.

11) Wait 10 s, then measure the output pressure.

12) Decrease Lsp to a value 0,5 bar lower than the nominal changeover point from loaded to empty (high to low) condition or reduce the Lcp pressure by 0,5 bar.

13) Wait 10 s, then measure the output pressure

14) Increase the Lsp to a value 0,5 bar higher than the nominal changeover point from empty to loaded (low to high) condition or the Lcp to a value 0,5 bar higher.

15) Wait 10 s, then measure the output pressure.

6.2.4.6.3 Pass/fail criteria

The output pressures measured in steps 3, 5, 7, 11, 13 and 15 shall all remain the same within a tolerance of ± 0,1 bar. No changeover shall occur even though the Lsp/Lcp has changed.

6.2.4.7 Characteristics of the output pressure in relation to the control signal Lcp of a variable load relay valve (type C and C1)

6.2.4.7.1 Test procedure

The test shall show the accuracy of the output pressure and the changeover in accordance with 4.2.2.

Prior to testing, the values of the output pressure BCP2, BCP3, BCP4, BCP5 and BCP6 together with control signals Lcp2 to Lcp6, as shown in Figure 7, representing the nominal empty and loaded pressure settings respectively, shall be established from the relevant design documentation. The nominal output pressures are related to a nominal input pressure of 3,8 bar.

Measurements shall be taken at the Lcp points defined in Table 6.

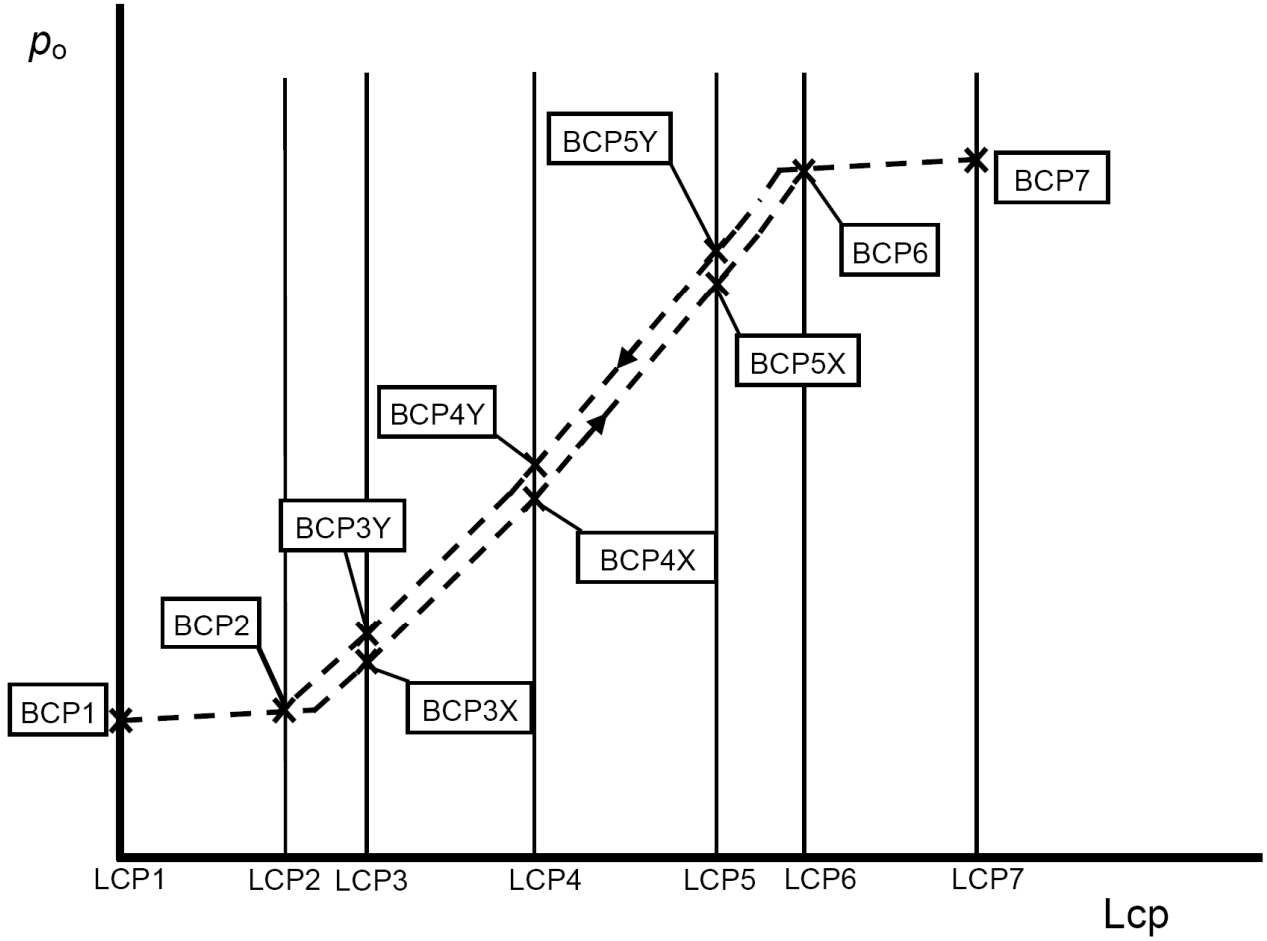
Table 6 — Measurement points

Control signal Lcp	Value	Explanation
Lcp1	0	Minimum pressure, loss of load signal
Lcp2	a	Nominal “empty” point
Lcp3	Lcp2 + 0,3 bar	Intermediate point
Lcp4	The middle (± 0,1 bar) between Lcp2 and Lcp6	Intermediate point
Lcp5	Lcp6 – 0,3 bar	Intermediate point
Lcp6	a	Nominal “loaded” point
Lcp7	Lcp6 + 1 bar	Overcharge point

[a] Value as given by the type plate or the relevant design documentation.

The device for controlling the signal pressure to change the relay valve ratio shall be at its lower/higher stops for testing the accuracy of the output pressure.

A diagram similar to Figure 7 shall be drawn by connecting the measured points using straight lines. The pressures are for emergency brake applications, with the Lcp being varied with the brake released.



Key

LCP1 - LCP7	measurement points of control signal Lcp from Table 6
BCP1 - BCP7	output pressures corresponding to LCP1 - LCP7; BCP X for rising Lcp pressure, BCP Y for falling Lcp pressure

Figure 7 — Characteristics of the output pressure p_o in relation to the control signal Lcp of a variable load relay valve

6.2.4.7.2 Test sequence

Using the test bench of 6.2.1, charge the auxiliary reservoir pressure to (9 ± 1) bar and set the input pressure to 0 bar (gauge 2).

Adjust the Lcp to the defined points (see Figure 7) using cocks 10, 11, 12 and electric to pressure controller 30. The sequence shall be Lcp1 – Lcp3 – Lcp4 – Lcp5 – Lcp6 – Lcp7 – Lcp5 – Lcp4 – Lcp3 – Lcp2.

When changing the Lcp, the input pressure shall remain at 0 bar. The change of the Lcp shall be done steadily with a rate of change of 0,05 bar/s to 0,1 bar/s, without any overshoot or correction.

At every Lcp setting point, increase the input pressure to (3,8 ± 0,02) bar within 3 s to 5 s, using electric to pressure controller 31. The change of the input pressure shall be conducted steadily, without any overshoot or correction. Measure the output pressures (gauge 4) at every point for the sequence above. The measuring shall take place 20 s after the input pressure has obtained its maximum to allow for stabilisation. Return the input pressure to 0.

6.2.4.7.3 Pass/fail criteria

The pressures BCP2, and BCP6 shall be the nominal values of maximum/minimum brake cylinder pressure (BCP), given by the type plate, related to Lcp2 resp. Lcp6, within a tolerance of ± 0,1 bar if the ratio is ≤ 1 and ± 0,15 bar if the ratio is > 1.

The differences BCP5Y-BCP5X, BCP4Y-BCP4X and BCP3Y-BCP3X shall not exceed 0,20 bar.

The difference between BCP1 and BCP2 shall not exceed 0,1 bar.

The difference between BCP6 and BCP7 shall not exceed 0,1 bar.

The differences BCP6-BCP5Y and BCP3X-BCP2 shall be > 0,1 bar.

6.2.4.8 Characteristics of the output pressure in relation to the input pressure of a variable load relay valve without kinked characteristic (type C, C1, D)

6.2.4.8.1 Test procedure

During the following test sequence every variation of the input pressure and the Lcp pressure shall be steady, without any overshot or change in the direction. The Lcp for the loaded condition shall be adjusted starting from a lower, for the empty condition to a higher value.

The rate of input pressure rise of fall shall be between 0,05 bar/s and 0,1 bar/s.

The device for controlling the signal pressure to change the relay valve ratio shall be at its lower/higher stops for testing the accuracy of the output pressure.

For the C1 type all tests are to be conducted for every stage of the output pressure level.

For the D type all tests are to be conducted for every input pressure port.

6.2.4.8.2 Test sequence

Using the test bench 6.2.1, charge the auxiliary reservoir pressure to (9 ± 0,5) bar and set the input pressure to 0 bar (gauge 2), and follow the step sequence as below.

1) Adjust the Lcp to the value Lcp4 (see Figure 7), corresponding to a typical mid load of a wagon.

2) Increase the input pressure (gauge 2) to 0,3 bar and hold for 5 s.

3) Increase the input pressure in steps to 3,8 bar, again holding for 5 s at each step, followed by decreasing the input pressure in steps to 0 bar holding for 5 s at each step. Record the input and output pressures at each step.

Repeat the above for the loaded condition by adjusting Lcp to Lcp6 (see Figure 7).

Repeat the above for the empty condition by adjusting Lcp to Lcp2 (see Figure 7).

The recorded input and output pressures shall be displayed in graphical form as in Figure 8 and Figure 9 to show the characteristics of the output pressure in relation to the input pressure.

6.2.4.8.3 Pass/fail criteria

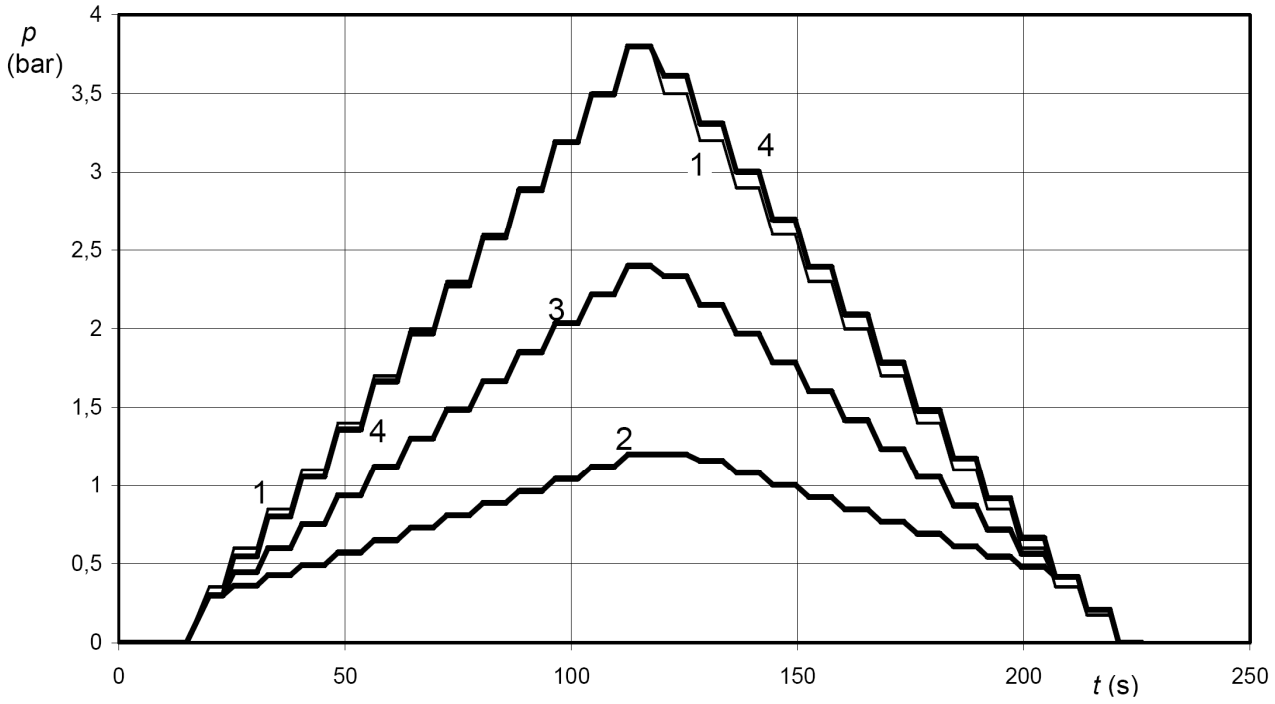
The output pressures BCP2, BCP6 of relay valve shall be the nominal values of maximum/minimum brake cylinder pressure (BCP), for the particular type designation of the Relay Valve, related to Lcp2 to Lcp6 (see Figure 7), within a tolerance of ± 0,1 bar.

The hysteresis shall be ≤ 0,15 bar.

The output pressure, when the input pressure is 0,3 bar, shall be ≥ 0,1 bar for all load conditions (initial sensitivity, 4.2.9).

The output pressure, when the input pressure is 0,7 bar, shall be ≥ 0,25 bar for all load conditions (minimum brake cylinder pressure, 4.2.1).

Each step of the input pressure shall cause a step of the output pressure (sensitivity, 4.2.9). For a relay valve with a ratio of 1 or greater, a reduction of the input pressure from the maximum value of (3,8 ± 0,02) bar, by 0,2 bar to (3,6 ± 0,02) bar, shall cause a reduction of the output pressure (sensitivity at reversal, 4.2.9). For a relay valve with a ratio of greater than 0,5 and less than 1 a reduction of the maximum value of (3,8 ± 0,02) bar by 0,4 bar to (3,4 ± 0,02) bar, shall cause a reduction of the output pressure (sensitivity at reversal, 4.2.9).



Key

1 input pressure

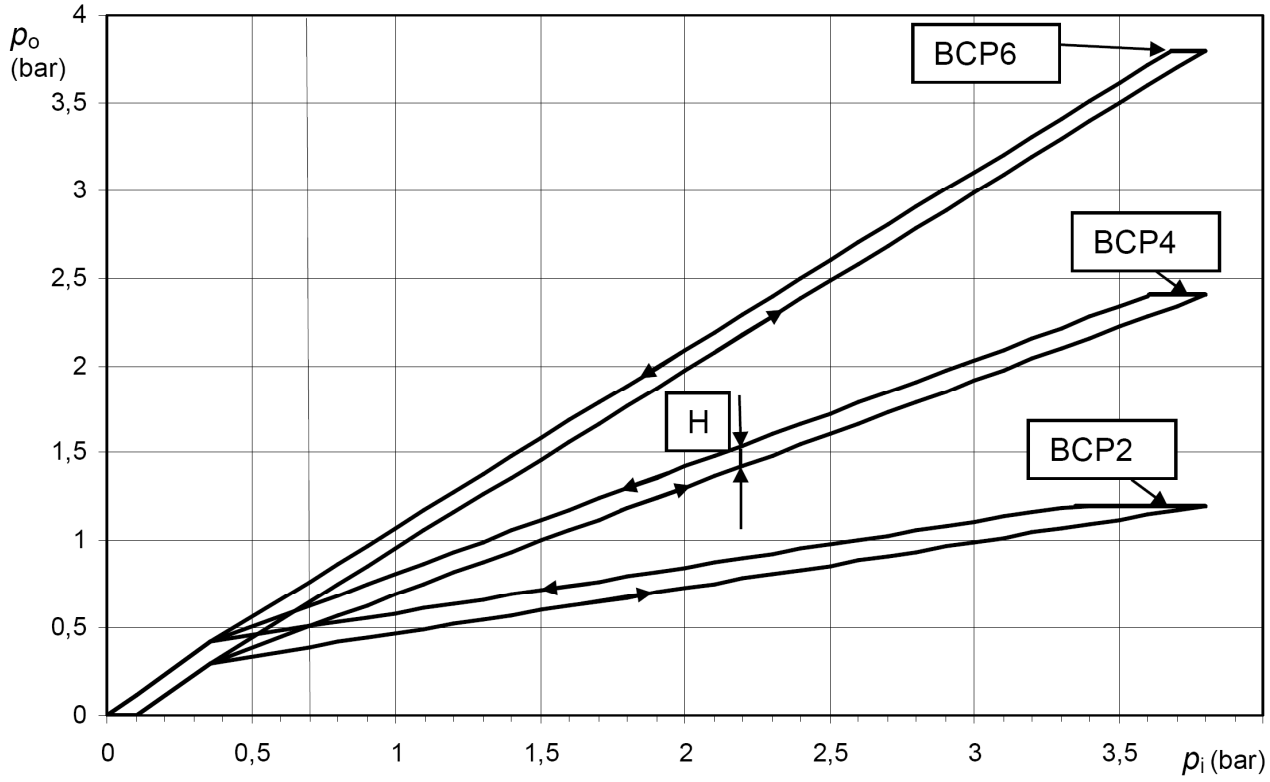
2 output pressure, empty

3 output pressure, middle load

4 output pressure, loaded

NOTE The figure is for information only – the test will provide the point values according to Figure 7 only.

Figure 8 — Characteristics of the output pressure and input pressure in relation to time of a variable load relay valve without a kinked characteristic



Key

BCP2 output pressure, empty

BCP4 output pressure, (any) middle load

BCP6 output pressure, loaded

H hysteresis

NOTE The figure is for information only – the test will provide the point values according to Figure 7 only.

Figure 9 — Characteristics of the output pressure p_o in relation to the input pressure p_i of a variable load relay valve without a kinked characteristic

6.2.4.9 Characteristics of the output pressure in relation to the input pressure of a variable load relay valve with kinked characteristic (type E)

6.2.4.9.1 Test procedure

Before the test the type of distributor valve for which the relay valve with kinked characteristic is intended to be used shall be established from the relevant design documentation.

Furthermore the load control pressures (Lcp) Lcp-x, Lcp-y Lcp-yy and Lcp-z which correspond to a maximum output pressure of 33 %, 67 %, 85 % and 100 % of the full loaded condition (see Figure 7, Lcp-z = Lcp 6) of the relay valve shall be defined, and the maximum output pressure itself, which is marked as BCP21 in Figure 11.

The rate of change of the input pressure used in the following tests shall be between 0,05 bar/s and 0,1 bar/s.

Every variation of the input pressure and the Lcp shall be done steadily, without any overshot or change in the direction.

The setting of Lcp for the loaded condition test (Lcp-z) shall be adjusted starting from a lower pressure, and when setting the Lcp for the empty condition test (Lcp-x) shall be adjusted starting from a higher pressure.

The device for controlling the signal pressure to change the relay valve ratio shall be at its lower/higher stops for testing the accuracy of the output pressure.

6.2.4.9.2 Test sequence

Using the test bench of 6.2.1, charge the auxiliary reservoir pressure to (9 ± 0,5) bar and set the input pressure to 0 bar (gauge 2). Then follow the step sequence as below.

1) Adjust the Lcp to Lcp-y (see Figure 10).

2) Increase the input pressure to 0,3 bar and hold for 5 s. Increase the input pressure in 0,1 bar steps to 3,8 bar. Record the input and output pressures at each step.

3) From an output pressure of 3,8 bar, decrease the input pressure in steps to 0,3 bar and in the last step to 0 bar. Record the input and output pressure at each step.

Repeat the above simulating the loaded condition by adjusting Lcp to Lcp-z.

Repeat the above simulating the intermediate load condition by adjusting Lcp to Lcp-yy.

Repeat the above simulating the empty condition by adjusting Lcp to Lcp-x.

The recorded input and output pressures shall be displayed in graphical form as in Figure 10 and Figure 11 to show the characteristics of the output pressure in relation to the input pressure.

6.2.4.9.3 Pass/fail criteria

The deviation of the characteristics from the mean value of output pressures obtained from sequences 2) and 3) above shall be less than 0,2 bar for all the following results.

The characteristics at a load level corresponding to ≤ 67 % of the maximum brake cylinder pressure (BCP) shall not be kinked.

The characteristics at a load level corresponding to >67 % of the maximum output pressure shall be kinked. The output pressure of any load condition of more than 67 % shall be equal (± 0,15 bar) to that of the 67 % condition, as long as the input pressure is less or equal to the defined value A (1,8 bar ≤ A ≤ 2,0 bar).

The output pressure for any load condition of more than 67 % shall be 33 % of the nominal value of maximum brake cylinder pressure for the actual relay valve type (± 0,15 bar), measured 5 s to 10 s after the input pressure has been increased to the defined value A.

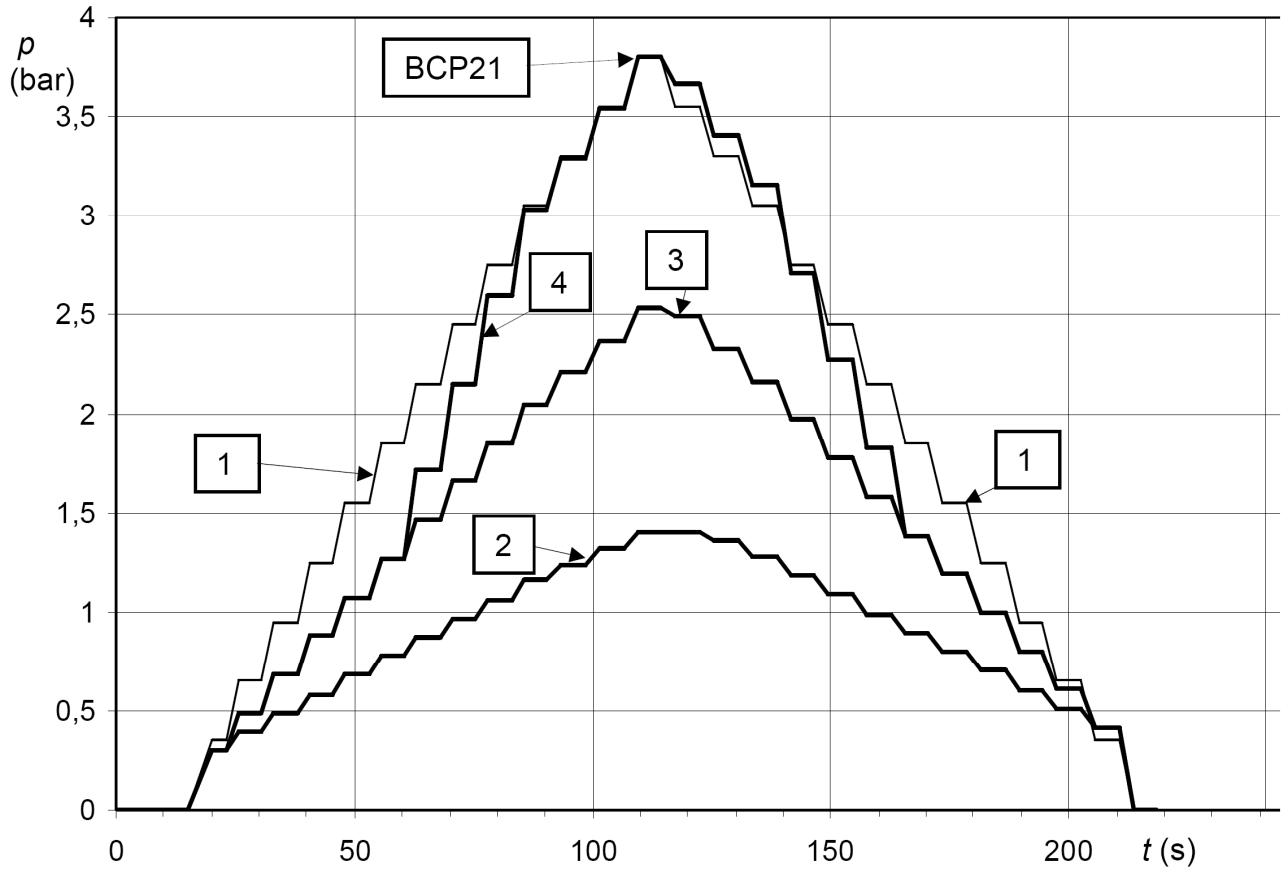
The output pressure for the maximum loaded condition shall be 80 % (± 0,15 bar), measured 5 s to 10 s after the input pressure has been increased to the value B (2,9 bar ≤ B ≤ 3,15 bar).

The increase in output pressure (BCP) achieved in the above tests, between the input pressure values A and B, shall be in relation to the increase in input pressure.

The output pressure, measured 5 s to 10 s after the input pressure has been increased to (3,80 ± 0,02) bar shall correspond to the value 100 % (BCP21). It shall be the nominal value of maximum brake cylinder pressure for the actual relay valve type, within a tolerance of ± 0,1 bar.

The hysteresis shall be ≤ 0,15 bar.

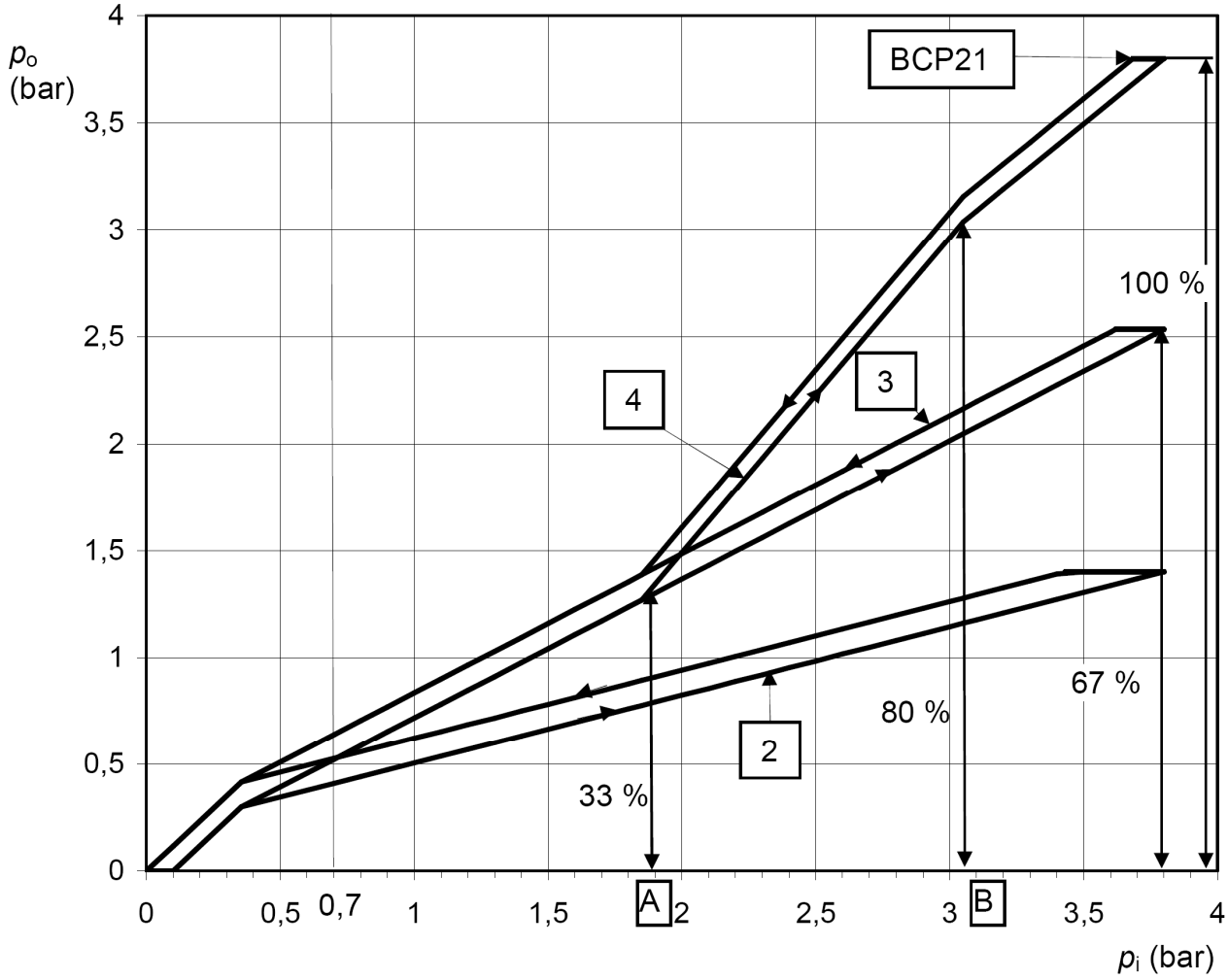
The output pressure, when the input pressure is 0,7 bar, shall be ≥ 0,25 bar for all load conditions (minimum brake cylinder pressure, 4.2.1).



Key

1	input pressure
2	output pressure, empty, at Lcp-x
3	output pressure, middle load, at Lcp-y
4	output pressure, loaded, at Lcp-z
BCP21	maximum output pressure at an input pressure of 3,80 bar

Figure 10 — Characteristics of the output pressure and the input pressure in relation to time of a variable load relay valve with a kinked characteristic



Key

2	output pressure, empty, at Lcp-x
3	output pressure, middle load, at Lcp-y
4	output pressure, loaded, at Lcp-z
BCP21	maximum output pressure at an input pressure of 3,80 bar
A	input pressure for equivalent brake pipe pressure reduction of 0,8 bar
B	input pressure for equivalent brake pipe pressure reduction of 1,2 bar

Figure 11 — Characteristics of the output pressure p_o in relation to the input pressure p_i of a variable load relay valve with a kinked characteristic

6.2.4.10 Characteristic of a variable load relay valve with a two stage function overlaid to the variable load brake function (type C1)

6.2.4.10.1 Test procedure

Prior to testing, the values of the output pressure BCP2, BCP3, BCP4, BCP5 and BCP6, both for the lower and the higher stage, together with load signal pressure Lcp2 and Lcp6, as shown in Figure 7, representing the nominal empty and loaded pressure settings respectively, shall be established from the relevant design documentation. The nominal output pressures are related to a nominal input pressure of 3,8 bar.

Additionally the nominal value and their tolerances of the control signal, causing the change from the lower to the higher stage and vice versa shall be established from the relevant design documentation.

The device for controlling the signal pressure to change the relay valve ratio shall be at its lower/higher stops for testing the accuracy of the output pressure.

6.2.4.10.2 Test sequence

The tests according to 6.2.4.7 and 6.2.4.8 shall be executed, the latter both for the lower and higher stage.

6.2.4.10.3 Pass/fail-criteria

The pass/fail-criteria from 6.2.4.7 and 6.2.4.8 are valid accordingly. The ratio of the higher value of the output pressure to the lower value shall be constant in the tolerance of ± 10 % for any load condition.

6.2.4.11 Characteristics of the output pressure in relation to the input pressure of a relay valve with one or more fixed ratios (type A, B1 and B2)

6.2.4.11.1 Test procedure

Before the test, the nominal value(s) of the maximum output pressure, obtained at an input pressure of (3,80 ± 0,02) bar shall be established from the relevant design documentation.

The rate of change of the input pressure used in the test shall be between 0,05 bar/s and 0,1 bar/s.

6.2.4.11.2 Test sequence

Using the test bench of 6.2.1, charge the auxiliary reservoir pressure to (9 ± 0,5) bar and set the input pressure to 0 bar (gauge 2).

Increase the input pressure to 1,0 bar before returning immediately to 0,3 bar and hold for 5 s. Increase the input pressure to 0,7 bar and then increase further in steps to (3,80 ± 0,02) bar, followed by a stepped decrease in input pressure to 0 bar. Record the input and output pressure at each step.

If the relay valve is designed to produce more than one maximum output pressure (e.g. empty-load relay valve), repeat the test for each relay valve ratio.

6.2.4.11.3 Pass/fail criteria

The maximum output pressures shall be the nominal values of maximum/minimum brake cylinder pressure (BCP) given by the type plate, within a tolerance of ± 0,1 bar.

The hysteresis shall be ≤ 0,15 bar.

The output pressure, when the input pressure is 0,3 bar, shall be ≥ 0,1 bar for all relay valve ratios (initial sensitivity, 4.2.9).

The output pressure, when the input pressure is 0,7 bar, shall be ≥ 0,25 bar for all relay valve ratios (minimum brake cylinder pressure, 4.2.1).

6.2.4.12 Sensitivity

6.2.4.12.1 Test procedure

Adjust the relay valve ratio to 1, or, if the specific relay valve does not provide this ratio, to the nearest to 1 possible value.

All increases or decreases of the input pressure shall be conducted at a rate between 0,10 bar/s and 0,20 bar/s. The increase and decrease of input pressure shall use equal steps with no overshoot or pressure reversal between steps.

6.2.4.12.2 Test sequence

6.2.4.12.2.1 Test sequence for relay valves with relay valve ratio of 1 or greater

Follow the following sequence.

1) Starting from input and output pressure at 0 bar, increase the input pressure to 0,30 bar and check that the output pressure rises to a minimum of 0,1 bar.

2) Increase the input pressure to 1,5 bar.

3) Increase the input pressure in 0,1 bar steps to 1,8 bar and check that the output pressure increases correspondingly. Increase the input pressure to 3,0 bar. After every step, hold the pressure constant for 10 s to 30 s.

4) Increase the input pressure in 0,1 bar steps to 3,3 bar and check that the output pressure increases correspondingly. After every step, hold the pressure constant for 10 s to 30 s.

5) Increase the input pressure further to 3,8 bar and hold for 10 s to 30 s.

6) Decrease the input pressure by 0,20 bar and check the output pressure starts to decrease.

7) Decrease the input pressure to 3,0 bar and then in three steps of 0,1 bar to 2,7 bar. After every step, hold the pressure constant for 10 s to 30 s.

8) Decrease the input pressure to 1,5 bar and then in three steps of 0,1 bar to 1,2 bar. After every step, hold the pressure constant for 10 s to 30 s.

9) Check that the output pressure decreases correspondingly.

6.2.4.12.2.2 Test sequence for relay valves with relay valve ratio less than 1 and greater than 0,5

Follow the following sequence.

1) Starting from input and output pressure at 0 bar, increase the input pressure to 0,30 bar and check that the output pressure rises to a minimum of 0,1 bar.

2) Increase the input pressure to 0,8 bar.

3) Increase the input pressure in 0,6 bar steps to 3,8 bar and check that the output pressure increases correspondingly. After every step, hold the pressure constant for 10 s to 30 s.

4) Decrease the input pressure by 0,4 bar and check the output pressure starts to decrease.

5) Decrease the input pressure in 0,6 bar steps to 0,8 bar. After every step, hold the pressure constant for 10 s to 30 s.

6) Check that the output pressure decreases correspondingly.

7) Decrease the input pressure to 0 bar.

6.2.4.12.3 Pass/fail criteria

The output pressure shall rise to a minimum of 0,1 bar with an input pressure of 0,30 bar.

The output pressure shall increase or decrease correspondingly by at least 0,05 bar in less than 10 s after the defined step increase or decrease of input pressure.

6.2.4.13 Additional test for relay valves with two, or more, input pressures (type D)

6.2.4.13.1 Procedure

The rate of change of the input pressures used in the following tests shall be between 0,05 bar/s and 0,1 bar/s.

Before the test, the nominal value(s) of the maximum output pressure, obtained at an input pressure of (3,80 ± 0,02) bar shall be established from the relevant design documentation.

6.2.4.13.2 Test sequence

Increase the input pressure 1 in 4 steps to 1,0 bar, 2,0 bar, 3,0 bar and 3,8 bar and hold 1 min at each step.

30 s after the beginning of the increase of the input pressure 1 increase the input pressure 2 in 4 steps to 3,8 bar as above and hold 1 min at each step.

In the case where more than two input pressures are used, increase each of the following input pressures 30 s after the beginning of the increase of the preceding input pressure in 4 steps as above to 3,8 bar and hold for 1 min at each step.

Reduce the pressures to 0 bar using the reverse of the increase sequence.

Repeat the above with input pressure 1 following input pressure 2.

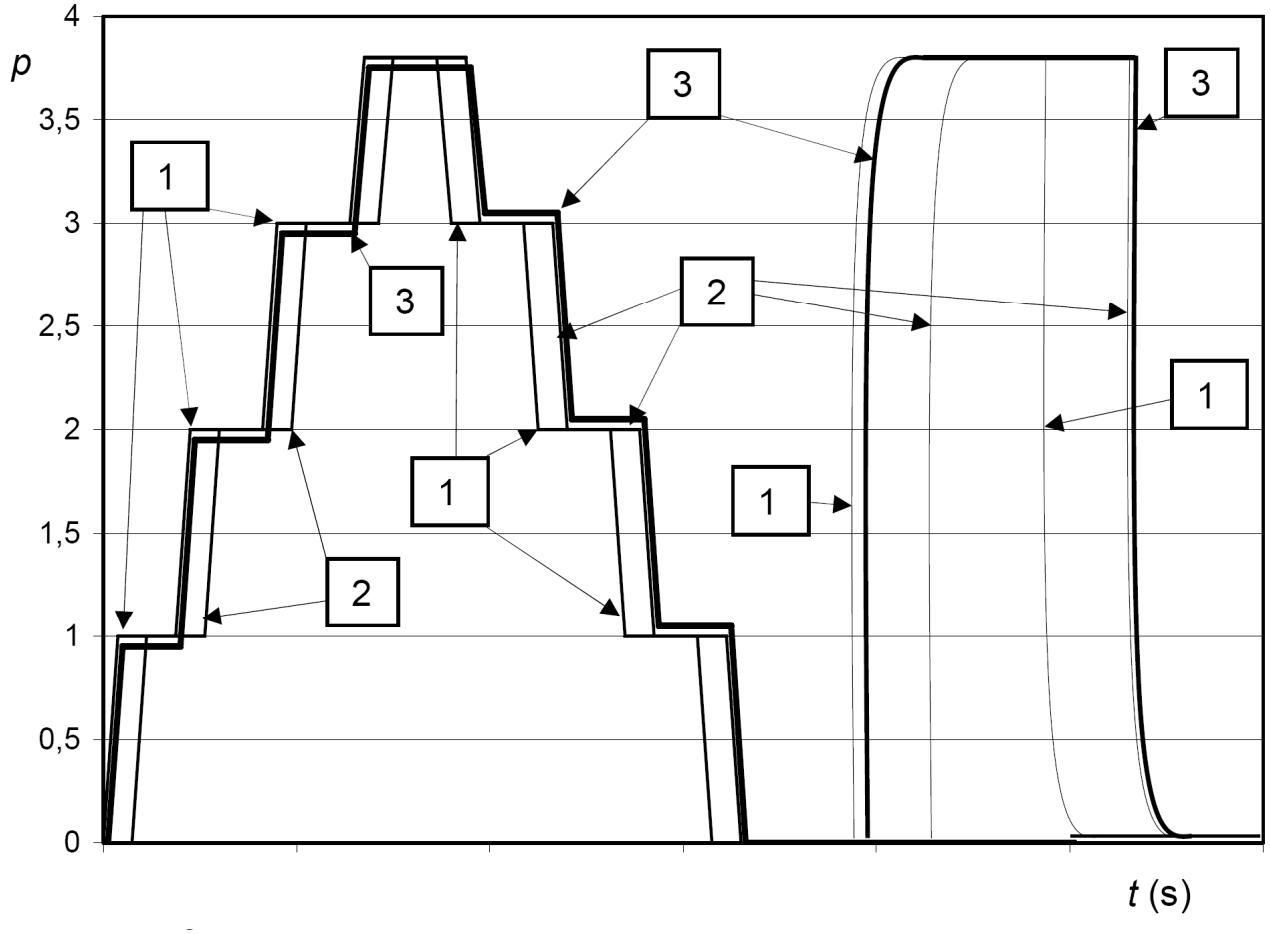
Simulate full applications by increasing first the input pressure 1 to 3,8 bar, followed by increasing input pressure 2 to 3,8 bar or vice versa, and hold for 1 min. In the case where more than two input pressures are used, increase the input pressures one by one to 3,8 bar, where the sequence may be in any order, and hold for 1 min.

Simulate the full release by decreasing first the input pressure 1 to 0 bar, followed by decreasing input pressure 2 to 0 bar or vice versa, and hold for 1 min. In the case where more than two input pressures are used, decrease the input pressures one by one to 0 bar, where the sequence may be in any order, and hold for 1 min.

NOTE Figure 12 illustrates the sequence for two input pressures.

6.2.4.13.3 Pass/fail criteria

The output pressure of the relay valve shall correspond to the highest of the input pressures. The tolerance of the maximum output pressure nominal values shall be ± 0,1 bar, if the nominal value is ≤ 3,8 bar and ± 0,15 bar, if the nominal value is > 3,8 bar, in the case where only one of the input pressures is pressurised. In the case where two or more input pressures are acting simultaneously, the output pressure tolerance shall be a maximum of ± 0,20 bar, if the nominal value is ≤ 3,8 bar and ± 0,30 bar, if the nominal value is > 3,8 bar.



Key

1 input pressure 1

2 input pressure 2

3 output pressure

Figure 12 — Output pressures as a result of two input pressures (“select high”) in relation to time

6.2.4.14 Interaction of a relay valve and a distributor valve - simulated test

6.2.4.14.1 Test procedure

Prior to the test, the limits of volume and pressure for which the relay valve can be used shall be established from the relevant design documentation, this shall include:

a) diameter of the brake cylinder;

b) stroke of the piston;

c) dead volume;

d) min. supply pressure;

e) maximum output pressure for a nominal input pressure (default (3,8 ± 0,1) bar);

f) shortest possible brake cylinder filling and venting time.

6.2.4.14.2 Test sequence

Using the test bench of 6.2.1, adjust the simulated brake cylinder volume to the defined size or to a size with an equivalent volume and stroke.

Follow the following step sequence:

1) Adjust the control pressure Lcp to 0 bar to simulate the “empty” condition.

2) With the relay valve input pressure set to 0 bar increase the input pressure to (3,8 ± 0,02) bar, at a rate of 3 s to 5 s to 95 % of the maximum value. Measure and record the time taken for the output pressure to rise to 95 % of the maximum value. Measure and record the maximum output pressure.

3) Decrease the input pressure to 0 bar.

4) Adjust the control pressure Lcp to a level Lcp3 (see Figure 7) and repeat 2) and 3) above.

5) Repeat 2) and 3) above for Lcp4 and Lcp5. At each point measure and record the value of output pressure.

6) Adjust the control pressure Lcp to the maximum level Lcp7, to simulate the “fully loaded” condition.

7) Repeat 2) above.

8) Decrease the input pressure to 0 bar in a time of 15 s to 18 s to 0,4 bar. Measure and record the delay in output pressure reaction time to the input pressure fall and the time taken for the output pressure to fall to 0,1 bar.

6.2.4.14.3 Pass/fail criteria

For each value of Lcp as set in the test sequence 1), 2) and 7) above, the output pressure shall obtain 95 % of its maximum value within 6 s after commencing the input pressure rise.

The maximum output pressure achieved in 2) and 7) above shall be within a tolerance of ± 0,1 bar.

The output pressure achieved in 4) and 5) above shall have a tolerance of ± 0,15 bar at Lcp3 and Lcp5 and a tolerance of ± 0,1 bar at Lcp4.

The time delay of the output pressure response to the input pressure fall shall be ≤ 10 % of the distributor maximum release time.

For 8) above, the time taken for the output pressure to fall to 0,1 bar shall be no longer than 15 s after the input pressure has reached 0,1 bar. The input pressure fall from 0,4 bar to ≤ 0,1 bar shall cause the output pressure to fall to ≤ 0,1 bar within 10 s.

6.2.4.15 Shock and vibration

6.2.4.15.1 Procedure

This test shall be made in accordance with the requirements contained in EN 61373:1999, Category 1, class A or B.

6.2.4.15.2 Test sequence

The following tests shall be performed in the order shown:

a) random vibration test in accordance with EN 61373:1999, Clause 8; functional tests 6.2.4.3, 6.2.4.8 and 6.2.4.12 shall be performed during the vibration test;

b) simulated long life testing at increased random vibration levels in accordance with EN 61373:1999, Clause 9; functional tests 6.2.4.3, 6.2.4.8 and 6.2.4.12 shall be performed prior to and after the vibration test;

c) shock testing in accordance with EN 61373:1999, Clause 10; during the test the relay valve shall have an input pressure sufficient to give an output pressure of (3 ± 0,1) bar.

6.2.4.15.3 Pass/fail criteria

The output pressure shall remain at its initial value ± 0,2 bar, throughout the duration of the shock.

Function and performance shall be within the defined limits.

Visual appearance and mechanical integrity shall not change.

6.2.4.16 Operation at extreme temperatures

6.2.4.16.1 General

The following tests shall be conducted on a relay valve at temperatures of – 40 °C, – 25 °C and + 70 °C, with the test bench of 6.2.1 placed in a thermostatic enclosure.

6.2.4.16.2 Leakage

6.2.4.16.2.1 Procedure

Repeat 6.2.4.3 at each of the temperatures.

6.2.4.16.2.2 Pass/fail criteria

At – 25 °C, also at + 70 °C the relay valve shall not have a leakage rate of greater than 0,01 Nl/min at normal working pressures.

Between – 40 °C and < – 25 °C the relay valve shall not have a leakage rate of greater than 0,1 Nl/min at normal working pressures.

6.2.4.16.3 Operation

6.2.4.16.3.1 Procedure

Repeat one of the subclauses 6.2.4.8 to 6.2.4.11 as applicable to the relay valve type and 6.2.4.12 for all relay valve types.

6.2.4.16.3.2 Pass/fail criteria

In the range from – 40 °C and < – 25 °C and at + 70 °C the values of sensitivity and hysteresis shall not be more than two times higher than at normal temperatures.

The tolerances of the pressures shall not be more than four times higher than at normal temperatures.

6.2.4.17 Interaction of a relay valve and a distributor valve – combination test

6.2.4.17.1 Test procedure

The combination of the relay valve and the distributor valve (fitted integral with or separate to the distributor) for which it is intended shall be tested using a suitable test rig.

6.2.4.17.2 Test sequence – Brake application for all distributor valve/relay valve combinations

With the distributor be in passenger timing mode, make an emergency brake application, in both the empty (Lcp2, Figure 7 or Lsp ≤ 0,5 bar), and fully loaded (Lcp6 Figure 7 or ≥ 3,0 bar), condition and record the distributor output and relay valve output pressures. Record the time from the start of the rise of the relay valve output pressure to 95 % of its maximum value.

6.2.4.17.3 Pass/fail criteria

For all distributor valve/relay valve combinations, except matched pairs of interoperable distributor valves and relay valves, the following pass/fail criteria apply.

a) For an input pressure to the distributor of 0 bar when the distributor output pressure is (3,8 ± 0,1) bar the accuracy of the relay valve output shall be ± 0,2 bar in the empty and loaded conditions.

b) The output pressure rise time (brake application time measured using an emergency brake application from the start of the rise of the output pressure to 95 % of its maximum value) of the relay valve shall be 3 s to 6 s with an input pressure rise time to the relay valve of 3 s to 5 s.

For matched pairs of interoperable distributor valves and relay valves, the following pass/fail criteria apply.

c) The maximum output pressure in the empty and fully loaded condition (as above) shall be within a tolerance of ± 0,1 bar (measured using an emergency brake application), when achieved by adjustment of the matched pair.

d) Relay valves Type C, C1, D and E as a matched pair shall have a performance at intermediate load conditions Lcp3 and Lcp5, providing an output pressure accuracy of ± 0,15 bar. At load condition Lcp4 the output pressure accuracy shall be ± 0,1 bar. This shall be tested with the load sensing pressure increasing from Lcp3.

e) The output pressure rise time (brake application time measured using an emergency brake application from the start of the rise of the output pressure to 95 % of its maximum value) of the relay valve shall be 3 s to 6 s with an input pressure rise time to the relay valve of 3 s to 5 s.

6.2.4.17.4 Test sequence – Brake release for all distributor valve/relay valve combinations

Make a full brake release.

6.2.4.17.5 Pass/Fail criteria

The output pressure shall continuously follow the drop of the input pressure (15 s – 20 s) from its maximum to 0,1 bar.

The time delay for the start of the drop of the output pressure shall be ≤ 10 % of the total allowed release time for the distributor valve.

When the input pressure has fallen to 0,05 bar, the output pressure shall fall to ± 0,05 bar not more than 15 s later.

7 Routine test and inspection

Tests shall be conducted on each relay valve following manufacture to show conformity at least with the requirements 4.2.1, 4.2.2, 4.2.6, 4.2.8, 4.2.9 and 4.2.10 These tests shall be conducted at an ambient temperature. Tests related to the serial production shall be specified by the manufacturer according to standardized quality management procedures or by exception shall be agreed between manufacturer and customer.

NOTE The tests may be executed in a modified procedure and at a special test bench according to the requirements of a serial production.

8 Type-validation

For a relay valve to be used on interoperable vehicles, an in-service trial may be required dependant on the verification requirements. Annex A contains typical requirements of an in-service trial that may be used to assess a relay valve when fitted in a system having an interoperable distributor.

For a relay valve to be used on interoperable vehicles, testing of the relay valve as part of the complete brake system both when static and running, when fitted to a vehicle with an interoperable distributor valve, should be conducted in accordance with the requirements of the vehicle brake system type tests as defined in the relevant system test clause of the applicable EN standard.

If required for the assessment of vehicle performance, to test the performance of a relay valve in combination with an interoperable distributor whilst fitted to a wagon, Annex B shows typical series of tests, which may be carried out.

9 Documentation

The supplier shall make available documentation for supply to the purchaser, as may be required and agreed between the parties, to provide evidence of the design compliance and quality of the product, and give details of the relay valve and its installation, operation and maintenance etc. Typical documentation may include the following:

— certification of conformity to design drawings and test/performance requirements;

— data sheet containing relay valve settings;

— installation drawings to enable the relay valve to be installed on a vehicle; these shall include all interface data required for connection to the vehicle or vehicle systems;

— part number and type designation together with applicable settings;

— technical description of the relay valve describing its function and operation;

— recommended maintenance activities;

— safety related documentation e.g. handling and disposal instructions, health and safety data sheets;

— the input pressures A and B (see 4.2.6) for a relay valve with kinked characteristic, type E;

— the nominal value of the control signal, causing the lower ratio and higher ratio level of the output pressure of a two stage relay valve type B, B1, B2.

To allow the wagon builder/designer to calculate the brake force in initial, the manufacture of the relay valve shall state the minimum output pressure related to a nominal input pressure of 0,7 bar on the installation or other applicable drawing, of the relay valve type.

10 Designation

Relay valves complying with this European Standard shall be designated as follows:

a) the number of this European Standard;

b) the manufacturer (name or logo);

c) the manufacturers type designation;

d) the part number.

11 Identification and marking

One or more durable identification plates giving the following information shall be permanently attached to each relay valve:

— the manufacturer (name or logo);

— the date of manufacturing (the week or month and year);

— manufacturers type designation;

— part number;

— serial number.

The identification plate shall be attached to the main body preferably in a position that can be seen when the relay valve is installed on the vehicle.

NOTE A separate plate may be fitted identifying overhaul dates or other data if required by the purchaser.

Annex A
(informative)

In-service trial

A.1 General

An in-service trial may be conducted on relay valves which are defined as a new product or a modified version of an existing product which has changed the design sufficiently such that it requires a new type designation.

A.2 Test set-up and sampling

The in-service trials should be conducted using a number of relay valves of the same type, with a minimum number of 10, fitted to vehicles running in agreed train formations running in defined service duties.

The relay valves should be taken from a representative production process and subject to the type testing requirements of this standard prior to the in-service trial.

A.3 Procedure

The in-service trial should be conducted for a minimum period of 12 months. During this time the functional performance of the relay valve should be monitored at agreed times on not less than 3 occasions. This monitoring should be carried out by performing static functional testing on all the vehicles fitted with trial relay valves, and by physical examination of the relay valves.

The following tests should be carried out on each trial vehicle equipped with at least one relay valve, where a change of load should be simulated both rising and falling through the full range of theoretical vehicle loads:

— application and release times over the complete load range;

— graduable application and release of the brakes (minimum 5 steps);

— variations in output pressure with load signal variation;

— leakage.

A.4 Pass/fail criteria

All functional requirements should be met and no physical deterioration should occur at the end of the 12 month trial.

Annex B
(informative)

Static vehicle and running tests

B.1 General

If required for the assessment of vehicle performance, to test the performance of a relay valve in combination with an interoperable distributor whilst fitted to a wagon, the following is a typical series of tests, which can be carried out. The test is of the complete wagon system and is influenced by the various brake system tolerances etc. and does not provide a test of the relay valve alone.

B.2 Test recommendations

B.2.1 Variable load relay valve

The following tests may be carried out on an individual wagon randomly selected, equipped with at least one variable load relay valve. The change in load should be both rising and falling through the full range and the vehicle should be moved before the next set of measurements following a change in load.

— Verification of the brake mass percentages for 120 km/h running. Progressive degradation from a brake mass percentage of 100 % to 90 % is allowed for block braked wagons as the load increases from 18 to 20 t axle loads.

— Verification of the brake mass percentages for 100 km/h running. Progressive degradation from a brake mass percentage of 100 % to 65 % is allowed for wagons progressively as the load increases from 65 % of the wagons maximum permissible weight (14,5 t axle load for a wagon designed for 22,5 t axle loads) to its maximum weight. The braked mass for wagons fitted with cast iron block brakes should not exceed 18 t according to the international technical rules available at the time covering all EU Member States.

— Application and release times over the complete load range.

— Graduable application and release of the brakes (minimum 5 steps).

— Variations in output pressure with load signal variation.

— Response time to change in load signal variation.

— Impact and short duration load variations not affecting load adjustment.

— Leakage.

Running tests may be carried out to verify:

— the equipment is insensitive to random load variations due to the movement of the vehicle;

— the brake mass percentages with (i) empty, (ii) half-loaded, (iii) load corresponding to a brake mass percentage of 100 % and (iv) full load; the brake mass percentage should not exceed 130 % irrespective of the load value, and for block braked wagons running at 120 km/h in the full load condition should not exceed 105 %.

B.2.2 Empty/load relay valve

Tests should be carried out on an individual wagon randomly selected, equipped with at least one automatic empty/load relay valve.

Tests should be carried out in the empty and loaded conditions.

The vehicle should be progressively loaded and unloaded in order to ascertain that the automatic changeover mechanism transfers from the “loaded” to “empty” mode, rising and falling, within the ± 5 % transition weight range.

NOTE The ± 5 % transition weight range is a function of the vehicle design and its influence on the load weighing device.

Where the equipment is designed to operate with varying load with the empty/load equipment, the running tests should be with the load at loads varied around the changeover weight to ensure that the mechanism is not affected by random load variations during normal operation.

If test results conform with the above requirements the tests should be carried out dynamically on an individual vehicle. Tests should include:

— application and release times in both modes;

— graduable application and release of the brakes (minimum 5 steps);

— brake application time in both modes;

— brake release time in both modes;

— variations in output pressure with load signal variation;

— response time to change in load signal variation;

— leakage.

Annex ZA
(informative)

A1 Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community (Recast)

This European Standard has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the Directive 2008/57/EC[1)].

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 for HS Rolling Stock, Table ZA.2 for CR Freight Wagons and Table ZA.3 for CR Locomotives and Passenger Rolling Stock, confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

1) This Directive 2008/57/EC adopted on 17th June 2008 is a recast of the previous Directives 96/48/EC 'Interoperability of the trans-European high-speed rail system' and 2001/16/EC 'Interoperability of the trans-European conventional rail system' and revisions thereof by 2004/50/EC 'Corrigendum to Directive 2004/50/EC of the European Parliament and of the Council of 29 April 2004 amending Council Directive 96/48/EC on the interoperability of the trans-European high-speed rail system and Directive 2001/16/EC of the European Parliament and of the Council on the interoperability of the trans-European conventional rail system'.

Table ZA.1 — Correspondence between this European Standard, the HS TSI RST published in the OJEU dated 26 March 2008 and Directive 2008/57/EC

Clauses/sub-clauses of this European Standard	Chapter /§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard is applicable.	4.Characteristics of the subsystem 4.2 Functional and technical specification of the subsystem 4.2.4 Braking §4.2.4.3 Brake system requirements §4.2.4.8 Brake requirements for rescue purposes §4.2.6.1 Environmental conditions, Environmental conditions §4.2.7.2.2 System protection, Fire safety, Measures to prevent fire	In Annex III, Essential Requirements 1.General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.5 1.2 Reliability and availability 1.5 Technical compatibility 1.3 Health Clause 1.3.2 1.4 Environmental protection Clause 1.4.2 2 Requirements specific to each Subsystem 2.4 Rolling Stock 2.4.1 Safety §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §3	.

Table ZA.2 — Correspondence between this European Standard, the CR TSI RST Freight Wagons dated July 2006, published in the OJEU on 8 December 2006 and its intermediate revision published in the OJEU on 14 February 2009 and Directive 2008/57/EC

Clauses/ sub-clauses of this European Standard	Chapter /§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard is applicable	4.Characterisation of the subsystem 4.2. Functional and technical specifications of the subsystem 4.2.4 Braking §4.2.4.1.2.2 Braking performance elements §4.2.4.1.2.7 Air supply §4.2.6 Environmental conditions §4.2.7.2 Safety protection, Fire safety 5 Interoperability constituents §5.3.3.2 List of constituents, Braking, Relay valve for variable load/Automatic empty-load change over brake §5.4.3.3 Constituents performances and specifications, Braking, Relay valve for variable load/Automatic empty-load change over brake 6 Assessment of conformity and/or suitability for use of the constituents and verification of the subsystem §6.2.3.3 Subsystem conventional rail rolling stock freight wagons, Specifications for assessment of the	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5 1.2 Reliability and availability 1.3 Health Clause 1.3.2 1.4 Environmental protection Clause 1.4.2 1.5 Technical compatibility 2 Requirements specific to each subsystem 2.3 Control-command and signalling 2.3.2 Technical compatibility§1 2.4 Rolling stock 2.4.1 Safety §3 2.4.2 Reliability and availability 2.4.3 Technical compatibility §3	The standard does not address the needs of Directive 2008/57/EC for Annex III, Essential Requirements: 2 Requirements specific to each Subsystem 2.6 Operation and Traffic Management – 2.6.1 Safety§2

	subsystem, Braking Annex I Braking, interfaces of interoperability constituents Annex P Braking performance, assessment of interoperability constituents Annex Q Assessment procedures, Interoperability Constituents Annex S Braking performance Annex FF Braking, List of approved brake components		

Table ZA.3 — Correspondence between this European Standard, the CR LOC and PASS RST TSI (final draft Rev 4.0 dated 24 November 2009) and Directive 2008/57/EC

Clauses/ sub-clauses of this European Standard	Chapter /§of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
The whole standard is applicable	4.Characterisation of the rolling stock subsystem 4.2 Functional and technical specification of the subsystem 4.2.4 Braking §4.2.4.3 Type of brake system §4.2.4.4 Brake command §4.2.4.5 Braking performance §4.2.4.10 Brake requirements for rescue purposes §4.2.6.1 Environmental conditions, Environmental conditions §4.2.10.2 Fire safety and evacuation, Material requirements	Annex III, Essential requirements 1 General requirements 1.1 Safety Clauses 1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5 1.2 Reliability and availability 1.3 Health Clauses 1.3.2 1.4 Environmental protection Clause 1.4.2 1.5 Technical compatibility 2 Requirements specific to each subsystem 2.4 Rolling stock 2.4.2 Reliability and availability 2.4.3 Technical compatibility §3	The full compliance with the TSI requirements depends on the way the product is integrated into the rolling stock.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard. 〈A1〉

[A1⟩ *deleted text* ⟨A1]

Bibliography

[1] UIC 540, *Brakes – Air Brakes for freight trains and passenger trains*

[2] UIC 541-1, *Brakes – Regulations concerning the design of brake components*

[3] UIC 541-04, *Brakes – Regulations concerning the manufacture of brake components – Self-adjusting load-proportional braking system and automatic 'empty-loaded' control device*

[4] UIC 543, *Brakes – Regulations governing the equipment of trailing stock*

[5] UIC 547, *Brakes – Air brake – Standard programme of tests*

[6] ISO 2533, *Standard Atmosphere*

[7] DIN 1343, *Referenzzustand, Normzustand, Normvolumen – Begriffe und Werte*

[8] EN ISO 228-2, *Pipe threads where pressure-tight joints are not made on the threads – Part 2: Verification by means of limit gauges (ISO 228-2:1987)*

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