1 Scope of application

This standard is applicable to the leak test of vacuum components. It is used to assign the required application range to a suitable test method in order to verify the vacuum tightness of a component. The measure of the leak tightness of a component is the leak rate in $mbar \cdot l \cdot s^{-1}$

This standard presents the subdivision of the vacuum ranges. The permissible test methods are then presented. The description of the permissible test methods and the maximum leak rate to be achieved are divided into recipients and vacuum components (assemblies, individual parts and mechanical feedthroughs). Finally, the information on drawings and in supplier orders is discussed.

Attached to this document is information on the partial flow method, the pressure rise test, as well as test report templates for the pressure rise test and the He integral leak test. This standard is only applicable in combination with the standards fromTable 1.

Table 1: Relevant standards

Designation	Title
DIN EN 1779	Non-destructive testing - Leak testing - Criteria for the selection of test methods and procedures
DIN EN ISO 20485	Non-destructive testing - Leak testing - Test gas method
DIN EN 1593	Non-destructive testing - Leak testing - Bubble test method
DIN EN 13184	Non-destructive testing - Leak testing - Pressure change method

2 Subdivision of the vacuum ranges

Vacuum components subject to mandatory testing are divided into different vacuum ranges. These vacuum ranges indicate the final end pressures of the assembled recipients in which the components are installed. The subdivision of the pressure ranges <1bar can be found inTable 2.

Table 2: Vacuum ranges

Vacuum range	Abbreviation	Pressure range in mbar
Rough vacuum	GV	$>1 \cdot 10^{-2}$
Fine vacuum	FV	$<1 \cdot 10^{-2}$ $>1 \cdot 10^{-4}$
High vacuum	HV1	$<1 \cdot 10^{-4}$ $>1 \cdot 10^{-6}$
	HV2	$<1 \cdot 10^{-6}$ $>1 \cdot 10^{-7}$
	HV3	$<1 \cdot 10^{-7}$ $>1 \cdot 10^{-8}$
Ultra high vacuum	UHV	$<1 \cdot 10^{-8}$

3 Leak test

This section defines the permissible leakage rates for vacuum components and which test methods can be used to determine them.

3.1 Vacuum test methods

The vacuum test methods according to DIN EN 1779 listed inTable3 are explained in more detail here. The use of a different test method can only be agreed upon. The use of localising methods is not suitable for a final inspection, but must be carried out in conjunction with a quantifying method.

The quantitative recording of a leak rate must be documented. Test report templates can be found in Appendices B and C.

Table3 : Vacuum test method

Designation	Abbreviation according to DIN EN 1779	Minimum measurable leak rate in $mbar \cdot l \cdot s^{-1}$	Type of method	Corresponding standard
He integral leak test* Standard: Vacuum method (integral)	A1	$1 \cdot 10^{-9}$	quantifying	DIN EN ISO 20485
He individual leak test Standard: Vacuum method (local)	A3	$1 \cdot 10^{-9}$	localising	DIN EN ISO 20485
Sniffer test	B4	$1 \cdot 10^{-6}$	localising	DIN EN ISO 20485
Bubble detection test (application of liquid)	C2	$1 \cdot 10^{-3}$	localising	DIN EN 1593
Pressure rise test**	D2	$1 \cdot 10^{-4}$	quantifying	DIN EN 13184

* A starting pressure of $\leq 1 \cdot 10^{-2}$ mbar is usually required for these methods. However, this depends on the working range of the leak detector used.

** With method D2, the total leakage rate plus outgassing is measured. When using this method, it is necessary to wait for the characteristic pivot point, from which the outgassing has less influence than the leak rate. Further information can be found in Appendix B.

3.2 Pumping units

To ensure the cleanliness of our systems, only oil-free pumps and leak detectors may be used from the HV2 range upwards. This is shown inTable 4.

Table 4: Permitted pumping units

Vacuum range	Oil-free pumps	Oil-lubricated pumps
GV	X	X
FV	X	X
HV1	X	X
HV2	X	
HV3	X	
UHV	X	

Furthermore, a pumping unit with a sufficiently low test-start pressure is required for the application of the pressure rise test in order to generate a reliable measurement. Further information can be found in the following chapters.

3.3 Leak testing of recipients

In higher pressure ranges up to HV1, either a pressure rise test (D2) in combination with a measurement of the individual He leakage rates according to the individual helium leakage test (A3) or an integral measurement of the total He leakage rate according to the integral He leakage test (A1) can be carried out.

In the pressure ranges HV2, HV3 and UHV, only a measurement of the leakage rate according to the He integral leakage test (A1) is permitted. This is shown inTable 5.

Table 5: Applicable methods

Vacuum range	Pressure rise test D2 in conjunction with individual He leak test A3	He integral leak test A1
HV1	X	X
HV2		X
HV3		X
UHV		X

3.3.1 Pressure rise test (D2)

A more detailed description of the measurement procedure, the evaluation and an example of a test report template can be found inAppendix B

Two tests must be carried out to obtain a statement about the outgassing and thus the purity of the recipient. The difference in the measured values between a test with and without a cold trap is a measure of the outgassing. The test start pressures and the maximum permissible leakage rates can be Table 6.

Table 6: Limit values for the pressure rise test (D2)

Vacuum range	Without cold trap		With cold trap	
	Maximum test start pressure in mbar	Maximum leak rate in $mbar \cdot l \cdot s^{-1}$	Maximum test start pressure in mbar	Maximum leak rate in $mbar \cdot l \cdot s^{-1}$
HV1	$5 \cdot 10^{-3}$	$5 \cdot 10^{-3}$	$5 \cdot 10^{-4}$	$5 \cdot 10^{-4}$

3.3.2 He-integral leak test (A1)

The He integral leak test (A1) measures the sum of all leakages. The measured maximum value of the helium leak rate during the test period is relevant. An example of a test report template can be found in Appendix C.

The limit values for the various vacuum ranges can be found inTable 7.

Table 7: Limit values for the He integral leak test

Vacuum range	Maximum integral He leakage rate according to the He integral leak test (A1) in $mbar \cdot l \cdot s^{-1}$
HV1	$1 \cdot 10^{-4}$
HV2	$1 \cdot 10^{-5}$
HV3	$1 \cdot 10^{-6}$
UHV	$1 \cdot 10^{-7}$

3.4 Leak testing of assemblies, individual parts and mechanical feedthroughs

A larger number of test methods are available for assemblies, individual parts and mechanical feedthroughs that must be vacuum-tight than for testing recipients. A breakdown of the permitted methods can be found inTable 8.

It should be noted that only the He integral leak test (A1) and the pressure rise test (D2) are permitted as quantifying methods. The He individual leak test (A3), the sniffer test (B4) and the bubble detection test (C2) are only permitted for localizing a leak.

Table 8: Permitted methods for testing

Vacuum range	**Quantifying**		**Localizing**		
	He integral leak test A1	**Pressure rise test D2**	**He individual leak test A3**	**Sniffer test B4**	**Bubble detection test (application of liquid) C2**
GV	X	X	X	X	X
FV	X	X	X	X	X
HV1	X	X	X	X	
HV2	X		X	X	
HV3	X		X	(X)*	
UHV	X		X	(X)*	

* Result quality depends on the experience of the tester; special qualification required

In higher pressure ranges up to HV1, either a pressure rise test (D2) can be carried out in combination with a measurement of the individual He leakage rates after the individual He leakage test (A3) or an integral measurement of the total He leakage rate after the integral He leakage test (A1). In the pressure ranges HV2, HV3 and UHV, only a measurement of the leakage rate according to the He integral leakage test (A1) is permitted.

When testing mechanical feedthroughs for leaks, it is important that they are tested in their operating state (in motion).

3.4.1 Pressure rise test (D2)

A more detailed description of the measurement procedure and the evaluation can be found inAppendix B. The test start pressures and the maximum permissible leakage rates can be found inTable 9.

Table 9: Limit values for the pressure rise test

Vacuum range	**Maximum test start pressure in mbar**	**Maximum leak rate in mbar·l·s^{-1}**
GV	1	1
FV	$5 \cdot 10^{-1}$	$5 \cdot 10^{-1}$
HV1	$5 \cdot 10^{-3}$	$5 \cdot 10^{-3}$

3.4.2 He integral leak test (A1)

The He integral leak test (A1) measures the sum of all leakages. The measured maximum value of the helium leak rate in the test period is relevant. An example of a test report template can be found in Appendix C.

The limit values for the various vacuum ranges can be found inTable 10.

Table 10: Limit values for the He integral leak test

Vacuum range	Maximum integral He leakage rate according to A1 in $mbar \cdot l \cdot s^{-1}$
GV	$1 \cdot 10^{-1}$
FV	$1 \cdot 10^{-2}$
HV1	$1 \cdot 10^{-4}$
HV2	$1 \cdot 10^{-5}$
HV3	$1 \cdot 10^{-6}$
UHV	$1 \cdot 10^{-7}$

4 Specification in drawings

In drawings, the leak rate is not specified as a value, but indirectly via the vacuum range.

The permissible test methods and limit values result from the type of component (recipient, individual part, assembly, feedthrough).

Example Maximum He integral leak rate of a recipient for a final ultimate pressure of $5 \cdot 10^{-7}$mbar (high vacuum range HV2): $1 \cdot 10^{-5} mbar \cdot l \cdot s^{-1}$

Specification: **HV2-tight according to LHH-N 000.320**

The specification must be placed near the title block.

5 Orders to suppliers

The vacuum range is also specified in orders that do not include a BLOA drawing.

Example: Maximum He integral leakage rate of a pressure transducer for use in the fine vacuum range (FV): $1 \cdot 10^{-2} mbar \cdot l \cdot s^{-1}$

Specification: **FV-tight according to LHH-N 000.320**

The information must be included in the order specification (Windchill Description).

Appendix A

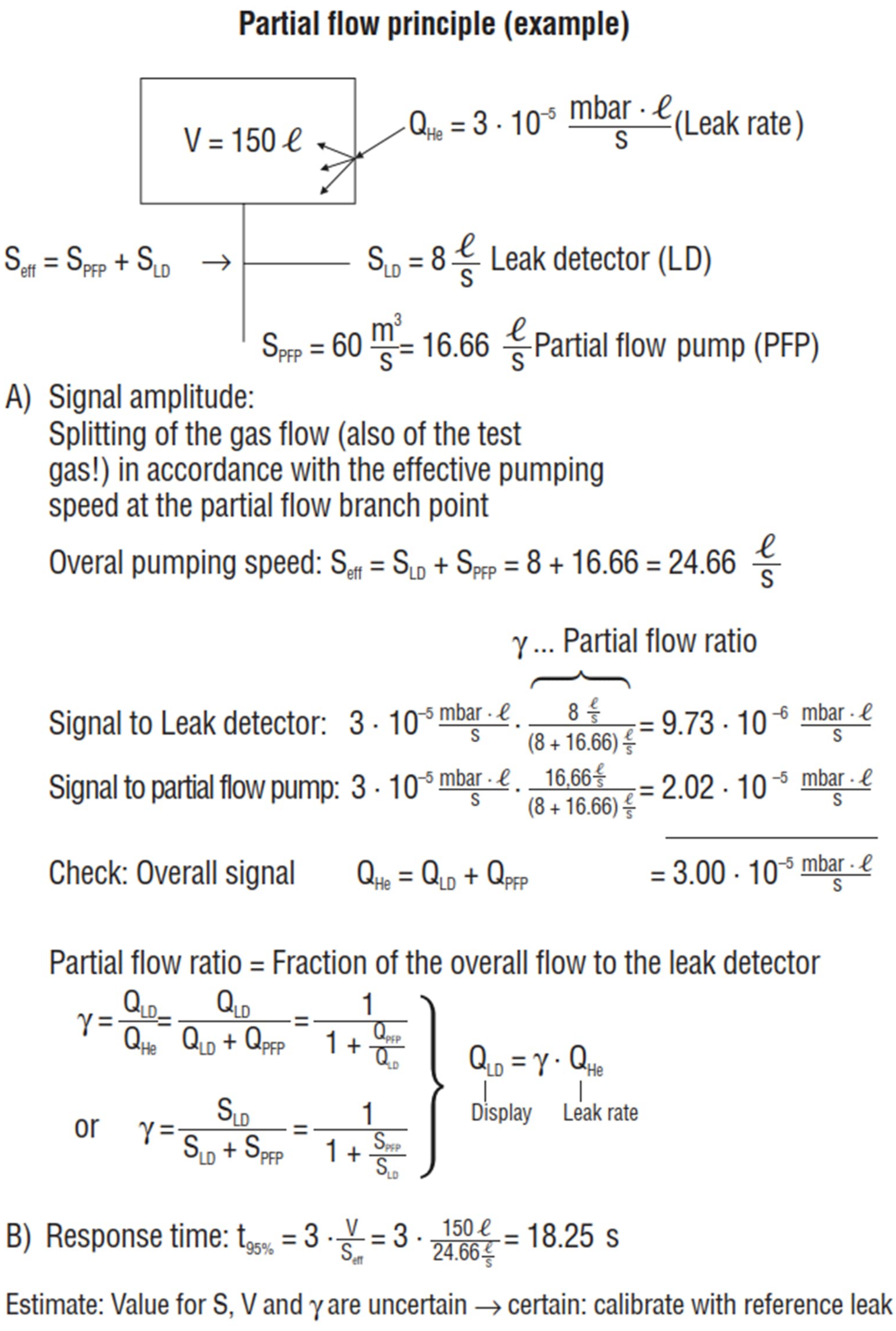

Figure 1: "Fig. 5.13 Partial flow principle" (W. Umrath, Fundamentals of Vacuum Technology; Cologne; 2016 (p.121))

Appendix B

The pressure rise test in accordance with DIN EN 13184 requires some additional information in order to be carried out correctly. The measurement and evaluation are described in more detail below in order to guarantee correct measurement of the leak rate. The pressure rise test measures the total leak rate including outgassing (seeFigure 2). If you have a look at curve 3, the pressure increase can be divided into two areas when pressure is plotted linearly over time, which are connected by a characteristic pivot point. The first area is a combination of outgassing and leak rate, which increases quasi-linearly up to the pivot. The pivot indicates the pressure above which the outgassing has a negligible influence on the pressure increase. The second area therefore describes a pressure increase that is dominated by leakage.

The measurement must only be carried out when the pumps have come to a standstill or have been separated from the volume. This is particularly important when using turbomolecular pumps. The lower the pressure range of the measurement and the lower the pressure of the pivot point, the lower the leakage rates that can be measured by the pressure rise test.

In order to reduce outgassing, the test volume can be conditioned beforehand by pumping it for a long time and, if necessary, baking it out. The parameters of this conditioning are specified in more detail in the test instructions. Another conditioning option is the use of a cold trap, which reduces the outgassing by fixing.

When measuring an unconditioned recipient, a pressure rise measurement with and without a cold trap is always required, as the difference between the two measurements allows a statement to be made about the outgassing of the recipient.

To calculate the leak rate, a starting point in the second quasi-linear range is selected and a doubling of the pressure or at least 30 minutes is needed. The leak rate Q is then calculated from the quotient of the pressure difference Δp and the time difference Δt multiplied by the test volume V:

$$Q = \frac{\Delta p}{\Delta t} \, x \, V$$

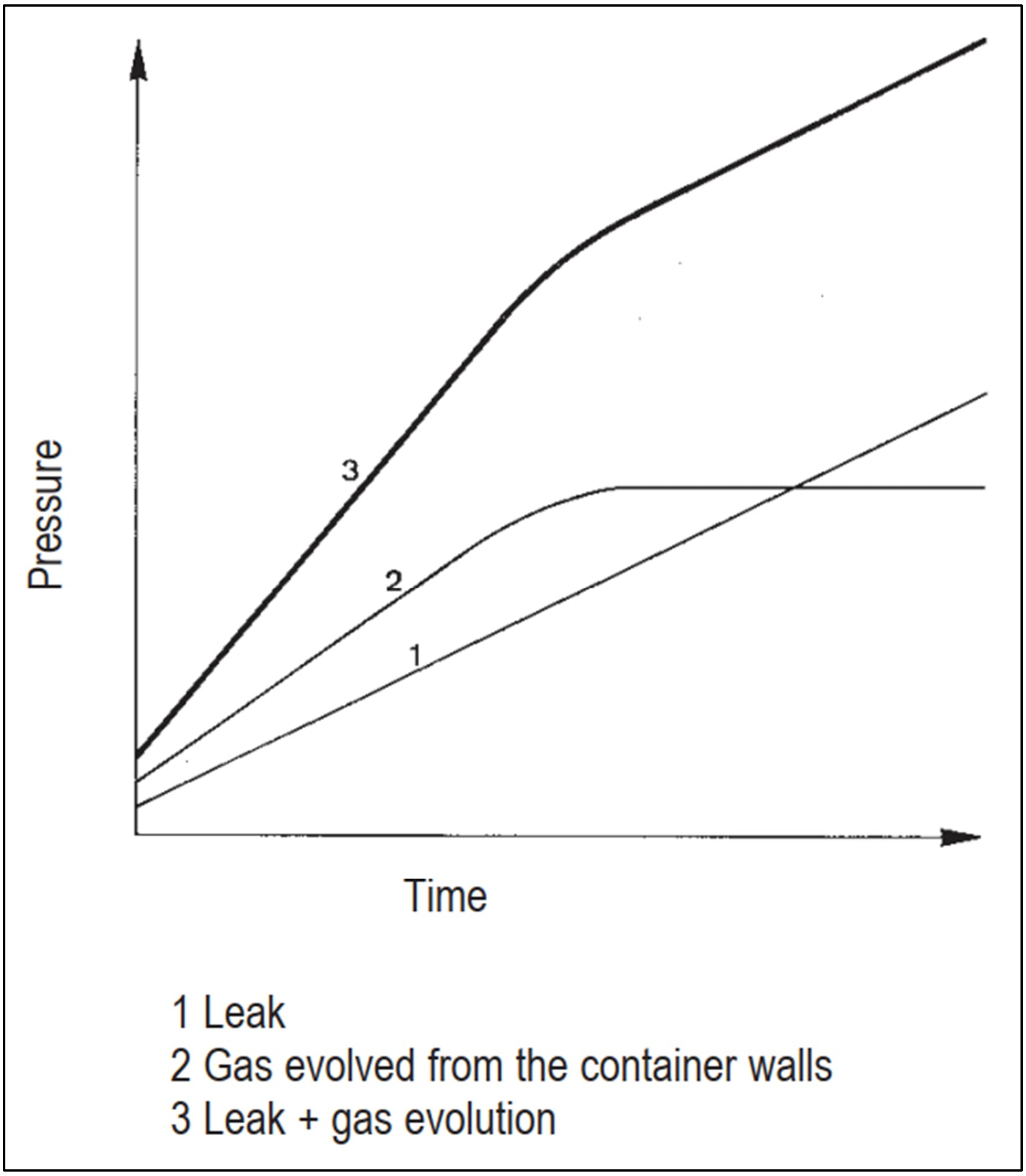

Figure 2: "Fig. 5.5 Pressure rise within a vessel after switching off the pump"
(W. Umrath, Fundamentals of Vacuum Technology; Cologne; 2016 (p.114))

Pressure Rise Test

Machine details:

Plant:			
Plant No.:		**Customer**	
Drawing No.:		**Order No.:**	
Comments:		**Material:**	

Test Data:

Test Location:		**Relative Humidity:**		%
Tester:		**Temperature:**		°C
Date:				

Vacuum Measuring Equipment Details

Pump station (all stages):			**Measuring Device:**	
Target End pressure:	< 5x10-3	mbar	**Gauge Type:**	
Actual End pressure:		mbar		

Pressure Rise Test:

Volume (V):		l	**Target pumping time:**	>12	h
			Actual pumping time:		h

Test with room temperature (total):			**Test with cold trap < -140° C (partial):**		
	pressure in mbar	**time in s**		**pressure in mbar**	**time in s**
start		0	**start**		0
pivot point			**pivot point**		
double pressure or 1800s			**double pressure or 1800s**		
leakrate		mbar·l/s	**leakrate**		mbar·l/s

Test Result:	

Protocol Creator:		**Date / Place:**	

He-Integral-Leak Test

BÜHLER

Machine details:

Plant:			
Plant No.:		**Customer**	
Drawing No.:		**Order No.:**	
Comments:		**Material:**	

Test Data:

Test Location:		**Relative Humidity:**	%
Tester:		**Temperature:**	°C
Date:		**Helium purity:**	

Vacuum Measuring Equipment Details

Dry Pump station:		**Measuring Device:**	
Target Start pressure:	< 1x10-2 mbar	**Gauge Type:**	
Actual Start pressure:	mbar	**Test Leak Target:**	≤1x10-6 mbar·l/s
Leak Detector:		**Test Leak Actual:**	mbar·l/s
Expiration date:		**Test leak SN:**	
Detection Sensitivity of the Leak Detction Measuring System (qHe) in mbar·l/s:		**Target Response Time:**	<60 s
Target: ≤1x10-8	**Actual:**	**Actual Response Time:**	s

He Leak Check:

Target Leak Rate(qHe) :	mbar·l/s (hPa·l/s)	**Target Time:**	600 - 900 s
Actual Leak Rate(qHe) :	mbar·l/s (hPa·l/s)	**Actual Time:**	s
Test Result:			
Protocol Creator:		**Date / Place:**	