Ventilation and pressure equalization systems

Sources

- UN Recommendations
- ADR RID Part 4 / 6
- IMDG Code, Part 4 / 6

1. Applicability

VPA 10 is applicable to packaging, inner packaging and IBC's.

2. Terms

Terms describing ventilation and pressure equalization systems are not included in DIN 55405, which covers packaging terms ("Begriffe für das Verpackungswesen"). For this reason, terms usually used in practice are listed here:

- air release valve
- pressure equalization system (for IBC's)
- ventilation appliances (only for gas outflow)
- safety valve (for tanks)
- pressure relief valve

For purposes of simplicity, in this paper the above systems and appliances are referred to as valves.

Differential pressure is the difference between overpressure or underpressure and atmospheric pressure.

3. Standard requirements/ definitions

The standard requirements are derived from the sources referred to above and the demands faced in practice.Valves must be able to equalize the pressure differences caused by, e.g. temperature fluctuations or chemical reactions. The user is responsible for establishing the influencing parameters and ascertaining the suitability of the valves.
The main standard requirements are:

- Temperature stability
  The valves must be able to resist thermal stresses associated with filling, transporting and using the packaging.
- Chemical resistance
  The valves must be resistant to attack by the packaged products.

- Gas inflow and outflow capacity
  This is the volume of gas that can be released per unit of time at a defined differential pressure**.**
- Response pressure
  This is the defined pressure at which the valve starts to function. A defined residual pres-sure is desirable if, e.g. the residual inside pressure serves to increase the stacking stability of the packaging.
- Leakproofness
  When used as intended, packaging fitted with valves must be just as leakproof as packaging without valves.
- Closing characteristic
  After pressure has been relieved and the response pressure has been reached again, the valve must be just as leakproof as it was originally.
- Service life
  This is the period over which the valve remains fully functional when it is used as itended.
- Mechanical stability
  The valve must be designed so that, in its original state or after being fitted with additional safety devices, it can resist the mechanical stresses to which it is exposed when it is used as intended.

4. Types

The valves most commonly used in the chemical industry are of the following types:

4.1 Valves

These are used when a defined overpressure is required in the packaging during use. Valves are usually also suitable for avoiding harmful underpressure when the packaging is filled with hot materials.

The different types are:
- mushroom valves (Fig. 1)
- ball valves (Fig. 2)
- slit or Bunsen valves (Fig. 3)

4.2 Membranes, fleeces, filters

These are used when the pressure inside the packaging differs minimally or not at all from the atmospheric pressure.

The different types are:
- membranes (Fig. 4)
- microporous membranes (Fig. 5)
- sintered membranes (Fig. 6)
- fleeces (Fig. 7)
- sintered filters made of glass or polyolefins (Fig. 8)

The manufacturer should always be consulted about the suitability of the membranes, fleeces, filters and combinations of these.

The table below shows the areas of application:

Valve type	Properties	Suitable for	Packaging
Microporous membrane (thin film)	• moderate mechanical stability • moderate gas inflow and outflow capacity • high liquid retention capacity	• almost all liquids • highly creeping liquids (with organic ingredients)	• small and large containers (bottles, canisters, drums, combi-IBC)
Sintered membran (thick film)	• high mechanical stability • high gas inflow and outflow capacity • low liquid retention capacity	• non-creeping liquids (without organic ingredients)	• small containers (bottles, canisters)
Fleece (flexible, thin, felt-like)	• moderate mechanical stability • high gas inflow and outflow capacity • low liquid retention capacity	• non-creeping liquids (without organic ingredients)	• small containers (bottles, canisters)
Sintered filter (rigid construction)	• high mechanical stability • high gas inflow and outflow capacity * low liquid retention capacity	• non-creeping liquids (without organic ingredients)	• small and large containers (bottles, canisters, drums, combi-IBC)

4.3 Combinations

This refers to combinations of the types referred to under 4.1 and 4.2.
An example of such a combination is shown in Fig. 9.

5. Tests

The tests to be carried out on each type are shown in the following table:

	Valve Types		
Tests	**Valves**	**Membranes, Fleeces, Filters**	**Combinations**
Chemical resistance	x	x	x
Gas inflow and outflow capacity	x	x	x
Response pressure	x	x [1]	x
Leakproofness (gases)	x		x
Leakproofness (liquids)	x	x	x
Closing characteristics	x		x
Functionality when exposed to the contents of the packaging	x	x	x

[1] Test when exposed to the contest of the packaging

5.1 Test of response pressure

5.1.1 Purpose

The test is used to evaluate the valves with regard to their response characteristic when overpressure occurs.

5.1.2 Procedure

The measuring instrument consists of a clamping device for the valve-type closure and a differential pressure meter. The test should be carried out on a statistically adequate number of closures. The tests should normally be carried out at room temperature (23°C). Where necessary, the temperature at which the valve is used should be selected accordingly.

The test closure is placed in the clamping device and the test procedure is started. The test program should be selected so that the pressure increase matches the intended application and takes place within a defined time (e.g. 0-30 kPa pressure increase within 30 seconds for canisters and drums). The valve must open within this time.

5.1.3 Test report

The test report should include the following information:

- description of the test object
- number of tested samples
- response pressure in kPa rounded off to 0.1 kPa (average value and standard deviation)
- measurement range of the test equipment
- date
- person, who carried out the test

5.2 Test of gas inflow and outflow capacity

5.2.1 Purpose

The test serves to assess the behaviour of the valves when pressure differences occur while gas is flowing through them.

5.2.2 Procedure

The measuring instrument consists of an adapter for the valve-type closures so that they can be connected to a compressed air source and a flow meter (e.g. a rotameter). The test should be carried out on a statistically adequate number of closures. Mushroom valves should be at least 72 hours old (calculated from the date of production). The tests should normally be carried out at room temperature (23°C). If necessary the tests should be carried out at the temperature at which the valve is intended to be used. The closure that is to be tested is screwed to an adapter. The pressure is then set to the selected supply pressure. Usually a series of measurements is carried out at three different pressures (e.g. 2 kPa, 15 kPa and 20 kPa). The volume flow is measured and recorded at each selected pressure.

5.2.3 Test report

The test report should include the following information:

- description of the test object (e.g. membrane-type or fleece-type closure)
- number of tested samples
- gas inflow and outflow capacity (volume flow) in dm^3/h (minimum, maximum and average values) for each supply pressure
- standard deviation in dm^3/h
- variation coefficient (V) in % (V = standard deviation/average value x 100)
- measurement range of the test equipment
- date
- person, who carried out the test

5.3 Test of the functionality of the valve when it is exposed to the contents of the packaging

5.3.1 Purpose
The test serves to demonstrate whether valves are suitable for use with the substances the packaging is intended to contain.

5.3.2 Procedure
The test should be carried out on a statistically adequate number of closures. Before the test, the response pressure and the inflow and outflow gas capacity of the valve type closures should be determined and each closure should be permanently labelled. The closures are then immersed in the substance that is to be stored in the packaging (the total surface of the inside of the closure should be wetted). Storage occurs at room temperatue (23°C). Different storage temperatures (e.g. 40°C/80% RH) are to be quoted accordingly. The immersion periods are usually 2, 4, 8, 16 and 24 hours, and 7, 14 and 21 days. After each immersion period, suitable material is used to dab the inside of the closure until it is free of the substance in which it has been immersed. The response pressure and the inflow and outflow gas capacity are then determined.

5.3.3 The test report should include the following information:
- description of the test object
- number of tested samples
- relative humidity (RH), if applicable
- storage temperature
- storage cycle
- response pressure of untreated valves before immersion, in kPa, rounded to 0.1 kPa
- gas inflow and outflow capacity of untreated valves before immersion, in dm^3/h
- gas inflow and outflow capacity of the valves after immersion, in dm^3/h
- response pressure of the valves after immersion, in kPa, rounded to 0.1 kPa
- date
- person, who carried out the test

5.4 Leakage Test

5.4.1 Usability test –Test of tightness against original flowable products

5.4.1.1 Purpose
Usability test for packaging materials dependently to product influence.

5.4.1.2. Procedure

The suggested packaging has to be filled up to 98% with the original product at room temperature. It is to close tight with the original lid concerning to the handling advice of the packaging producer. The filled and closed container has to be turned upside down, so the lid will be loaded with the hydrostatic pressure of the content. To prevent the pressure growing higher than the hydrostatic power a pressure discharge has to be placed on the topside. The closed and positioned packaging is to be stored at room temperature for 24 hours. If there is not any leakage the closure system passes. A contamination of the surface of the lid is acceptable if the reaction pressure and the gas permeability still suits.

5.4.1.3. Documentation / Test Report

The test report has to content:

- Detailed description of the test object and the wrap
- Number of tested samples
- Original content
- Test result
- Date of test
- Person who tested (full name)

5.4.2. Intake examination – Test of tightness with substitutes products

5.4.2.1. Purpose

Test as routine for intake examination of packaging materials.

5.4.2.2. Procedure

The suggested packaging has to be filled up to 98% with the substitute product at room temperature. It is to close tight with the original lid concerning to the handling advice of the packaging producer (e.g. torque).
Substitutes are
saline free coloured water for neutral products
sodium hydroxid solution, 2% for alkaline products
acetic acid solution, 2%, for acid products
The filled and closed container has to be placed horizontal with the lid on the lowest point. It is to make sure, that the function of the lid is not effected by the way of storage.

The container is to store 30 minutes at room temperature. During this time indicator paper or filter paper is to place under the lid to make any leakage visible.

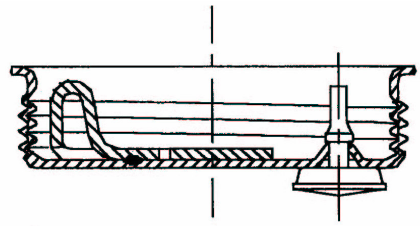
The test passes if there is no leakage. A contamination of the surface of the lid is acceptable if the reaction pressure and the gas permeability still suits.

5.4.2.3. Documentation / Test Report

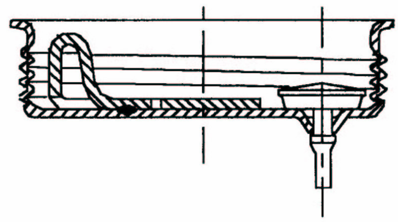
The test report has to content:

- Detailed description of the test object and the wrap
- Number of tested samples
- Original content
- Test result
- Date of test
- Person who tested (full name)

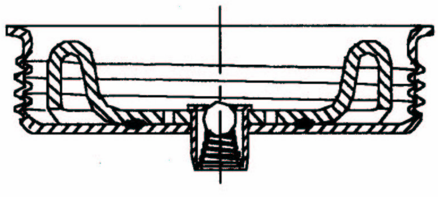
Mushroom valve (gas inflow)
Fig. 1a



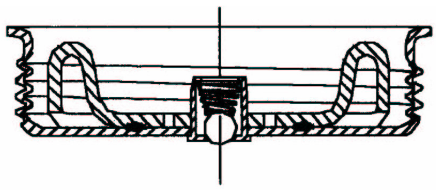
Mushroom valve (gas outflow)
Fig. 1b



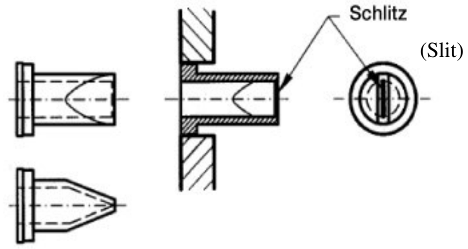
Ball valve (gas inflow)
Fig. 2a



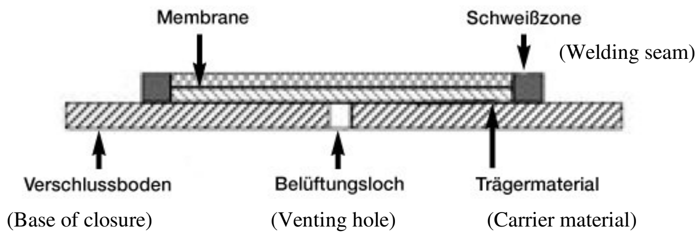
Ball valve (gas outflow)
Fig. 2b



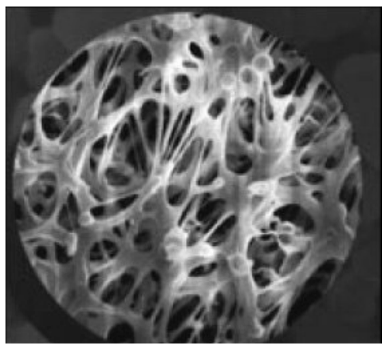
Slit or Bunsen valve
Fig. 3



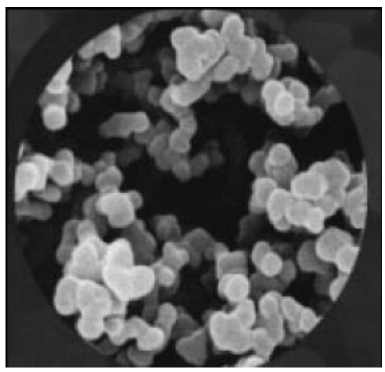
Membrane
Fig. 4



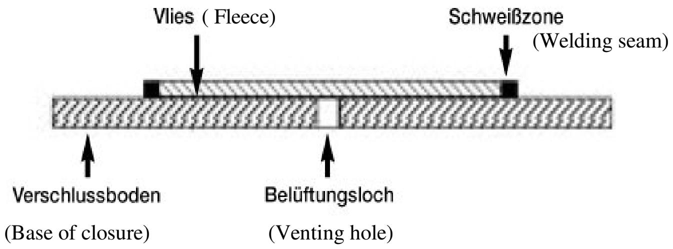
Microporous Membrane
Fig. 5



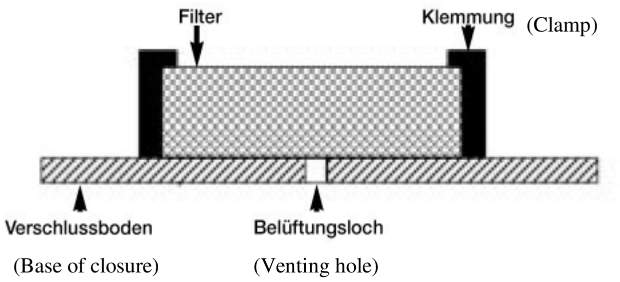
Sintered Membrane
Fig. 6



Fleece
Fig. 7



Filter
Fig. 8



Venting combination of mushroom valve and membrane
Fig. 9