



## **RULES**

### **PUBLICATION 33/P**

#### **AIR PIPE CLOSING DEVICES**

July  
2022

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków complete or extend the Rules and are mandatory where applicable.

GDAŃSK

PRS *Publication No. 33/P – Air Pipe Closing Devices – July 2022*, based on the IACS Unified Requirements P3 (Rev.5 Apr. 2021) is an extension of the requirements contained in *Part VI – Machinery Installations and Refrigerating Plants* of the *Rules for the Classification and Construction of Sea-going Ships*.

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# CONTENTS

	Page
<b>1 General requirements</b> .....	5
1.1 The closing devices shall automatically: .....	5
<b>2 Design</b> .....	5
<b>3 Materials</b> .....	5
<b>4 Testing</b> .....	6
4.1 Testing of Air Pipe Automatic Closing Devices .....	6
4.2 Testing of Non-metallic Floats .....	6
4.3 Testing of Metallic Floats .....	7
<b>5 Tightness test</b> .....	7
5.1 Tightness Test of Air Pipe Closing Devices .....	7
5.2 Hydraulic Test of Closing Devices Casings .....	9
<b>6 Marking</b> .....	9
<b>7 Determination of air pipe closing device flow characteristics</b> .....	9
7.1 General Requirements .....	10
7.2 Measurement of Fluid Flow by Means of Orifice Plates Inserted in Pipe .....	10
7.3 Calculation of Flow Resistance.....	12
7.4 Discharge / Reverse flow test.....	13



## 1 GENERAL REQUIREMENTS

Air pipe closing devices, where required by the *Rules for the Classification and Construction of Sea-going Ships*, shall be permanently fixed and be of an approved type.

1.1 The closing devices shall automatically:

- prevent the free entry of water into the tanks, and
- allow the passage of air or liquid to prevent excessive pressure or vacuum coming on the tank.

## 2 DESIGN

2.1 Air pipe automatic closing devices are to be so designed that they withstand both ambient and working conditions, and be suitable for use at inclinations up to and including +40°.

2.2 Air pipe automatic closing devices are to be so constructed as to allow inspection of the closure and the inside of the casing, as well as the changing of the seals.

2.3 In the case of air pipe closing devices of the float type, suitable guides are to be provided to ensure unobstructed operation under all working conditions of heel and trim as specified in 2.1.

2.4 Efficient ball or float seating arrangements are to be provided for the closures. Bars, cage or other devices are to be provided to prevent the ball or float from contacting the inner chamber in its normal state and made in such a way that ball or float is not damaged when subjected to water impact due to a tank being overfilled.

2.5 Air pipe closing devices are to be self-draining.

2.6 The clear area through an air pipe closing device in the open position is to be at least equal to the area of the inlet.

2.7 The maximum allowable tolerances for wall thickness of floats should not exceed  $\pm 10\%$  of thickness. Where side covers are provided and their function is integral to providing functions of the closing device as outlined in 1.1, they shall have a minimum wall thickness of 6 mm. If the air pipe head can meet the tightness test in 5.1 without the side covers attached, then the side covers are not considered to be integral to the closing device, in which case a wall thickness less than 6 mm can be acceptable for side covers.

2.8 The inner and the outer chambers of an automatic air pipe head is to be of a minimum thickness of 6 mm.

## 3 MATERIALS

3.1 Casings of air pipe closing devices shall be of approved metallic materials adequately protected against corrosion.

3.2 For galvanised steel air pipe heads, the zinc coating is to be applied by the hot method and the thickness is to be 70 to 100 microns.

3.3 For areas of the head susceptible to erosion (e.g. those parts directly subjected to ballast water impact when the tank is being pressed up, for example the inner chamber area above the air pipe, plus an overlap of 10° or more either side) an additional harder coating should be applied. This is to be an aluminium bearing epoxy, or other equivalent, coating, applied over the zinc.

**3.4** Closures and seats made of non-metallic materials shall be compatible with the media intended to be carried in the tank and to sea water and suitable for operating at ambient temperatures between  $-25^{\circ}\text{C}$  and  $85^{\circ}\text{C}$ .

## 4 TESTING

### 4.1 Testing of Air Pipe Automatic Closing Devices

Each type and size of air pipe closing automatic device is to be surveyed and tested at the manufacturer's works or other acceptable location according to PRS' practice. The minimum test requirements for an air pipe closing device shall include the following:

- .1 Tightness test during immersion in/emerging from water. The test procedure is given in paragraph 5.
- .2 Determining the flow characteristics of the air pipe closing device. The measurement of the pressure drop versus rate of volume flow is to be carried out using water and with any intended flame or insect screens in place. The recommended procedure for measuring pressure drop in air pipe closing device is given in paragraph 7.
- .3 Discharge / reverse flow test. The test procedure is given in paragraph 7.4.

### 4.2 Testing of Non-metallic Floats

Impact and pressure loading tests shall be carried out on the floats before and after pre-conditioning, according to the below Table:

Test condition	Test temperature [ $^{\circ}\text{C}$ ]		
	-25	20	85
Dry	+	+	+
After immersion in water	+	+	+
After immersion in oil fuel	-	+	-

NOTES: The total period of immersion in water and oil fuel is to be at least 48 hours. The total period of keeping the floats at the above specified temperatures before dry test is to be at least 24 hours.

„+“ test required; „-“ test not required

#### 4.2.1 Impact Test

The test may be conducted on a pendulum type testing machine. The floats shall be subjected to 5 impacts of 2,5 Nm each and shall not suffer either permanent deformation, cracking or surface deterioration at this impact loading. Subsequently, the floats shall be subjected to 5 impacts of 25 Nm each. At this impact energy level, some localized surface damage at the impact point may occur. No permanent deformation or cracking of the floats shall appear.

#### 4.2.2 Compression Loading Test

Compression tests are to be conducted with the floats mounted on a supporting ring of a diameter and bearing area corresponding to those of the float seating with which it is intended that float shall be used. For ball type float, loads shall be applied through a concave cap of the same internal radius as the tested float and bearing on an area of the same diameter as the seating. For a disc type float, loads are to be applied through a disc of equal diameter as the float.

A load of 3450 N shall be applied for one minute and maintained for 60 minutes. The deflection shall be measured at intervals of 10 minutes after attachment of the full load. The record of deflection against time is to show no continuing increase in deflection and, after release of the load, there shall be no permanent deflection.

### 4.3 Testing of Metallic Floats

Tests shall be conducted in accordance with 4.2.1. The tests shall be carried out at room temperature and in the dry condition.

## 5 TIGHTNESS TEST

### 5.1 Tightness Test of Air Pipe Closing Devices

An automatic closing device is to be subjected to a series of tightness tests involving not less than two (2) immersion cycles under each of the following conditions:

- a) The automatic closing device is to be submerged slightly below the water surface at a velocity of approximately 4 m/min. and then returned to the original position immediately. The quantity of leakage is to be recorded.
- b) The automatic closing device is to be submerged to a point slightly below the surface of the water. The submerging velocity is to be approximately 8 m/min and the air pipe vent head is to remain submerged for not less than 5 minutes. The quantity of leakage shall be recorded.
- c) Each of the above tightness tests are to be carried out in the normal position as well as at an inclination of 40 degrees under the strictest conditions for the device. In cases where such strictest conditions are not clear, tests shall be carried out at an inclination of 40 degrees with the device opening facing in three different directions: upward, downward, sideways (left or right). (See Figure 1 to 4)

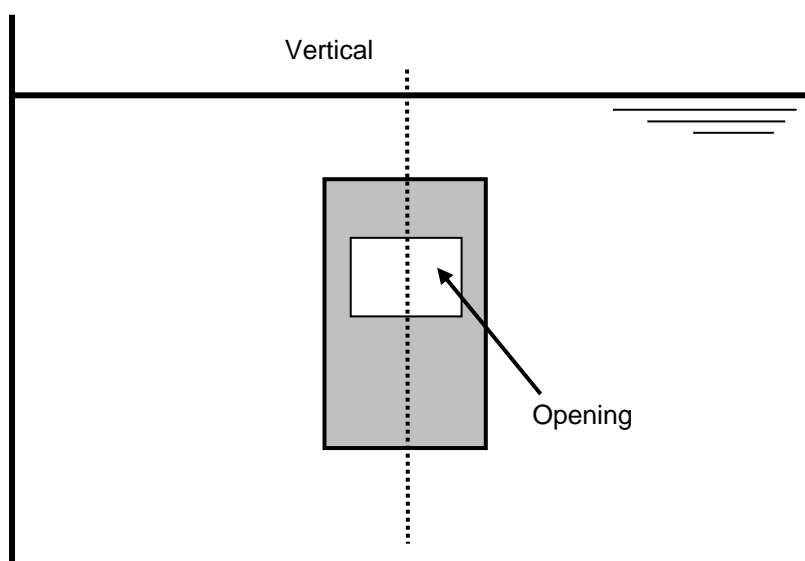


Fig 1. Example of normal position

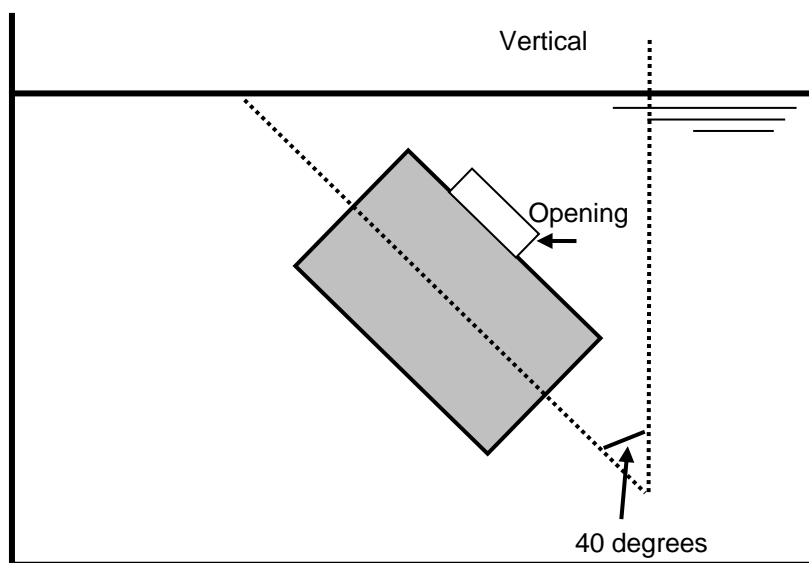


Fig 2. Example of inclination 40 degrees opening facing upward

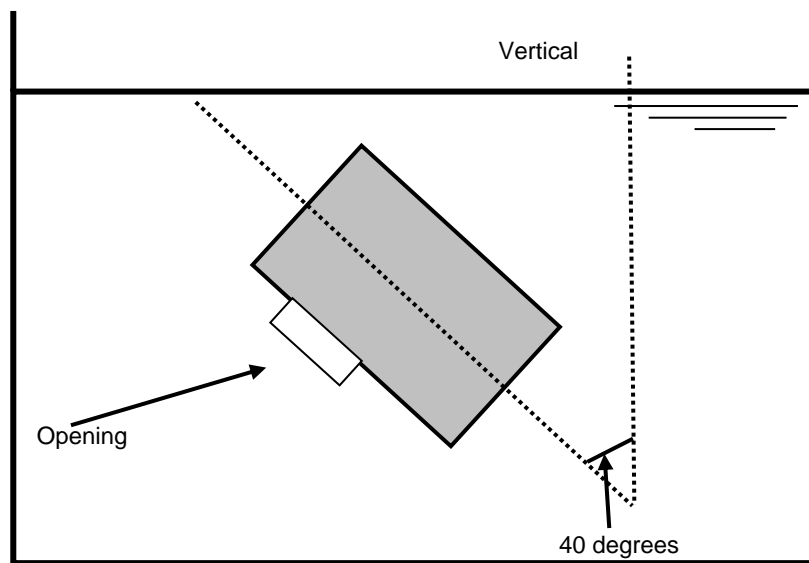


Fig 3. Example of inclination 40 degrees opening facing downward



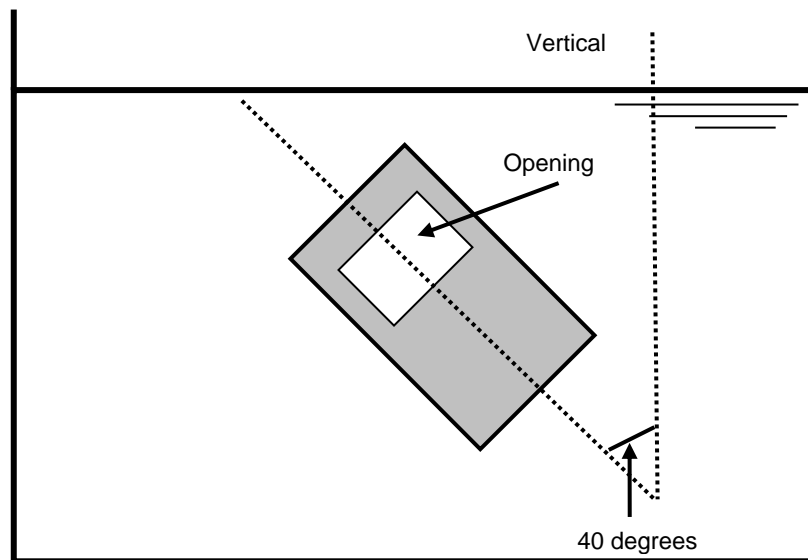


Fig 4. Example of inclination 40 degrees opening facing sideways

The maximum allowable leakage per cycle shall not exceed 2 ml/mm of nominal diameter of inlet pipe during any individual test.

## 5.2 Hydraulic Test of Closing Devices Casings

Casings of air pipe closing devices, selected at random, are to be subjected to a hydraulic pressure equal to 0.2 MPa. The casings shall show neither leakages nor deformations.

## 6 MARKING

Air pipe closing devices shall be marked with the following particulars:

- nominal diameter DN,
- resistance coefficient  $\zeta$ ,
- type,
- manufacturer.

## 7 DETERMINATION OF AIR PIPE CLOSING DEVICE FLOW CHARACTERISTICS

On the test stand, the pressure drop versus rate of volume flow is determined for each nominal diameter of the air pipe closing device size range, subjected to test.

To determine the  $\zeta$  value which is related to the velocity, a sufficient number of measurements are to be made with different rates of volume flow.

If the flow testing is carried out with orifice plates, the following data are to be recorded for each measuring point:

- differential pressure of the orifice,
- flow coefficient (C) of the orifice,
- Reynolds number (ReD) related to the inner pipe diameter,
- rate of volume flow and pressure drop at the air pipe closing device.

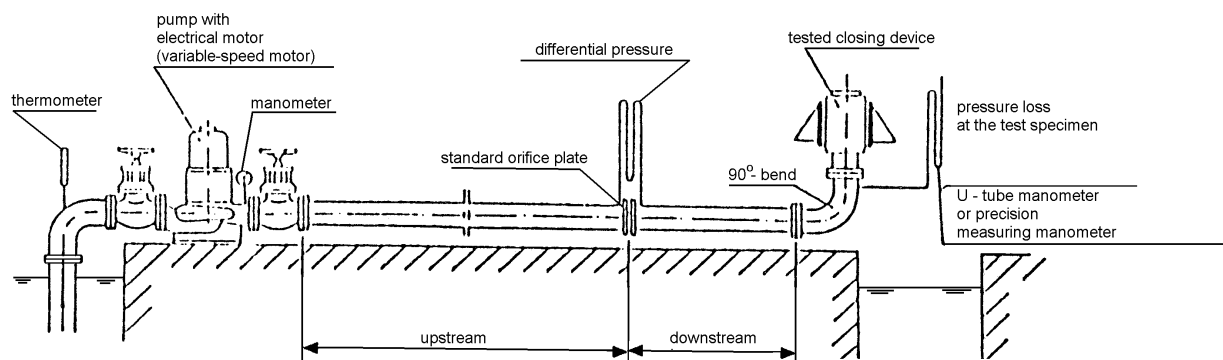
Flow characteristics changes shall be graphically represented.

## 7.1 General Requirements

- the measuring equipment for determining mass and/or rate of volume flow shall comply with recognized standards,
- the measuring equipment shall be fitted at such points of the piping where full velocity is reached and irrotational flow exists. As a rule this requirement is met if straight piping lengths upstream and downstream the orifice plate are in accordance with the standards. The value of specific gravity and viscosity of the test medium under operating conditions should be known.
- the rate of volume flow should be constant,
- in the measuring section, the pipe shall be completely filled with the flowing fluid.

## 7.2 Measurement of Fluid Flow by Means of Orifice Plates Inserted in Pipe

Test stand for determining resistance coefficient (Test medium: water)



**Notes** to determining the  $\zeta$  value.

The rate of volume flow is calculated as follows:

$$\dot{V} = m \cdot \frac{\pi}{4} \cdot D^2 \cdot \alpha \cdot \sqrt{2 \cdot \frac{\Delta p}{\rho_{\text{H}_2\text{O}}}}, \quad [\text{m}^3/\text{s}]$$

or

$$\dot{V} = C \cdot \frac{\pi}{4} \cdot d^2 \cdot E \cdot \sqrt{2 \cdot \frac{\Delta p}{\rho_{\text{H}_2\text{O}}}}, \quad [\text{m}^3/\text{s}]$$

Taking into account, in the above formulae, the values of tests results and introducing:

$$f = m \cdot \frac{\pi}{4} \cdot D^2 \cdot 3600 \sqrt{\frac{2g}{1000} \left( \frac{\rho_{\text{Hg}}}{\rho_{\text{H}_2\text{O}}} - 1 \right)}$$

we obtain:

$$\dot{V} = f \cdot \alpha \sqrt{h}, \quad [\text{m}^3/\text{h}]$$

or

$$\dot{V} = f \cdot C \cdot E \sqrt{h}, \quad [\text{m}^3/\text{h}]$$

where  $h$  is given in mm Hg.

Symbols:

$D$  - inside diameter of piping, [m]

$d$  - inner diameter of orifice plate, [m]

$m = \beta^2 = \frac{d^2}{D^2}$  aperture ratio, [-]

$\beta = \frac{d}{D}$  diameters ratio, [-]

$\nu = \frac{\eta}{\rho}$  kinematic viscosity, [m<sup>2</sup>/s]

$\rho$  - specific gravity, [kg/m<sup>2</sup>]

$\eta$  - absolute viscosity, [Pa·s]

$\alpha$  - flow coefficient of orifice plate as a function of Reynolds number, [-]

$Re_D = \frac{D \cdot w}{\nu}$

$w = \frac{\dot{V}}{A}$  velocity of test medium, [m/s]

$A$  - cross-section of piping, [m<sup>2</sup>]

$g$  - acceleration of gravity, [m/s<sup>2</sup>]

$\Delta p = h \cdot g (\rho_{\text{Hg}} - \rho_{\text{H}_2\text{O}})$ , [N/m<sup>2</sup>]

$h$  - differential pressure taken at standard orifice plate (U-tube mercury manometer), [mm Hg]

$E$  - velocity coefficient, [-]

$$E = \frac{1}{\sqrt{1 - \beta^4}} = \frac{D^2}{\sqrt{D^4 - d^4}}$$

$C$  - flow coefficient as a function of Reynolds number ( $Re_D$ ), [-]

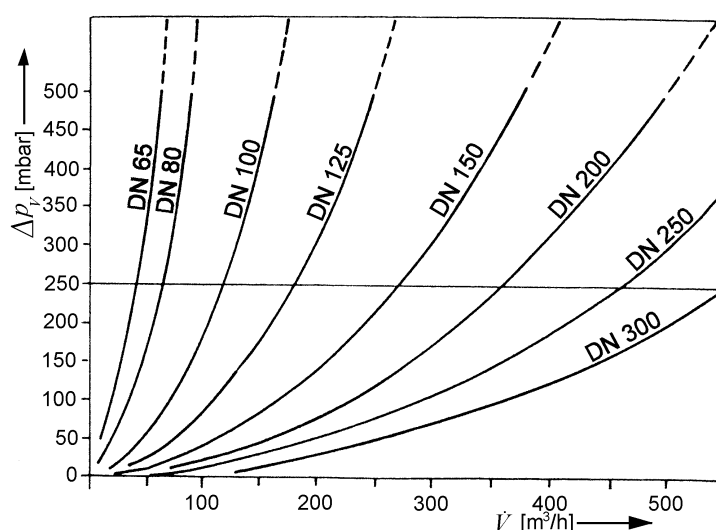
$C = \frac{\alpha}{E}$

$\rho_{\text{Hg}}$  - the specific gravity of mercury, [kg/m<sup>3</sup>]

$\rho_{\text{H}_2\text{O}}$  - the specific gravity of water may be approximately taken equal to 1000 kg/m<sup>3</sup>.

The kinematic viscosity depending on temperature can be taken from the relevant diagrams.

The exact value of  $C$  for standard orifice plates is experimentally determined and can be taken from the relevant diagrams.



Flow resistance curves for various dimensions of the same type air pipe closing devices.

$\Delta p_v$  – pressure drop at the tested closing device

$\dot{V}$  – rate of volume flow

Where practicable, for each nominal diameter the flow resistance characteristics shall be determined experimentally. If the pump capacity is not adequate for nominal diameters exceeding DN 300, the  $\zeta$  value for the air pipe closing device shall be determined by flow resistance calculations. If flow resistance curves show hydraulic analogy, the  $\zeta$  value will not change, even for bigger nominal diameters. Hydraulic analogy exists if, at constant resistance head and equal velocity of flow, the rates of volume flow satisfy the ratio:

$$\frac{\dot{V}_1}{\dot{V}_2} = \frac{d_2^2}{d_1^2}$$

#### Notes:

For marking the air pipe closing devices, see paragraph 6 – MARKING.

The  $\zeta$  value is calculated for flow velocity in the connecting flange and determined for the flow resistance equal to 0.025 MPa.

### 7.3 Calculation of Flow Resistance

Since air pipe closing devices can be also regarded as part of overflow pipes, it is to be ensured that the whole volume of liquid will be discharged through the air pipe device without exceeding the design pressure of the tank. To meet this requirement, the total flow resistance of air pipes and overflow pipes should be known at designing air pipe system. The total flow resistance of air pipes consists of the resistance of straight pipe lengths, the resistance of the fittings and valves and is expressed in terms of pressure loss. Furthermore, apart from the above-mentioned resistances, the vertical differences within the system, i.e. the height of the air and overflow pipe, measured between the tanktop and the air pipe closing device, shall be taken into account in the calculations.

Flow resistance components:

$$I \quad \Delta p_v = \lambda \cdot \frac{l}{d} \cdot \frac{w^2}{2} \cdot \rho, \text{ [N/m}^2\text{]}$$

$$\text{II} \quad \Delta p_v = \zeta \cdot \frac{w^2}{2} \cdot \rho, [\text{N/m}^2]$$

$$\text{III} \quad \Delta p_v = H \cdot g \cdot \rho, [\text{N/m}^2]$$

where:

$\Delta p_v$  – pressure loss, [N/m<sup>2</sup>]

$l$  – length of straight pipe, [m]

$\lambda, \zeta$  – resistance coefficients, [-]

$H$  – vertical difference, [m]

I – for straight pipe lengths

II – for fittings and valves

III – for vertical differences

The sum of pressure losses (I, II, III) cannot exceed the tank design pressure.

#### 7.4 Discharge / Reverse flow test

The air pipe head shall allow the passage of air to prevent excessive vacuum developing in the tank. A reverse flow test shall be performed. A vacuum pump or another suitable device shall be connected to the opening of the air pipe leading to the tank. The flow velocity shall be applied gradually at a constant rate until the float gets sucked and blocks the flow and the velocity at the point of blocking shall be recorded. 80% of the value recorded will be stated in the certificate.

##### 7.4.1 Alternative to the reverse flow test

For pipes heads of 400 mm diameter and above, as an alternative to the reverse flow test, a numerical simulation test based on computational fluid dynamics (CFD), to be carried out in conjunction with limited representative testing to establish the validity of the CFD modelling and results, may be accepted.

CFD predictions for air pipe heads can be validated against the available actual reverse flow test results of the same size and type of air pipe heads. The accuracy of the CFD modelling and the major assumptions used for the calculations are to be documented. Mesh convergence studies are to be carried out and documented. The velocity at the point of blocking shall be recorded . 80% of the value recorded will be stated in the certificate.

#### List of amendments effective as of 1 July 2022

<i>Item</i>	<i>Title/Subject</i>	<i>Source</i>
<a href="#">5.2</a>	Tightness test	IACS UR P3 (Rev.5 2021)
<a href="#">7.4.1</a>	Alternative to the reverse flow test	IACS UR P3 (Rev.5 2021)