THEORETICAL BASES OF SEPARATION

Separation is the process of division of solid, liquid, and vapor phases in the flow.

The separators that are used in fields are classified according to the following criteria:

- intended use: **active and test;**
- geometric form: **cylindrical and bullet;**
- geometric arrangement: **vertical, horizontal, and inclined;**
- way of phases separation: **mechanical, liquid,** and electric.

Separators with mechanical separation of phases, mostly used in fields now, according to the nature of the forces that are used for separation, are divided into:

- **gravitational;**
- **cyclone (centrifugal);**
- **inertial;**
- **filtration.**

CALCULATION OF GAS AND LIQUID SEPARATOR CAPACITY

Calculation of Vertical Gravitational Gas Separator

Precipitation of drops and solid particles from the gas in the gravitational separator takes place due to the following two reasons: sharp decrease of the gas flow rate and difference in the densities of the gas and liquid (solid) phases.

Figure 1 – Vertical Gravitational Gas Separator

In order for the separation to be effective, it is necessary that the calculated gas flow rate in the separator should be less than the precipitation rate of the liquid and solid particles that move under the influence of the gravitational force in the counter-current gas flow, i. e.: $\upsilon_{\mathrm{g}} < \upsilon_{p}$

Gas upward travel rate in the vertical separator (m/s) with the account of the operating conditions is determined on the basis of the following expression: $\longrightarrow$ (1, 2)

Precipitation rate of the liquid drops (solid particles) that have a form of a small ball can be determined in accordance with the Stocks' and formula: → (3)

If a particle precipitation direction in the gas flow is taken as a positive direction, it precipitates at the rate of: → (4)

In practice, when conducting any calculations, the particle movement rate is taken equal to: → (5)

Technological characterization of some vertical separators with the tangential inlet

Code of separator	Working pressure, MPa	Gas capacity , th.m^3/d	Height of separator. m	Conditional diameter mm	Volume of separator, m^3	Mass of separator, kg
TTB 160-400	16,0	305	3950	400	0,40	640
TTB 160-600	16,0	686	4130	600	0,9	2450
TTB 100-800	10,0	875	4330	800	1,8	3736
TTB64-1000	6,4	1100	4420	1000	2,9	3550
TTB25-1200	2,5	940	4360	1200	4,2	2682
TTB 16-1400	1,6	972	4440	1400	5,8	2688
TTB6-1600	0,6	670	4490	1600	7,6	2387'.

Calculation of Vertical Gravitational Liquid Separator comes down to the fact that, in order to obtain the rate of gas bubbles rise, it is necessary that the following condition should be met: $\upsilon_l < \upsilon_g$

The rate of gas bubbles rise in the liquid is usually determined in accordance with the Stocks' formula but absolute gas viscosity should be replaced by absolute liquid viscosity .

Taking into account the correlation (3), the vertical gravitational liquid separator capacity can be found out in accordance with the formula: $\longrightarrow$ (7, 8)

CALCULATION OF HORIZONTAL GRAVITATIONAL SEPARATOR

Figure 2 – **Horizontal Gravitational Gas Separator**

Calculation of horizontal Gravitational Gas Separator

The capacity of the horizontal gravity separator gas is calculated using the formula (1), which impose additional factor $n = l/D_s$ (actual distance between the entry and exit pipes of gas, which is accepted $l \geq 3$ m). $\longrightarrow$ (9)

The capacity of the horizontal gravity separator for liquid calculated by the following formula $\longrightarrow$ (10)

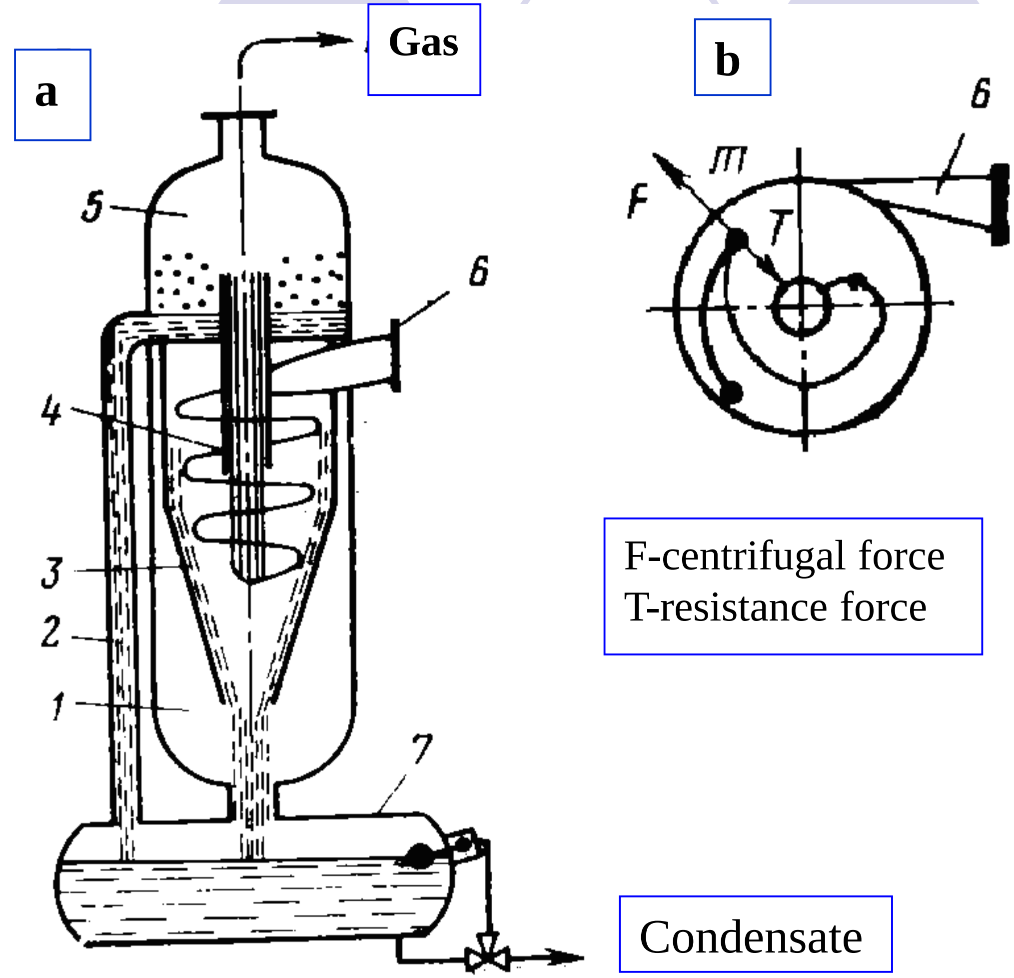
F - surface area of liquid, depending on the height of the liquid level in the separator, *square meters*.

BASIC PARAMETERS OF HORIZONTAL SEPARATORS

Code of separator	Working pressure, MPa	Capacity		Length of separator, mm	Conditional diameter mm	Mass of separator, kg
		for gas, th.m^3/d	for oil, m^3/d			
НГС64-1400	6,4	560	2000	5925	1400	7900
НГС64-1600	6.4	1260	5000	7735	1600	13 400
НГС64-2200	6,4	2200	10 000	8505	2200	28 350
НГС40-2600	4,0	3000	20 000	11 490	2600	33 800
НГС40-3000	4,0	4400	30 000	12 730	3000	47 200

Calculation of Cyclone Separators (fig. 3).

Gas-liquid flow at a great flow rate (10-25 m/s) gets into the tangential nipple that is inclined at some angle. Due to the centrifugal gravitational force **F**, the liquid drops precipitate on the body wall of the cyclone and flow down in the form of a film. The gas that is lighter than the liquid is directed to the center of the cyclone.



a-general view of separator; b-calculation diagram of separator; 1-separator body; 2-drain pipe; 3-cyclone body; 4-diagram of gas movement in the cyclone; 5-section of entrapped water separation; 6-tangential oil and gas mixture inlet; 7-condensate inlet

Figure 3 – Diagram of Cyclone Separator

It is assumed that the centrifugal force that influences the particle is equal to the resistance force created by the gas and it prevents the particle movement in radial direction.

The liquid particles movement rate in the cyclone depending on their dimensions is determined in accordance with the formula:

1. For diametr less 0,08 mm $\longrightarrow$ Stocs formula
2. For bigger particles 0,08 to 0,8 mm $\longrightarrow$ Allen formula
3. For the biggest particles more 0,8 mm $\longrightarrow$ Newton formula

The cyclone separator diameter D at the set gas flow rate is determined: $\longrightarrow$

Pressure losses in the cyclone are determined in accordance with the formula: $\longrightarrow$

The resistance coefficient hardly depends on the flow rate. However, it depends on the correlation between the area of the outlet and inlet nipples (ξ=2 – 4).

Capacity of cyclone separators, th.m^3/d

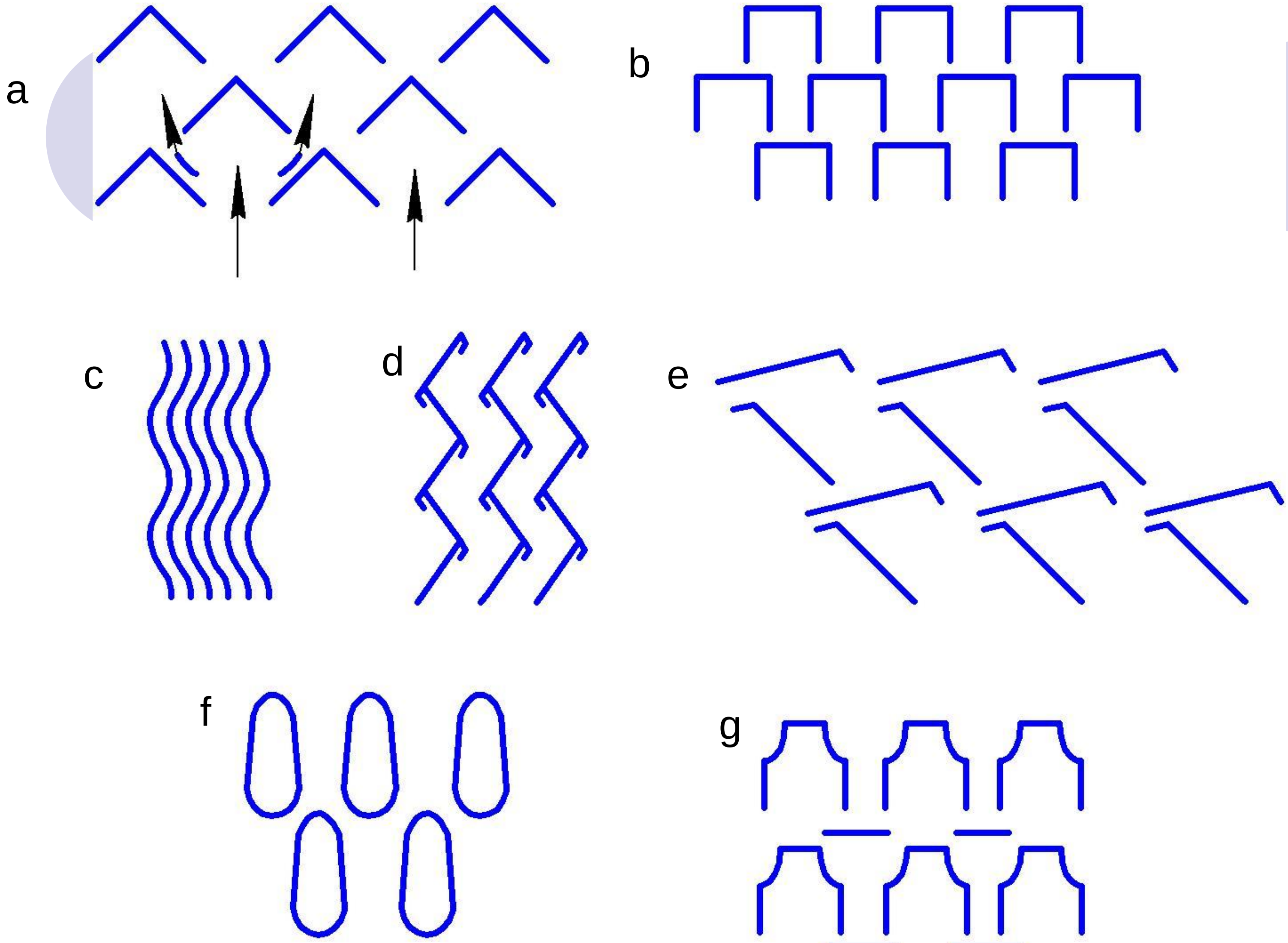
Diameter of cyclone, cm	Working pressure, MPa						
	1	2,5	6,4	10	16	20	25
80	**1-1,7**	**25-42**	**65-108**	**100-170**	**160-270**	**200-340**	**-**
100	**1,8-3**	**45-75**	**115-190**	**180-300**	**290^480**	**360-600**	**500-750**
150	**4-7**	**100-170**	**260-450**	**400-700**	**700-1100**	**800-1350**	**900-1750**
200	**7-12**	**200-300**	**460-770**	**720-1200**	**1160-1900**	**1450-2400**	**1800-3000**
250	**13-21**	**330-540**	**830-1380**	**1300-2150**	**2000-3400**	**2600-4300**	**-**
300	**18-30**	**470-770**	**1190-1980**	**1900-3100**	**3450-4900**	**3700-6200**	**-**
350	**24-40**	**640-1040**	**1620-2690**	**2500-4200**	**4000-5500**	**5000-8500**	**-**
400	**31-52**	**830-1350**	**2100-3510**	**3300-5500**	**6100-8700**	**6500-11000**	**-**
500	**48-80**	**1290-2100**	**3290-5480**	**5200-8600**	**9600-13 500**	**10 200-17 200**	**-**

Calculation of separators with nozzles comes down to determination of the nozzle incoming flow rate at which there is no explosion and crushing of the liquid drops that precipitated onto the nozzle.

The critical gas flow rate in (m/s) that characterizes this process is determined: ⟶

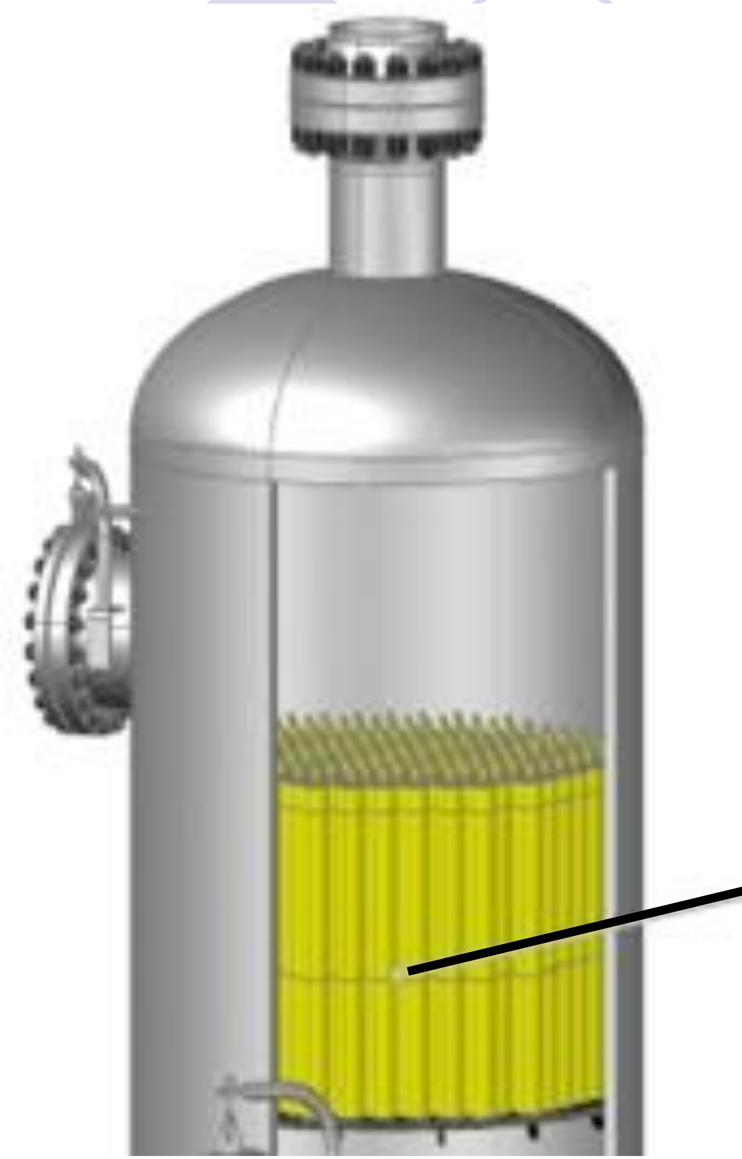
A=0,65 for the wire nozzle and the A coefficient may be in range from 0,4 to 0,9 for the louvre nozzle.

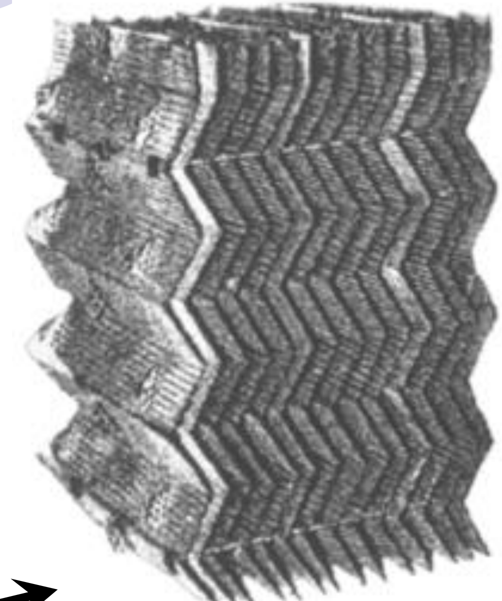
The nozzle cross section area in (m^2) is determined in accordance with the formula: ⟶



a – angular; b - in form groove; c - louvre nozzle; d - nozzle in form blade;
e - f – in the form of drops; g - in form moving stream (plume)

Nozzles of some types





Louvre nozzle