

**ERASMUS  
MARINE ENGINEERING SYSTEMS  
(auxiliary equipment and systems)**

# Auxiliary equipment



- pumps
  - ventilators, compressors
  - steering gears
  - refrigerating equipment
  - fresh water generators
  - bilge separators
  - fuel and lubrication oil separators
  - etc.
-

# Pumps

3



---

# Types

- mechanical energy transferred to the energy of fluids
  - according to the energy change:
    - ✦ dynamic (rotodynamic, velocity)
    - ✦ positive displacement (static, volumetric)
  - **dynamic**
    - ✦ **centrifugal**, axial, diagonal
    - ✦ special effect pumps – eductor-jet
  - **static** (plunger, piston, screw, lobe etc.)
-

# Application



- dynamic, especially centrifugal:
    - ✦ large capacities, cargo, water
  - positive displacement pumps
    - ✦ high pressures, fuel, lube oil, bilge
-

# Basics



- energy of fluid
  - self-priming
  - cavitation
  - $\text{NPSH}_r$  and  $\text{NPSH}_a$
  - capacity regulation
-

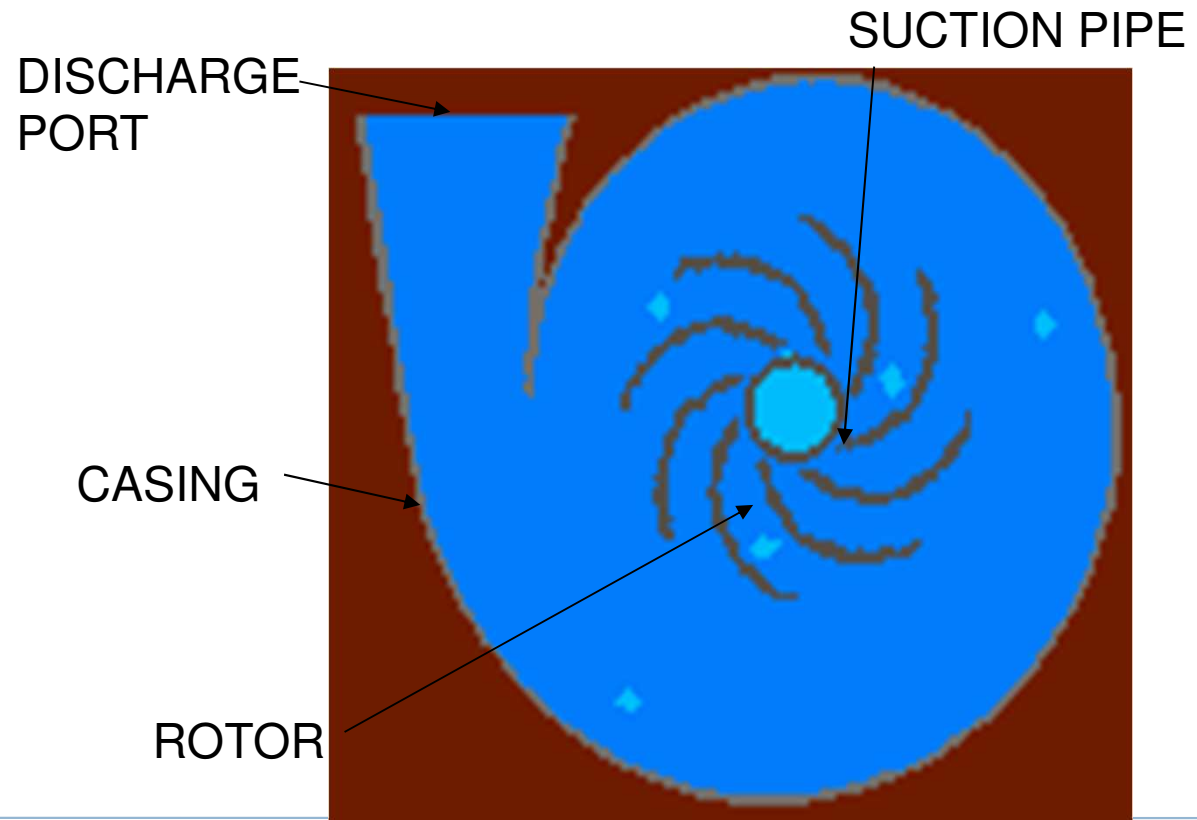
# Starting - operation



- Positive displacement pumps should never be operated with the valve in the discharge line being closed – there would be a continual pressure build up that would cause the pump or pipeline failure or both
  - Dynamic pump should be started with the discharge valve closed and also during its operation the valve could be closed without any danger at least for a short period
-

# Turbopumps

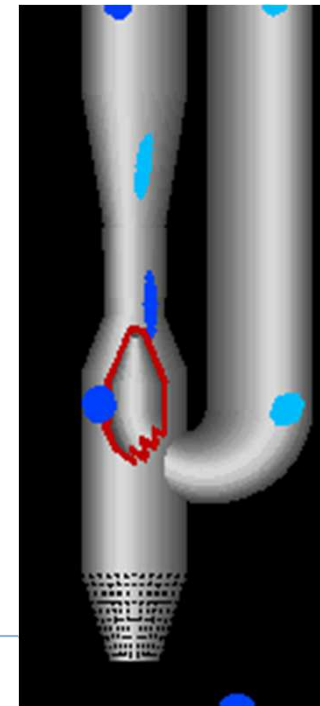
→ centrifugal, axial (propeller), diagonal





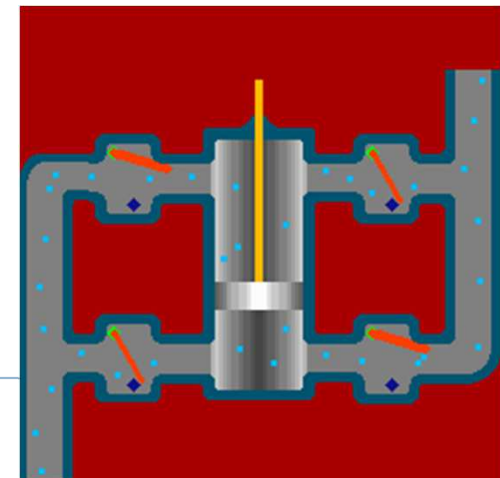
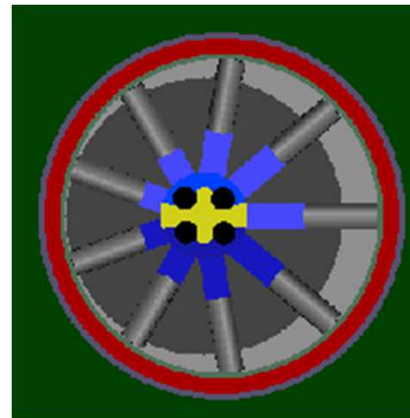
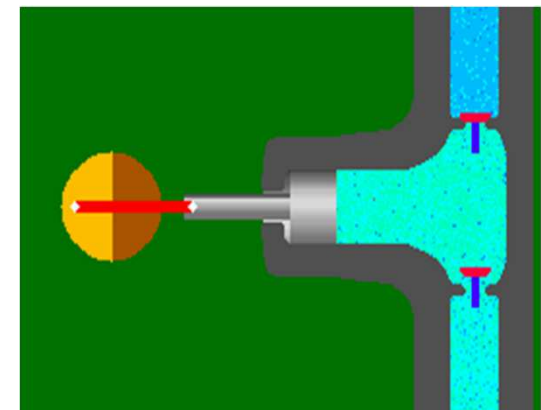
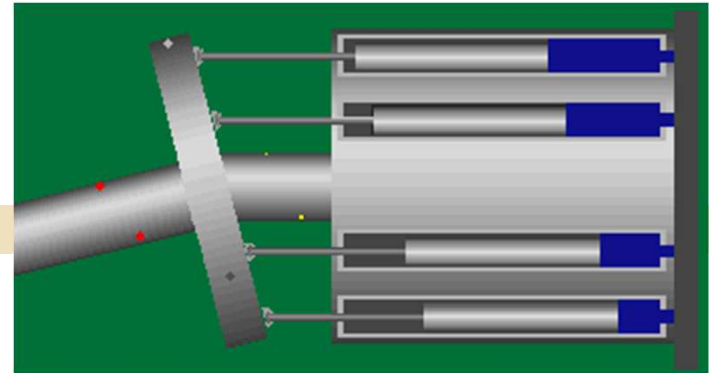
# Ejectors

- ejector-jet pumps
  - ✦ self-priming
  - ✦ no movable parts, has to have a primary fluid
  - ✦ application: cargo and ballast tanks stripping, FWG, two fluids mixing



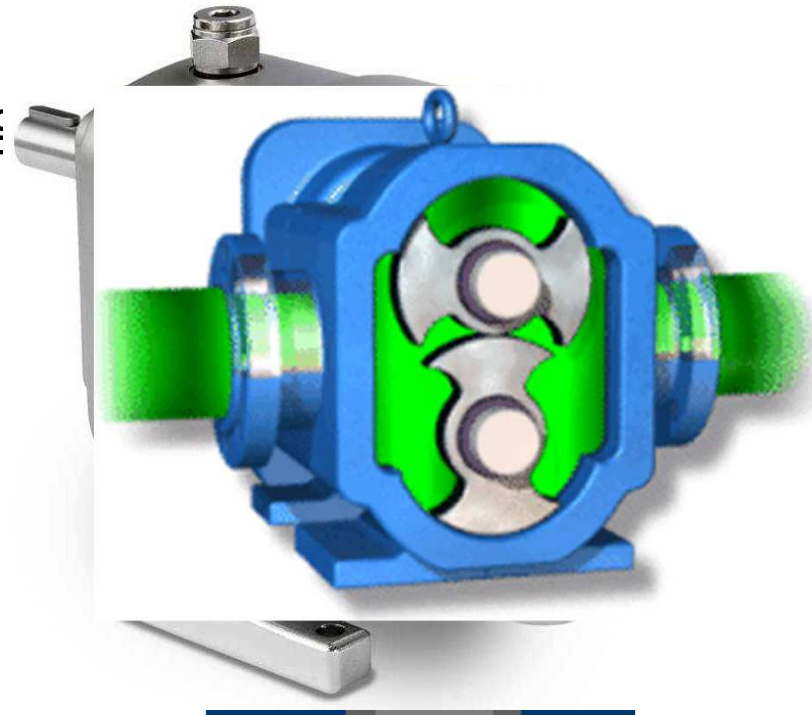
# Piston and plunger

- self-priming
- with rotational plungers
- radial movement
- odd number of plungers
- fine regulation of capacity and direction
- supply isn't constant
- application:
  - ✧ **stripping**
  - ✧ **hydraulic systems**



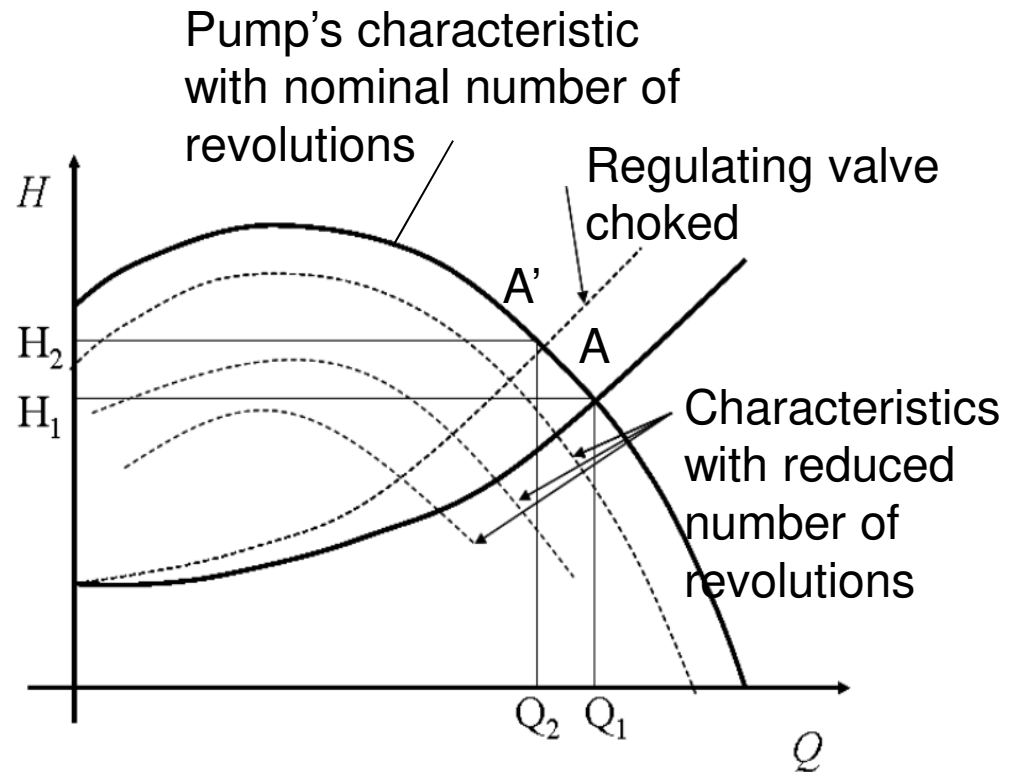
# Screw, gear..

- application: **hydraulic systems**
- capacity regulation:
  - ✦ number of revolution change
  - ✦ by-pass
- self-priming
- construction
  - ✦ 1, 2, 3 screws
  - ✦ 2 gears



# Pressure-capacity diagram of the c. pump

- working point movement
- by changes of piping's characteristic – throttling of the discharge valve
- throttling of the suction valve could result with the pump cavitations
- by changes of pump's characteristic
- depends on the driving engine
  - ✦ steam turbine – steam throttling valve
  - ✦ electric motor (3 phase AC): cutting off pares of poles, frequency converters
  - ✦ hydraulic drive
  - ✦ diesel engine



# Starting



- Turbo pumps (centrifugal) are started with discharge valve closed, and after pump has been started the valve is slowly opened
  - often the valve is automatic (flap) with weights, and will automatically close after stopping of the pump
  - positive displacement pumps are not allowed to be started with the discharged valves being closed – although there is a protecting safety valve
-

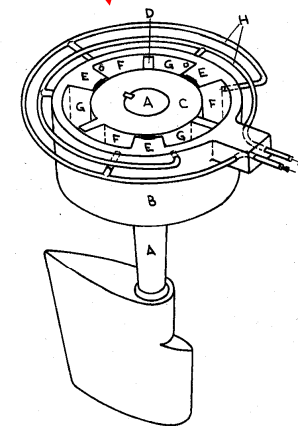
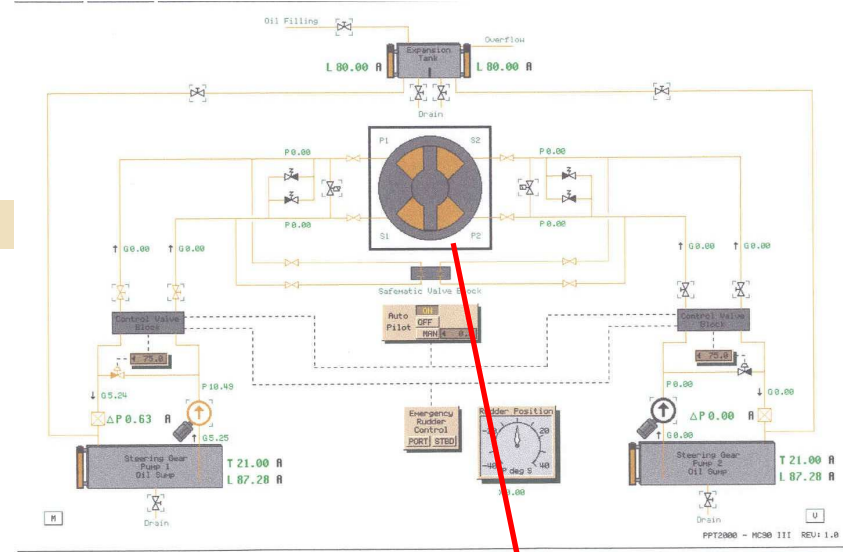
# Ventilators vs. compressors



- ventilators create very small pressure increase when compared to the pressure increase that could be created by compressors
  - application of ventilators: ventilation and climatization for crew spaces, air supply for boilers of boiler combustion gas suction
  - application of compressors: compressed air systems (starting and service air), refrigerating equipment
-

# Steering gear

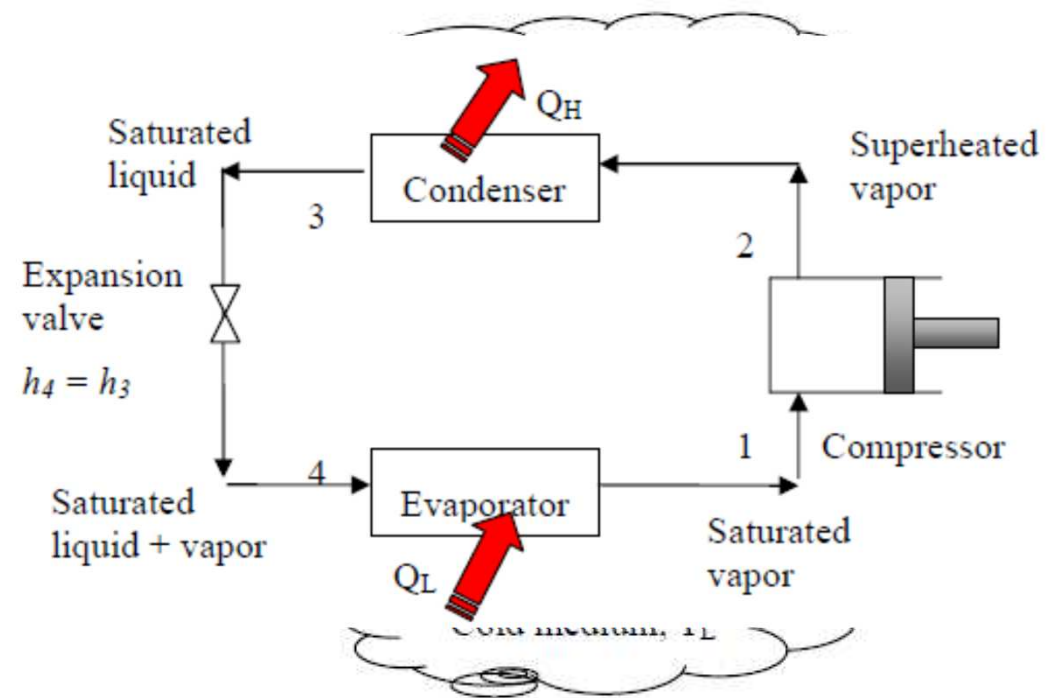
- hydraulic
- rotary vane or piston type
- main and auxiliary
- emergency steering



- |                    |                             |
|--------------------|-----------------------------|
| A Vratilo kormila  | E Fiksno krilo              |
| B Stator           | F Komora promjenjivog tlaka |
| C Zvezdasti rotor  | G Komora promjenjivog tlaka |
| D Okretljivo krilo |                             |

# Refrigeration

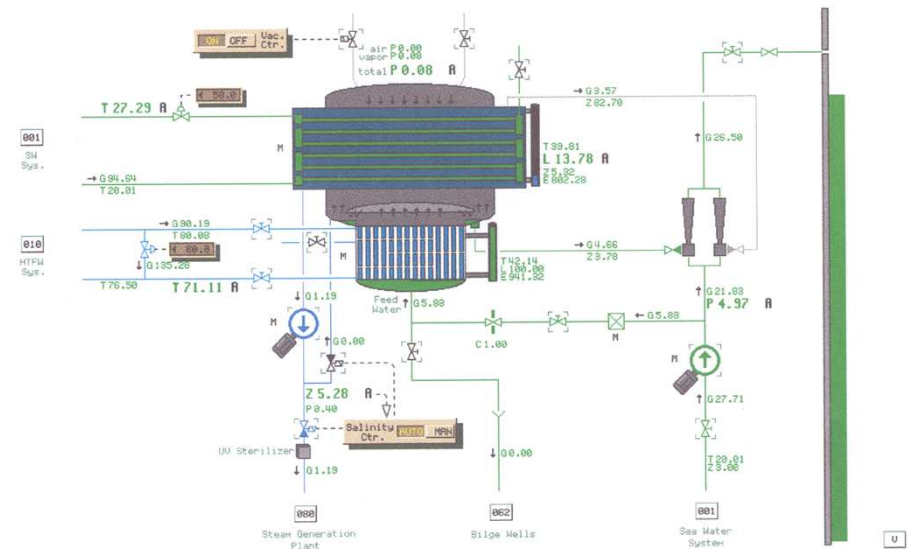
- food preservation
- climatization
- liquified gases
- fishing ships
- etc.





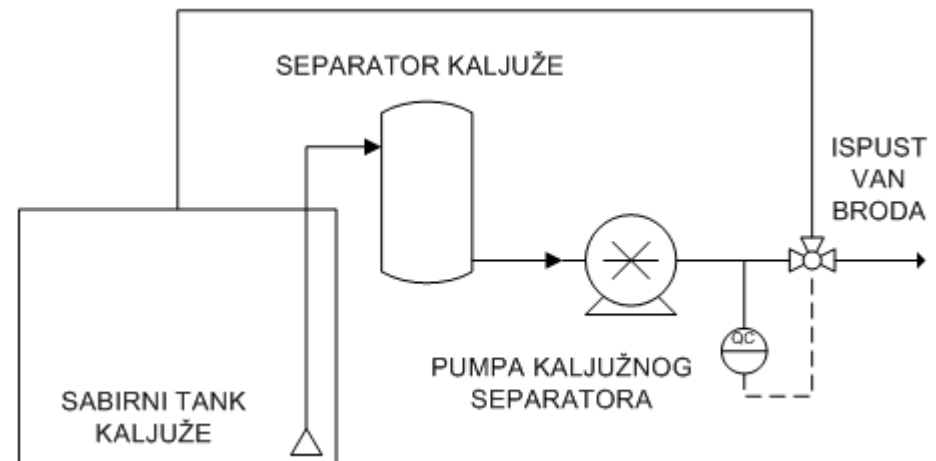
# Fresh water generator

- distilled water
- crew and passengers (mineralized and sterilized)
- diesel engines cooling
- boiler feed water



# Bilge separators


- engine room bilge water oil content must not be higher than 15 ppm
- separates particles and oil from water
- 'Turbulo' and 'Hamworthy'



# Auxiliary Piping (systems)

- diesel propulsion: lubricating oil, fuel oil, cooling water (sea and fresh), compressed air, steam, scavenging air, exhaust gases
  - general purpose: fire extinguishing, bilge, ballast etc.
  - cargo related (heating, cooling – liquefying, unloading, stripping&draining, inert gas...)
-

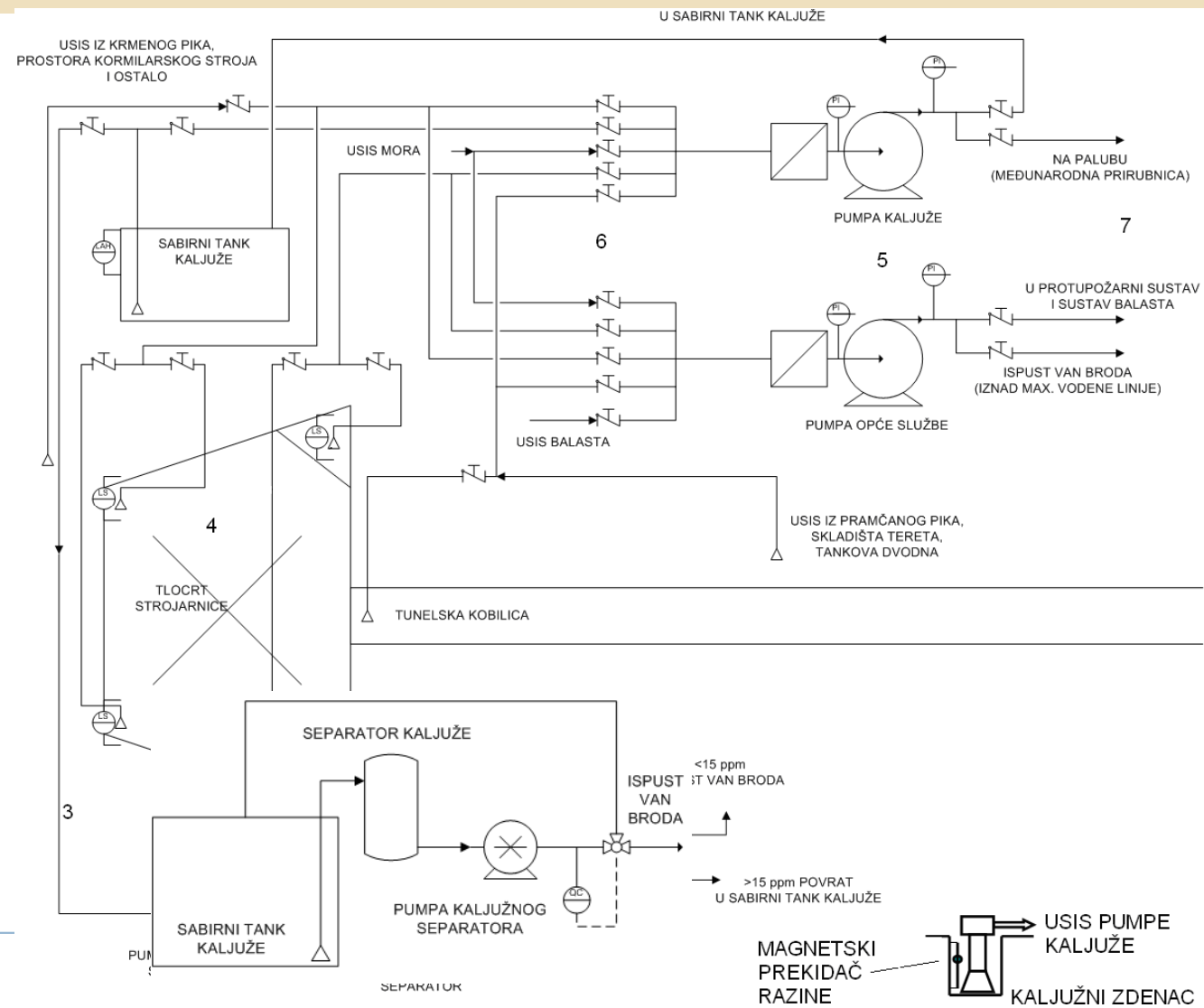
# Elements

- 
- pipes
  - pumps, compressors etc.
  - valves
  - control and regulation elements
-


# Bilge

- in every space of the structure without gravitation draining there has to be a bilge suction branch
  - danger: free water affects stability and trim – efficiency of the propeller, it's oily and therefore flammable, it affects the forces in the structure
  - it's not allowed to be released in to the sea – it's collected in a bilge tank, cleaned and then released
-

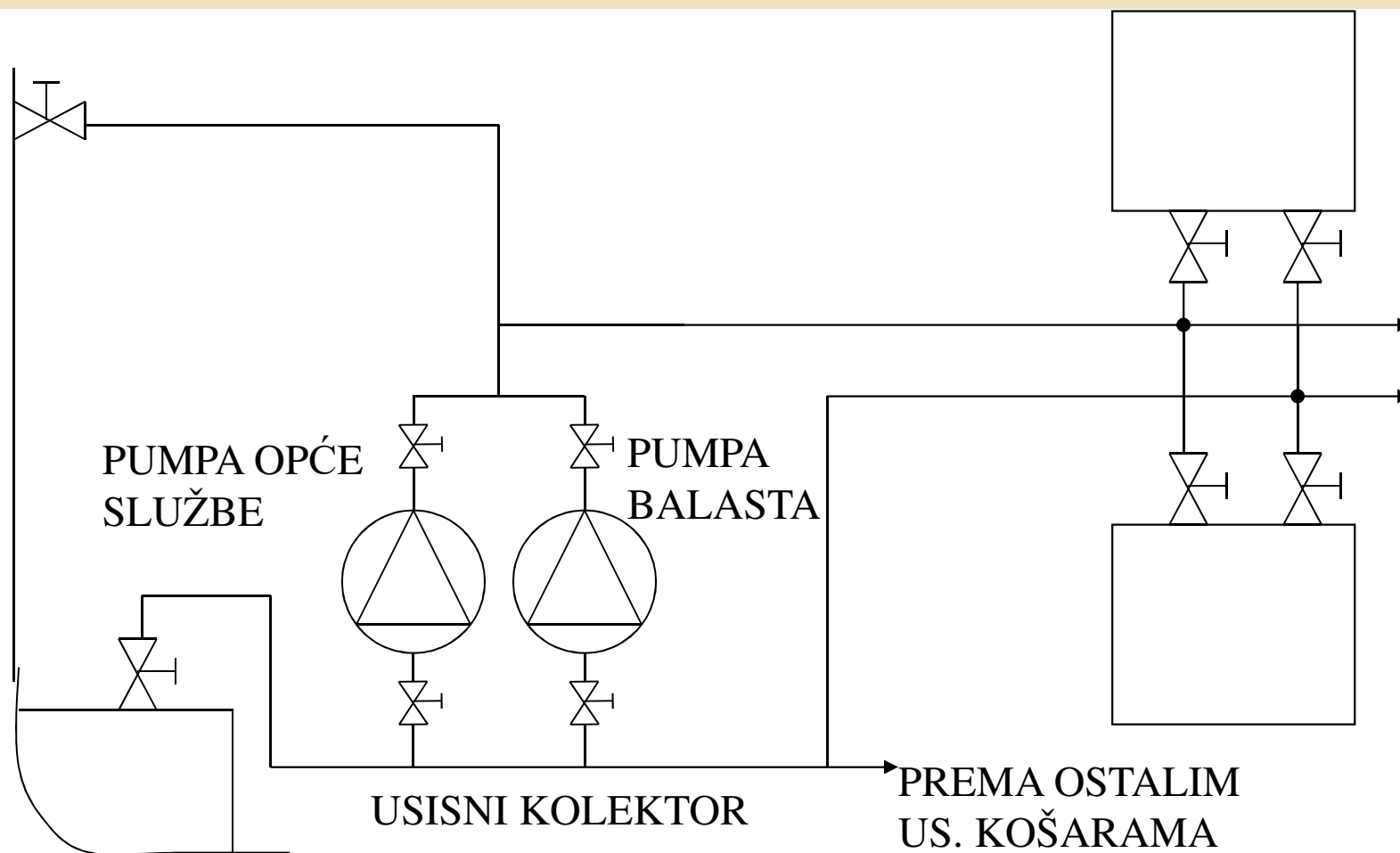
# Bilge system



# Ballast system

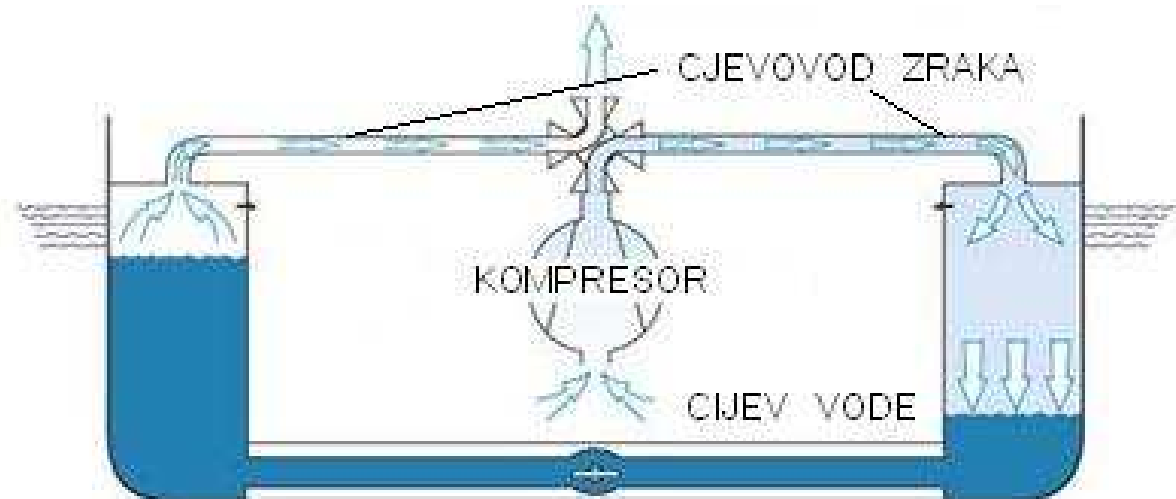
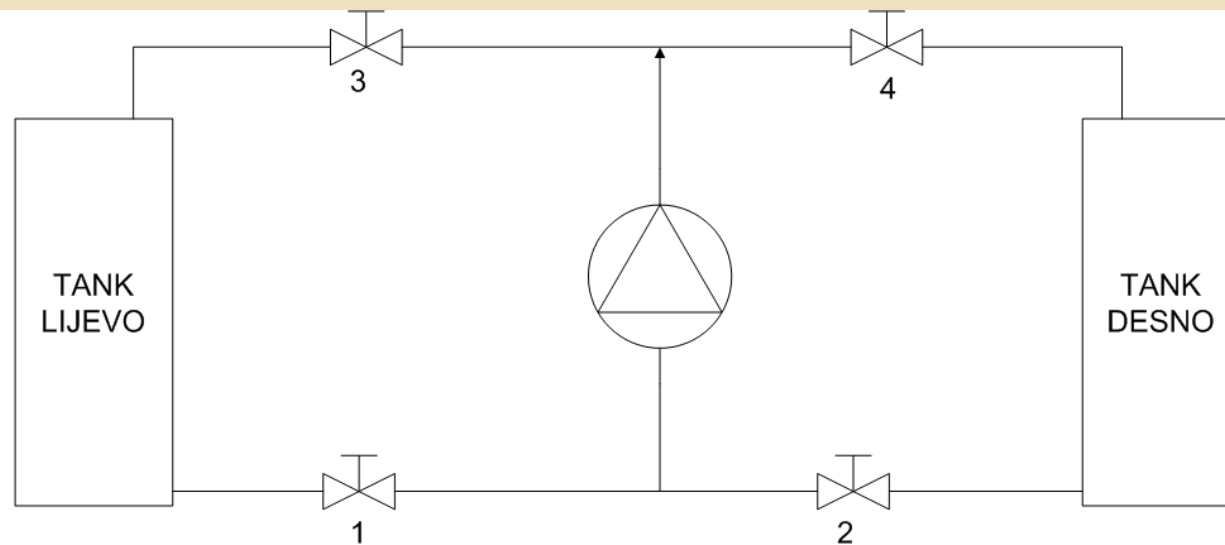
- 
- intentionally used sea water to correct the trim, stability, structural forces
  - ballast tanks: double bottom, side, forepeak, afterpeak
-

# Ballast





# Antiheeling

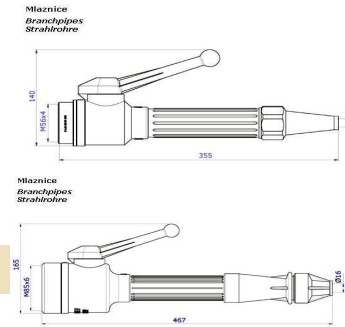


# FIREFIGHTING SYSTEMS



- Main (sea water)
  - “Sprinkler”; “water mist”; “hi-fog”
  - Gas (CO<sub>2</sub>, Halon, FE-13...)
  - Foam
  - Dry Powder
  - etc.
-

# Main Fire Extinguishing System



- pressure at least 2 bar, up to 4 bar on large passenger ships
- fire pump's capacity depends on dimensions of the ship (L, B, D)
- at least 2 mechanically driven pumps
- flexible hoses (15-18 m for open spaces, 8-10 m for closed spaces)
- separated from each other not more than 40 m on open decks and not more than 20 m on closed decks
- flexible hoses should be mounted on the valves in case of passenger ship that could carry more than 36 passengers

# CO<sub>2</sub>

- has no smell nor color (procedure?)
  - it is electrically non-conductive
  - 1,5 times heavier than air – extinguishes a fire by reducing the oxygen content
  - suppress all types of fires except type D (Al, Mg and their alloys)
  - above 5% of volume causes suffocation
  - high ratio of expansion – rapid discharge
-

## CO2 fire suppression system

- it is allowed be used in closed spaces only (cargo holds, engine room...)
- agent is stored it two different ways:
  - ✦ high pressure cylinders
  - ✦ low pressure tanks
- amount of CO<sub>2</sub> on board:
$$G=1,79V\phi$$
where V means the most voluminous space

*Releasing: at least 85% of G during not more than 2 min in the engine room*

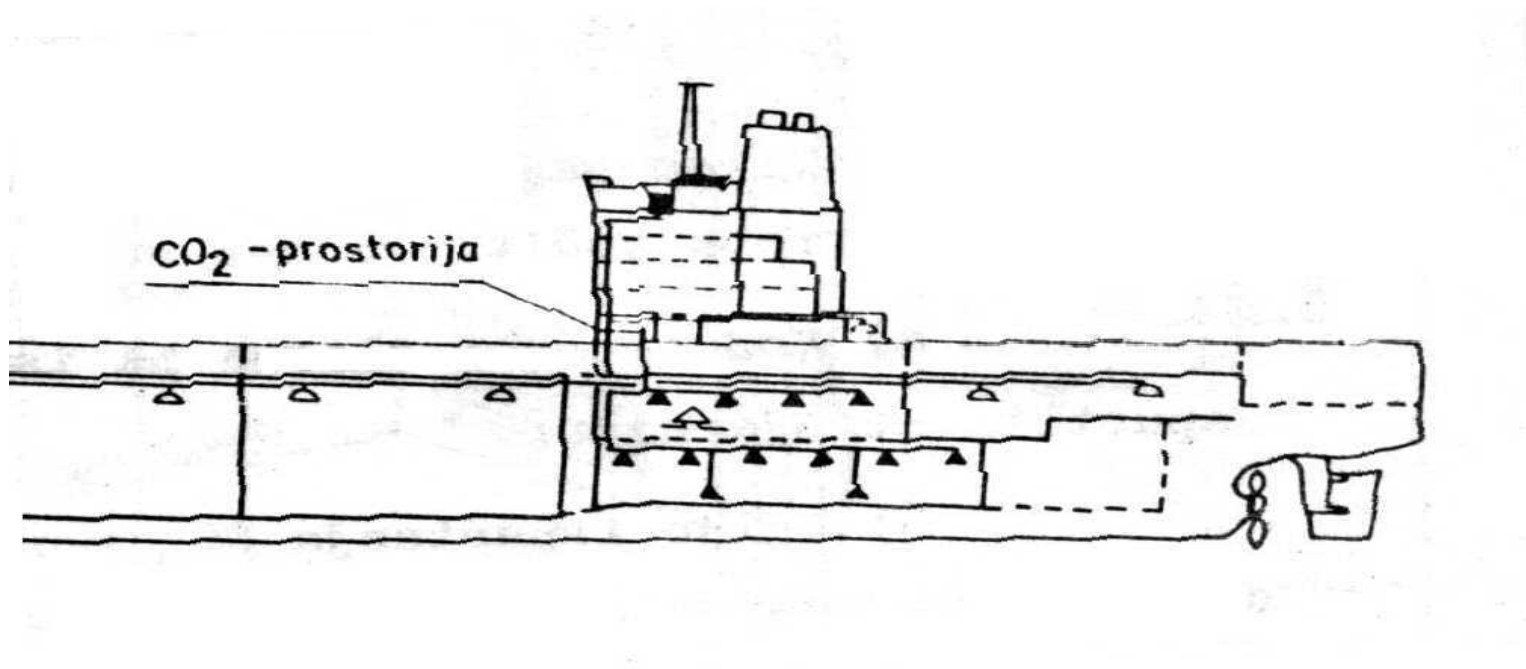
## High pressure system

- cylinder pressure 56 bar at 20°C
  - CO<sub>2</sub> mass: 45 kg (30-50)
  - when temperature in the CO<sub>2</sub> room reaches the level of 54°C – cylinders have to be cooled
-

## Low pressure system

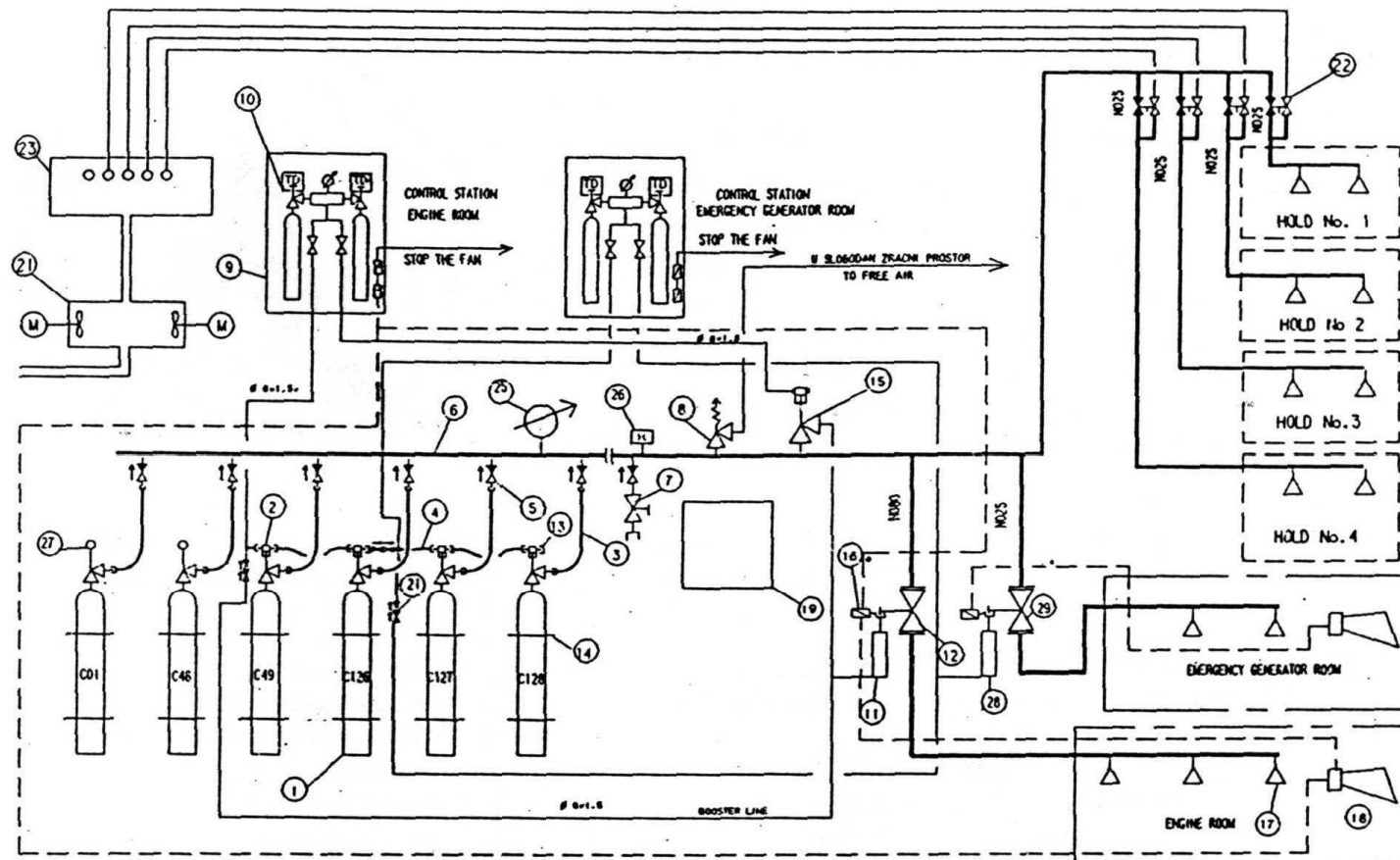
- one or only few tanks
  - pressures up to 2 MPa
  - tank(s) refrigerating system
-

# CO<sub>2</sub> fire suppression system





# CO2 fire suppression system



# Procedure in the engine room

## → Procedure:

- ✦ CO<sub>2</sub> alarm (visible and audible)
- ✦ engine room abandonment
- ✦ forced ventilation is shut down automatically
- ✦ if pumps are not shut down automatically they should be shut down locally
- ✦ fast closing valves on tanks placed in the engine room should be closed (mechanically or pneumatically)
- ✦ after being assured that everyone has left the space the responsible officer can release the agent

*Engine room ventilation is permitted after 36 hours or more.*

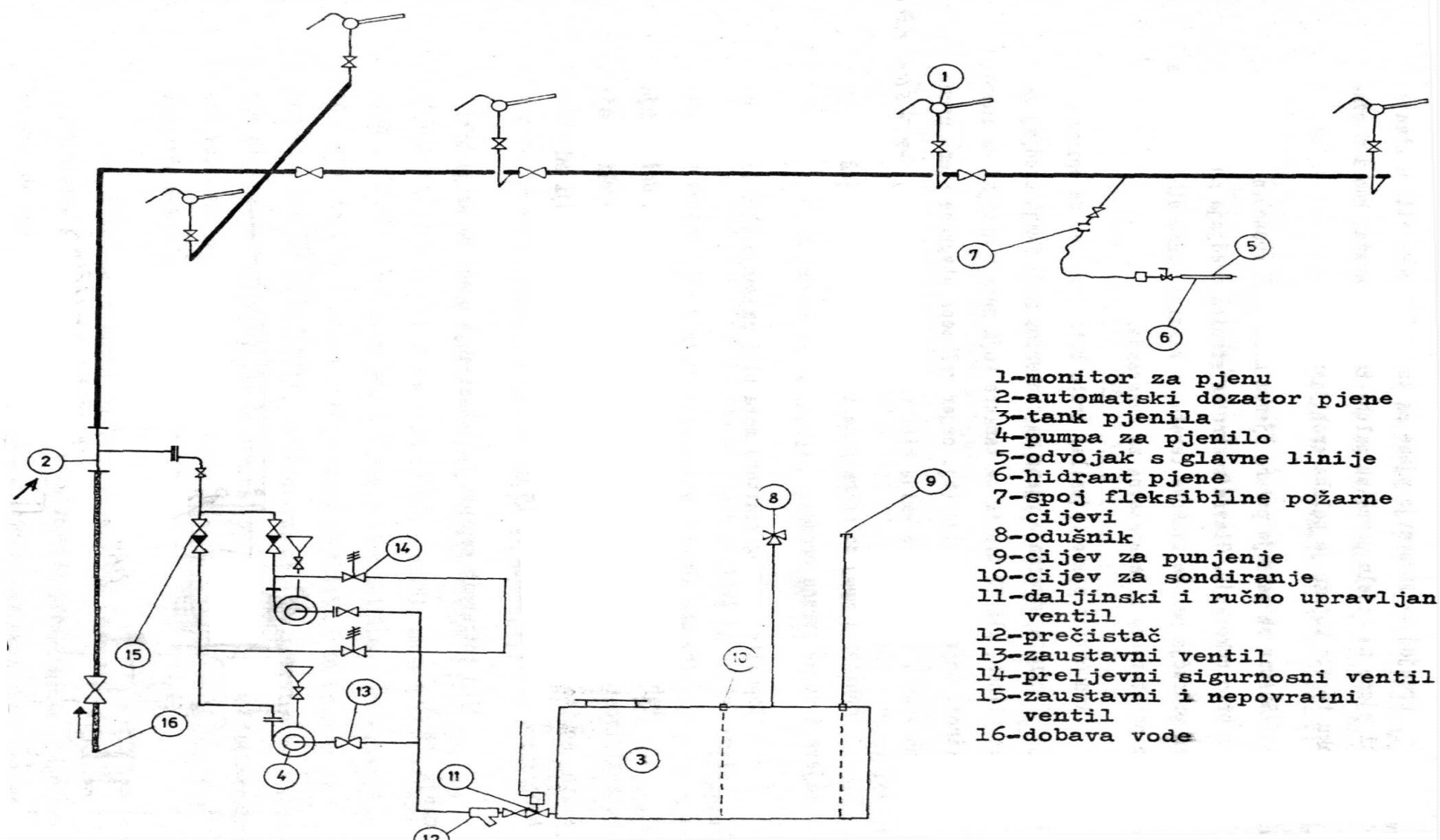
# Exploitation

- CO<sub>2</sub> cylinders are tested periodically by weighing
  - if 10% or more of mass is lost – replacing
  - at least 50% + 1 cylinder always on board
-

# Foam

- a mixture of water, foaming agent and air (mechanical of air foam)
  - suppress fire by suffocation (but it also cools down the space, it can be used as a barrier...)
  - suffocating, cooling, separating, blanketing, insulating and displacing effect
  - it is classified as: high expanded foam; medium expanded foam; low expansion foam
-

# Foam System on Deck



# System Elements



## **Venturi Proportioner**

DN 80 to DN 350  
Flow rates  
150 to 25 300 l/min  
Foam admixture infinitely adjustable from 0 – 7 %



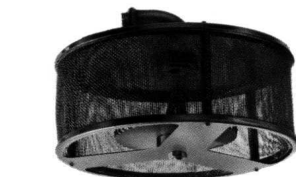
## **Inline Inductor PR**

PR 6 to PR 55  
Flow rates  
150 to 3500 l/min  
Foam admixture  
2 to 5 %



## **Induction Regulator ZR**

ZR 4 to ZR 32  
Foam admixture 5 % at water flow rates of 400 to 3200 l/min.

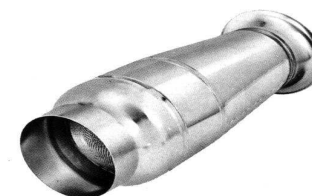


## **Low Expansion Foam Nozzle S7**

S7/26, S7/40  
Flow rate 58 l/min and 90 l/min at 5 bar  
Expansion ratio approx. 1 : 6 to 1 : 10

## **Medium Expansion Foam Maker LM st**

LM2 - 75st, LM2 - 150st  
Flow rate 200 l/min at 5 bar  
Expansion ratio  
LM2 - 75st = approx. 1 : 75  
LM2 - 150st = approx. 1 : 150



## **High Expansion Foam Generator st**

100st, 200st, 450st, 1250st  
Flow rate 100 to 1250 l/min at 3 bar  
Expansion ratio up to 1 : 1000



## **Vapour Seal Box Sto**

Sto 4 to Sto 32  
suitable for Low Expansion Foam maker L st



## **Foam Pourer Sk**

Sk 4 to Sk 32  
suitable for vapour seal box Sto



## **Foam/Water Monitor**

manually or remote controlled (electrically or hydraulically)  
Flow rate 800 to 10,000 l/min  
Expansion ratio approx. 1 : 5



# Halon

- chemicals made from methanium ( $\text{CH}_4$ ) or ethanium ( $\text{C}_2\text{H}_6$ )
  - **H1301**, H1211, H2402
  - can be used in fires of class A, B, C or E
  - 3 times more efficient than  $\text{CO}_2$
  - systems can be used in closed spaces only
  - anticatalytic effect after 5% in concentration
  - **ozone depleting chemicals**
-

# History



- came on market in the 1960s
  - most effective gaseous fire fighting agent
  - widespread application
  - by the late 1980s evidence indicated that they are dangerous to environment
  - Montreal Protocol of 1987 required a phaseout of new production
-



# Halon 1301 effect on human beings



vol[%]	time [min]
<7	15
7-10	1
10-15	0,5
>15	dangerous

→ if exposed to very high temperatures dangerous acids can be made (HF, HBr or Br<sub>2</sub>)

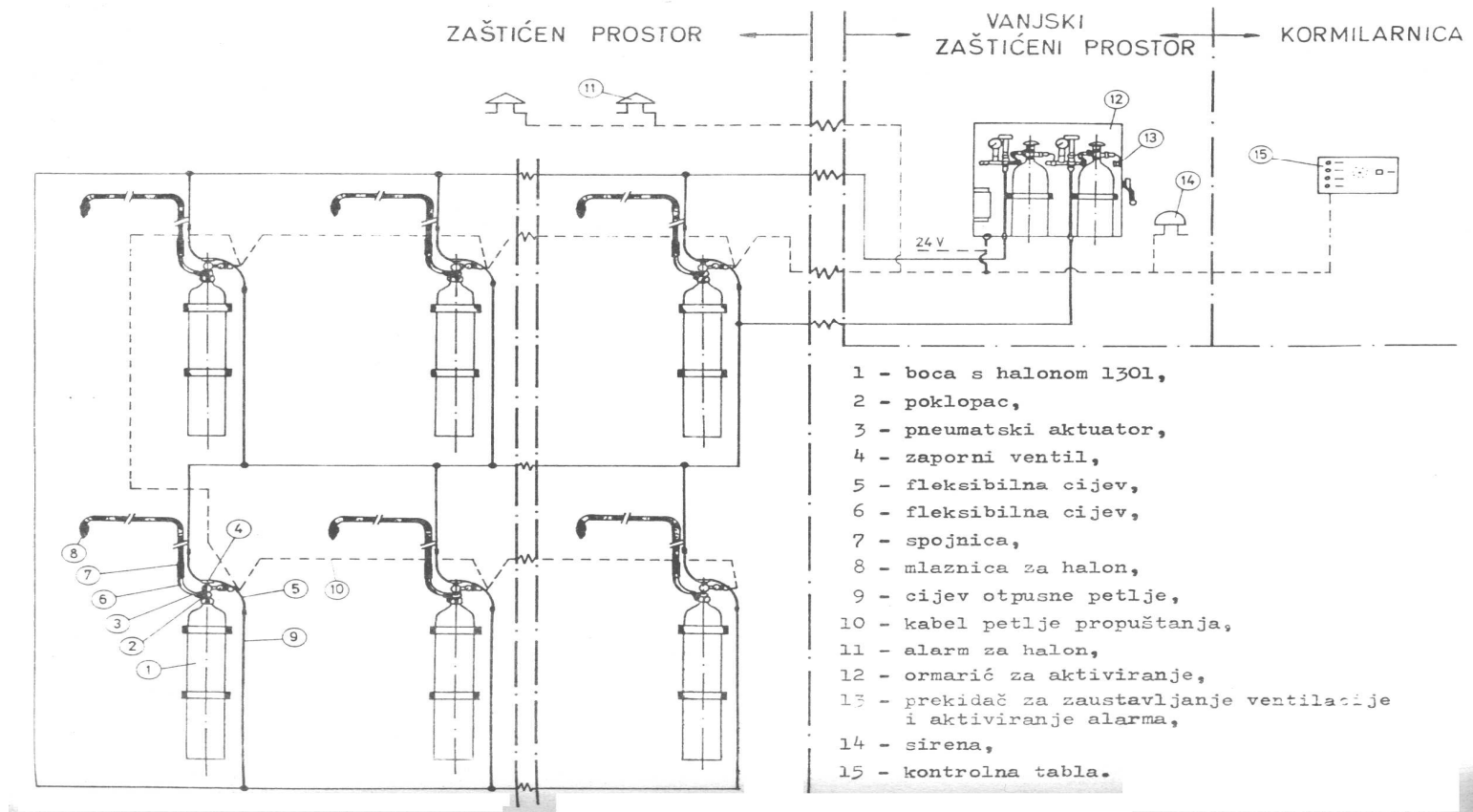
---

# Halon 1301 System



- application: engine rooms, pump stations, vehicle decks (without cargo)
  - cylinders usually with nitrogen
  - required amount has to be released during not more than 20 s
  - pressures: 25 or 42 bar  $\pm 5\%$
  - two different systems: total flooding or local
  - weighing => if 10% is lost - replacement
-

# System



## Current Status of Halon 1301

- there is no legal obligation to remove the system from service
  - the system can be legally recharged with recycled agent (available on the market)
  - no new agent is being produced
  - the replacement of the halon with **halon alternative system** should be considered
-

# Halon Alternatives




- Inergen

- FM-200


- FE-13

---

# Inergen

- 
- blend of three naturally occurring gases: nitrogen, argon and carbon dioxide
  - electrically nonconductive
  - it is safe for use in human occupied facilities
  - would not damage sensitive electronic equipment
  - has zero ozone depletion, zero global warming, and zero atmospheric lifetime
-

# Inergen

- 
- the strategy employed by an Inergen system is like no other modern suppression system today
  - it lowers the oxygen content to a point sufficient to sustain human life, but insufficient to support combustion
  - it is stored in cylinders near the protected area
-

## FM-200

- chemically known as heptafluoropropane, also known as HFC-227ea
  - by leading toxicologists found to be safe for use when people are present
  - employed to protect areas formerly protected by halon 1301
-



## FE-13

- developed by Du Pont as chemical refrigerant
  - its molecules absorb heat, but also exhibit some ability to inhibit the chain of combustion in the manner of halon 1301
  - ideal for inerting of occupied spaces
-

# Dry Powder

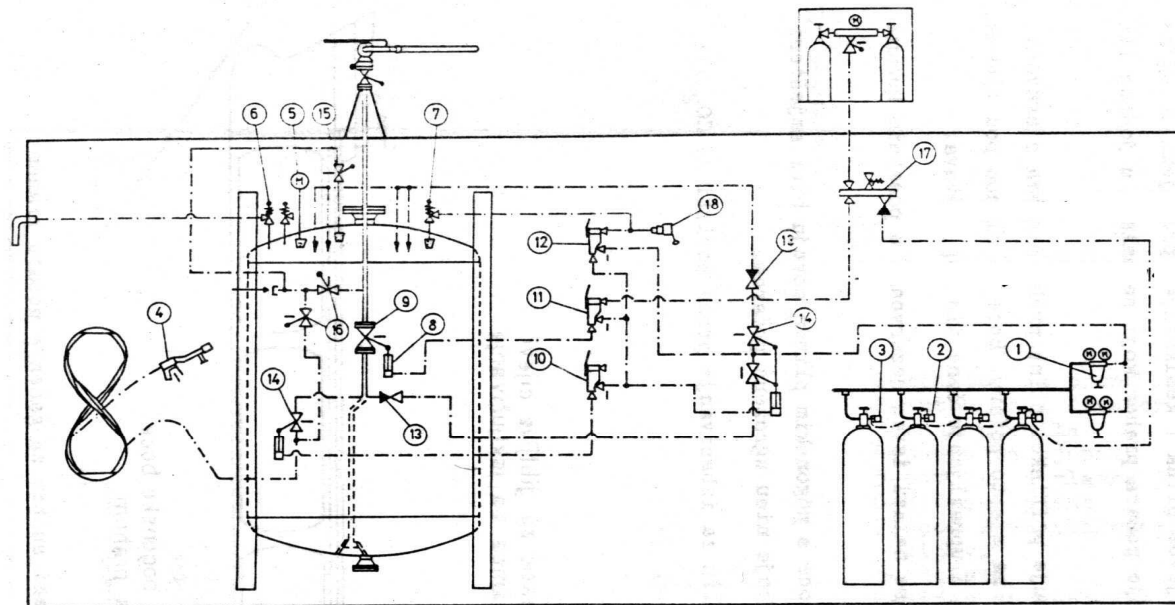
- universal fire extinguishing agent (potassium, sodium salts...)
  - extinguishing effect: **suffocation**, cooling effect, anticatalytic effect
  - high temperature in protected area causes the chemical reaction by which the CO<sub>2</sub>, water vapor and soda are formed
  - propulsions gas is CO<sub>2</sub> or N<sub>2</sub>
  - extinguishing procedure in closed spaces as in case of CO<sub>2</sub> system
-

# Dry Powder System



- chemical tankers and LPG/LNG ships
  - two completely independent units
  - propulsions gas in separated cylinders
  - closed spaces: design mass has to be released during not more than 30 s
  - powder container: contains amount of powder for at least 45 s
-

# System



1-redukциони ventil,  
2-pneumatski aktuator,  
3-ručno/pneumatski aktuator,  
4-mlaznica za prah,  
5-manometar,  
6-sigurnosni ventil,  
7-preljevni ventil,  
8-tlačni ventil,  
9-kuglasti ventil,

10-pilot ventil za distribucioni ventil mlaznice praha,  
11-pilot ventil za distribucioni ventil monitora,  
12-pilot ventil s tlačnim cilindrom,  
13-nepovratni ventil,  
14-kuglasti ventil,  
15-kuglasti ventil,  
16-kuglasti ventil,  
17-ventilska stanica s nepovratnim ventilom i ventilom  
za propuštanje,  
18-otpusni ventil.

# Sprinkler System




- used in crew and passenger spaces
  - divided into sections with separate alarms
  - fire suppression starts automatically at 68°C or 79°C
  - sprinkling speed not less than 5 l/m<sup>2</sup>
  - pressure for at least 28 m<sup>2</sup> (1 bar)
  - dry and wet system
-

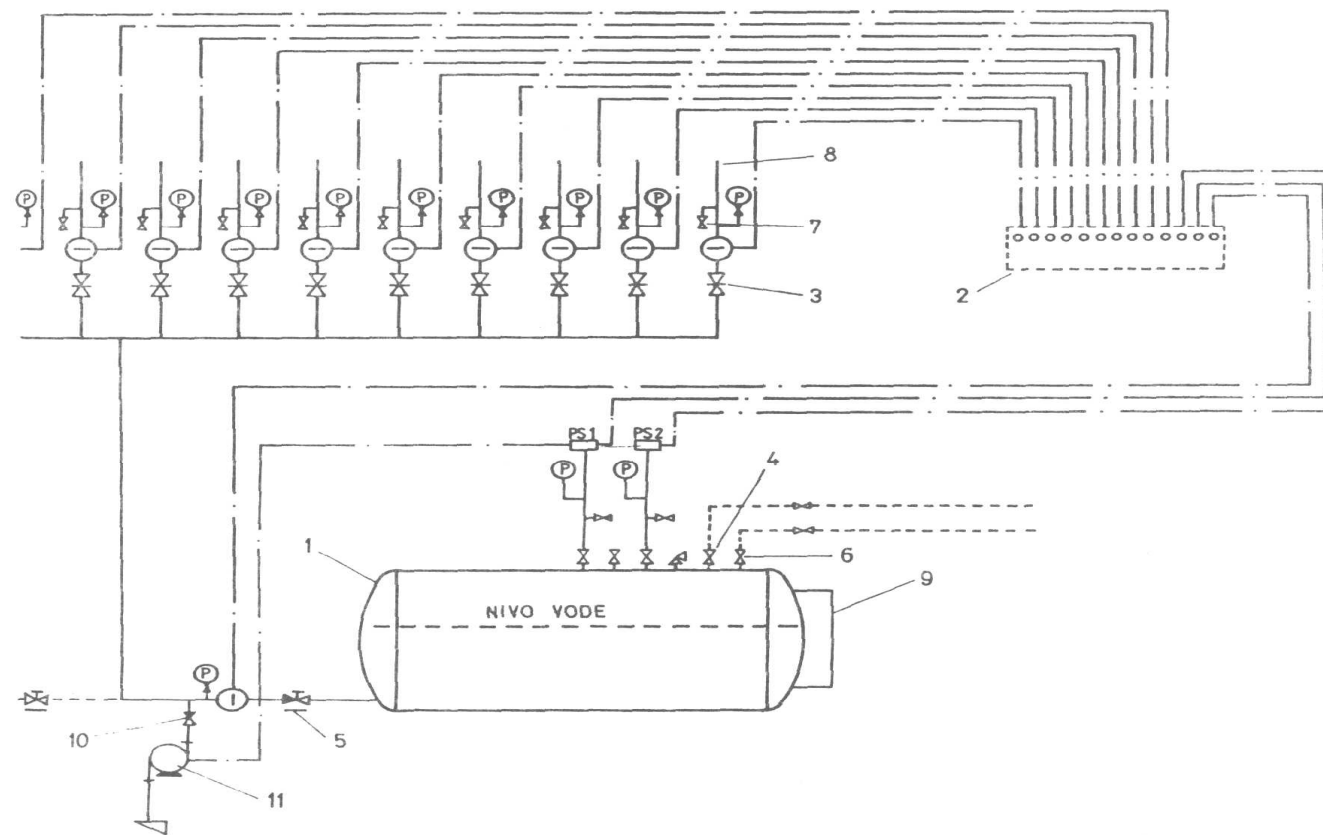
# Sprinkler System

- system is under pressure from a pressure vessel (tank)
  - testing: every section has its own testing cock which releases the same amount of water as does one sprinkler in case of fire
-

# Sprinkler

- 
- opening is closed with the glass bulb filled with a temperature sensitive liquid and a small air bubble
  - temperature increase causes the liquid to expand which results with pressure increase inside the bulb; at certain temperature (pressure inside) bulb bursts
  - liquid color indicates the bursting temperature
-

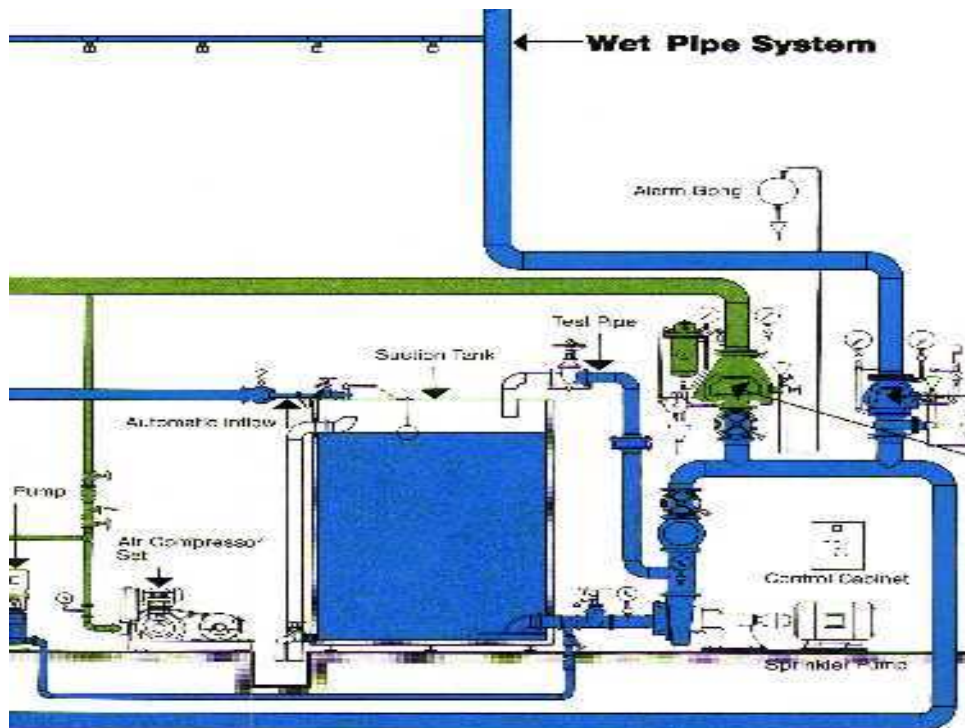
# Sprinkler system



Automatski sustav za gašenje požara  
prskanjem (Sprinkler-uredjaj)



# Sprinkler



## Spray Sprinklers (upright type)



are installed in buildings where exposed routing of sprinkler pipes is permissible, e.g. in storage rooms, factories, warehouses with high storage racks, etc.

## Spray Sprinklers (pendent type)



are used when the pipes can be installed above suspended ceilings, e.g. in office buildings, hospitals, department stores, etc.

## Conventional Sprinklers (upright or pendent type)



also wet the ceiling in the event of fire. For this reason they are used above all in buildings with combustible ceilings (or exposed steel structures).

## M-Sprinklers (pendent type)



spray the extinguishing water evenly beneath the ceiling. They are therefore preferably used in rooms with gridded ceilings or above suspended ceilings, in warehouses with storage racks, etc.

## Sidewall Sprinklers (pendent type)



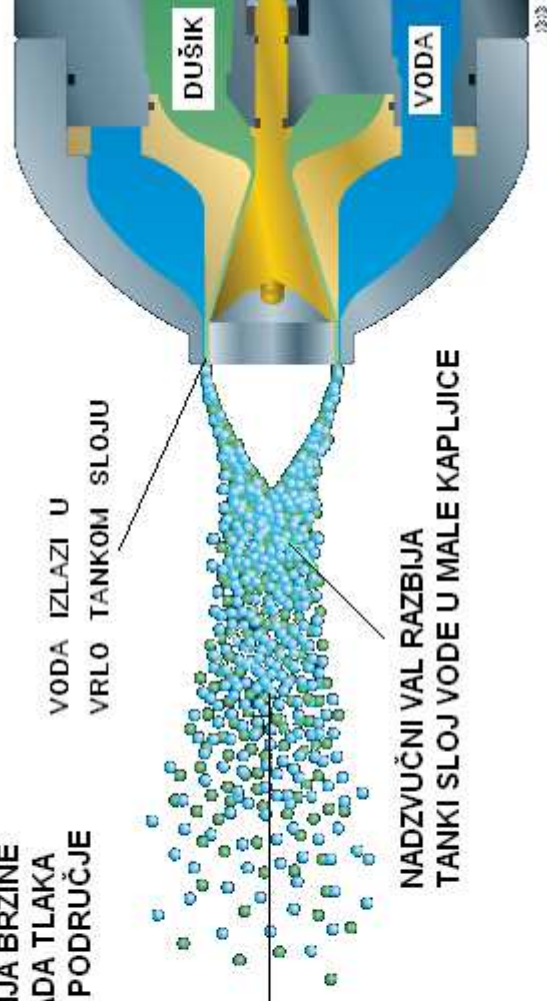
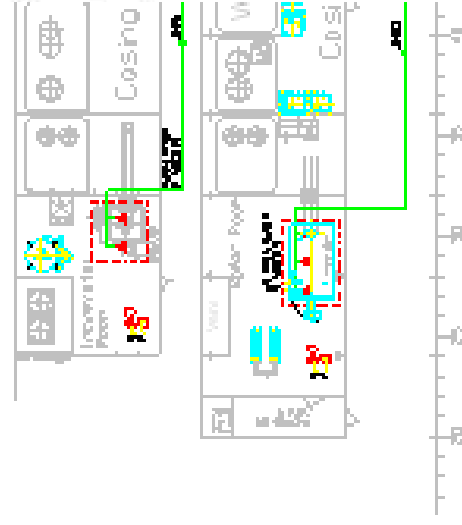
spray the water to one side only. For this reason they are used in rooms where location in the centre of the room is not possible, e.g. in corridors, hotel rooms, etc.

# Water myst system

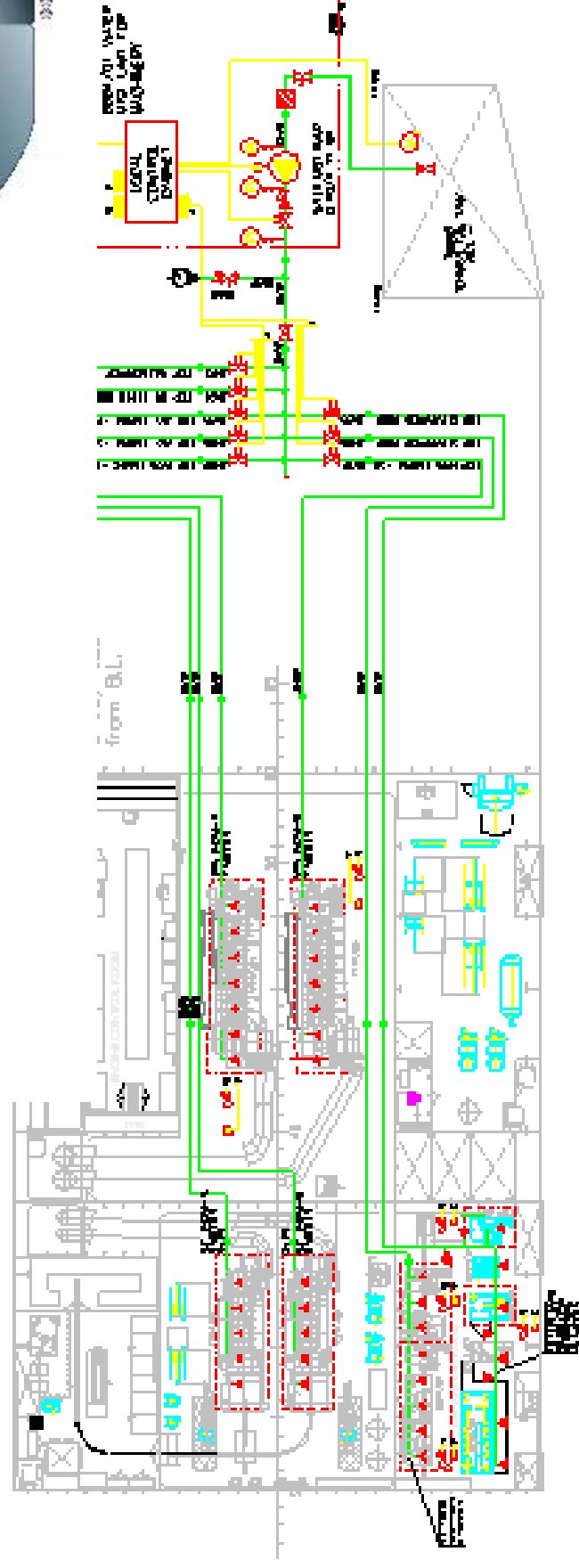
- higher pressures when compared to sprinkler
- application is possible even in the engine room

	Number of droplets	Diameter	Area	Time of evaporation
Sprinkler	1	1 mm	1	1 s
Water myst	40	0,3 mm	10	0,1 s
<b>Hi-fog</b>	<b>8000</b>	<b>0,005 mm</b>	<b>400</b>	<b>0,003 s</b>

ZBOG POVEĆANJA BRZINE  
STRUJANJA I PADA TLAKA  
VODA STRUJI U PODRUČJE  
ATOMIZACIJE



NADZVUČNI VAL RAZBIJA  
TANKI SLOJ VODE U MALE KAPLJICE



## Emergency fire pump

- placement: forepick (different than main fire p.)
  - independent drive
  - drive: diesel engine or gas turbine (fuel amount for 3 hours + 15 hours); electric motor or electrohydraulic drive
  - capacity: two jets on opposite sides of the ship, but not less than 25 m<sup>3</sup>/h
-