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

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

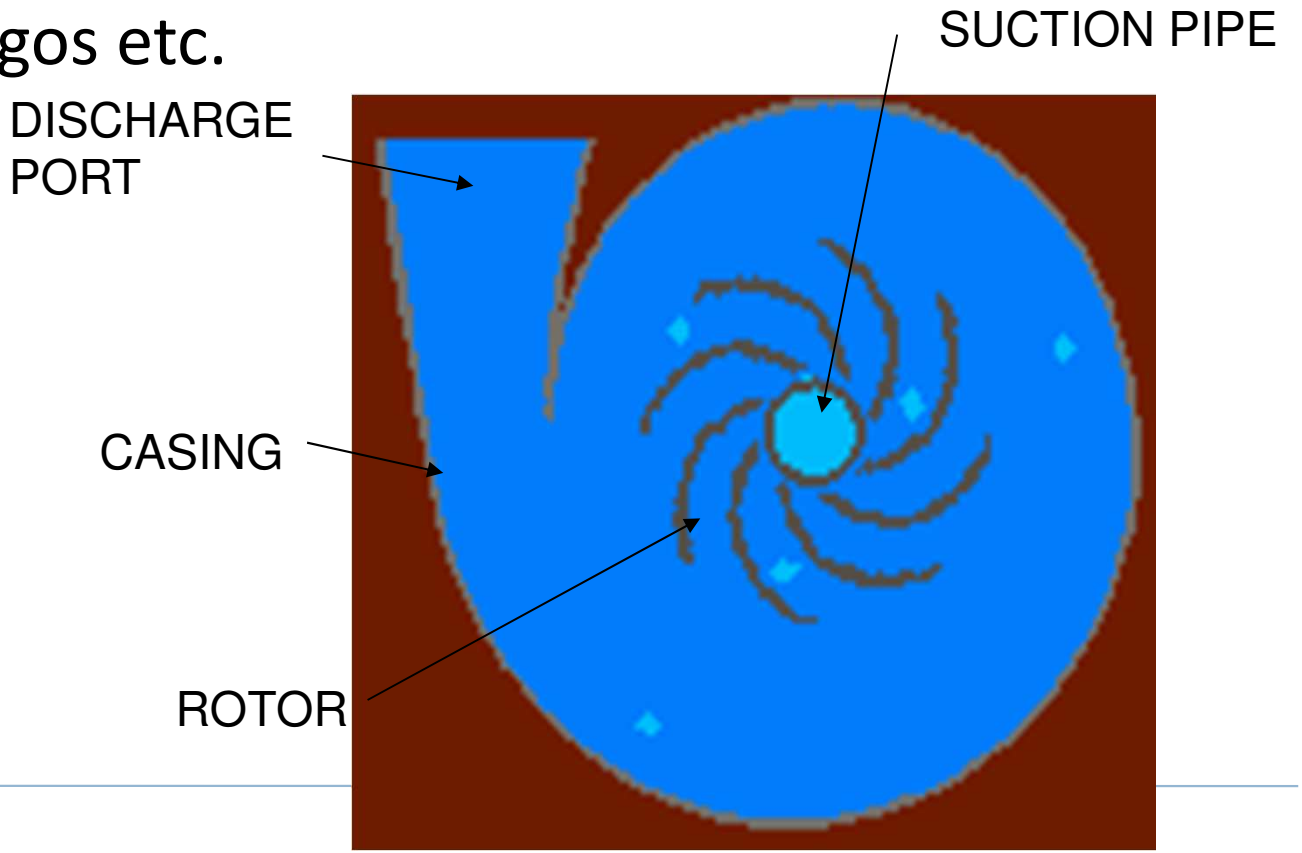
- energy of fluid
- self-priming
- cavitation
- $NPSH_r$ and $NPSH_a$
- capacity regulation

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

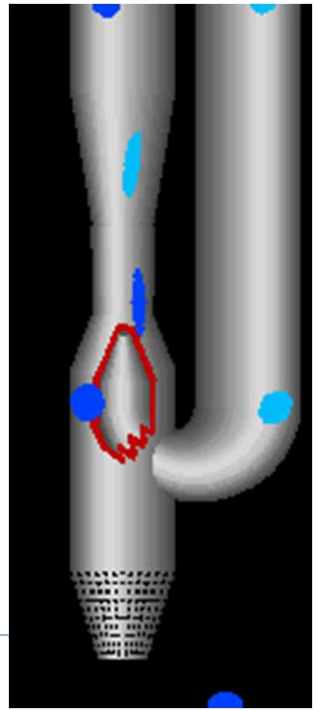
Turbopumps

- centrifugal, axial (propeller), diagonal
- application on board ships: sea and fresh water, various cargos etc.

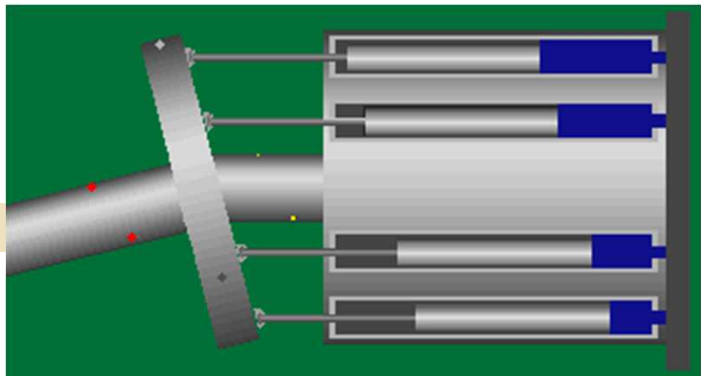


Ejectors

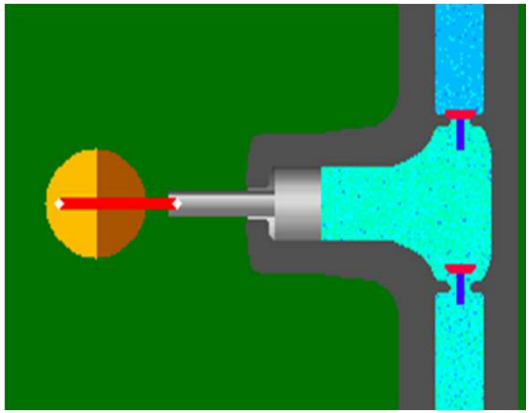
- ejector-jet pumps
  - self-priming
  - no movable parts, has to have a primary fluid
  - application: cargo and ballast tanks stripping, FWG, two fluids mixing

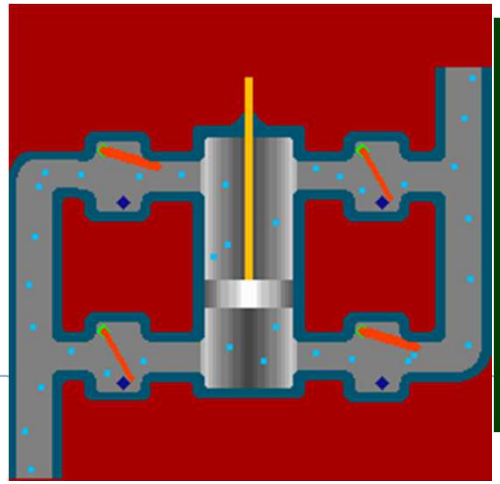


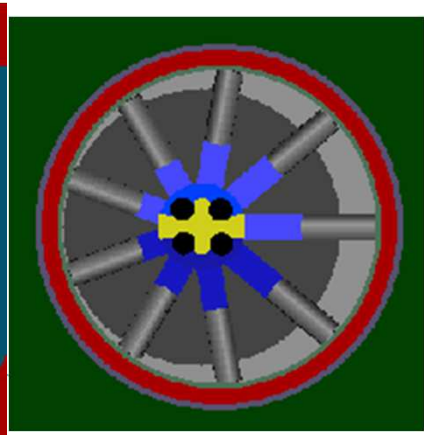
Piston and plunger



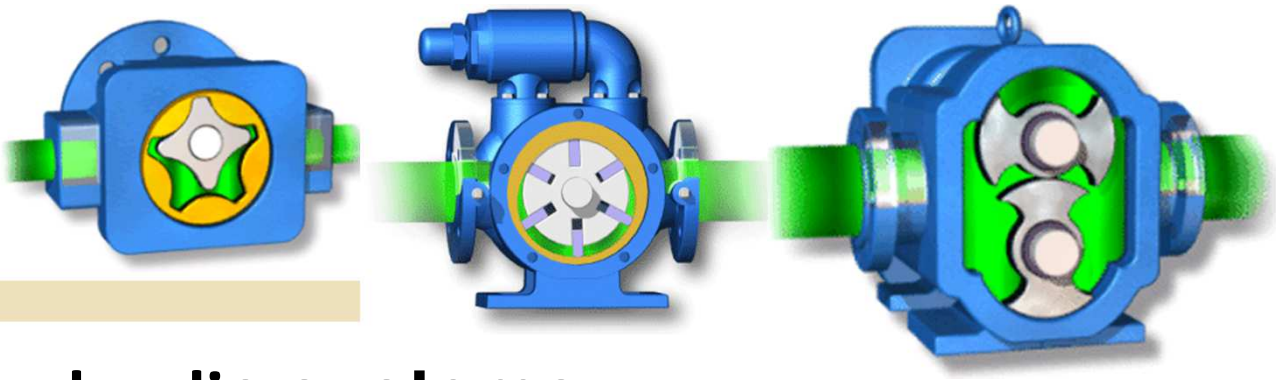
- self-priming
- with rotational plungers
- radial movement
- odd number of plungers
- fine regulation of capacity and direction
- supply isn’t constant
- application:
  - **stripping**
  - **hydraulic systems**



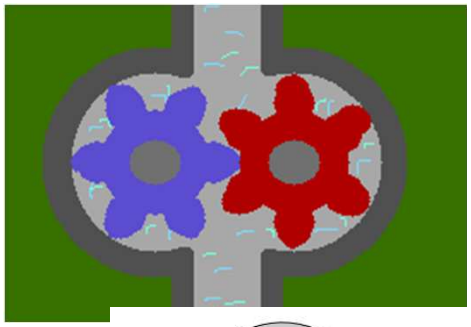


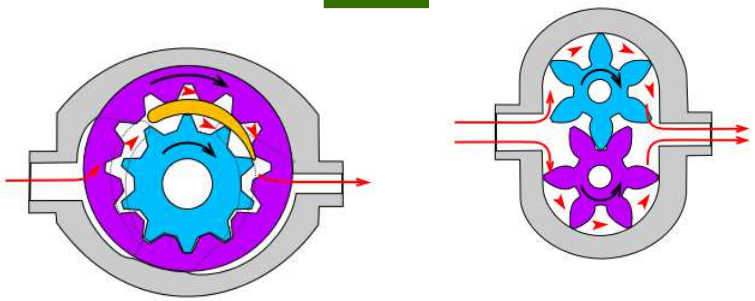


Screw, gear..



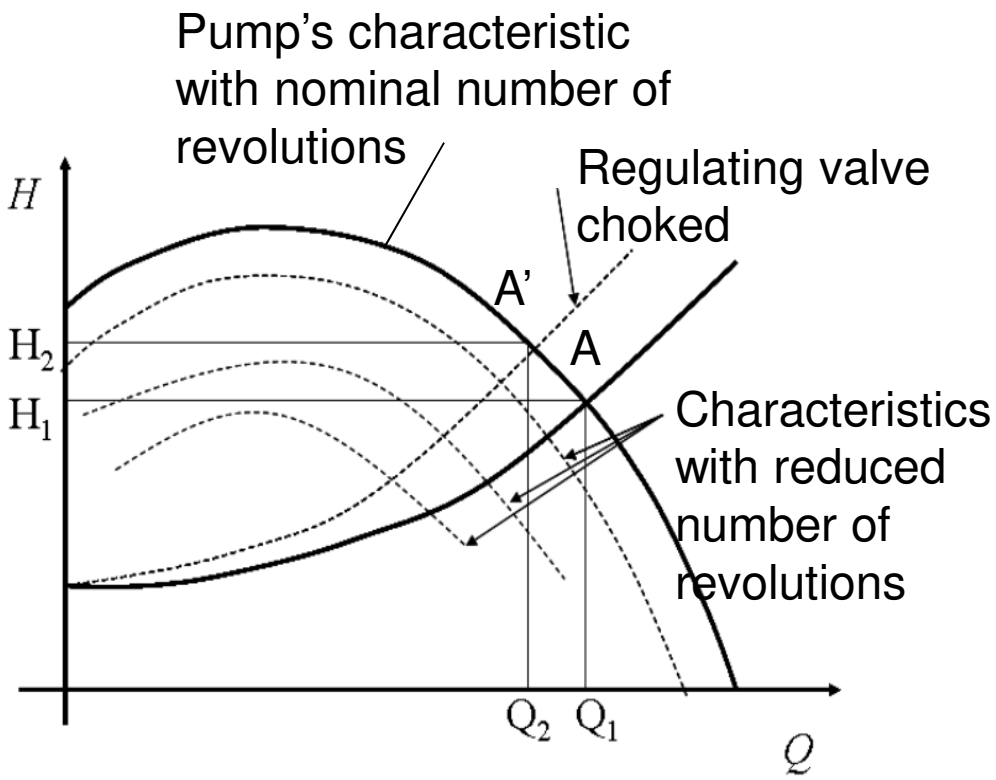
- application: **hydraulic systems**
- capacity regulation:
  - number of revolution change
  - by-pass
- self-priming
- construction
  - 1, 2, 3 screws
  - 2 gears





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 cavitation
- 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

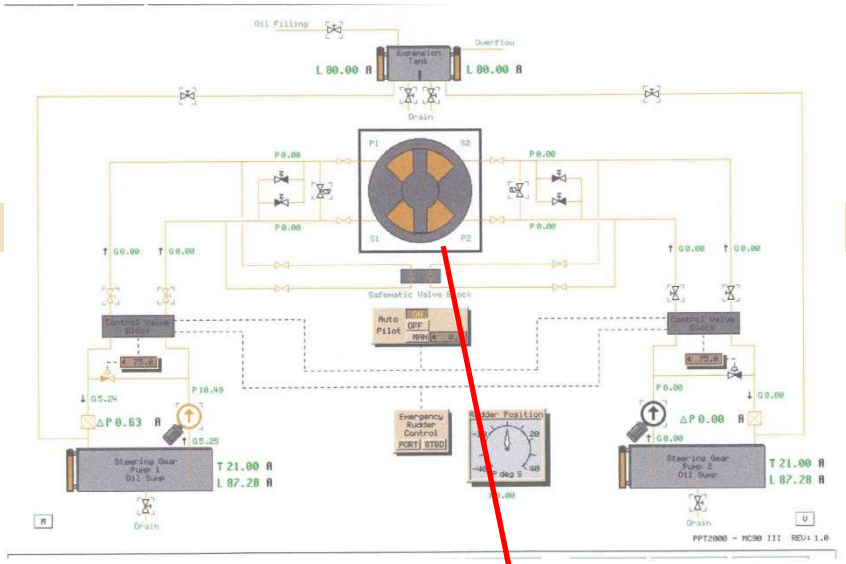
- Turbo pumps (centrifugal) are started with discharge valve closed, and after pump has been started the valve is slowly opened
- often the valve is automatic (flap) with weights, and will automatically close after stopping of the pump
- positive displacement pumps are not allowed to be started with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

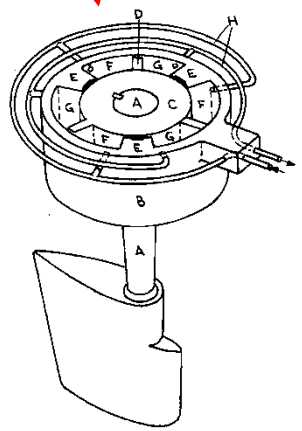
Ventilators vs. compressors

- ventilators create very small pressure increase when compared to the pressure increase that could be created by compressors
- application of ventilators: ventilation and acclimatization 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

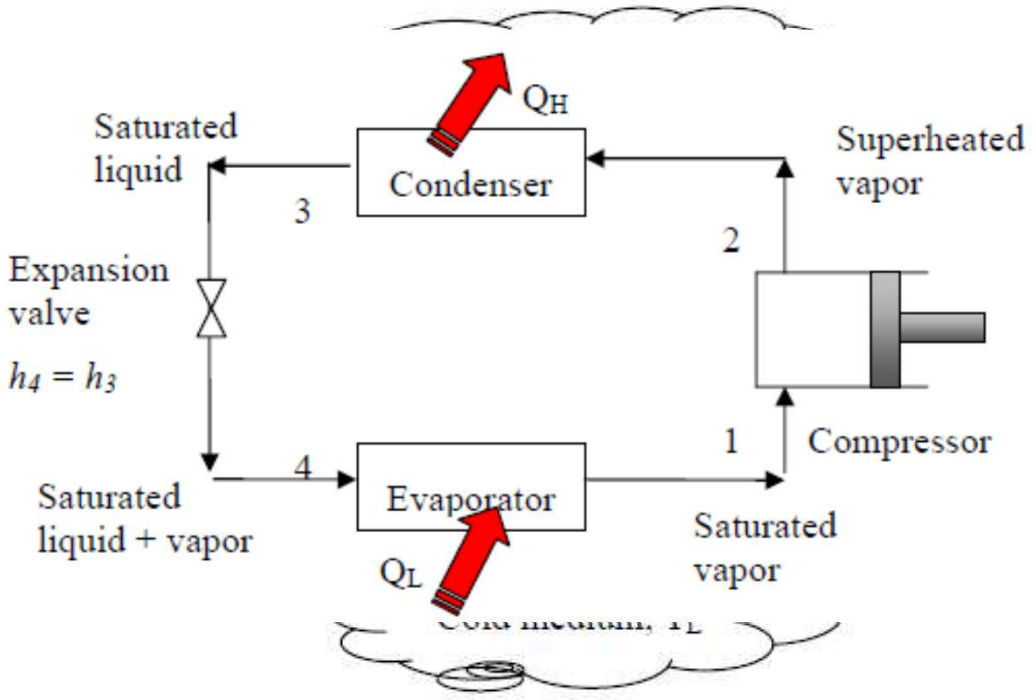




A Vratilo kormila
B Stator
C Zvjezdasti rotor
D Okretljivo krilo
E Fiksno krilo
F Komora promjenjivog tlaka
G Komora promjenjivog tlaka

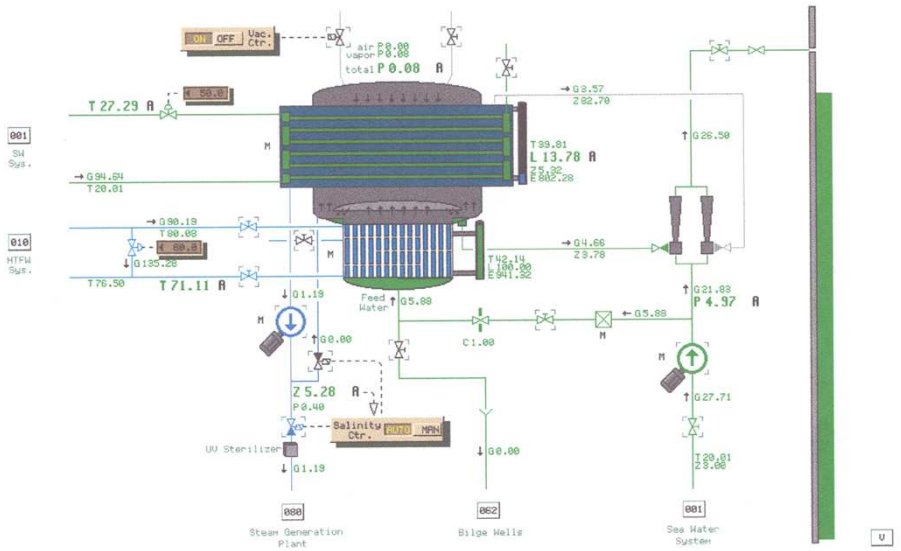
Refrigeration

- food preservation
- acclimatization
- liquefied gases
- fishing ships
- etc.



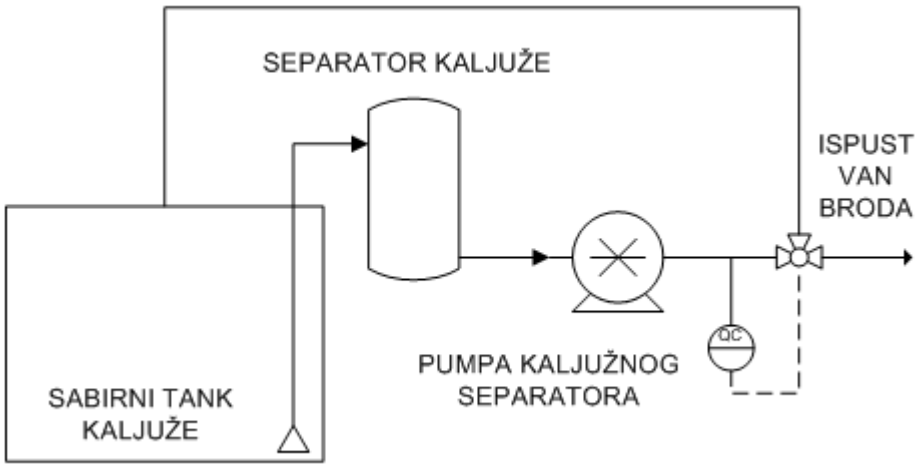
Fresh water generator

- 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...)

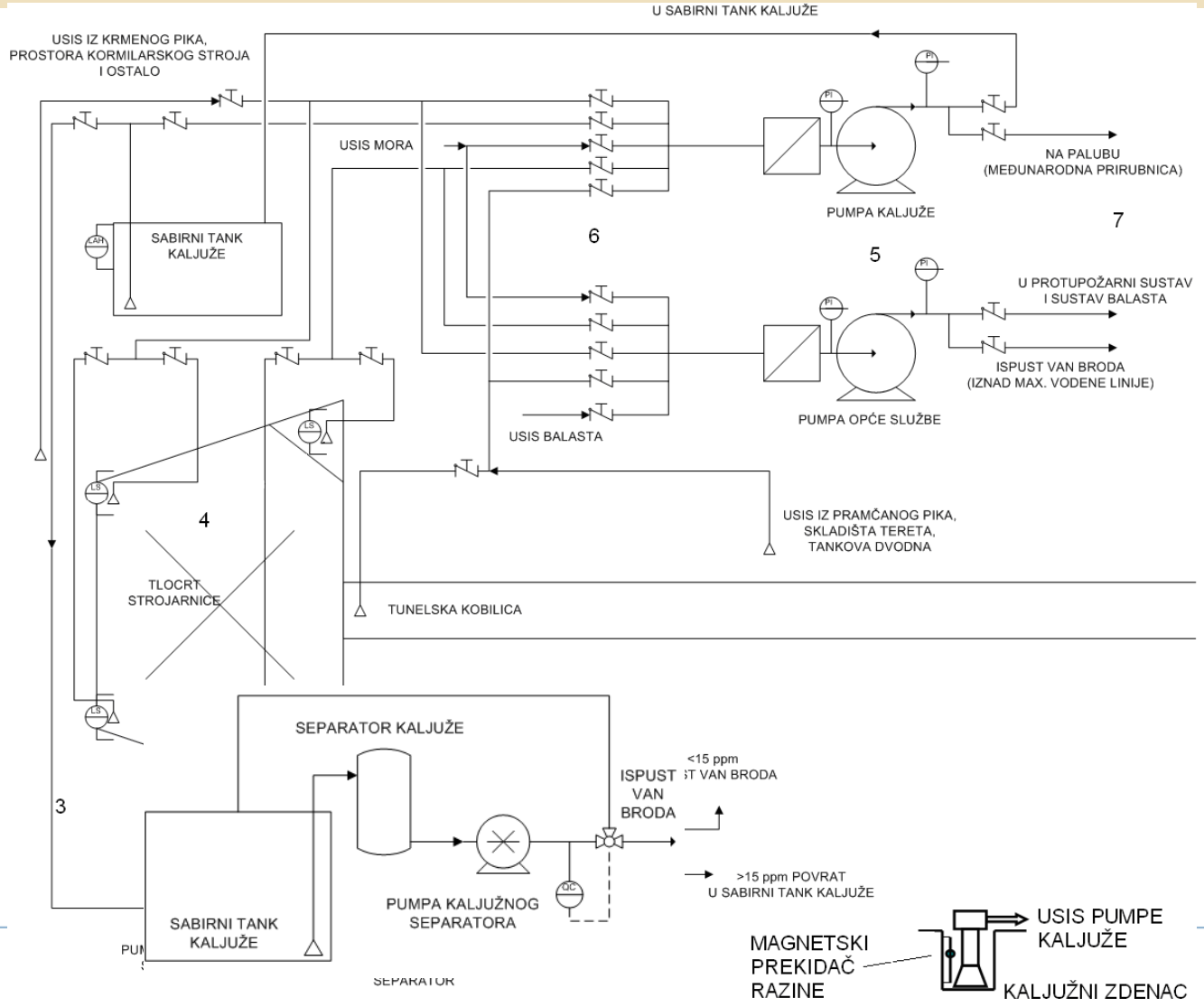
Elements

- 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 see – it's collected in a bilge tank, cleaned and than released

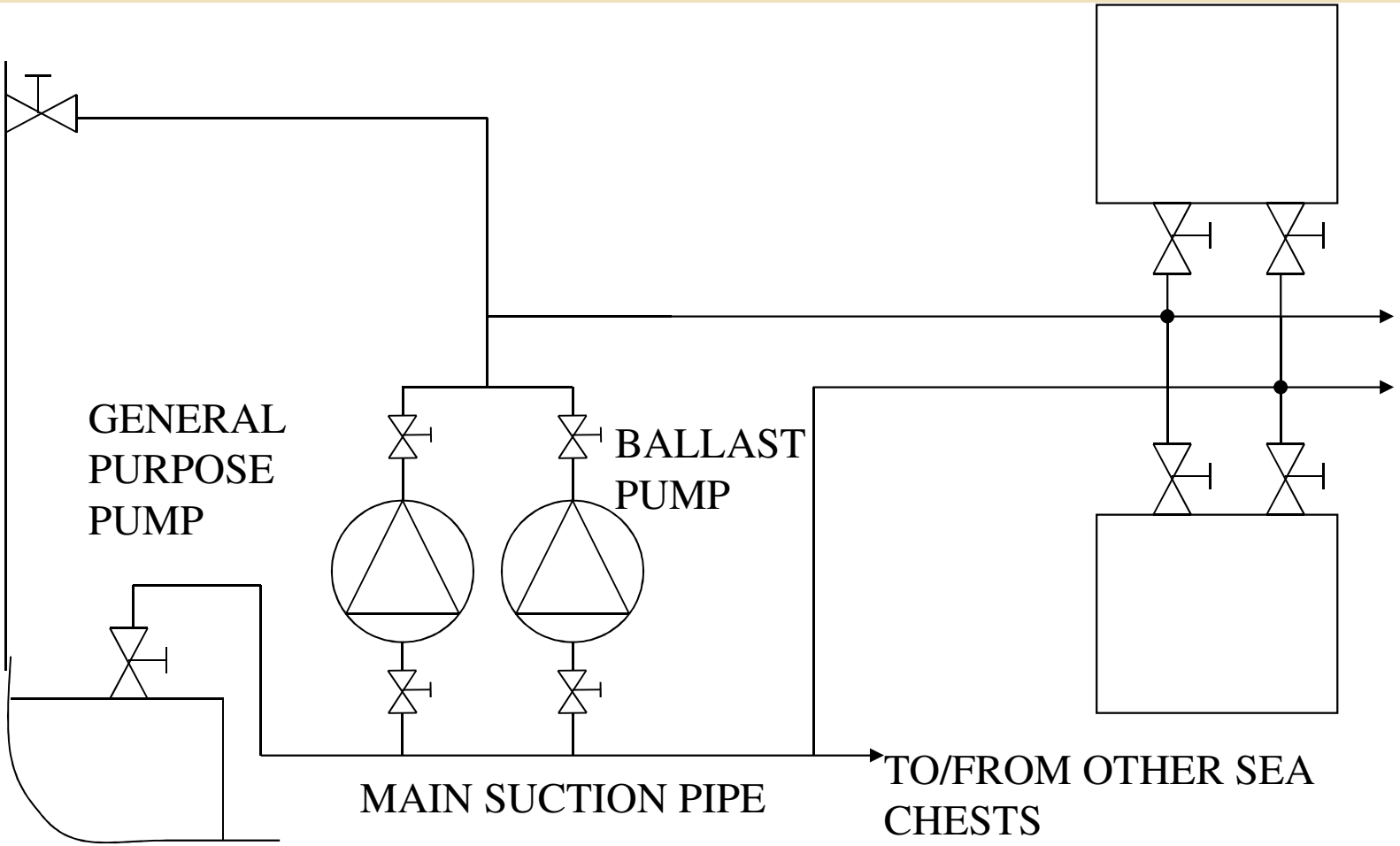
Bilge system



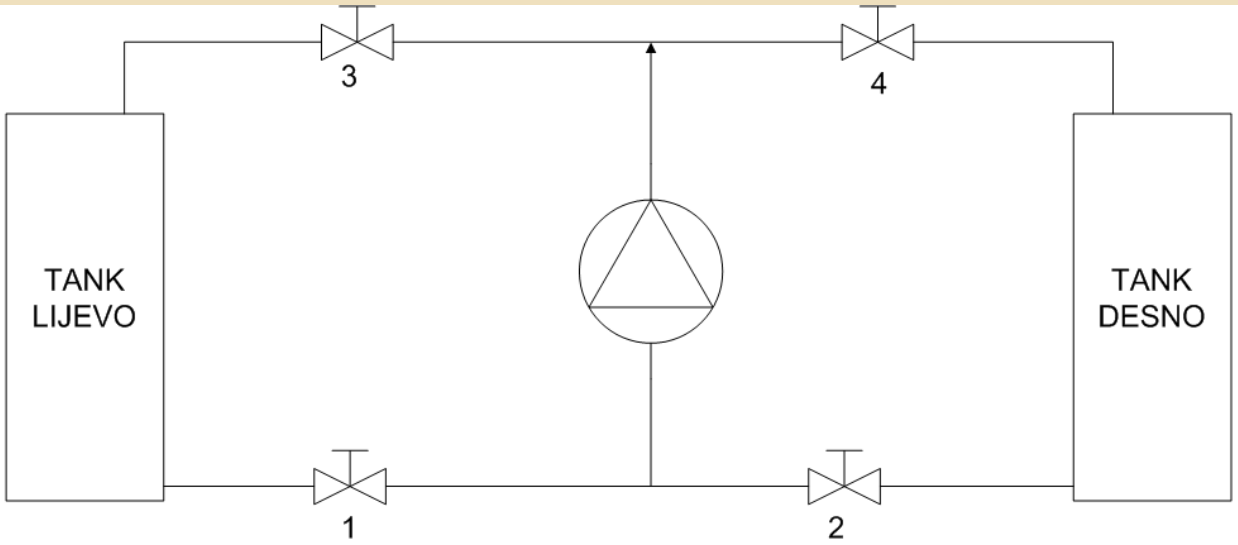
Ballast system

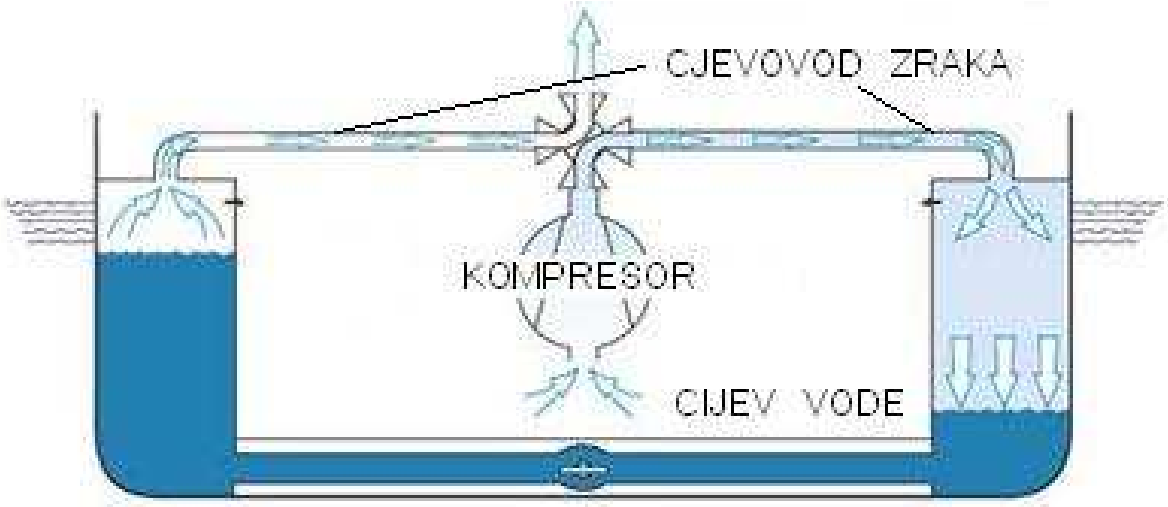
- intentionally used sea water to correct the trim, stability, structural forces
- ballast tanks: double bottom, side, forepeak, after peak

Ballast


GENERAL
PURPOSE
PUMP
BALLAST
PUMP
MAIN SUCTION PIPE
TO/FROM OTHER SEA
CHESTS

Antiheeling





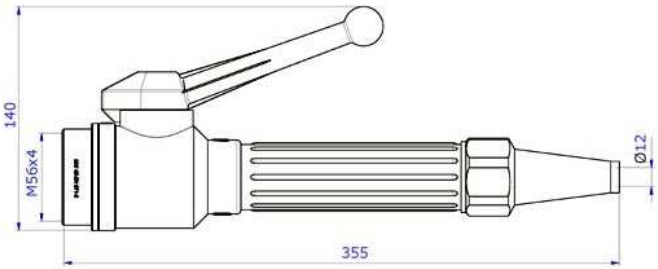
FIREFIGHTING SYSTEMS

- Main (sea water)
- “Sprinkler”; “water mist”; “hi-fog”
- Gas (CO_2, Halon, FE-13…)
- Foam
- Dry Powder
- etc.

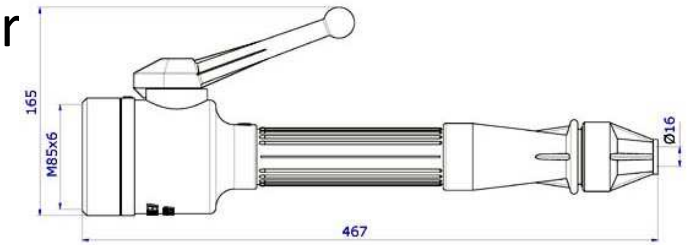
Main Fire Extinguishing System

- 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 pump
- flexible hoses (15-18 m for open spa
  spaces)
- separated from each other not more
  decks and not more than 20 m on cl
- flexible hoses should be mounted o
  passenger ship that could carry mor

Mlaznice
Branchpipes
Strahlrohre



Mlaznice
Branchpipes
Strahlrohre



CO_2

- 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

CO_2 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_2 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

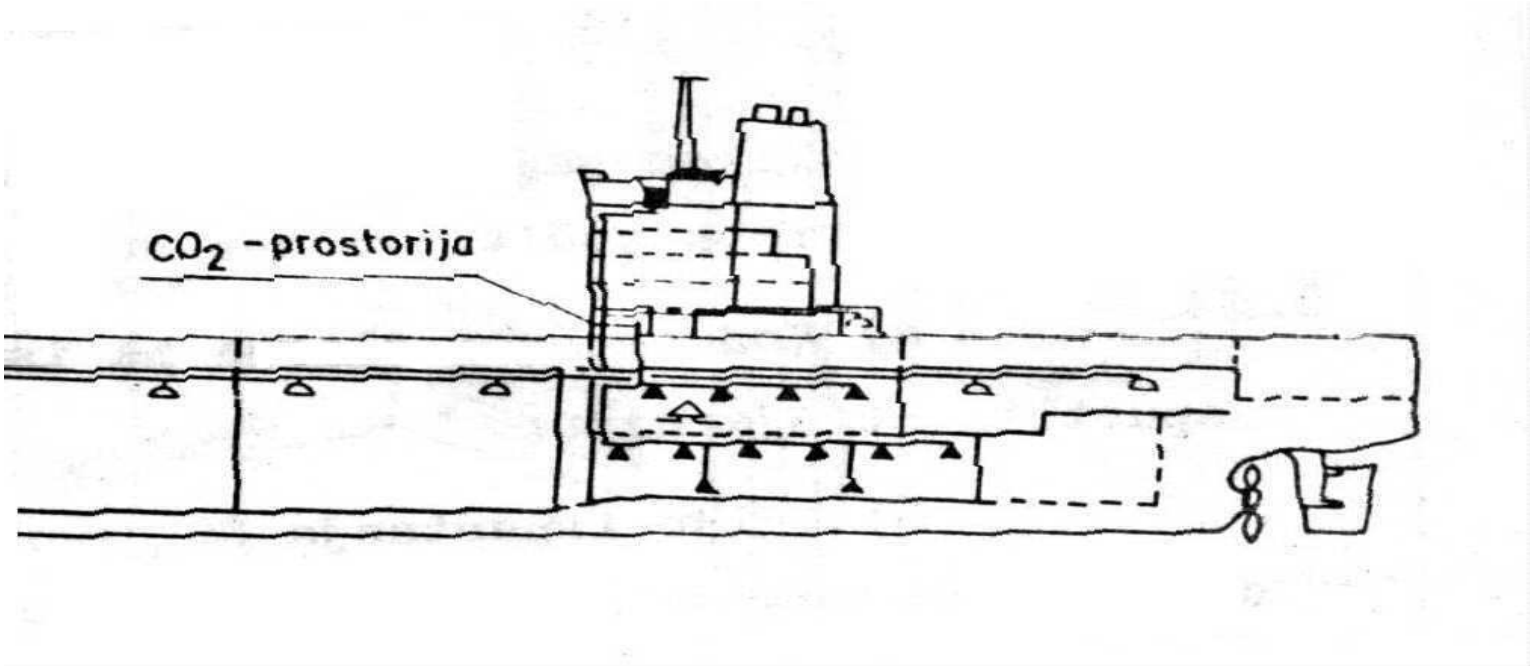
High pressure system

- cylinder pressure 56 bar at 20°C
- CO_2 mass: 45 kg (30-50)
- when temperature in the CO_2 room reaches the level of 54°C – cylinders have to be cooled down

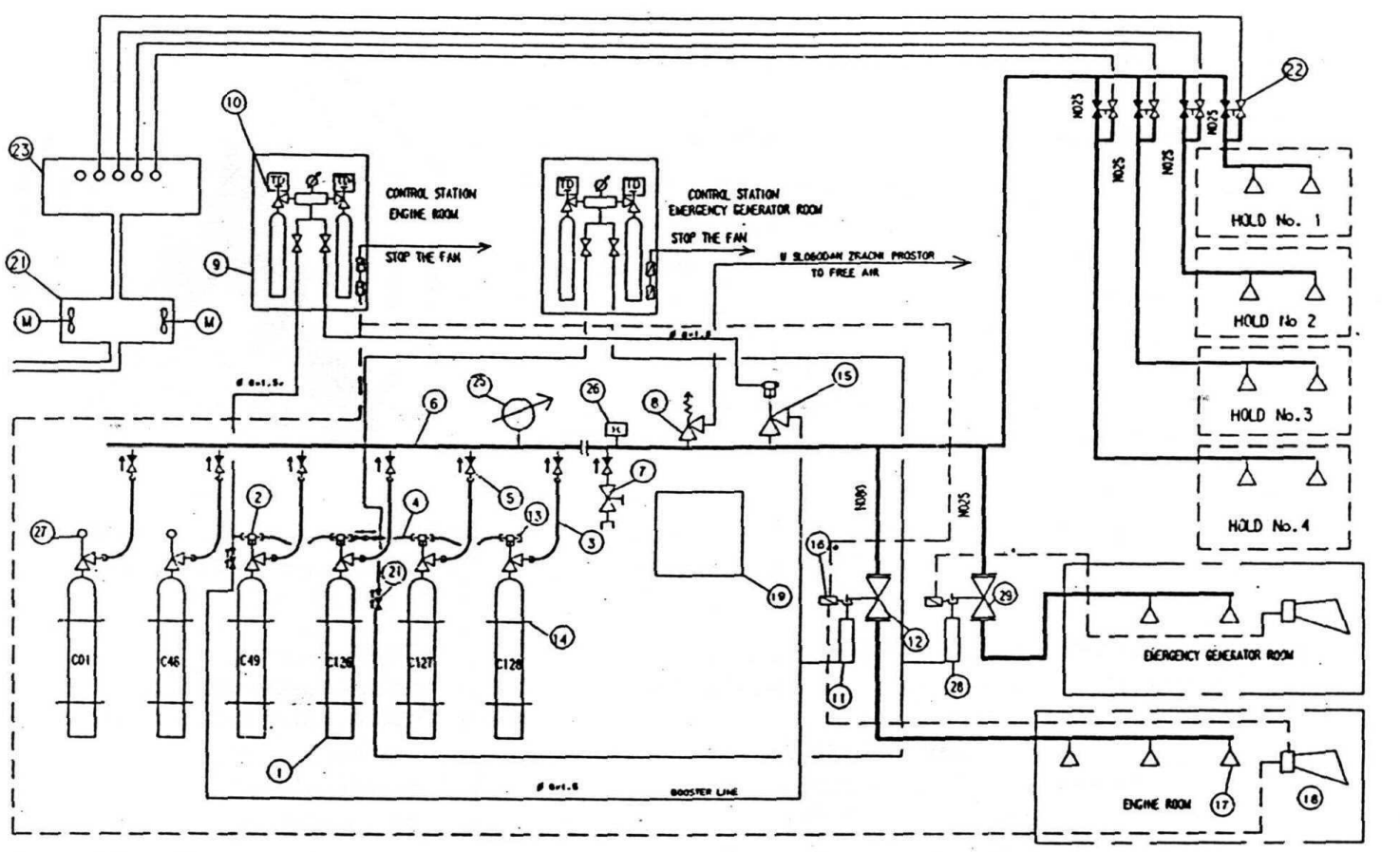
Low pressure system

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

CO2 fire supression system



CO_2 fire supression system



Procedure - engine room

- Procedure:
  - CO_2 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.

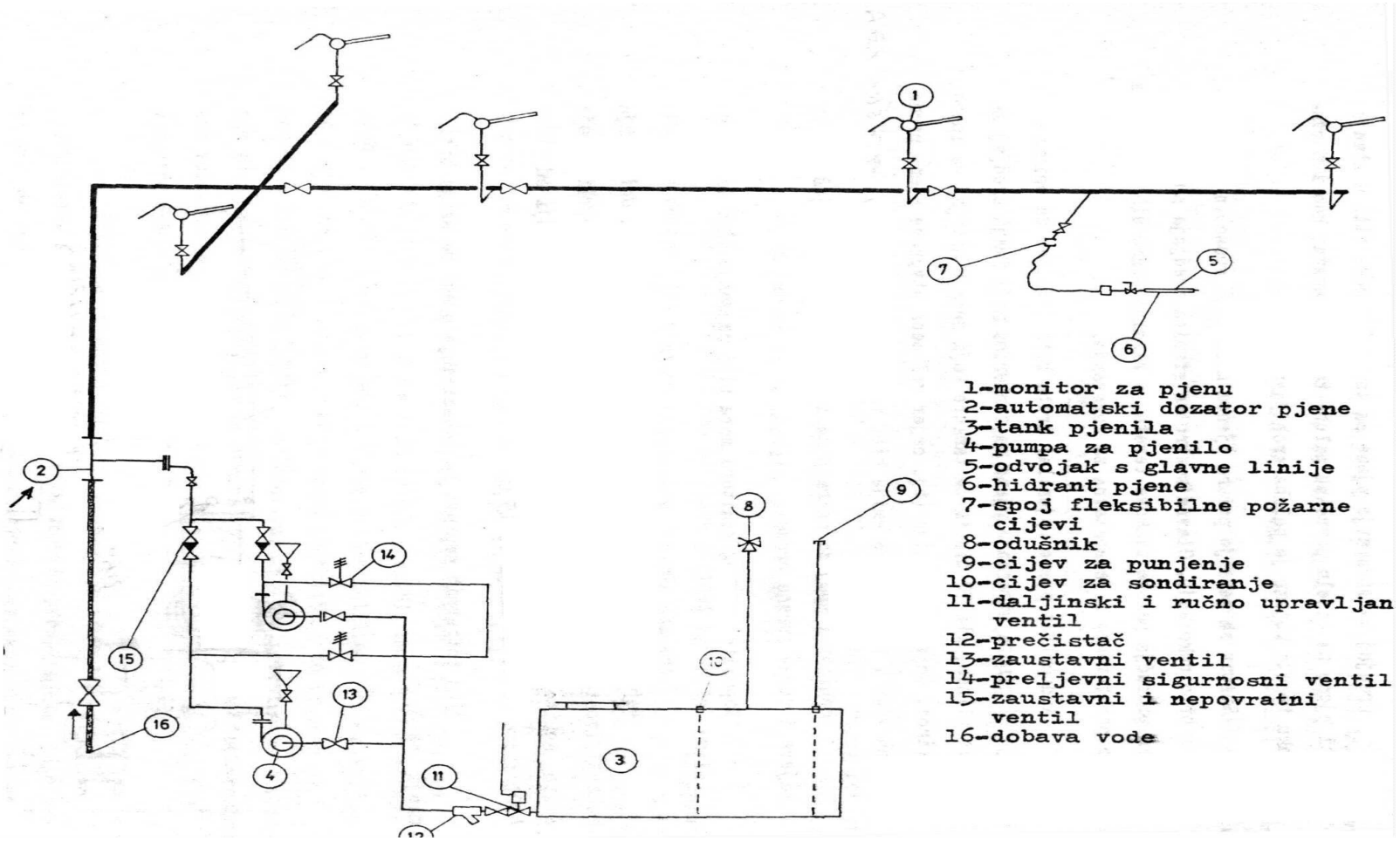
Exploitation

- CO_2 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 expansion foam; medium expansion 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 methane (CH_4) or ethane (C_2H_6)
- **H1301**, H1211, H2402
- can be used in fires of class A, B, C or E
- 3 times more efficient than CO2
- systems can be used in closed spaces only
- Anti catalytic 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 phase-out of new production

Halon 1301 effect on human beings

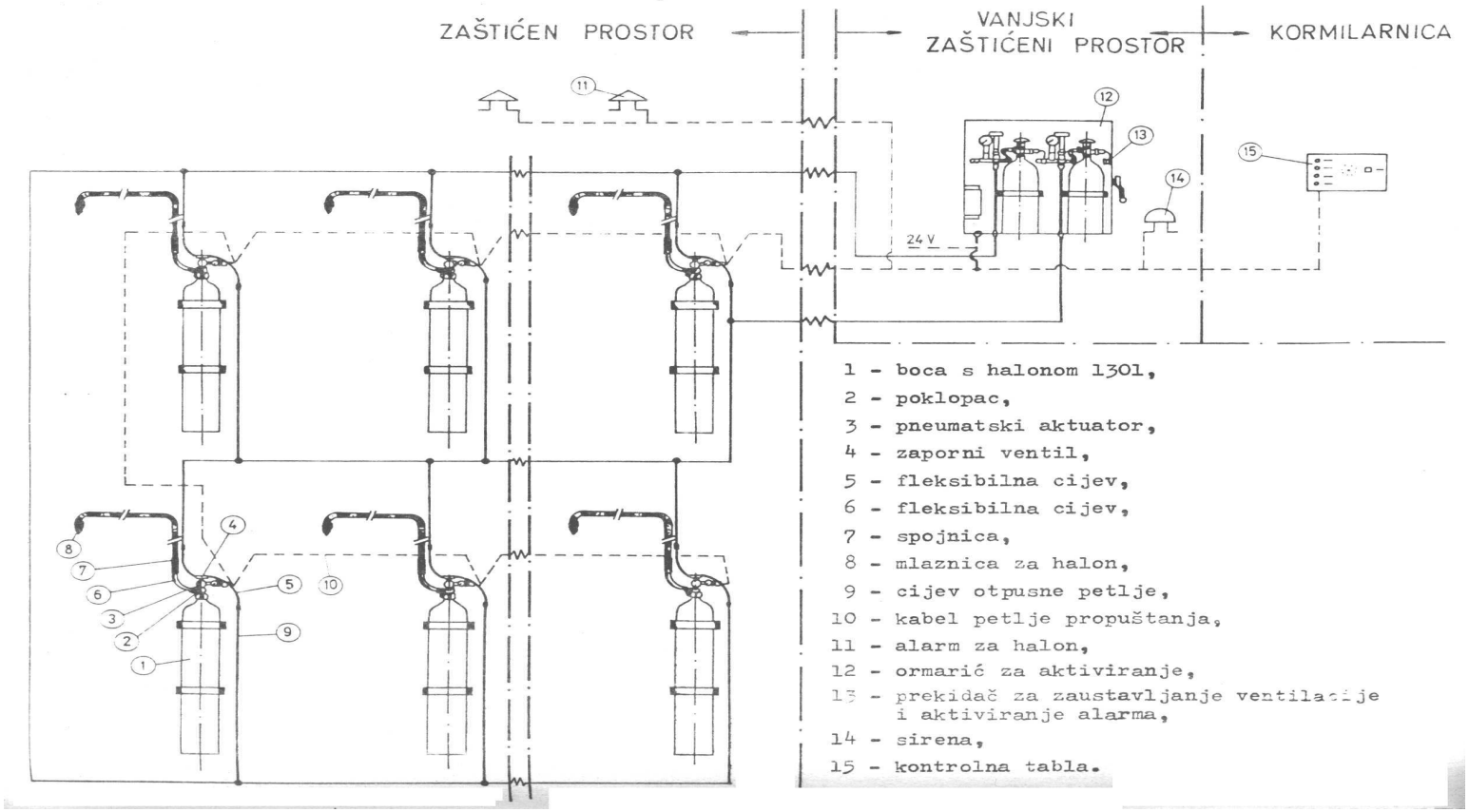
vol[%]	time [min]
<7	15
7-10	1
10-15	0,5
>15	dangerous

➔ if exposed to very high temperatures dangerous acids can be made (HF, HBr or Br2)

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 ±5%
- two different systems: total flooding or local
- weighing => if 10% is lost - replacement

System


ZAŠTIĆEN PROSTOR
VANJSKI ZAŠTIĆENI PROSTOR
KORMILARNICA
24 V
1 - boca s halonom 1301,
2 - poklopac,
3 - pneumatski aktuator,
4 - zaporni ventil,
5 - fleksibilna cijev,
6 - fleksibilna cijev,
7 - spojnica,
8 - mlaznica za halon,
9 - cijev otpusne petlje,
10 - kabel petlje propuštanja,
11 - alarm za halon,
12 - ormarić za aktiviranje,
13 - prekidač za zaustavljanje ventilacije i aktiviranje alarma,
14 - sirena,
15 - kontrolna tabla.

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

- A 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 for occupied spaces

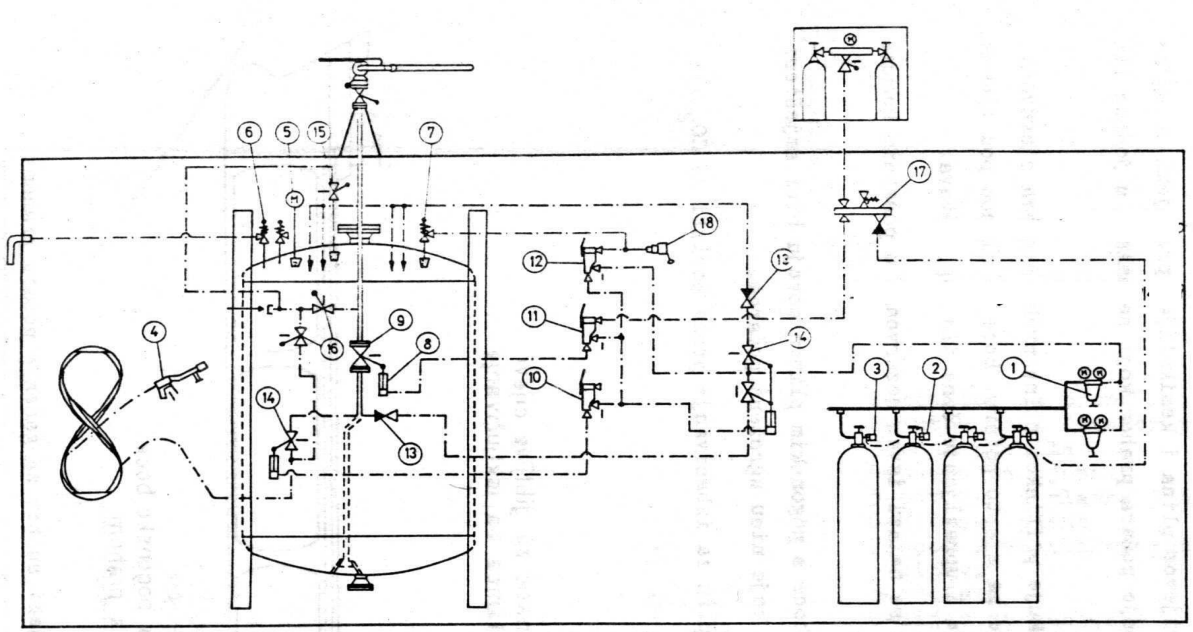
Dry Powder

- universal fire extinguishing agent (potassium, sodium salts…)
- extinguishing effect: **suffocation**, cooling effect, anti catalytic effect
- high temperature in protected area causes the chemical reaction by which the CO_2, water vapor and soda are formed
- propelling gas is CO_2 or N_2
- extinguishing procedure in closed spaces as in case of CO_2 system

Dry Powder System

- chemical tankers and LPG/LNG ships
- two completely independent units
- propelling gas in separated cylinders
- closed spaces: designed mass has to be released during not more than 30 s
- powder container: contains amount of powder for at least 45 s of operation of every fixed or portable powder extinguisher

System



1-redukcioni 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^2
- pressure for at least 28 m^2 (1 bar)
- dry and wet system

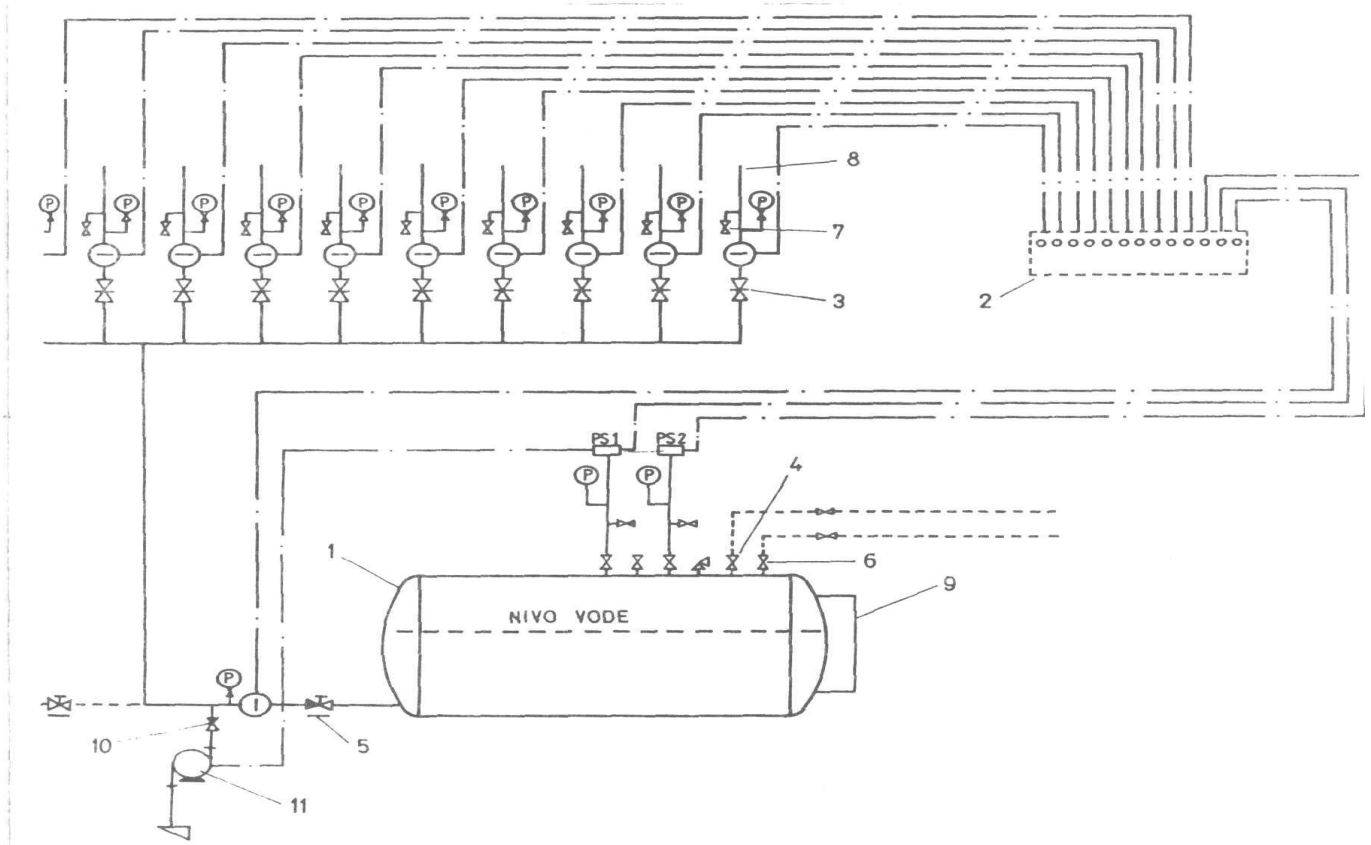
Sprinkler System

- 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

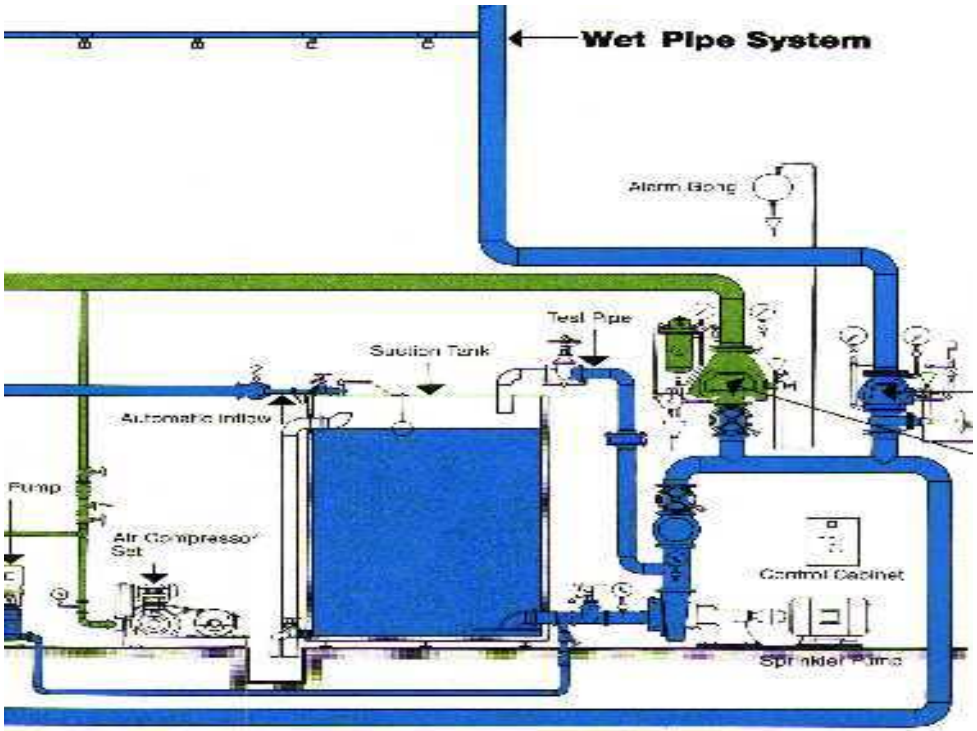
- opening is closed with the glass bulb filled with a temperature sensitive liquid and a small air bubble
- temperature increase causes the liquid to expand which results with pressure increase inside the bulb; at certain temperature (pressure inside) bulb bursts
- liquid color indicates the bursting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

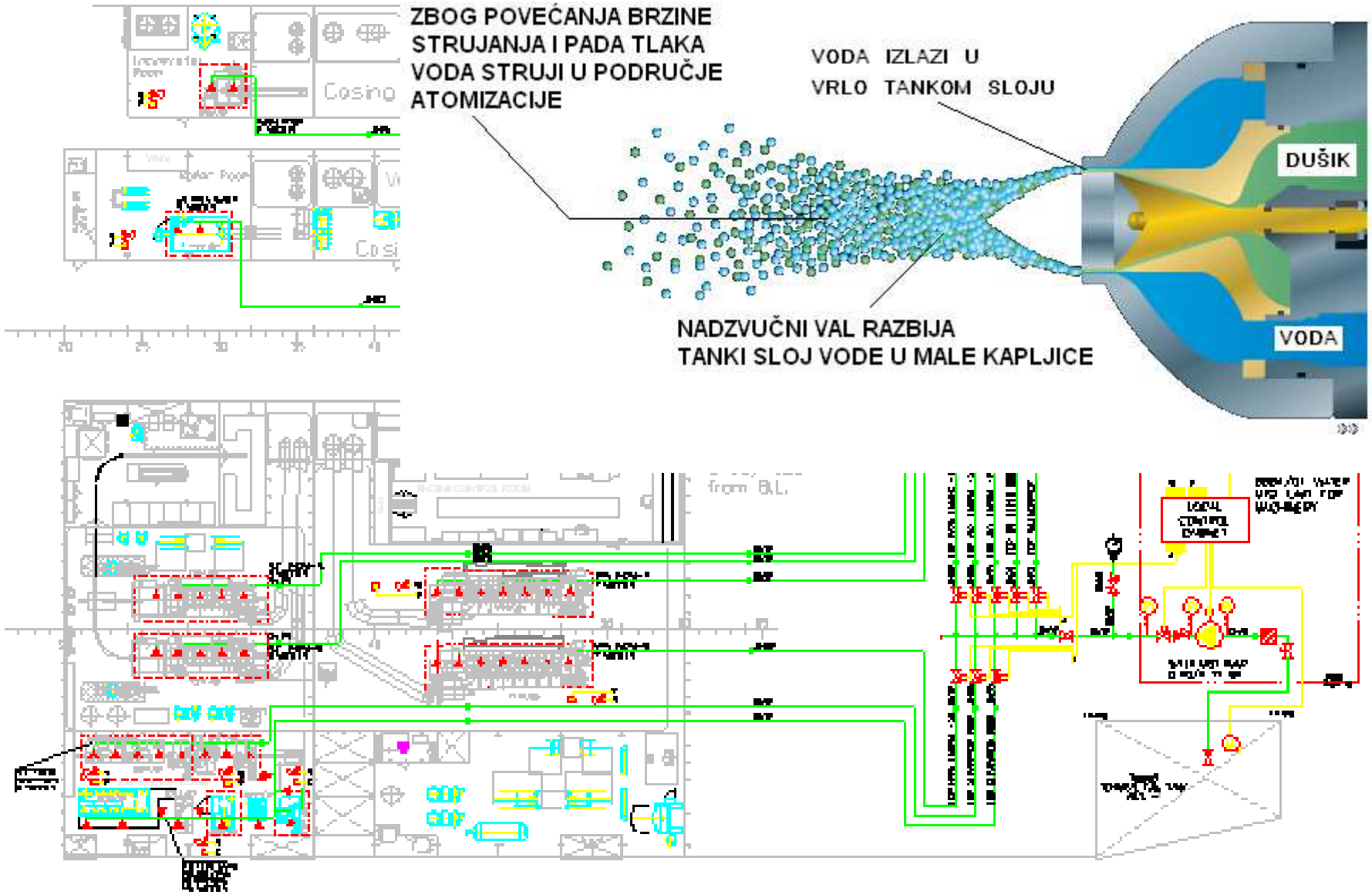
Sidewall Sprinklers (pendent type)

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 mist 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 mist	40	0,3 mm	10	0,1 s
Hi-fog	**8000**	**0,005 mm**	**400**	**0,003 s**


ZBOG POVEĆANJA BRZINE
STRUJANJA I PADA TLAKA
VODA STRUJI U PODRUČJE
ATOMIZACIJE
VODA IZLAZI U
VRLO TANKOM SLOJU
DUŠIK
VODA
NADZVUČNI VAL RAZBIJA
TANKI SLOJ VODE U MALE KAPLJICE

Emergency fire pump

- placement: fore pick (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^3/h