A design concept of fire protection system for an ecological floating dock

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ABSTRACT

This paper presents possible fire risks to an ecological floating dock and a design concept of its fire prevention system. The design concept covers: the water main fire system, froth- smothering system for fire prevention of the main deck area and CO_2 – fire extinguishing system for fire prevention of engine room, workshop and cable duct of the dock.

Keywords : floating dock, electric installations, fire protection systems

INTRODUCTION

Designing the floating docks, offshore drilling units or other ocean engineering objects requires to apply an individual approach to a much larger extent than that in the case of sea-going ships.

This can be specially observed in the design process of fire protection systems. Such publications as design guidance or hand books do not pay much attention to the fire protection problems concerning individual protection of docks and other ocean engineering objects.

In the set of regulations which determine principles of designing the docks in the area of fire protection, because of their general form, the main burden of creating a concept of dock fire protection is put on the designer's experience.

A number of built docks as compared with that of ships is very small therefore a level of designer experience gained in designing fire protection systems for docks is rather low. Due to a small number of orders for such elaborations possible emergence of experts solely in the area of fire protection of docks, out of all experts in fire protection of sea-going ships, is practically excluded.

Special character of the objects in question makes it necessary to include not only designers but also representatives of fire units to discussions on the problems since docks are elements of equipment of shipyards and some harbours in which regular fire fighting units are responsible for their fire protection. As a result, when designing the fire protection systems for such objects one should be aware of the relevant regulations being in force in shipyards. This is why many designs of fire protection systems for docks may be effectively improved in practice. Moreover, because many engineering branches are involved in solving fire protection problems, the designer responsible for fire protection of an ocean engineering object should have broad knowledge in the area of : fire fighting systems, electronic engineering associated with work of fire detection systems, fire fighting procedures, general knowledge on maritime engineering objects, and sometimes – even elements of law.

Similar problems have been met during design process of the fire protection system for the ecological dock designed in the frame of "EUREKA"project. The design was first of all based on the Rules for the Classification and Construction of Docks of Polish Register of Shipping. As information on location of future operation of designed dock was lacking the most versatile use of it was assumed.

This is connected with the necessity of analyzing fire hazards to a dock operating in ship building mode and also ship repair one. From the point of view of the designer of fire protection systems it may be limited to a large extent to the problems associated with conditions of evacuation of persons, i.e. those in the range not connected with operation of fire extinguishing systems, and covered by separate elaborations. Due to the lack of suitable data the problem of adjusting the design to regulations of national administration was left to be solved in further design stages of the dock. Docks are designed rather rarely and they are intended for long lasting use that results in limited possibility of basing on proved solutions in designing the docks. This is why appear great differences in effectiveness of new fire protection systems as compared with the existing ones. The observation may be related to e.g. fire detection and signaling systems which very fast evolve along with development of electronics.

CHARACTER OF FIRE RISK TO THE ECOLOGICAL DOCK

The ecological dock designed in the frame of the EUREKA ECOLOGICAL DOCK project has many features differing it from the existing classical docks. This also relates to the problems which affect the form of the fire protection design concept. From the point of view of fire protection the following problems are very rarely met: the glass roof over the dock, which, in some circumstances, may be conductive to spreading a possible fire (however real influence of the roof remains not tested). An additional risk factor is its own power source – the combustion engine driving electric generator. From obvious reasons the dock's power plant fitted with the combustion engine and the associated lubricating oil, fuel oil and exhaust gas systems as well as electrical systems associated with electric power production, should be accounted for as the sources of additional risk, in the design in question. Moreover according to the design project the dock is equipped with a cable duct connecting dock's side walls, workshop and electric switching station.

Places of the ecological dock, especially hazardous to fire

No.	Name of place	Description of risk
1	Main deck	During the dock's operation a ship or other offshore floating object is docked in it. It is assumed that on the docked object all fire extinguishing systems and other fire protection ones are out of order. As the dock is assumed versatile its operation is possible both in the ship-repairing and ship-building modes. Description of other risks resulting from the particular modes of dock's operation is given below.*
2	Engine room	In this compartment a high fire risk is due to work of fuel supply, oil lubricating and exhaust gas systems associated with combustion engine operation.
3	Cable duct together with vertical casings	In the cable ducts, due to possible occurrence of shortings in electric cables and restricted access to them, providing for a fire fighting system is necessary for these spaces.
4	Workshop compartment	The compartment is characterized by a higher fire risk as fire-risky operations are conducted in it, such as : welding, work with electrical tools, storage of combustible materials.
5	Electric switching station	In this compartment a fire risk results from the accumulation of many electric installations in one place.

* Fire risks to the docked objects can be classified by using many criteria, among which the following are considered the most important :

❖ **Mode of operations carried out on the dock**
The mode of operations carried out on the dock is of a great importance in creating fire risk. A docked offshore object can be in state of construction or repair works. Distinction of the two modes of operation affects fire risk to the dock crucially. Building the ship is much less dangerous in contrast to ship repair work carried out on the dock. It results first of all from that on the ship under repair inflammable materials and their vapours may be often found, as well as accumulation of wood in the form of furniture and other outfit elements may occur. The ship under repair is often used up, its electrical installations may be in a bad technical state, some of its systems usually are almost unserviceable, sometimes the ship's crew is still onboard. All the factors increase potential fire risk. In the fire protection design for the ecological dock in question the ship repair mode was assumed as being more hazardous.

❖ **Kind of docked object**
Fire risk to a docked object obviously depends on its specificity. A to-be-repaired fuel oil tanker is the most dangerous because of its tanks which may be, e.g., not sufficiently emptied from oil residuals and gases. Size of fire risky compartments on board the docked object and easiness of access to them also greatly affects the fire protection design process, for instance ro-ro ships have closed spaces between the decks, which involve additional fire risk resulting from difficult access for use of dock's fire fighting systems, another example is a docked offshore drilling unit whose some elements may reach over the upper deck of dock's side walls, that makes fire fighting more difficult.

In the course of the performed analysis in advance of commencing the design work the most unfavourable conditions associated with fire risk were assumed. In the working design stage of the fire protection system the fire hazard analysis should be agreed with fire protection experts.

DESIGN CONCEPT OF FIRE PROTECTION SYSTEM FOR ECOLOGICAL DOCK

After performing the fire risk analysis for the dock as well as after consulting it with experts dealing with fire protection in shipyards and ports , the design concept of fire protection of the ecological dock in question was elaborated.

Specification of fire protection elements for the ecological dock

No.	Name of item	Application
1	Water fire main system	Required by PRS Rules, the overall dock fire fighting system covering all the working area of the dock and its side wall decks, and having an unlimited amount of fire extinguishing medium.
2	Froth fire-extinguishing system	The low - expansion froth fire-extinguishing system cooperating with the water system, and covering all the working area of the dock and its side wall decks.
3	Carbon dioxide smothering system	The fire fighting system for dock's engine room, electric switching station, cable duct and workshop, started manually or in result of operation of the fire detection and signaling system.
4	Fire detection and signaling system	Not covered by this design
5	Fire fighting outfit	Fire extinguishers, fire electric generating sets, fire hoses, fire-hose nozzles, froth nozzles, fire blankets etc.

This specification shows only one design variant of fire extinguishing systems for the dock in question.

Description of the designed water fire main system

In the concept design stage designing of the water fire main system consists in :

- ✦ determination of parameters of water fire and emergency pumps
- ✦ preliminary selection of size and route of water pipe lines and the most favourable arrangement of fire hydrants
- ✦ determination of optimum parameters of all elements of hydrant equipment.

The rule requirements in this range could be greatly limited in the case of permanent water supply to the dock's fire main system from a land-based water source.

Calculations of the water fire main system were carried out with assuming the largest ship possible to be docked, due to lack of any publication concerning an individual procedure of designing the fire extinguishing systems for docks.

Principles of selection and calculation of water fire pumps

Two fire main pumps simultaneously operating and one fire emergency pump of the same capacity as the main pump were assumed to be applied. Their calculations were carried out on the basis of the assumption that during operation of the system two hydrants most distant from the pumps are under work. Hydrant hoses of 50 mm diameter and 20 m in length, cooperating with the nozzles of 19 mm outlet, were assumed. The maximum capacity of the system was calculated on the basis of the following formula :

$$Q_c = k \cdot m^2$$

where :

$m = 1.68\ [L\ (B+H)]^{0.5} + 25$

$k = 0.008$ for the objects over 1000 RT

L, B, H – main dimensions of the largest ship to be docked.

$$Q_c = 180\ m^3/h$$

Moreover, in compliance with the PRS Rules, it is possible to apply water ballast pumps as fire pumps, however the condition of simultaneous starting the water fire main system and ballast system must be satisfied in order to make it possible to dock out the ship in emergency of a fire in dock compartments. The water fire main pumps should be located on both sides of the dock that makes it possible to obtain uniform parameters of water flow for both sides of the dock. To determine the pressure head of the fire pumps the following formula has to be applied :

$$P_p = H \cdot \rho \cdot g \cdot 10^{-6} + p_h + \Delta p_{str}$$

where :

- H – height from water level to the highest located fire hydrant valve [m]
- ρ – water density [kg/m^3]
- g – gravity acceleration [m/s^2]
- p_h – water pressure before hydrant valve [MPa]
- Δp_{str} – sum of pressure losses for the least favourably located valve.

The pressure before hydrant valve p_h = 0.28 MPa was assumed in accordance with the requirements of the PRS Rules. Now only the sum of pressure losses for the least favourably located valve remains for calculation. It consists of the losses resulting from friction drag of water flow through piping as well as the losses resulting from local drag in piping elements. Therefore it is necessary to carry out hydraulic calculations on the basis of the schematic diagram of the system divided into sections; for each of them the calculations are performed separately and then their results are added together.

$$\Delta p_{str} = \rho\ [\Sigma\ (\Sigma\ \xi_{ij} + \lambda_i \cdot l_i/D_i)\ w_i^2/2 + w_h^2/2] \cdot 10^{-6}$$

where :

- ρ – water density [kg/m^3]
- $\Sigma\ \xi_{ij}$ – sum of local drag coefficients in ith section
- λ_i – linear drag coefficient in ith section
- l_i – length of ith section [m]
- D_i – diameter of ith section pipe [m]
- w_i – velocity of water flow in ith section [m/s]
- w_h – water flow velocity before hydrant valve [m/s].

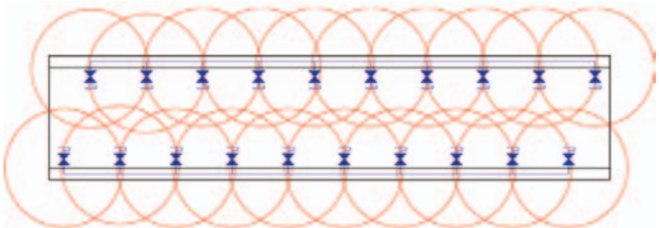
The pressure head of the pumps should be as follows :

$$P_p \geq 0.6\ MPa$$

In order to select a fire pump its maximum power demand should be determined in advance on the basis of energy balance of the dock, as well as its allowable gabarites.

Principles of pipe line design procedure

Designing the pipe lines of water fire main system for the dock should start from optimization of arrangement of fire hydrant valves. The basic criterion of the arrangement is the possibility of leading 20 m hydrant hoses to every point on the dock. The most effective method for arranging the hydrant valves is to map particular fire-fighting posts (at each hydrant valve) as the circles of 20 m radius, which have to tightly cover the entire protected space. In the case of the ecological dock the use of the method made it possible to reduce the number of fire fighting posts by 4 units due to shifting the valve lines on both sides of the dock by 4 m, to each other.



Dimensions - as on the schematic diagram of the water main system. The radius of every circle, R = 20 m.

Fig. 1. *Method of arranging the hydrant valves on the dock (the authors' original drawing).*

The next phase is selection of pipe line diameters. Diameters of particular kinds of pipe lines are chosen on the basis of the system's schematic diagram by using the following formula :

$$D \geq 9.4032 \cdot Q^{0.5}$$

where :

Q – maximum volumetric rate of water flow through a given section of pipe line at the assumed water flow velocity w = 4 m/s .

Specification of kinds of the pipe lines used in the water fire main system for the ecological dock

No.	Name of pipe line	Nominal diameter D [mm]
1	The pipeline between the pump and water main	90
2	The vertical main pipe line for branch pipes leading to hydrant valves	50
3	The pipe line connecting the fire systems in both dock's side walls	125

The pipes should be installed inside the side walls so as prevent them against direct atmospheric exposure, a temperature below 0°C in particular. Non-heat resistant materials cannot be applied to the pipe lines unless they are suitably insulated. The pipe lines should be fitted with draining equipment.

Specification of elements of the designed water fire main system

No.	Name	Number of pieces
1	Main fire pump (or ballast one)	2
2	Emergency fire pump	1
3	Vertical pipe lines for branch pipes leading to hydrant valves, D = 50 mm	-
4	Pipe line from fire pump to water main, D = 90 mm	-
5	The pipe line connecting the fire systems in both dock's side walls, D = 125 mm	-
6	Φ52 hydrant valve	74
7	H52/20 hydrant hose	38
8	Hose nozzle of 19 mm outlet diameter	38
9	Hydrant hose box	38

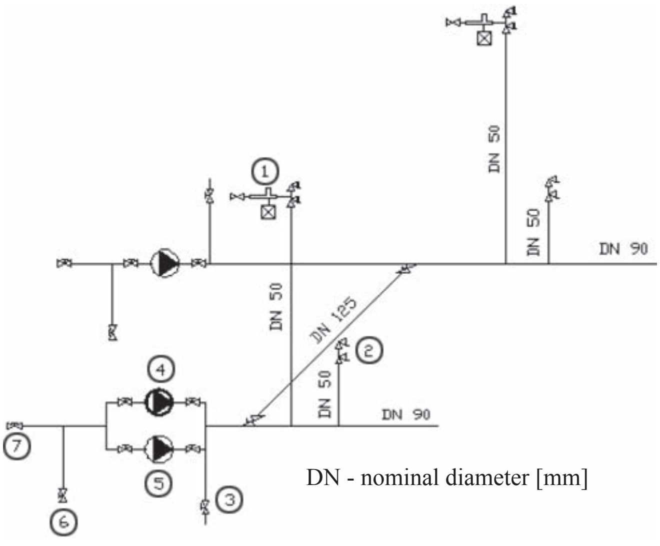


Fig. 2. *Schematic diagram of the main elements of the designed water fire main system for the ecological dock. (the author's original drawing)* ***Legend*** *: **1** – fire fighting post for water and froth fire-extinguishing – froth stub pipe, pipe line choke, frothing liquid tank, two hydrant valves; **2** – fire fighting post for water extinguishing - two hydrant valves; **3** – cut-off valve in pipe line to the right side wall ballast system (the same on the left side wall); **4** – fire emergency pump; **5** – water fire main pump for the right side wall (the same on the left side wall); **6** – kingston valve for water input to the right side wall (the same on the left side wall); **7** – cut-off valve for water input from a land-based water system, installed in the right side wall (the same on the left side wall).*

The described method determines an algorithm of preliminary designing the water fire main system for the dock, applying a strict approach to fire protection problems. In reality during design process many simplifications are possible to be applied under the consent of classification society's surveyor provided the designer has in his disposal a more exact information on real working conditions of the designed object.

Description of the froth fire-extinguishing system designed for fire protection of the main deck area of the ecological dock

Decision on application of an additional fire fighting system is left to the designer, however in the PRS rules any arguments justifying it cannot be found. Nonetheless, the preliminary design calculations of such installation were performed as the versatile character of the dock was assumed. The dock in question should be fitted with a permanent froth fire-extinguishing system for fire protection of the dock's main deck and a docked object because the possibility of docking the tankers whose systems are out of operation, has been assumed.

The application of the froth fire-extinguishing system for docked objects is necessary in the case when various inflammable liquid substances are stored in them. This is rather inexpensive in the case of the designed fire fighting system because in the proposed type of froth fire-extinguishing system the use has been made from some elements and the principle of work of the water fire main system required by the rules. This way no large investments associated with its application are necessary.

In contrast to elsewhere proposed design solutions of fire protection system for ecological dock the proved production method of a low-expansion froth by using pipeline choke, was selected. The designed froth fire – extinguishing posts are arranged on the upper decks of both dock's side walls, inside hydrant valve boxes. Every post is composed of the pipeline choke terminated in stub pipe with Φ52 universal root, and the frothing agent tank connected to it. The pipeline choke is connected to the water fire main system and makes it possible – due to its construction – to produce a low-expansion froth smoothly.

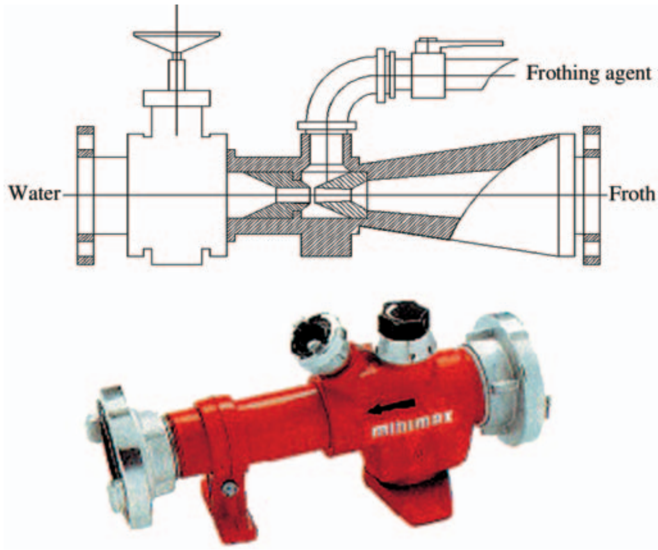


Fig. 3. *Schematic diagram and photograph of pipeline choke (acc. Catalogue of products of MINIMAX Co.).*

In this case the shown solution is the least expensive. Moreover, under assumption that the froth fire-extinguishing system is not equipped with fire-fighting monitors this solution would not require additional frothing agent pumps, that – in consequence – makes its reliability greater. Due to its simplicity the design system is versatile and makes it possible to adjust kind of froth to a particular fire hazard. It seems to confirm that : *the simplest the best*. Owing to application of the concept, to design any frothing agent tank is not necessary. Producers of frothing agents of the kind deliver them in ready-made tanks which are suitable for temporary installation on board the dock to be connected to pipe line chokes. This greatly simplifies the process of supplementing amount of the frothing agent within the system, and generates next savings.

Calculations of main parameters of the designed froth fire-extinguishing system

A low-expansion froth of the expansion ratio $L_s = 8 \div 12$ was assumed as the fire-extinguishing medium applied in the froth fire-extinguishing system for the dock. Froths of the kind are used to extinct fires of inflammable liquids. In this design also possible work of the installation by using various frothing agents is assumed. By adjusting the choke individual selection of concentration of frothing agent in the mixture is possible.

The specific consumption of 6% frothing agent is:

$$Q = 0.06\ (F \cdot c)$$

where :

$F = 3000\ m^2$ - deck area of the largest ship possible to be docked (with some margin)

$c = 0.6\ dm^3/min{\cdot}m^2$ – average froth delivering rate for the entire deck of docked object :

$$Q = 108\ dm^3/min$$

The required standard amount of stored frothing agent (together with a surplus) for fire extinction within the standard time t :

$$Q_c = t \cdot Q$$

where :

t = 30 min – standard time of fire-extinguishing

$$Q_c = 3240\ dm^3$$

The required standard amount of stored frothing agent for particular fire froth-extinguishing posts and selection of capacity of the tanks installed at the fire fighting posts :

as required : $V = 180\ dm^3$ – as assumed : $V_{zb} = 200\ dm^3$

Water delivery rate from the fire main system, required for operation of the fire froth-extinguishing system :

$$Q_w = F \cdot c \cdot [(100\% - 6\%) / 100\%] =$$
$$= 1.80\ m^3/min\ (108\ m^3/h)$$

An alternative concept of the froth fire-extinguishing system is the solution consisting in application of froth monitors to deliver froth to a protected area. The solution provides some advantages resulting from the possibility of more favourable froth streams manoeuvring, as compared with the above considered one. However the solution is much more expensive and complicated. The differences results first of all from the necessity of application of frothing agent pumps , additional pumps delivering water to the system, or designing a pipe line to connect the system with a land water source.

Calculations of main parameters of fire froth-extinguishing system equipped with froth monitors

The specific consumption of 6% frothing agent – under assumption that the deck area of docked object is fire-protected with the use of froth monitors :

$$Q = 0.06 \cdot (F \cdot c)$$

where :

$F = 3000\ m^2$

$c = 3\ dm^3/min{\cdot}m^2$ – average rate of froth delivering onto the entire deck area of docked object in the case of application of froth monitors :

$$Q = 540\ dm^3/min$$

The required standard amount of stored frothing agent (together with a surplus) for fire extinction within the standard time t :

$$Q_c = t \cdot Q$$

where :

t = 30 min – standard time of fire extinguishing.

$$Q_c = 16200\ dm^3$$

Capacity of frothing agent tank with the assumed 5% surplus :

$$V = 17\ m^3$$

Capacity of froth agent pumps :

$$Q_p = 1.25 \cdot Q = 675\ dm^3/min\ (40.50\ m^3/h)$$

Total capacity of water supply pumps for the fire froth-extinguishing system fitted with froth monitors :

$$Q_w = 507.60\ m^3/h$$

In the case if two froth monitors are assumed the calculated capacity values of frothing agent and water pumps have to be divided by two.

Description of the designed CO_2 - - smothering system intended for the protection of engine room, workshop, electric switching station and cable duct

In the PRS Rules for the Classification and Construction of Floating Docks the necessity of application of a CO_2 - - smothering system for the protection of such compartments as engine rooms, cable ducts etc located on the dock, is not clearly stated. The mentioned compartments are not required to be attended though they contain many fire hazardous objects in engine room, electric switching station, workshop and cable duct between dock's side walls such as e.g. electric generating sets , electric switchboards and cables hence their risk to fire is much greater as compared with other compartments. Possible fire in any of the above mentioned compartments could be detected too late. It seems that this is sufficient reason to consider application of an automatic volumetric fire extinction system for those compartments. The volumetric fire extinction method consists in filling a protected space with a gas medium not supporting the combustion process. Therefore during designing the systems of the kind special attention should be paid to correct assessment of volume of a given protected space.

„*The rated volume of protected space V* – gross volume of the protected space limited by water-tight or gas-tight bulkheads, walls and decks, without any deduction for volume of structural elements and equipment contained therein" (according to the PRS Rules for the Classification and Construction Sea-going Ships, Part V p. 1.2).

Calculation principles for parameters of main elements of CO_2 - smothering systems

The most classical solution of volumetric fire extinction system is the application of CO_2 - smothering one. For the ecological dock in question a CO_2 high pressure system (using gas cylinders) designed with the use of standardized elements offered by ANSUL INC, was proposed.

The designing procedure for such system consists in :

- ➲ finding the correct location of CO_2 extinction station
- ➲ calculation of a required amount of fire-extinguishing medium
- ➲ choice of solution for triggering the system working, and
- ➲ choice of parameters of CO_2 distributing pipe lines, as well as other components of the system.

The designed system is intended for fire protection of the following spaces of the dock

No.	Name of space	Capacity (volume) [m^3]	Percentage volumetric ratio relative to the largest one
1	Compartment of electric generating sets	160	50 %
2	Electric switching station	320	100 %
3	Workshop	80	25 %
4	Cable duct together with vertical casings	312	98 %

According to the PRS Rules the required amount of carbon dioxide for fire-extinguishing systems should be calculated with the use of the following formula :

$$G = 1.79 \cdot V \cdot \varphi$$

where :

V – rated volume of the largest space to be protected [m^3]
φ – compartment filling ratio, φ = 0.35 – for engine rooms whose total volume is determined with accounting for volume of casings.

$$G = 200.48 \text{ kg}$$

Carbon dioxide for such systems is stored in cylinders. To calculate a number of CO_2 cylinders located in the CO_2 fire extinction station the following formula should be applied :

$$n = G/V_{zb} \cdot \beta$$

where :

G – amount of carbon dioxide for protection of a given space (compoartment) [kg]
V_{zb} – capacity of CO_2 cylinders [dm^3]
β – filling ratio of CO_2 cylinders [kg/dm^3].

<u>The capacity of CO_2 cylinders</u>, V_{zb} = 67.5 kg was obtained on the basis of a design handbook for high-pressure CO_2 smothering systems, published by ANSUL Inc.

<u>The filling ratio of CO_2 cylinders</u>, $\beta \leq 0.675$ kg/dm^3 at the rated cylinder pressure $p \geq 12.5$ MPa, was assumed in accordance with the PRS Rules.

<u>Number of cylinders</u>, n = 4.4 was obtained from the calculations hence by rounding up 5 CO_2 cylinders of ANSUL Inc. production, were finally assumed.

The next phase of designing is to decide where CO_2 fire extinction station has to be located. In accordance with the rules of classification societies such stations should be located on open decks. Moreover they should be separated from adjacent compartments with gas-tight decks and walls. Thermal insulation should be provided so as to ensure a positive temperature inside the station.

In the course of designing of such small CO_2 - smothering systems the designer should decide whether the designed system has to serve for local or total fire protection purposes. In the case in question the second variant should be accepted as the dock's machinery compartments and cable duct are unattended.

Photographs and schematic diagrams of the local CO_2 - smothering system are presented in Fig. 4 and 5.

Currently, producer of fire protection systems makes a complete catalogue of system components available to the designer. However majority of producers stipulates that only original components made by a given producer have to be applied. Therefore the role of the designer in selecting particular elements for a fire protection system has become very limited.

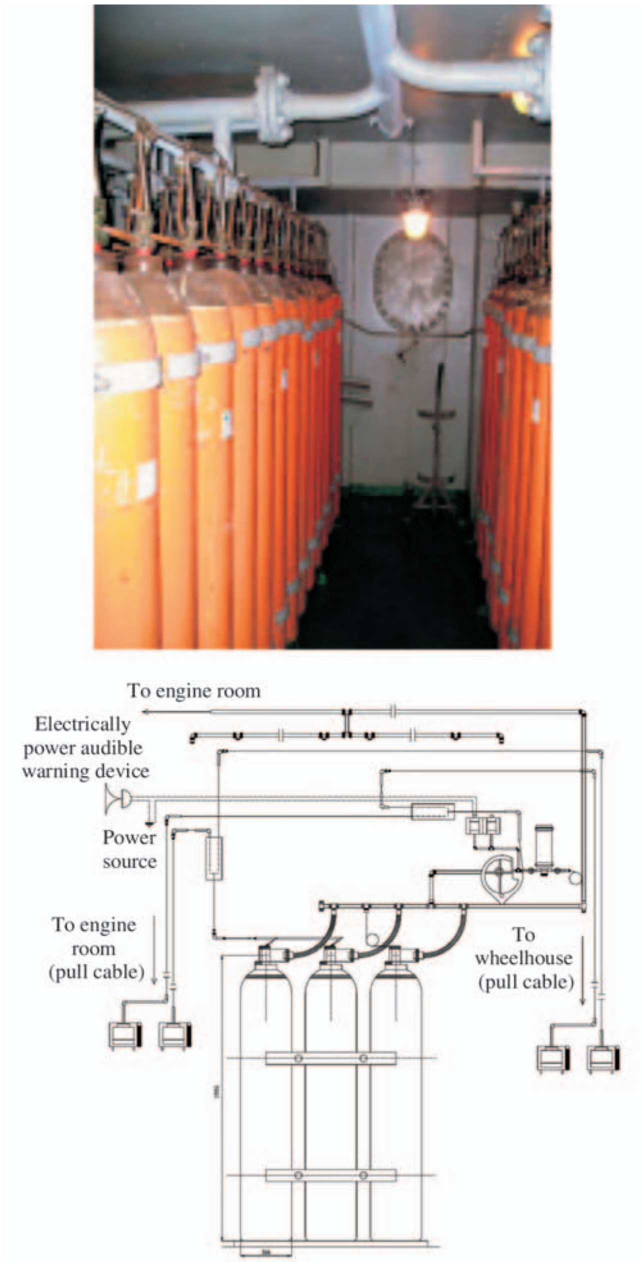


Fig. 4 and 5. *Photographs and schematic diagrams of the local CO_2 - smothering system for fire protection of the emergency electric generating set.*

Choice of pipe line diameters for CO_2 - smothering systems consists in making use of the following principle given in the PRS Rules :

$$d^2 \geq \sum d_i^2$$

and

$$d^2/m = d_i^2/m_i$$

where :

d – inlet pipe line diameter equal to sum of all cross-sectional areas of cylinder valves [mm]
d_i – i-th branch pipe line diameter [mm]
m – mass of CO_2 amount which has to be delivered through the inlet pipe line [kg]
m_i – mass of CO_2 amount which has to be distributed through the i-th branch pipe line [kg].

The cross-sectional area of ANSUL GV97 cylinder valve is :

$$D_z = 20 \text{ mm}$$

Diameters of the pipe lines leading to particular compartments were calculated by using the following formula and schematic diagram :

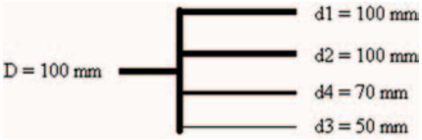


Fig. 6. *Auxiliary schematic diagram for calculation of pipe line diameters of CO_2 - smothering system intended for the ecological dock in question.*

Calculations of the parameters of another components have been omitted as they are of a minor importance in the course of conceptual designing the CO_2 - smothering system.

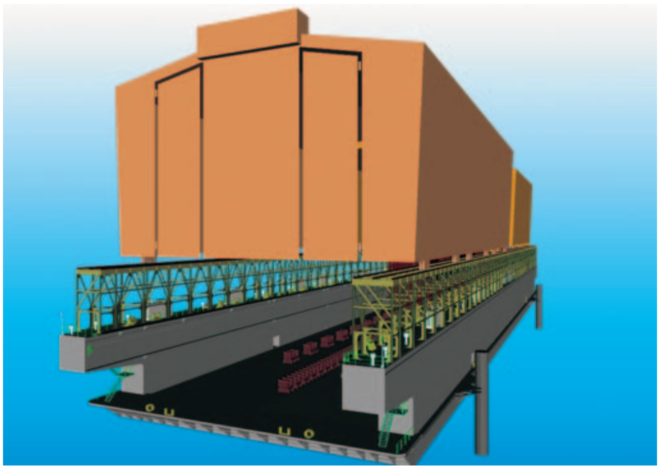
The CO_2 - smothering system can cooperate with fire detection and warning systems. In such case the fire extinction procedure is controlled by an approved central fire extinction station. The relevant procedure may approximately proceed in the following steps :

- ❖ detection of a fire automatically by a fire detector, or by pushing a button of manual fire alarm
- ❖ activation of time-delay counting to make a check, and possible immediate extinction of a fire in one of the protected compartments, and in the same time automatic switching-off the ventilating systems in these compartments, and switching-in the audible fire warning alarm
- ❖ after ending the time-delay counting or intentional cutting-off the time delay by an operator, starting the system of sealing all openings in the endangered compartment
- ❖ starting the fire extinction system.

For safety reasons such procedure should be always determined and strictly obeyed.

The presented design and associated calculations represent only one of the possible variants of fire protection system for the ecological dock designed in the frame of "EUREKA" project. Only an analysis of several elaborations of the kind makes it possible to choose an optimum solution. It seems to be many possible variants of fire protection system for the dock since its designer has a wide room for decision making in this respect.

An intention of the designer of the described concept was to present the most practically realizable set of technical solutions applicable to the fire protection system for floating docks.



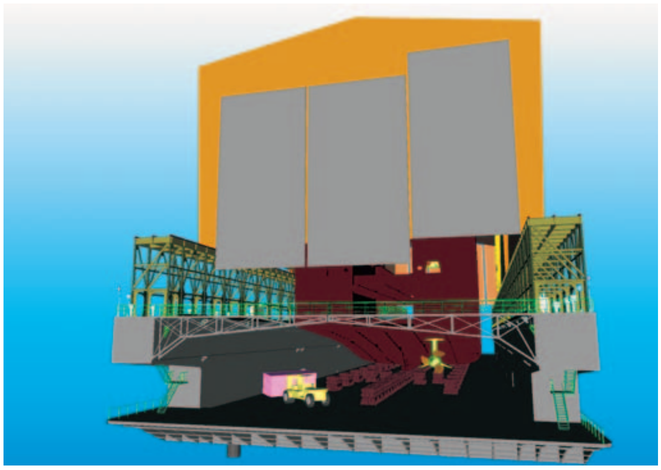


Photo : Cezary Spigarski