Design of a Fire Extinguishing System with Gas Clean Agent Halocarbon HCFC Blend A Fire Extinguishing Media in the Ship's Engine Room

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Abstract. The engine room is one of the most critical compartment that have significant level of risk. There are many equipments, devices, and environmental aspects considered having potential caused of fire. Those of the potential components could rise probability of fire. Therefore safety operation on engine room should become as a main aspect for the engine room operation. Considered on environment issue, fire suppression medium Halocarbon HCFC Blend A (AF11E) would become as prospective fire suppression medium on the future. This research discussed the design of fire suppression system piping using the fire suppression medium Halocarbon HCFC Blend A for the ship engine room. The research was started with calculation for determining the number of discharge nozzle, the required extinguishing agent supply, and piping design. The final results of this research were the required extinguishing agent supply amount were 1126.916 kg for 70 kg for each cylinder bottle contents, and 15 extinguishing cylinders were required, the recommended pipe sizes were 4-inch discharge pipe, 3-inch main pipe, 2-inch separator pipe, and 1-inch branch pipe, and the number of outlet nozzles used was 49.

Keywords: Clean Agent, Discharge Nozzle, Engine Room

1. Nomenclature

C	*Agent design concentration* (vol %)
m	*Mass flow rate* (kg/s)
Q	*Volumetric flow rate* (m^3/s)
s	*Specific volume* (m^3/kg)
T	*Temperature* (^{o}C)
t	*Time for flooding* (s)
V	*Volume of the protected hazard* (m^3)
W	*Quantity of clean agent* (kg)

M. U. H. Al Rasyid and M. R. Mufid (eds.), *Proceedings of the International Conference on Applied Science and Technology on Engineering Science 2023 (iCAST-ES 2023)*, Advances in Engineering Research 230,
https://doi.org/10.2991/978-94-6463-364-1_35

1. INTRODUCTION

The engine room is an important part of the ship for smooth operations during sailing as well as when docking and loading and unloading. Where the engine room is located on ships that have international shipping capabilities, with the classification bureau used is the Lloyd Register.

Given the importance of the existence of equipment in the engine room, it is necessary to pay attention to security and smooth operation by considering and anticipating possibilities that hinder the operation of the engine room. One of the things that need to be considered is efforts to prevent fire hazards that occur due to fuel leaks or drips that can threaten and cause a fire hazard in the engine room. In accordance with [7] which states that "the ship's engine room is equipped with a fixed fire extinguishing system (Fix Extiguishing System)". It is also explained in [4], that every ship must be equipped with a fire extinguishing system to prevent fires, including the ship's engine room.

In this research, the design of a fire extinguishing system pipeline for the engine room of a ship is carried out using Gas Clean Agent Halocarbon HCFC Blend A fire extinguishing media. The choice of this type of extinguishing media is very appropriate, because this media is able to extinguish fires effectively when compared to other extinguishing media. This type of media has a discharge time of 10 seconds [6]. The process of this research included determining the capacity and requirement of extinguishing media, calculating the flow rate of the flooding system, determining the required number of discharge nozzles and designing the piping system. The codes and standards used as references in this research were the Lloyd Register and the NFPA (National Fire Protection Association).

2. METHODOLOGY

2.1 Design Concentration

The minimum design concentration was determined by [6] as the extinguishing concentration or agent concentration needed to extinguish the fire. Following were the provisions for the Minimum design concentration according to
[6]:

a) Minimum design concentration for class A was Minimum Extinguishing Concentration (MEC) class A x 1.2 safety factor.
b) Minimum design concentration for class B was MEC class B x 1.3 safety factor.
c) Minimum design concentration for class C
was MEC class A x 1.35 safety factor.

2.2 Specific Volume

Based on [6] to calculate the specific volume of extinguishing media for Gas Clean Agent Halocarbon HCFC Blend A, it could be calculated using Equation (1).

$$s = 0{,}2413 + 0{,}00088t \quad (1)$$

2.3 Total Flooding Quantity

Based on [6] to calculate the required amount of halocarbon clean agent, it could be calculated using Equation (2).

$$W = \frac{V}{S}\left(\frac{C}{100-C}\right) \quad (2)$$

To determine the estimated number of tubes needed, it could be calculated by Equation (3), namely by dividing the amount of clean agent for the entire system by the actual tube capacity and then rounding up the next integer [2].

$$Number\ of\ cylinders = \frac{Quantity\ of\ clean\ agent\ (kg)}{Cylinder\ capacity\ (kg)} \quad (3)$$

2.4 Flow Rate Flooding System

In [6] it is stated that for a halocarbon clean agent, the discharge time required to reach 95% minimum design concentration with 20% safety factor was no more than 10 seconds. To determine the flow rate, it was done by dividing the weight of the extinguishing media flowing in the pipe by the maximum discharge time, which was 10 seconds. To calculate the flow rate of the flooding system, Equation (4) was used.

$$Q = \frac{W}{t} \quad (4)$$

2.5 Piping System

For gaseous fire extinguishing system piping according to [4], each pipe of this gaseous fire extinguishing system had to be made of galvanized steel or corrosion resistant steel. The minimum thickness of steel pipe for gas fire extinguishing systems can be seen in Table 1. While the diameter of the pipe can be determined based on the flowrate on the pipe, for the flowrate limit could be seen in Table 2.

Table 1 Minimum thickness for steel pipe for gas fire extinguishing system

External diameter D, in mm	Minimum thickness, in mm	
	From bottles to distribution station	From distribution station to nozzles
21,3 - 26,9	3,2	2,6
30 - 48,3	4	3,2
51 - 60,3	4,5	3,6
63,5 - 76,1	5	3,6
82,5 - 88,9	5,6	4
101,6	6,3	4
108 - 114,3	7,1	4,5
127	8	4,5
133 - 139,7	8	5
152,4 - 168,3	8,8	5,6

Table 2 Flowrate limit

Flow Rate Limit :				
Pipe Diameter (in.)	*Minimum Flow Rate*		*Maximum Flow Rate*	
	lb/s	*kg/s*	*lb/s*	*kg/s*
½	1.0	0.5	3.0	1.4
¾	2.0	0.9	5.5	2.5
1	3.5	1.6	8.5	3.9
1 ¼	6.0	2.7	12.5	5.7
1 ½	9.0	4.1	20.0	9.1
2	14.0	6.4	30.0	13.6
2 ½	20.0	9.1	55.0	24.9
3	30.0	13.6	90.0	40.8
4	55.0	24.9	125.0	56.7
5	90.0	40.8	200.0	90.7
6	120.0	54.4	300.0	136.1

2.6 Discharge Nozzle

In determining the number of discharge nozzles used, it was necessary to find the area of the protected room and the discharge nozzle emission protection area used by Equation (5).

$$Number\ of\ Nozzles = \frac{Protected\ area}{Nozzle\ jet} \quad (5)$$

3. RESULTS

3.1 Determination of the Need for Extinguishing

Media

- Design Concentration

The minimum design concentration for clean agents was based on NFPA 2001, the minimum design concentration for classes B was MEC Class B x 1.3 safety factor and the Minimum Extinguishant Concentration HCFC Blend A table for MEC class B was 9.9, so a Design Concentration Class B value of 13 was obtained.

- Specific Volume

Calculation of the specific volume using Equation (1).

s = 0,2413+0,00088t
= 0,2413+0,00088(35)
= 0,2722 m^3/kg

So the specific vapor value was obtained of 0,2722 m^3/kg at a temperature of 35°C.

To determine the need for a clean agent extinguishing media supply, it could be determined by Equation (2).

$$W = \frac{V}{S}\left(\frac{C}{100-C}\right)$$
$$= \frac{2185{,}975\ m^3}{0{,}2722\frac{m^3}{kg}}\left(\frac{13}{100-13}\right)$$
$$= 1126{,}916\ kg$$

So the required extinguishing media supply was 1126,916 kg. Then to determine the number of tubes used could be determined by Equation (3).

$$Number\ of\ cylinders = \frac{Quantity\ of\ clean\ agent\ (kg)}{Cylinder\ capacity\ (kg)}$$
$$= \frac{1126{,}916\ kg}{75\ kg}$$
$$= 15$$

So the results obtained were 15 tubes of clean agent with a size of 75 kg.

3.2 Flowrate Flooding System

It was stated that for clean agent halocarbon, the discharge time required to reach 95% minimum design concentration with 20% safety factor was not more than 10 seconds. To determine the flowrate, Equation (4) was used.

$$Q = \frac{W}{t}$$
$$= \frac{1126{,}916}{10}$$
$$= 112{,}6916\ kg/s$$

So that the value of the flowrate flooding system was obtained, which was 112.6916 kg/s.

3.3 Piping Design

In this design, the pipe material used was galvanized steel pipe. The diameter of the pipe used determined based on the Table 2. For the main pipe flowrate of 14,086 kg/s, a diameter of 3 inches or 80 mm is used. For discharge pipe flowrate of 28,173 kg/s, a diameter of 4 inches or 100 mm was used.For the dividing pipe flowrate of 6,629 kg/s, a diameter of 2 inches or 50 mm was used. For branch pipe flowrate of 2,286 kg/s, a diameter of 1 inch or 25 mm.

3.4 Determination of the Required Number of Discharge Nozzles

The calculation used Equation (5) with the protected engine room area of 495 m^2 and the protected partial deck area of 406,656 m^2 with a nozzle spacing specification of 18.29 m^2.

$$Number\ of\ Nozzles = \frac{901{,}656\ m^2}{18{,}29\ m^2}$$
$$= 49$$

So the total number of discharge nozzles required 49 discharge nozzles.

4. CONCLUSION

Based on the description of the discussion that had been carried out, it c ould be concluded that the fire extinguishing piping system with clean agent halocarbon HCFC Blend A uses galvanized steel pipe material with the size of the pipe used is 4 inches for the discharge pipe, 3 inches for the main pipe, 2 inches inch for the dividing pipe, and 1 inch for the branch pipe. As well as the required number of discharge nozzles of 49 and the required extinguishing media supply requirement of 1126.916 kg, with the required number of tubes of 15 tubes with a capacity of 75 kg, and the flowrate flooding system value is 112.6916 kg/s with a maximum discharge time for 10 seconds.

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