

# **FIRE EXTINGUISHING OF GAS TURBO COMPRESSOR COMPARTMENT BY WATER MIST**

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## **ABSTRACT**

Processes of fire extinguishing of internal volume gas turbo compressor compartment by water mist were investigated. Positive results of fire suppression were received for burn of oil pans and burn of higher pressure oil fluid (heat energy more 1 MWt). One oil pool situated under turbine (pool size 3 m<sup>2</sup>), six oil cups were on the floor and eight oil cups were near and over turbine (cup size 0,06 m<sup>2</sup>).

Tests were conducted in closed and semi-closed compartment. Maximum size for open area was 14 m<sup>2</sup>. The main result of tests is an approval for possibility of using water mist system for fire protection gas turbo compressor compartment.

## **INTRODUCTION**

In compliance with requirement of Russia fire rule (НПБ 110-2003) it seems necessary to protect oil station, compressor and engine compartment with using the automatically fire suppression system.

For successful suppression of fire in encumbered area was designed construction of system, which provided water mist drops to each point of the area. This system was completed from higher pressure cylinders (work pressure 150 bar, capacity 35 dm<sup>3</sup>, mass of water 14 kg in each cylinder). Higher velocity water drops stream was generated by special nozzles.

Typical fire fighter process by water mist is a local method of extinguishing, but we developed special design of system which may be used for total suppression compartments of compressor station. The possible scenarios of the accident may be burning of oil in the pan under of turbine, fire in the closed area under deck and fire dispersed oil spray. Water mist is not use for fire suppression of gas discharge, that free burn down.

Size of engine compartment is 6.0×6.0×4.0 m, turbine mounted on the long axis. Spill of oil and jet of oil generating the spray of droplets represent the main fire danger. Flashpoint for turbine oil is 170-186 °C. Ignition may be start when jet of oil stream hit at the high heated surface of equipment. Size of compressor compartment is 6.0×6.0×4.0 m and border with engine compartment. In the compartment is mounted oil system for compressor with 3000 kg of oil.

The pan for collection of spill is situated under compressor. Oil station of engine is situated near engine compartment and has tank for oil (tankage 0,5m<sup>3</sup>), pipeline, strainer, pump (work pressure 3 bar). Special electrical equipments for heating and lighting of compartment installed here too. Main object of investigation is the determination of intensity and time supply of water mist to compartment. Main design problem is the determination nozzles

occupation. As a safety criteria of successful fire suppression is complete liquidation of flame and absence of reflash.

## INVESTIGATIONS

For development of optimal design of fire suppression water mist system were made real scale tests on the real turbine-compressor container house. As a model of fireplace in engine compartment were used 14 cups, total area  $0.3 \div 0.35 \text{ m}^2$ . Cups were installed on the floor and over of the floor on the heights 0.5, 1.0, 1.5, 2.0 m. For tests as fuel was used a mixture of gas- kerosene (50:50). Total heat energy assigned fireplace were  $\sim 0.35 \text{ MW}$ . Under turbine was occupied pan with area  $3 \text{ m}^2$  and heat energy fireplace  $\sim 3 \text{ MW}$ . Imitation of fire oil jet from depressurizing high pressure pipeline was realized by jet fuel nozzle, work pressure 15-40 bar and heat energy  $1 \div 3 \text{ MW}$ . For registration of system work parameters and process of fire suppression in the space of compartment were installed thermocouples. For investigation of dynamic process of water flow were installed pressure sensors in cylinder and pipeline.

For successful fire suppression in the room with equipment was developed design of water mist system. High velocity water mist drops stream can cover all surface of compartment.

Average water supply intensity for fire suppression was  $4000 \text{ g/m}^2\text{sec}$ , time of this supply less than 4 sec. At the first part of extinguishing process during 2.5 sec formed one-phase water flow in the pipeline by pressure 20 bar. Water drops formed as a result of dynamic atomization water flow in air space. Formed size of drops at this regime are  $100 \text{ }\mu\text{m}$ , velocity of drops are 30-40 m/sec. At this condition forms high kinetic energy stream of drops, which can overcome heat border of fire and suppress flame. At this condition realize local surface process of fire extinguishing open area.

Second part of fire suppression process from 2.5 to 10.0 sec may be classified as a total method fire suppression of low energy deep-seated fire. This process is two-phase flow of water-gas mixture in pipeline and atomization water by pressure 30-35 bar to drops average size  $50 \text{ }\mu\text{m}$  moving with velocity 65-75 m/sec.

For oil reflash prevention from high temperature surface of equipment use durable action of atomization water mist water supply intensity for cooling  $3-4 \text{ g/m}^2\text{sec}$  during 3-4 min.

During the experiment was measured increase of average temperature of volume compartment. At the moment of extinguish by two-phase flow of water-gas mix was fixed process of suppression of fire. At the finish moment of extinguish (10 sec after start) was fixed reduction temperature to 593 K. After cooling process temperature reduce to 330 K.

Generated micro size drops at the time of extinguishing and cooling regime of function exclude deformation of turbine casing as a result of cooling shock.

## CONCLUSIONS

The results of investigation are basic materials for design individual projects placing of nozzles for effective total fire suppression in the compartments of turbo compressor station. Design exposed surface protected by one nozzle  $0,70 \pm 0,15 \text{ m}^2$ . Height of location nozzles over exposed surface must be no more than 2.2 m. Horizontal distance between nozzles must be determine for real design of compartment, but must be more than 0.8 m. Nozzles must be

guidance and fixed in direction to protected surfaces. Strongly prohibit of nozzles placing near turbine casing, less than 1m from turbine surface, and guidance to this surface.

For fire protection of concealed volume should use subsidiary nozzles. Design concealed surface protected by one nozzle is  $0,70 \pm 0,15 \text{ m}^2$ .

On the base of results investigations was developed technical project of water mist fire suppression system for compartment of turbo compressor station which composed of 6 cylinders for extinguishing, pipeline and 42 nozzles. For long cooling compartment use 2 subsidiary cylinders and 2 nozzles. Total load of water which used for successful fire suppression is 84 kg.