HI-FOG® 高压细水雾保护汽车工业

PART 1

应用案例

PART 2

火灾测试
及系统认证

PART 3

系统组件

Mr. Frank Huang 黄自元

客户经理

HI-FOG ®高压细水雾系统，中国大陆

第一部分 应用案例

无情的火灾，惨重的教训

时间：2007年12月4日

地点：西班牙潘普洛纳（Pamplona）大众工厂油漆车间

原因：尚未得到许可，对油漆车间进行改造。期间，关闭CO2系统，以防气体系统动作伤人。因电焊出现明火，导致油漆车间火灾，但因CO2系统关闭，使得油漆车间没有灭火系统保护。

火灾损失：整个油漆车间烧毁，停产1年，直接损失6500万欧元

方案对比/CO2

- 有效降低大型事故损失风险：系统改造、维修等操作时，可不关闭HI-FOG系统
- 对人是安全的，无人员伤害
- 灭火系统时刻处于待命状态
- 不需30秒的延时，发生火灾后，可立即启动HI-FOG系统
- 喷漆室火灾烟气得到净化，大大降低烟气对着火区域和未着火区域的设备损失，也可降低火灾烟气对大气的污染
- 系统维护安全，且费用低
- 可取消气瓶间防火门
- 喷漆车间无需密封

HI-FOG® 在大众的应用

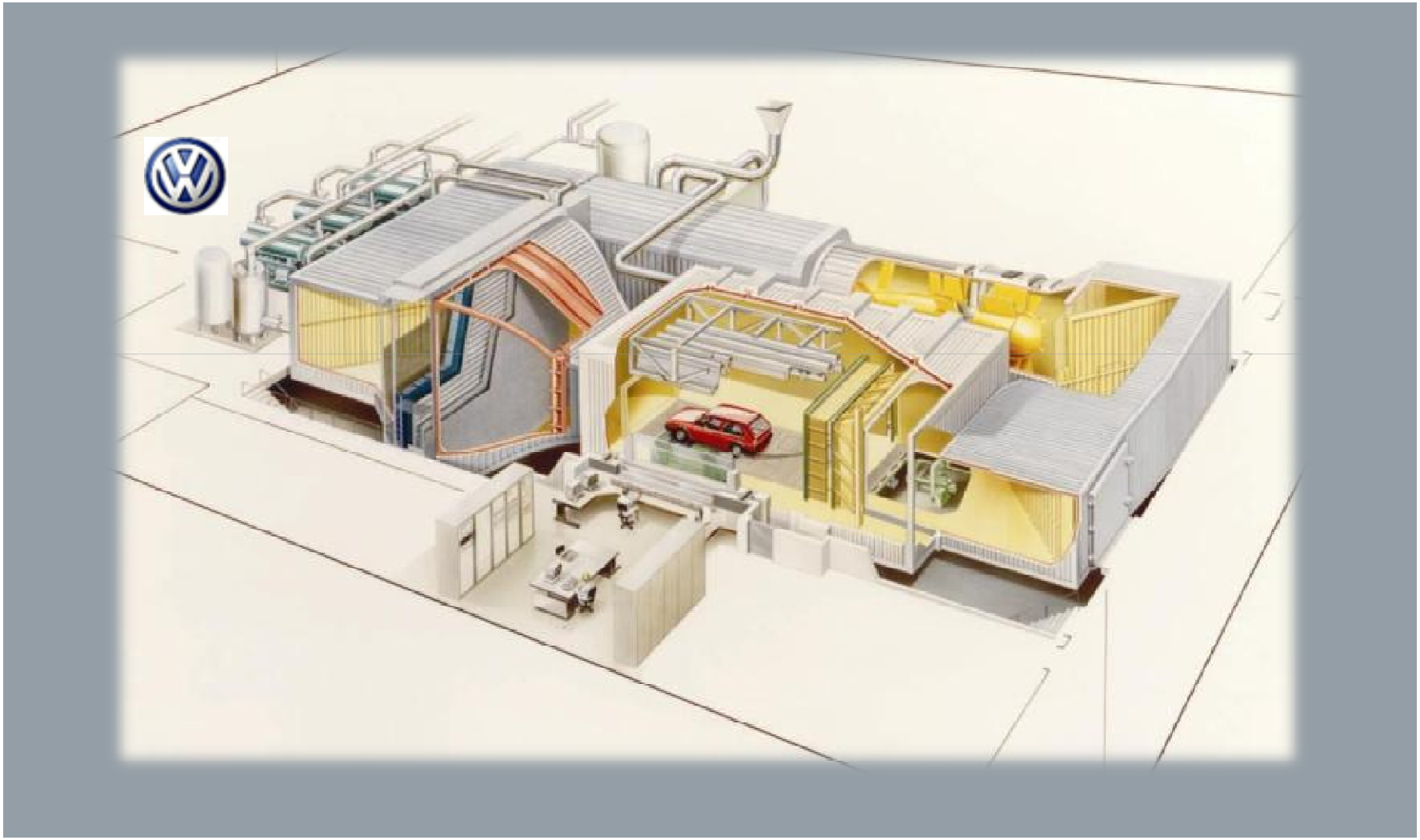
- 南非
- 俄罗斯
- 印度
- 美国
- 德国

大众生产线保护

喷漆生产线

大众汽车发动机测试单元

通风管道和风洞

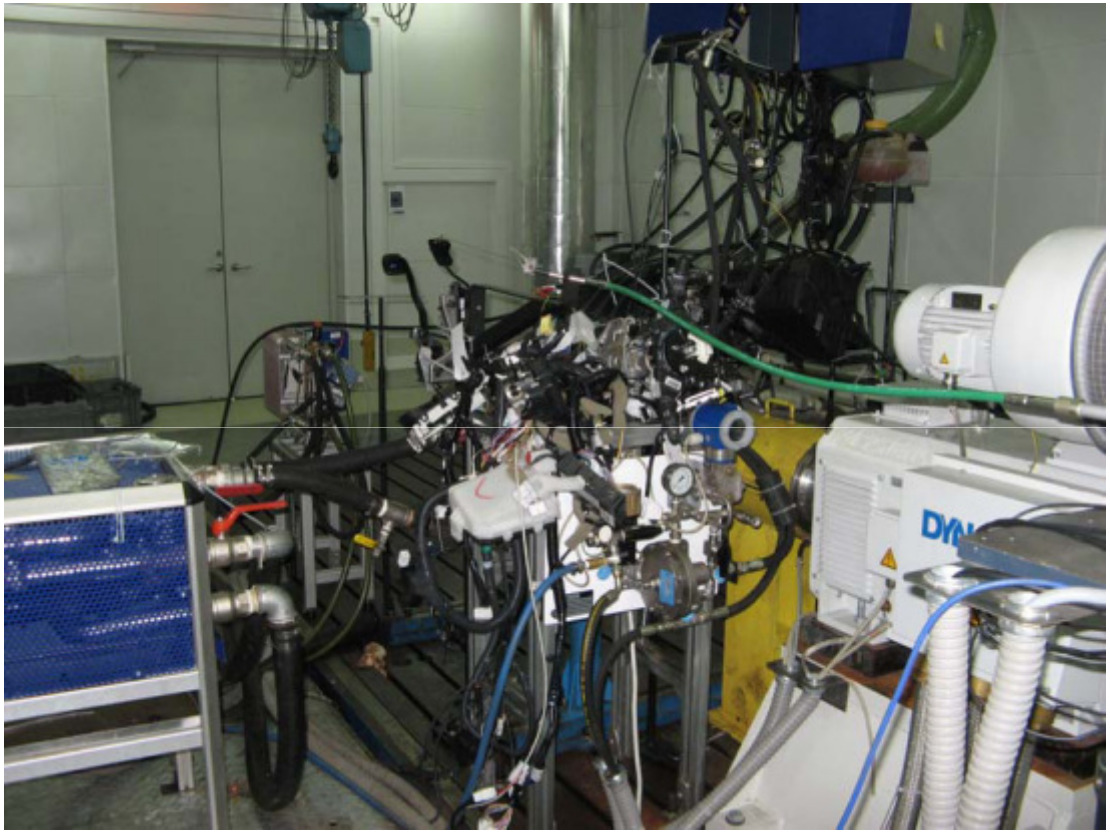


大众喷漆车间

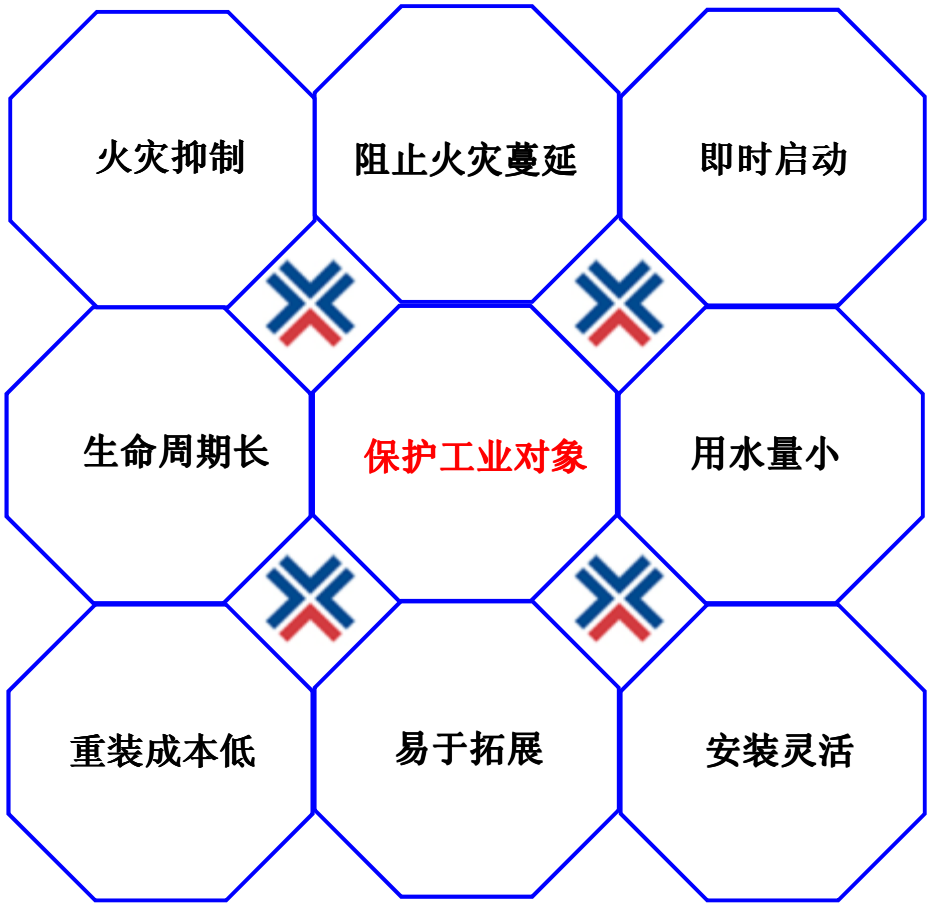
大众喷漆车间

大众喷漆车间

美国通用Pontiac工厂试验室



HI-FOG® 适用于汽车工业对象保护



第二部分
HI-FOG® 火灾实验及系统认证

陆上应用火灾试验标准

Application / Class A	Authority
LH / OH1 (hotels, offices etc)	FM 5560, VdS (CEN)
OH2 (parking garages)	VdS
OH3 (shopping malls)	VdS
Computer room subfloors / raised floors	FM 5560, VdS
Cable tunnels	VdS (CEN)

European hazard classification

LH	certain areas in schools and offices, prisons
OH1	**Data processing(computer room, excluding tape storage)** hospitals, hotels, libraries, restaurants, schools, offices, concrete factories...
OH2	museums, laundries, car parks, bisquit factories, breweries, metal factories…
OH3	paper factories, cable factories, plastic factories, mills, electronics factories…
OH4	theatres, concert halls, cigarette factories, match factories...

陆上应用火灾试验标准

Application / Class B	Authority
Machinery space / compartment protection	FM 5560 (CEN)
Machinery space / local protection	FM 5560
Industrial fryers	FM 5560
Deep-fat fryers	(CEN)
Wet benches	FM 5560

HI-FOG® 火灾试验

海上应用

- Accommodation spaces, public spaces, service areas
- Balconies
- Special category and Ro-Ro spaces
- Deep fat fryers
- Galley and laundry ducts
- Machinery spaces: compartment protection
- Machinery spaces: local application
- Various navy applications

陆上应用：楼宇与建筑

- Light & ordinary hazard 1 occupancies e.g. hotels, offices
- Ordinary hazard 2: parking garages
- Ordinary hazard 3 e.g. archives, shopping malls
- Ordinary hazard 4 e.g. theatres, cinemas
- Prisons
- Computer rooms
- Concealed spaces with cables / cable ducts

陆上应用： 工业与能源

- Gas turbines, machinery spaces and special hazard machinery spaces
- Outdoor transformers
- Industrial oil cookers
- Industrial cable tunnels
- Wet benches
- Fume hoods
- Anechoic rooms

HI-FOG® 火灾试验

陆上应用： 隧道与交通

- Road and railway tunnels
- Climatic test tunnels
- Trains
- Metro escalators

其它

- Window cooling
- Structural protection
- Smoke extraction
- Operational fire fighting

FM

Specification Tested

Certificate of Compliance

Water Mist System

This is to certify that the company indicated below is listed in the FM Approval Guide Specification Tested Products section. The HI-FOG 2000 models C10-57C/0, C11-57C/0, C20-57C/0, C21-57C/0, S10-57C/0, and S20-57C/0 bulb type water mist nozzles were tested in accordance with the standard listed below. See the Marioff Corporation Oy listing in the FM Approval Guide – Fire Protection section for further details.

Marioff Corporation Oy
Virnatie 3
FIN-01301
Vantaa, Finland

FM Approvals confirms that the above nozzles were tested and found to comply with the following standards:

International Maritime Organization (IMO) Resolution A.800(19), "Revised Guidelines for Approval of Sprinkler Systems Equivalent to that Referred to in SOLAS Regulation II-2/12", November 23, 1995, Appendix 1 and 2.

The nozzles must be installed in accordance with the manufacturer's Design, Installation, Operation, and Maintenance Manual, MO/ES/10/DIOM/IMO/00, Revision 1.0, June 2000.

Project Identification: 3011392

Report Date: June 18, 2001

Roger L. Allard, Assistant Vice President
FM Approvals

July 18, 2005
Date

FM Approvals

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APPROVAL REPORT

SPRINKLER PUMP UNIT (SPU) WATER MIST PUMP SYSTEM

Prepared for:

Marioff Corporation Oy
P.O. Box 86
Virnatie 3, FIN-01301
Vantaa, Finland

Project Identifier: 3016381
Class: 5560
Date of Approval: MARCH 23, 2005

Authorized By: Roger L. Allard

Roger L. Allard, Assistant Vice President

FM Approvals
1151 Boston-Providence Turnpike
P.O. Box 9102
Norwood, MA 02062

An FM Global Enterprise

SPRINKLER PUMP UNIT (SPU) WATER MIST PUMP SYSTEM

from

Marioff Corporation Oy
P.O. Box 86
Virnatie 3, FIN-01301
Vantaa, Finland

I INTRODUCTION

1.1 Marioff Corporation Oy requested FM Approvals to examine their Sprinkler Pump Unit (SPU) electric motor driven water mist pump system for use with Approved Marioff water mist systems.

1.2 This Report is limited to the examination of the water mist pump system as described in Section II of this Report.

1.3 **Standards**

Title	Number	Date
Water Mist Systems (Draft)	FM Approvals Class 5560	September 2004
Controllers for Electric Motor and Diesel Engine Driven Fire Pumps	FM Approvals Class 1321	August 2002
Water Mist Fire Protection Systems	NFPA 750	2003
Stationary Pumps For Fire Protection	NFPA 20	2003

1.4 The water mist pump system described in this Report must be installed in accordance with FM Global Property Loss Prevention Data Sheets and the manufacturer's design and installation manual that applies to the water mist system with which it is used and the pump operating and maintenance manual (Document Reference: *SPU Operating and Maintenance Manual* – Document Number P31000FM, 20 January 2005). Deviations from these guidelines shall void the Approval of the system.

1.5 There is no Approval listing associated with this Report. The FM Approval Guide listing for this pump system will appear as part of future Marioff water mist fire suppression system Approvals that utilize this device.

1.6 This Report may be freely reproduced only in its entirety and without modification.

MARIOFF
A UTC Fire & Security Company

HI-FOG MT4全淹没系统保护机械设备间及货船泵房间（V≤3300 m³）

Product SPU/SPUD 31 Aug 2005

火灾试验摘要	HI-FOG MT4全淹没系统保护机械设备间及货船泵房间（V≤3300 m³）
测试标准	IMO MSC/Circ. 1165 *用于保护机械设备间及货船泵房间的水基灭火系统认证导则（修订版）*
概述	针对2200m³和3300m³的发动机室的9种火灾场景，总共进行了24次机械设备间灭火试验和4次温度控制试验。火灾场景包括无遮挡和遮挡的喷雾火、流淌火、油池火和A类火灾及其组合。试验过程中，在允许的15分钟内，所有火均被扑灭，而且温度控制到期望的水平。

结论 HI-FOG MT4高压细水雾系统技术参数见下表，满足SOLAS协会的II-2/10规程对容积不超过3300m3的A类机械设备间和泵房间灭火系统的要求。

最大安装高度（m）	喷头型号	流量系数(lpm/bar$^{1/2}$)
3	4S 1MB 6MB 1000	1.4
5	4S 1MC 8MB 1000	1.9
11	5S 1MC 8MC 1000	3.9

最低工作压力	50bar
安装位置	吊顶
喷射方	垂直向下
最大安装间距	4m
距离保护对象的距离	1.25-4m
最小喷雾强度	0.1 lpm/m²

1. 引言

自1994年10月1日起，哈龙灭火系统禁止在船上应用，为此国际海事组织（IMO）提出了哈龙替代的指导方案。MSC/Circ.1165 火灾试验程序旨在评价SOLAS II-2/10定义的A类机械设备间和货船泵房间的用于替代哈龙的全淹没水基灭火系统的系统性能。

针对2200m³和3300m³的应用空间，按照MSC/Circ.1165标准，总共进行了24次机械设备间灭火试验和4次温度控制试验。

2. 试验布置

试验空间为芬兰Marioff公司最大的试验室，图1和图2为两种不同试验场所及喷头布置示意图。3300m³试验场所为正方形的，平面尺寸为18.5 m x 18.5 m。而2200m³试验场所为矩形的，平面尺寸为12 m x 18.5 m。两种试验场所的最大高度为11 m。在其中一面墙的中间设一个2 m x 2 m 的开口。

火灾模型布置在发动机模型上或旁边，见图和图2。燃料既包括低闪点的庚烷，不仅可模拟汽油火灾，而且其毒性更低；也包括高闪点的轻质柴油火。火灾场景见表1。每次试验过程中，先引燃火灾，预燃试验规定的5s-2min的时间后，手动启动HI-FOG系统。自系统启动15min内扑灭所有火灾且没有复燃，方可通过灭火试验测试。在温度控制试验中，温度必须控制在100℃以下，方可通过温度控制测试。

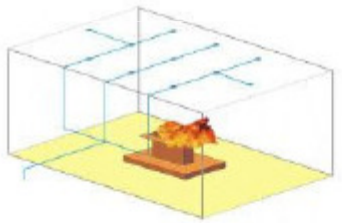


图1. 2200 m³发动机试验空间及火点布置示意图

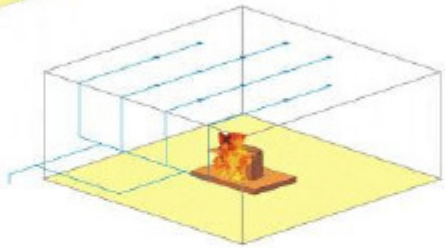


Figure 2.
3300 m3发动机试验空间及火点布置示意图

HI-FOG MT3 systems for protection of combustion turbines, machinery spaces and special hazard machinery spaces with unlimited volumes

Product SPU&NAU

10 Sep 2003

Fire test summary HI-FOG MT3 systems for protection of combustion turbines, machinery spaces and special hazard machinery spaces with unlimited volumes.

Test standard *FMRC Draft performance requirements for fine water spray systems for the protection of combustion turbines, machinery spaces and special hazard machinery spaces with volumes exceeding 9175 ft³ (260 m³).*

Summary Ten machinery space fire extinguishing tests were conducted in a 3300 m³ enclosure according to the Factory Mutual (FM) test protocol. The fire scenarios included both exposed and obstructed spray fires, cascade fires, pool fires and class A fires, and their combinations. Most of the fires are required to be extinguished; suppression is enough for a few of them. The HI-FOG MT3 system extinguished all fires within 14 min. Scaling rules for varying volumes and heights were developed using experimental results measured in three different enclosure volumes.

Conclusions The HI-FOG MT3 fire protection system with the principal installation criteria below was shown to meet the performance requirements set by FMRC for the protection of combustion turbines, machinery spaces and special hazard machinery spaces of large volumes.
For scaling in varying volumes and heights the key parameters are the average water flux density, the nitrogen concentration and its discharge rate.

Spray head configuration	Distribution network	
	Water	Gas
Type	5S 1MC 8MC 1000	4S 300 9MF 10G0
K factor	3,9	24
Max coverage area	22 m²	38 m²
Max coverage volume	206 m³	370 m³
Max ceiling height	11 m	

Operating parameters	
Min water pressure	70/13 bar
Average water flux density	0,12 lpm/m³
Gas cylinder type	N_2 / 50 l / 200 bar
Number of Gas cylinders	3.36 V [100 m3] - 10.8 (V = enclosure volume)

1. Introduction

Factory Mutual Research Corporation has provided a fire test protocol for evaluating the performance of fine water sprays against fires representative to combustion turbines, machinery spaces, and special hazard machinery spaces. The test procedures are almost identical to those of the document MSC/Circ.668/728 by the International Maritime Organization (IMO).

Machinery spaces include such hazards as auxiliary turbine rooms, oil pumps, oil reservoirs, fuel filters, gear boxes, drive shafts, lubrication skids, and diesel engine rooms. Special hazard machinery spaces include occupancies such as internal combustion engine test cells and machinery spaces with incidental use, or storage, of flammable liquids with volatilities similar to those of n-heptane.

Ten fire extinguishing tests in accordance with the FM procedures were conducted.

2. Test arrangement

The test enclosure was formed by the large test facility of Marioff Corporation Oy at Virkkala, Finland. Figure 1 shows a schematic view of the test enclosure. The square-shaped enclosure had an 18,5 m x 18,5 m flat floor and a maximum height of 11 m equalling a total volume of 3300 m³. A 2 m x 2 m opening was constructed at the middle of one of the walls.

Test fires were arranged at and on the engine mock-up as indicated in Figure 1. The fuel used was either low flash point heptane, which resembles regular gasoline except for its lower toxicity, or high flash point light diesel oil. The fire scenarios together with the relevant acceptance criteria are summarised in Table I. In each test the fire was first ignited and after a preburn time of 5 s – 2 min the HI-FOG system was manually activated. The test was run for 15 min after activating the HI-FOG system.

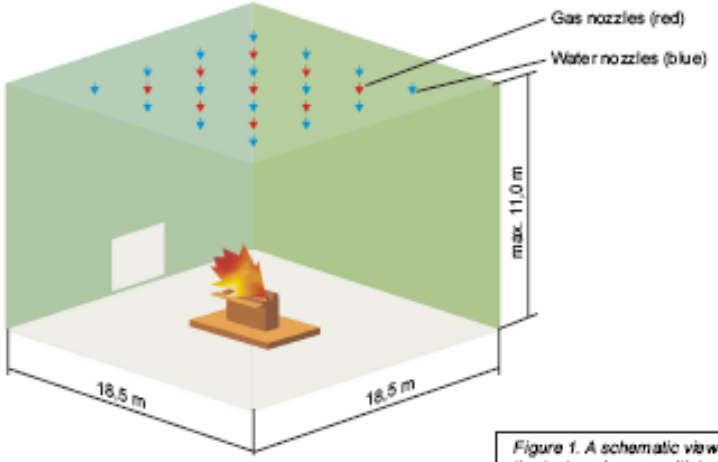


Figure 1. A schematic view of the test enclosures with test engine mock-up (Test #2).

Test	Fire scenario	Test fuel	Heat release rate (MW)	Requirement
1	Low pressure horizontal spray on top of the engine	Diesel oil	6	Extinguishment
2	Low pressure spray on top of the engine aligned 45° upward striking a 12-15 mm diameter rod	Diesel oil	6	Extinguishment
3	Low pressure concealed horizontal spray fire on one side of the engine	Diesel oil	6	Extinguishment
4	High pressure horizontal spray fire on top of the engine	Diesel oil	2	Extinguishment
5	Low pressure, low flow concealed spray fire + 0.1 m² pool fire on the side of the engine	Diesel oil	1	Spray extinguish. Pool: suppress.
6	Concealed heptane pool (0,81 m²) fire	Heptane	2,4	Suppression
7	Flowing fire (0.25 kg/s) from the top of the engine	Heptane	28	Extinguishment
8	A wood crib in a 2 m² pool fire on the side of the engine	Heptane	7,5	Extinguishment
Opt1	A 0.1 m² diesel fuel saturated insulation mat ignited under a spray fire	Diesel oil	<1	Spray extinguish. Pool: suppress.
Opt2	A burning 1 m² diesel fuel saturated insulation mat on the side of the simulated engine	Diesel oil	<1	Suppression

Table 1. The test scenarios

3. HI-FOG system

The HI-FOG MT3 system discharges both water mist and nitrogen. The system consists of two separate pipeworks, one for plain water and one for plain gas. All the nozzles are to be mounted in the ceiling level or other overhead locations, pointing downward. The objective is to have a homogeneous mixture of water mist and gas throughout the space.

Proper mixing in the 3300 m³, 11 m high enclosure, was achieved by dividing the water line into two zones that were operated at different pressures. A pressure unbalance was hence created in the enclosure, which ensured the best possible distribution of the mist droplets. Both zones were equipped with 8 spray heads of type 5S 1MC 8MC 1000, and the pressure in the zones was alternated periodically so that one line was always operated at a low pressure (13 bar) and the other one at a high pressure (70 bar). The gas line was operated with up to 100 N_2 cylinders and nine spray heads of type 4S 300 9MF 10G0. The full test set-up is shown in Figure 2. Pressure curves measured during a full discharge are shown in Figure 3.

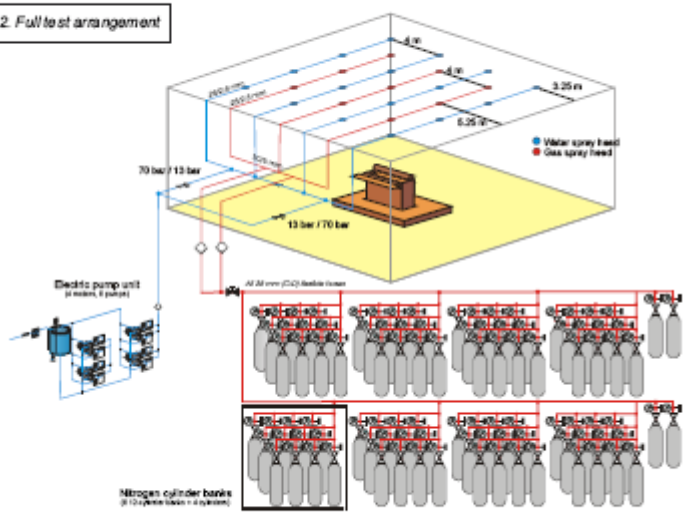
The plain water line is capable of extinguishing all the big fires (relative to the enclosure size) and in any case it provides cooling for the enclosure and protects the equipment and structure. In the present tests the plain water discharge extinguished the test fires #1 - #4 and Opt 2. The maximum number of gas cylinders was applied in tests #5 - #7 and Opt 1. In test #7 the full gas capacity was used only for safety reasons, to suppress the huge heptane fire instantaneously, prior to complete extinguishment.

Scaling rules to any volumes, based on experimental results in three different volumes and theoretical approach, were generated. The rules are based on plain and simple physical facts of inerting the enclosure atmosphere by water vapour and nitrogen, the relative weight of water vapour being higher in smaller enclosures and approaching a constant, low concentration in larger enclosures. Consequently, the required nitrogen concentration increases with increasing volume. In small volumes, less than some 350 m³, no nitrogen is needed. In large volumes the oxygen concentration due to nitrogen discharge approaches 16 vol-%, which does not pose any danger to people. The installation guidelines for varying volumes and heights are not the subject of the present summary.

4. Results

All the tests were passed: the fires were extinguished in less than 14 min after starting the suppression and no re-ignition occurred. Extinguishment was achieved also in the cases where suppression would have been enough for an acceptable performance.

Figure 2. Full test arrangement



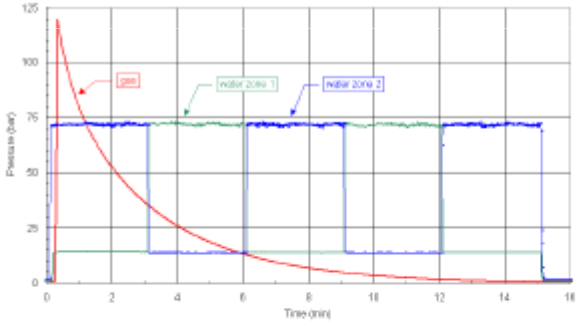


Figure 3. Pressure curves for a full system discharge

NOTE: The tests described form the basis for the FM type approval application.

A complete description of the tests and their results are given in the Test Report No. RTE584/02, VTT Building and Transport, May 2002

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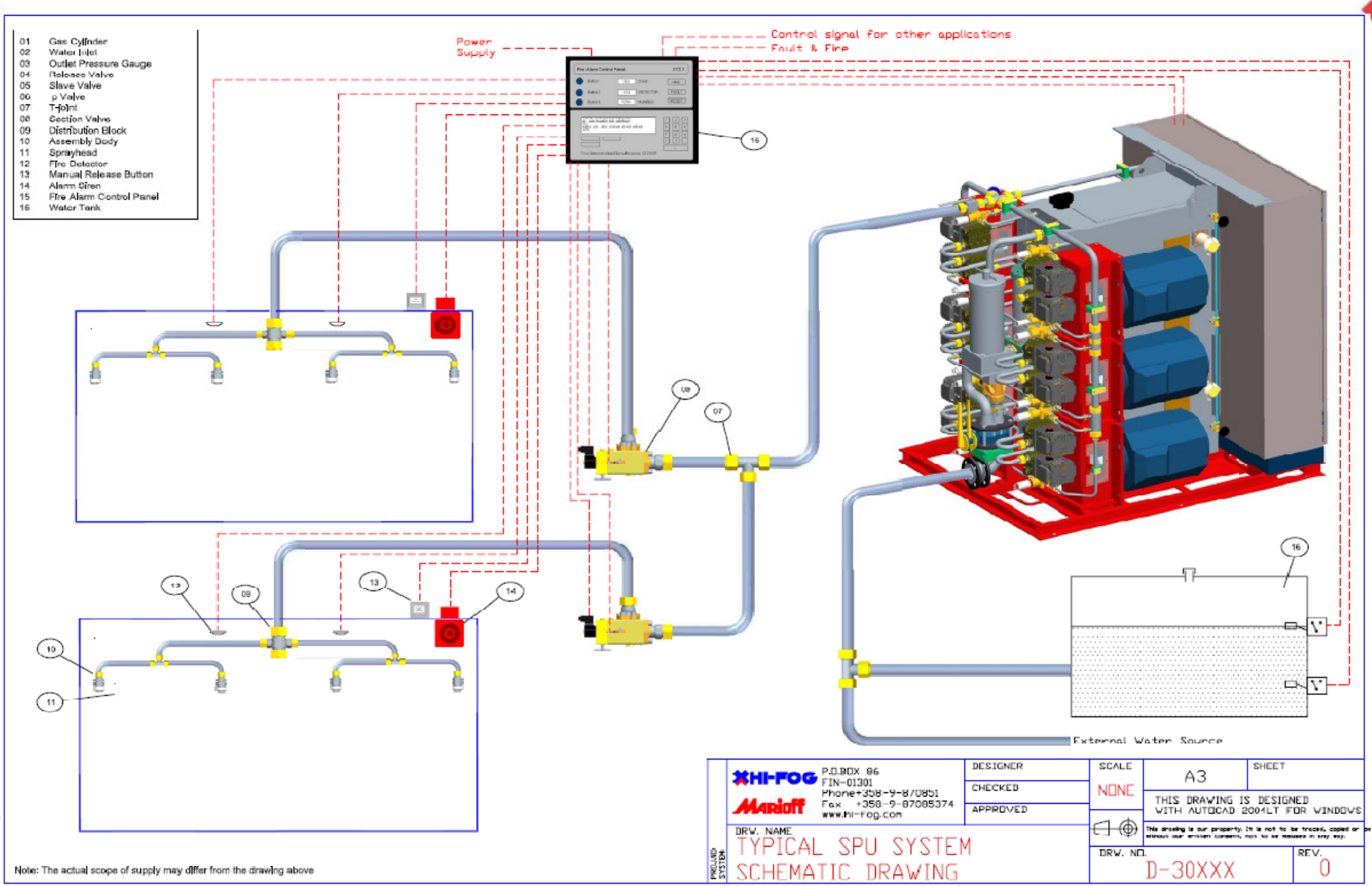
第三部分

HI-FOG® 高压细水雾系统组件

HI-FOG® SPU系统构成



HI-FOG® 系统组件

电动泵组单元

- 外界供水和供电
- 模块化设计
- 保护时间无限制
- 连续稳定供水
- 供水压力达140 bar
- Marioff设计和装配

HI-FOG® 系统组件

阀门

手动和远程控制

流量和/或压力开关

- 湿式
- 预作用
- 开式
- ……

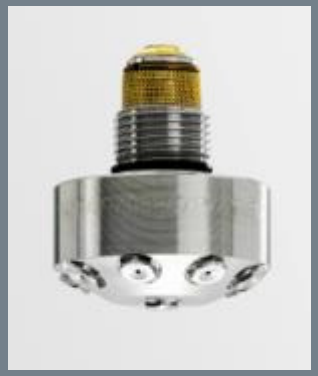
HI-FOG® 系统组件

HI-FOG® 1000-series sprinkler

HI-FOG® 1000-series sprinkler

HI-FOG® 1000-series sprinkler

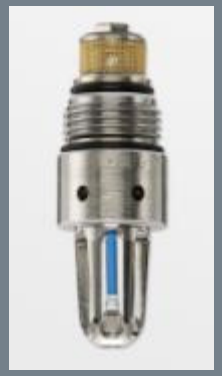
HI-FOG® 1000-series spray head



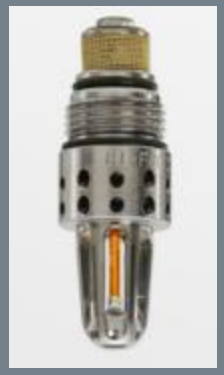
HI-FOG® 1000-series spray head

HI-FOG® pop-up spray head for aircraft hangars

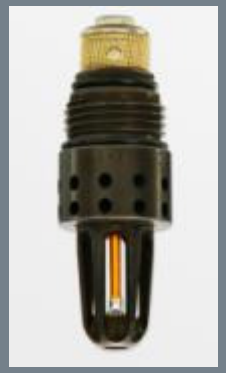
HI-FOG® 系统组件



HI-FOG® 2000-series sprinkler

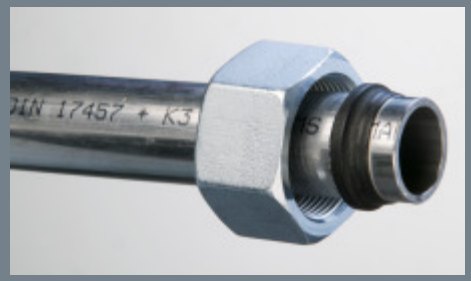


HI-FOG® 2000-series sprinkler



HI-FOG® 2000-series sprinkler antique finish

High-quality stainless steel tubing



High-quality fittings, no welding on-site


THANK YOU
Marioff
HI-FOG®