MSC/Circ.373/Res.1
10 May 1988

REVISED STANDARDS FOR THE DESIGN, TESTING AND LOCATING OF DEVICES TO PREVENT THE PASSAGE OF FLAME INTO CARGO TANKS IN OIL TANKERS

1 INTRODUCTION

1.1 Purpose

The 1981 and the 1983 Amendments to the International Convention for the Safety of Life at Sea, 1974 (SOLAS) include revised requirements for fire safety measurements for tankers. Regulations II-2/59 of these amendments contains provisions concerning venting, purging, gas-freeing and ventilation. Regulation II-2/59.1.5 states:

"The venting system shall be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of these devices shall comply with the requirements established by the Administration which shall contain at least the standards adopted by the Organization."

1.2 Application

1.2.1 These Standards are intended to cover the design, testing, locating and maintenance of "devices to prevent the passage of flame into cargo tanks" (hereafter called devices) of tankers and combination carriers carrying crude oil and petroleum products having a flashpoint of 60 degrees C (closed cup) or less, and a Reid vapour pressure below atmospheric pressure and other products having a similar fire hazard.

1.2.2 Oil tankers and combination carriers fitted with an inert gas system in accordance with Reg. 62 shall be fitted with devices which comply with these standards, except that the tests specified in 3.2.3 and 3.3.3.2 are not required. Such devices are only to be fitted at openings unless they are tested in accordance with 3.4.

1.2.3 These standards are intended for devices protecting cargo tanks containing crude oil, petroleum product, and flammable chemicals. In the case of the carriage of chemicals, the test media referred to in section 3 can be used. However devices for chemical tankers dedicated to the carriage of products with MESG * less than 0.9 mm should be tested with appropriate media.

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* Reference is made to IEC Publication 79-1.

1.2.4 Devices shall be tested and located in accordance with these Standards.

1.2.5 Devices are installed to protect:

.1 openings designed to relieve pressure or vacuum caused by thermal variations (Reg.II-2/59.1.2.1);

.2 openings designed to relieve pressure or vacuum during cargo loading, ballasting or during discharging (Reg.II-2/59.1.2.2);

.3 openings designed for gas-freeing as described in the proposed regulation II-2/59.2.2.3 (see appendix 1).

1.2.6 Devices shall not be capable of being by-passed or blocked open unless they are tested in the by-passed or blocked open position in accordance with Section 3.

1.2.7 These standards do not include the consideration of sources of ignition such as lightning discharges since insufficient information is available to formulate equipment recommendations. All cargo handling, tank cleaning and ballasting operations shall be suspended on the approach of an electrical storm.

1.2.8 These standards are not intended to deal with the possibility of the passage of flame from one cargo tank to another on tankers with common venting systems.

1.2.9 When outlet openings of gas-freeing systems on tankers not fitted with inert gas systems are required to be protected with devices, they shall comply with these Standards except that the tests specified in 3.2.3 and 3.3.3.2 are not required.

1.2.10 Certain of the tests prescribed in section 3 of these Standards are potentially hazardous, but no attempt is made in this circular to specify safety requirements for these tests.

1.3 Definitions

For the purpose of these Standards, the following definitions are applicable.

1.3.1 "Flame arrester" is a device to prevent the passage of flame in accordance with a specified performance standard. Its flame arresting element is based on the principle of quenching.

1.3.2 "Flame screen" is a device utilizing wire mesh to prevent the passage of unconfined flames in accordance with a specified performance standard.

1.3.3 "Flame speed" is the speed at which a flame propagates along a pipe or other system.

1.3.4 "Flash back" is the transmission of a flame through a device.

1.3.5 "High velocity vent" is a device to prevent the passage of flame consisting of a mechanical valve which adjusts the opening available for flow in accordance with the pressure at the inlet of the valve in such a way the efflux velocity cannot be less than 30 m/s.

1.3.6 "Pressure/vacuum valve" * is a device designed to maintain pressure and vacuum in a closed container within preset limits.

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* Pressure/vacuum valves are devices to prevent the passage of flame when designed and tested in accordance with these Standards.

2 STANDARDS

2.1 Principles

2.1.1 Depending on their service and location devices are required to protect against the propagation of:

.1 moving flames; and/or
.2 stationary flames from pre-mixed gases;
after ignition of gases resulting from any cause.

2.1.2 When flammable gases from outlets ignite, the following four situations may occur:
.1 At low gas velocities the flame may:
.1 flash back; or
.2 stabilise itself as if the outlet were a burner.
.2 At high velocities the flame may:
.1 burn at a distance above the outlet; or
.2 be blown out.

2.1.3 In order to prevent the passage of flame into a cargo tank, devices must be capable of performing one or more of the following functions:
.1 permitting the gas to pass through passages without flashback and without ignition of the gases on the protected side when the device is subjected to heating for a specified period;
.2 maintaining an efflux velocity in excess of the flame speed for the gas, irrespective of the geometric configuration of the device and without the ignition of gases on the protected side when the device is subjected to heating for a specified period; and
.3 preventing an influx of flame when conditions of vacuum occur within the cargo tanks.

2.2 Mechanical Design Standards

2.2.1 The casing or housing of devices shall meet similar standards of strength, heat resistance and corrosion resistance as the pipe to which they are attached.

2.2.2 The design of devices shall allow for ease of inspection and removal of internal elements for replacement, cleaning or repair.

2.2.3 All flat joints of the housing shall be machined true and shall provide for a joint having an adequate metal-to-metal contact.

2.2.4 Flame arrester elements shall fit in the housing in such a way that flame cannot pass between the element and the housing.

2.2.5 The clear area through flame arresters shall be at least 1.5 times the cross-sectional area of the vent line.

2.2.6 Resilient seals may be installed only if their design is such that if the seals are partially or completely damaged or burned, the device is still capable of effectively preventing the passage of flame.

2.2.7 Devices shall allow for efficient drainage of moisture without impairing their efficiency to prevent the passage of flame.

2.2.8 The casing and element and gasket materials shall be capable of withstanding the highest pressure and temperature to which the device may be exposed under both normal and specified fire test conditions.

2.2.9 End-of-line devices shall be so constructed as to direct the efflux vertically upwards.

2.2.10 Fastenings essential to the operation of the device, i.e. screws, etc., shall be protected against loosening.

2.2.11 Means shall be provided to check that any valve lifts easily without remaining in the open position.

2.2.12 Devices in which the flame arresting effect is achieved by the valve function and which are not equipped with the flame arrester elements (e.g. high velocity valves) must have a width of the contact area of the valve seat of at least 5 mm.

2.2.13 Devices shall be resistant to corrosion in accordance with 3.5.1.

2.2.14 Elements, gaskets and seals shall be of material resistant to both seawater and the cargoes carried.

2.2.15 The casing or housing shall be capable of passing a hydrostatic pressure test as required in 3.5.2.

2.2.16 In-line devices shall be able to withstand without damage or permanent deformation the internal pressure resulting from detonation when tested in accordance with Section 3.4.

2.2.17 A flame arrester element shall be designed to ensure quality control of manufacture to meet the characteristics of the prototype tested in accordance with these standards.

2.3 Performance Standards

2.3.1 Devices shall be tested in accordance with 3.5 and thereafter shown to meet the test requirements of 3.2 to 3.4 as appropriate.

2.3.2 Performance characteristics such as flow rates under both positive and negative pressure, operating sensitivity, flow resistance and velocity shall be demonstrated by appropriate tests.

2.3.3 Devices shall be designed and constructed to minimize the effect of fouling under normal operation conditions. Instructions on how to determine when cleaning is required and the method of cleaning shall be provided for each device in the manufacturers' instruction manual.

2.3.4 Devices shall be capable of operating in freezing conditions and if any device is provided with heating arrangements so that its surface temperature exceeds 85 degrees C then it shall be tested at the highest operating temperature.

2.3.5 Devices based upon maintaining a minimum velocity shall be capable of opening in such a way that a velocity of 30 m/s is immediately initiated, maintaining an efflux velocity of at least 30 m/s at all flow rates and when the gas flow is interrupted, be capable of closing in such a way that this minimum velocity is maintained until the valve is fully closed.

2.4 Flame Screens

2.4.1 Flame screens shall be:

.1 designed in such a manner that they cannot be inserted improperly in the opening;

.2 securely fitted in openings so that flames cannot circumvent the screen; and

.3 able to meet the requirements of these standards, except that the test specified in 3.2.3 need not be complied with. 2.5 Sizing, location and installation of devices

2.5.1 For determining the size of devices to avoid inadmissible pressure or vacuum in cargo tanks during loading or discharging calculation of pressure losses shall be carried out. The following parameters shall be taken into account:

.1 loading/discharge rates;

.2 gas evolution;

.3 pressure loss across devices, taking into account the resistance coefficient;

.4 pressure loss in the vent piping system;

.5 pressure at which the vent opens if a high velocity valve is used; and

.6 density of the saturated vapour/air mixture

2.5.2 Devices shall be located at the outlets to atmosphere unless tested and approved for in-line installation. Devices for in-line installation may not be fitted at the outlets to atmosphere unless they have also been tested and approved for that position.

2.5.3 Except as may be permitted in 1.2.2, flame screens referred to in 2.4 shall be fitted only at vacuum inlets through which vapours cannot be vented to atmosphere. Flame screens shall be protected against mechanical damage.

2.5.4 Where end-of-line devices are fitted with cowls, weather hoods and deflectors, etc., these attachments shall be fitted for the tests described in section 3.2.

2.5.5 Where detonation flame arresters are installed, as in-line devices venting to atmosphere, they should be located at a sufficient distance from the open end of the pipeline so as to preclude the possibility of a stationary flame resting on the arrester.

2.5.6 When venting to atmosphere is not performed through an end-of-line device according to 2.5.4, or a detonation flame arrester according to 2.5.5, the in-line device has to be specifically tested with the inclusion of all pipes, tees, bends, cowls, weather hoods, etc., which may be fitted between the device and atmosphere. The testing shall consist of the flashback test of 3.2.2 and, if for the given installation it is possible for a stationary flame to rest on the device, the testing shall also include the endurance burning test of 3.2.3.

2.5.7 Means shall be provided to enable personnel to reach devices situated more than 2 m above deck to facilitate maintenance, repair and inspection.

3 TYPE TEST PROCEDURES

3.1 Principles

3.1.1 Tests shall be conducted by a laboratory acceptable to the Administration.

3.1.2 Only one device shall be submitted for each type test programme. Such a device

shall have the same dimensions and most unfavourable clearances expected in the production model.

3.1.3 Tests described in this Section using gasoline vapours (a non-leaded petroleum distillate consisting essentially of aliphatic hydrocarbon compounds with a boiling range approximately 65 degrees C /75 degrees C), technical hexane vapours, or technical propane, as appropriate, and referred to in this section are suitable for all devices protecting tanks containing a flammable atmosphere of the cargoes referred to in 1.2.1. This does not preclude the use of gasoline vapours or technical hexane vapours for all tests referred to in this Section.

3.2 Test procedures for flame arresters located at openings to the atmosphere

3.2.1 The test ring shall consist of an apparatus producing an explosive mixture, a small tank with a diaphragm, a flanged prototype of the flame arrester, a plastic bag *1) and a firing source in three positions (see Appendix 2).*2) Other test rigs may be used, provided the tests referred to in this section are achieved to the satisfaction of the Administration.

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*1) The dimensions of the plastic bag are dependent on those of the flame arrester, but for the flame arresters normally used on tankers the plastic bag may have a circumference of 2 m and a length of 2.5 m and the wall thickness of 0.05 mm.

*2) In order to avoid remnants of the plastic bag from falling back on to the device being tested after ignition of the fuel/air mixture, it may be useful to mount a coarse wire frame across the device within the plastic bag. The frame should be so constructed as not to interfere with the test result.

3.2.2 A flash-back test shall be carried out as follows:

.1 The tank, flame arrester assembly and the plastic bag *1) enveloping the prototype flame arrester shall be filled with the most easily ignitable propane/air mixture *3). The concentration of the mixture should be verified by appropriate testing of the gas composition in the plastic bag. Where devices referred to in 2.5.6 are tested, the plastic bag shall be fitted at the outlet to atmosphere. Three ignition sources shall be installed along the axis of the bag, one close to the flame arrester, another as far away as possible therefrom, and the third at the midpoint between these two. These three sources shall be fired in succession, one during each of the three tests.

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*1) The dimensions of the plastic bag are dependent on those of the flame arrester, but for the flame arresters normally used on tankers the plastic bag may have a circumference of 2 m and a length of 2.5 m and the wall thickness of 0.05 mm.

*3) Reference is made to IEC-Publication 79-1.

.2 If a flash-back occurs, the tank diaphragm will burst and this will be audible and visible to the operator by the emission of a flame. Flame, heat and pressure sensors may be used as an alternative to a bursting diaphragm.

3.2.3 An endurance burning test shall be carried out in addition to the flashback test, for flame arresters at outlets where flows of explosive vapour are foreseeable:

.1 The test rig as referred to in 3.2.1 may be used, without the plastic bag. The flame attester shall be so installed that the mixture emission is vertical. In this position the mixture shall be ignited. Where devices referred to in 2.5.6 are tested, the flame arrester shall be so installed as to reflect its final orientation.

.2 Endurance burning shall be achieved by using the most easily ignitable gasoline vapour/air mixture or the most easily ignitable technical hexane vapour/air mixture

with the aid of a pilot flame or a spark igniter at the outlet. By varying the proportions of the flammable mixture and the flow rate, the arrester shall be heated until the highest obtainable temperature on the cargo tank side of the arrester is reached. The highest obtainable temperature may be considered to have been reached when the rate of rise of temperature does not exceed 0.5 degrees C per minute over a ten minute period. This temperature shall be maintained for a period of ten minutes, after which the flow shall be stopped and the conditions observed. If difficulty arises in establishing thermal stability, the following criteria shall apply. When the temperature has reached the apparent maximum, using the most severe conditions of flammable mixtures and flow rate, but increases at a rate in excess of 0.5 degrees C per minute over a ten minute period, endurance burning shall be continued for a period of two hours from the time the most severe apparent conditions have been established, after which the flow shall be stopped and the conditions observed. Flashback shall not occur during this test.

3.3 Test procedures for high velocity vents

3.3.1 The test rig shall be capable of producing the required volume flow rate. In appendices 3 and 4 drawings of suitable test rigs are shown. Other test rigs may be used provided the tests are achieved to the satisfaction of the Administration.

3.3.2 A flow condition test shall be carried out with high velocity vents using compressed air or gas at agreed flow rates.

The following shall be recorded:

.1 The flow rate. Where air or a gas other than vapours of cargoes with which the vent is to be used is employed in the test, the flow rates achieved shall be corrected to reflect the vapour density of such cargoes.

.2 The pressure before the vent opens. The pressure in the test tank on which the device is located shall not rise at a rate greater than 0.01 N/mm**2/min.

.3 The pressure at which the vent opens.

.4 The pressure at which the vent closes.

.5 The efflux velocity at the outlet which shall not be less than 30 m/s at any time when the valve is open.

3.3.3 The following fire safety tests shall be conducted using a mixture of gasoline vapour and air or technical hexane vapour and air, which produces the most easily ignitable mixture at the point of ignition. This mixture shall be ignited with the aid of a permanent pilot flame or a spark igniter at the outlet:

.1 Flashback tests in which propane may be used instead of gasoline or hexane shall be carried out with the vent in the upright position and then inclined at 10 degrees from the vertical. For some vent deigns further tests with the vent inclined in more than one direction may be necessary. In each of these tests the flow shall be reduced until the vent closes and the flame is extinguished, and each shall be carried out for at least 50 times. The vacuum side of combined valves shall be tested in accordance with 3.2.2 with the vacuum valve maintained in the open position for the duration of this test, in order to test the efficiency of the device which must be fitted.

.2 An endurance burning test as described in 3.2.3 shall be carried out. Following this test the main flame shall be extinguished and then, with the pilot flame burning or the spark igniter discharging, small quantities of the most easily ignitable mixture shall be allowed to escape for a period of ten minutes, during

which time flashback shall not occur. For the purposes of this test the soft seals or seats shall be removed.

3.4 Test rig and test procedures for detonation flame arresters located in-line

3.4.1 A flame arrester shall be installed at one end of a pipe of suitable length and of the same diameter as the flange of the flame arrester. On the exposed flange a plastic bag *1) shall be affixed. The pipe shall be filled with the most easily ignitable mixture of propane and air, which shall then be ignited. The velocity of the flame near the flame arrester shall be measured and shall have a value of that for stable detonations.

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*1) The dimensions shall be at least 4 m circumference, 4 m length and material wall thickness of 0.05 mm.

3.4.2 Three detonation tests shall be conducted and no flashback shall occur through the device and no part of the flame arrester shall be damaged or show permanent deformation.

3.4.3 Other test rigs may be used provided the tests are achieved to the satisfaction of the Administration. A drawing of the test rig is shown in Appendix 5.

3.5 Operational test procedures

3.5.1 A corrosion test shall be carried out. In this test a complete device including a section of the pipe to which it is fitted shall be exposed to a 20 per cent sodium chloride solution spray at a temperature of 25 degrees C for a period of 240 hours, and allowed to dry for 48 hours. An equivalent test may be used to the satisfaction of the Administration. Following this test all movable parts shall operate properly and there shall be no corrosion deposits which cannot be washed off.

3.5.2 A hydraulic pressure test shall be carried out in the casing or housing of a simple device, in accordance with 2.2.1.

4 MISCELLANEOUS

4.1 Marking of device

Each device shall be permanently marked, or have a permanently fixed tag made of stainless steel or other corrosion-resistant material, to indicate:

.1 manufacturer's name or trade mark;
.2 style, type, model, or other manufacturer's designation for the device;
.3 size of the outlet for which the device is approved;
.4 approved location for installation including maximum or minimum length of pipe if any between the device and the atmosphere;
.5 direction of flow through the device; and
.6 indication of the test laboratory and report number.
.7 compliance with the requirements of MSC/Circ.373/Rev.1.

4.2 Laboratory report

4.2.1 The laboratory report shall include:

.1 detailed drawings of the device;
.2 types of tests conducted. Where in-line devices are tested, this information should include the maximum pressures and velocities observed in the test;

.3 specific advice on approved attachments;
.4 types of cargo for which the device is approved;
.5 drawings of the test rig;
.6 in the case of high velocity vent, the pressures at which the device opens and closes and the efflux velocity; and
.7 all the information marked on the device in 4.1.

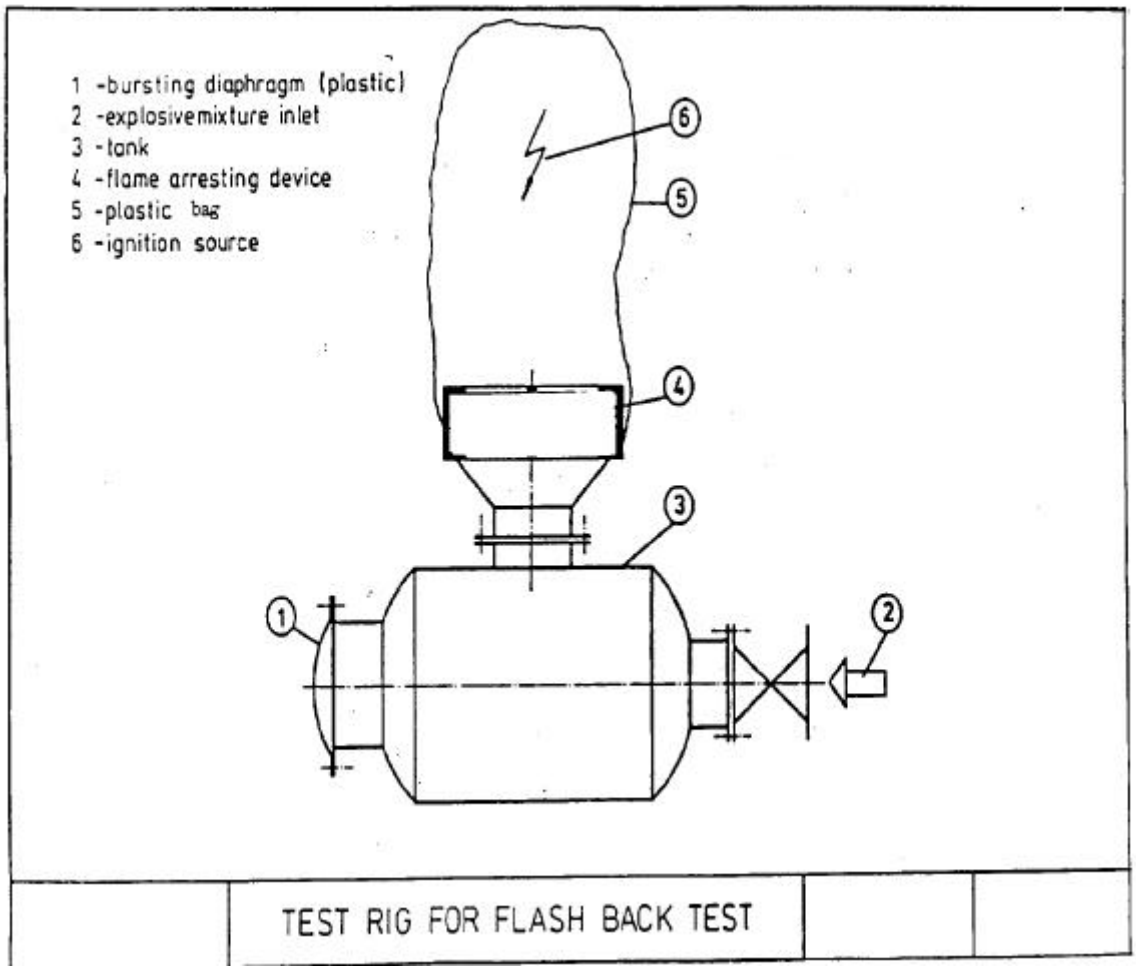
4.3 Manufacturer's instruction manual

4.3.1 The manufacturer shall supply a copy of the instruction manual, which shall be kept on board the tanker and which shall include:

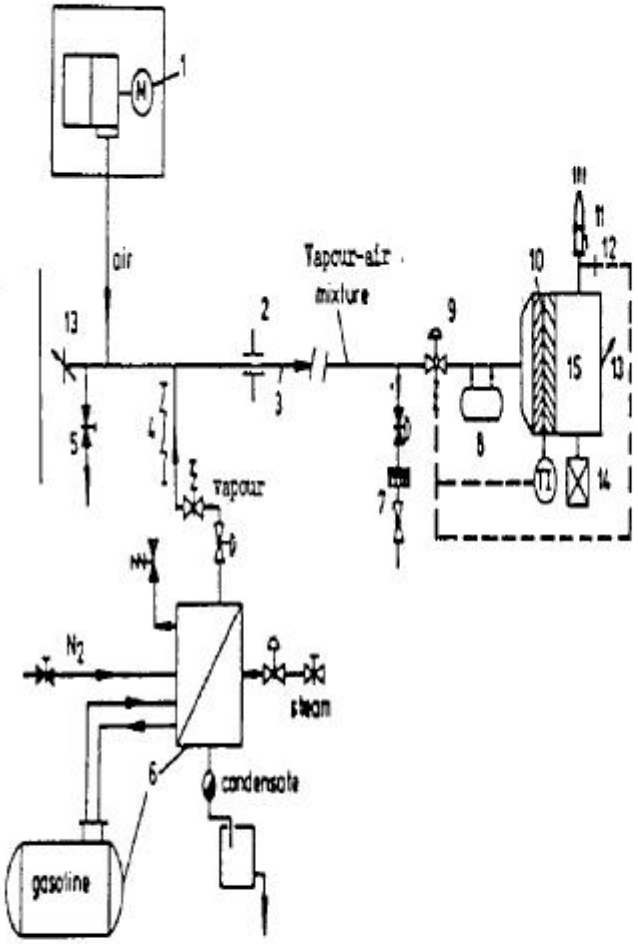
.1 installation instructions;
.2 operating instructions;
.3 maintenance requirements including cleaning (See 2.3.3);
.4 copy of the laboratory report referred to in 4.2; and
.5 flow test data, including flow rates under both positive and negative pressures, operating sensitivity, flow resistance and velocity, shall be provided.

APPENDIX 1 - PROPOSED AMENDMENTS TO REGULATION II-2/59

APPENDIX 2 - Test rig for flash back test



APPENDIX 3 - Schematic Plan of the Test Plant for High Velocity Valves (endurance burning test only)

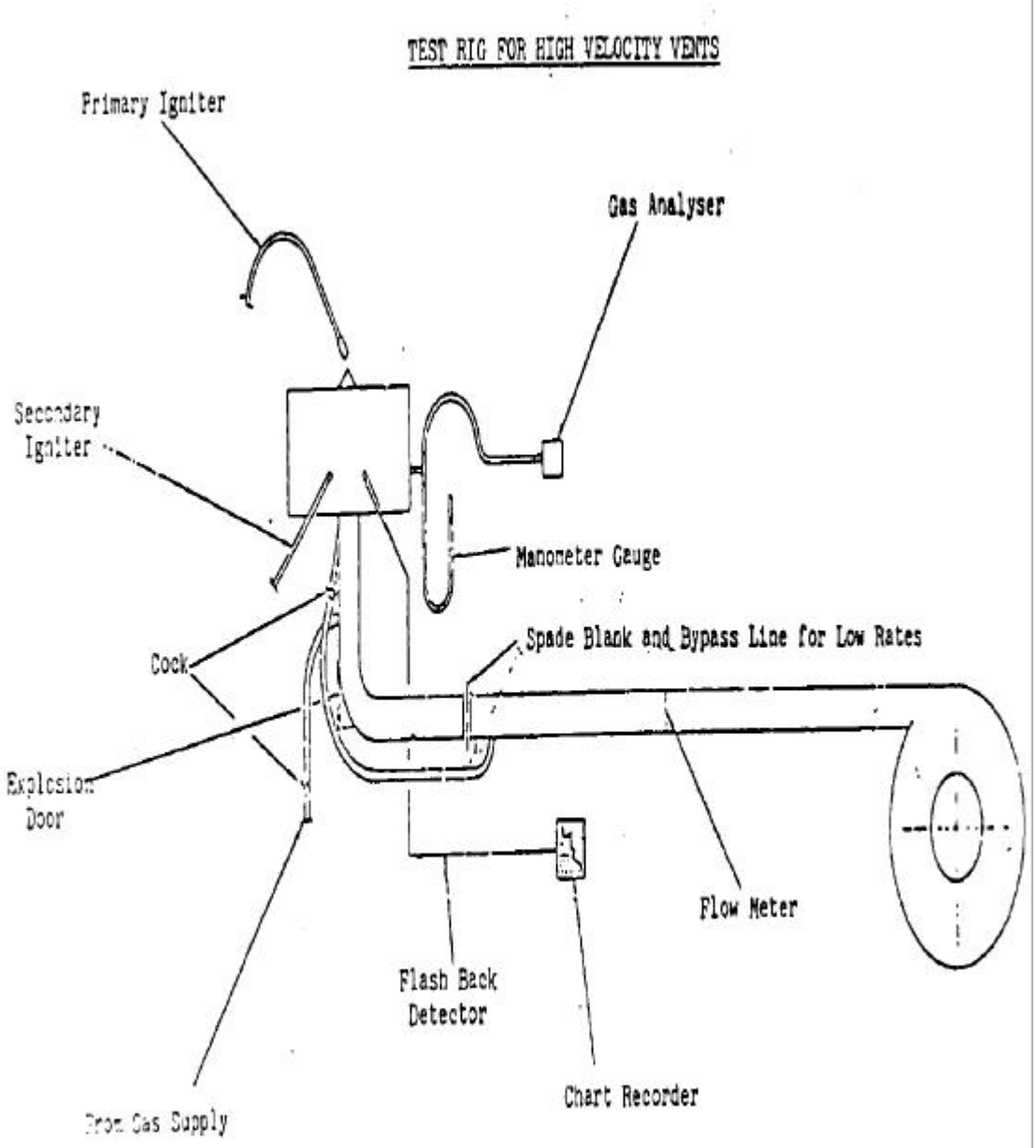


1 fan with variable speed
2 volume rate indicator
3 pipe (500 mm diameter), length ~ 30 m
4 heated vapour pipe
5 air bypass
6 evaporator and liquid storage tank
7 vapour/air-mixture bypass
8 extinguishing agents
9 control and quick action stop valve
10 explosion arresting crimped ribbon with temperature control for the safety of the test plant
11 high velocity valve to be tested
12 flame detector
13 bursting diaphragm
14 concentration indicator
15 tank

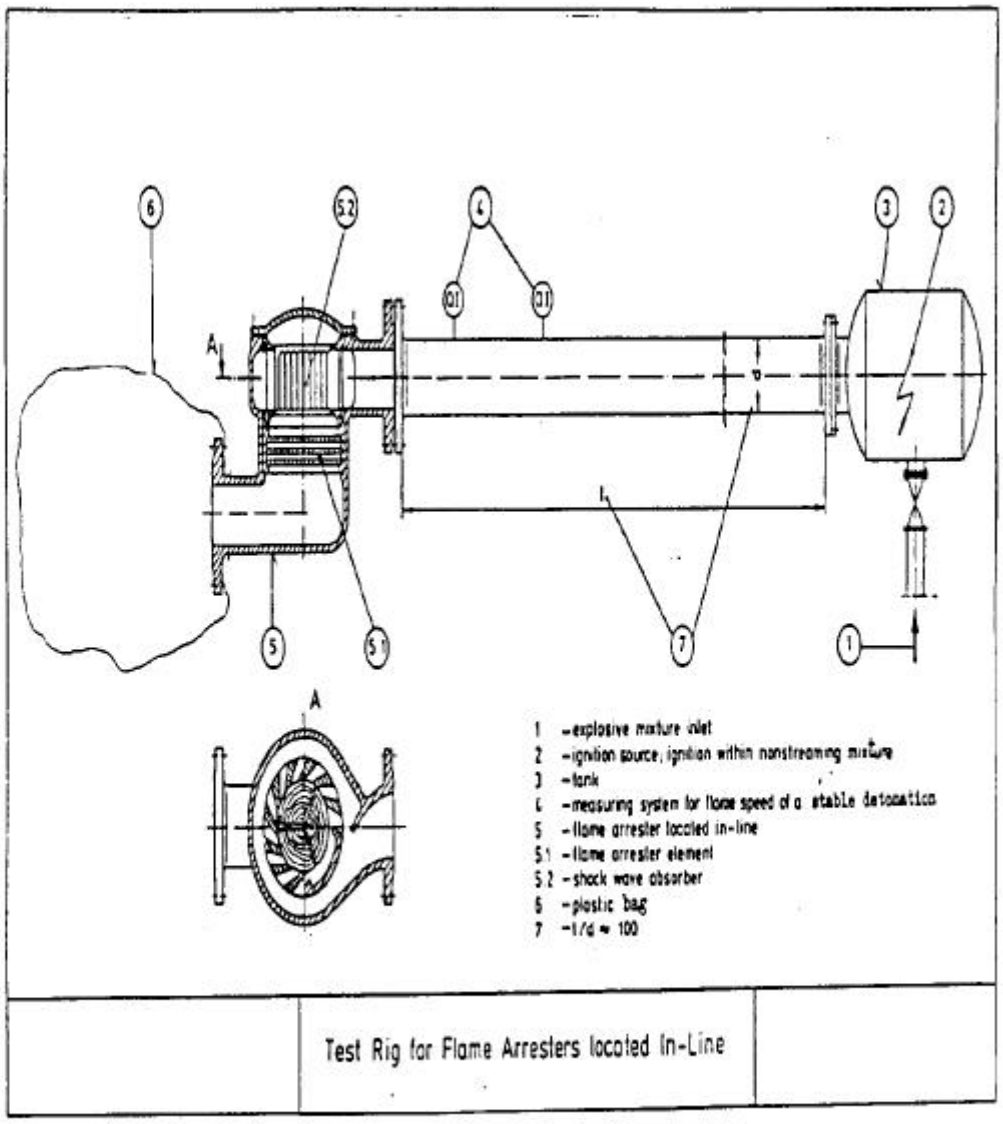
Appendix 3

Schematic Plan of the Test Plant for High Velocity Valves (endurance burning test only)

APPENDIX 4 - Test rig for high velocity vents



APPENDIX 5 - Test rig for Flame Arresters located In-Line



Test Rig for Flame Arresters located In-Line