FIREDASS
Fire Detection and Suppression Simulation

Minimum Performance Standard for Class C Cargo Compartment Fire Suppression Systems

CONTRACT N^{O}: BRPR-CT95-0040

PROJECT N^{O}: BE95-1977

TITLE: FIREDASS - Fire Detection and Suppression Simulation

PROJECT COORDINATOR: GEC-Marconi Avionics

PARTNERS: **Cerberus Guinard**
SINTEF NBL
University of Greenwich
National Technical University of Athens
DLR
Civil Aviation Authority

Subcontractor: Ginge Kerr

REPORT N° : 560/62186
Project Reference N° - 1.1-4
Revision : Draft E
Date: July 1996
Copy No.

PROJECT FUNDED BY THE EUROPEAN COMMISSION UNDER THE BRITE/EURAM PROGRAMME

COMMERCIAL IN CONFIDENCE

FIREDASS
Minimum Performance Standard for Class C Cargo Compartment Fire Suppression Systems
Contract No. BRPR-CT95-0040
Project Reference No. 1.1-4
560/62186, Draft E, July 1996

DOCUMENT CHANGE CONTROL

This document is issued and controlled by:

Mission Avionics Division
GEC Marconi Avionics

Revisions will only be issued to the Copy Holders as shown in the Distribution List.

Unauthorised copies of this document are NOT to be made.

Queries relating to this document and requests for additional copies shall be made to the above control authority.

The FIREDASS Consortium comprises: GEC-Marconi Avionics Limited, Cerberus Guinard, SINTEF NBL, University of Greenwich, National Technical University of Athens, Civil Aviation Authority, DLR and Ginge Kerr

FIREDASS
Minimum Performance Standard for Class C Cargo Compartment Fire Suppression Systems
Contract No. BRPR-CT95-0040
Project Reference No. 1.1-4
560/62186, Draft E, July 1996

List of Active Sheets
as at July 1996

All sheets are at revision Draft E

Page	Revision

Page	Revision

Page	Revision

Throughout this document a vertical line in the margin indicates places where there has been a change in content from the previous issue.

FIREDASS
Minimum Performance Standard for Class C Cargo Compartment Fire Suppression Systems
Contract No. BRPR-CT95-0040
Project Reference No. 1.1-4
560/62186, Draft E, July 1996

DISTRIBUTION LIST

Copy Number	Distribution	Appointment
-	Master	GMAv MAD Technical Library
1-2	GEC Marconi Avionics	
3	Cerberus Guinard	
4	SINTEF NBL	
5	University of Greenwich	
6	National Technical University of Athens	
7	DLR	
8	Civil Aviation Authority	
9	Ginge Kerr	
10	Aerospatiale	
11	Swissair	
12	British Airways	
	IHRWG members	

ABSTRACT

This document provides guidance for the performance required of Fire Suppression Systems designed to replace the standard practice halon systems currently in use in aircraft Class C cargo bays in the fire threat conditions herein specified.

FIREDASS
Minimum Performance Standard for Class C Cargo Compartment Fire Suppression Systems
Contract No. BRPR-CT95-0040
Project Reference No. 1.1-4
560/62186, Draft E, July 1996

CONTENTS

ILLUSTRATIONS

FIREDASS
Minimum Performance Standard for Class C Cargo Compartment Fire Suppression Systems
Contract No. BRPR-CT95-0040
Project Reference No. 1.1-4
560/62186, Draft E, July 1996

Page No 1

Error! Bookmark not defined.1213131620

1. INTRODUCTION

This document provides guidance for the performance required of Fire Suppression and Detection Systems designed to replace the standard practice halon systems currently in use in aircraft Class C cargo bays in the fire threat conditions herein specified.

2. AIMS AND ADVISORY

2.1 System Requirement

The Class C cargo compartment fire suppression system must be designed and installed to allow the continued safe flight and landing of the aircraft in the event of a fire occurring in the cargo or baggage likely to be carried in that compartment.

2.2 Environmental

Existing fire protection measures, required by Airworthiness Regulations, are largely based on the use of halons. For all practical purposes, production of halons has ceased under the provisions of the Montreal Protocol. The primary environmental characteristics to be considered in assessing a new agent are Ozone Depletion Potential (ODP), Global Warming Potential (GWP), and Atmospheric Lifetime. The agent selected should have environmental characteristics in harmony with international laws and agreements, as well as applicable local laws. This Minimum Performance Specification sets out means of assessing the technical performance of potential alternatives, but in selecting a new agent it should be borne in mind that an agent which does not have a zero or near-zero ODP, and the lowest practical GWP and Atmospheric Lifetime, may have problems of international availability and commercial longevity.

2.3 Toxicological

The toxicological acceptability of an agent is dependent on its use pattern. As a general rule, the agent must not be allowed to present an unacceptable health hazard for workers during installation and maintenance of the extinguishing system. In areas where passengers or workers are present, or where leakage could cause the agent to enter the passenger compartment, at no time should the agent concentration present an unacceptable health hazard. Following release in fire extinguishment, the cumulative toxicological effect of the agent, its pyrolytic breakdown products, and the by-products of combustion must not pose an unacceptable health hazard.

3. THE FIRE THREATS

The following fire threats shall be detected and suppressed to meet the protection criteria in section 5.

3.1 Deep Seated Within a Cargo Container

This is typically a fire resulting from self igniting materials within cargo that is packed in an aircraft cargo container.

3.2 Deep Seated Within Loose Luggage

This is typically a fire resulting from self igniting materials within luggage loose stowed in slings or in appropriate cargo volumes.

3.3 Surface Fires

This fire is typically the surface burning of luggage (or Cargo), and ignited from external heat sources. The fuels may be the surface materials themselves or the spillage/seepage of inflammable substances or liquids from within the luggage/cargo.

3.4 Pressurised Containers

See Appendix B

4. FIRE DETECTION

4.1 Initial Detection

The fire detection system or systems must provide the Flight Deck crew with warning of the fire within one minute, in accordance with JAR25.858(a)

5. PROTECTION CRITERIA

The fire suppression and detection systems shall provide protection as follows:

5.1 Structure

The fire protection systems shall ensure that the structure does not experience any unsafe temperatures that could adversely affect the continued safe flight and landing of the aircraft.

5.2 Toxic gas

Hazardous quantities of smoke, flames, or extinguishing agent, must be excluded from any compartment occupied by the crew or passengers, in accordance with JAR25.857(c)(3)

5.3 Hazards to Aircraft Operation

The fire protection systems shall ensure the continued safe flight and landing of the aircraft. In addition the fire protection agent/system shall not cause malfunction of any flight critical systems or components. The effect of possible breakdown products of the fire protection agent should also be considered.

6. SYSTEM REQUIREMENTS

6.1 System Fire Resistance

The fire protection system must be designed and installed so that the likely exposure of any system components to the effects of fire will not adversely affect the operation of the system.

6.2 Displays and Controls

6.2.1 Displays

As a minimum, displays shall be provided of:

- Fire Warning
- System Serviceability
- Fire Location (e.g. Which cargo hold or part of aircraft)

6.2.2 Controls

Controls shall be provided on the flight deck to discharge the fire suppressant agent or to activate the system where automatic agent discharge is a function of the system. Control of ventilation and draughts must be provided within the cargo compartment so that the extinguishing agent used can control fires that may start within the compartment in accordance with JAR 25.857 (c) (4)

6.3 System Reliability

6.3.1 Inadvertent Operation

Inadvertent operation of the fire protection system, unless shown to be extremely improbable, must not prevent the continued safe flight and landing of the aeroplane (ACJ No. 1 to JAR 25.1309).

6.3.2 Reliability

The probability of the fire protection system becoming inoperable shall be such that the objectives of JAR 25.1309 are met.

6.4 System Performance Demonstration

The following shall be demonstrated by the fire protection system:

(1) The fire protection system shall demonstrate that the fires as defined in section 3.1. and 3.2 are controlled in accordance with the test requirements of Appendix A.

(2) The fire protection system will fully operate within the airflow requirements as defined in Appendix A

(3) The fire protection system shall not present a pressure hazard when discharged which will endanger the aircraft

(4) The fire protection system shall perform its intended function under all the environmental conditions of the aircraft operational envelope.

7. DEFINITIONS AND ABBREVIATIONS

7.1 Definitions

Fire Detection System	A system or systems which will provide the Flight Deck crew with a warning of a fire.
Fire Suppression System	A system or systems which will control the fire.
Fire Protection System	The fire detection and suppression system

7.2 Abbreviations

FAA	Federal Aviation Administration
IHRWG	International Halon Replacement Working Group
IR	Infrared
NOAEL	No Observed Adverse Effects
TBD	TBD

7.3 References

JAR 25	Joint Aviation Requirements for Large Aeroplanes
RTCA/DO-160	Radio Technical Commission for Aeronautics "Environmental conditions and test procedures for airborne equipment"
IHRWG	Likely threats in Class C Cargo Compartments Cargo Compartment Halon Replacement Agent/System Proposed Minimum Performance Standards
TSO6517	Defines LD3 Cargo containers

APPENDIX A - TEST REQUIREMENTS

A1 GROUND TEST CONDITIONS

Tests should be accomplished in test article under the following conditions:

A1.2 Air Flow Rate

The volumetric air flow rate before and after fire detection must be representative of any inflight air flow through the cargo compartment + 10% - 0%

For the FIREDASS programme, the following leakage airflow rates shall be used:

Test Cell	Volume	Surface Area	Leakage airflow
SINTEF Test Cell	$31m^3$ (1068 cu ft)	$65m^2$	12 litre/sec
GMAv cargo compartment	$45m^3$ (1600 cu ft)	45 m^2	18 litre/sec
DLR cargo compartment	$105m^3$ (3620 cu ft)	186 m^2	25 litre/sec

For the FIREDASS programme, any tests conducted with forced 'air conditioning' ventilation shall use an airflow system which will provide an air change in the compartment every 5 minutes.

Appendix C provides more detailed information on how these figures were derived and specifies the operational and physical conditions for the FIREDASS project

A1.3 Humidity

All combustible materials must be conditioned to 21°C ±11°C (70°F ±20 °F) and at 65% maximum relative humidity until moisture equilibrium is reached or for 24 hours.

A1.4 Ambient Temperature

All tests must be performed at an ambient temperature of 21°C ±11°C (70°F ±20 °F).

A1.5 Low Temperature

A test of the system and agent on a fire must be conducted at a temperature representative of the lowest average sustained temperature expected during the most severe operation. (Reference DO-160).

A2 FLIGHT TEST CRITERIA

A2.1 Acceptable Operating Conditions

In an empty compartment concentrations and operating conditions found acceptable under Appendix A5 are obtained and maintained for the duration of time required.

A2.2 Cargo bay Liners

The integrity of the compartment lining system is not breached. This must be evaluated by testing with a full compartment which would be the worst case for overpressurisation following system discharge.

A2.3 Conditions in Occupied Areas

Conditions in any occupied area of the aircraft must not exceed No Observed Adverse Effects Limit (NOAEL), during the above tests.

A3 TEST FACILITIES

A3.1 Baseline Test Article Size

A3.2 Cargo Compartment Test Articles

Test articles must be representative of aircraft cargo compartments.

A3.3 Cargo Test Article Size for Flooding Agents

Cargo tests with flooding agents must be conducted in test articles of 1000, 3000, and 5000 cubic feet + 10% - 0% for general applications or the most appropriate test article size for specific applications.

A3.4 Cargo Test Article Size for Directed Agents

Cargo tests for directed agents may be conducted in a test article in excess of 1000 cubic feet for general applications providing sufficient test evidence, is also provided to prove that test article volume has nil or a clearly quantifiable effect.

A4 TEST INSTRUMENTATION

Test articles shall as a minimum be equipped with the following calibrated instrumentation:

A4.1 Thermocouple

The thermocouple to be used for testing must be 1/16 inch ceramic sheathed, type K, grounded thermocouple with a nominal 30 American wire gauge (AWG) size conductor. Accuracy: $\pm$ 1°C $\pm$0.375% or a suitably calibrated equivalent type.

Thermocouples are to be positioned a maximum of 1.7 metres apart longitudinally and a maximum of 1.5 metres apart laterally in the roof of the test article, and installed to provide temperature measurement 10 cms (4 inches) above the compartment liner.

A4.2 Gas Measurement

The gas sampling and analysis unit used to measure the concentration of carbon monoxide, carbon dioxide and oxygen shall meet the following specification

	Gas Composition	Accuracy
Oxygen	0 to 25% minimum (by volume)	<±0.5%
Carbon Dioxide	0 to 25% minimum (by volume)	<±0.5%
Carbon Monoxide	0 to 25% minimum (by volume)	<±0.5%

The gas sampling unit shall sample the gas concentration at a minimum of one point. The sampling point shall be positioned at the centre of the compartment cross-section, and at the maximum practical distance from the fire source.

A4.2.4 Air Flow

The air flow in the test cell shall be measured by appropriate flowmeter(s) located in the inlet duct(s). The flowmeter(s) shall have an accuracy of <1% over the range specified in section A1.2.

A4.2.5 Air pressure

The pressure inside the test chamber shall be monitored using an appropriate pressure transducer. The transducer shall have an accuracy of <1% of the reading.

A5 TEST DETAILS

All tests must be conducted at least 5 times for each condition to ensure result credibility. This number may be reduced by agreement with the Certifying Authorities, where early test results provide evidence of particularly satisfactory performance.

A5.1 Baseline Test Fire Load

Class B materials consisting of one litre of Jet A fuel in 1 metre x 1 metre square and 3cm max. deep pan, positioned in an empty cargo bay test article at two heights. The worst case location of the pan, with respect to system performance, must be used for each of the two defined heights.

A5.1.1 Height of Fire Load

A5.1.1.1 Bottom Height

0.25 metre from the floor

A5.1.1.2 Top Height

0.25 metre from the liner ceiling

A5.1.2 Baseline Test Ignition

Electrical or pyrotechnic methods may be utilised to ignite the Fire Load.

A5.1.3 Baseline Test Suppression System Performance

The system shall extinguish the fire and prevent re-ignition for a period of 5 minutes, or shall achieve the pass criteria listed in Appendix A7 until the fire load is consumed.

A5.1.4 Observations

Temperature measurement at each thermocouple shall be recorded at a maximum of 7 seconds intervals.

Oxygen, Carbon Monoxide and Carbon Dioxide measurements within the cargo bay test article shall be recorded at 5 minute intervals. Air flow measurements shall be recorded at 1 minute intervals, air pressure shall be continuously measured and recorded.

Where practical, visual, video or I R video observation of ignition, fire development, effect of agent, extinguishment, or re-ignition of the fire should be made.

Where practical, additional instrumentation such as additional temperature sensors in the vicinity of the pan should be employed to monitor the fire progress.

All observations and measurements shall be presented in a concise time related test report.

A6.2 Cargo Tests

Class A materials consisting of cardboard boxes 45.7cm (18 ins) x 45.7cm (18 ins) x 45.7cm (18 ins) loosely filled with a nominal 0.73Kg (1.6lbs) of shredded bond paper. Total weight of each filled box to be 1.81Kg $\pm$ 0.18Kg (4lbs $\pm$ 0.4lbs).

The cardboard boxes shall meet the following requirements:

Carton style 201 in 200K/C/200T

0201 Style of carton. It is standard 4 flaps on top, 4 flaps on top, 4 flaps on bottom flat plain box.

200K Grammage, 200 gms per square metre of Kraft paper

C Denotes the corrugation in the middle of the layer between top and bottom of a side.

200T Grammage, 200 gms of test paper

The cardboard box shall be untreated and not have undergone any treatment to give it additional heat resistance.

A6.2.1 Deep Seated (Container) Fire

Three LD3 containers are to be used for this test, one container to be filled with thirty three packed cardboard boxes as shown in Figure 111 and Figure 222.

A6.2.1.1 Ignitor Installation

Two electrical resistance ignitors should normally be installed in case of first ignitor failure.

Select one of the cardboard boxes and cut 3 off ventilation holes in one of the 18 inch x 18 inch (457mm x 457mm x 457mm) cardboard box sidewalls (see Figure 333 for position and size of these holes).

Install the ignitors into the shredded paper in positions as shown in Figure 333.

The open sided LD3 container shall be positioned in the cargo bay fire test rig (positioned as per Figure 222).

The top and bottom flaps of each of the cardboard boxes shall be sealed by folding each side in, no staples or tape should be used to secure the top and bottom. The box containing the ignitors shall be located as shown in Figure 111 with the 3 ventilation holes facing the sloping side of the container. An internal temperature measuring thermocouple, shall be passed through the small hole located in the side of the LD3 container and positioned in the top of the cardboard box containing the ignitors.

33 off cardboard boxes, including the ignitor box, each of total weight 4lbs (1.81Kg) shall be installed into the open LD3 style cargo container, and the side closed with a Lexan (or similar) cover.

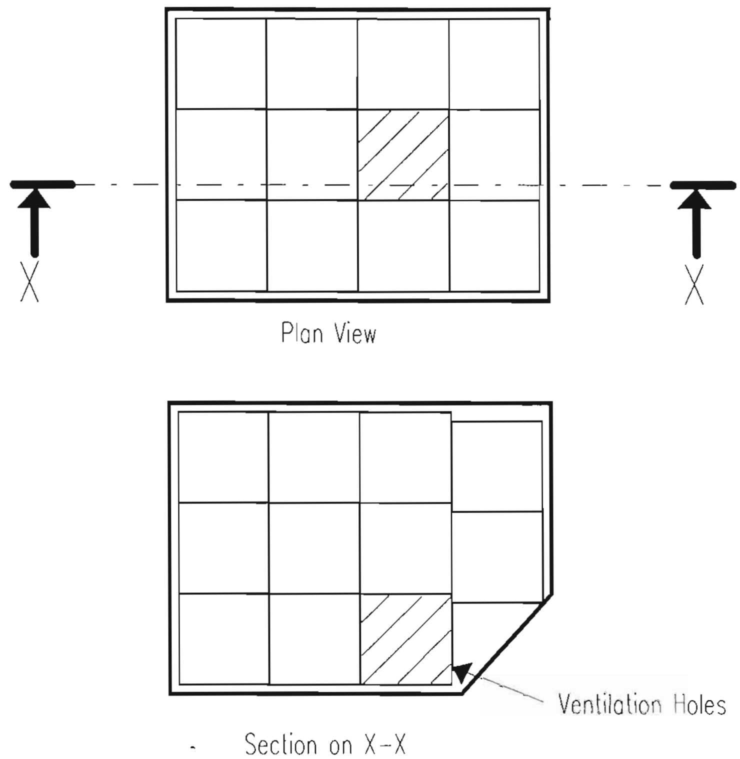

Figure 1 Position of Fire Ignition System and Cardboard Boxes

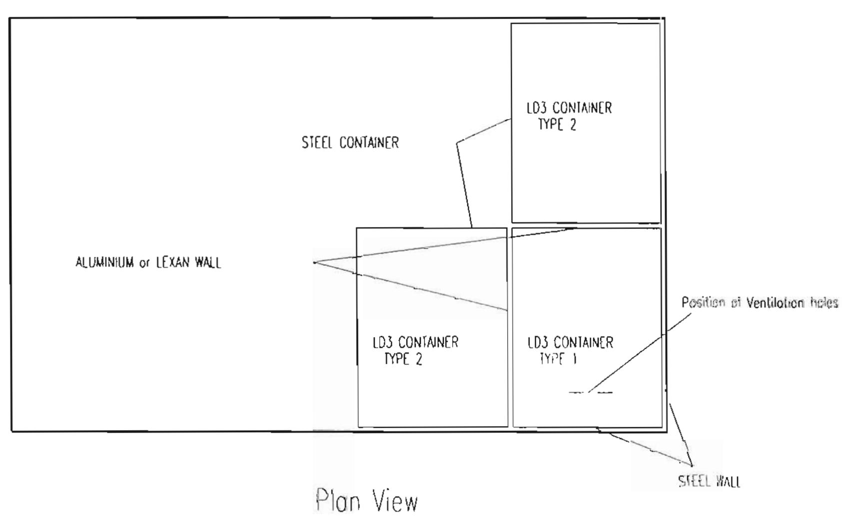

Figure 2 Position of ULD Cargo Containers in Fire Test Cell

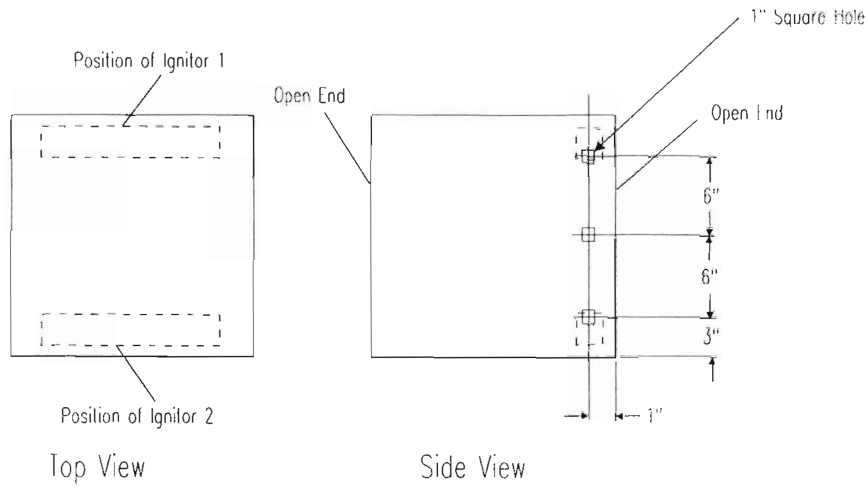

Figure 3 Position of Ignitors and Ventilation Holes in Cardboard box

A6.2.1.2 Test Duration

Tests should be conducted to evaluate the performance of the agent/system to suppress, control, or extinguish the fire over periods of 90 minutes, 180 minutes, 240 minutes, or as appropriate to a specific aircraft Certification requirement.

A6.2.1.3 Observations

Temperature measurement at each thermocouple shall be recorded at a maximum of 7 seconds intervals.

Oxygen, Carbon Monoxide and Carbon Dioxide measurements within the cargo bay test article shall be recorded at 5 minute intervals. Air flow measurements shall be recorded at 1 minute intervals, air pressure shall be continuously measured and recorded.

Where practical, visual, video or I R video observation of ignition, fire development, effect of agent, extinguishment, or re-ignition of the fire.

The initial development of the fire shall be monitored by recording the temperature of a thermocouple in the ignition box at 7 second intervals for the first 15 minutes of the test.

Data from any control or warning sensors shall be recorded as appropriate.

All observations and measurements shall be presented in a concise time related test report.

A6.2.2 Deep Seated (Loose Luggage) Fire

A 30% by volume load of cardboard boxes filled as specified in A6.2, shall be positioned two boxes deep commencing at one end of the test article. Where the fire suppression/extinguishing agent to be used can accumulate on the floor of the test article, the bottom layer of boxes are to be kept above any such accumulation.

A6.2.2.1 Ignitor Installation

One cardboard box shall contain the ignitor installations in accordance with A6.2.1.1. This box shall be located in the bottom layer of boxes, one box in from the end and centrally positioned. Example Figure 444

A6.2.2.2 Test Duration

Tests should be conducted to evaluate the performance of the agent/system to suppress, control, or extinguish the fire over periods of 90 minutes, 180 minutes, 240 minutes, or as appropriate to a specified aircraft Certification requirement.

A6.2.2.3 Observations

Temperature measurement at each thermocouple shall be recorded at a maximum of 7 seconds intervals.

Oxygen, Carbon Monoxide and Carbon Dioxide measurements within the cargo bay test article shall be recorded at 5 minute intervals. Air flow measurements shall be recorded at 1 minute intervals, air pressure shall be continuously measured and recorded.

Where practical, visual, video or I R video observation of ignition, fire development, effect of agent, extinguishment, or re-ignition of the fire should be made.

The initial development of the fire shall be monitored by recording the temperature of a thermocouple in the ignition box at 7 second intervals for the first 15 minutes of the test.

Data from any control or warning sensors shall be recorded as appropriate.

All observations and measurements shall be presented in a concise time related test report.

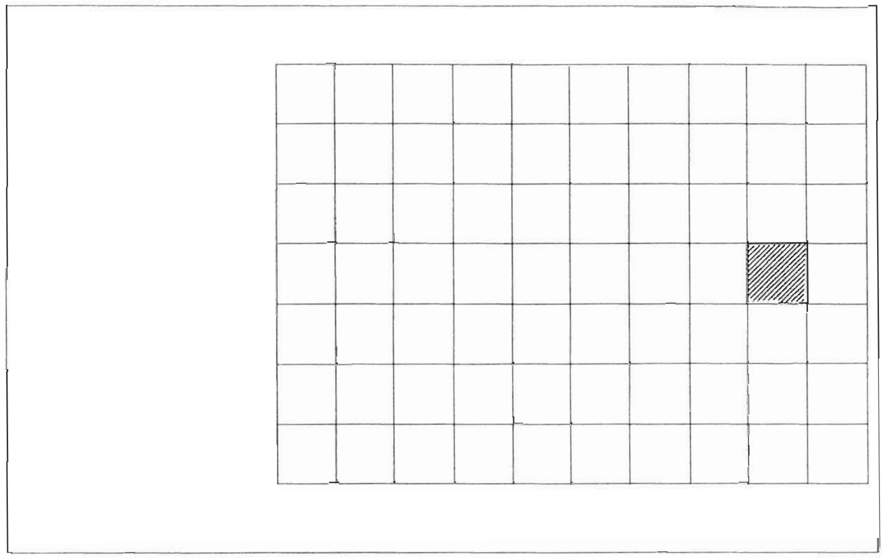

Figure 4 Loose Luggage Test Load Example

A7 PASS/FAIL CRITERIA

The following Pass/Fail criteria are the defined limits for the purposes of the FIREDASS programme.

A7.1 Temperatures

A7.1.1 Maximum Continuous Temperature

The maximum continuous temperature 4 inches above the liner at any one position shall not exceed 250°F/121 °C.

A7.1.2 Temperature Excursions

Temperatures in the cargo compartment between 400 °F/204 °C and 1000 °F/538 °C at any one point may be reached, provided that the total time spent within this temperature range does not exceed 5 minutes.

A7.1.3 Temperature

Temperature excursions within the cargo compartment above 1000°F/538°C will constitute an immediate failure.

A7.1.4 FIREDASS - no liner tests

Where tests are conducted to check the performance of the fire suppression system, and no liners are present in the test cell. The following pass/fail limits can be used:

Temperatures measured on the inside wall of the cargo compartment between 400 °F/204 °C and 1000 °F/538 °C at any one point may be reached, provided that the total time spent within this temperature range does not exceed 5 minutes.

A7.2 Pressure Change

The pressure differential within the cargo compartment shall be maintained at less than 0.375 psi (pressure loading for blow out panels to vent, See Appendix C). This must be evaluated by testing with a full compartment which would be the worst case for overpressurisation following system discharge.

A7.3 Toxic Gas Concentrations

Concentrations of toxic gases measured in the passenger cabin during Cargo bay (Deep Seated) tests must be shown to be equivalent or better than the levels now accepted for the use of 5% by volume concentration of halon 1301 for the specific test.

These are: TBD

Higher concentrations will be acceptable if human tolerance can be demonstrated or detailed analysis shows that higher concentrations can be handled by ventilation system improvements or any other acceptable means.

A7.4 Reliability

The probability of the fire protection system becoming inoperable should be no worse than 10^{-3} per hour (ACJ No. 1 to JAR 25.1309).

A7.5 Fire Detection

The fire detection system shall as a minimum provide a warning of the fire within one minute.

APPENDIX B - PRESSURISED CONTAINERS

More research is required to define the requirements for the testing of pressurised containers in cargo compartments. The following define a possible requirement for this type of fire hazard. It should be noted that this test will not be considered during the FIREDASS project.

B1 PRESSURISED CONTAINERS

The recent changes of propellant types in Pressurised Containers, creates an additional hazard. Pressurised Containers can be ruptured by over pressurisation which is heat induced from a surrounding fire. The resultant ignition of the Pressurised Container contents may create an explosion which should ideally be suppressed or whose consequences must be controlled in specific circumstances.

B1.1 Pressurised Container Test Article Size

Pressurised Container tests shall be conducted in a test article of 1000 cubic feet + 10% - 0%.

B1.2 Pressurised Container Test

Thirty two cardboard boxes shall be positioned in a four box by four box by two layer stack in the centre of the test article. The bottom layer of boxes may be empty, the top layer packed with standard rags. On top shall be positioned five, soft sided suitcases maximum size 76.2cms (30ins) x 50.8 (20 ins) x 22.86cms (9ins) filled with rags and laid flat. The centre suitcase shall contain a 7 ounce (minimum) can of air freshener wound with a nichrome wire heater element. On top of the Pressurised Container containing suitcase, shall be placed another identical size suitcase filled with rags(See Figure 555).

Each of the suitcases shall be equipped with a thermocouple wired to recording equipment.

B1.3.1 Test Conditions

The test shall be conducted with a flooding agent concentration in accordance with the design requirements of the agent for long term protection. In the case of a directed agent, this is to be deployed in accordance with the design requirements and where applicable at the average frequency found applicable in tests for Deep Seated (Loose Luggage) fires TBD minutes after fire detection to TBD minutes after fire detection.

B1.3.2 Test Duration

In the event that the agent subdues the fireball which may result from Pressurised Container rupture, and any ensuing fire, the test may be terminated 15 minutes after the fire is shown to be extinguished.

In the event that the agent does not subdue the fireball, the test should be continued for 90, 180, or 240 minutes as appropriate to desired certification, or until at least 15 minutes after the fire has been extinguished or controlled to a condition where safe entry to the test article is assured.

In the event that the agent subdues the fireball such that no observable effect occurs, the suitcase containing the Pressurised Container shall be equipped with instrumentation (e.g. air pressure measurement) to identify the time at which rupture occurs.

B1.3.3 Observations

Temperature measurement at each thermocouple in the test article and in the suitcases, shall be recorded at a maximum of 7 second intervals.

Oxygen, Carbon Monoxide and Carbon Dioxide measurements within the cargo bay test article shall be recorded at 5 minute intervals. Air flow measurements shall be recorded at 1 minute intervals, air pressure shall be continuously measured and recorded.

Where practical, visual, video or I R video observation of the effect of Pressurised Container rupture, fire development, effect of agent, extinguishment, or re-ignition of the fire should be made.

All observations and measurements shall be presented in a concise time related test report.

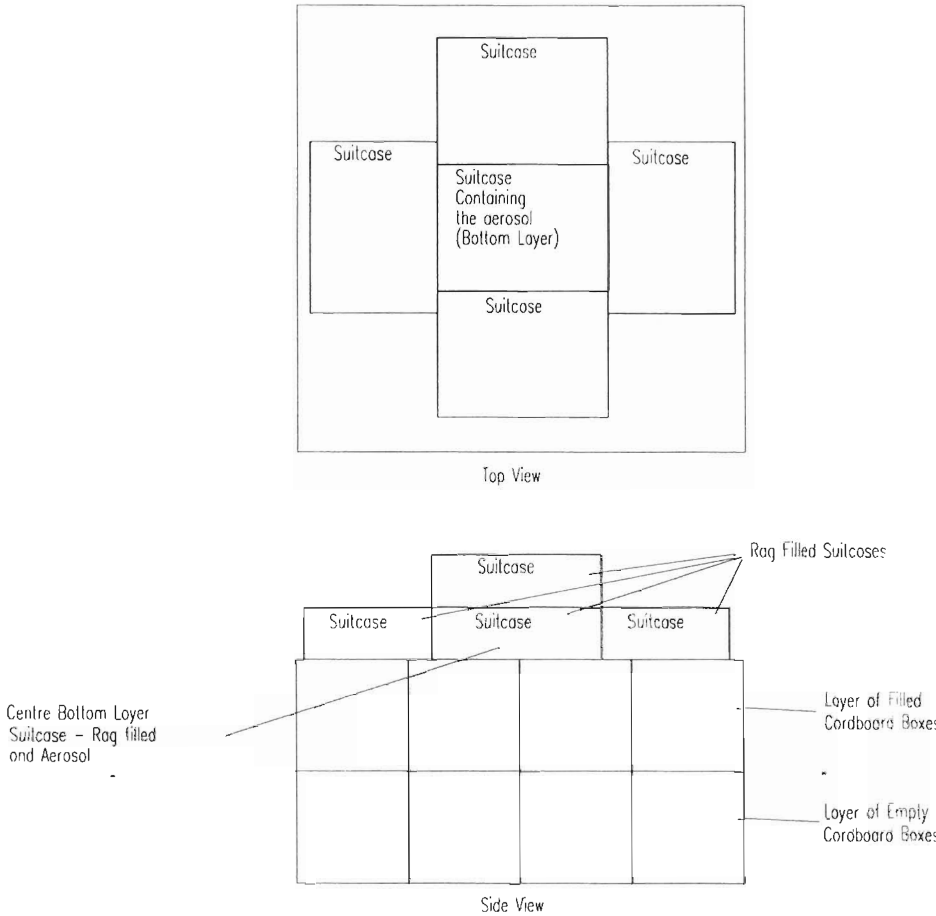

Figure 5 Pressurised Container Test Set up

APPENDIX C - OPERATIONAL AND PHYSICAL CONDITIONS

C1. INTRODUCTION

This Appendix defines for the purposes of the FIREDASS project the operational and physical conditions assumed to apply to an aircraft cargo compartment in which there is a fire detection system and a built-in fire suppression system, in JAR 25.857 (c) such a system is classified as a Class C cargo compartment.

C2. OPERATIONAL PROCEDURES

C2.1 Normal Operation prior to detection

Normal operation prior to detection of a fire. There are essentially two conditions which could apply:

C2.1.1 'Air conditioned' ventilation.

This is usually provided by the airframe manufacturer as a customer option and will typically be specified by the airline if they envisage carrying large numbers of animals on any one flight or they may be carrying animals in very hot climates, the airflow is often dictated by the need to control temperature.

C2.1.2 Leakage and ventilation airflow.

This results due to leakage out from around the external cargo door seal and air being drawn into the cargo compartment from the passenger cabin through gaps in joints. In addition some aircraft provide a small ventilation airflow (often at one location) partially to ensure pressure equalisation and partially for comfort of small animals that may occasionally be carried.

C2.2 Procedures following detection of a fire.

The detector system monitoring conditions within the compartment is designed to alert the crew to the presence of a fire within one minute of the start of the fire.

The crew will then:

i) Shut off the airflow
ii) Activate the fire extinguishing system

Q1 How long to do this ?
Q2 What percentage of JAR25 aircraft have 'air conditioning' ventilation ?

Q3 How often is the 'air conditioning ventilation' system used ?

Q4 Do many aircraft have a dedicated system providing very low ventilation airflow and is this shut off on detection of a fire?

C3 PHYSICAL CONDITIONS

When at cruise altitude there is typically a pressure differential between the inside of the fuselage and the outside atmosphere of 8.5 psi. The cabin (and hence the cargo compartment) are maintained at a pressure altitude of 8000ft. typically. It is pressure differential that causes air to leak around the cargo door seals and leaks in the cargo compartment that allow air from the cabin to enter the compartment and hence produce the leakage airflow.

It should be remembered that airflow in this direction acts in the interest of occupants by helping to prevent smoke and fumes form entering the cabin.

The temperature in the cabin is under control of the crew and would normally be set at a comfortable value around 20°C. The cargo hold temperature would typically be lower, say 15°C.

The cargo compartment is also designed to relieve any pressure differential that may occur as a result of rapid decompression by means of blow-out panels, these are designed to vent at a loading of 0.375 psi.

When a halon 1301 extinguishing system is used the quantity of halon that has to be provided is determined by the requirement to maintain 3% concentration by volume for the remainder of he flight. In order to minimise the quantity of halon carried it is necessary to minimise the leakage airflow, however there is no defined maximum permitted airflow.

For a Class D cargo compartment which does not have a fire extinguishing system but instead relies on oxygen depletion the airflow permitted is defined in ACJ JAR 25.857 (d) the maximum airflow permitted is derived from the formula $W = 2000 - V$. Where W = ventilation and leakage airflow in cu. ft./hour and V = the capacity of the compartment in cu ft up to the maximum permitted size of 1000 cu. ft.

Therefore the maximum airflow permitted for a Class D compartment of 1000 cu ft is 1000 cu ft per hour or 7.5 litres/sec.

Tests in a 5000 cu ft compartment with a 2% fire load and no extinguishing system also demonstrated that for leakage rates of 4500 cu ft per hour the fires were on the borderline of producing results the same as those produced with no airflow. However for higher leakage rates the rate of combustion did rise (Ref. FAA RD-70-42).

From discussion with manufacturers the typical leakage for a Class C compartment may be 50% higher than for a Class D compartment. the leakage is approximately proportional to the surface area of the compartment.

In those compartments which have forced 'air conditioning' ventilation an air change every 5 minutes is typical.

C4 TEST CONDITIONS

Fire test facilities to be used for the FIREDASS project are all located at, or very close to, sea level.

C4.1 Airflow

SINTEF test cell is 31m^3 (1068 cu. ft) with a surface area of approximately 65 m^3, a leakage airflow of 12 litres per second would be appropriate.

GMAv cargo compartment is 45 m^3 (1600 cu. ft) with a surface area of 95m^3, an airflow of 18 litres per second is appropriate.

DLR cargo compartment is 105 m^3 (3620 cu ft) with a surface area of 186 m^2, an airflow of 35 litres per second is appropriate.

C4.2 Vent area

The vent area from the compartment to atmosphere is very small, in normal operation the maximum leakage occurs because of the 8.5 psi. pressure differential across the door sealing surfaces, calculation yields an area of only a few mm^2 as being sufficient to develop the required airflow. However the inlet 'vent area' into the compartment is not defined, it is distributed around the compartment and is much larger, a value of 1cm^2 per m^2 surface area is suggested.