NATO STANDARD

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PROCEDURES FOR THE ASSESSMENT OF FIRE PROTECTION LEVELS FOR LAND VEHICLES

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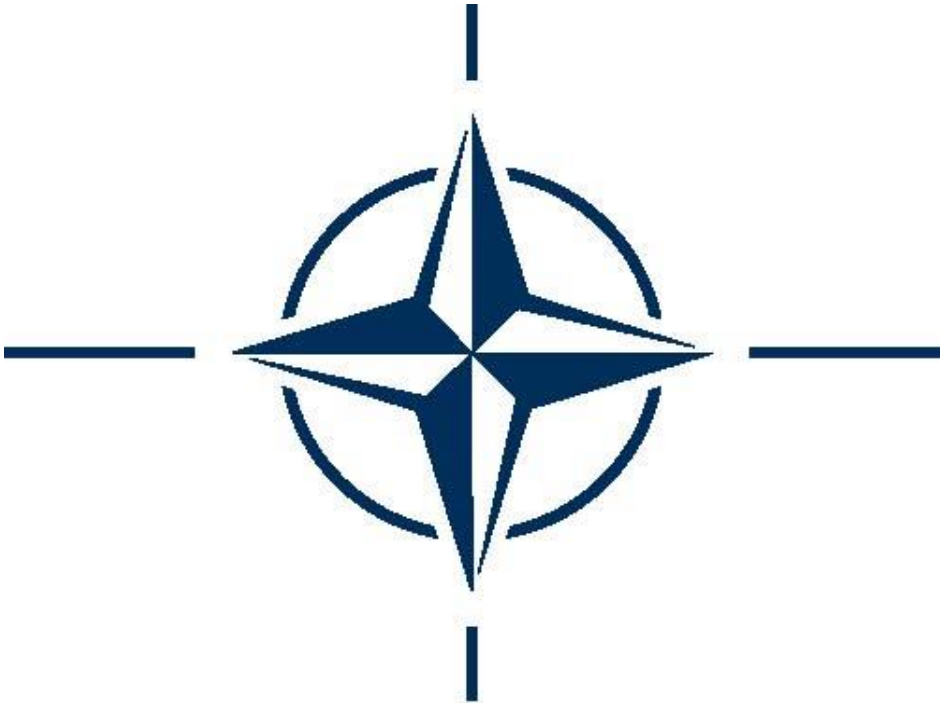

NORTH ATLANTIC TREATY ORGANIZATION

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NATO LETTER OF PROMULGATION

9 November 2018

1. The enclosed Allied Engineering Publication AEP-4317, Edition A, Version 1, PROCEDURES FOR THE ASSESSMENT OF FIRE PROTECTION LEVELS IN LAND VEHICLES, which has been approved by the nations in the NATO Army Armaments Group, is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4317.

2. AEP-4317, Edition A, Version 1, is effective upon receipt.

3.

4. This publication shall be handled in accordance with C-M(2002)60.

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
Note: The reservations listed on this page include only those that were recorded at time of promulgation and may not be complete. Refer to the NATO Standardization Document Database for the complete list of existing reservations.	

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RECORD OF SPECIFIC RESERVATIONS

[nation]	[detail of reservation]
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CHAPTER 1 INTRODUCTION

1.1. Aim

The aim of this AEP is to define several common levels of fire threats and associated protection levels for land vehicles. For each level there are minimum requirements and common tests which fire detection and fire extinguishing systems must pass in order to be suitable for the protection of land vehicles, irrespective of the nature of the vehicle or of the way it is used.

1.2. Scope

There are a large number of potential fire threats. This AEP applies to the most common one, hydrocarbon fires. The following threats are not considered in this edition of the AEP: suppression of ammunition, propellants, pyrotechnic devices, external fires (e.g. tire fires) and lithium battery fires. These types of threats will be addressed in future revisions of this AEP.

This AEP does not replace any nations' fire safety regulations.

1.3. Definitions

1. AFES: Automatic Fire Extinguishing System (In this AEP this includes types of fixed fire extinguishing systems and fire / explosion suppression systems). A typical system consists of fire detection sensor(s) and extinguisher(s) capable of delivering a defined mass of extinguishant without human involvement.
2. Built in self testing capability: An internal test indicating the readiness state of the FES/AFES. This test can be simple (e.g. a continuity test) or complicated (e.g. built in test of microprocessor), depending on system design.
3. Crew compartment: All enclosed areas within a vehicle which are usually occupied during operation, including the driver's station, turret, and/or troop carrying areas.
4. Engine compartment: An enclosed area within a vehicle containing the engine and some elements of the transmission.
5. FES: A fixed fire extinguishing system that may or may not include fire detection that requires human involvement for activation.
6. Flame extinction time detection device: A small flame supervised by an optical sensor(s) to detect extinction of the flame (for an example see Annex H).
7. Pre-burn time: For pan fires the time from when the fire has propagated across the pan(s) to the time the extinguishing system is initiated.
8. Recommended: Action which could be followed by discretion of national authority
9. Shall: Mandatory action
10. Should: Action which could be waived by national authority

11. Two-shot system: An AFES/FES that is able to carry out two independent extinguishing actions within the same protected compartment.

CHAPTER 2 THREAT LEVELS

Vehicle mission profiles dictate that the equipment will be exposed to varying fire and explosion threats. Therefore, the fire protection system for each vehicle should reflect variations in mission profiles. To accommodate for these variations, several threat levels are described in this chapter. The requirements to achieve the respective threat levels are described in chapter 3.

Threat level	Description	Full description and examples
0	No protection	This threat level is for information purpose only. Vehicles at this level are considered to have no fire protection equipment.
1	Very slow growing fire	Develops over tens of seconds to minutes allowing crew to stop and exit the vehicle and fight the fire from the outside e.g. smoldering fire
2	Slow growing fire	Develops over several to tens of seconds. This time span allows the crew to react manually and fight the fire. Examples for slow growing fires are - a personal heater malfunction in crew compartment - a fuel leakage in engine compartment.
3	Fast growing fire	Develops over one to several seconds, not allowing the crew to react manually (e.g. Molotov cocktail).
4	Deflagration	Develops over milliseconds, not allowing the crew to react manually or safely exit the vehicle (e.g. ballistic or blast event).

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CHAPTER 3 REQUIREMENTS

3.1 General requirements

There may be different types of systems in a vehicle; one installed in the crew compartment to increase personnel survivability, one installed in the engine compartment to preserve the vehicle's mobility function, one installed in a hydraulics or auxiliary power unit (APU) compartment, etc. For the remainder of this AEP all systems not in the crew compartment are summarized under the term engine compartment fire extinguishing system.

Each compartment will be assigned a separate level of protection. (for example, a level 2 for the engine compartment and level 4 for the crew compartment).

All these systems must meet the following requirements.

3.1.1 System requirements

The crew must have an indication if extinguishing system / hand held fire extinguisher is operational (i.e. not already discharged). For example for a gas system it could be a pressure indication.

Level 3 and level 4 AFES shall have a built in self-testing capability either manually activated (press button by crew in crew compartment) or automatic (i.e. by on board electronics) that indicates the system status to the crew in less than 10 seconds (i.e. by a green or red light).

If an AFES is installed and detects a fire in the engine compartment, it must be signaled to the crew, (i.e by red warning light or audible alarm).
If an AFES is installed in crew compartment, it must not be activated by sources described in Annex A.

3.1.2 Survivability requirements

Activation of the fire extinguishers / fire extinguishing system must not be harmful to the crew. The survivability criteria in annex B must be met.

Any fixed system must protect at least 90% of the crew compartment. This is to be demonstrated to the national authority by a system analysis.

3.1.3 Requirements for two-shot systems

3.1.3.1 Crew compartment

For two-shot systems each shot shall be capable of independently meeting all of the applicable requirements of section 3.

3.1.3.2 Engine compartment

For two-shot systems each shot should be capable of independently meeting all of the applicable requirements of section 3. The combination of shots shall meet all of the applicable requirements of section 3.

3.2 Minimum requirements for level 1 protection

No detection for either crew or engine compartment. Crew must detect the fire threat without specific equipment. (i.e. by visual observation of smoke or flames.)

Vehicle must be equipped with a hand held fire extinguisher compliant with an appropriate standard, (EN 3 or NFPA 10 / UL 711 or equivalent).
No further testing is required.

3.3 Minimum requirements for level 2 protection

3.3.1 Engine compartment

No automatic detection required. The engine compartment must be equipped with a fixed manual fire extinguishing system.
To qualify for level 2, one of the two tests described below shall be conducted successfully:

- Pan fire testing (4.2.1)
- Agent concentration testing (4.2.2)

3.3.2 Crew compartment

No automatic detection required. The crew compartment must be equipped with either a fixed manual fire extinguishing system or a manual hand held fire extinguisher inside the crew compartment.
If a fixed system is used, to qualify for level 2, one of the two tests described below shall be conducted successfully:

- Pan fire testing (4.2.1)
- Agent concentration testing (4.2.2)

If a hand held fire extinguisher compliant with an appropriate standard, EN 3 or NFPA 10 / UL 711 or equivalent is used, no further testing is required.

3.4 Minimum requirements for level 3 protection

3.4.1 Engine compartment

The engine compartment must be equipped with a fire suppression system which includes an automatic detection system
To qualify for level 3 in engine compartment, the following test shall be conducted successfully:

- Detection and extinguishing (4.3.3)

3.4.2 Crew compartment

The crew compartment must be equipped with an extinguishing system which includes an automatic detection system.
To qualify for level 3 in crew compartment, one pair of the following tests shall be conducted successfully:

- Concentration measurements (4.3.2) and Detection in crew compartment (see section 4.3.4)

or

- Pan fire for level 3 crew compartment (both sub tests) (4.3.1)

3.5 Minimum requirements for level 4 protection

3.5.1 Engine compartment

The engine compartment shall be equipped with a two-shot system.
In addition to requirement 3.1.3 the first shot shall be automatic and independently comply with the requirements in 3.4.1 (engine compartment test for level 3 systems). In addition, the complete system shall comply with the bilge fire and spray fire tests in Annex G. It is recommended that the system is capable of a delayed extinguisher activation to allow engine airflow to reduce.

3.5.2 Crew compartment

The protected compartment must be equipped with an automatic fire extinguishing system. The system shall be able to detect and extinguish a deflagration of fuel mist.
To qualify for level 4 one of the following combinations of tests shall be conducted successfully:

- Fire ball testing (4.4.1) and concentration testing (4.4.3)

or

- Threat munition initiated fire (4.4.2) and concentration testing (4.4.3)

In both cases national authorities have the option to use an operational vehicle or a mock-up.

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CHAPTER 4 TEST PROCEDURES

4.0 General remarks

In this chapter, test procedures for the qualification of the AFES/FES are presented. The selection of tests is according to the protection level requirements (chapter 3). This does not preclude the national authority from conducting additional tests.
All reports on tests in this chapter should be prepared according to annex D.

4.0.1 Preparation of the vehicle

While preparing a vehicle for a test it is important to keep in mind that the test vehicle or mock-up should represent an in-service vehicle as closely as possible. If the vehicle is used in several different variants, all of these should be tested separately, except in the case of only minor differences between configurations.
Nevertheless it is also important to note that all of the tests described below, even if successful, can severely damage the vehicle being tested. This is due to the toxic and corrosive gases emitted by the fires during testing. Therefore, in many cases it is a good idea to replace damageable equipment by more robust mockups of similar size and placement. The damageable equipment must not be taken out of the vehicle without a mockup replacing it. This is because all extinguishing agents have to follow a complex flow pattern from the nozzle(s) to cover the vehicle interior. Missing equipment may change these flow patterns and affect the test results.
Air conditioning and fans affect air movement inside the vehicle including in the engine compartment. This can affect the distribution of extinguishing agent and because of that the extinguishing times and test results may be affected. Air conditioning, fans and other equipment influencing airflow should be set to values which are typical for combat situations as determined by the National Authority.
All hatches and doors shall be closed, unless the mission scenario dictates otherwise.
Modification of the vehicle to allow instrumentation or remote monitoring, for example cutting access holes in the vehicle by removing or modifying vision blocks, drainage panels, access panels, etc. for providing access routes for wiring, cables, etc. should be minimized and properly sealed.
In crew compartments, to correctly represent the flow of air and extinguishing agent, crew simulants (dummies) shall be installed and should be positioned and secured in a typical combat position for the particular crew position. They, when feasible, should be dressed in the appropriate ensemble. It is recommended to conduct testing with a fully occupied vehicle and with minimum occupants.
Nations should decide which size percentile is represented by crew simulants.
It is recommended to test with combinations of hatches open/closed, ventilation on/off, and full/minimum stowage in order to represent different mission configurations.

4.0.2 Ignition Sources

Possible ignition sources for all fire testing are:

a) Electric arc
b) Torch
c) Pyrotechnic squib
d) Match
e) Hot wires

NOTE: The ignition sources must not activate the detection system (if installed).

4.0.3 Measurement Devices

4.0.3.1 *Sensors for tests with fire*

To get accurate time measurements of fire on and off conditions, all fires should be covered by video documentation and temperature measurement.
If in special cases video documentation is not appropriate (e.g. powder system tests), the national authority may decide that temperature measurements are sufficient.

4.0.3.2 *Sensors for crew compartment survivability*

For assessment of crew compartment survivability, in addition to the sensors mentioned elsewhere, the following sensors are necessary (see also Annex B).

i) Pressure
ii) Temperature:
    (1) Temperature inside vehicle
    (2) Temperature @ manikin (under / protected by clothing)
iii) Oxygen concentration
iv) Acid gases
v) Sound (for concentration tests only)

4.0 Test procedures for level 1

None.

4.2 Test procedures for level 2

4.2.1 Pan fire testing for level 2 (crew and engine compartment)

For pan fire testing the vehicle shall be prepared according to section 0.1. The FES is set to manual operation. One or more fire pans are placed into the vehicle. Minimum size of the combined area of the pans is 0.04 m². The height of the fuel within the pan shall be at least 1.5 cm, preferably on a water base of 1 cm. The total height of the pan shall be at least 2.5 cm above the fuel surface.
Permissible fuels are F-35 (JP-8), F-63 or F-54 (Diesel) heated to a minimum of 60°C (140°F).

A pre-burn time is required. If more than one pan is used within one test, all fire pans shall be ignited within 20 seconds. The pre-burn time is measured beginning from the time the last fire is ignited and shall be a minimum of 30 seconds. Then the discharge of the suppression agent is activated manually.
For a successful test, the fires shall be extinguished no later than 30 seconds after start of discharge of the suppression system without re-flash. In addition, in crew compartment survivability criteria at Annex B shall be met.
This test shall be conducted a minimum of three times with pans placed at various locations within the protected compartment. The placement of the pans should reflect areas where fires are most likely to occur.

4.2.2 Agent concentration testing for Level 2

For concentration testing the vehicle shall be prepared according to chapter 0.1. Extinguishing agent container must be weighed before installation. In addition to 4.0.3 the placement of following sensors for extinguishing agent concentration are mandatory: Placement of 4 or more sensors (or inlets of suction pipes) inside the protected space, at least one of those at head height. The sensors must be able to measure with a frequency of > 1 Hz.

2) Testing:
   a) Measurement for > 2 min after agent discharge, > 5 min for crew compartments
3) After test:
   a) Weigh extinguishing agent container
4) Test evaluation:
   a) For a successful test design concentration must be maintained for 500 ms simultaneously at all measurement locations in protected compartment within 30 seconds of extinguisher activation

4.3 Test procedures for level 3

4.3.1 Pan fire for level 3 crew compartment

This test is divided into two sub tests. Both tests must be prepared and executed in the same way as the pan fire tests in chapter 4.2.1, with the only differences described below.

For both sub tests a fire pan of 0.2 m^2 is placed into the crew compartment of the vehicle. It is filled with > 1 L heptane in a way that the whole surface is covered.

Sub test 1 is to assess extinguishing time. Sub test 2 is to assess system performance including both detection and extinguishing times.
For sub test 1 after fuel ignition the fire shall be allowed to develop for 10 seconds before the extinguishing system is manually activated. For a successful sub test 1,

the fire must be extinguished in less than 5 seconds after activation of the extinguishing system.
For sub test 2 the AFES is turned on. For a successful sub test 2 after ignition of the fuel the fire must be extinguished within 10 seconds and survivability criteria (Annex B) met.
Both sub tests shall be conducted a minimum of three times with pans placed at various locations within the protected volume. The placement of the pans should reflect areas where fires are most likely to occur.

4.3.2 Concentration measurement for level 3

This test shall be conducted in accordance with 4.2.2 agent concentration testing, with the following additional pass criterion: Design concentration must be reached within 5 seconds after activation.

4.3.3 System test in engine compartment (detection and extinguishing)

This test shall be conducted in accordance with 4.2.1 pan fire testing, with the only differences described below:
Heptane shall be used as fuel. No pre-burn time is required. For a successful test, the fire must be detected and extinguished and the vehicle must remain operational (at a reduced capability defined by National Authority). The timing between detection of the fire and activation of the extinguisher shall be consistent with vehicle operation procedures.
This test shall be conducted a minimum of three times with pans placed at various locations within the protected volume. The placement of the pans should reflect areas where fires are most likely to occur.

4.3.4 Detection in crew compartment

For this test the vehicle shall be prepared according to section 4.0.1. The AFES is set to automatic mode. A fire pan is placed into the vehicle. Gasoline is filled into the pan.

1) Size of the pan is 0.04 m². The height of the fuel within the pan should be minimum 1.5 cm, preferably on a water base of 1 cm. The total height of the pan should be a minimum of 2.5 cm above the fuel surface.
2) For a successful test the test fire must be detected within 5 seconds after ignition
3) The detection system must not be activated by sources described in Annex A

This test shall be conducted a minimum of three times with pans placed at various locations within the protected volume. The placement of the pans should reflect areas where fires are most likely to occur.

4.4 Test procedures for level 4

4.4.1 Fire ball testing

A fire ball generator (FBG) shall be set up for the protected volume. The FBG should be placed within the vehicle to simulate a realistic fireball scenario based on the vehicle layout (fuel tanks, etc.) and potential threat shotlines.

1) One example for a FBG:
   a) A heater plug is placed at the bottom of a metal spherical cap with a diameter of approximately 47.5cm. The spherical cap is placed into the vehicle interior, with the heater plug facing towards the fuel nozzle at a distance of about 1.5m.
   b) In preparation of an experiment, the heater plug is heated up until it is glowing orange.
   c) A mixture of seven parts F-35 and one part n-heptane is heated to a temperature of 81 +- 5 °C.
   d) At the beginning of each experiment, an injection pump is activated which pumps the fuel mixture through a hydraulic line to the spray nozzle. The hydraulic line should be heated to approximately 65 °C to prevent the F-54 mixture from cooling down while travelling towards the nozzle.
   e) The fuel mixture is atomized in the spray nozzle and the resulting fuel aerosol spreads inside the vehicle interior towards the heater plug. As the expanding fuel aerosol cloud reaches the glowing heater plug, it is ignited, resulting in a deflagration.
   f) The injection pump is switched off after 3s of operation. During each test, about 0.2L fuel is applied.
2) The FBG shall be adjusted in a way that the k-value of the fireball generated in the protected volume is in the range of 1 to 2 bar.m/s.
   a) This might be achieved e.g. by using different spray nozzles or varying the pressure in the hydraulic line.
   b) k-value computation is according to Lewis von Elbe $K_{ae} = \left(\frac{dP}{dt}\right)_{max} V^{1/3}$
      i) P is the pressure inside the crew compartment prior to extinguisher activation
      ii) V is the volume of the crew compartment
      iii) The k-value is related to the strength of the deflagration and allows comparison between different FBG test procedures.

The fireball must be detected and extinguished by the AFES and the crew compartment survivability criteria (Annex B) must be met

A minimum of two tests should be conducted.

4.4.2 Threat munition initiated fire

Testing using threat or appropriate surrogate threat munitions is essential for assessing the performance and survivability of an AFES. For effective testing, it is

important that the test vehicle resembles as closely as possible an in-service vehicle. All components with burning liquids, like fuel tanks and hydraulic lines, should be complete and functional. Likewise the ventilation system should be working.

1) An overmatch threat directed at vehicle
   a) i.e. a shaped charge to a lightly armored vehicle
   b) Shot lines should be directed at fuel tanks or hydraulic systems
2) Fuel tank or hydraulic line
   a) Should be at maximum operating temperature
   b) Should be at maximum operating pressure
   c) Fuel tanks should be filled in the range of 50% to 80%
   d) The shot line should be through the liquid fuel
3) All hatches should be closed (unless mission scenario dictates otherwise)
4) Ventilation turned on
5) In crew compartment survivability criteria (Annex B) must be met
6) In addition to the requirements listed in Annex D the test report should give details about
   a) The threat
   b) The shotline (azimuth, elevation, impact location)
   c) Description (pictures) of all damage

Depending on the details of the test setup, some threat munition initiated fires might be less severe, fulfilling the survivability criteria of Annex B without an AFES. It is therefore advisable to conduct some baseline testing without an AFES to assess the fire severity. If necessary, the test setup should be changed to guarantee a high fire severity.

4.4.3 Concentration testing

1 Test preparation according to 4.2.2 with following changes:
   a) placement of sensors (mandatory):
      i) Extinguishing agent:
         (a) If very fast sensors for the concentration of extinguishing agent are available (>100Hz): placement of 3 or more sensors inside the protected space, at least one of those at head height
         or
         (b) Slower sensors: placement of 3 or more sensors inside the protected space, at least one of those at head height and placement of 3 additional flame extinction time detection devices (see drawing in Annex H)
      ii) Pressure:
         (a) 2 or more pressure transducers

2 For a successful test

2.1 Annex B criteria must be met.

2.2 With a fast concentration measurement device:

2.2.1 Design concentration must be met throughout the crew compartment within 250 ms after extinguisher activation

2.2.2 Inerting concentration shall be maintained at all sensor locations for > 10 seconds

2.3 If slower sensors are used:

2.3.1 Flame extinction time detection: All flames extinguished in less than 150 ms on average, < 250 ms max

2.3.2 Inerting concentration shall be maintained at all sensor locations for > 10 seconds

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CHAPTER 5 SYSTEM DESIGN CONSIDERATION

It is recommended that the AFES system has an internal power supply lasting more than 10 minutes in the case of a catastrophic loss of electrical power.

High pressure (>= 1000kPa) extinguishing agent containers stored in the crew compartment should be tested to be shatter proof. For testing use MIL-DTL-7905H sections 3.3.9.1 and 4.6.9.1 or a similar national procedure.

The systems described here are safety/protection systems. As such they should withstand environmental impacts and threats like mine aggression on a level defined by the vehicle program for safety / essential systems.

Environmental testing shall be conducted in accordance with vehicle specifications.

Climatic impact of extinguishing agents including GWP and ODP (Global Warming Potential and Ozone Depletion Potential) shall be assessed in accordance with national regulations.

Two shot systems should have a detection system not only capable of fire detection but also if it was successfully extinguished.

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ANNEX A – SOURCES OF FALSE ALARMS FOR OPTICAL DETECTION SYSTEMS

The system shall not react in the presence of the following lighting sources at a distance equal or superior to that listed below.

Type of light source	Distance to detector
Sunlight	Direct illumination
Intermittent sunlight	" "
Lighted cigarette or cigar	5 cm
Lighter flame 2 cm high	10 cm
Lighted (wooden or cardboard) match, including striking	20 cm
Vehicle lighting, any power or type	Any distance
Photographic flash	45 cm
Flash from arc welding, 4 mm …. 300A	150 cm
Lighting from acetylene welding, properly adjusted flame 16 mm diameter and 130 mm length	150 cm
Small arms muzzle flash	150 cm
Bright color clothing, including red and safety orange	Any distance
Cell phone LED flash	45 cm

Details of light source type are defined by National Authorities.

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ANNEX B – CREW COMPARTMENT SURVIVABILITY CRITERIA

Parameter	Requirement	Fire testing	Discharge testing	Concentration testing
Fire Suppression	Extinguish all flames without reflash	X		
Skin Burns	Less than second degree burns (<1316°C-s (2400°F-sec) over 10 seconds or heat flux < 160kJ/m^2 (3.9 cal/cm^2))	X		
Overpressure	No ear damage, < 4 psi (<27 kPa)			X
Overpressure	No lung damage, < 11.6 psi (<80 kPa)	X		
Agent Concentration	Meet national occupational safety limits			X
Acid Gases	(HF + HBr + 2·COF2) Less than 746 ppm-min (5 min dose)	X		
Oxygen	Levels Not below 16% for more than 5 sec	X		X
Discharge	Impulse Noise No hearing protection limit: <140 dBP Single hearing protection limit: <165 dBP (e.g. noise reduction headset) Measured at typical crew locations without fire.		X	X
Discharge Forces	Not to exceed 8 g averaged over 30 ms at assumed head mass of 4.5 kg and a head-neck distance of 16 cm or <137 kPa at 12,7 cm Measured at typical crew locations without fire.		X	
Fragmentation	Fire extinguishing system must not emit fragments >300 micrometer		X	

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ANNEX C – PROPERTIES OF GASEOUS AGENTS

The data presented in this annex is for information only. National environmental, health and safety regulations have precedence.

Table C-1:

Agent	Minimum design concentration n-heptane (Class B) fires [Vol-%]	NOAEL [Vol-%]	LOAEL [Vol-%]	GWP 100yr	ODP
CF_3I	4.2	0,2	0,4	5	<<1
CO_2	36	0,5	~4	1	0
FK-5-1-12	5.9	10	> 10	1	0
HFC 125	11.3	7,5	10	3400	0
HFC 227 ea	8.7	9	10,5	3500	0
HFC 236 fa	8.3	10	15	9400	0
N_2	43.7	42.8	52.3	0	0
Halon 1301	5.0	5,0	7,5	6900	10
Halon 1211	5.0	0,5	1,0	1300	3

NOAEL: No Observed Adverse Effect Level
LOAEL: Lowest Observed Adverse Effect Level
GWP: Global Warming Potential
ODP: Ozone Depletion Potential

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ANNEX D – TEST REPORT

All test reports written according to this AEP shall include at least the following information:

1) Name and address of the testing facility
2) AEP test procedure
3) If the test is performed inside: description of test enclosure including size, ventilation details and room temperature (before the test)
4) If the test is performed outside: weather conditions, including temperature, rain, wind speed and wind direction with respect to the test vehicle
5) Detailed description of the vehicle used in the test
   a) Exact type and version of the vehicle
   b) Detailed documentation of the extinguishing system to be tested, including
      i) Type and placement of fire detectors
      ii) Type of extinguishing agent
      iii) Type and placement of nozzles
      iv) Software version (if applicable)
   c) Placement of all equipment stored inside the vehicle
      i) E.g. photographic documentation and/or stowage plan
   d) Status of all appliances affecting air movement inside the vehicle
      i) E.g. engine fan speed, air condition switched on/off
      ii) State of all doors, hatches and other vehicle openings (open/close)
   e) Documentation of all modifications to the vehicle, e.g. cutting access holes to provide access routes for wiring.
6) If applicable: placement of human manikins
7) Placement and type of all thermocouples and other sensors used during the test
8) Testing equipment and measurement instruments used
9) Conditions of the extinguishing agent containers before the test
   a) volume of the container
   b) pressure
   c) temperature
   d) weight
10) For tests with fire:
   a) Fuel (type and temperature)
   b) Description and placement of fire pans or nozzles
   c) Method of ignition
   d) Pre-burn time
   e) Extinguishing time (separate for all fires if there is more than one pan fire)
11) For tests without fire (concentration testing):
   a) Time after start of discharge when all extinguishing agent sensors report concentrations above the minimum design concentration

b) Duration of extinguishing agent concentrations at all sensor locations being above the minimum design concentration

12) Quantity extinguishing agent discharged during the test
    a) Weight of the container before and after the test
13) Charts of all data collected by the sensors during the test
14) Any special observations made during the test
15) Date and time the test was performed
16) Date and identification number of the test report
17) Signature of the person responsible for the testing

Additional information (not mandatory):

18) Extinguishing Agent discharge time
19) Reaction time between ignition of flame and response of the extinguisher valve

ANNEX E – SUMMARY OF PROTECTION LEVELS

E 1 Crew minimum requirements for protection levels

Level	fire propagation timescale (estimated)		Standard	Test Procedure
1	Tens of seconds to minutes	Detection	By crew	None
		Extinguishing	Hand held fire extinguisher	None
2	Several to tens of seconds	Detection	By crew	None
		Extinguishing	Hand held fire extinguisher	None
			30 s + Annex B	4.2.1 pan fire
			30 s	4.2.2 concentr.
3	One to several seconds	Detection	5 s	4.3.4
		Extinguishing	5 s	4.3.1 pan fire
			5 s	4.3.2 conc.
		D & E	10 s + Annex B	4.3.1 T2
4	Milliseconds	Extinguishing	250 ms	4.4.3 conc.
		D & E	Fire out Annex B	4.4.1 fire ball
			Fire out Annex B	4.4.2 threat munitions

Table E-1

E 2 Engine minimum requirements for protection levels

Level	fire propagation timescale (estimated)		Standard	Test Procedure
1	Tens of seconds to minutes	Detection	By crew	None
		Extinguishing	Hand held fire extinguisher	None
2	Several to tens of seconds	Detection	By crew	None
		Extinguishing	30 s	4.2.1 pan fire
			30 s	4.2.2 conc.
3	One to several seconds	D & E	Operational engine	4.3.3

4	Few seconds; Two-shot system	D & E	Operational engine	Annex G

Table E-2

ANNEX F – OPERATING ENVIRONMENT REQUIREMENTS

Any automatic fire extinguishing system conform to this AEP shall function properly when exposed to harsh environments and shall show no deterioration in functionality afterwards. Especially there must be not false alarms and no accidental discharge. Harsh environments include exposure to

- High temperature
- Low temperature
- High humidity
- Vibration
- Shock
- Water immersion
- Fuel application to equipment surface
- Salt fog
- Dust
- Fungus
- Low / high voltage
- EMC (Electromagnetic Compatibility)
- EMI (Electromagnetic Interference)
- NEMP (Nuclear Electromagnetic Pulse)
- TREE (Transient Radiation Effects on Electronics)

Test conditions and test procedures shall follow the vehicle program.

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ANNEX G – ADDITIONAL TEST PROCEDURES

G 1.0 Bilge fire test in engine compartment

For bilge fire testing the vehicle should be prepared according to section 4.0.1. Permissible fuels are F-35 (JP-8), F-63 or F-54 (Diesel). The amount of fuel needed to cover the bilge floor while allowing airflow above the fuel surface shall be determined empirically. The fuel shall be preheated to 65°C (150ºF) before pouring it into the bilge.
An electrical spark generator or auxiliary flame initiator should be used to ignite the fuel pool. The igniter shall be placed in a region where ignition sources, such as power cables, may be present.
The fuel ignition source shall remain active for 20 seconds following automatic discharge of the first bottle agent, then discontinued.

The AFES alarm shall be remotely acknowledged 5 seconds after the extinguishing system discharges. If fire alarm signal is still indicated, the test director shall wait 15 seconds and order the remote shutdown of the engine. After engine shutdown, the AFES panel will be monitored for 5 minutes. If a fire indication is present, the test director will order the remote activation of the second shot.
Therefore, second discharge will not occur in less than 20 seconds after the first discharge. These delay times are estimates of driver response times to maneuver to a temporary staging area, shut down the engine, activate the second shot, disengage primary power, and exit the vehicle.
If a fire indication is present on the AFES panel within the next five minutes, the test is a fail.
The test vehicle will be monitored after the event using the thermal instrumentation and video cameras (interior and exterior views) to determine if there are any fires that the on-board AFES did not extinguish. The test range backup fire suppression system will be used in response to visible flames, smoke, or rapidly rising temperatures at the discretion of the test director in order to preserve the test asset. However, prior to employment of the backup system, a waiting time of not less than 10 seconds (generally 15 to 30 sec from the time the fire is detected) will be observed for data acquisition. The test director may decide to shut down the engine at any time to minimize damage to the vehicle or to mitigate potential safety hazards. In those cases the test is a fail.
For a successful test, the fire must be detected and extinguished and the vehicle must remain operational (at a reduced capability defined by National Authority).

The timings mentioned in this test procedure are recommended. If necessary they may be changed to be consistent with vehicle operating procedures as determined by the national authority.

G 2.0 Spray fire test procedure for engine compartment

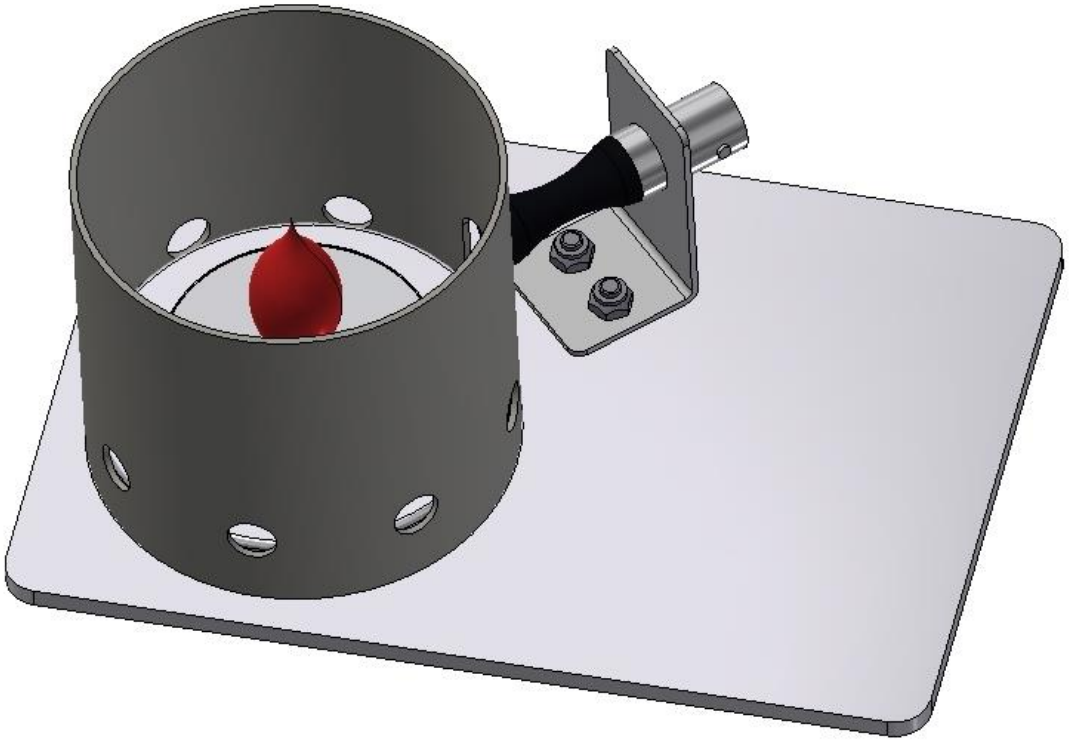
This test shall be conducted according to G 1.0, with the following changes:

A hazard analysis shall be performed by examining the engine fuel component layout to determine probable locations of fuel leaks that may result in a fire.
Permissible fuels are F-35, F-63 or F-54. Engine fuel leak fire simulation tests will be conducted with the fuel pre-heated to 65°C (150°F) and pressurized with nitrogen to 10 psi prior to introduction into the engine compartment via the spray nozzle. The spray flow rate will be determined empirically; however, it will not exceed the maximum possible flow rate through the fuel line. The spray nozzle and igniter will be located near electrical wiring to simulate an electrical short. The spray and igniter will then be remotely started. The fuel spray, ignition source, and engine will remain active for 20 seconds following automatic discharge of the first bottle agent, then discontinued.

The remainder of the test, including the assessment of pass/fail criteria, is conducted according to G 1.0.

ANNEX H – FLAME EXTINCTION TIME DETECTION DEVICE

The flame extinction time detection device shall be manufactured according to the following specification:



Picture 1: View of the flame extinction time detection device

Dimensions of the mounting plate: 130mm x 90mm
Overall height: 65mm
Diameter of the measurement cylinder: 60mm
Material: Steel sheet

Flame: Paraffin wax in an aluminium cup (tea light) with a diameter of 39 mm

Photodetector / light sensor: Area of view covering the complete flame

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