Transport Canada Transports Canada

Advisory Circular

Subject: **Rooftop Heliport Fire Fighting Protection**

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Table of Contents

1.0 INTRODUCTION 2
1.1 Purpose 2
1.2 Applicability 2
1.3 Description of Changes 2
2.0 REFERENCES AND REQUIREMENTS 2
2.1 Reference Documents 2
2.2 Cancelled Documents 3
2.3 Definitions and Abbreviations 3
3.0 BACKGROUND 4
3.1 Performance Based Standards Related to Fire Protection 4
4.0 TOUCHDOWN AND LIFT OFF AREA (TLOF) GENERAL PHYSICAL CHARACTERISTICS RELATED TO FIRE PROTECTION 4
4.1 Specific Rooftop Fire Protection Standards 5
5.0 TLOF SURFACE CONSTRUCTION MATERIALS AND FIRE RESISTANCE 7
6.0 ACCESS AND EGRESS POINTS 8
6.1 Fire Protection along Approach/Departure Pathways 8
7.0 FIXED FOAM SYSTEMS 9
8.0 SUMMARY 11
9.0 INFORMATION MANAGEMENT 11
10.0 DOCUMENT HISTORY 11
11.0 CONTACT OFFICE 11
APPENDIX A — RELEVANT PART III – SUBPART 5 - CANADIAN AVIATION REGULATIONS 12
APPENDIX B — RELEVANT PART III – SUBPART 5 – CARS - STANDARDS 13
APPENDIX C - RELEVANT NFPA 418 - STANDARDS FOR HELIPORTS – 2016 EDITION 16
APPENDIX D – EXTRACT FROM STRUCTURES 2008: CROSS BOARDERS © 19
APPENDIX E – ACCEPTABLE ASTM STANDARD TEST METHODS FOR ALUMINIUM 22
APPENDIX F -- FOAM TEST PARAMETER EXPECTATIONS 25

1.0 Introduction

(1) This Advisory Circular (AC) is provided for information and guidance purposes. It describes an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards. In some cases recommendations and/or best practices are suggested.

1.1 Purpose

(1) The purpose of this document is to reiterate the heliport standards associated with rooftop heliport fire protection as detailed in the *Canadian Aviation Regulations* (CAR) 325 and provide clarification concerning heliport physical design characteristics associated with rooftop heliports.

(2) Guidance is provided concerning the design and composition of rooftop heliport surfaces and support structure with regards to fire protection.

(3) The AC also provides guidance on acceptable means of fire protection on a rooftop heliport and how these means of fire protection can be tested to verify compliance with the standards.

1.2 Applicability

(1) This document applies to all Canadian heliport operators, heliport designers, Transport Canada Civil Aviation (TCCA) Headquarters and regional personnel, and helicopter operators operating into certified heliports.

1.3 Description of Changes

(1) Not applicable.

2.0 References and Requirements

2.1 Reference Documents

(1) It is intended that the following reference materials be used in conjunction with this document:

- (a) Aeronautics Act (R.S., 1985, c. A-2);
- (b) Part III, Subpart 5 of the Canadian Aviation Regulations (CARs) — *Heliports*;
- (c) Standard 325 of the CARs — *Heliport Standards*;
- (d) ICAO – International Standards and Recommended Practices – Annex 14, Volume II – Heliports;
- (e) National Fire Protection Association (NFPA 30) – Flammable and Combustible Liquids Code, 2018 edition;
- (f) National Fire Protection Association (NFPA 99) – Health Care Facilities Code, 2018 edition;
- (g) National Fire Protection Association (NFPA 418) – Standard for Heliports, 2016 edition;
- (h) TP 2586 – Heliport and Helideck Standards and Recommended Practices, 3rd Edition
- (i) UK-CAA – CAP 437 – Standards for offshore helicopter landing areas
- (j) UK-CAA – CAP 1264 – Standards for helicopter landing areas at hospitals.

2.2 Cancelled Documents

(1) Not applicable.

(2) By default, it is understood that the publication of a new issue of a document automatically renders any earlier issues of the same document null and void.

2.3 Definitions and Abbreviations

(1) The following **definitions** are used in this document:

(a) **Elevated heliport** means a heliport elevated more than 75 cm above the normal elevation of the ground. For the purposes of Fire Protection 'elevated' refers to heliports that are on structures such as parking garages (not occupied buildings) and not raised surface level heliports built in a column or pedestal design raised on the ground.

(b) **Emergency landing area** - means an area where an unavoidable landing or ditching may take place with a reasonable expectancy of no injuries to persons or damage to property on the surface.

(c) **FATO** - means a final approach and take-off area, which consists of a defined area over which the final phase of a helicopter approach maneuver to hover or land is completed and from which the take-off maneuver is commenced.

(d) **H1, H2, H3** – Classifications of the heliport approach and take-off surfaces related to the obstacle environment and the availability of emergency landing areas. Determines the performance requirements of the helicopter using the facility.

(e) **Means of Egress** means a continuous path of travel provided for the escape of persons from any point in a *building* or contained open space to a separate *building*, an open public thoroughfare, or an exterior open space protected from fire exposure from the *building* and having access to an open public thoroughfare. *Means of egress* includes *exits* and *access to exits*. (National Building Code of Canada, 2010 edition and National Fire Code of Canada, 2010 edition.)

(f) **Non-combustible** – A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. (NFPA 418, subsection 5.4.1.1(1))

(g) **Non-porous** – means a material that is fuel tight such that there are no leaks and containment is achieved.

(h) **Rooftop Heliport** for the purposes of Fire Protection is any heliport or part thereof, built on or overtop of a structure (building) occupied by persons.

(i) **Storage tank** – For the purposes of containing flammable liquids, compressed gas or liquefied gas – any vessel having a liquid capacity that exceeds 230 L (60 US gal) and is intended for fixed installation. (NFPA 30, subsection 3.3.52.6)

(j) **TLOF** - means a touchdown and lift off area, which consists of a load-bearing area on which a helicopter may touch down or lift off.

(k) V_{TOSS} **–** Take-off Safety Speed for Category 'A' Rotorcraft. The velocity at which point the helicopter can climb at least 100 fpm with one engine inoperative (OEI).

(2) The following **abbreviations** are used in this document:

(a) **ASCE**: American Society of Civil Engineers

(b) **ASTM**: American Society for Testing and Materials

(c) **CAR(s)**: Canadian Aviation Regulations.

(d) **DIFFS**: Deck integrated firefighting system(s).

(e) **FMS:** Fixed Monitor System

(f) **HOM**: Heliport Operations Manual.

(g) **ICAO**: International Civil Aviation Organization.

(h) **NFPA**: National Fire Protection Association.

(i) **RMS:** Ring-Main System (as an alternative to DIFFS or FMS on an existing installation);

(j) **TCCA:** Transport Canada Civil Aviation

(k) **UK - CAA**: Civil Aviation Authority (UK)

3.0 Background

3.1 Performance Based Standards Related to Fire Protection

(1) In 1999 after several years of consultation with industry stakeholders, TCCA introduced, significantly updated voluntary performance based heliport standards to replace the much older prescriptive heliport standards and recommended practices detailed in TP 2586. In June 2007 CARs 305 and the associated Heliport Standards detailed in CARs 325 came in to force. The new regulations recognized the uniqueness of heliports and established a stand-alone structure different from the certified airport regulations (CARs 302). There were significant updates and improvements regarding fire protection especially for rooftop heliports.

(2) Canada, as a signatory of the Chicago Convention on International Civil Aviation, has an obligation to either follow international standards or develop their own standards consistent with international practices. The standards established by ICAO, as detailed in Annex 14 Volume II – Heliport Standards and Recommend Practices predominantly only address the aviation aspects of Rescue Fire Fighting (RFF).

(3) In Canada the notion of ‘Fire Protection’ or more broadly stated ‘RFF” goes beyond the aviation related requirements and incorporates building code and fire code minimum standards especially for rooftop heliports that are built over occupied buildings. The Canadian standards for fire protection at rooftop heliports follow many of the standards and principles outlined in NFPA 418, as such many of the references made within this AC pertain to NFPA 418. There are several differences and additional standards as opposed to the NFPA 418 standards that will also be further detailed in the AC.

(4) The CARs 325 standards are written in a hybrid style; that is to say, prescriptive standards are used when required, usually to establish a minimum baseline in line with the recognized safety parameters usually associated with fire protection and objective standards are used when more than one way could be employed to achieve the required standard. These standards are only an established minimum and if a higher standard is asked by the local fire department, that higher standard will be followed. The intent was for the CARs 325 – Fire Protection standards, to establish a minimum starting point for the buildings’ fire protection, so that heliport designers and builders would not be faced with costly “after the fact” surprises.

4.0 Touchdown and Lift Off Area (TLOF) General physical characteristics related to fire protection

(1) Some generalized standards required for all above ground heliports whether they be elevated or rooftop (as defined for Fire Protection purposes) include:

(a) Drainage from the TLOF shall not allow flammable liquid to enter passenger-holding areas, access points, stairways, elevator shafts, ramps, hatches, or other openings;

(b) The TLOF shall be surrounded by a peripheral berm designed to contain 100 per cent of the fuel capacity of the largest helicopter for which the heliport is certified; and

(c) A raised edge surrounding a TLOF is provided to control fuel, the height of the raised edge shall not be higher than 7.5 cm.

(2) In order to meet the requirement for containing 100% of fuel capacity, a leak-proof trough around the complete exterior perimeter of the TLOF or the Final Approach and Take-Off area (FATO) (if physically larger and supplied) is required. A berm edge can be used in conjunction with a trough set-up to help contain, direct and/or trap the fuel. The berm which can be up to 7.5 cm high can be used along sides of the TLOF/FATO that do not have a trough to direct fuel in a specific direction when incorporated with a slight slope of the TLOF surface.

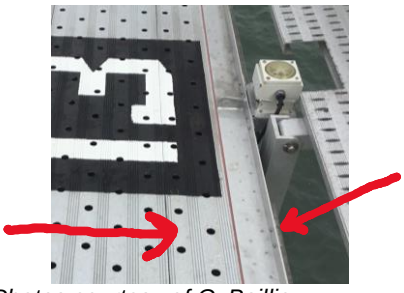
(3) Most rooftop installations include drainage pipes below the heliport surface and include a collection tank that may contain a fuel/water separator. A collection tank is not necessarily required if the trough/drainage pipes are designed for the maximum fuel containment. The requirement for a collection tank and/or separator, although not a specific requirement under the CARs may be dictated by local environmental regulations. The purpose of 100% containment is to ensure that fuel (burning or otherwise) cannot reach the roof of the building below the heliport surface. The trough should be wide enough and at least at the same height of the TLOF/FATO surface so that fuel cannot flow or splash over the trough. A grated perforated cover can also be used over the trough, especially in areas of the ramps, stairways, access points, etc.

Note: the requirement for a 100% fuel containment (leak-proof) with or without a peripheral berm is not a requirement stated in the NFPA 418 standard. It is however a CARs requirement and is consistent with recognized international standards.



Photos courtesy of C. Baillie

Example of a fuel containment trough at the Outer edge of the TLOF



Photos courtesy of C. Baillie

Fuel containment trough under perforated cover combined with 2 cm high outer berm

4.1 Specific Rooftop Fire Protection Standards

(1) The following lists some of the more specific standards required only for rooftop heliports; those heliports overtop occupied structures:

(a) main structural support beams[1] that could be exposed to a fuel spill have a fire-resistance rating of not less than 2 hours;

[1] NFPA 418 section 5.2, uses the term 'main structural support members' that includes both horizontal beams and vertical columns. The intent of the CAR Heliport Standard was to include all structural members.

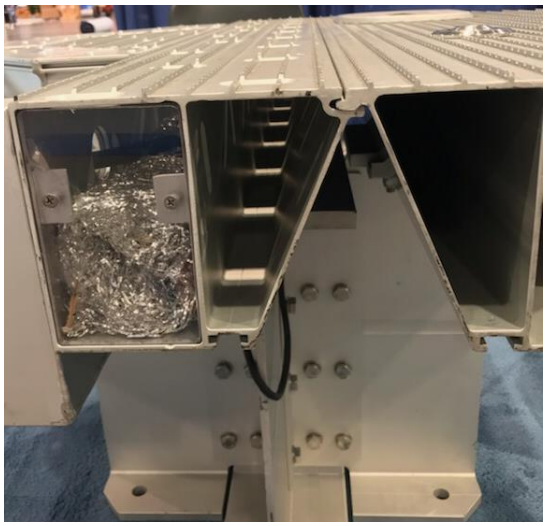
(b) the TLOF be pitched to provide drainage that flows away from passenger holding areas, access points, stairways, elevator shafts, ramps, hatches, and other openings not designed to collect drainage; and

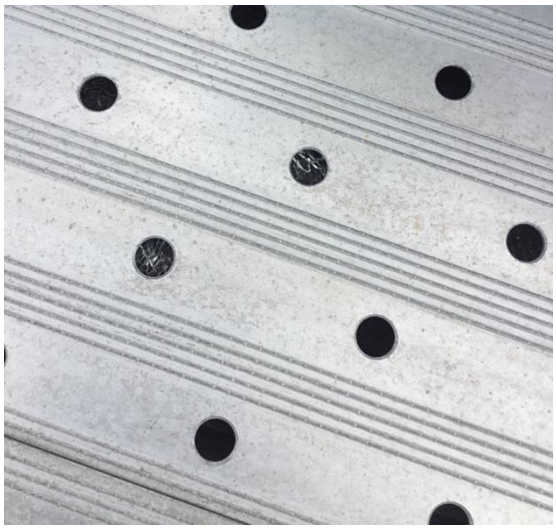
(c) the TLOF surface be constructed of non-combustible, nonporous materials.

(2) Traditionally rooftop heliports were built with concrete (usually reinforced) and/or steel or a combination of these products. Concrete and steel, by its' nature, are considered non-combustible and nonporous thus no specific fire rating is provided.[2] Section 5.0 further details acceptable materials for heliport surface and support structures.

(3) Most rooftop TLOFs are pitched between 0.5% and 1.0% (the standard allows for a maximum of 2%) to assist with fuel drainage and may even be grooved. Even though a TLOF surface may be pitched and/or grooved, it does not alleviate the requirement for a complete trough and/or berm combination around the TLOF as described in section 4.1. A ruptured helicopter fuel tank can slosh fuel up and over a 1 to 2% pitched slope (without a trough or berm).

(4) Nonporous materials means no leaks (fuel-tight), the fuel must be contained. Thus joining materials either between surface joints or between differing materials also needs to be non-combustible and nonporous. Fuel cannot be able to seep to the support structure or the rooftop below the heliport surface. A passive fire-retarding system consisting of a perforated or grated surface, which, in the event of a fuel spill from a ruptured helicopter tank, is capable of removing significant quantities of un-burned fuel, water and foam, and is fuel-tight, would be considered as an acceptable surface structure.





Photos courtesy of Bayards Aluminium Contructies B.V. The Netherlands (Note: There are several other manufactures of similar systems that may be acceptable.)

(5) The intent is for all current certified rooftop heliports to be constructed of non-combustible, nonporous materials. If a TLOF surface material used [at an existing certified heliport] is not inherently non-combustible or does not meet any of the recognized testing standards detailed in section 5.0, then the support structure for the heliport needs to have a 2 hour fire resistance rating. This can be obtained by either the structural materials having a 2 hours resistance rating or by using a material attached to the support structure that has a 2 hour fire resistance rating. The intent is for the heliport surface to withstand burning or the support structure to withstand a failure and possible collapse of the helipad, to allow for occupants of the building below the heliport to evacuate. This is a building and fire code requirement. If this condition can be obtained

[2] NFPA 418 section 5.4, plus explanatory notes, states that aluminum is NOT automatically accepted as non-combustible.

then an Equivalent Level of Safety or 'modification of standards' may be considered[3]. (Regional Aerodromes Inspectors can assist with this process.)

(6) Should the surface not be considered non-combustible (meets approved test standards) and the support structures for the TLOF/FATO do not have a 2 hour fire resistance rating then a site specific exemption may be considered if other risk mitigation factors are used, such as a class 'A' (2 hr. resistance rating) for the rooftop surface below the heliport. An exemption will only be considered for existing heliports and will not apply to future built rooftop heliports. An exemption is not to be used as a means of non-compliance for an initial certification. The national exemption that addressed this option has not been renewed and expired 15 March 2019. When an Equivalent Level of Safety has been met, the process detailed in SI 302-001 will be followed, otherwise a full exemption process will apply when an Equivalent Level of Safety has not necessarily been met.

5.0 TLOF Surface construction materials and fire resistance

(1) As was stated above, traditionally rooftop heliports have been built with concrete (usually reinforced) and/or steel or a combination of these products. Concrete and steel, by its' nature, are considered non-combustible and nonporous thus no specific fire rating is provided[4]. Appendix C is an extract from a study from the American Society of Civil Engineers (ASCE) reviewing the fire resistance of various concrete mixtures related to time and thickness. Most concrete rooftop heliports in Canada have been built to accommodate the Sikorsky 76 series, Bell 212/412 series or the AW 139 helicopters. As indicated in the study, even a siliceous aggregate mix would be considered as non-combustible and would also have a 2 hour fire resistance rating at only 5 inches thick. Heliports in Canada are usually built with a combination of steel (for infrastructure) and concrete thus the actual thickness of the concrete and its combined fire resistance timeframe with the steel can be difficult to calculate. The CARs heliport standard only requires the TLOF surface to be non-combustible and nonporous. Concrete rooftop heliports designed for all helicopters should have the concrete mixture and thickness verified to determine that the material is non-combustible.

(2) More recently, rooftop heliports have been built with the surface material being an aluminium alloy. Although this is relatively new for rooftop heliports in Canada, it has existed in the offshore Helideck design and construction for many years. There are many advantages, such as significant weight reduction and reduced construction timeframes that are making the aluminium alloy construction a viable option. The aluminium association (in the USA) has performed ASTM E 136 tests on alloys AA-6061 and AA-5083. (See Appendix E – Acceptable ASTM standard test methods for Aluminium). These have been proven to meet the requirements as detailed in NFPA 418, to be considered as non-combustible. The European (alloy) equivalents like AA-6082, AA-6005 and AA-6063, have similar properties as AA-6061. The Canadian equivalent test is CAN4-S114-M80, Standard Method of Test for Determination of Non-Combustibility in Building Materials. Any designer or builder using an aluminium alloy for the surface of the TLOF/FATO would be required to provide an attestation showing a recognised test standard and verification that the materials used are tested as non-combustible. Not all aluminium alloys are automatically

[3] Staff Instruction (SI) 302-001, Assessment and Issuance of Conditions to an Airport or Heliport Certificate provides guidance to regional inspectors on the process to follow in order to meet these conditions.

[4] NFPA 418: Standards for Heliports (2016 Edition), Annex A, section A.5.4.1.1 states in part that the provisions of these standards do not require inherently non-combustible materials to be tested in order to be classified as non-combustible materials. A.5.4.1.1 (1) further states that examples of such materials include steel, concrete, masonry and glass.

considered as non-combustible. There are currently several worldwide helideck/heliport designers/builders that build to these standards.

6.0 Access and Egress points

(1) CAR 325.46(2) states more specific standards that are required only for rooftop heliports; those heliports overtop occupied structures. Some of those standards include:

(a) at least two means of egress from the TLOF be provided;

(b) the helicopter rooftop landing pad have at least two access points that provide rapid access to fire-fighting personnel;

(c) where buildings are provided with a fire alarm system, a manual pull station be provided near each designated means of egress from the roof; and

(d) no smoking signs be erected at access and egress points of the heliport.

(2) For the purposes of this standard, the main walkway or ramp to the TLOF/FATO used for the passenger/patient and equipment transfer is considered to be one of the two required access/egress points. Although not specifically stated (in CAR 325) the second egress point should be at least 90 degrees from each other as measured from the center of the TLOF. The egress points should be located remotely from each other, not less than 9.1 m (30 ft) apart, and no two egress points should be located on the same side of the TLOF/FATO. (NFPA 418, section 5.5.1, 5.5.2 & 5.5.3) Although these are not specific requirements in the Canadian heliport standards they are recommended as points of best practice. Even though the Building Code definition for 'means of egress' is specific, for the heliport standards, the means of egress is simply, immediate exit from the TLOF. Local and/or National Building Codes vary and may detail additional egress from the roof requirements (beyond the TLOF). Conversely the codes may have reduced egress requirements from the roof, usually dictated by building occupancy levels.

(3) As stated in CAR 325.25(3) the heliport surface shall be pitched away from the egress points. If a passive fire-retarding system as described in section 4.1 is utilized, the heliport surface need not be pitched. (NFPA 418, section 5.3.3)

6.1 Fire Protection along Approach/Departure Pathways

(1) CAR 325.46(2) states more specific standards that are required only for rooftop heliports; those heliports overtop occupied structures. Some of these additional standards include:

(a) flammable liquids,

(b) compressed gas, and

(c) liquefied gas shall not be permitted within the approach/departure path.

(2) Although this standard is associated specifically to rooftop heliports, it should be equally applied to surface level and elevated heliports. Once again, the purpose is to be protecting persons or property on the ground. This is in line with the definition of a suitable emergency landing area and also conforms to the requirements established by NFPA 418 (section 4.3), NFPA 30[5] and NFPA 99[6]. In order to meet these requirements, if this situation arises, three options exist: move or

[5] NFPA 30: Flammable and Combustible Code (2018 edition), section 22.15 Collision Protection for Aboveground Storage Tanks. Where a tank is exposed to vehicular impact, protection shall be provided to prevent damage to the tank.

[6] NFPA 99: Health Care Facilities Code (2018 edition), section 11.7 Liquid Oxygen Equipment, subsection 11.7.3 Container Storage, Use and Operation, paragraph 11.7.3.2 Containers shall not be placed in the following areas: (3) Where they are subject to damage from falling objects. Also paragraph 11.6.2.3 Cylinders shall be protected from

remove the storage tanks, re-align the approach and take-off surface pathway, or protect the tanks (and their associated pipelines) from possible damage.

(3) The intent of this standard is to address storage tanks (and their associated pipelines) usually associated with the heliport facility and within close proximity (150m). It does not include parked or transiting vehicles, below surface pipelines and residential propane tanks or BBQ propane tanks.

(4) Although this standard does not differentiate between the classifications (H1, H2 and/or H3) of the approach/takeoff pathways, clarification is required as to the intent of the standard and some guidance regarding distances to be assessed. Discussions with local Fire Marshals have indicated that the provision to 'protect' tanks holding flammable liquids or gases does not differentiate between the potential of damage from ground occurrences or from air occurrences. The heliport standard (325.46(2)(h)) does not provide prescriptive defined boundaries and unfortunately both the Canadian National Fire Code and Building Code as well as the NFPA, do not provide further useful criteria, thus a common sense, practical approach is required.

(5) For all heliports with approach/take-off pathways classified as H1, H2 and/or H3, the first 150m (below the pathways) originating from the outer edge of the FATO and within the confines of the identified approach/take-off pathway width shall be free of storage tanks (and their associated pipelines) or any other above ground pipelines containing flammable, compressed or liquefied gases. The 150m dimension falls within the specific terms of Standard 325.46(2)(h) and represents the most critical portion of the approach/take-off pathway surface. The dimension also represents the average distance required for a single engine helicopter to be able to reach emergency landing areas spaced further apart along the remainder of the identified approach/take-off pathway. In addition, it is the average distance required for a multi-engine helicopter conducting a Category 'A' departure profile to reach its V_{TOSS} velocity. The 150m length corresponds with the assessment distance required for the marking and lighting of obstacles, thus should be relatively easy to add to the assessment process.

(6) Beyond 150m H1 classified approach/take-off pathways do not require additional assessment for storage tank (and their associated pipeline) locations as it is assumed that the multi-engine helicopter should be able to deal with emergencies and fly away without impacting surface based storage tanks. H2 and H3 classified approach/take-off pathways from 150m out to 625m should have no storage tanks (and their associated pipelines) or any other above ground pipelines within the identified emergency landing areas or within 15m of the outer edge of the identified emergency landing area. The 15m distance corresponds with Standard 325.46(1)(a) that requires a distance separation from the other edge of the FATO and storage tanks.

7.0 Fixed foam systems

(1) CAR 325.47 details the requirements for extinguishing agents and equipment. Most rooftop heliports in Canada are designed to handle helicopters greater than 15 m in length, thus the rooftop requires either a foam hose line capable of producing a foam solution of 325 L/min. for at least 2 minutes or a fixed foam system capable of producing 4.1 L/min. per m^2 for total landing pad surface coverage for 5 minutes. Standard 325.47(2) states that the foam concentrate conform to CAN/ULC-S560 specifications[7]. This is a Category 3 application used for aircraft rescue firefighting and includes all Category 1 applications. Currently no other foam concentrates are acceptable. [Appendix F details the Foam Test Parameter Expectations.] The

damage by means of the following specific procedure: (2) Oxygen cylinders shall not be stored near elevators or gangways or in locations where heavy moving objects will strike them or fall on them.

[7] Underwriters' Laboratories of Canada (ULC), Standards Bulletin 2006-09 expands upon the definition of CAN/ULC-S560-06 – Standard for Category 3 Aqueous Film-Forming Foam (AFFF) Liquid Concentrates.

designer/installer of the foam systems is to provide verification (i.e. an attestation or affidavit) confirming that the installed system meets the required standards.

(2) The performance standard allows for any assortment of foam application equipment systems to achieve the foam output levels. (NFPA 418, section 5.7.2.4) They include a Ring Main-system (RMS) that utilizes multiple fixed located nozzles along each side of the TLOF/FATO outer perimeter usually all attached to single or multiple pipes to transfer the foam solution.

(3) A Fixed Monitor System (FMS) is also fairly common. Two (2) or more monitors are required that oscillate, and in some cases can be remotely operated. It has been found that a single monitor cannot either provide the foam output levels or the landing pad coverage. When employing an FMS, consideration should be taken to place individual monitors on opposite sides of the TLOF/FATO as this would facilitate adequate surface coverage during varying wind conditions. (NFPA 418, section 5.7.2.2) In addition, as FMS monitors discharge at very high pressure volumes, care needs to be taken when establishing the angle limits of oscillation so as to not impede access and egress points. This is verified for compliance at initial certification.

(4) Deck integrated Fire Fighting Systems (DIFFS) consisting of pop up valves located across the TLOF surface have been used in the offshore Helideck environment for many years and have recently been introduced for use at rooftop heliports in several international locations including the UK, Italy, Germany and Australia. This type of system can be used either on a solid surface or incorporated with the passive fire-retarding system. The DIFFS is considered as an acceptable means of foam application within Canada.

(5) Below are examples of several foam application systems currently in use around the world.



Photos courtesy of C. Baillie
Pop up valve from a DIFFS



Photos courtesy of C. Baillie
Complete DIFFS on a solid surface



Photos courtesy of C. Baillie
RMS with 2 valves per side



Photos courtesy of C. Baillie
Remote controlled FMS

8.0 Summary

(1) There are a number of unique Canadian standards that incorporate building code and fire code requirements. Many of these standards are universally adopted in other countries. There are several prescriptive standards, such as foam discharge rates and there are several performance based standards such as foam application method, that allow for flexibility within the standards.

(2) The extensive list of Appendices is to help provide guidance in a number of technical areas directly or indirectly referenced within the standards.

(3) The Fire Protection standards first and foremost are designed to protect occupants of the structure or building below the rooftop heliport and as a secondary benefit, aid in extinguishing the fire on the heliport to allow for crew and passengers to exit the helicopter safely or for rescue crew to access the helicopter safely.

9.0 Information management

(1) Not applicable

10.0 Document history

(1) Not applicable

11.0 Contact office

For more information, please contact:

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E-mail: TC.Flights.Standards-Normesdevol.TC@tc.gc.ca

We invite suggestions for amendment to this document. Submit your comments to:

Civil Aviation Communications Centre - Centre de communications de l'Aviation civile

services@tc.gc.ca

Original signed by Pierre Ruel for

Robert Sincennes
Director, Standards
Civil Aviation

Appendix A — Relevant Part III – Subpart 5 - Canadian Aviation Regulations

Division V — Physical Characteristics

305.25 (4) The operator of an elevated or rooftop heliport shall ensure that the heliport meets the special requirements for an elevated or rooftop heliport set out in the applicable heliport standard in respect of

(*a*) TLOFs;

Division XIII — Emergency and Other Services

Fire Protection Services

305.46 (1) The operator of a surface-level heliport or of a heliport over a parking garage or on an elevated structure that is not an occupied building shall ensure that fire protection services are provided at the heliport and that those services and the fire resistance of the structure meets the requirements of the applicable heliport standard.

(2) The operator of a rooftop heliport shall ensure that fire protection services are provided at the heliport and that those services and the fire resistance of the structure meets the requirements of the applicable heliport standard.

Extinguishing Agents and Equipment

305.47 The operator of a heliport shall

(*a*) determine the requirements for extinguishing agents and equipment used for fire protection at the heliport based on the longest dimension helicopter for which the heliport has been certified;

(*b*) ensure that the agents and equipment are in accordance with the applicable heliport standard; and(*c*) provide a fire extinguisher or firefighting system that is protected from freezing.

Appendix B — Relevant Part III – Subpart 5 – CARs - Standards

325.25 Physical Characteristics

Special Requirements for Elevated/Rooftop Heliports

CAR 325.25(3) For the purposes of subsection 305.25(4) of the *Canadian Aviation Regulations*, the following constitutes the special requirements for Elevated/Rooftop heliports*:*

(a) in addition to the technical specifications already set out in paragraph 325.25(1)(*e*), the requirements for TLOF are the following:

(v) drainage from the TLOF shall not allow flammable liquid to enter passenger-holding areas, access points, stairways, elevator shafts, ramps, hatches, or other openings,

(vi) where, as specified in the HOM, no other measures have been taken to reduce fire hazard caused by fuel spillage, TLOF shall be surrounded by a peripheral berm designed to contain 100 per cent of the fuel capacity of the largest helicopter for which the heliport is certified, and

(vii) where, as specified in the HOM, a raised edge surrounding a TLOF is provided to control fuel, the height of the raised edge shall not be higher than 7.5 cm;

325.46 *Fire Protection*

CAR 325.46(2) For the purposes of subsection 305.46(2) of the *Canadian Aviation Regulations,* the requirements in respect of fire protection for a rooftop heliport, are the following:

(a) main structural support beams that could be exposed to a fuel spill shall have a fire-resistance rating of not less than 2 hours;

(b) the TLOF shall be pitched to provide drainage that flows away from passenger holding areas, access points, stairways, elevator shafts, ramps, hatches, and other openings not designed to collect drainage;

(c) the TLOF surface shall be constructed of non-combustible, nonporous materials;

(d) at least two means of egress from the TLOF shall be provided;

(e) the helicopter rooftop landing pad shall have at least two access points that provide rapid access to fire-fighting personnel;

(f) where buildings are provided with a fire alarm system, a manual pull station shall be provided near each designated means of egress from the roof;

(g) no smoking signs shall be erected at access and egress points of the heliport; and

(h) flammable liquids, compressed gas, and liquefied gas shall not be permitted within the approach/departure path.

325.47 *Extinguishing Agents and Equipment*

(1) For the purposes of subsection 305.47(1) of the *Canadian Aviation Regulations*, the performance standards for firefighting equipment and agents based on the longest helicopter for which the heliport is certified are the following:

Helicopter overall length	Surface level and elevated Heliports	Rooftop Heliports
Up to but not including 15m	***Extinguisher with a minimum rating of 4-A: 80-B**	***Extinguisher with a minimum rating of 40-A: 320-B** ***or*** **Hose line capable of producing a foam solution at 150 L/min. for a minimum of two minutes** ***or*** **Foam fixed system capable of producing 4.1 L/min. per m^2 and covering the entire roof landing pad for 5 minutes**
15m and up to but not including 25m	***Extinguisher with a minimum rating of 10-A:120-B**	**Hose line capable of producing a foam solution at 325 L/min. for a minimum of two minutes** ***or*** **Foam fixed system capable of producing 4.1 L/min. per m^2 and covering entire roof landing pad for 5 minutes**
25m and up to but not including 35m	***Extinguisher with a minimum rating of 30-A: 240-B**	**Hose line capable of producing a foam solution at 1000 L/min. for a minimum of two minutes** ***or*** **Foam fixed system capable of producing 4.1 L/min. per m^2 and covering the entire roof-landing pad for 5 minutes.**
**** One or more extinguishers or systems may satisfy the requirements.*** NOTE: Extinguisher ratings are according to certification testing under the applicable Underwriter Laboratory of Canada (ULC) Standard.		

(2) For the purposes of subsection 305.47(2) of the *Canadian Aviation regulations*, the requirements in respect of extinguishing agents are the following:

(a) where foam concentrates is provided as an extinguishing agent, it shall

(i) comply with the specifications of the Underwriters Laboratory of Canada (CAN-ULC S560), and

(ii) be suitable for the type of equipment to be used at the heliport;

(b) where foam concentrates of different types or from different manufacturers are provided as extinguishing agents, they shall not be mixed unless the Underwriters Laboratory of Canada has established, under the applicable ULC Standard, that they are completely interchangeable and compatible;

(c) where dry chemical is provided as an extinguishing agent it shall

(i) comply with the specifications of the Underwriters Laboratory of Canada (CAN-ULC S514), and

(ii) be suitable for the type of equipment to be used and compatible with the foam selected at the heliport; and

(d) where there is any possibility that a firefighting extinguisher or a system will freeze, freeze protection shall be provided.

Appendix C - Relevant NFPA 418 - Standards for heliports – 2016 edition

Chapter 4 General Requirements – Land-Based Facilities

4.1 General. The requirements in this chapter shall apply to all land-based facilities. *(See Chapter 8 for requirements applying to offshore heliports.)*

4.3 Tank and Equipment Locations

4.3.1 Storage, handling and use of flammable and combustible liquids shall be in accordance with NFPA 30.

4.3.2 Oxygen and other medical gases shall be stored and used in accordance with NFPA 99.

4.3.3 Aboveground flammable liquid storage tanks, compressed gas storage tanks, fuel storage tanks, and liquefied gas storage tanks shall be laterally located at least 50 ft (15.2 m) from the edge of the FATO area as defined in FAA AC 150/5390-2C, *Heliport Design Advisory Circular.*

4.8* Means of Egress. At least two means of egress that lead to a public way shall be provided from the landing pad.

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Chapter 5 Rooftop Landing Facilities

5.1 General. The requirements in Chapter 4 and 5 shall apply to all rooftop landing facilities.

5.2* Structural Support. Main structural support members that could be exposed to a fuel spill shall be made fire resistant using listed materials and methods to provide a fire-resistance rating of not less than 2 hours.

5.3 Landing Pad Pitch. The rooftop landing pad shall be pitched to provide drainage at a slope of 0.5 percent to 2 percent.

5.3.1 The pitch of the pad shall be designed to protect, at a minimum, the primary egress path, passenger holding area, rooftop hanger, and fire protection activation system.

5.3.2 Drainage flow shall not penetrate alternate egress points, stairways, ramps, hatches, and other openings not designed for drainage.

5.3.3 The pitch of the pad shall not be required where the pad consists of a passive fire protection grid surface designed and listed for fuel catchment and containment.

5.4 Landing Pad Construction Materials.

5.4.1 The rooftop landing pad surface shall be constructed of approved noncombustible, nonporous materials.

5.4.1.1* A material that complies with any of the following shall be considered a noncombustible material:

(1)* A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat

(2) A material that is reported as passing ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*

(3) A material that is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, *Standard Test Method for Behavior of Materials in a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*

[NFPA 101, 2015 edition]

5.4.2 The contiguous building roof covering within 50 ft (15.2 m) of the landing pad edge shall have a Class A fire resistance rating for exterior fire exposure, and shall be tested according to FM 4470, *Approval for Class 1 Roof Covers,* ANSI/UL 790, *Standard Test Methods for Fire Tests of Roof Covering,* or ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings.*

5.5* Means of Egress. Two means of egress from the rooftop landing pad to the building's egress system shall be provided.

5.5.1* The egress points shall be located at least 90 degrees from each other as measured from the center of the landing pad (TLOF).

5.5.2 The egress points shall be remotely located from each other, not less than 30 ft (9.1 m) apart.

5.5.3 No two egress points shall be located on the same side of the rooftop landing pad.

5.5.4* Means of egress from the landing pad shall not obstruct flight operations.

5.7 Fire Protection

5.7.1.2* The foam discharge rate for the fire-extinguishing system shall be 0.10 gpm/ft^2 (4.1 L/min·m^2) for aqueous film forming foam (AFFF).

5.7.2 Fixed Foam Fire-Extinguishing System

5.7.2.1 Fixed foam fire-extinguishing systems shall be designed and installed in accordance with NFPA 11, NFPA 16, or an equivalent standard, as appropriate, except as modified by this chapter.

5.7.2.2* The area of application of foam discharge for fixed discharge outlet systems shall be the entire rooftop landing pad.

5.7.2.3 The duration of foam discharge for the fixed discharge outlet system shall be 10 minutes. *[Note: This was increased from 5 minutes in the 2011 edition. An amendment in 2019 will reduce the 10 minutes back to 5 minutes.]*

5.7.2.4 A fixed nozzle discharge outlet system shall be one of the following: fixed stationary nozzles around the perimeter, two or more oscillating monitors/nozzles, or in-deck nozzles within the perimeter of the deck.

5.7.2.5 Where fixed foam systems utilizing fixed deck nozzles or oscillating foam turrets, or both, are installed, system components shall be listed or approved.

5.7.8 Acceptance Testing.

5.7.8.1 Fixed Foam Fire-Extinguishing Systems. The fixed foam discharge outlet system shall be tested with foam to determine the coverage of the rooftop landing pad.

5.7.8.1.1 The system shall cover 95 percent of the rooftop landing pad during the test.

5.7.8.1.2 The access points for firefighting and for egress shall be covered.

Annex A (NFPA 418) Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.4.8 The two means of egress can also be used for access to the landing pad for fire-fighting and / or rescue operations. Where doors accessing the interior of the building are locked, an approved means should be provided for entry of emergency responders.

A.5.2 Where the landing pad is nonporous, fuel-tight, and provided with a proper drainage system, and where fuel cannot flow to support members, the main structural support members would not need to be fire rated.

A.5.4.1.1 The provisions of 5.4.1.1 do not require inherently noncombustible materials to be tested in order to be classified as noncombustible materials. [NFPA 101, 2015 edition]

A.5.4.1.1 (1) Examples of such materials include steel, concrete, masonry, and glass. [NFPA 101, 2015 edition]

A.5.5 Design of the means of egress from a rooftop landing pad might involve a compromise among several different code requirements. Rooftop landing pads bring with them an inherent risk. The means of egress must be provided for safety to human life. Strict compliance with a code's requirements for rated stairways off the landing pad is not the intent of this standard. The intent of this standard is to provide a minimum safeguard to provide a reasonable degree of safety to all persons on the roof. The building's egress system is dictated by the adopted building code. Once those persons enter the building's egress system, they are away from the FATO area.

A.5.5.4 When considering the means of egress from the landing pad and for the rooftop, obstructions to the FATO need to be avoided since they can create unsafe flight conditions that have been shown to cause aircraft accidents. Exterior, open stairways leading to the building's egress system should not encroach into the FATO.

A.5.7.2.2 Consideration should be given to the environmental conditions of the rooftop landing pad in the design of the system, including wind, exhaust fans, and other factors that affect the distribution of the foam on the rooftop landing pad.

Appendix D – Extract from Structures 2008: Cross Boarders ©

ASCE Fire and Concrete Structures Paper[8]

This paper provides structural engineers with a summary of the complex behavior of structures in fire and the simplified techniques which have been used successfully for many years to design concrete structures to resist the effects of severe fires.

One of the advantages of concrete over other building materials is its inherent fire-resistive properties; however, concrete structures must still be designed for fire effects. Structural components still must be able to withstand dead and live loads without collapse even though the rise in temperature causes a decrease in the strength and modulus of elasticity for concrete and steel reinforcement.

In the design of structures, building code requirements for fire resistance are sometimes overlooked and this may lead to costly mistakes. It is not uncommon, to find that a concrete slab floor system may require a smaller thickness to satisfy ACI 318 strength requirements than the thickness required by a building code for a 2-hour fire resistance. For sound and safe design, fire considerations must, be part of the preliminary design stage.

Determining the fire rating for a structure member, can vary in complexity from extracting the relevant rating using a simple table to a fairly complex and elaborate analysis. In the United States, structural design for fire safety is based on prescriptive approach.

Concrete

The change in concrete properties due to high temperature depends on the type of coarse aggregate used. Aggregate used in concrete can be classified into three types: carbonate, siliceous and lightweight. Carbonate aggregates include limestone and dolomite. Siliceous aggregate include materials consisting of silica and include granite and sandstone. Lightweight aggregates are usually manufactured by heating shale, slate, or clay.

Steel

Reinforcing steel is much more sensitive to high temperatures than concrete. Hot-rolled steels (reinforcing bars) retain much of their yield strength up to about 800 °F, while cold-drawn steels (prestressing strands) begin to lose strength at about 500 °F. Fire resistance ratings therefore vary between prestressed and non-prestressed elements, as well as for different types of concrete.

Fire Resistance Rating

Fire resistance can be defined as the ability of structural elements to withstand fire or to give protection from it. This includes the ability to confine a fire or to continue to perform a given structural function, or both. Fire Resistance Rating (or fire rating), is defined as the duration of time that an assembly (roof, floor, beam, wall, or column) can endure a “standard fire” as defined in ASTM E 119 (American Society of Testing and Material – Building Construction and Materials).

[8] David N. Below, P.E., S.E., and Mahmoud E. Kamari, PhD.

Fire Endurance of Structures

Figure 5 shows the effect of fire on the resistance of a simply supported reinforced concrete slab. If the bottom side of the slab is subjected to fire, the strength of the concrete and the reinforcing steel will decrease as the temperature increase. However, it can take up to three hours for the heat to penetrate through the concrete cover to the steel reinforcement. As the strength of the steel reinforcement decreases, the moment capacity of the slab decreases. When the moment capacity of the slab is reduced to the magnitude of the moment caused by the applied load, flexural collapse will occur. It is important to point out that duration of fire until the reinforcing steel reaches the critical strength depends on the protection to the reinforcement provided by the concrete cover.

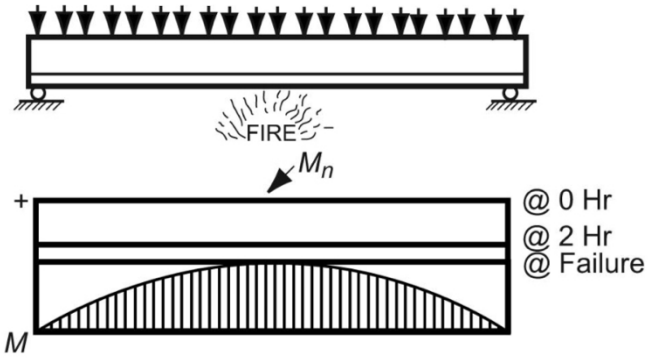


Figure 5 Effect of fire on the resistance of a simply supported reinforced concrete slab

ACI 216 Method

Although testing according to ASTM E 119 is probably the most reliable method, the time and expense required to build and test the assemblies makes this method impractical and is actually unnecessary for most situations. The methods contained in ACI 216.1 (2) are based on fire research performed from 1958 through 2005 and are by far the most commonly used in typical design situations. The fire resistance (based on the heat transmission end point) of a concrete member or assembly is found by calculating the equivalent thickness for the assembly and then finding the corresponding rating in the charts and tables provided. The equivalent thickness of solid walls and slabs with flat surfaces is the actual thickness.

Thickness Requirements

Test results show that fire resistance in concrete structures will vary in relation to the type of aggregate used. Table 1 shows a summary of the minimum thickness requirements for floor slabs and cast in place walls for different concrete types and for different fire resistance ratings.

Table 1 Minimum thickness for cast in place floor and roof slabs, in.

	Fire resistance rating				
Concrete type	1 hr.	1.5 hr.	2 hr.	3 hr	4 hr.
Siliceous aggregate	3.5	4.3	5.0	6.2	7.0
Carbonate aggregate	3.2	4.0	4.6	5.7	6.6
Sand-lightweight	2.7	3.3	3.8	4.6	5.4
Lightweight	2.5	3.1	3.6	4.4	5.1

Conclusion

Concrete's excellent fire resistance has been proven by many tests performed for over 60 years. The American Concrete Institute and various building codes have developed prescriptive and analytical methods based on the fire tests on concrete components of structures. These methods provide architects and engineer a relatively easy way to select member proportions and reinforcement requirements for all but the very unusual structures. For the very unusual structures, alternate methods are available to adequately model or to test the complex behaviour of reinforced concrete components subject to fire.

Appendix E – Acceptable ASTM Standard test methods for aluminium

The two standard test methods summarized in this appendix are the accepted and referenced standards in NFPA 418.

ASTM E136 - 16a

Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C

Significance and Use

5.1 While actual building fire exposure conditions are not duplicated, this test method will assist in indicating those materials which do not act to aid combustion or add appreciable heat to an ambient fire.

5.2 Materials passing the test are permitted limited flaming and other indications of combustion.

1. Scope

1.1 This fire-test-response test method covers the determination under specified laboratory conditions of combustion characteristics of building materials.

1.2 Limitations of this fire-test response test method are shown below.

1.2.1 This test method does not apply to laminated or coated materials.

1.2.2 This test method is not suitable or satisfactory for materials that soften, flow, melt, intumesce or otherwise separate from the measuring thermocouple.

1.2.3 This test method does not provide a measure of an intrinsic property.

1.2.4 This test method does not provide a quantitative measure of heat generation or combustibility; it simply serves as a test method with selected (end point) measures of combustibility.

1.2.5 The test method does not measure the self-heating tendencies of materials.

1.2.6 In this test method materials are not being tested in the nature and form used in building applications. The test specimen consists of a small, specified volume that is either *(1)* cut from a thick sheet; *(2)* assembled from multiple thicknesses of thin sheets; or *(3)* placed in a container if composed of granular powder or loose-fiber materials.

1.2.7 Results from this test method apply to the specific test apparatus and test conditions and are likely to vary when changes are made to one or more of the following: *(1)* the size, shape, and arrangement of the specimen; *(2)* the distribution of organic content; *(3)* the exposure temperature; *(4)* the air supply; *(5)* the location of thermocouples.

1.3 This test method includes two options, both of which use a furnace to expose test specimens of building materials to a temperature of 750°C (1382°F).

1.3.1 The furnace for the apparatus for Option A consists of a ceramic tube containing an electric heating coil, and two concentric vertical refractory tubes.

1.3.2 The furnace for the apparatus for Option B (Test Method E2652) consists of an enclosed refractory tube surrounded by a heating coil with a cone-shaped airflow stabilizer.

1.4 This test method references notes and footnotes that provide explanatory information. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this test method.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.6 This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire-hazard or fire-risk assessment of the materials, products, or assemblies under actual fire conditions.

1.7 Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

ASTM E2652 - 18

Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C

Significance and Use

5.1 While actual building fire exposure conditions are not duplicated, this test method will assist in indicating those materials which do not act to aid combustion or add appreciable heat to an ambient fire.

5.2 This test method does not apply to laminated or coated materials.

5.3 This test method is technically equivalent to ISO 1182.

5.4 When appropriate pass/fail criteria are applied, materials that are reported as passing this test by complying with those criteria (such as the ones in Appendix X2) are typically classified as noncombustible materials.

1. Scope

1.1 This fire-test-response test method covers the determination under specified laboratory conditions of the combustibility of building materials. Under certain conditions, with the appropriate pass/fail criteria, the results from this test are used to classify materials as noncombustible materials.

1.2 Limitations of this fire-test response test method are shown below.

1.2.1 This test method does not apply to laminated or coated materials.

1.2.2 This test method is not suitable or satisfactory for materials that soften, flow, melt, intumesce or otherwise separate from the measuring thermocouple.

1.2.3 This test method does not provide a measure of an intrinsic property.

1.2.4 This test method does not provide a quantitative measure of heat generation or combustibility; it simply serves as a test method with selected (end point) measures of combustibility.

1.2.5 This test method does not measure the self-heating tendencies of materials.

1.2.6 In this test method materials are not being tested in the nature and form used in building applications. The test specimen consists of a small, specified volume that is either *(1)* cut from a thick sheet; *(2)* assembled from multiple thicknesses of thin sheets; or *(3)* placed in a container if composed of granular powder or loose fiber materials.

1.2.7 Results from this test method apply to the specific test apparatus and test conditions and are likely to vary when changes are made to one or more of the following: *(1)* the size, shape, and arrangement of the specimen; *(2)* the distribution of organics content; *(3)* the exposure temperature; *(4)* the air supply; *(5)* the location of thermocouples.

1.3 This test method references notes and footnotes that provide explanatory information. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this test method.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.5 This test method is technically equivalent to ISO 1182 (see also Annex A2 and 6.4.5).

1.6 This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire-hazard or fire-risk assessment of the materials, products, or assemblies under actual fire conditions.

1.7 Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

1.8 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.9 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Appendix F -- Foam test parameter expectations

In order to be certified, the Heliport fire extinguishing system must meet the regulations as stated in the Canadian Aviation Regulations, in this case CAR 305. Those regulations are supported and described more fully in the standards to those regulations, in this case CAR 325. Transport Canada sometimes uses other internationally recognized safety parameters, such as National Fire Protection Association (NFPA) and/or Underwriter's Laboratories of Canada (ULC) standards to provide additional detail and/or examples of equivalent levels of safety. In this case ULC Standards Bulletin 2006-09 detailing the requirements of CAN/ULC-S560-06 and NFPA 412 are referenced.

Foam is defined in NFPA 412 as "a stable aggregation of small bubbles of lower density than oil or water that exhibits a tenacity for covering horizontal surfaces. Air foam is made by mixing air into water solution, containing a foam concentrate, by means of suitably designed equipment. It flows freely over a burning liquid surface and forms a tough, air-excluding, continuous blanket that seals volatile combustible vapors from access to air. It resists disruption from wind and draft or heat and flame attack and is capable of resealing in case of mechanical rupture. Fire-fighting foams retain these properties for relatively long periods of time."

The quality of a foam blanket can be assessed by testing a sample for three characteristics:

1) Foam Expansion – the ratio between the volume of foam produced and volume of solution used in its production. This is a measure of thickness and integrity of the foam blanket produced.
2) Foam Drainage Time – The time in minutes it takes for 25% of the total liquid contained in the foam sample to drain from the foam. This is a measure of how long lasting the foam blanket will be as well the flow ability and integrity of the foam blanket.
3) Foam Solution Concentration – the amount of a foam concentrate by volume contained in a solution, expressed as a percentage. Establishes the legitimacy of the foam proportioning, expansion and drainage time data.

In order to avoid any disputes or disagreements on the observed quality of the foam blanket produced, observation of the testing and documented analysis of the testing for foam expansion, foam drainage time and foam solution concentration will be accepted to verify the quality of the foam blanket produced during the test.

Appendix B reiterates the requirements for foam systems detailed in CAR 325.47. Reference is made to **CAN/ULC S560** [S560-06] that is expanded upon below:

4. Detailed Requirements

4.2 Expansion and Drainage

4.2.1 When tested as described in Subsection 5.6, a 1.0 ± 0.02% solution, a **3.0 ± 0.1 % solution**, or a 6.0 ± 0.1 % solution of foam liquid concentrate shall produce a foam possessing a **minimum average expansion of 5.0** and a **minimum 25 % average drainage time of 2.5 min**.

5.6 Expansion and Drainage

5.6.3 The nozzle is to be held at a height of 1 m and directed onto the collection back board from a distance of 2.0 ± 0.3 m in accordance with the methods and procedures specified in **NFPA 412, Standard**

for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment. Expansion and 25 % drainage time is then to be determined.

NFPA 412 – Chapter 4 Rescue and Fire-Fighting Vehicle Foam Production and Performance Testing, states in part:

4.1 Foam and Foam System Tests

4.1.1. – The expansion ratio and 25 percent drainage time are the foam characteristics that shall be determined. Additionally, the foam concentration shall be determined, both as a test of the vehicle proportioning system and to establish the legitimacy of the expansion and drainage data obtained.

4.2.3 – Foam samples shall be analyzed for expansion and drainage time using the criteria specified in Section 5.1 of the standard.

4.2.4 – Foam samples shall be analyzed for concentration as specified in Section 5.2 of this standard.

NFPA 412 - Chapter 5 Performance Criteria, states in part:

5.1 Expansion Ratio and Drainage Time Requirements. Foams shall be tested as specified in 6.3.2 and 6.3.3 of this standard and shall meet at least the performance requirements specified in Table 5.1

Table 5.1 Foam Quality Requirements

Foam Agents	Minimum Expansion Ratio	Minimum Solution 25% Drainage Time in Minutes	
		Test Method A	Test Method B
AFFF or FFFP air-aspirated	5:1	3	2.25
AFFF or FFFP non-air-aspirated	3:1	1	0.75
Protein	8:1	N/A	10
Fluoroprotein	6:1	N/A	10

5.2 Foam Solution Concentration

5.2.1 Foam solution concentration shall be tested in accordance with Section 6.2 of this standard.

5.2.3 For nominal 3 percent concentrates, the concentration shall be between 2.8 percent and 3.5 percent for turret and ground sweep nozzles and between 2.8 percent and 4.0 percent for handline and undertuck nozzles.

NFPA 418 – Standard for Heliports, states in part:

5.7.2 Fixed Foam Fire-Extinguishing Systems

5.7.2.1 Fixed foam fire-extinguishing Systems shall be designed and installed in accordance with NFPA 11, NFPA 16, or an equivalent standard, as appropriate, except as modified by this chapter.

NFPA 16 – Installation of Foam-Water Sprinkler and Foam-Water Spray Systems, states in part:

A-5-3.1 The following are acceptance test recommendations.

2. Aqueous film-forming foam.

- Expansion: 3:1 to 8:1
- 25 percent drainage time: 60 seconds minimum

These data apply to foam characteristics determined by the method specified in Appendix C of NFPA 11 – Standard for Low, Medium and High Expansion Foam

NFPA 11 – Standard for Low, Medium and High Expansion Foam – Annex C Tests for the Physical Properties of Foam, states in part:

C.1.6 Foam Testing. The foam samples, as obtained in the procedures described in C.1.1 through C.1.5, are analyzed for expansion, 25 percent drainage time, and the foam solution concentration.

Reference Publications:

CAN/ULC-S560-06, Standard for Category 3 Aqueous Film-Forming Foam (AFFF) Liquid Concentrates – April 2006

CAN/ULC-S563-06, Standard for Category 3 Film-Forming Fluoroprotein (FFFP) Foam Liquid Concentrates – February 2016

NFPA 418-2016 – Standard for Heliports

NFPA 412-2003 – Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment

NFPA 11-2002 – Standard for Low, Medium and High Expansion Foams

NFPA 16-1999 – Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems

ANSULITE AFC-3DC 3% AFFF Concentrate Data Sheet (A4 Format, Rev. 02)

ANSULITE AFC3B 3% AFFF Concentrate Data Sheet (Rev. 01)