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Airport hydrogen fuelling facility operations

Exploitation d'installation aéroportuaire d'avitaillement en hydrogène

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

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Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/PAS 15594 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*.

Introduction

When this document was introduced in the ISO/TC 197 programme of work, all aircraft- and airport-relevant procedures, systems and components concerning hydrogen technologies were in an early development state, and the technical solutions that would enable the future use of hydrogen as a fuel for aviation were not fully developed.

The development of this document within ISO/TC 197 depended on the progress achieved within the European Aeronautic Defence and Space Company (EADS)-Airbus Cryoplane project. However, this project is no longer planned to start in the near future, and there are no other relevant practical projects underway.

ISO/TC 197 experts are convinced that the subject of using liquid hydrogen in commercial aviation is of great importance and will gain new momentum in the next decade. As a result, the latest results are presented in this Publicly Available Specification to make the information available to all interested parties.

This document is not to be regarded as an International Standard. It records the latest results of ISO/TC 197 experts until the subject of using liquid hydrogen in commercial aviation gains interest.

It is understood that this document is far from complete and that it represents the knowledge available at the time of publication. Should work on this subject resume in the next years, the primary objective of the standardization work will be to ensure safety at all phases of handling while taking into account the conditions prevailing at civil airports and the results of risk assessment studies.

Airport hydrogen fuelling facility operations

1 Scope

This Publicly Available Specification specifies the fuelling procedures, hydrogen boil-off management procedures, storage requirements of hydrogen, and characteristics of the ground support equipment required to operate an airport hydrogen fuelling facility.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14687, *Hydrogen fuel — Product specification*

ISO 20421-1, *Cryogenic vessels — Large transportable vacuum insulated vessels — Part 1: Design, fabrication, inspection and testing*

ASME 1998, *Boiler and Pressure Vessel Code*

KSC[1)]-STD-Z-0009C, *Cryogenic Ground Support Equipment, Design of, Standard for*

KSC-STD-Z-0005B, *Pneumatic Ground Support Equipment, Design of, Standard for*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
block fuel
quantity of fuel to be used for refuelling prior to each flight

3.2
refuelling block time
time needed to refuel the aircraft, measured between connection and disconnection of the couplings

3.3
inert gas
nonflammable and nonreactive gas

EXAMPLES Helium, nitrogen, carbon dioxide.

1) Kennedy Space Center.

4 Symbols and abbreviated terms

AP	auxiliary power unit
CO	carbon monoxide
CO_2	carbon dioxide
C_nH_m	hydrocarbon containing n carbon atoms and m hydrogen atoms
EADS-Airbus	European Aeronautic Defence and Space Company
GH_2	gaseous hydrogen
LH_2	liquid hydrogen
N_2	nitrogen
O_2	oxygen

5 Fuelling procedures

5.1 General requirements

At the airport, the following situations shall be considered:

— normal refuelling during ground turnaround, with an onboard system in cold condition up to the refuelling/boil-off coupling;

— defuelling of the system on the ground due to planned maintenance activities and applicable troubleshooting cases;

— refuelling of a warm, air-floated onboard system before putting into service and after planned maintenance activities and applicable troubleshooting cases.

The airport infrastructure shall provide the ground support equipment required for performing the above-mentioned refuelling and defuelling operations, including the aircraft tank warm-up and precooling, the necessary purification and purging processes, and the evacuation and GH_2/LH_2 recovery that is required for defuelling operations and refuelling of a warm onboard system. Purge, precooling and warm-up procedures for the onboard fuel system shall be required only for putting into service, maintenance and troubleshooting activities.

The connection point between the aircraft and the ground support equipment shall consist of two couplings (similar but mistake-proof), a refuelling coupling for providing the tanks with LH_2, and a boil-off coupling for the discharge of GH_2. In Annex A, Figure A.1 provides an example of an aircraft refuelling and defuelling interface point and Figure A.2 an example of a hydrogen aircraft-fuel system layout.

5.2 Bonding and grounding procedures

Airport personnel shall apply appropriate bonding and grounding procedures prior to performing any refuelling or defuelling operations on an aircraft.

5.3 Refuelling of a cold system

For normal refuelling during ground turnaround, the airport personnel shall ensure that the tanks are cold and still contain a small quantity of fuel. The time required for the refuelling of a cold system shall be minimized and shall be such that the aircraft-refuel block time requirements can be met (see Annex B). The time required for the refuelling of a cold system shall include an acceptable time for connection and disconnection, including time for cleaning of inner cavities from air at connection and from hydrogen at disconnection, and time for warming before disconnection.

In order to perform the refuelling of a cold system, airport personnel shall use the following refuelling procedure.

a) Establish the connection of the refuelling and boil-off couplings between the aircraft and ground support equipment. Purging and precooling of the refuelling connecting hose and coupling need not be performed.

b) After the refuelling system is in “ready” mode, open the tank refuelling and boil-off valves to start the refuelling operation.

c) Monitor the fuel level of the tanks and control it using the refuelling and boil-off valves.

d) After filling the tanks, close the refuelling and boil-off valves and separate the couplings and auxiliary connections.

NOTE 1 The renunciation of purge, purification, evacuation and precooling at the coupling can be justified by existing advanced coupling designs.

NOTE 2 During the refuelling of a cold system, no boil-off gas is expected due to recondensation within the onboard tank.

5.4 Defuelling

For yearly maintenance checks or any troubleshooting, airport personnel may need to defuel the aircraft tanks. Defuelling of the aircraft fuel system shall be done using the refuelling and boil-off couplings.

After coupling the aircraft with the refuelling and boil-off connectors of the ground support equipment, an overpressure pipe on the gas side within the onboard tank should deplete the tanks back to the airport stationary storage tank or portable tank container. The onboard pumps could assist the depletion.

If warming up and purging of the aircraft tanks and piping are required, they shall be done using temperature-conditioned inert gases.

5.5 Refuelling of a warm system

Refuelling of a warm, air-floated onboard system shall be carried out before putting an aircraft into service and after planned maintenance activities and applicable troubleshooting cases. Perform the refuelling of a warm system as follows.

a) Purge the tank and piping system with an inert gas (evacuated, if possible) to remove the air or other foreign gases from the system. Decrease the foreign gas concentration within the system to an acceptable level that is yet to be determined, and measure at the boil-off coupling.

b) Purge the tank and piping system and precool with conditioned hydrogen to remove the inert gas from the system. Decrease the inert gas concentration within the system to an acceptable level that is yet to be determined, and measure at the boil-off coupling.

NOTE At the time of the publication of this PAS, no detailed procedure for refuelling a warm onboard fuel system could be given, because the initial state of the system before purge could differ and was not really known. The same applied to the required end-state of the system after purge and precooling. The requested procedure may vary due to the design of the onboard tank and piping system. The development task is to define a procedure which is optimized with respect to cost, time required, careful material handling, and safety aspects.

5.6 Monitoring of fuelling parameters

5.6.1 Monitoring during refuelling of a cold system

Control and monitoring during the refuelling of a cold system shall be implemented at one master logic point. A refuelling and monitoring panel shall provide the necessary monitoring indication and enable the selection of all possible automatic/manual procedures, including the preselection of the fuel quantity from the information provided by the aircraft automatic fuel-level control. Shut-off valves in connection with level indication shall execute the refuelling procedure. To avoid tank overfilling, the airport personnel shall monitor onboard-tank liquid level, pressure, temperature and valve positions.

The recommended position for the refuelling control and monitoring-panel is near the refuelling and boil-off couplings integrated in the aircraft structure. The possibility of monitoring the procedure from the aircraft cockpit and ground supply equipment should also be considered.

5.6.2 Monitoring during defuelling and refuelling of a warm system

Airport personnel shall perform control and monitoring during defuelling and refuelling of a warm system. Control and monitoring provisions shall be available from the airport ground infrastructure.

5.7 Monitoring of the safety parameters

5.7.1 General requirements for monitoring devices

Monitoring of the safety parameters is aimed at decreasing the risk associated with handling flammable and cryogenic fuel. Monitoring devices shall not interfere with the refuelling operations, and they shall not be an ignition source.

As much as possible, monitoring devices should be independent of external power supplies, and instead have their own internal power supplies. Devices that take their energy from the fuel (its pressure, flow, or low temperature) or are an integral part of the fuelling system should be given preference.

When a faulty condition is detected, monitoring devices shall trigger an interruption of the fuel flow if the line is already open, or the locking of the main valve if the line is still closed. An audible and/or visible alarm shall be activated indicating the kind of failure and where it occurred.

5.7.2 Monitoring of interface leakage

Interface leakage shall be monitored during the fuelling and defuelling operations. Interface-leakage monitoring shall enable the detection of

— leaks from the lines or the connections,

— open or not fully or faulty closed connections,

— other abnormal conditions that might be dangerous.

The tightness of the connection shall be verified by measuring the pressure decrease or increase in a suitably selected volume or by measuring the pressure difference between such a volume and atmosphere.[2)]

When a leak is detected, personnel shall verify the suspected area with foaming agents, leak detectors or equivalent methods.

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2) Measuring pressure decrease or volume increase for tightness of a connection is not very responsive. However, no alternative technology was available at the time of the publication of this PAS. By the time any serious construction of large fuelling facilities for aircraft materializes, the field of hydrogen detection/situational awareness systems should be more mature and could be the preferred method of control and monitoring.

5.7.3 Overpressure

A mechanical contact manometer or an equivalent device shall be used to monitor overpressure in the onboard fuel system and shall be used to stop the fuelling operation immediately when an overpressure condition is detected.

5.7.4 Heat insulation deterioration

Airport personnel shall monitor signs of deterioration of the vacuum insulation. Suitable criteria shall be established to determine the amount of insulation deterioration that is acceptable, and that which requires repair or replacement. Deterioration of insulation can easily be detected in an early stage by observing the outer surface of the vacuum space becoming cold, and water condensing or even freezing on it.

A spot on which such effects can be detected shall be in the view of the airport personnel responsible for the refuelling operations. Means to detect temperatures that are too low can also be used.

In the open air or in a hangar, the air humidity is high enough for water vapour to undergo condensation. In areas where air humidity is too low, means other than visual inspection should be used to detect signs of deterioration of the vacuum insulation.

NOTE A metal rod that contracts when it cools and breaks a contact when its length falls under a certain threshold can be used to monitor deterioration of the insulation.

6 Hydrogen boil-off management

Airports that service hydrogen aircraft shall be equipped with boil-off gas user systems. These systems shall be designed to collect hydrogen boil-off gas generated in the onboard LH_2 tank (see Annex C for a description of the boil-off gas problem) during the following aircraft modes:

a) ground overnight parking (approximately 12 h);

b) long-time overhaul with cold tanks;

c) applicable failure cases.

The connection point between the aircraft and ground support equipment shall be the boil-off coupling, which allows a gas feed to the airport boil-off gas user system for utilization.

7 Storage of hydrogen

7.1 Storage capacity

The storage capacity for LH_2 shall be established based on the demand for hydrogen at the airport. LH_2 requirements for airports range from a few tons per day to 6 000 000 kg per day for a large airport.

7.2 Storage means

LH_2 shall be stored at the airport either in portable tank containers or in stationary storage tanks. Considerations for the selection of storage means are provided in Annex D.