International Civil Aviation Organization

WORKING PAPER

AN-Conf/14-WP/25
18/6/24
(Information Paper)
English only

FOURTEENTH AIR NAVIGATION CONFERENCE

Montréal, Canada, 26 August to 6 September 2024

Agenda Item 2: Timely and safe use of new technologies
2.1: Evolving aircraft technologies contributing to LTAG

CONSIDERATIONS FOR REGULATORS ON THE INTRODUCTION OF SUSTAINABLE AVIATION FUELS (SAF) AT HIGHER BLEND RATES

(Presented by Airports Council International (ACI) and the International Coordinating Council of Aerospace Industries Associations (ICCAIA))

EXECUTIVE SUMMARY

Currently shortage of supply means that in most cases Sustainable Aviation Fuel (SAF) is blended with conventional aviation turbine fuel at low concentrations: in the order of a few per cent. But, as SAF becomes more available there are likely to be circumstances where the blend will significantly increase. This could then become a limiting factor under the current regulatory framework and could have significant consequences for fuel suppliers, manufacturers, airports, airlines and the travelling public.

This paper provides information on the current certification methodology for conventional fuel and SAF, the blending requirements, and longer-term considerations for regulators and for the aviation industry.

A technical annex is found in the appendix to this paper, which provides more detail on the specific nature of the different fuel types and the operational constraints.

1. BACKGROUND

1.1 Conventional aviation turbine fuel is produced to specific standards required to meet the often-extreme operating requirements of jet aircraft. The long-standing international standard has been specified by ASTM International (formerly the American Society for Testing and Materials) as D1655. Within this certification there is a distinction between Jet A and Jet A-1 which have freezing points of -40°C and -47°C respectively. There are other national standards but for the purpose of this paper we refer to those adopted by ASTM International.

1.2 Using the same testing methodology there are further standards adopted for SAF. These specifications are set out in the annexes to ASTM D7566 according to specific and recognized pathways. For example, A1 refers to the Fischer-Tropsch pathway; A2 to the Hydroprocessed Esthers and Fatty Acids (HEFA) pathway; and A5 the Alcohol-to-Jet pathway. D7566 will be expanded as new pathways are recognized.

1.3 Although it is technically possible in certain circumstances to use SAF at 100 per cent this requires specific waivers by national regulators and most notably civil aviation authorities. For most uses SAF will be blended with conventional fuel and recertified to the requirements of D1655. In these cases this blending will be much less than 50 per cent SAF (the current maximum depending on the pathway). Once blended and recertified to D1655 it may be treated in the same way as any other fuel so certified and is hence known as “drop-in” fuel.

1.4 It is evident that currently, and for the next few years, due to low production volumes of SAF, commercially available fuel will all be certified to D1655 standards.

1.5 However, as SAF supplies increase, and recognizing that this increase will not occur at the same rate in all parts of the world, there will be a need to consider the potential impacts for supply, distribution and use at airports. Regulators will need to consider the regulatory standards applying to aircraft and engine manufacture, the ASTM standards themselves and blending requirements, and the effect of operations at and around airports. The critical “pinch-point” occurring if some aircraft are able to operate using higher percentages of D7566 certified fuel while others are limited to that certified to D1655. We term those fuels with higher percentages of D7566 certified fuel as “non-drop-in”.

1.6 This paper also encourages regulators to consider a commonly and mutually recognized certification process (based on ASTM D4054): a “clearinghouse” to support new and innovative pathways by coordinating, managing and conducting standard evaluation process, by cost sharing and co-funding and by mutualizing resources and expertise.

1.7 This Information Paper has been written to raise awareness of the challenges associated with SAF non-drop-in fuel, which will be phased into production, so that regulators are aware of the potential technical certification requirements and so operators can prepare to deal with changes in infrastructure and logistics that may be necessary.

2. DISCUSSION

2.1 The ICAO Long-term Aspirational Goal (LTAG) has determined a goal of Net Zero carbon emissions from international aviation by 2050. Decarbonization of aviation is already underway as a consequence of actions taken within the industry. As identified by the LTAG, and confirmed in several other reports, achieving Net Zero 2050 heavily relies on increased use of SAF, but it is evident that given the current regulatory framework the maximum amount of SAF that could be used is 50 per cent given the blending requirement with conventional fossil fuel. This would also assume an even distribution of supply to match demand, but in reality some localities are likely to be able to supply and consume higher blends sooner rather than later, particularly if an agreed global fuel accounting system is in place. Existing global roadmaps indicate that the overall system is set to exceed 50 per cent SAF use in the 2040 timeframe, though in some regions, or under some very select circumstances, this could be achieved by the middle of the next decade. Timelines are available in the appendix to this paper.

2.2 Thus, it will be important to ensure compatibility with the current and overall ecosystem (aircraft, engines and fuel systems, airports, etc.) and under very high safety conditions. Whilst the manufacturers have set a goal of ensuring compatibility with 100 per cent SAF by 2030 for newly certified and produced aircraft; and some will also develop retrofit technology to allow the existing fleet to operate on higher SAF concentrations, it is by no means certain that all aircraft will be able to operate using this “non-drop-in” fuel immediately, if at all.

2.3 Consequently, the question of fuel certification is crucial and must take these challenges and potential risks into account to enable a smooth transition towards the distribution and use of cleaner fuels by 2050.

2.3.1 As described in paragraph 1.1, in order to be considered to be certified as Jet A or Jet A-1, a fuel must meet the standards laid out in ASTM D1655. Any fuel that meets this standard alone can be used in currently-certified turbine powered aircraft at 100 per cent. D1655 defines key parameters of the fuel, such as: fuel composition, freezing point, flash point, kinematic viscosity, smoke point, corrosiveness, water separation, energy content, additives and contaminants. Overall, it sets stringent technical specifications to ensure the safety, performance and compatibility of aviation turbine fuels for use in aircraft and aircraft engines.

2.3.2 Similarly, ASTM D7566, has been developed for the use of SAF. provides a comprehensive set of specifications and requirements for the production and use of aviation turbine fuel containing synthesized hydrocarbons, ensuring that these fuels meet the necessary quality and performance standards for use in aviation.

2.3.3 More details are provided in the appendix.

2.4 The manufacturing industry is looking to certify aircraft capable of operating with 100 per cent SAF by 2030. But, although new aircraft might be made compatible with 100 per cent SAF through new materials for the seals or calibrated gauging; some older aircraft which are not certified for 100 per cent SAF, would either need to be retrofitted and made SAF compatible. Depending on the scale of the problem, which is as yet unclear, airports might need to provide availability of both drop-in and non-drop-in fuels.

2.5 It should also be noted that, while the aircraft and engines themselves would be certified to operate on 100 per cent of SAF by 2030, it is by no means certain that there will either be sufficient supply of SAF, or the ability of fuel suppliers to deliver 100 per cent SAF at the airports given that a single fuel farm will be the source of that supply.

2.6 Airports typically supply fuel from a fuel farm located at the airport, but provided by one or more fuel producers from remote refineries. Although many fuel company names are often seen, the fuel itself is the same – all of it certified to D1655. The fuel is distributed around the airport through pipelines, usually underground, and metered supply to the aircraft is provide by the fuel supplier. It is thus not possible to provide different branded fuel to different aircraft, nor is it possible to supply drop-in SAF and non-drop-in SAF though a single supply line.

2.7 Two primary options would then present themselves, both of which would incur significant costs in infrastructure development. One would be to install new parallel fuel lines to service aircraft depending on their need for drop-in or non-drop-in fuel, or to designate some stands for each type of fuel. However, this latter option would lead to operational challenges for airlines and airports. It should be noted that other options are also possible, including, but not limited to, retrofitting older aircraft and engines, the addition of synthetic aromatics, or limiting the percentage blend to a value less than 100 per cent.

2.7.1 In order to meet the volume of SAF required to meet the LTAG of net zero emissions by 2050, the industry may benefit from the use of both drop-in and non-drop in SAF. However, time is needed for the technology and infrastructure development required for non-drop-in SAF to be established. This is why it is necessary to work today to qualify the compatibility of this type of fuel on products and infrastructures, to determine the impacts and anticipate their future deployment. Thus drop-in SAF will continue to be the route for more immediate emissions reductions first.

3. CONCLUSION

3.1 The purpose of this information paper is to raise awareness.

3.2 That the current fuel certification process is adequate for the short to medium term, but a review procedure is needed as SAF becomes more available; that manufacturers are developing aircraft and engine types that are 100 per cent SAF capable; that manufacturers are also developing technology that might be retrofitted to allow for high blend levels of SAF; but that some aircraft and engine types might continue to require fuel certified only to D1655 standards; the ability for industry to reach the LTAG could therefore require supply of both drop-in and non-drop-in SAF which has significant technological and regulatory consequences.

3.3 The industry will continue to develop its thinking on these issues and their consequences and will keep regulators informed.

— — — — — — — —

APPENDIX

DEFINITIONS (GLOSSARY)

ATF = Aviation Turbine Fuel also known as JET Fuel

SAF, LCAF (Reference: ICAO SARPs Annex 16 — *Environmental* Protection , Volume IV — *Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*)

SAF = Sustainable Aviation Fuel is defined as a "renewable or waste-derived aviation fuel that meets the CORSIA Sustainability Criteria"

LCAF = Lower Carbon Aviation Fuel is defined as "a fossil based aviation fuel that meets the CORSIA Sustainability Criteria" **-** These aviation fuels have the same carbon content as other aviation fuels.

Eligibility with threshold 10% vs. conventional fuel (89g CO2e/MJ)

Summary of the key differences between drop-in and non-drop-in SAF is as follows:

Composition:
100% Drop-in SAF: These fuels are chemically similar to conventional Jet A or Jet A-1 fuels and can be used without any modifications to aircraft engines through existing fueling infrastructure. They are typically produced from renewable feedstocks using multiple conversion processes (ASTM D1655).

100% Non-Drop-in SAF: These fuels are blends of synthesized hydrocarbons with conventional jet fuel. They are not chemically similar to conventional jet fuel and may have different properties, such as higher freezing points or different energy content. They require specific approvals and may have limitations on their use in certain aircraft types.

Production Methods:
100% Drop-in SAF: Production methods for drop-in SAF include hydro processing, Fischer-Tropsch synthesis, and other advanced biofuel processes. These methods are designed to produce hydrocarbons that are similar to those found in conventional jet fuel.
100% Non-Drop-in SAF: Non-drop-in SAF can also be produced using similar methods, but they are blended with conventional jet fuel to achieve the desired composition. The production of non-drop-in SAF may involve additional processing steps to meet the required specifications.

Compatibility:
100% Drop-in SAF: These fuels are compatible with existing aircraft engines, fuel systems, and infrastructure, requiring no modifications for use. They can be used in any proportion with conventional jet fuel.
100% Non-Drop-in SAF: Non-drop-in SAF may require modifications to aircraft engines or fuel systems to ensure compatibility. They may also have limitations on their use in certain aircraft types or under certain operating conditions.

Regulatory Approval:
100% Drop-in SAF: Drop-in SAF that meet the specifications outlined in standards such as ASTM D1655 and ASTM D7566 can be used without additional approvals.
100% Non-Drop-in SAF: Non-drop-in SAF may require additional approvals or certifications due to their different composition and properties. Regulatory bodies such as the FAA and EASA may require additional testing and analysis to ensure their safety and compatibility.

A summary of the challenges regarding non-drop-in fuels are as follows:

Compatibility: Non-drop-in SAF may have different chemical compositions and properties compared to conventional jet fuels. Ensuring that these fuels are compatible with existing aircraft, engines, fuel systems, and infrastructure is crucial to prevent operational issues and safety concerns.

Performance: Non-drop-in SAFs may have different energy densities, freezing points, and combustion characteristics compared to conventional jet fuels. Ensuring that these fuels perform effectively and safely in aircraft engines under a wide range of operating conditions is essential.

Engine and Component Compatibility: Non-drop-in SAFs may require modifications to aircraft engines, fuel systems, and components to ensure compatibility and performance. This can include changes to fuel lines, seals, and other components to withstand the different properties of these fuels.

Storage and Handling: Non-drop-in SAFs may have different storage and handling requirements compared to conventional jet fuels. Ensuring that these fuels are stored and handled safely to prevent contamination, degradation, or other issues is critical.

Supply Chain Reliability: SAFs produced from renewable feedstocks, which can introduce variability in supply compared to conventional jet fuels. Ensuring a reliable supply chain for these fuels is essential to prevent disruptions in fuel availability.

Cost and Scalability: Non-drop-in SAFs will potentially be more expensive to produce than conventional jet fuels, which can impact their scalability and commercial viability. However, their greater environmental performance will be an important element to face environmental cost issues for the long-term. Ensuring that these fuels can be produced cost-effectively at scale is crucial for their widespread adoption.

Addressing these technical risks will require extended cooperation among fuel producers, airlines, aircraft manufacturers, and regulatory agencies to develop and implement standards, guidelines, and best practices for the safe and effective use of non-drop-in SAFs in aviation.

Detailed Technical Summary of ASTM D1655

- **Fuel Composition**: Specifies the acceptable ranges of various components such as hydrocarbons, aromatics, sulfur, and additives. For example, it sets limits on the amount of sulfur and aromatics to ensure environmental and engine compatibility.
- **Freezing Point**: Specifies the maximum allowable freezing point to ensure the fuel remains liquid at low temperatures encountered during flight.
- **Flash Point**: Specifies the minimum flash point, which is the temperature at which the fuel can ignite when exposed to an open flame. This is important for safety during handling and storage.

- **Kinematic Viscosity**: Specifies the acceptable range of viscosity, which affects the flow characteristics of the fuel and its ability to lubricate fuel system components.
- **Smoke Point**: Specifies the minimum smoke point, which is a measure of the fuel's ability to produce smoke when burned. This is important for visibility during engine operation.
- **Corrosiveness**: Specifies the maximum acidity level to prevent corrosion of fuel system components.
- **Water Separation**: Specifies the maximum allowable amount of water that can be separated from the fuel, as water can cause engine performance issues.
- **Energy Content**: Specifies the minimum energy content of the fuel to ensure it provides the required energy for aircraft operations.
- **Additives**: Specifies the types and amounts of additives that can be added to the fuel to improve its performance and stability.
- **Contaminants:** Specifies the maximum allowable levels of contaminants such as particulates, salts, and metals, which can affect fuel quality and engine performance.

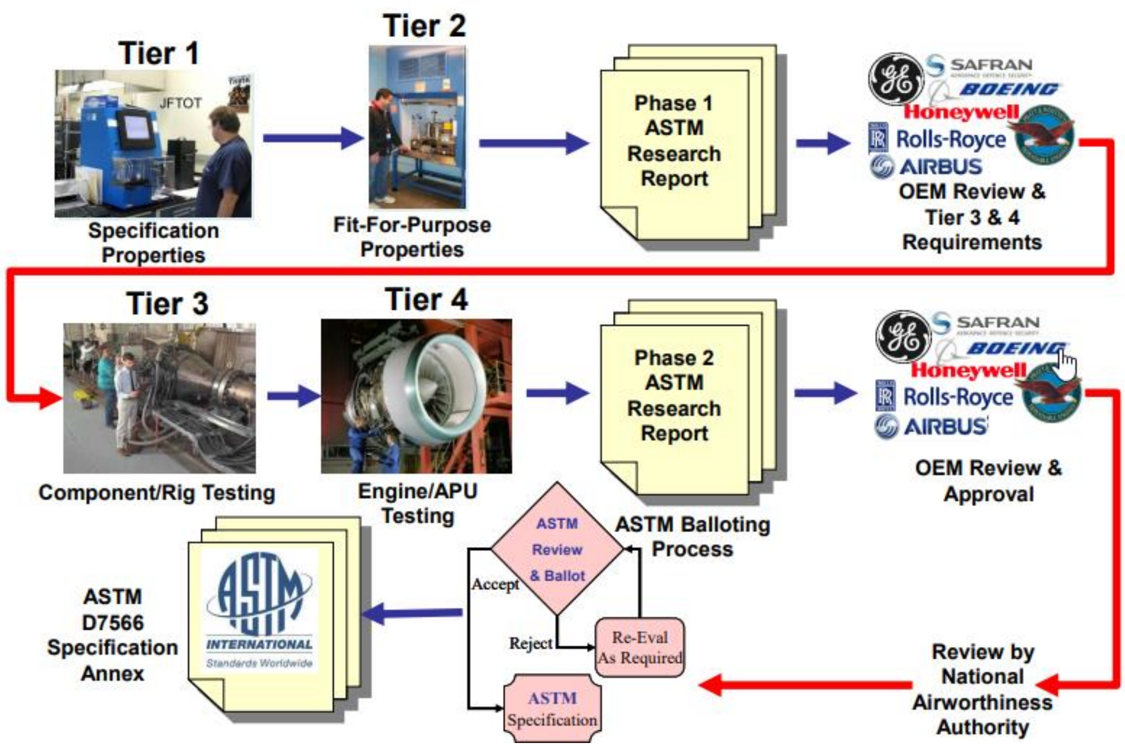
Detailed Technical Summary of ASTM D7566

- **Scope:** The standard covers the physical and chemical properties, performance characteristics, and specifications for neat, synthesized hydrocarbons and blends of synthesized hydrocarbons with conventional jet fuel for use in aviation.
- **Synthesized Hydrocarbons**: The standard defines synthesized hydrocarbons as those produced by chemical or biological conversion processes from renewable sources such as biomass or non-petroleum feedstocks.
- 8 pathways (ASTM D7566 annexes) are certified so far:
    1. Fischer-Tropsch Hydroprocessed Synthesized Paraffinic Kerosine (SPK)
    2. Synthesized Paraffinic Kerosine from Hydroprocessed Esters & Fatty Acids (HEFA SPK)
    3. Synthesized Iso-Paraffins from Hydroprocessed Fermented Sugars (SIP)
    4. Synthesized Kerosine with Aromatics derived by Alkylation of Light Aromatics from Non-Petroleum
    1. Sources (SPK-A)
    5. Alcohol-To Jet Synthetic Paraffinic Kerosene (ATJ-SPK)
    6. Synthesized Kerosine from Hydrothermal conversion of Fatty Acid Esters & Fatty Acids (CHJ)
    7. Synthesized Paraffinic Kerosine from Hydroprocessed Hydrocarbons, Esters & Fatty Acids (HC-HEFA SPK)
    8. Alcohol-To-Jet Synthetic Paraffinic Kerosene with Aromatics (ATJ-SKA)
- **Blends**: ASTM D7566 specifies the maximum allowable percentage of synthesized hydrocarbons in blends with conventional jet fuel, ensuring that the blended fuel meets the required specifications for aviation use.
- **Physical and Chemical Properties**: The standard outlines the required properties for aviation turbine fuel containing synthesized hydrocarbons, including density, freezing point, flash point, distillation characteristics, and thermal stability.
- **Performance Characteristics**: ASTM D7566 includes requirements for the performance characteristics of the fuel, such as lubricity, corrosion protection, and compatibility with materials commonly used in aviation fuel systems.
- **Specification Limits**: The standard sets limits for various properties of the fuel, such as sulfur content, aromatics content, and distillation temperatures, to ensure that the fuel meets the necessary quality standards for aviation use.

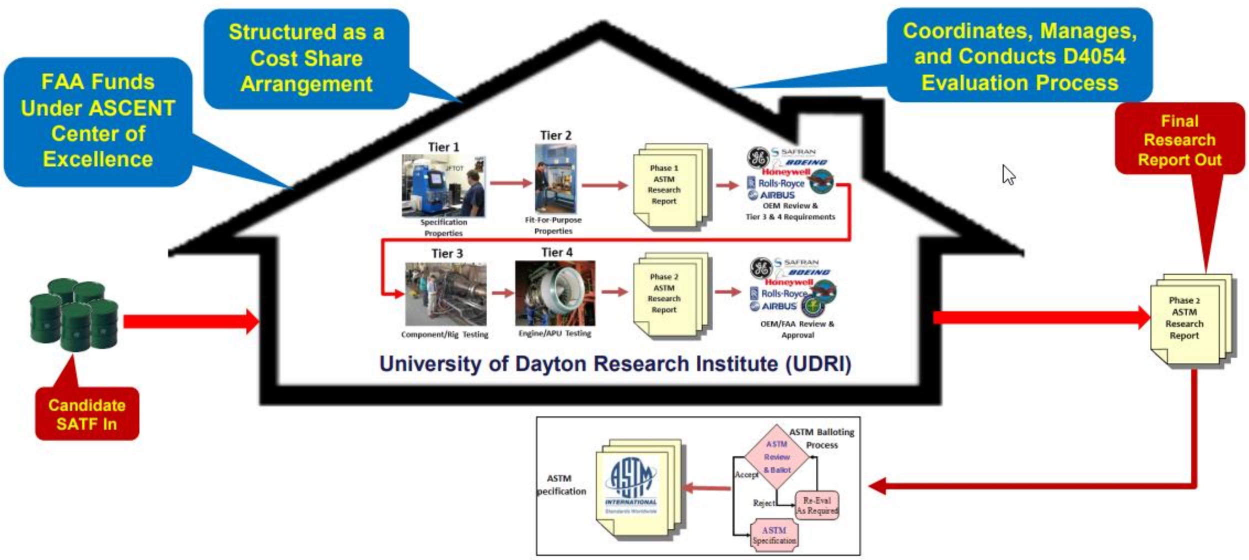
- **Testing Methods**: ASTM D7566 specifies the testing methods to be used to determine compliance with the standard, including methods for measuring properties such as density, sulfur content, and distillation characteristics.
- **Certification**: The standard includes requirements for the certification of aviation turbine fuel (ATF) containing synthesized hydrocarbons, including documentation of compliance with the standard and records of testing and production processes (i.e. see ASTM D4054 process description below)
    - An ATF manufactured, certified, & released to all the requirements of Table 1 of D7566, meets the requirements of Specification D1655 & shall be regarded as Specification ASTM D1655 ATF.
    - It also meets the requirements of and is regarded as Def Stan 91-091, CGSB 3.23-2020, DCSEA 134 E & other specifications.
    - By meeting the requirements of ASTM D1655, DEF STAN 91-091, … the ATF is approved for flight (ASTM D7566 is not approved for flight unless recertified as one of the approved fuel specifications).

State of the art on certification (ASTM pathways from feedstock to Fuel) - detail of ASTM D7566 annexes

ASTM D4054 evaluation and certification process



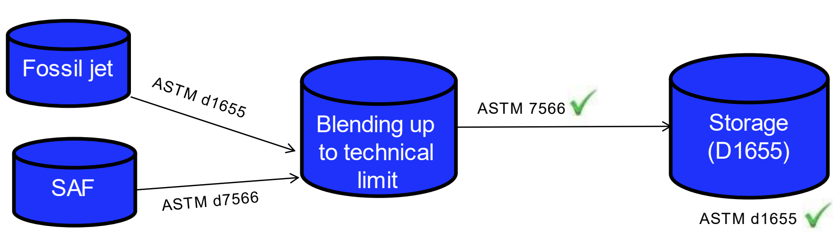
D4054 Clearinghouse concept (detail of the FAA clearinghouse)



Considerations

Blending:

- Availability of blending and storage infrastructure:
  - Access to existing infrastructure for blending reduces cost as new facilities would not be needed. It is important to consider that at least four tanks may be required for blending: one for the fossil fuel, one for the neat biojet fuel, one for blending, and one for the blended fuel. Depending on the volumes of the respective fuels, additional tanks may be required.



— END —