Detailed report of the data and quality control tailored solution for delivering SAF in fellow and other airports

D 9.3

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Author(s):	ADR supported by CPH, CPK, LTOU, SAS, NISA, BKL
Contact person:	Giampiero Goretti: giampiero.goretti@adr.it Simone Santini: simone.santini@adr.it Maria Sole Salomoni: mariasole.salomoni@adr.it

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Content

List of figures

List of tables

List of acronyms

Abbreviation	*Extended name*
ADR	Aeroporti di Roma
ASTM	American Society for Testing and Materials
CPH	Copenhagen Airport
CPK	Warsaw Airport
COA	Certificate of Analysis
CoQ	Certificate of Quality
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EI	Energy Institute
FCO	Fiumicino Airport
GHG	Greenhouse Gas
HEFA	Hydrotreated Esters and Fatty Acids
HVO	Hydrotreated Vegetable Oil
HRS	Hydrant Refueling System
ISCC	International Sustainability and Carbon Certification
JIG	Joint Inspection Group
KPI	Key Performance Indicator
RED	Renewable Energy Directive
RTC	Recertification Test Certificate
SAF	Sustainable Aviation Fuels
SBC	Synthetic Blend Component
VNO	Vilnius Airport

Executive summary

In order to ensure the reliable and safe integration of Sustainable Aviation Fuel into airport systems, it is essential to define robust data monitoring frameworks and quality control procedures, aligned with international standards and adaptable across different airport configurations. Deliverable 9.3 of the ALIGHT project aims to address these technical and operational challenges, providing a comprehensive overview of regulatory requirements, monitoring tools, safety procedures, and best practices drawn from partner airports. The goal is to support a harmonized and efficient SAF deployment, minimizing risks and ensuring high product integrity throughout the airport supply chain.

Chapter 1 offers a detailed overview of the current regulatory landscape governing the use, handling, and quality assurance of aviation fuels. The analysis covers both international technical standards (such as ASTM D1655/D7566 and JIG) and relevant European legislation, including the ReFuelEU Aviation Regulation.

Chapter 2 focuses on data monitoring related to SAF tracking and reporting. It outlines the main chain of custody models, such as mass balance and physical segregation, which directly impact fuel traceability and monitoring effectiveness. In particular, the chapter highlights the main Key Performance Indicators (KPIs) that airports generally monitor, as the volume of SAF delivered and the associated GHG emissions reductions.

Chapter 3 focuses on quality control protocols applied to SAF and Jet A-1 within the airport perimeter. It describes the multilayered inspection and sampling processes carried out from the moment the fuel enters the airport until its final use on aircraft. It also examines the compatibility of SAF with existing control procedures. The chapter highlights best practices for quality assurance adopted.

Chapter 4 outlines the main reference standards for fuel safety procedures, with a primary focus on the Joint Inspection Group (JIG) guidelines. It examines the roles and responsibilities of the key stakeholders involved in ensuring operational safety and highlights relevant international standards, including IATA's guidance on refueling safety procedures.

Finally, **Chapter 5** presents the case studies of the ALIGHT partner airports, Copenhagen, Rome Fiumicino, and Vilnius, focusing on their approaches to data monitoring, quality control testing, and safety procedures related to both Jet A-1 and SAF management. For each airport, the specific fuel supply chain configuration is reported. Warsaw Airport is not included in the analysis because it is still in an early development phase and currently lacks publicly available information on SAF operations.

The conclusion chapter highlights that SAF can be seamlessly integrated into existing airport fuel systems using the same JIG-based infrastructure and procedures. From a quality and safety perspective, SAF is treated in the same way as conventional Jet A-1, with no need for adjustments to standard operational protocols. Monitoring is not performed on the individual fuel molecule, as the mass balance approach is applied. Instead, the fuel supplier communicates

the quantity of SAF delivered to both the fuel farm operator and the airline, ensuring traceability within the system.

Introduction

This deliverable is part of project ALIGHT WP 9 and it provides an in-depth analysis of the tools, methods, and practices currently adopted by the partner airports, at the time of writing this Deliverable (08/2025), for monitoring and ensuring the quality of SAF, as well as the safety procedures applied during the storage, handling, and distribution phases. The objective is to assess how the partner airports, namely Copenhagen Airport Kastrup (CPH), Roma Fiumicino Airport (FCO), Vilnius Čiurlionis International Airport (VNO), Warsaw Centralny Port Komunikacyjny (CPK), apply monitoring, quality control, and safety procedures in the management of both SAF and Jet A-1.

The integration of SAF, similarly to Jet A-1, into airport fueling systems requires the implementation of robust monitoring mechanisms and the adoption of specific procedures to ensure both fuel quality and operational safety throughout the entire supply chain, from initial reception to final delivery onboard aircraft.

The analysis focuses both on the identification of performance indicators (KPIs) that can support a consistent and data-driven monitoring approach, and on the review of existing quality control protocols at all stages of the fueling process, including fuel reception, storage at airport facilities, and final delivery to aircraft. These aspects are examined in order to assess the extent to which SAF management practices are aligned with those already in place for Jet A-1, and whether adjustments are needed to maintain equivalent standards of quality and safety.

In addition to quality control aspects, the document also explores the safety procedures associated with fuel management, analyzing how airports are modifying or extending protocols originally designed for Jet A-1 to accommodate the operational specificities of SAF. Particular attention is paid to the degree of compatibility between existing safety standards and the operational conditions required by SAF, with the aim of enabling a seamless integration that does not compromise established risk management systems.

One of the main outcomes of the study is a comparative assessment between the processes applied to SAF and those traditionally used for Jet A-1. This comparison aims to identify any gaps in current practices, determine whether existing Jet A-1 protocols can be applied to SAF without structural or procedural changes, and highlight areas where new technical or operational solutions may be needed. This evaluation is essential for defining effective integration pathways and minimizing operational risks during the transition toward more sustainable fuels.

The analysis presented in this Deliverable is intended to support the development of shared best practices and operational guidelines to facilitate the deployment of SAF across European airports. In doing so, it contributes to the broader objective of enabling a safe, efficient, and scalable transition to sustainable aviation fuels, in line with the sector's decarbonization targets and relevant regulatory frameworks.

The methodology used to prepare this document involved conducting surveys and interviews with the main airport operators participating in the project—namely CPH, ADR, LTOU, and

CPK—alongside additional meetings with fuel farm operators and airline companies to gain deeper insights into the practical and logistical aspects of SAF management.

Given that CPK Airport is still in the early stages of design, no binding arrangements or finalized solutions have yet been established with regard to the areas covered in this Deliverable. Therefore, the chapter related to Warsaw Airport has not been included.

1 Regulatory Framework

In this Deliverable, the key aspects of fuel monitoring, management, and the related safety procedures will be thoroughly analyzed for both Jet A-1 and SAF. First of all, below are reported some key definitions that clearly distinguish the different types of fuels involved:

- **Conventional Jet Fuel**: a fuel produced by refining fossil-based hydrocarbons such as crude oil, condensates, shale oil, or tar sands. It complies with international specifications such as ASTM D1655 or Def Stan 91-091.
- **Synthetic Blend Component (SBC)**: a synthetic fuel produced through defined chemical processes and certified under ASTM D7566 Annexes. This component, commonly referred to as "Neat SAF," is designed to be blended with conventional jet fuel.
- **Sustainable Aviation Fuel (SAF)**: an aviation fuel that meets international technical specifications and complies with environmental and sustainability criteria. SAF is ready for delivery to aircraft and contains a portion of SBC blended with Conventional Jet Fuel.

These definitions serve as the foundation for understanding the technical and regulatory differences between fuel types and they represent the starting point for a structured assessment of quality control processes throughout the supply chain.

The primary standards adopted by both airports and operators throughout the supply chain are those defined by the **Joint Inspection Group** (hereinafter referred to as JIG).

The Joint Inspection Group (JIG), founded in the early 1970s, is the world's leading organization for the development of standards related to aviation fuel supply, covering the entire supply chain from refinery to aircraft refueling. JIG standards are adopted globally, both by member companies and by non-affiliated organizations.

Since 2002, JIG has operated as a non-profit organization, supported by founding guarantor members including BP, Chevron, Eni, ExxonMobil, KPC, Shell, and Total. The organization is open to all companies involved in Jet Fuel handling. All membership revenues are fully reinvested to support the dissemination and continuous improvement of the standards, as well as participation in international initiatives related to aviation fuel and operational best practices.

The following are the main JIG standards[1] in the areas of fuel data and quality control:

1. **JIG 1 – Into-Plane Fueling:** It covers quality control and operational procedures for direct aircraft refueling. It includes pre-refueling inspections, equipment management, sampling protocols, and personnel training. Issue 13, published in September 2021.
2. **JIG 2 – Airport Depots & Hydrant Systems Standard for airport storage facilities and hydrant refueling systems (HRS):** It defines volumetric measurement procedures, contamination control, tank maintenance, and fuel traceability. Issue 13, released in September 2021.

3. **JIG 4 – Smaller Airports**: Designed for smaller airports (<10 million liters/year), where fuel is delivered via road or rail. It combines fuel storage and into-plane operations adapted to limited infrastructure. Issue 4, published in September 2021.
4. **JIG HSSEMS – Health, Safety, Security & Environmental Management System**: Standard for managing health, safety, security, and environmental practices within fuel facilities. It outlines requirements for HSSE audits, planning, training, and continuous improvement. Issue 3, available since September 2021.
5. **EI/JIG 1530 – Quality Assurance for Manufacture, Storage & Distribution**: Developed in collaboration with the Energy Institute (EI). It covers upstream quality assurance across the supply chain, from refinery to airport (terminals, pipelines, transport). Includes quality control, batch tracking, documentation, measurements, and SAF management. 2nd Edition, released in May 2019.
6. **JIG Governance & Assurance Manual:** It outlines JIG's internal governance structure, decision-making processes, and assurance and audit program. Published in April 2024.

Other important references to consider include the **AFQRJOS (Aviation Fuel Quality Requirements for Jointly Operated Systems)**[2], which, although is not a formal standard, serves as a detailed checklist of quality requirements and technical specifications for Jet A-1 and Sustainable Aviation Fuel used in jointly operated systems. Alongside the **ASTM International standards and DEF STANs (Defence Standards)** establish rigorous product specification and compliance standards, ensuring safety, optimal performance, and compatibility with aviation infrastructure.

Another key reference is the **Energy Institute (EI)**, a professional membership organization based in the United Kingdom that provides guidelines and best practices across the energy sector. In the context of aviation, EI plays a significant role in promoting efficient and sustainable fuel management. It has published several important technical documents for the industry, including JIG/EI 1530, EI 1533, and EI 1550.

Regarding the fuel sustainability monitoring, reporting and accounting, reference should also be made to **RED II/RED III**, the **Union Database**, **CORSIA**, and **ISCC** certification schemes.

The **RED II/III Directive** of the European Union sets increasing targets for the use of renewable fuels in the transport sector, including mandatory SAF quotas, and require verification of feedstock sustainability, supply chain traceability, and greenhouse gas (GHG) emission reductions compared to fossil fuels.

At an international level, **CORSIA (ICAO)** allows airlines to use sustainable SAF to reduce the net emissions that need to be offset for international flights, also requiring traceability and certified GHG savings. In both cases, certifications such as **ISCC or RSB** are essential to demonstrate compliance with environmental, social, and traceability criteria, and to correctly allocate environmental benefits across the value chain.

Directive RED II establishes the requirement to use a Union Database (UDB) for liquid and gaseous fuels used in the transport sector. This centralized digital system is designed to ensure full traceability of renewable fuel volumes along the supply chain, in order to prevent double counting and to confirm their eligibility towards national renewable energy targets in the transport sector. The certification body ISCC, actively involved in the implementation process of the UDB, provides regular updates on its development status and timeline through System Updates, which are sent via email to system users, recognized certification bodies, and members of the ISCC Association.

The regulatory frameworks along the supply chain are illustrated in the Figure 1:

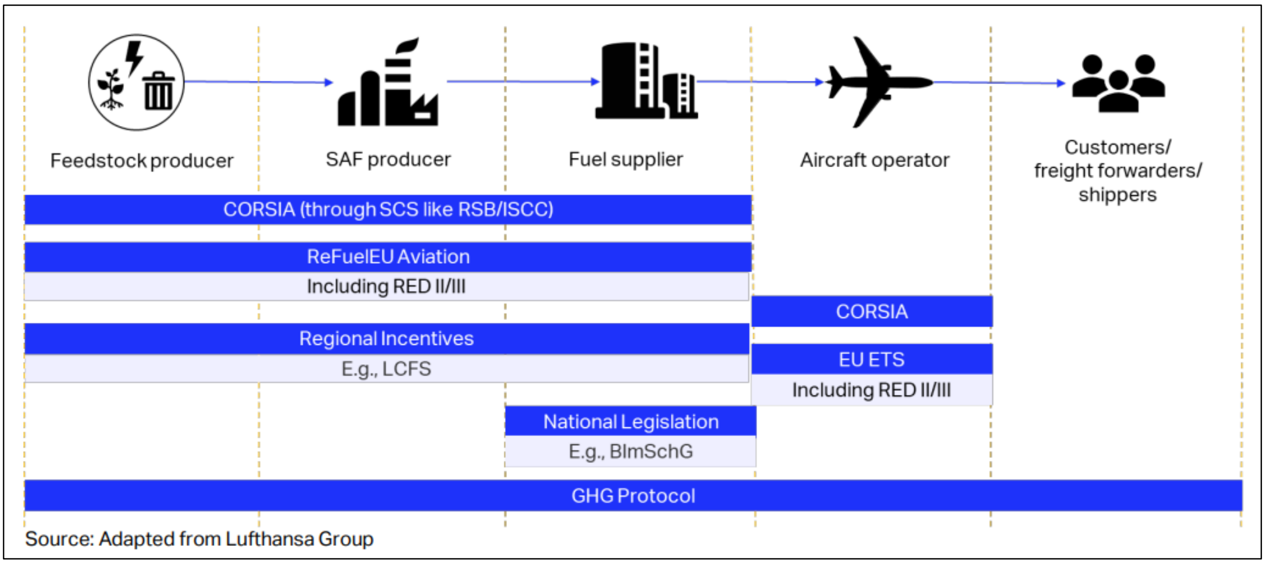

Figure 1 - Regulatory frameworks along the supply chain[3]

An important aspect to highlight, as shown in the figure, is that under the ReFuelEU Aviation regulation, the obligation to place a minimum share of SAF on the market lies with producers/importers, while refueling operators have no direct obligations either towards producers or airlines regarding the use of SAF. However, aircraft operators are included in the ETS mechanisms and CORSIA regulations for emissions accounting.

2 Data Monitoring Systems

Fuel data monitoring is a fundamental process within the Jet A-1 and SAF supply chain. This is always true for the proper management of handled fuel at airports, but it becomes even more important when SAF is involved, as tracking the amount of sustainable fuel delivered and utilized is essential for the proper allocation of sustainability attributes.

As previously mentioned, the monitoring process mainly follows the standards defined by the Joint Inspection Group (JIG) and is closely linked to what is known as the Chain of Custody Model, a methodology that defines how fuel, especially SAF, is handled and managed.

The term Chain of Custody refers to the systematic tracking, management, and control of materials and their associated documentation throughout all stages of the supply chain. The three main Chain of Custody models are: Physical Segregation, Mass Balance and Book and Claim.

Table 1 presents the different chains of custody models, each of which impacts how data is monitored.

Chain of Custody Model	Physical Segregation	Mass Balance	Book and Claim
Ensures output of certified materials claim does not exceed the input	Yes	Yes	Yes
Physical traceability is possible	Yes	Yes (through allocation)	Restricted (decoupled)
Origins of a final product can be identified	Yes	Yes (through allocation)	Restricted (decoupled)
Mixing of certified and non-certified materials	No	Yes	Yes
Administrative and logistical cost and efforts	Highest	Medium	Lowest

Table 1. Chain of custody models

The Physical Segregation and the Mass Balance models correspond precisely to the different possible physical supply chain approaches of the SAF, which are already described in several deliverables of the ALIGHT project, such as Deliverable 9.2, where it is shown that the most popular model in the real-world contexts of airports that are introducing SAF is Mass Balance. This approach is preferred since it involves the blending of SAF with conventional Jet A-1, allowing the usage of existing infrastructure, such as pipelines, instead of building new dedicated facilities.

On the other hand, the Physical Segregation model ensures that a specific batch of product, such as a SAF shipment, can be reliably linked to a defined set of sustainability attributes or criteria, providing transparency and traceability throughout its entire lifecycle.

Book and claim system allows the environmental attributes of a product, such as reduced greenhouse gas emissions, to be separated from the physical product and transferred to another party through a dedicated registry. In this model, the buyer and seller do not need to be connected through a physical supply chain: the buyer "books" a specific quantity of sustainable fuel at the time of purchase and later "claims" the associated environmental benefits to support their sustainability targets. Although the fuel is not physically delivered in the same airport where the buyer is landing, the buyer acquires the environmental benefits, receiving an independently verified certificate to substantiate the claim. This system, which complements the mass balance approach, enables access to SAF for all aircraft operators, supports cost-efficient SAF deployment at any location, maximizes the environmental benefits of SAF, and accelerates the decarbonization of the aviation sector.

As can be seen from the table, the Physical Segregation model offers the greatest transparency and reliability in tracking fuel data, at the cost of high management costs, while the Book and Claim model the exact opposite. The Mass Balance model falls in the middle.

Scientific world is now discussing about the environmental impact that the various modality has on the Local Air quality, as discussed in the Deliverable 3.2.

In real cases, since Mass Balance is the most widely adopted approach for the fuel supply chain and given that SAF molecules cannot be physically tracked from production to aircraft, airlines typically certify their SAF provision through direct contractual agreements with fuel suppliers. These suppliers, in turn, report to the fuel farm operator, at variable intervals, the amount of SAF delivered and the corresponding airline to which it has been allocated.

Key Performance Indicators (KPIs)

At the airport level, a set of key performance indicators is monitored regularly to assess operational efficiency and environmental impact, particularly in relation to fuel supply and usage. The main set of KPIs monitored are:

- **Fuel Volumes Distributed**: tracks the total volume of jet fuel and SAF distributed at the airport over a defined period. It helps assess overall fuel demand, monitor supply chain performance, and evaluate the adoption rate of alternative fuels such as SAF.
- **Associated Emissions**: quantification of the greenhouse gas (GHG) emissions associated with fuel consumption at the airport, including both conventional jet fuel and SAF. It provides insight into the carbon footprint of airport operations and supports reporting requirements for sustainability and decarbonization targets.

Regarding SAF, these are the main KPIs that are usually monitored:

- **SAF volumes**: the quantity of SAF supplied to the airport is generally communicated directly by the fuel suppliers to the fuel farm operators or, more broadly, to the entities responsible for managing fuel operations within the airport premises.
- **Origin and production pathway of the SAF:** the feedstock type and the technological pathway used for SAF production (e.g., HEFA, FT-SPK, Alcohol-to-Jet) should be

clearly identified, as they directly affect the fuel's sustainability performance and eligibility under regulatory schemes.

- **Chain of custody applied (mass balance, segregation, etc**.): the method used to track and verify the sustainable origin of SAF along the supply chain should be monitored, distinguishing whether a mass balance, book and claim, or physical segregation approach has been implemented, in accordance with sustainability certification requirements.
- **Associated GHG emissions (for compliance with RED III and CORSIA**): lifecycle greenhouse gas emissions savings associated with the SAF should be calculated and reported, considering feedstock, production, and transport stages, in line with methodologies required under RED III and ICAO's CORSIA framework.

- **Documentation and certifications (ISCC, RSB, etc.):** All SAF deliveries must be accompanied by valid documentation demonstrating compliance with recognized sustainability and traceability standards (e.g., ISCC, RSB), which are essential for both regulatory and voluntary claims.

These KPIs are crucial for supporting decarbonization strategies, meeting regulatory reporting obligations, and identifying opportunities for improvement across the airport fuel ecosystem.

Digitalization of monitoring

To support the monitoring of various KPIs related to fuel management, today there are numerous platforms, models, and software solutions available. From an operational, logistical, and strategic perspective, their digital implementation offers numerous advantages, significantly enhancing the efficiency, transparency, and resilience of fuel-related activities. Through real-time data acquisition, processing, and transmission, these systems provide essential insights to support data-driven decision-making, involving all stakeholders in the supply chain, from airport authorities to fuel operators and airlines.

Access to accurate and up-to-date data on volumes, quality parameters, consumption patterns, and supply chain status enables more effective planning, better resource allocation, and the adoption of predictive maintenance strategies.

The ability to monitor all fuel-related transactions in real time also simplifies billing, reconciliation, and reporting processes, ensuring full traceability and regulatory compliance, with particular attention to SAF distribution and the achievement of sustainability targets.

The goal of digitalization is to enable structured and continuous monitoring of key data, such as which airlines are using SAF and in what quantities, who the fuel suppliers are, real-time data on the utilization of fuel management assets (e.g., storage facilities, pipelines, hydrant systems), and performance-related information on asset conditions. All of this information, along with additional data depending on the specific needs of each airport, could be collected and stored on a single platform. This would offer a dual benefit: providing a real-time overview of airport asset status, with the ability to generate alerts in case of unexpected conditions and maintaining a comprehensive database of historical data. The objective is to make this information readily accessible to all relevant stakeholders, including the operational, administrative, and decision-making departments within the airport, in order to improve end-to-end supply chain monitoring and streamline reporting activities for airlines and airports.

3 Quality Control Procedures

As with data monitoring, quality control procedures apply to all fuels operated in the airport, both Jet A-1 and SAF.

Fuel production standards

The first step of quality control concerns the production stage of fuel and are therefore aimed at certifying its quality as a product. The applicable standards to be considered are ASTM and DEF STAN. In particular, the following standards apply to Jet fuel and SAF:

- **ASTM D1655 – Standard Specification for Aviation Turbine Fuels This**: it is the primary specification for conventional Jet fuel (Jet A and Jet A-1). It defines performance requirements, allowable compositions, and test methods for aviation turbine fuels.
- **ASTM D7566 – Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons**: this standard covers SAF blended with conventional Jet A-1 and Neat SAF. It specifies the allowable synthetic blending components and requires that the final blend meets the requirements of ASTM D1655.
- **ASTM D4054 – Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives**: it provides a framework for evaluating and certifying new SAF production pathways before they can be included under ASTM D7566.
- **DEF STAN 91-091 – Turbine Fuel, Kerosene Type, Jet A-1**: the UK Ministry of Defence specification for Jet A-1 fuel. It is widely adopted by military and some civil operators in Europe. Functionally similar to ASTM D1655 but includes additional testing and tighter limits for some parameters.

Figure 2 summarizes the different CoQs (Certification of Quality) produced by fuel type, with reference to the standards just described.

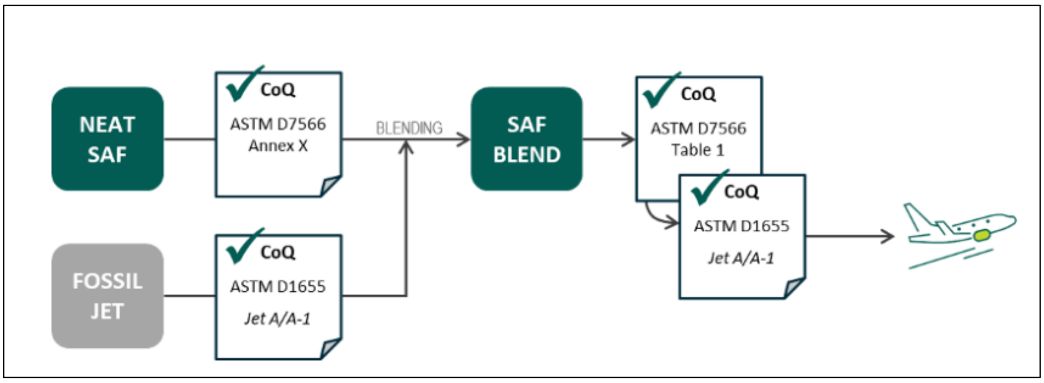

Figure 2 - SAF Standards and certifications

These standards define the required characteristics of the product, including quality parameter limits, required laboratory tests (such as density, freezing point, aromatic content, etc.), approved components, and the procedures for product qualification.

The technical documents demonstrating fuel quality which have to accompany the product to its destination are the following:

- **Refinery Certificate of Quality (RCQ):** it describes the quality of an aviation fuel product. It contains measurement results made by the product originator's laboratory of all the properties listed in the latest issue of the relevant specification. It provides information on the use of additives (including types and amounts of such additives) and details relating to the identity of the originating refinery and the traceability of the product described. RCQs shall always be dated and signed by an authorized signatory.
- **Certificate of Analysis (COA):** it contains the results of measurements made of all the properties included in the latest issue of the relevant specification. It provides information relating to the originating refiner's identity and the traceability of the product described. COA shall be dated and signed by an authorized signatory.
- **Recertification Test Certificate (RTC):** it demonstrates that recertification testing has been carried out to verify that the aviation fuel quality has not changed and remains within the specification limits. The RTC shall be dated and signed by an authorized laboratory representative carrying out the testing. The results of all recertification tests shall be checked to confirm that the specification limits are met and that no significant changes have occurred in any of the properties.

Fuel handling standards

Once the fuel has met the ASTM or DEF STAN specifications, the previously introduced **JIG guidelines** come into play, detailing how the product must be handled, transported, quality-checked, and stored on the ground throughout the airport supply chain.

Figure 3 illustrates the main standards for fuel handling along the supply chain.

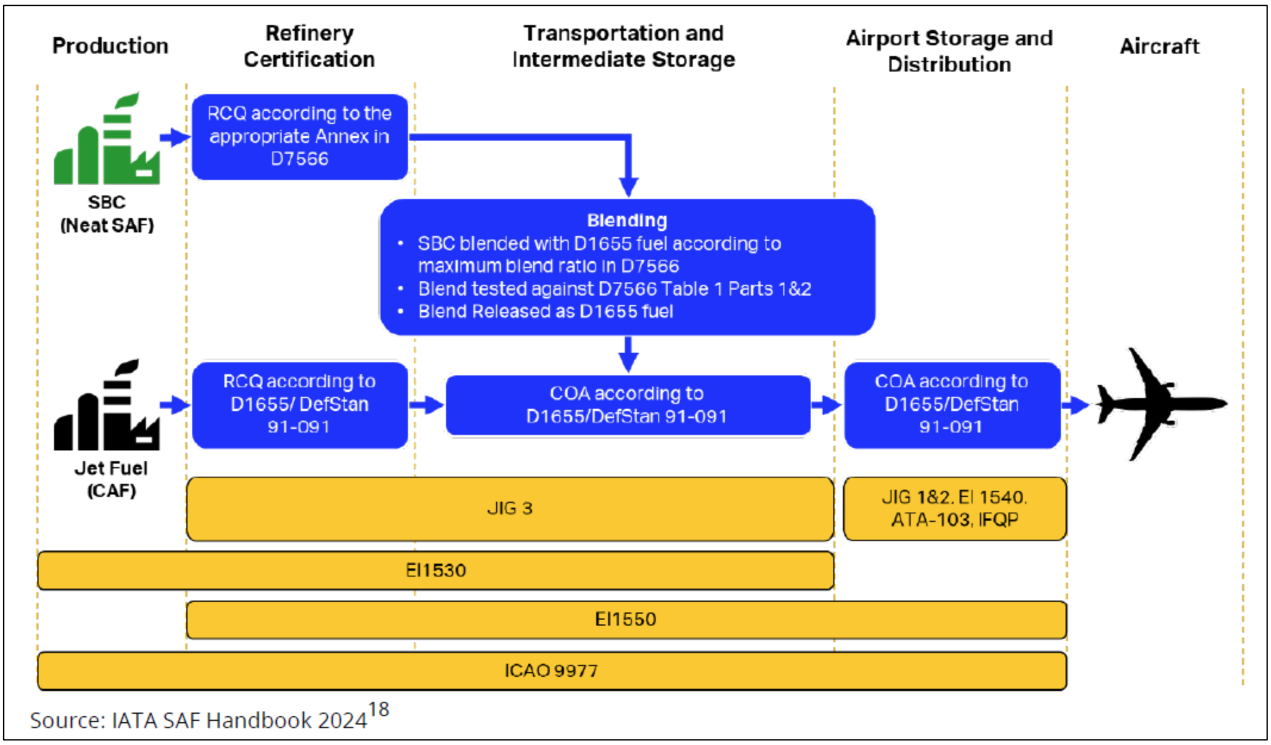

Figure 3 - Standards for Quality Control of JET-A1 and SAF

One of the main technical bulletins published by JIG (Joint Inspection Group) is the Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS). The AFQRJOS Checklist Issue 36, released in February 2025, defines the quality requirements for Jet A-1 fuel intended for Jointly Operated Fueling Systems, ensuring alignment with international standards for fuel handling safety and quality.

The checklist is widely used by fuel depot operators, fuel suppliers, into-plane service providers, airlines, and airport authorities to ensure that the fuel delivered and handled complies with JIG operational standards and key technical specifications, specifically:

a. **DEF STAN 91-091 Issue 18** – December 2024, issued by the UK Ministry of Defence, for kerosene-type turbine fuel Jet A-1 (NATO Code F-35, Joint Service Designation: AVTUR)
b. **ASTM D1655** – U.S. standard specification for aviation turbine fuel "Jet A-1"

Fuel meeting the AFQRJOS requirements is referred to as “Jet A-1 to Checklist” or “Checklist Jet A-1.” This designation allows producers and suppliers to deliver fuel that complies with either of the two recognized specifications.

However, it is important to note that the AFQRJOS Checklist is not an independent specification but rather a consolidated operational summary of the two referenced standards. As such, production, blending, and distribution facilities cannot release fuel based solely on the Checklist. Each delivery must be accompanied by a certificate of compliance with one of the official specifications.

The checklist outlines a core set of quality control tests for Jet A-1 fuel, including:

- Visual appearance inspection
- Saybolt color measurement
- Density and freezing point determination
- Aromatic content analysis
- Particulate contamination testing
- Detection of free water and other contaminants

In addition, the blend composition must be verified, detailing the volumetric percentages of conventional, hydroprocessed, and synthetic components, with special attention to the use of additives (e.g., antioxidants), which must be clearly declared with qualification references and quantities added.

Each fuel batch must be accompanied by a certificate of quality, including at least the following information:

- Specification name, issue number, and any amendments
- Full contact details of the testing laboratory
- Tank number and batch identifier
- Quantity of fuel in the batch
- Tested properties, specification limits, test methods, and results
- Additives used, including qualification and quantities
- Name, title, or electronic signature of the authorized certifying personnel
- Date of certification.

The Aviation Fuel Quality Requirements for Jointly Operated Systems for Jet A-1 are defined in Table 2:

Tests and other requirements that are unique to the following specifications for the product shown:
(a) Ministry of Defence, DEF STAN 91-091 Issue 18, dated 28th December Jet A-1
(b) ASTM D1655 – Jet A-1 Latest Issue

In conjunction with the following test requirements

PROPERTY	LIMITS	TEST METHOD Note 1		REMARKS	Source of Requirement
		IP	ASTM		
APPEARANCE - Visual appearance	Clear, bright and visually free from solid matter and un-dissolved water at ambient fuel temperature			See Note 2	Defence Standard 91 – 091 Issue 18
Colour	Report		D156 or D6045	See Note 3	
- Particulate contamination mg/L max	1.0	423	D5452	See Note 4	
Or					
- Particulate, cumulative channel particle counts	Channel counts / ISO code	565 or 577	D7619	See Note 4	
ISO Code & Individual Channel Counts ≥ 4 µm(c) ≥ 6 µm(c) ≥ 14 µm(c) ≥ 21 µm(c) ≥ 25 µm(c) ≥ 30 µm(c)	 Report / Max 19 Report / Max 17 Report / Max 14 Report Report Report / Max 13			See Note 5	
COMPOSITION Total Acidity, mg KOH/g Max	0.015	354	D3242		Defence Standard 91 - 091 Issue 18
Components at point of manufacture:					
Non Hydroprocessed Components, %v/v	Report (incl. 'nil' or '100%')			See Note 6	Defence Standard 91 - 091 Issue 18
Severely Hydroprocessed Components, % v/v	Report (incl. 'nil' or '100%')			See Note 6	
Synthetic Components, %v/v Co-processed Components, %v/v	Report (incl. 'nil' or '50%') 15% max			See Note 6-7-8,9 Note 10	
VOLATILITY Distillation Initial Boiling Point, °C	Report	123	D86	D7345, See Note 11 Or IP 406 or D2887 Note 11	Defence Standard 91 - 091 Issue 18
Thermal Stability Tube rating: One of the following requirements shall be met: (1) Annex A1 VTR, VTR Color Code	<3 Max (No peacock or abnormal color deposits)	323	D3241	Note 12	ASTM D1655-24
(2) Annex A2 ITR or Annex A3 ETR, or **Annex A4** MWETR, nm average over area of 2.5 mm2	85 nm max				

Water Separation Characteristics Without approved Static Dissipator Additive (SDA) With approved SDA **With or without approved SDA**	85 min 70 min 88 min		D3948 D8073	See Note 13	Defence Standard 91 - 091 Issue 18
CONDUCTIVITY Electrical Conductivity, pS/m	50 min to 600 max	274	D2624	See Note 14	Defence Standard 91 - 091 Issue 18
LUBRICITY BOCLE wear scar diameter, mm max	0.85		D5001	See Note 15	Defence Standard 91 - 091 Issue 18
ADDITIVES	**Refer to relevant sections of the primary specifications.** The types and concentrations of **all** additives used shall be shown on the original Certificates of Quality and on all other quality documents when they are added downstream of the point of manufacture. Names, qualification reference and quantity from DEF STAN 91-091/18 shall be quoted on quality certificates. When the original dosage of additives is unknown, it has to be assumed that first doping was applied at maximum dose rate. When additives are diluted (with hydrocarbon solvent only) to improve handling properties prior to addition, it is the concentration of active ingredient that shall be reported. See Annex A of DEF STAN 91-091 for detailed advice. See **1.8** about requirements for management of change in refineries.				

Table 2 - Requirements for Jointly Operated Systems for Jet A-1

As outlined in **Deliverable D2.2 of the ALIGHT[4]** project, quality control and sampling procedures are always carried out upon fuel receipt, although the specific methods vary depending on the mode of transport.

In the most common case of **pipeline delivery**, the JIG 2 control protocol is applied: the unloading point must follow the color-coding system specified by EI1542 (Aviation Fuel Pipeline and Storage Tank Identification from Energy Institute), and the fuel must pass through a filter/water separator compliant with EI1581 (Aviation Fuel Filtration and Water Separation Equipment from Energy Institute), with continuous monitoring of differential pressure to detect impurities. For single-grade deliveries, samples are collected at the start, midpoint, and end of the batch, and the fuel density is compared with the value stated in the Release Certificate. For multi-grade supplies, sampling is carried out every two hours and at batch transitions, following clear procedures to avoid mixing at product interfaces.

In **deliveries by road tanker or train**, a visual "clear & bright" test (white bucket test) is conducted, density is checked, and differential pressure is monitored during unloading, with additional water tests on filters if necessary. In the case of ship deliveries, JIG guidelines are strictly followed: tank compartments are inspected, ullage is compared with cargo documents, intermediate and retention samples are collected, and in-line control samples are taken during pumping. In all cases, any anomalies, such as excess water or abnormal density, are promptly addressed according to established operational procedures.

Focus – SAF standards

JIG has also published an **informational technical document related to SAF**.

The evaluation process for determining the suitability of Synthetic Blending Components (SBCs), including component control, blending and testing requirements, and their qualification for inclusion in aviation fuel standards, is governed by ASTM D4054, Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives.

Figure 4 represents the process related to the ASTM D4054 standard.

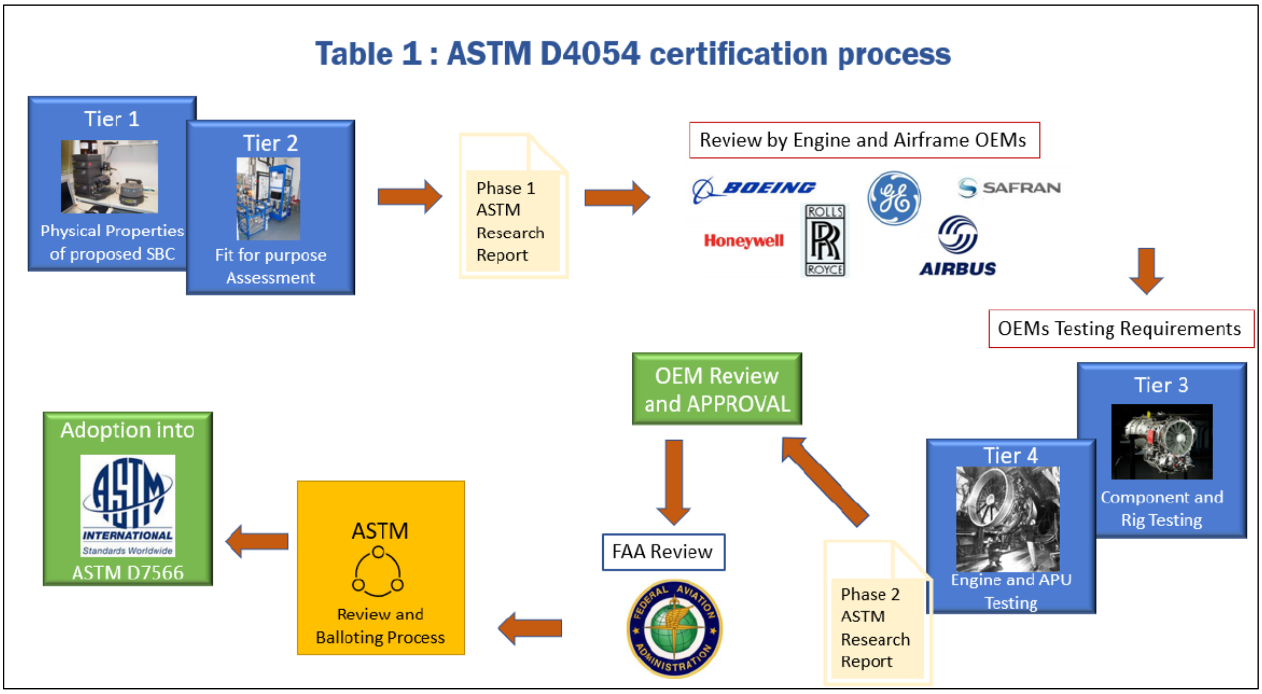

Figure 4 - ASTM D4054 certification process[5]

From the perspective of supply and product standards, the ASTM certification process ensures that, once synthetic blending components (SBCs) are mixed with conventional jet fuel, the resulting Sustainable Aviation Fuel (SAF) meets the required technical specifications and is fully compatible with existing fuel infrastructure. This allows SAF to be transported, stored, and distributed through current airport systems without the need for modifications.

The **ASTM D7566** standard defines the requirements for SAF production and blending, incorporating the outcomes of the ASTM D4054 qualification process, which assesses the molecular composition and production methods of SBCs. Each annex of D7566 specifies the approved component type and its maximum allowable blending ratio. When SAF blends are released as jet fuel compliant with ASTM D1655, it is not mandatory to report the synthetic content on the Certificate of Quality (COQ). However, this is required under Def Stan 91-091, which also mandates full traceability back to the point of manufacture.

Since 2012, jet fuels containing up to 50% synthetic components have been included in the JIG AFQRJOS checklist, which references ASTM D7566. To avoid duplication, Def Stan 91-091 fully incorporates D7566 provisions and adds further requirements in Annex B, specifically for fuels from non-conventional sources. Additional guidance on traceability within fungible transport systems is provided in EI/JIG 1530.

Finally, the IATA Fuel Quality Pool (IFQP) conducts regular audits of fuel suppliers and infrastructure to verify compliance with ASTM standards, Def Stan 91-091, and the JIG AFQRJOS checklist.

ASTM D1655 states that once a fuel has been properly blended and certified according to ASTM D7566, it can be immediately released as ASTM D1655-compliant jet fuel and treated accordingly throughout the rest of the supply chain. This means that duplicate laboratory testing is not required, as the analytical data used to demonstrate compliance with D7566 can also be used for D1655. After the release, the specific requirements of D7566 no longer apply, and any subsequent recertification must follow the procedures outlined in Table 1 of D1655. ASTM allows synthetic blending components (SBCs) to be mixed either with certified conventional jet fuel (Jet A-1) or with other conventional blending components. The initial blend point is considered the point of origin, from which the Certificate of Quality (COQ) is issued. Recertification testing is not permitted. Historically, this document was often referred to as a Refinery Certificate of Quality (RCQ), since jet fuels were traditionally produced at refineries. However, with the introduction of SAF, blending may now occur outside of refinery settings, which has led the industry to adopt the broader term COQ. In this sense, an RCQ is simply a specific case of a COQ. When SAF is released as ASTM D1655 jet fuel, there is no requirement to declare the percentage of synthetic components on the COQ.

In contrast, **Def Stan 91-091**, while fully incorporating the technical requirements of ASTM D7566 through a dedicated Annex B on fuels from non-conventional sources, adds specific additional conditions. It requires that any conventional component used for blending with SAF must already be certified as finished jet fuel conforming to Def Stan 91-091. As a result, SBCs are typically blended with fully certified jet fuel. Furthermore, the COQ must state the percentage of SAF in the blend and include a clear reference to the originator's COQ for each synthetic component used. This ensures full traceability of SAF batches throughout the downstream supply chain and is especially important in the event of reblending. According to Clause B.5, the originator's COQ must be available and referenced in the final documentation, and it must accompany the certified batch along with details of the synthetic component concentration. Additionally, the standard mandates the performance of the BOCLE lubricity test at the point of manufacture. These requirements are intended to ensure that the maximum allowed proportion of synthetic content is not exceeded during any downstream blending.

In summary, while ASTM D1655 enables a more streamlined and flexible approach to SAF handling, Def Stan 91-091 introduces more stringent requirements related to traceability, control, and documentation, aiming to maintain high levels of safety and fuel quality throughout the supply chain.

The tables below are extracted from ASTM D7566 – 20b. The Part 1 outlines the basic requirements for Sustainable Aviation Fuel (SAF), while Part 2 provides the additional requirements.

Part 1—Basic Requirements			
Property		Jet A or Jet A-1	Test Method[B]
COMPOSITION			
Acidity, total mg KOH/g	Max	0.10	D3242/IP 354
Aromatics: One of the following requirements shall be met:			
1. Aromatics, volume percent	Max	25	D1319 or IP 156[C]
2. Aromatics, volume percent	Max	26.5	D6379/IP 436
Sulfur, mercaptan,[D] mass percent	Max	0.003	D3227/IP 342
Sulfur, total mass percent	Max	0.30	D1266, D2622, D4294, D5453, or IP 336
VOLATILITY			
Distillation			
Distillation temperature, °C:			D86,[F] D2887/IP 406,[E] D7344,[G] D7345,[G] IP 123[F]
10 % recovered, temperature (T10)	Max	205	
50 % recovered, temperature (T50)		report	
90 % recovered, temperature (T90)		report	
Final boiling point, temperature	Max	300	
Distillation residue, percent	Max	1.5	
Distillation loss, percent	Max	1.5	
Flash point, °C	Min	38[H]	D56 or D3828[I], IP 170[I] or IP 523[I]
Density at 15 °C, kg/m³		775 to 840	D1298/IP 160 or D4052 or IP 365
FLUIDITY			
Freezing point, °C	Max	−40 Jet A[J] −47 Jet A-1[J]	D5972/IP 435, D7153/IP 529, D7154/IP 528, or D2386/IP 16
Viscosity −20 °C, mm²/s[K]	Max	8.0	D445/IP 71, Section 1, D7042[L] or D7945
COMBUSTION			
Net heat of combustion, MJ/kg	Min	42.8[M]	D4529, D3338, D4809 or IP 12
One of the following requirements shall be met:			
(1) Smoke point, mm, or	Min	25.0	D1322/IP 598
(2) Smoke point, mm, and	Min	18.0	D1322/IP 598

Table 3 - Basic requirements for Sustainable Aviation Fuel (SAF)

Part 2—Extended Requirements			
Property		Jet A or Jet A-1	Test Method[B]
COMPOSITION			
Aromatics: One of the following requirements shall be met:			
1. Aromatics, volume percent	Min[R,S]	8	D1319 or IP 156 or D8305[X]
2. Aromatics, volume percent	Min[R,S]	8.4	D6379/IP 436
VOLATILITY			
Distillation			D2887/IP 406[E] or D86[F] or IP 123[F] or D7344[G,V] or D7345[G]
T50-T10, °C	Min[S,T]	15	
T90-T10, °C	Min[S,T]	40	
LUBRICITY			
Lubricity, [F]mm	Max	0.85	D5001
FLUIDITY[U]			
Viscosity −40 °C, mm²/s	Max	12	D445/IP 71, Section 1[W], or D7945

Table 4 - Additional requirements for Sustainable Aviation Fuel (SAF)

4 Safety and Secure Procedures

Beyond the phases of monitoring and quality control, implementing robust safety procedures is essential to ensure the secure handling and management of aviation fuel across all stages of airport operations. These protocols play a critical role in protecting personnel, infrastructure, and the environment from the risks associated with fuel storage, transfer, and use.

Just as strict standards govern fuel quality monitoring, safety procedures are also regulated by internationally recognized frameworks. Chief among them are the Joint Inspection Group (JIG) guidelines, which provide a comprehensive set of best practices and mandatory safety measures for all stakeholders involved in the aviation fuel supply chain. Adhering to these standards not only reduces operational risks but also ensures regulatory compliance, enhances operational reliability, and strengthens environmental protection.

The primary references for aviation fuel safety are:

- **JIG Standard 1**: It covers quality control and operational procedures for direct aircraft refueling. It includes pre-refueling inspections, equipment management, sampling protocols, and personnel training.
- **JIG Standard 2**: It defines volumetric measurement procedures, contamination control, tank maintenance, and fuel traceability.
- **JIG HSSE Guidelines**: covering health, safety, security, and environmental aspects across all fuel operations.

Additional safety requirements are issued by organizations such as IATA (International Air Transport Association) and individual National Aviation Authorities, which may enforce specific local laws and operational conditions that must be observed in conjunction with JIG procedures.

For example, the IATA IFTP Standard Fueling Procedures – Service Levels and Safety[6] document provides a comprehensive and detailed framework of standard operating procedures related to aircraft refueling. This manual establishes fundamental guidelines to be followed throughout all stages of the refueling process, including precise instructions for operations both before and after the actual fueling. Specifically, the document clearly defines procedures for aircraft positioning and handling to ensure that operations are carried out safely and efficiently. It also outlines the definition and management of fuel safety zones, designated safety areas around the refueling point where specific measures must be taken to minimize fuel-related risks.

An important section is dedicated to electrostatic safety, addressing the precautions necessary to prevent static charge build-up that could cause sparks or fires during refueling. Additionally, the document provides operational guidance for situations where refueling takes place with passengers still on board the aircraft, a crucial detail for ensuring the highest level of safety for both passengers and personnel. Regarding responsibilities, the document includes a clear and structured table that divides the main precautions and duties between the different parties involved: the airline, the fuel company, or both. This distinction allows for precise identification of roles and responsibilities, facilitating coordination and accountable management of the entire refueling operation.

All safety procedures, whether related to fuel storage (fuel farm), hydrant systems (HRS), or into-plane refueling, are built on clearly defined roles and responsibilities among the main stakeholders:

- The **fuel farm operator** is responsible for safe storage, periodic inspection of tanks and pipelines, spill prevention systems, and quality assurance before fuel is released into the hydrant system. In some airports, the fuel farm operator is also responsible for the HRS distribution system.
- The **airport operator** oversees the integrity of infrastructure, coordinates emergency procedures, defines safety zones, and ensures the overall safety of refueling areas in compliance with both international and local regulations.
- The **into-plane service provider** (e.g., handling company or airline contractor) is responsible for carrying out refueling operations safely, verifying bonding/grounding, monitoring fuel pressure, and responding to abnormalities or leaks during aircraft fueling.

Importantly, the introduction of SAF does not require changes to these safety procedures. Once SAF arrives at the airport and is confirmed to meet the relevant specifications (e.g., ASTM D1655 or Def Stan 91-091), it is treated in the same manner as Jet A-1. This means it follows identical safety protocols throughout storage, handling, and aircraft refueling processes.

Finally, all stakeholders must ensure compliance not only with international standards (e.g., JIG, IATA, ASTM) but also with local and national safety regulations, which may impose additional controls depending on the airport's location and operational context.

5 Airports Case Studies

The following subsections describe the approaches adopted by the partner airports with respect to the key topics outlined above: fuel monitoring, quality control and safety procedures. Each airport's practices reflect how these elements are implemented in real-world operations, offering insight into the alignment with international standards and the integration of SAF within existing fuel management systems.

All information related to consolidated practices and standards in terms of data monitoring, quality controls and safety procedures reflect the situation as of the date of preparation of this deliverable.

5.1 Copenhagen Airport (CPH)

As described in ALIGHT Deliverable 9.2, the fuel supply chain for Copenhagen Airport is reported in the following Figure 5.

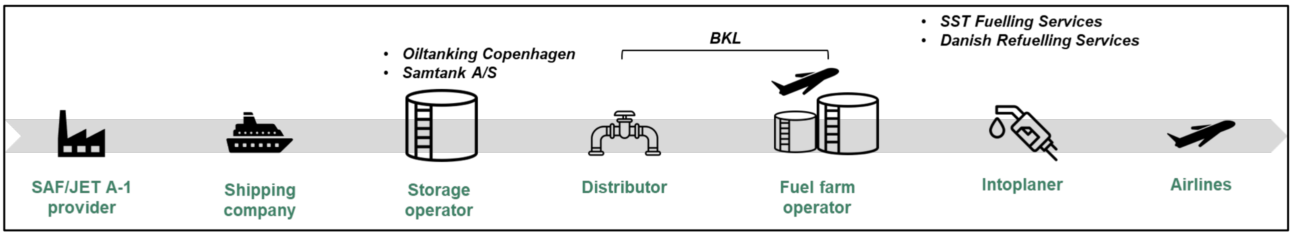

Figure 5 - CPH supply chain[7]

BKL is the responsible of the pipeline from Prøvestenen terminal to the airport, hydrant service provider at the airport and the fuel farm operator for CPH.

Data Monitoring

Copenhagen Airport (CPH) does not currently monitor the flow of fuel which enters or exit from it. Instead, it receives an annual report from the fuel farm operator BKL, which provides aggregated data on the total volume of aviation fuel supplied to airlines operating at the airport. The fuel arriving at the airport is a blending of conventional Jet A-1 and SAF, but the report does not disaggregate quantities between the two types, so CPH does not currently have access to specific data on the amount of SAF delivered or used.

A mass balance system for tracking fuel, including SAF, is in place at the airport; however, it is not actively monitored or managed by CPH. The oversight and reporting of Jet A-1 fuel throughput remains under the responsibility of BKL, which communicates the total annual volumes to CPH. This data is shared via email and are not integrated into CPH's Enterprise Resource Planning (ERP) system.

Looking ahead, it is anticipated that the European Union Aviation Safety Agency's (EASA) annual technical report will begin to include airport-level data, potentially providing greater transparency on SAF usage. Once data for the year 2025 become available, efforts will be made to formally request detailed fuel-related information from the Danish Civil Aviation Authority (CAA), including SAF-specific metrics.

In terms of emissions monitoring, CPH operates three Local Air Quality (LAQ) measurement stations on-site. These stations monitor key pollutants, including nitrogen oxides (NOx), ultrafine particles (UFP) and black carbon. The data collected from these stations is currently transferred manually via email and, similarly to the fuel data, it is not yet incorporated into the airport's centralized data systems. CPH expects to gain improved access to emissions-related data starting next year through the Union Database or via the Danish CAA, which would support more robust environmental monitoring and reporting.

BKL has no mandatory reporting obligations for emissions related to its operations, but it voluntarily monitors them in line with the guidelines set by the companies that make up the consortium. In particular, BKL calculates its carbon footprint and implements various actions to reduce or offset its direct emissions, as the use of renewable electricity (wind, hydro, solar) and biodiesel (HVO), airlines climate compensation programs, and energy efficiency upgrades have been made to buildings, and efforts focus on reducing overall energy use.

Quality control

Regarding fuel quality control, CPH fuel farm operator (BKL) carries out thorough inspections and procedures in compliance with the Joint Inspection Group (JIG) standards, as outlined in the chapter 3. These controls cover all key phases of fuel handling, from receipt, storage, and filtration to delivery into aircraft, ensuring that the fuel consistently meets international specifications in terms of safety, cleanliness, and performance. The airport's adherence to JIG guidelines guarantees alignment with industry's best practices and supports the safe and efficient operation of both Jet A-1 and SAF. The JIG standards are comprehensive and more stringent than local legislation; therefore, they are always followed, and no additional requirements need to be met.

Referring to the tests described in ALIGHT Deliverables D9.2 and D3.2, the next section outlines the quality control procedures related to the procurement of a batch of SAF.

***Focus – First Delivery quality control*[8]**

As outlined in D9.2, the first delivery of the SAF blend was agreed to be transported in a segregated DCC fuel truck from Belgium to Denmark and delivered directly to BKL's fuel farm at CPH. Subsequent deliveries, instead, would be shipped to the Touchstone port, unloaded into DCC's dedicated storage tanks, and then transferred to BKL's fuel farm at CPH through the jet fuel pipeline.

The overall fuel handling process is designed to ensure rigorous quality control at every stage. It begins at the Prøvestenen terminal, located 7 km from the airport, where aviation fuel is received by barge. Upon arrival, the fuel undergoes comprehensive quality verification in accordance with ASTM and JIG standards. Only after successful compliance testing is the fuel stored and subsequently transferred via a dedicated pipeline to Copenhagen Airport (CPH). At the airport's intermediate fuel farm, further quality inspections are carried out to confirm product integrity prior to final uplift into aircraft.

Air Greenland received the fuel ticket and, instead of the PoS (Proof of Sustainability), DCC provided two distinct documents describing the environmental attributes of the purchased SAF: a "SAF sustainability statement" and a "SAF letter" from DCC. This is because, in preparation to the upcoming RFEUA regulation, DCC was aware that they would need to surrender the unique PoS to competent authorities as proof of compliance; providing Air Greenland with a "SAF sustainability statement" and a "SAF letter" was a feasible alternative.

In the "SAF sustainability statement," the SAF component is described in two sections. Section one provides a general description of the product purchased, including the following data points:

SAF Sustainability Statement – section one

- Type of SAF product - pathway
- Quantity of SAF in m^3 and tons
- Average life cycle GHG intensity
- Energy content presented in MJ
- GHG savings in relation to baseline of 94g. CO_2/MJ
- Sustainability Certification mentioning the scheme used (RSB, ISCC, etc.)
- Status of compliance with EU RED criteria
- Chain of custody break point with responsible stakeholder.

SAF Sustainability Statement – section two

- Supplier sustainability certificate number
- Batch number
- Blending ratio
- Quantity in m^3 and tons
- Energy content
- Actual density at 15˚C
- Amount in tons
- Conversion process
- Feedstock
- Country of origin of feedstock
- Lifecycle emission

Although the use of trucks to deliver fuel is not common practice at CPH, it has been done before and there are specific JIG processes within the rulebook that describe actions needed to ensure security and safety. These JIG procedures were therefore considered for implementation when evaluating the delivery of the SAF blend using trucks.

Safety and Secure

At Copenhagen Airport, BKL, the operator of the fuel farm, is also responsible for ensuring safety in all operations related to fuel handling between the storage facilities and the hydrant refueling system (HRS). This includes overseeing the safe transfer, monitoring, and management of fuel within this segment of the supply chain, in compliance with regulatory standards and industry best practices. No additional fuel safety measures for SAF were taken given that, from a fuel handler's perspective, ASTM D1655 qualified SAF blends that arrive at the airport are handled identically to CAF volumes.

5.2 Rome Fiumicino Airport (FCO)

As described in ALIGHT Deliverable D9.2, released at the end of August 2025, the following Figure 6 illustrates the fuel supply chain for Fiumicino Airport.

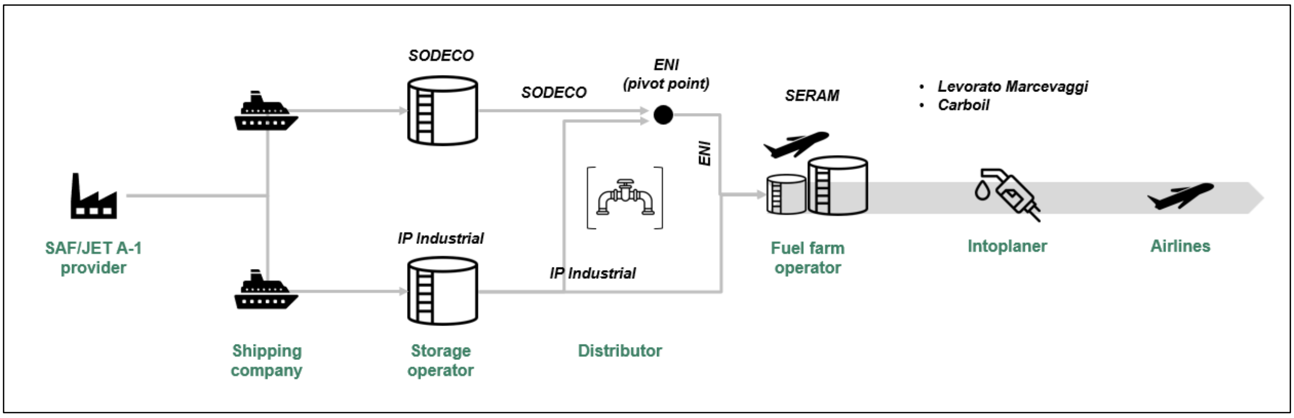

Figure 6 - FCO supply chain

Data monitoring

Fuel monitoring at the airport is carried out meticulously by the fuel farm operator (SERAM) for both incoming and outgoing flows, with the objective of ensuring full traceability and consistency between the quantities received and those delivered.

The monitoring is performed with volumetric meters at the depots, measuring the tank level variation in order to assess the actual amount of both incoming and outgoing fuel. The filling level of deposits is updated every 5 minutes, ensuring continuous and real-time tracking of the fuel inventory.

On the fiscal side, SERAM is responsible for managing an official loading and unloading register in accordance with the regulations of the Italian Customs Agency.

- For incoming fuel, the fuel suppliers upload the quantity of Jet A-1 delivered on the Customs Agency's portal (note: currently, only Jet A-1 is shown, with no separate tracking for SAF). SERAM verifies the amount of fuel actually received and uploads its own data to the portal, highlighting any discrepancies compared to the supplier's report. The Italian Customs Code defines the procedures and acceptable tolerances for these discrepancies.
- For outgoing fuel, SERAM does a daily reconciliation between the sum of all fuel delivery memoranda (i.e. official documents containing the declaration of fuel delivered to aircraft for each refueling performed) issued throughout the day and the volume variation calculated through volumetric meters. This comparison is also uploaded to the Customs Agency's portal.

This system ensures complete traceability of the fuel and supports compliance not only with quality and safety requirements but also with fiscal and customs obligations.

Quality control

When fuel arrives at SERAM facilities, it undergoes an initial quality check using a dual filtration system. The first filter is designed to retain solid particles, while the second is specifically engineered to remove excess water from the fuel. This filtration step is part of a layered safety protocol, as similar filtering procedures have already been carried out earlier along the fuel supply chain before it reaches the airport.

After this first stage, the fuel is transferred to storage tanks where it is allowed to settle (decant) for a minimum of 12 hours. This decantation process enables any remaining impurities or water to naturally separate and settle at the bottom of the tank. Following this phase, the bottom of the tank is drained from the lowest point to remove any residual contaminants.

Subsequently, laboratory tests are performed to check the fuel's quality parameters. The fuel is also filtered again before entering the Hydrant Refueling System (HRS) pump, which distributes the fuel to the aircraft.

During the actual refueling operation, the fuel passes through an intoplane unit, which serves both as a certified flow meter and as an additional filtration stage, ensuring one final layer of safety before the fuel enters the aircraft.

Immediately before refueling begins, further checks are carried out. A visual inspection is performed, and the fuel is tested with specialized water-detecting test papers. These litmus-like strips react by changing color in the presence of even trace amounts of water. If any water is detected, draining operations are repeated until the sample is fully clean and meets the required safety specifications.

This multi-step process ensures the highest level of fuel integrity and safety before any fuel reaches the aircraft tanks.

As described by Copenhagen Airport, and with reference to the tests carried out at FCO for the introduction of SAF, the next section outlines the quality control tests performed as well as the safety and operational procedures implemented for this specific case.

Focus – pilot test quality control

During the initial SAF procurement trials at Fiumicino Airport, quality assurance procedures applied to SAF strictly followed the same protocols used for conventional aviation fuel (CAF), with no need for additional certification steps or documentation. ENI, the fuel supplier, issued a standard Release Certificate of Quality (RCQ) for the SAF blend, which detailed all key parameters to guarantee compliance and fuel safety. These included visual inspection, corrosion resistance, particulate contamination at the production stage, chemical stability and composition, absence of contaminants, refining characteristics, water separation capacity, incidental materials, electrical conductivity, volatility, lubricity, low-temperature fluidity, additive content, and combustion performance.

During first Pilot test, carried out using a track, before SAF blend could have been accepted into the airport infrastructure, specifically in the SERAM depot, several preliminary safety and compliance checks were conducted. These included a safety briefing for the tanker driver, inspection of tanker seals, review of customs documentation, and validation of all fuel quality records. Once successfully verified, the tanker was weighed at the weighbridge and, in accordance with Fiumicino Airport's security procedures, escorted by Aeroporti di Roma (ADR) and SERAM staff through the customs checkpoint into the secure airside area.

At the SERAM airside refueling station, the tanker was positioned on a dedicated paved surface, with all applicable safety measures enforced, including fire protection equipment, controlled access, and spill containment readiness. Then SERAM technicians collected a fuel sample for standard quality control tests, such as water detection via tanker drainage and density measurement. Upon successful completion of these checks, the fuel was authorized for unloading into the airport's fueling system.

Safety and security

Refueling operations, including all safety-related procedures, are carried out in accordance with the standards and best practices defined by the Joint Inspection Group (JIG), in addition to the operator's internal manuals and applicable regulations.

These operations are under the direct responsibility of the Aircraft Operator, who must appoint a qualified individual known as the Refueling Supervisor (or Fueling Supervisor). This person is responsible for overseeing the operation, ensuring compliance with the procedures outlined both in this document and in the operator's manuals, and managing any contingencies that may arise. If the Refueling Supervisor is not the same person as the aircraft Commander, the Commander must introduce and identify themselves to all ground personnel involved in the operation.

If refueling is planned with passengers on board, prior authorization must be obtained from ADR-CLD Flight Control. In accordance with Regulation (EU) 452/2014, the provisions of Regulation (EU) 965/2012 also apply to third-country operators conducting scheduled operations at Fiumicino Airport.

In the event of a fuel spill, anyone who detects it must immediately inform both the Refueling Supervisor and the fueling operator, stop the fueling process, and activate all relevant safety and fire emergency procedures.

When refueling from hydrant refueling system (HRS) points onto the apron, if the fuel flow cannot be stopped through standard procedures, the emergency stop button must be used to shut off the fuel supply from the HRS. All apron stands, including those not connected to the HRS network, are equipped with two wheeled fire extinguishers. Stands equipped with HRS hydrants also include an emergency stop button.

Defueling operations are not permitted during passenger boarding, disembarkation, or while passengers are on board. Any extracted fuel must be stored in an empty tank dedicated to the specific aircraft and cannot be reused until authorized by customs. This procedure does not address customs-related aspects of fuel removal.

5.3 Vilnius Airport (VNO)

As described in ALIGHT Deliverable D9.2, the following Figure 7 illustrates the fuel supply chain for Vilnius Airport:

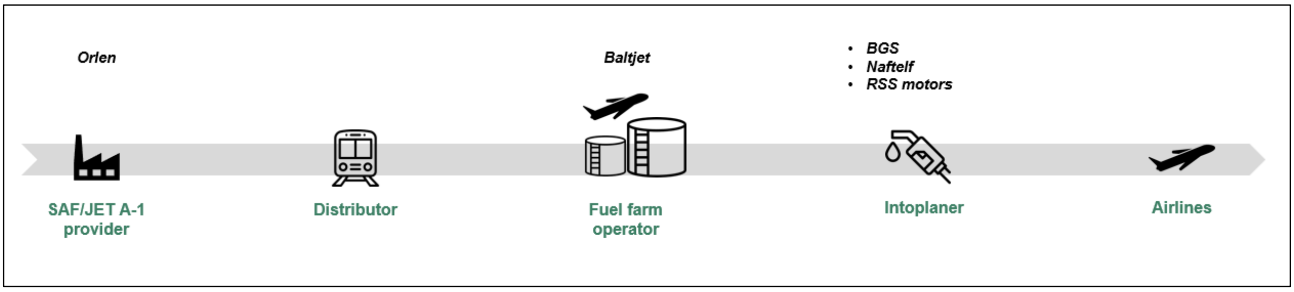

Figure 7 - VNO supply chain

Data monitoring

BaltJet, as fuel farm operator, is responsible for monitoring every new batch of fuel which arrives at the airport. For each new fuel delivery, BaltJet tracks the fuel volumes variation at deposits and submits monthly reports to the airport managing body. This process is also applied to SAF. JIG 1 requirements are applied to all Jet fuel, including SAF. No additional systems are currently planned for the management or monitoring of SAF.

There is no dedicated platform or database for tracking SAF or Jet A-1 deliveries; data is provided periodically by the fuel farm operator in Excel or similar formats. Similarly, all monitored data inside the airport are manually collected from multiple departments and service providers. Although this approach is not considered efficient by operators, there are no plans to introduce automated solutions.

CO_2 and GHG emissions are monitored under Scope 3 using the Airport Carbon Accreditation (ACA) system, with no separate monitoring systems in place for fuels.

Each department manages its own data according to relevant standards (e.g. accounting or international standards), and at year-end, a sustainability officer consolidates this information into a single report. The process is essentially the same as for Jet A-1, with monitoring limited to sustainability reporting and Scope 3 emissions tracking.

All monitoring and decision-making are overseen by the airport administration, although their role is limited, as the contractual relationships between fuel suppliers and the fuel farm operator are the primary mechanism ensuring SAF supply. LTOU is developing a data warehouse (DWH), but in its initial phase it will not consolidate SAF or GHG data from different systems.

Quality control

Fuel quality checks at the airport are primarily the responsibility of the fuel farm operator, BaltJet. The role of the airport managing body is to ensure that quality checks are properly carried out, and this is overseen by the internal Quality Control Department. No specific changes are planned for SAF, as the testing procedures remain the same as those applied to Jet A-1, in accordance with JIG standards.

All documentation and quality verifications are managed by BaltJet, while the Aviation Security Department is responsible for the release letter verification. Monthly audits are conducted to review how quality documentation is checked, and no procedural changes are foreseen for SAF at this stage. The same standards used for Jet A-1 are applied to blended fuels, with the only difference being the SAF percentage in the blend, as all other quality parameters are verified at the supplier's factory before delivery. Fuel arrives at the airport fully certified, and safety officers check the freight transport waybill upon delivery by train to the airside fuel depot.

No gaps have been identified in the current quality control system, and no changes to the monitoring or verification process are currently planned.

Safety and security

At Vilnius Airport (VNO), fuel is delivered either by railcars through the railway gates or by road vehicles entering via Checkpoint 1 (KPP1). The transportation is carried out by certified airport fuel suppliers, who operate under approved security programs that include specific fuel inspection measures, which they are required to implement. The airport, for its part, inspects incoming vehicles and personnel. There is currently no pipeline infrastructure in place, nor are there plans to construct one.

Fuel arriving by train is sourced directly from the blending producer’s facility, and safety officers verify the cargo documentation upon arrival, while all remaining documentation is handled by the fuel depot. For road transport, traditional ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road) requirements are applied. VNO is responsible for monitoring groundwater contamination at Jet A-1 storage sites, following a monitoring program coordinated with the Lithuanian Geological Survey.

This environmental monitoring continues regardless of whether the fuel is Jet A-1 or SAF. At present, no changes have been introduced in relation to SAF, and the airport has not implemented any additional or stricter environmental or safety protocols specifically for SAF.

6 Examples of Other Airports

The analysis and meetings revealed that nearly all European airports adhere to JIG standards, which are widely recognized and more stringent than individual national regulations.

To date, no publicly available studies have shown significantly different evidence regarding data monitoring, quality control, and safety procedures compared to those presented in the previous chapters.

Below is a case study from London Heathrow Airport regarding the digitalization for the monitoring of both Jet A-1 and SAF.

London Heathrow Airport[9]

At London Heathrow Airport, Swissport piloted the digitization of monitoring processes for both Jet A-1 and SAF, as documented in the "Into-Plane Fuels Management System" by VAREC.

In particular, Swissport implemented an advanced digital fuel management solution to streamline and optimize into-plane refueling operations. The integration of the FuelsManager® Dispatch & IntoPlane System, developed by Varec, enabled full digitalization of the refueling process, from flight dispatch to transactional reconciliation. The system interfaces directly with Heathrow's Flight Information Display System (FIDS) and manages flight priorities centrally, while rugged mobile devices installed on fuel trucks ensure real-time, bidirectional communication between operators and the control center. These devices also enable automatic data capture from metering systems during fueling operations, eliminating reliance on handwritten tickets and voice communications.

This setup has led to significant benefits for Swissport, including improved productivity of refueling staff, enhanced data accuracy, and real-time transaction capture, allowing same-day fuel reconciliation and reducing errors associated with manual inputs. Through seamless integration with British Airways' systems, reconciled data is automatically transmitted in IATA-standard XML format, streamlining fuel consumption validation and laying the groundwork for future integration with pilot devices.

The case of Heathrow exemplifies how the digital transformation of fuel operations not only increases operational efficiency and traceability of Jet A-1, but also provides a scalable infrastructure for the future adoption and quality control of SAF across the airline network.

7 Conclusions and best practices

The analysis of applicable standards, combined with the input gathered from partner airports and meetings with fuel farm operators (notably BKL at Copenhagen Airport and SERAM at Fiumicino), leads to a clear conclusion: in terms of fuel management, quality control, and safety procedures, blended SAF is handled in the same way as Jet A-1. This is done in full compliance with ASTM specifications and in accordance with the technical guidelines established by the Joint Inspection Group (JIG), which is recognized as the operational reference standard by all stakeholders involved in the airport fuel supply chain.

Evidence collected confirms that JIG standards serve as the primary benchmark for all activities related to fuel storage, handling, and distribution within the airport perimeter. Feedback from partner airports, as well as from the companies responsible for managing fuel farms, highlights that SAF has been fully integrated into existing operational procedures without requiring any major technical or infrastructural adjustments.

As a result, SAF can be managed using current infrastructure, technologies, and operational protocols already in place for Jet A-1, enabling the seamless integration of sustainable fuel into airport systems. This approach offers a concrete advantage in accelerating SAF deployment by avoiding operational disruptions and additional costs, thus supporting a smooth transition toward more sustainable solutions without compromising current standards of safety, efficiency, and operational quality.

Finally, it is worth noting that none of the operators contacted reported any gaps to be addressed in the existing supply chains, which can therefore be considered well-established for the coming years.

These findings are consistent with the outcomes of other deliverables within the ALIGHT project and reinforce the notion that SAF's compatibility with existing infrastructure is a key enabler for its widespread adoption in the aviation sector, supporting long-term decarbonization and environmental sustainability goals.

The analysis shows that airport operators have a limited operational role in fuel monitoring, quality control, and safety management. These responsibilities are primarily held by the fuel farm operators, who oversee all critical fuel handling activities within the airport grounds, as detailed in Deliverable 9.2 of the ALIGHT project.

Consolidated Practices

- **Operational Handling of SAF as Jet A-1:** blended SAF is managed in the same way as Jet A-1, using existing infrastructure, procedures, and technical standards. This approach is fully compliant with ASTM D1655/D7566 specifications and aligned with JIG operational guidelines.
- **Use of JIG Standards**: the Joint Inspection Group (JIG) standards (e.g., JIG 1, JIG 2, JIG/EI 1530) are the reference framework adopted by all stakeholders in the airport fuel supply

chain. These standards ensure consistency in fuel handling, safety procedures, and product integrity.

- **Quality Control Protocols**: fuel quality is ensured through multiple layers of inspection and testing: upon receipt, during storage, and prior to aircraft refueling. Testing includes checks for water content, density, visual clarity, and particulates. SAF batches are subject to the same rigorous controls as Jet A-1, following JIG/EI protocols.
- **Batch Traceability and Documentation:** all SAF movements are tracked with complete batch traceability, from delivery to final uplift. Key documentation—such as certificates of analysis, blending ratios, and quality inspection logs—is typically shared by fuel suppliers with fuel farm operators or directly with airports. This exchange of information ensures transparency, accountability, and accurate reporting across the entire supply chain.
- **Integration with Existing Infrastructure**: the compatibility of SAF with existing tanks, pipelines, and hydrant systems allows for its integration without the need for major infrastructure modifications. This operational continuity is a key enabler for SAF adoption at scale.
- **No new safety procedures required**: Similarly to what was observed regarding quality control, there are no differences or gaps in safety procedures for the handling of SAF compared to Jet A-1. However, there are still isolated cases of dedicated deliveries by truck, for which some partner airports have developed ad hoc procedures.

8 References

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[1] JIG - website
[2] JIG - Aviation Fuel Quality Requirements for Joint Operations Systems (AFQRJOS) Checklist
[3] SAF Handbook IATA
[4] ALIGHT Deliverable D2.2
[5] JIG – Technical Aviation Document Sustainable Aviation Fuel
[6] IATA - Standard Into-Plane Fueling Service Levels and Safety
[7] ALIGHT Deliverable D9.2
[8] ALIGHT Deliverable D3.2
[9] VAREC - Into-plane Fuels Management System From Fuel Farm to Take Of