UK SAF Clearing House

Supporting the testing and qualification of sustainable aviation fuels (SAF)

UK Sustainable Aviation Fuels Clearing House (UK SAF CH) RTFA webinar

Wednesday 16 April 2024

Department for Transport

University of Sheffield | Energy Innovation Centre

RICARDO

UK SAF Clearing House

Supporting the testing and qualification of sustainable aviation fuels (SAF)

Introduction

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UK SAF CH Director

Department for Transport

University of Sheffield | Energy Innovation Centre

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Agenda

1. A History of Aviation Fuel Standards
2. What are the Aviation Fuel Standards relevant to SAF/SATF
3. ASTM International D4054 Evaluation Standard Practice and progress
4. UK SAF CH Overview
5. UK SAF CH Activity and Client Base
6. UK SAF CH International Engagement
7. Support to those exploring existing pathways
8. Q&A

A History of Aviation Fuel Standards

Advancing Aircraft Designs and Performan

US and British Military Specificatio

Pre-1944 Gasoline, Diesel, Illuminating Kerosene (Lamp Oil) British RDE/F/DER/210 (1943)

1944 JP-1 1st US Jet Fuel

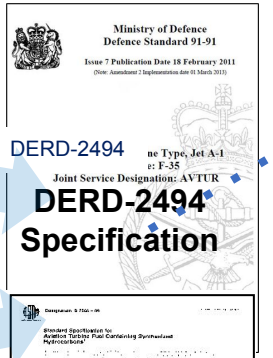
1945 JP-2 Wide-Cut Jet Fuel

1947 JP-3 Higher Vapor Pressure Jet Fuel DERD-2482 British Jet Fuel

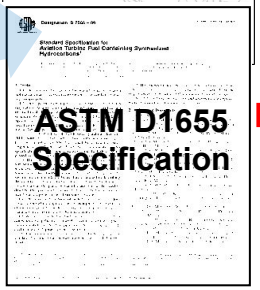
1951 JP-4 Reduced Volatility Jet Fuel

1953 JP-5 Aircraft Carrier Ops

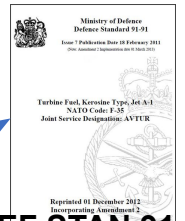
1956 JP-6 Improved Thermal Stability JPTS High Altitude Ops



DERD-2494 Specification

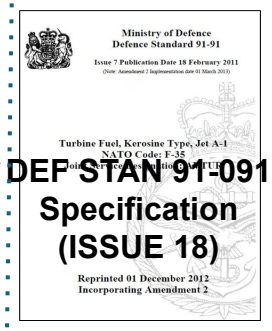


ASTM D1655 Specification



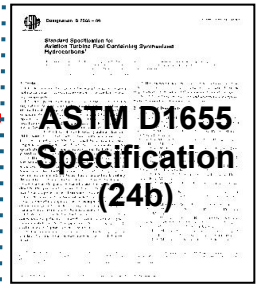
DEF STAN 91-91 Specification (1994)

Continued Evolution



DEF STAN 91-091 Specification (ISSUE 18)

Continued Evolution



ASTM D1655 Specification (24b)

Commercial Aviation

1940

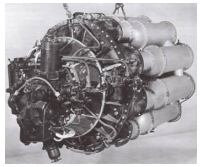
1950

1960

2025

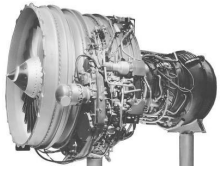
A History of Aviation Fuel Standards

Existing Fuel

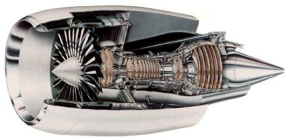


1950's

1970's

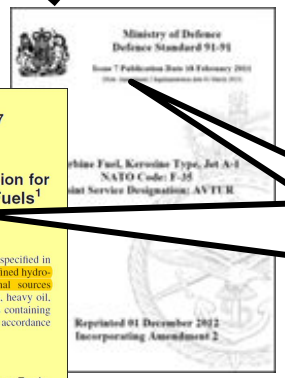


1990's



2000's

Newer Engines



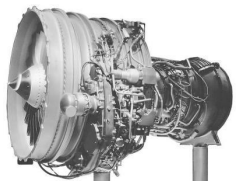
ASTM D1655 & DEF STAN 91-091 Jet Fuel Specifications

A History of Aviation Fuel Standards

The Airworthiness Authorities do not certify fuel,

they certify airplanes and engines to operate on specified fuel

Fuel Specification



Engine Operating Limitations

Aircraft Operating Limitations

Aircraft Flight Manual (AFM)

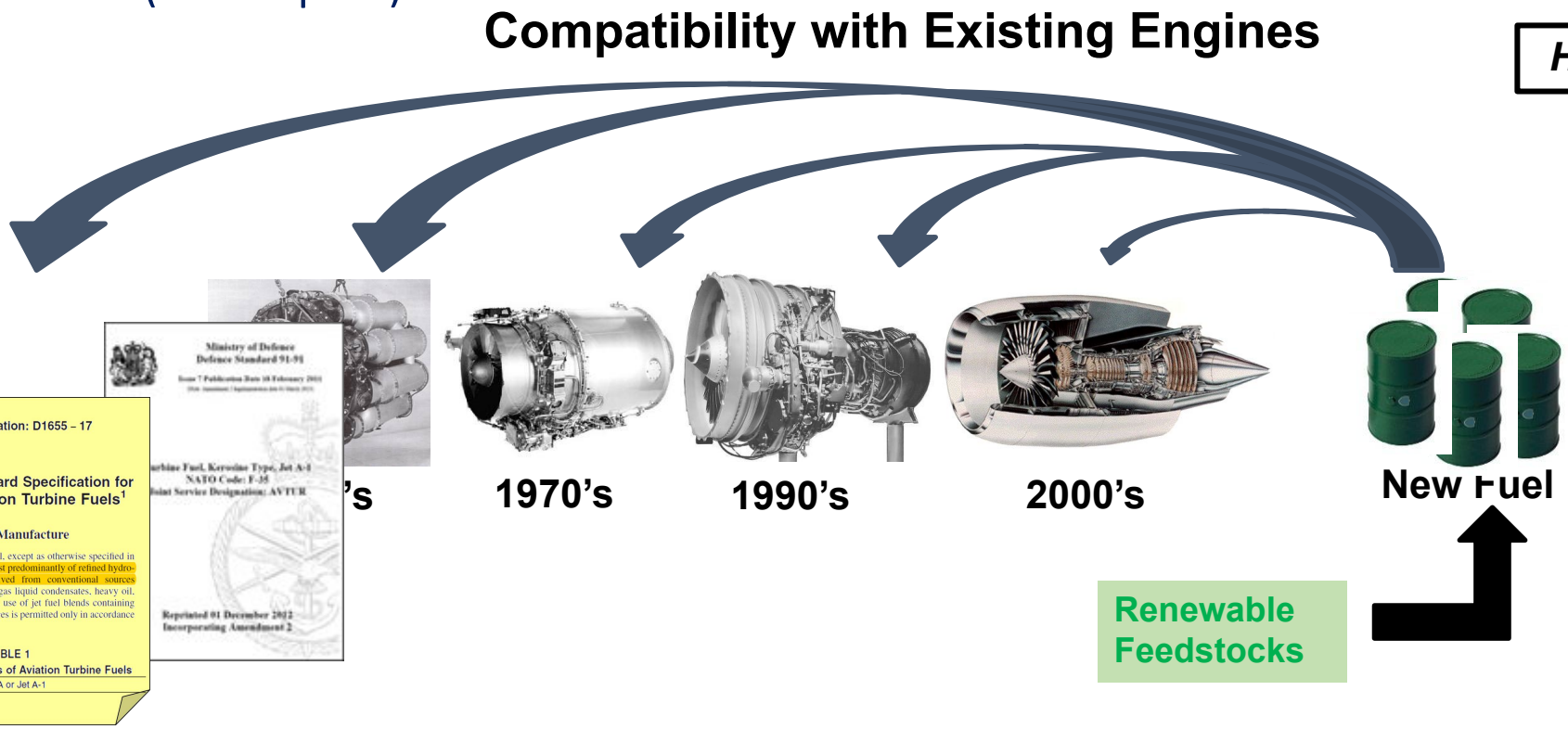
No person may operate a civil aircraft without complying with the operating limitations specified in the approved AFM

National Airworthiness Authorities do not approve jet fuel or jet fuel producers (excluding Russian and China)

Airworthiness regulations require airlines to use only the jet fuel specified by the OEM in the AFM

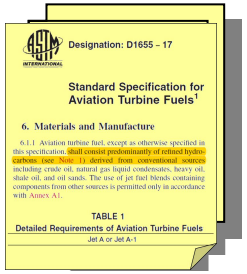
A History of Aviation Fuel Standards

New Fuels Must be Backwards Compatible
(or 'Drop-in')



Aviation Fuel Standards

Technical documents commercial aviation relies on for fuel safety:


Designation: D1655 – 17

Standard Specification for Aviation Turbine Fuels[1]

6. Materials and Manufacture

6.1.1 Aviation turbine fuel, except as otherwise specified in this specification, shall consist predominantly of refined hydrocarbons (see Note 1) derived from conventional sources including crude oil, natural gas liquid condensates, heavy oil, shale oil, and oil sands. The use of jet fuel blends containing components from other sources is permitted only in accordance with Annex A1.

TABLE 1
Detailed Requirements of Aviation Turbine Fuels
Jet A or Jet A-1

ASTM D1655

STANDARD SPECIFICATION for Aviation Turbine Fuel (**Jet A/A-1**)


Ministry of Defence
Defence Standard 91-91

Turbine Fuel, Kerosine Type, Jet A-1
NATO Code: F-35
Joint Service Designation: AVTUR

Reprinted 01 December 2012
Incorporating Amendment 2

DEF STAN 91-091

STANDARD SPECIFICATION for Aviation Turbine Fuel (**Jet A-1**)

[HARMONIZED with D1655 & D7566]

ASTM D7566

STANDARD SPECIFICATION for Aviation Turbine Fuel Containing Synthetic Components (Synthetic Blend Components (SBC))

(SATF) Synthetic Aviation Turbine Fuel

ASTM D4054

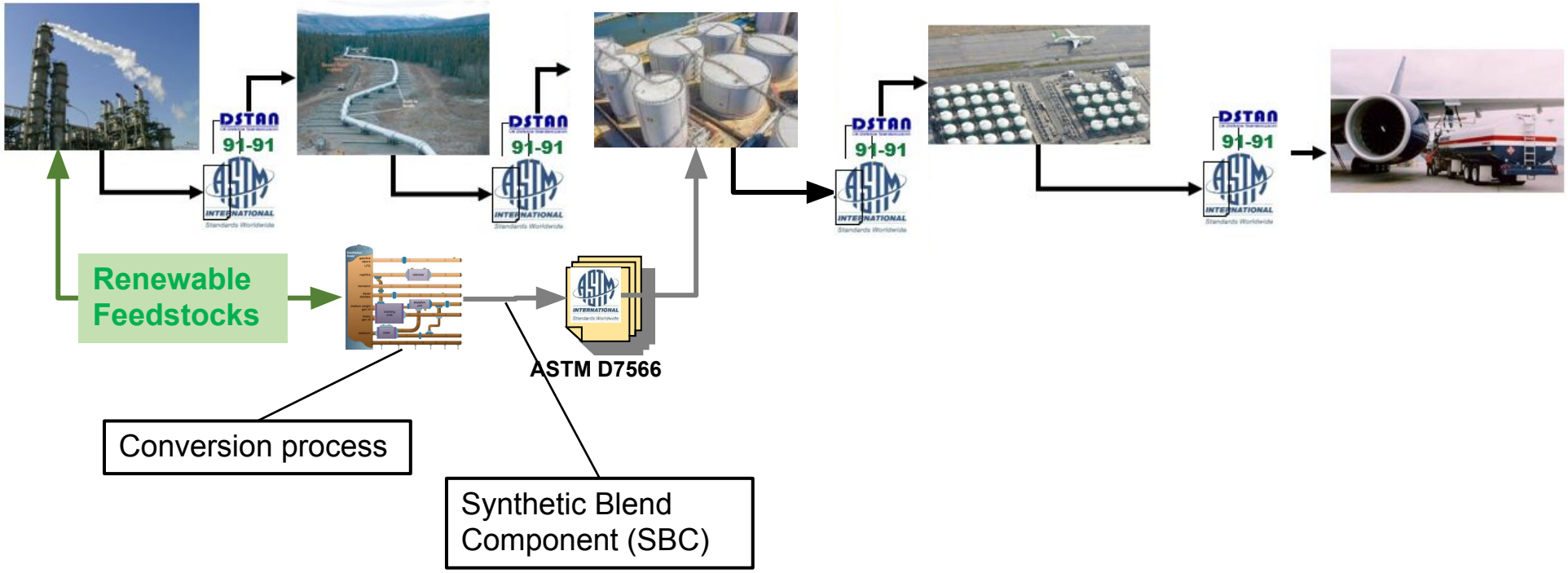
STANDARD PRACTICE for Evaluating New Aviation Fuels and Additives

Used for technical the development of specifications

(Note: Other, post-refinery quality assurance documents are relied on such as EI/JiG 1530 and 1533, aircraft AMMs, etc)

Aviation Fuel Standards

Aviation Fuel Standards through the logistical supply chain



* In most countries, but excludes China and Russia and some others

Aviation Fuel Specifications

New SATF Meets Existing Operating Limitations, Therefore Approved to Use on Virtually All Existing Aircraft

4 D1655 = D7566
Conventional Jet Fuel Spec | Drop-In Jet Fuel Spec

1 
Aircraft Approved Operating Limitations Based on Industry Fuel Specifications

Jet A and Jet A-1 Fuel

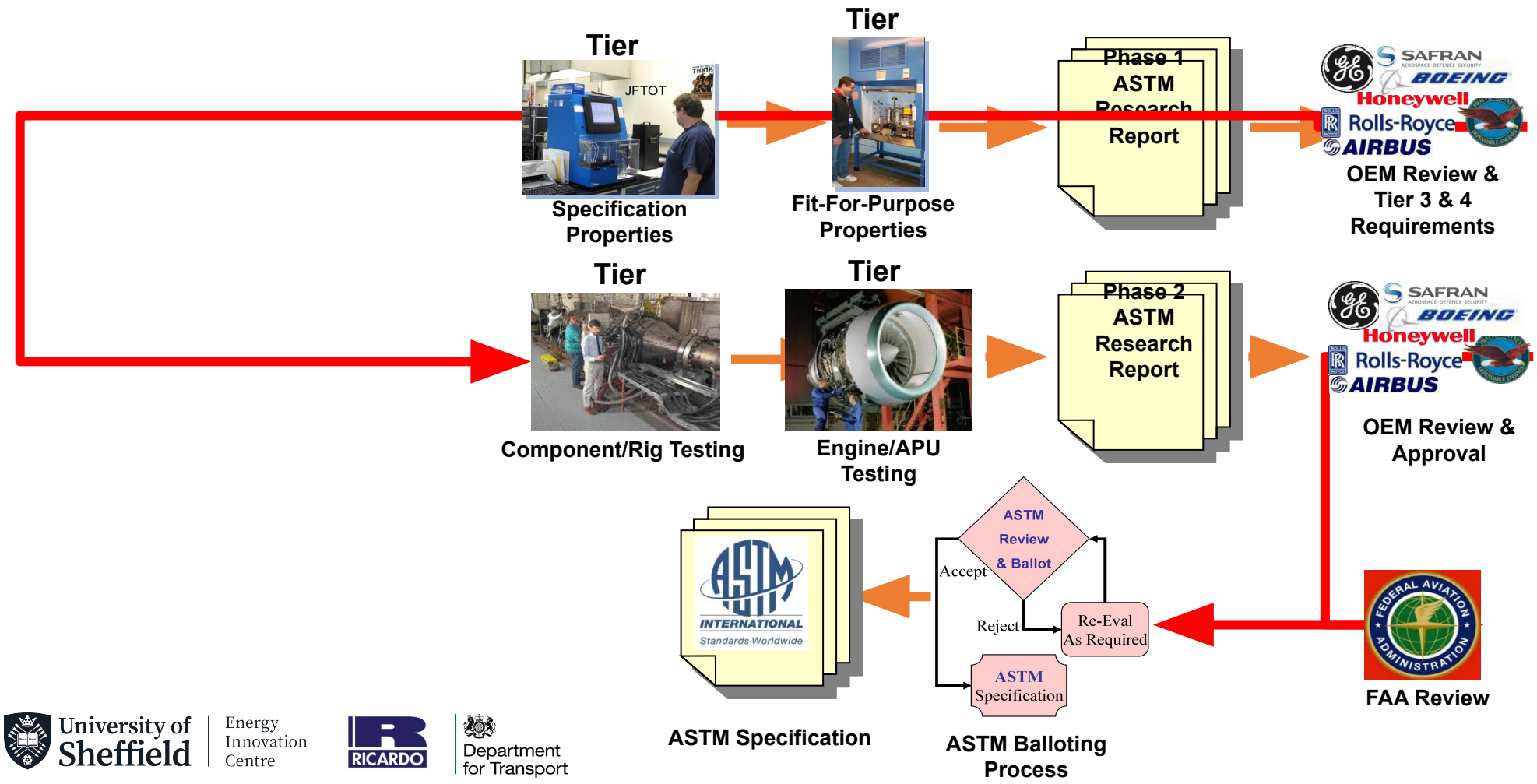
2 ASTM D4054
SATF Evaluation Process
If New SATF Meets Conventional Jet Fuel Composition & Properties

New Feedstocks

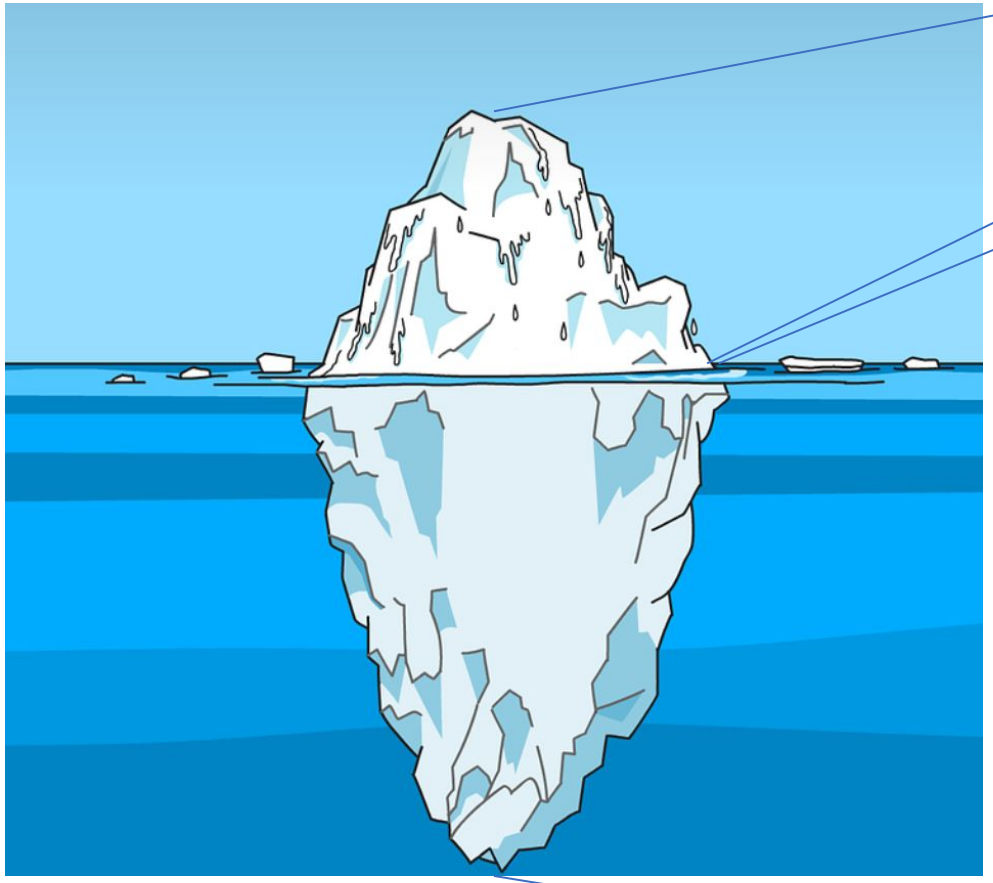
3 ASTM D7566
Drop-In Jet Fuel Spec
Then New SBC Annex Added to Drop-In Fuel Spec

Aviation Fuel Specifications

D4054 Evaluation Process



Aviation Fuel Specifications



Tier 1
Fuel Specification Properties
Relating to Engine Safety, Performance, and Durability (ASTM D1655/DEF STAN 91-091, MIL-DTL-83133, MIL-DTL-5624)

Tier 2
Fit-for-Purpose Properties

CHEMISTRY
- Hydrocarbon chemistry (carbon number, type and distribution)
- Trace Materials

BULK PHYSICAL AND PERFORMANCE PROPERTIES
- Boiling Point Distribution
- Vapor/Liquid Ratio
- Thermal Stability Breakpoint
- Lubricity
- Response to Lubricity Improver
- Viscosity vs. Temperature
- Specific Heat vs. Temperature
- Density vs. Temperature
- Surface Tension vs. Temperature
- Bulk Modulus vs. Temperature
- Thermal Conductivity vs. Temp.
- Water Solubility vs. Temperature
- Solubility of Air (oxygen/nitrogen)

ELECTRICAL PROPERTIES
- Dielectric Constant vs. Density
- Electrical Conductivity and Response to Static Dissipator

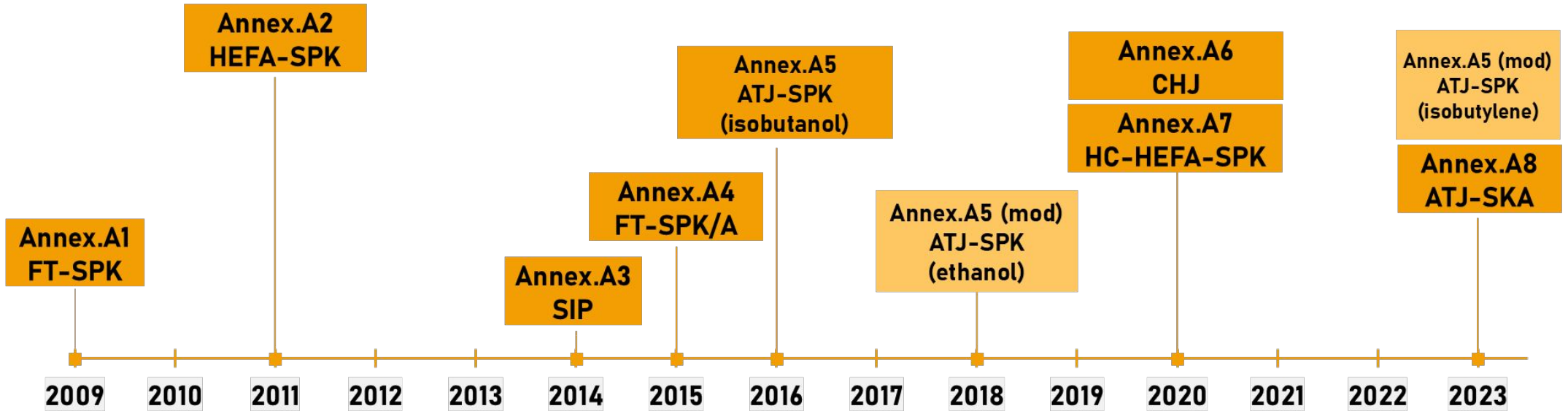
GROUND HANDLING/SAFETY
- Effect on Clay Filtration
- Filtration (coalescers & monitors)
- Storage Stability
  - Peroxides/Potential Gum
- Toxicity
- Flammability Limits
- Autoignition Temperature
- Hot Surface Ignition Temperature

COMPATIBILITY
- Preliminary materials compatibility
- Additive Compatibility & Perf (New Additives Only)

Aviation Fuel Specifications

Approved SATF pathways: 8 (plus 2 major annex modifications)

International collaboration—Annex proponents from: France, Germany, United Kingdom, Japan, Netherlands, South Africa, Sweden, and United States



Aviation Fuel Specifications

The Clearinghouses are working with producers from across the globe to advance SATF pathways

1. **Marathon** (USA) – synthesized aromatic kerosene (SAK)
   Feedstock: commercial sugars | Process: hydrodeoxygenation
2. **CSIR-IIP** (India) – synthesized kerosene with aromatics (SKA)
   Feedstock: FOG | Process: adapted HEFA
3. **OMV ReOil** (Austria) – synthesized kerosene with aromatics (SKA)
   Feedstock: waste plastic | Process: pyrolysis oil + refinery ops
4. **Revo** (Japan) – HEFA with higher cycloparaffins
   Feedstock: FOGs | Process: HEFA
5. **ExxonMobil/Honeywell UOP/Halder-Topsoe** (USA/ Denmark) – Methanol-to-Jet (MTJ)
   Feedstock: Methanol | Process: dehydrogenation + oligomerization
6. **CleanJoule** (USA) – synthesized cycloparaffins (SCP)
   Feedstock: Isoprene | Process: oligomerization + hydroprocessing
7. **UPM** (Finland) – synthesized kerosene with aromatics (SKA)
   Feedstock: Crude Tall Oil (CTO) | Process: hydroprocessing + fractionation
8. **IH²** (USA) – cycloparaffinic kerosene
   Feedstock: wood/cellulous | Process: hydropyrolysis + hydroconversion
9. **Sheffield** (UK) – Soli s-to-Jet (SBtJ)
   Feedstock: Sewage Biosolid| Process: Hydrothermal liquefaction (HTL) + hydroprocessing

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UK SAF Clearing House – Overview

Vision

To support the growth of a UK SAF production industry and the targets defined in the UK SAF Mandate (2% SAF blend by 2025 and 10% by 2030) by providing cross-industry support for the development, testing and qualification of SATF/SAFs

UK SAF Clearing House

University of Sheffield | Energy Innovation Centre

RICARDO

Background

- Funded by the UK Department for Transport (DfT)
- Launched in November 2023
- Delivered by University of Sheffield, Energy Innovation Centre in partnership with Ricardo UK

Objectives

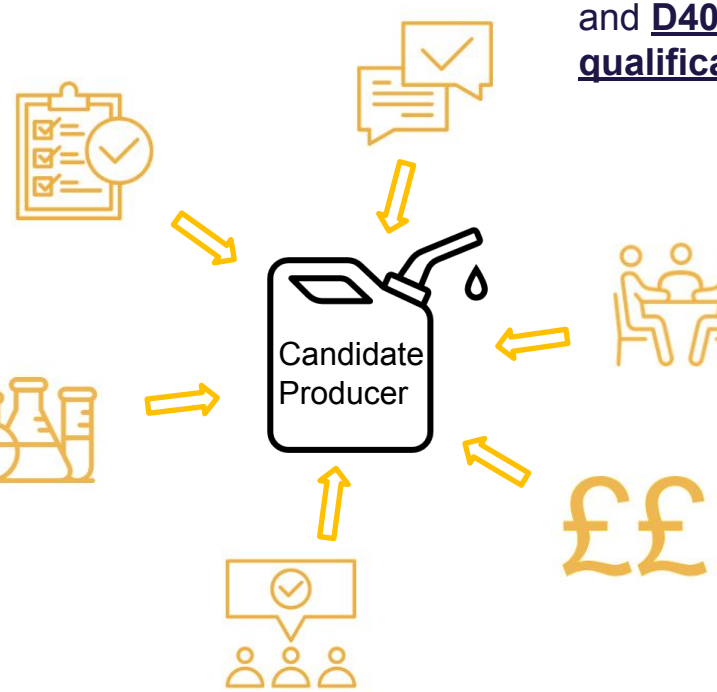
1. Provide cross-industry support for the development, testing, and qualification of SATF/SAFs
2. Develop and enhance UK test capability by managing a network of test facilities
3. Act as a platform for UK based users, producers, test facilities and industry stakeholders to network
4. Maintain industry wide engagement, to monitor and positively contribute to the international aviation fuel industry
5. Advise on opportunities and challenges associated with development and deployment of SATF/SAF from a technical perspective

UK SAF Clearing House – Overview

Support provided to producers:

Advice and guidance on SAF testing and **D4054 evaluation and qualification requirements**

Free at the point of use for all Fuel Readiness Levels (FRL)



Networking with **industry stakeholders and experts** (Clearing House Advisory Group (CHAG))

Access to **Test Facilities, Pilot scale Hydro-processing and Fractionation facilities**

Access to **DfT grant funding** for testing and sample transportation costs

Access to a **comprehensive website**: Clearing House services and latest SAF news and developments

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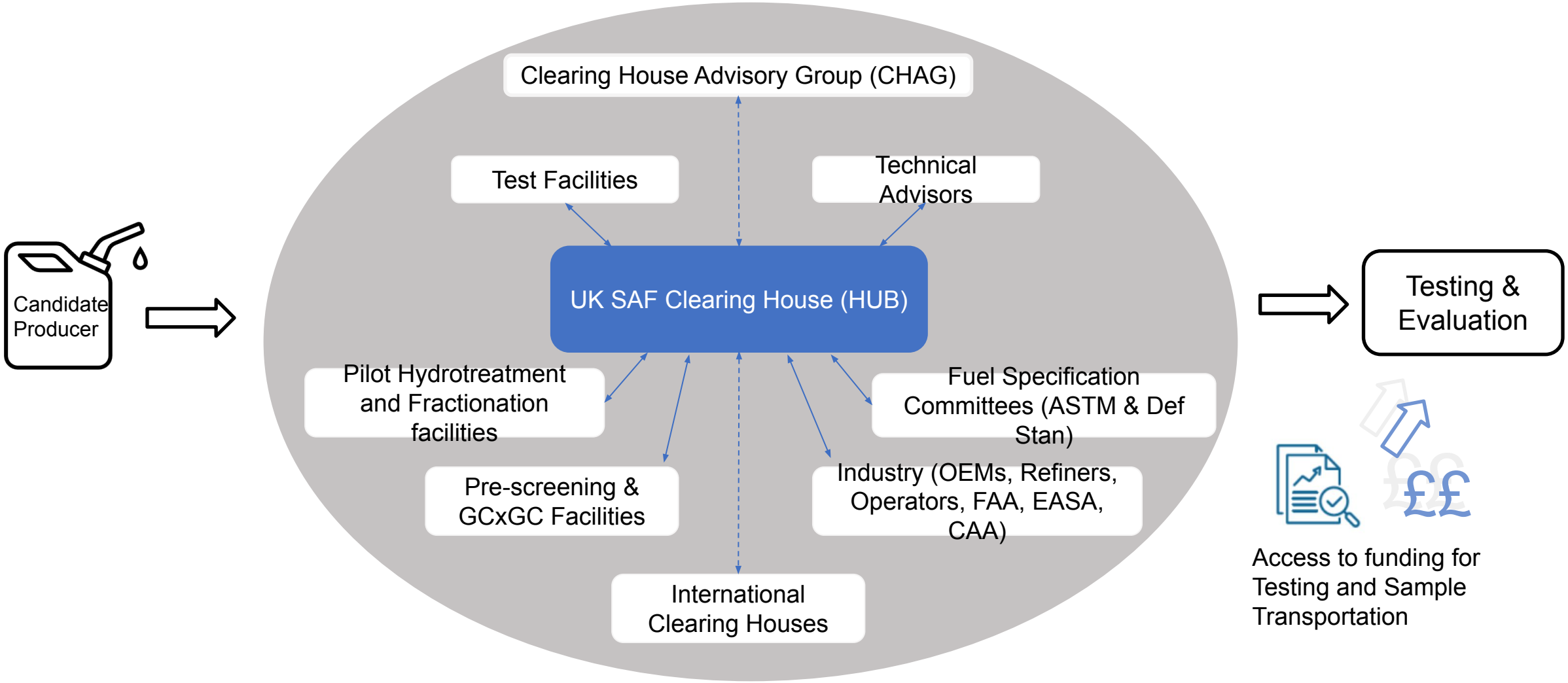
UK SAF Clearing House – Overview



UK SAF Clearing House – Overview

Network of Test Facilities

- Coordinate a **network of recognised test facilities** that evidence meeting **industry standards** for carrying out specific fuel testing and analysis
- **Access to pre-screening facilities** which require minimal volumes of fuel to provide basic compositional analysis coupled with predictive fuel property capabilities
- Detailed understanding of **Test Capability across** the UK
- **University of Sheffield, Energy Innovation Centre** - Plan to have their facility **online in 2025** and ISO 17025 by the end of 2025. Including full GC x GC analysis aligned to UDRI & US Clearing House

AmSpec
CORYTON FOR A CLEANER FUTURE
SGS
intertek caleb brett
University of Sheffield | Energy Innovation Centre

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center
WASHINGTON STATE UNIVERSITY

UK SAF Clearing House – Overview

Hydroprocessing Capability

- A range of pilot scale hydro-processing and fractionation facilities now on the books.
- Thus far, 6 producers have benefited from this service and 1 is actively producing samples.

ASG Analytik-Service

DROCHAID RESEARCH SERVICES LTD

KIT Karlsruher Institut für Technologie

CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

HyPro

green fuels

Fraunhofer

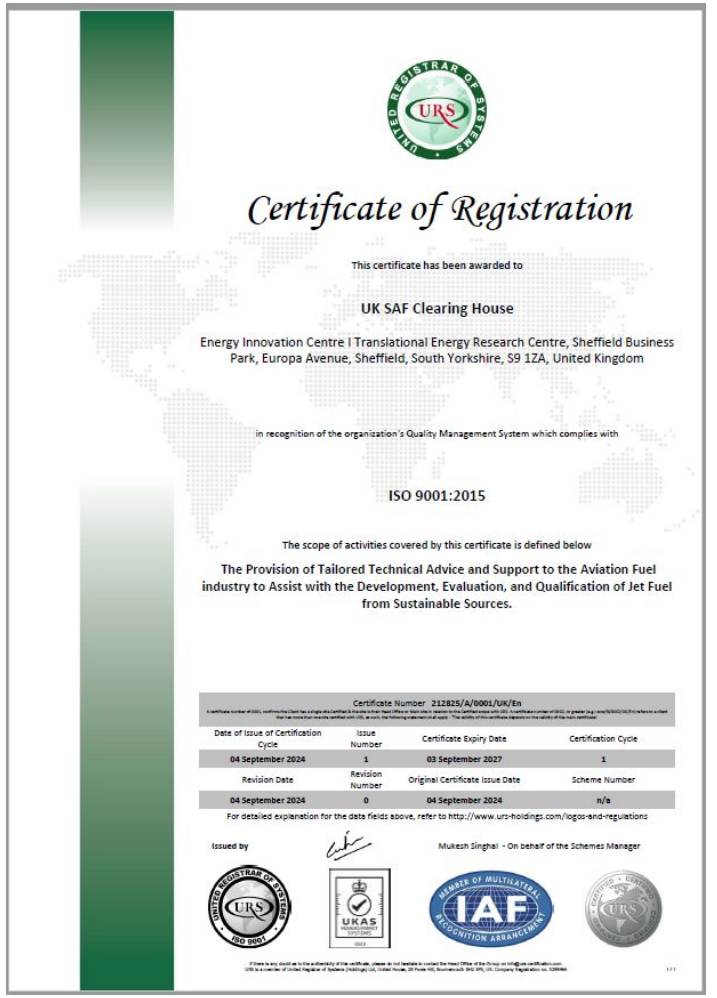
GHENT UNIVERSITY

LCT DRIVING CHEMICAL TECHNOLOGY

UK SAF Clearing House – Overview

Quality Assured Service

- ISO 9001:2015 Quality Management System Certificate awarded August 2024.
- An international recognised quality management system (QMS) standard that helps organizations improve their performance. The most widely used QMS standard in the world.
- Enables UK SAF CH to identify and meet customer expectations
- Demonstrates UK SAF CH commitment to quality
- Helps organizations consistently provide products and services that meet requirements
- Promotes continuous performance improvement



Certificate of Registration

This certificate has been awarded to

UK SAF Clearing House

Energy Innovation Centre I Translational Energy Research Centre, Sheffield Business Park, Europa Avenue, Sheffield, South Yorkshire, S9 1ZA, United Kingdom

in recognition of the organization's Quality Management System which complies with

ISO 9001:2015

The scope of activities covered by this certificate is defined below

The Provision of Tailored Technical Advice and Support to the Aviation Fuel industry to Assist with the Development, Evaluation, and Qualification of Jet Fuel from Sustainable Sources.

Certificate Number 212825/A/0001/UK/En

Date of Issue of Certification Cycle	Issue Number	Certificate Expiry Date	Certification Cycle
04 September 2024	1	03 September 2027	1
Revision Date	**Revision Number**	**Original Certificate Issue Date**	**Scheme Number**
04 September 2024	0	04 September 2024	n/a

For detailed explanation for the data fields above, refer to http://www.urs-holdings.com/logos-and-regulations

Issued by

Mukesh Singhal - On behalf of the Schemes Manager

Clearing House Advisory Group (CHAG)

Provides independent oversight of operations and is an independent open-invitation committee of experts from across the aviation fuel industry from production, distribution to use and

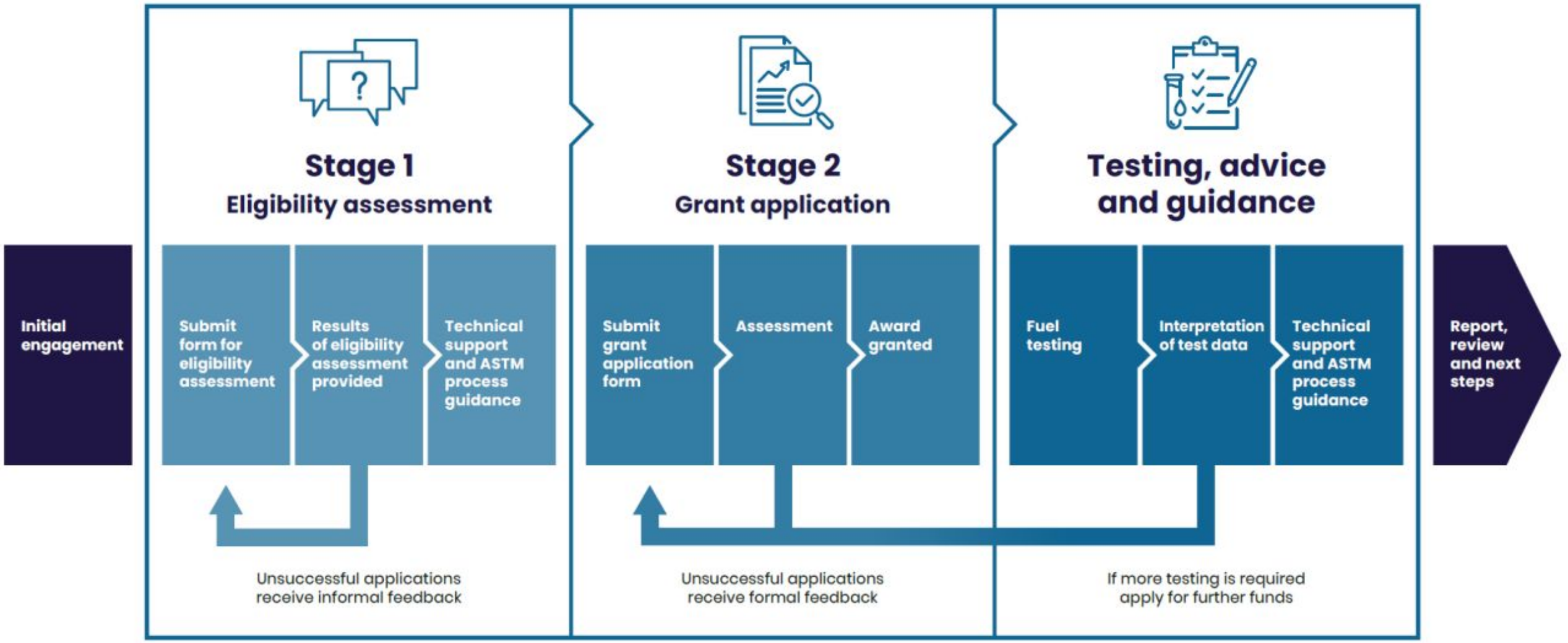
Includes representation from:

- original equipment manufacturers (OEMs)
- the international standards organisations including ASTM, Defence Standards
- academics and experts
- UK Ministry of Defence (MoD)
- major fuel producers
- US and EU Clearing Houses
- UK Department for Transport (DfT)

The committee's role is **to oversee and advise on the set-up and running of the Clearing House's procedures, processes** and operating model, to best serve the industry.

Members may be co-opted to advise on specific technical issues.

UK SAF Clearing House technical support - Custom Journey



UK SAF Clearing House – Activity

Engagement

Training & Guidance

Research & Development

Scaling

Evaluation Process

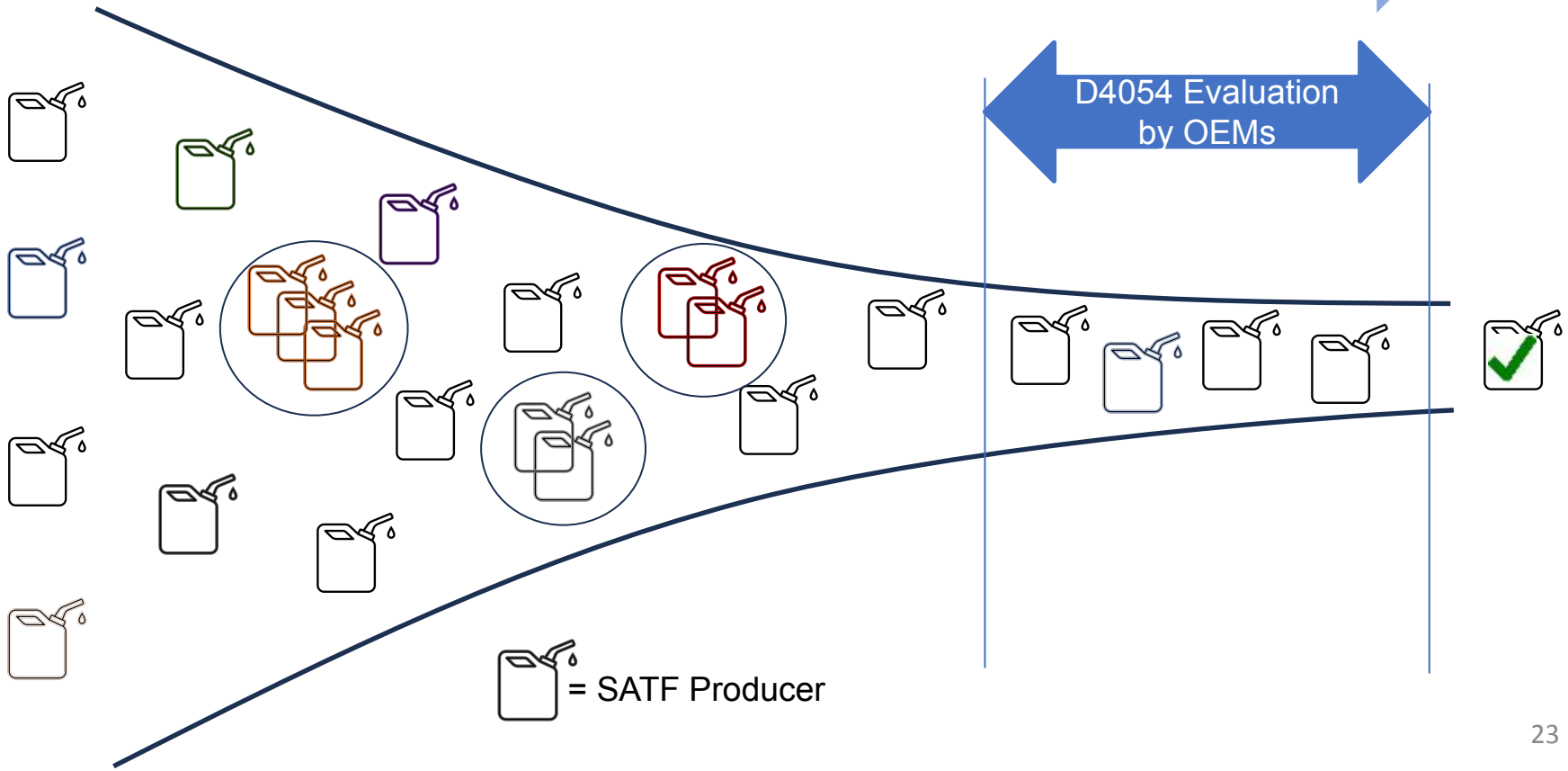
New SATF Pathway

Technology Readiness Level (TRL) / Fuel Readiness Level (FRL)

Engagement with industry & evaluation process throughout

SATF Evaluation Funnel

- Prepare Producers.
- Provide Reliable Data.
- Facilitate OEMs.



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UK SAF Clearing House – Activity

Fuel Readiness Level (FRL)

FRL	Description	Toll Gate	Fuel Quantity+
1	Basic Principles Observed and Reported	Feedstock /process *principles* identified.	
2	Technology Concept Formulated	Feedstock /*complete* process identified.	
3	Proof of Concept	Lab scale fuel sample produced from realistic production feedstock. Energy balance analysis executed for initial environmental assessment. Basic fuel properties validated.	0.13 US gallons (500 ml)
4.1 4.2	Preliminary Technical Evaluation	System performance and integration studies entry criteria/specification properties evaluated (MSDS/D1655/MIL 83133)	10 US gallons (37.8 litres)
5	Process Validation	Sequential scaling from laboratory to pilot plant	80 US gallons (302.8 litres) to 225,000 US gallons (851,718 litres)
6	Full-Scale Technical Evaluation	Fitness, fuel properties, rig testing, and engine testing *	80 US gallons (302.8 litres) to 225,000 US gallons (851,718 litres)
7	Fuel Approval	Fuel class/type listed in international fuel standards**	
8	Commercialization Validated	Business model validated for production airline/military purchase agreements – Facility specific GHG assessment conducted to internationally accepted independent methodology	
9	Production Capability Established	Full scale plant operational++	

\+ Quantities required for risk mitigation reference
* As referenced in ASTM approved protocols
** As listed in original equipment manufacturers' manuals for aircraft and engines
++ color coding reference Phase of development green (technology phase), yellow (qualification phase), blue (deployment phase)

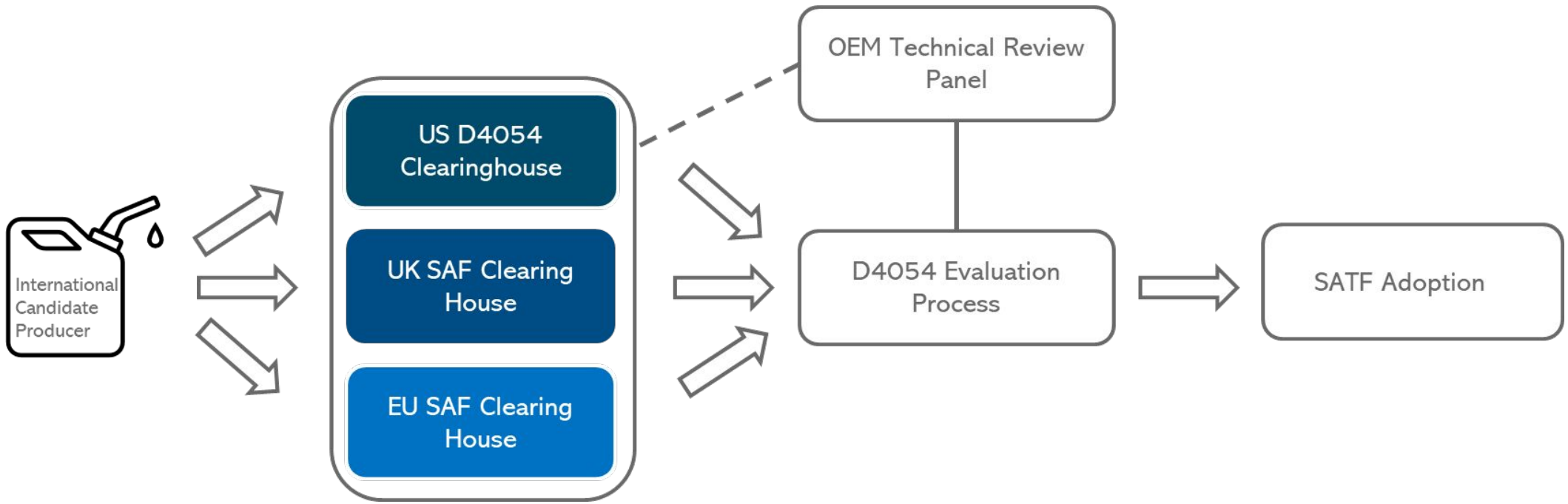
ASTM D4054 2024-a

TABLE 1 Typical Fuel Volume Requirements to Evaluate a New Fuel or New Fuel Additive

NOTE 1—Fuel volumes shown are for a single test fuel. In most cases, a baseline fuel of equal volume will be required in addition to the new fuel blend stock, new fuel finished blend, or fuel additive blend being evaluated.

Tier	Tier Testing Description	Fuel Volume U.S. Gallons (Litres)	Note
1	Fuel Specification Properties	10 (37.8 L)	
2	Fit-for-Purpose Properties	80 (320.8 L)	
3	Component and Rig Tests	250 to 10 000 (946.3 L to 37 854.1 L)	Fuel volume depends on component type
4	Engine Test	450 to 225 000 (1703 L to 851 718 L)	Fuel volume depends on engine type and whether it is a performance or endurance test

UK SAF Clearing House – International Context



UK SAF CH international Support Activity

- **OEMs** - Attend regular OEM meetings and engage with latest challenges
- **ASTM** - Full members of ASTM - Committee D02 (Petroleum Products, Liquid Fuels, and Lubricants.) Specifically, subcommittee D02.J0 (Aviation Fuels)
- **Various ASTM working groups** – Where the work, data and research reports for ASTM standards are carried out.
- **AFC, ExCo** - Committee members, regular attendance at AFC
- **International Clearing Houses -** Coordinating with US and EU Clearing Houses. Fuel Producer Support, D4054 Evaluation process improvements

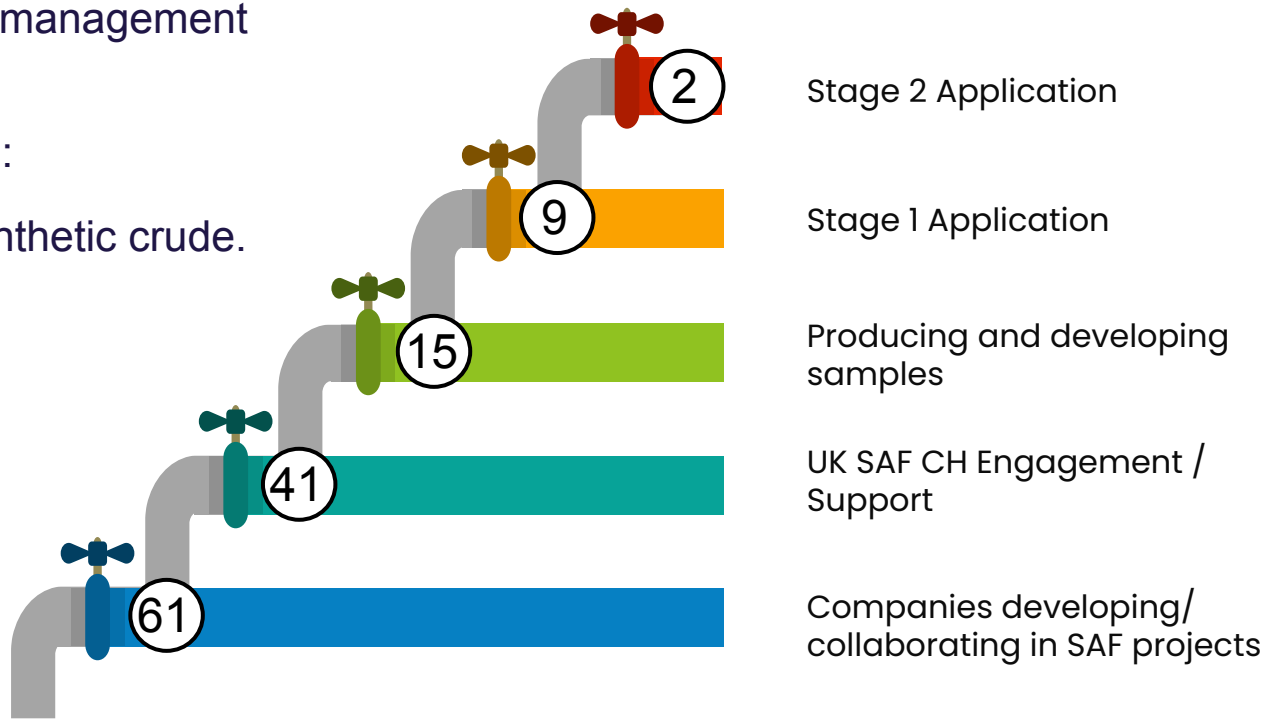
1. D4054, FFP Method Standardisation Study
2. D4054 Research Report Templates
3. D4054 Process Improvements
4. Online OEM Portal for data collection
5. Template & Coaching for SATF Producer Presentations
6. Hybrid Meeting Organisation and Agenda Scheduling

UK SAF Clearing House – Client Base

UK SATF Development to date…

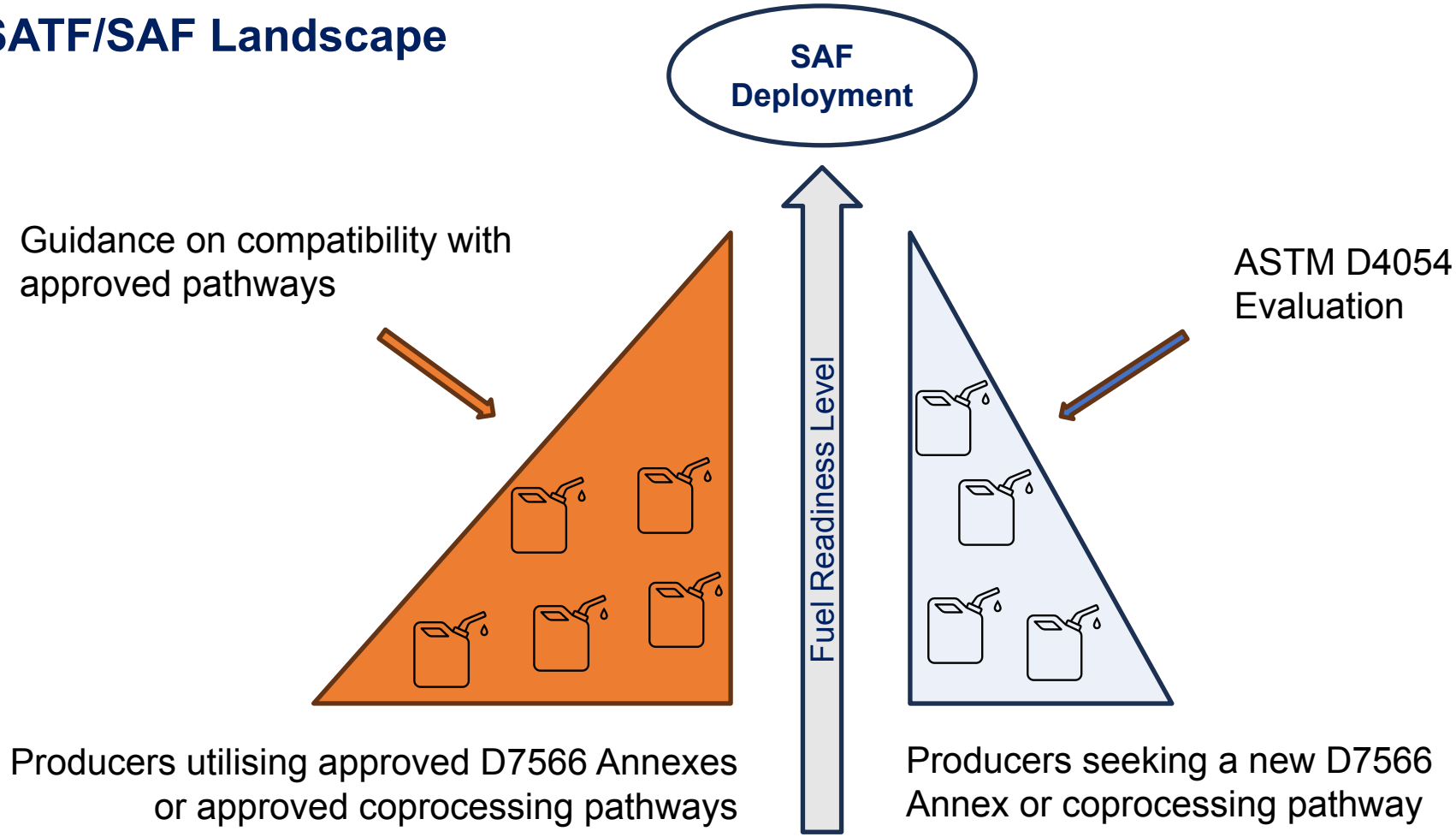
- Estimated **60 companies** developing/collaborating in SAF projects in the UK. Globally recognised standard for quality management

- **41 clients** have received support from UK SAF CH:
  - 15 producing and developing samples of a synthetic crude.
  - 9 completed stage 1 application
  - 2 completed stage 2 application



UK SAF Clearing House – Client Base

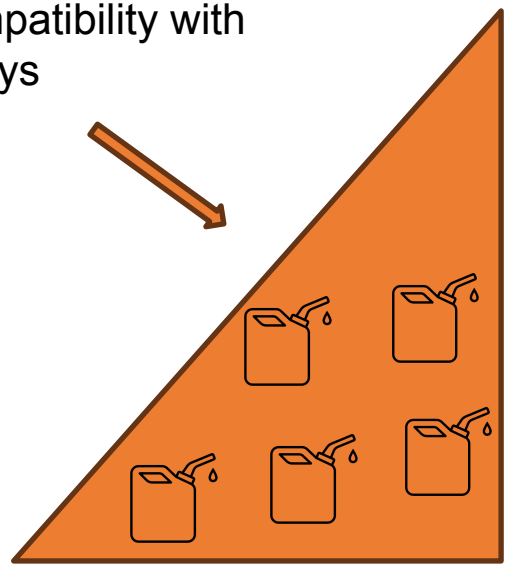
UK SATF/SAF Landscape



UK SAF Clearing House – Client Categorisation

UK SATF/SAF Landscape

Guidance on compatibility with approved pathways



Producers utilising approved D7566 Annexes or approved coprocessing pathways

What evidence is required to confirm compliance with existing D7566 Annex?

Who is the Authority?

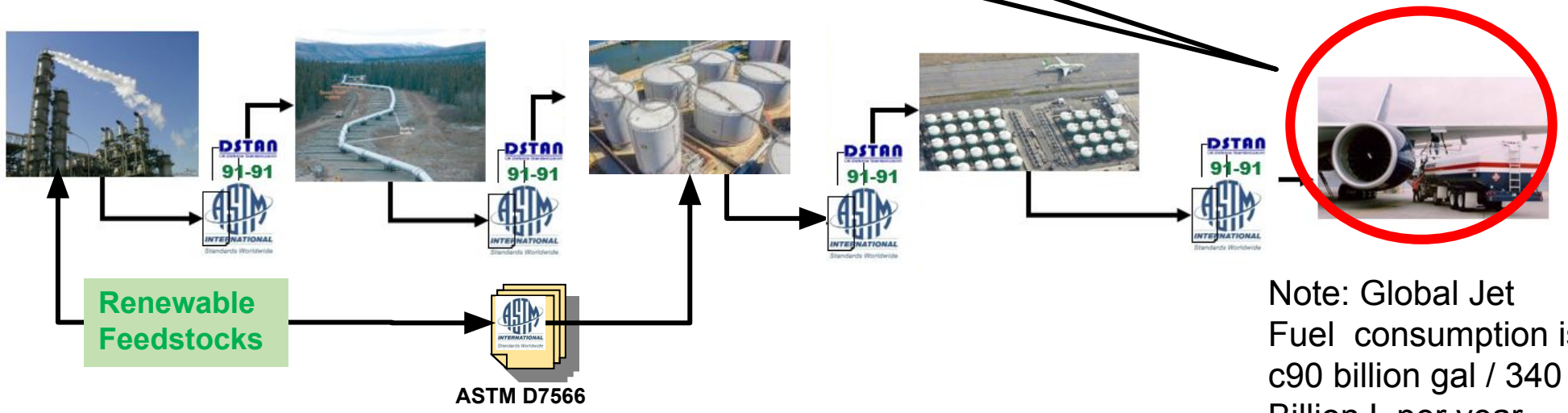
What else does a producer have to do from a compliance perspective?

UK SAF Clearing House – Operational Quality

What Aviation Regulatory Authority Oversight??

Aviation regulatory authority to control fuel quality and performance begins at wing of airplane*

…but, the Aviation Authorities don't test aviation fuel at uplift to aircraft! Why not?

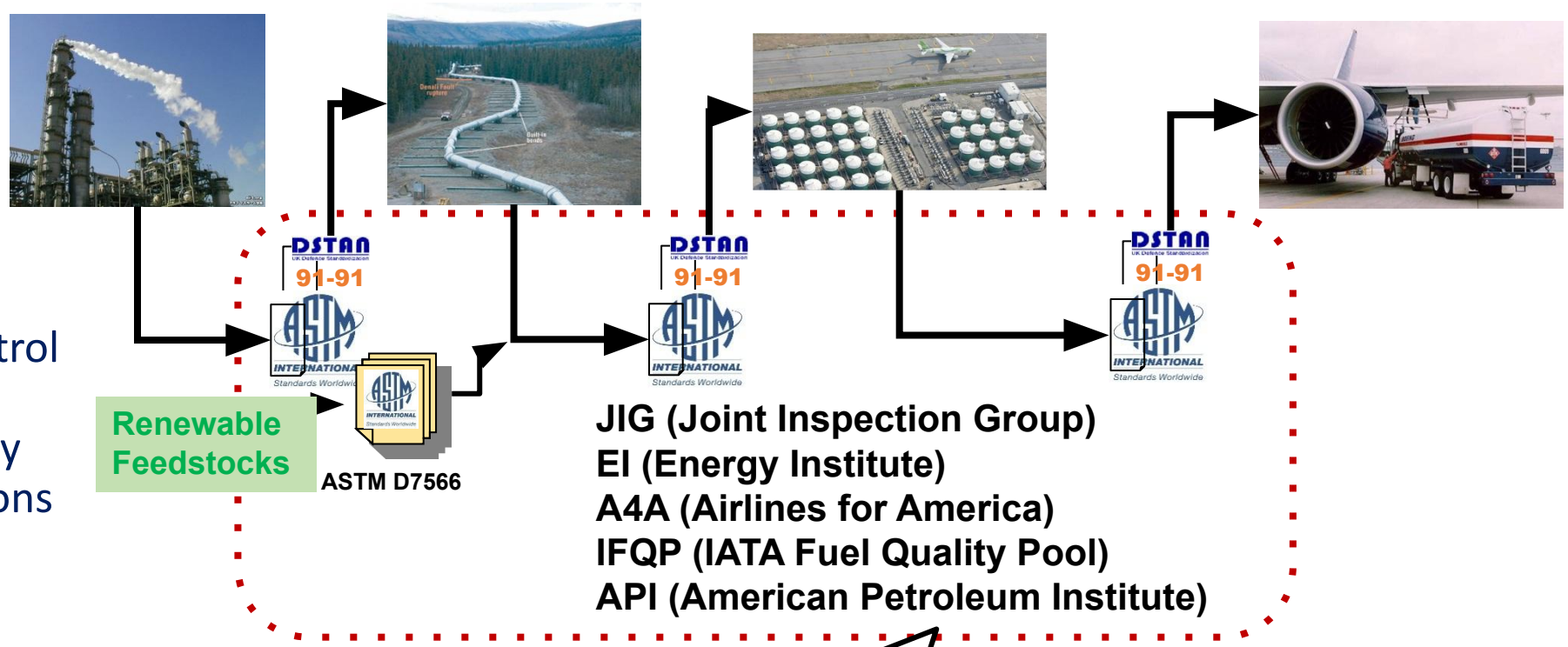


Note: Global Jet Fuel consumption is c90 billion gal / 340 Billion L per year

* In most countries, but excludes China and Russia and some others

UK SAF Clearing House – Operational Quality

Aviation Fuel Quality Control Relies on Industry Oversight…and Industry Relies on Fuel Specifications



Industry Quality Control Systems are Built Around Industry/Military Fuel Specifications

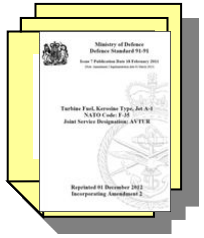
Aviation Fuel Specifications

Fuel Standards

ASTM D7566
STANDARD SPECIFICATION for Aviation Turbine Fuel Containing Synthetic Components **(SATF) Synthetic Aviation Turbine Fuel**


Designation: D1655 – 17
Standard Specification for Aviation Turbine Fuels[1]
6. Materials and Manufacture
TABLE 1
Detailed Requirements of Aviation Turbine Fuels
Jet A or Jet A-1

ASTM D1655
STANDARD SPECIFICATION for Aviation Turbine Fuel (**Jet A/A-1**)



DEF STAN 91-091
STANDARD SPECIFICATION for Aviation Turbine Fuel (**Jet A-1**) [HARMONIZED with D1655 & D7566]

Quality Assurance Standards

EI/JIG 1530, EI/JIG 1533, etc

Aviation Fuel Specifications

EASA Safety Information Bulletin (18th February 2025)

From January 2025, aviation fuel suppliers shall ensure that all the aviation fuel made available to aircraft operators at each European Union airport contains the minimum share of SAF (SBC of sustainable origin). The introduction of legislation such as (EU) 2023/2405 (ReFuelEU Aviation) and the UK SAF Mandate, require the gradually increase of SAF blend ratios over time, starting at 2% in 2025 across the whole of Europe.

SIB 2025-01 recognises the risk with the growing adoption of SATF, and the increased potential of receiving fuel or SBC, which does not meet quality criteria, due to the novelty and complexity of SBC production, handling, and blending processes. Furthermore, it is perceived that the higher price of SBCs, as compared to fossil jet fuel, may attract fraudulent activities, further increasing the risk of out-of-specification fuel.

The SIB details specific 'recommendations' in this regard for; **fuel suppliers and blending facilities, design approval holders (OEMs), Aerodrome operators, organisations involved in storing and dispensing of fuel, National Competent Authorities (NCAs), aircraft operators.**


EASA SIB No.: 2025-01

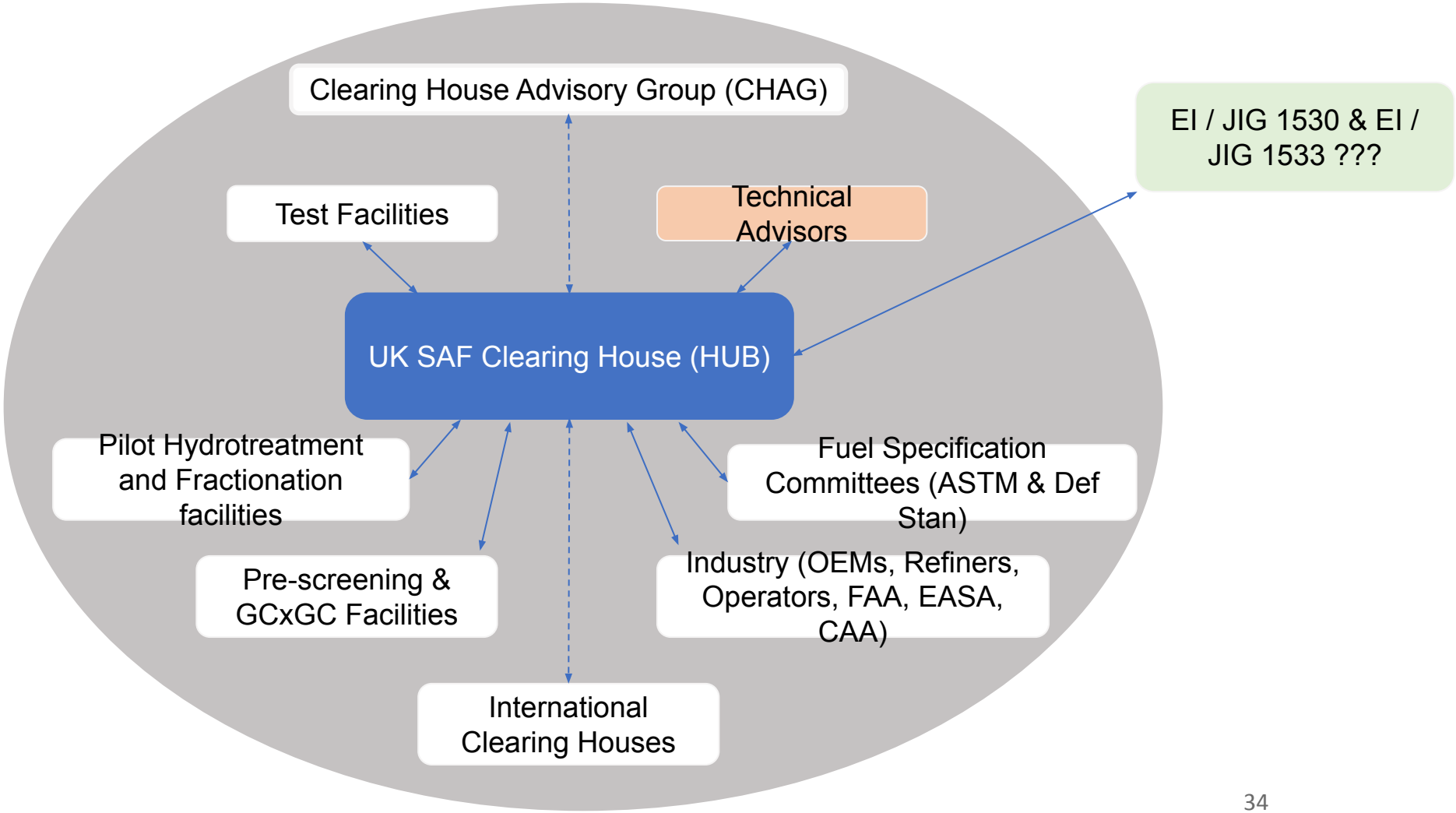
EASA
European Union Aviation Safety Agency

Safety Information Bulletin
Airworthiness – Operations – Aerodromes
SIB No.: 2025-01
Issued: 18 February 2025

Subject: Risks Related to Out of Specification Aviation Turbine Fuels

https://ad.easa.europa.eu/ad/2025-01

UK SAF Clearing House – Overview



UK SAF Clearing House

UK SAF Clearing House contact information

For further technical support and guidance please visit
https://www.safclearinghouse.uk
or
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https://www.safclearinghouse.uk

UK SAF Clearing House

Supporting the testing and qualification of sustainable aviation fuels (SAF)

Q&A

UK SAF Clearing House – Activity