Fit-for-Purpose Evaluation in Shell's Sustainable Aviation Fuel Development

8th International Workshop on Aviation and Climate Change

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 CONFIDENTIAL May 31, 2023

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Shell’s net carbon intensity

Also, in this **presentation** we may refer to Shell’s “Net Carbon Intensity”, which includes Shell’s carbon emissions from the production of our energy products, our suppliers’ carbon emissions in supplying energy for that production and our customers’ carbon emissions associated with their use of the energy products we sell. Shell only controls its own emissions. The use of the term Shell’s “Net Carbon Intensity” is for convenience only and not intended to suggest these emissions are those of Shell plc or its subsidiaries.

Shell’s net-Zero Emissions Target

Shell’s operating plan, outlook and budgets are forecasted for a ten-year period and are updated every year. They reflect the current economic environment and what we can reasonably expect to see over the next ten years. Accordingly, they reflect our Scope 1, Scope 2 and Net Carbon Intensity (NCI) targets over the next ten years. However, Shell’s operating plans cannot reflect our 2050 net-zero emissions target and 2035 NCI target, as these targets are currently outside our planning period. In the future, as society moves towards net-zero emissions, we expect Shell’s operating plans to reflect this movement. However, if society is not net zero in 2050, as of today, there would be significant risk that Shell may not meet this target.

Forward Looking Non-GAAP measures

This **presentation** may contain certain forward-looking non-GAAP measures such as **[cash capital expenditure]** and **[divestments]**. We are unable to provide a reconciliation of these forward-looking Non-GAAP measures to the most comparable GAAP financial measures because certain information needed to reconcile those Non-GAAP measures to the most comparable GAAP financial measures is dependent on future events some of which are outside the control of Shell, such as oil and gas prices, interest rates and exchange rates. Moreover, estimating such GAAP measures with the required precision necessary to provide a meaningful reconciliation is extremely difficult and could not be accomplished without unreasonable effort. Non-GAAP measures in respect of future periods which cannot be reconciled to the most comparable GAAP financial measure are calculated in a manner which is consistent with the accounting policies applied in Shell plc’s consolidated financial statements.

The contents of websites referred to in this **presentation** do not form part of this **presentation**.

We may have used certain terms, such as resources, in this **presentation** that the United States Securities and Exchange Commission (SEC) strictly prohibits us from including in our filings with the SEC. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov.

Agenda

- Shell Aviation: Over 100 Years of Going Beyond
- Key Factors in SAF Definition
- SAF Development Status
- Fit-for-Purpose Properties for SAF Evaluation
- Promising Findings and Challenges
- Continuous Journey to Net Zero

Shell Aviation: 100+ Years Advancing in Aviation Industry

Shell Aviation: 100+ Years of Going Beyond

- Building blocks of the modern aviation industry
- Setting safety standards
- Game-changing aviation
- Cutting emissions from aviation

Shell's Integrated Strategy to Sustainable Fuels

- Versatile Feedstock Acceptance
- Optimized Processing
- Customized Fuel Products

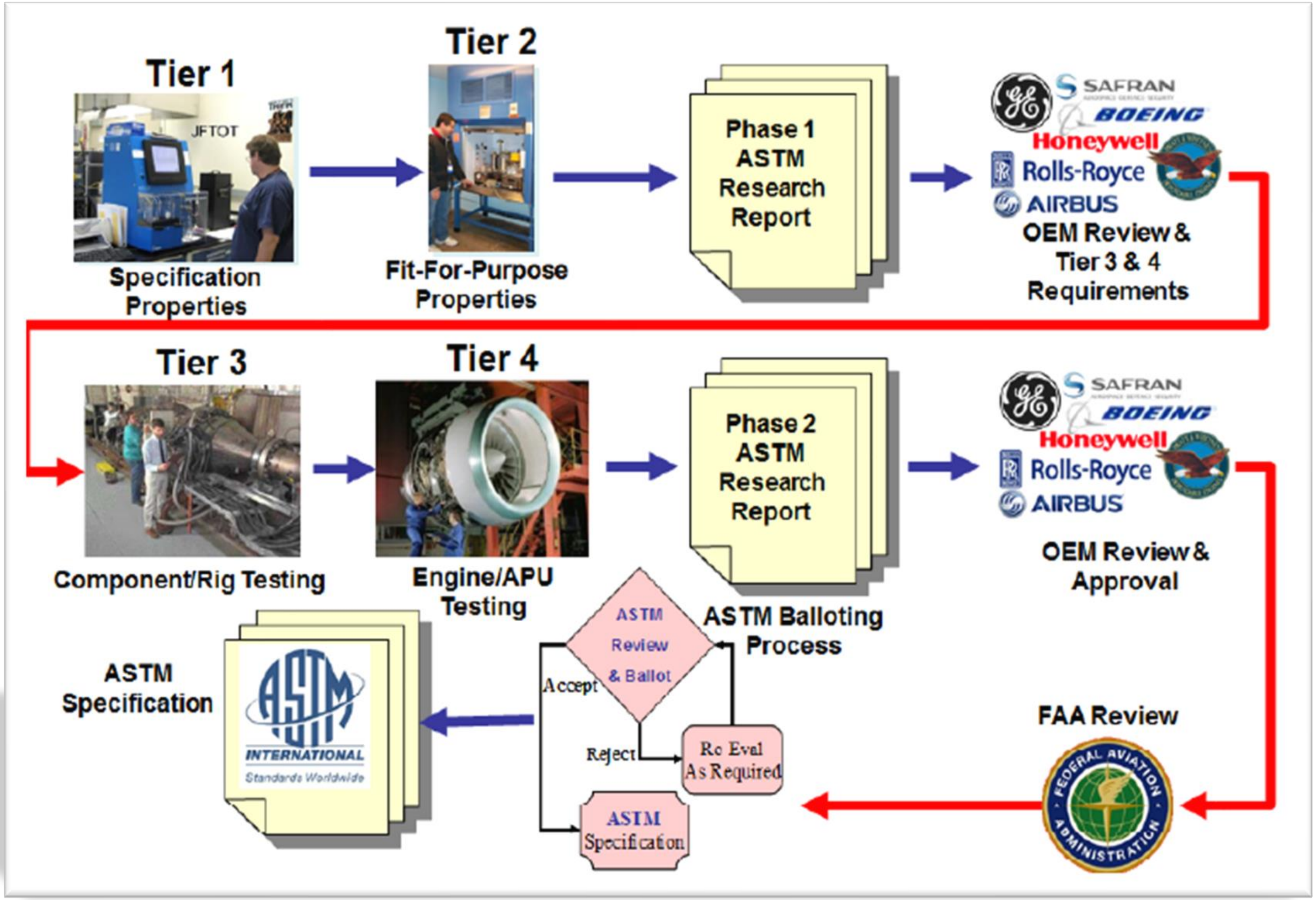
Criteria for Sustainable

- Reduction in Lifecycle Carbon Emission
- Limited fresh-water requirements
- No competition with needed food production
- No deforestation

SAF Feedstocks Challenges

- Varieties of SAF Feedstocks
- Processing Challenges
- Impacts of Trace Contaminants
- Logistics Challenges
- USDA (Dept. of Agriculture) Efforts

ASTM SAF Approval



Source: FAA website

SAF Routes

- ❑ ASTM D7566 Annexes Update
  - ✓ FT/HEFA/SIP/(SPK/A)/ATJ/CHJ/HC-HEFA
  - ✓ Maximum blending ratio
- ❑ EI 1533 and SBC Quality Assurance
- ❑ Co-Processing
  - ✓ ASTM D1655 Annex 1&2
  - ✓ Increasing bio-feed % in co-processing
- ❑ More to Come

Fit-for-Purpose (FFP) Properties to Evaluate for SAF Approval

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TABLE 2 Fit-for-Purpose Properties

Fuel Property	Test Method[A]	Units	Min	Max	Comments
CHEMISTRY					
Hydrocarbon Types	ASTM D2425	mass %	Report		Determines normal and iso-paraffins, cyclo-paraffins, mono-aromatics, indans, indanes, tetralins, naphthalenes, acenaphthenes, acenaphthalenes, tricyclic aromatics.
Aromatics	ASTM D1319 or ASTM D6379	Vol %	8 8.4	25 26.5	
Hydrogen	ASTM D5291 , D3701, or D7171	mass %	Report		
Trace materials					
Organics					
Carbonyls	ASTM E411	µg/g (ppm by mass)	Report		No limits established.
Alcohols	EPA Method 8015	m % or mg/L (ppm)	Report		
Esters	EPA Method 8260	mg/L (ppm)	Report		
Phenols	EPA Method 8270	mg/L (ppm)	Report		
Inorganics: N	ASTM D4629	mg/kg (ppm by mass)	Report		
Trace Elements					
Cu	ASTM D6732	µg/kg (ppb by mass)		< 20	
Al, Ca, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Si, Sn, Sr, Ti, V, Zn	ASTM D7111 or UOP 389	mg/kg (ppm by mass)	Report		
BULK PHYSICAL AND PERFORMANCE PROPERTIES					
Boiling point distribution	ASTM D86	°C			Based on CRC World Survey and Defense Logistics Agency Energy Petroleum Quality Information System survey.
Initial Boiling Point		°C	Report		
10 % Recovery (T10)		°C	150	205	
20 % Recovery		°C	Report	Report	
30 % Recovery		°C	Report	Report	Minimum and maximum values are based on Coordinating Research Council World Survey and Defense Logistics Agency Energy Petroleum Quality Information System survey.
40 % Recovery		°C	Report	Report	
50 % Recovery (T50)		°C	165	229	
60 % Recovery		°C	Report	Report	
70 % Recovery		°C	Report	Report	
80 % Recovery		°C	Report	Report	
90 % Recovery (T90)		°C	190	262	
Final Boiling Point		°C		300	
T50 - T10		°C	15	—	
T90 - T10		°C	40	—	
Simulated Distillation	ASTM D2887		Report Full Range		
Thermal Stability, JFTOT Breakpoint	ASTM D3241, Appendix X2	°C	See Comment		Additives cannot degrade breakpoint.
Deposit Thickness at Breakpoint	ASTM D3241, Annex A3 (Ellipsometer) or ASTM D3241, Annex A2 (interferometer)	nm	Report		
Lubricity	ASTM D5001	mm WSD		0.85	Based on DEF STAN 91–091 requirements.
Response to Corrosion Inhibitor/ Lubricity Additive	ASTM D5001	mm WSD	Conform[B]		See Fig. A1.2 for typical response.
Viscosity vs. Temperature	ASTM D445 or D7042	mm^2/s	Conform[B]		Plot viscosity at –40 °C (or freezing point plus 5 °C, whichever is higher), –20 °C, 25 °C, and 40 °C. See Fig. A1.1 for typical values.
Specific Heat vs. Temperature	ASTM E1269	kJ/kg/K	Conform[B]		See Fig. A1.3 for temperature ranges, typical values, and temperature variations. Specific Heat on a dodecane standard must run and submitted along with the fuel value.
Density vs. Temperature	ASTM D4052	kg/m^3	Conform[B]		Plot density at –20 °C, 20 °C, and 60 °C. See Fig. A1.4 for typical values.
Surface Tension vs. Temperature	ASTM D1331	mN/m	Conform[B]		See Fig. A1.5 for minimum values and typical variation.
Isentropic Bulk Modulus vs. Temperature and Pressure	ASTM D6793	MPa	690 MPa (100 000 psi)		Limits not known; see Fig. A1.6 for typical values and variation.
Thermal Conductivity vs. Temperature	ASTM D2717	watts/m/K	Conform[B]		Limits not known; see Fig. A1.7 for typical values and variation.
Water Solubility vs. Temperature	ASTM D6304	mg/kg	Conform[B]		See CRC Handbook of Aviation Fuel Properties for typical values.
Air Solubility (oxygen/nitrogen)	Ostwald & Bunsen Coefficient (mm^3 of gas/mm^3 of fuel)		Conform[B]		See Fig. A1.9 for typical values. OEM experience is based on the air solubilities of TS-1 and JP-5, which is the least and most dense and volatile to which engines are currently designed.
True Vapor Pressure vs. Temperature	ASTM D6378	kPa or psi	Report –28, 12, 25, 38, 78, and 200 °C		See Fig. A1.10 for typical true vapor pressures for various jet fuel types.
Flash Point	ASTM D56, D3828, or D93	°C		68	
Freezing Point Test Methods—Response to Manual vs. Automatic Phase Transition	ASTM D2386 and D5972	°C	Conform[B]		
ELECTRICAL PROPERTIES					

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TABLE 2 *Continued*

Fuel Property	Test Method[A]	Units	Min	Max	Comments
Dielectric Constant vs. Density	ASTM D924	N/A	Conform[B]		See Fig. A1.8 for typical values.
Conductivity Response	ASTM D2624	pS/m	Conform[B]		See Fig. A1.9 for typical response.
GROUND HANDLING PROPERTIES AND SAFETY					
Effect on Clay Filtration	ASTM D3948	MSEP No.	See Comment		No impact when compared to Jet A
Filtration – Coalescer Filters & Monitors (water fuses)	API/EI 1581	ppm by volume	See Comment		No impact when compared to Jet A
Storage Stability					
Peroxides	ASTM D3703	mg/kg (ppm by mass)	—	8.0	Store for 6 weeks at 65 °C.
Potential gums	ASTM D5304	mg/100 mL	—	7.0	Store for 16 h at 100 °C.
Toxicity	MSDS Review				
Flammability Limits	ASTM E681	°C	See Comment		No impact when compared to Jet A
Autoignition Temperature	ASTM E659	°C	See Comment		No impact when compared to Jet A
Hot Surface Ignition Temperature	FED-STD-791, Method 6053 or ISO 20823	°C	See Comment		No impact when compared to Jet A
COMPATIBILITY & PERFORMANCE (New Additives Only)					
Compatibility With Other Approved Additives	ASTM D4054, Annex A2	N/A	See Comment		Antioxidant, Corrosion Inhibitor/Lubricity Additive Fuel System Icing Inhibitor, Static Dissipator Additive No visible separation, cloudiness, solids, or darkening of color.
New Additive Performance	ASTM D4054, Annex A2	N/A			
PRELIMINARY MATERIALS COMPATIBILITY					
With Selected O-ring Elastomers		N/A	See 6.4.3		Nitrile, Fluorosilicone and Fluorocarbon (Viton) Elastomers

Fit-For-Purpose (FFP) Evaluation in ASTM D4054

- Chemistry
- Bulk Physical and Performance Properties
- Electrical Properties
- Ground Handling/Safety
- Compatibility

Source: FAA website

SAF FFP Properties Finding: Aromatics Level

- Seal swell
- Contrails impact
- Fuel efficiency impact
- What else?

SAF FFP Properties Finding: Electrical Properties

- Dielectric Constant
  - Fuel level gauge
- Electric Conductivity and Response to SDA
- Electrostatics during fuel transportation, fuel treatment (filtering, coalescer, etc.), and fueling operation

SAF FFP Properties Finding: Lubricity

- ASTM D5001 BOCLE Wear Scar Diameter
- Response to clay treatment
- Response to CI/LI additive

Our Pathway to Net-Zero

- Improve Aircraft Efficiency
- SAF Development and Application
- Offsetting Emissions

Thank You