Specifications, Standards and Governance

Contents

• Fuel and fuel specification overview
• Examples of leading specifications
• Specifications in context
• Specification vs quality assurance
• Governance procedures and processes
• Past and Future developments

Main specification groups

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Commercial Version</th>
<th>NATO Code</th>
<th>Military Version</th>
<th>NATO Code</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosine</td>
<td>Def Stan 91-095</td>
<td>F15</td>
<td>Def Stan 91-087</td>
<td>F41</td>
<td>Main fuel types for commercial and military use</td>
</tr>
<tr>
<td></td>
<td>ASTM D1655 Jet A/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Flash</td>
<td>N/A</td>
<td></td>
<td>Def Stan 91-086</td>
<td>F48</td>
<td>For aircraft carrier use</td>
</tr>
<tr>
<td>(AVCats)</td>
<td>ASTM D5972 or 09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Russian Tr-8/85</td>
<td>KP-85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special Applications</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AvGas</td>
<td>Out of scope</td>
<td>Out of scope</td>
<td></td>
<td></td>
<td>Not used for R or except for military emergency use</td>
</tr>
</tbody>
</table>

Notes:
- Full designations have not been used for brevity.
- Generally, military versions have FSII and CI/LA added as mandatory vs civil where such additives are not required.
- OEMs tend to approve all civil and military fuel versions for all applications.
Commercial vs Military Specs.
- Most military specifications have commercial (civil) version as base fuel plus additives
  - Engine/airframe design and operational requirements
    - Fuel system icing inhibitor – required due to lack of fuel heating and icing risk
    - Corrosion inhibitor/lubricity aid – protection of pumps from excess wear or failure
- Increasing use of civil fuels for military applications
  - Def Stan development primarily by Def Stan 91-091 and then read-across
  - US Military adoption of Jet A
  - Reduction in FSII levels

Fuel Composition – Bulk Components

Fuel Composition – Trace Components
- Direct Measurement:
  - Acidity, Sulphur, Mercaptans, Water and Particulate, FAME,
- Indirect Measurement:
- Controlled Trace Compounds:
  - Additives
  - Incidental Materials

(AKA: SPK, FT-SPK, Bio-SPK, HRJ, HEFA...)
Fuel Additives

- **ANTI STATIC** - to prevent static discharge during refuelling
- **FUEL SYSTEM ICING INHIBITOR** - to prevent any water in the fuel from freezing
- **CORROSION INHIBITOR / LUBRICITY AID** - to prevent corrosion of fuel delivery pipes and to enhance lubricity
- **BIOCIDE** - to treat microbiological growth in aircraft fuel tanks
- **ANTI OXIDANTS** - added at the refinery to prevent peroxide formation
- **METAL DEACTIVATOR ADDITIVE** - prevents catalytic metals degrading thermal stability
- **SPECIALIST ADDITIVES** - >100 thermal stability enhancing additive, Aquarius water solvation additive.

*Most additives have "side-effects" that means correct dosage is important*
Specification in context

What specifications do:
- Define composition, quality and (minimum) performance of fuel
- Provide basis for aircraft certification
- Provide basis for purchase contract
- Assume established raw materials, processes, good workmanship and no contamination during transport

What specifications do not do:
- Require testing of all critical parameters
- Define cleanliness at skin of the aircraft
- Fully ensure fuel is “fit for purpose”
- Do not list what is not allowed

OEMs are primarily concerned about fuel meeting specification and being “fit for purpose” at the skin of the aircraft.

Specification & Quality Control

Is fuel fit for purpose at the skin of the aircraft?

"Nirvana”:
- Fuel is refined tested and certified compliant at refinery (batch release)
- Re-test at subsequent points (limited tests)
- Fuel is shipped to airport and delivered to aircraft unchanged
- User receives compliant and certified fuel – completely unchanged

"Reality”:
- Fuel is refined tested and certified compliant at refinery but...
- Picks up water and particulate on the way
- May contact other products directly and pass through fungible systems
- May pick up traces contaminants from system adsorption/desorption ("plate out")
- Does user receive fit for purpose fuel?

Does user receive fit for purpose fuel?

What and how much contamination is acceptable?

Specification Compliance + Quality Assurance + Traceability = Fit For Purpose

Documentation and Regulation

Documentation Roles:
- Specification (The Product) : Defines basic requirements but assumes much
- Handling Procedures and QA (The Packaging): Assures product remains fit for purpose
- Roles can be confused and different approaches are taken

Key Issues:
- Specifications (The Product)
- Handling Procedures and QA (The Packaging)
- What change is acceptable?
- Allowance for approved “Incidental Materials”

ASTM vs Defence Standard approach?
Airworthiness Authorities (EASA, FAA etc.)

Governance of supply

Energy Institute documents

Associated documentation

- DEFSTANDARD 91-091 - Embodying the most stringent requirements in the following specifications for the grade shown:
  - (a) British MoD DEF STAN 91-091/Issue 7, Amendment 1, dated 16 December 2011, in force 8 July 2012
  - (b) ASTM D 1655 – 11b, Jet A-1

- ICAO Doc 9977 Manual on civil aviation jet fuel supply - The need for the management of aviation fuel quality throughout the supply chain has been recognized by the International Civil Aviation Organization (ICAO), which has included this document in the civil aviation authorities of the 191 Member States of ICAO. EI/JIG 1530 is included in the ICAO Manual as a key reference.

- EI 1550 - Handbook on equipment used for the maintenance and delivery of clean aviation fuel

- EI/JIG STANDARD 1530 - Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports

- EI/JIG STANDARD 1581 & 1582 (filter/separators), 1583 (filter monitors), 1590 (microfilters), 1596 (filter vessels), 1598 (electronic sensors)

- IATA - Turbine fuel specifications

- OEM Documentation - Equipment type certificate, operating instructions, maintenance manuals etc. Define approved fuels and additives

- ASTM/EI Test Methods - referenced in specification documents.

- ATA Specification 103 - Standard for Jet Fuel Quality Control at Airports
Specifications are not static.....

- Specifications as a driver for change
- Respond to changes in production/infrastructure
- New test methodologies and limits
- New additives for supply security or new function
- New applications

Current examples of major changes

- Introduction of alternative and renewable fuels
- Approval of FAME (bio-diesel), MDA control
- Metrological and instrumental methods
- >100 additive, new CI/LA formulations, Aquarius
- Use of commercial grades for military use.

Industrial Stakeholders

Environmental Influences

- Major OEMs
- Fuel Specifications
- Performance vs Cost and Availability
- Sustainability of Supply

User Requirements

- Test Methodology
- Operations
- Operators
- Operators' Manual
- Fuel Suppliers
- Specification
- Ron 91
- Sustainability
- Supply
- Test Methodology
- User Requirements

Sustainability of Supply

Fuel Specifications and Engine Certification

- Engines/ Aircraft are Certified to operate on specific fuels.
  - Common Name: Jet Fuel, Jet Kerosine, Jet A, Jet A-1
  - Specifications: US - ASTM D1655 (civil) and JP8,5 etc, UK – Def Stan 91-091 etc
- Fuel Quality is critical to engine (and aircraft) safety, performance (and emission profile).
- Fuel specifications define.
  - Composition properties and performance.
  - Allowable source materials and processes.
- Operators duty is to ensure fuel “meets specification and is free from contamination”*

* Key FAA/EASA requirement on commercial operators
Non conventional product specification

- ASTM D7566 has two key elements:
  - Annexes with specific controls for non-conventional process and blendstock
  - Final blend controls (ASTM D1655 equivalence)
- Fuels produced and tested to ASTM D7566 are then certified as ASTM D1655 Jet A/A-1 before dispatch
Summary

- Fuel specifications control fuel properties, composition and performance at key points in the supply chain
- Specification control has its strengths and weaknesses
- With some variants they set a global standard
- They set a min. standard for production and use
- They are under constant challenge and development

Further discussion

- Homework question
  - Review test methods quoted in Def Stan 91-091 and be ready to discuss how well these tests meet the needs of the specifications intent as part of further discussion and analysis
- Future fuel specification development
  - Subject of further discussion time permitting
AVGAS (See Shell web site)

• Avgas 100 - The standard high octane fuel for aviation piston engines. It has a high lead content and is dyed green. There are two major specifications for Avgas 100, the ASTM D910 and UK DEF STAN 91-90. These two specifications are essentially the same, differ only in allowed antioxidant content, oxidation stability requirements, and max lead content.

• Avgas 100LL - This is the low lead version of Avgas 100. Low lead is a relative term. There is still up to 0.56 g/litre of lead in Avgas 100LL. This grade is listed in the same specifications as Avgas 100, namely ASTM D910 and UK DEF STAN 91-90. Avgas 100LL is dyed blue.

• Avgas 82UL - This is a relatively new grade aimed at the low compression ratio engines which don’t need the high octane of Avgas 100 and could be designed to run on unleaded fuel. Avgas 82UL is dyed purple and specified in ASTM D6227.

History of AVGAS Grades -Avgas is gasoline fuel for reciprocating piston engine aircraft. As with all gasolines, avgas is very volatile and is extremely flammable at normal operating temperatures. Procedures and equipment for safe handling of this product must therefore be of the highest order.

Avgas grades are defined primarily by their octane rating. Two ratings are applied to aviation gasolines (the lean mixture rating and the rich mixture rating) which results in a multiple numbering system e.g. Avgas 100/130 (in this case the lean mixture performance rating is 100 and the rich mixture rating is 130).

In the past, there were many different grades of aviation gasoline in general use e.g. 80/87, 91/96, 100/130,108/135 and 115/145. However, with decreasing demand these have been rationalised down to one principle grade, Avgas 100/130. (To avoid confusion and to minimise errors in handling aviation gasoline, it is common practice to designate the grade by just the lean mixture, i.e. Avgas 100/130 becomes Avgas 100).

Some years ago, an additional grade was introduced to allow new fuel to be used in engines originally designed for grades with lower lead contents. This grade, named Avgas 91/96, has been established by the Shell Co. All equipment and fuel line handling maps are colour coded and display prominently the API markings denoting the actual grade carried. Currently there are major grades that are internationally used, Avgas 100LL and Avgas 82UL. In some identification literature one sees Avgas 91LL. In others it is referred to as Avgas 100/91.

Very recently a new grade of Avgas 82/87 has been introduced in an attempt to meet the needs of the low compression ratio engines. It has a higher vapour pressure and can be manufactured from motor gasoline components. It is targeted to those aircraft which are fitted, for low compression ratio engines.