Telemetric Aviation Fuel Certification

Roadmap to a New Specification QAV-S

Aviation Fuel Projects Consulting
GmbH & Co. KG

ProQR
CLIMATE NEUTRAL
ALTERNATIVE FUELS

Published for
ProQR - Climate Neutral Alternative Fuels
Brazilian-German Technical Cooperation for Sustainable Development

Author
Dr. Dietmar Posselt

Technical Review
Torsten Schwab (GIZ)

Text Revision
Michael Wesley Hylind

Graphic design and layout
Barbara Miranda

ProQR Management
Eduardo Soriano Lousada (MCTIC)
Torsten Schwab (GIZ)
Contatos

Deutsche Gesellschaft für Internationale
Zusammenarbeit (GIZ) GmbH
SCN Quadra 1 Bloco C Sala 1401 - 14º andar
Ed. Brasília Trade Center
70711-902 Brasília-DF, Brasil
+55 61 2101-2170

ProQR Execution

MCTIC
Rafael Silva Menezes
Diane Christiana Parreira da Silva
Gustavo de Lima Ramos

GIZ
Marcos de Oliveira Costa
Viola Rebekka Kammertöns

October, 2019

Contacts

Ministério da Ciência, Tecnologia, Inovações e Comunicações
Coordenação-Geral de Estratégias e Negócios
Departamento de Tecnologias Estruturantes
Secretaria de Empreendedorismo e Inovação
Esplanada dos Ministérios - Bloco E – Sala 346
70.067-900, Brasília–DF, Brasil
+55 61 2033-7817

Deutsche Gesellschaft für Internationale
Zusammenarbeit (GIZ) GmbH
SCN Quadra 1 Bloco C Sala 1401 - 14º andar
Ed. Brasília Trade Center
70711-902 Brasília-DF, Brasil
+55 61 2101-2170

This study was prepared in connection with the project Climate Neutral Alternative Fuels (ProQR) realized through the German-Brazilian Technical Cooperation for Sustainable Development in partnership with the Ministry of Science, Technology, Innovation and Communications (MCTIC) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative based on a decision adopted by the German Bundestag.

The ProQR project has the objective of creating an international reference model for alternative fuels without climate impact for air transport and other sectors without electromobility potential.

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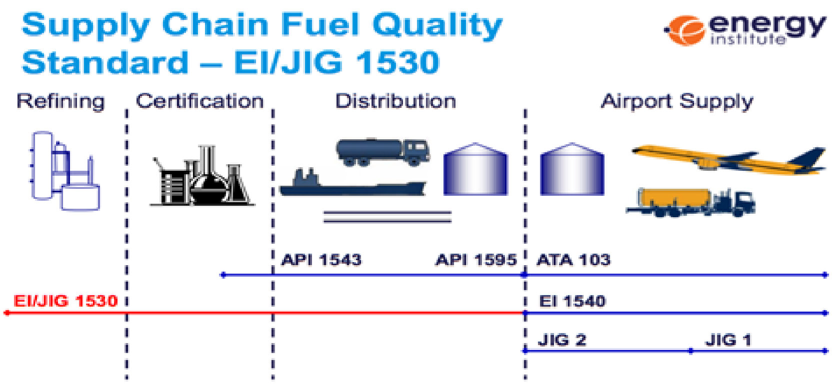
1. Introduction

This document provides a basic overview about the certification process for the manufacture and use of aviation fuels, i.e. turbine aviation fuel JET A-1 and Aviation Gasoline (Avgas). It should mainly be regarded as a guidance document for the possible realization and launching of decentralized aviation fuel production in collaboration with Brazilian authorities and stakeholders as well as international partners of the aviation fuel community. The final goal is the development and implementation of new technologies, strategies and manufacturing sites for new sustainable synthetic JET A-1 and Avgas fuels in Brazil.

The report comprises introductions into current fuel certifications and specifications and the use of fuel additives. A chapter about potential options for the development and introduction of modern telemetric tools to better enable dedicated and decentralized manufacturing capacities for synthetic aviation fuel components including recommendations is included as well. Finally, a roadmap for the implementation of a new Brazilian turbine aviation fuel quality standard **QAV-S** and a related demonstration plant is pointed out. Thus, the document represents a first basic approach for a future development of fuel certification processes within the innovative ProQR project for decentralized aviation fuel production facilities in Brazil.

2 Aviation fuel certifications – Status quo

Aviation fuel quality assurance is based on certification at point of manufacture and procedures to verify that the quality of the aviation fuel concerned has not significantly changed and remains within the specification limits during distribution and delivery to airports and subsequently to aircraft. Proper documentation is an essential part of this process.



In order to support these important quality assurance requirements, the Energy Institute (EI) Quality Standard **EI/JIG 1530** provides mandatory requirements and good practice recommendations for manufacture, storage and distribution of aviation fuels to airports describing how to comply with fuel specifications. The Energy Institute committed to ICAO to make all organizations worldwide aware of EI/JIG 1530. Key documents are e.g.

- Refinery Certificate of Quality
- Certificate of Analysis
- Recertification Test Certificate
- Release Certificate

It may be that other field tests are undertaken and the results recorded in addition to provide further quality assurance.

Relevant parts of this standard have to be identified, potentially amended and finally implemented into a quality assurance program for decentralized aviation fuel production facilities in Brazil. For example, main differences between a centralized and decentralized production of any aviation fuels are some absent quality assurance and certification requirements because of the changed common supply chain as a whole. In the case of having a decentralized manufacturing site, transportation and possibly interim storage including the usage of different transportation vehicles (rail, barges, road tankers, others) are absent which reduces the amount of required analytical work and any recertifications throughout the supply chain significantly. This also includes possible unforeseen occasional field tests. Depending on actual production and storage capacities at decentralized sites it may be that further improvements are likely, but which have to be verified first, e.g. lower use of storage stability additives (please see also chapter **3. ADDITIVES**).

Examples for important and relevant aviation fuel specification parameters are given below in Chapters **2.1** and **2.2.**

2.1 Turbine Aviation Fuel JET A-1 – QAV-1

This chapter provides an overview about important and characteristic key properties and aspects covered by specifications DEF STAN 91-091 and RANP 778-2019.

Visual Appearance	Density
Colour	Freeze Point
Particulates	Viscosity (-20 °C)
Acid Number	Smoke Point
Aromatics	Naphthalene Content
Sulphur	Specific Energy
Mercaptane Sulphur	Copper Corrosion
Doctor Test	Thermal Stability
Composition: level of hydrogenated products, synthetic components	Existent Gum
	Microseparometer
	Conductivity
Distillation	Lubricity

Table 1: Key Specification Parameters of JET A-1 and QAV-1

With regard to synthetic fuel components ASTM D7566 has to be taken into consideration in addition.

2.2 Aviation Gasoline Avgas 100LL – GAV 100LL

This chapter provides an overview about important and characteristic key properties and aspects covered by specifications DEF STAN 91-090 and RANP 5-2009.

Visual Appearance	Specific Energy
Colour	Knock Rating MON/RON
Sulphur	Copper Corrosion
Distillation	Existent Gum
Density	Potential Gum
Vapour Pressure	Conductivity
Freeze Point	Water Reaction

Table 2: Key Specification Parameters of Avgas 100LL and GAV 100LL

Since the primary function of Turbine Aviation Fuel and Avgas is to power an aircraft, *specific* energy is a key fuel performance property. Other important performance properties are *knock resistance, volatility, fluidity, stability, non-corrosivity, and cleanliness.*

3 The use of additives

Chemical additives are typically used in aviation fuels for one of two reasons:

- to prevent degradation of the fuel itself (e.g. the use of antioxidants to prevent oxidation)
- to enhance a particular fuel property (e.g. the use of a conductivity improver or thermal stability improver)

Normally, the proper use of fuel additives represents the most beneficial options regarding costs and logistics in order to generate reliably special fuel properties in contrast to special fuel blending procedures which are typically more complex and costly.

Some aviation fuel additives are typically added in refineries while other additives may be added in the refinery/point of manufacture or further downstream in supply installations. The use of additives in aviation fuels is carefully controlled and limited because of the potential undesirable side effects. Only qualified additives of defined composition and amount approved by the airframe and engine manufacturers, and cited by the relevant fuel specification authority, may be used.

The following table covers the list of approved additives for commercial aviation according DEF STAN 91-091 (JET A-1) and DEF STAN 91-090 (Avgas). The meanings of the classification of additives is as follows:

- Mandatory: Shall be present between defined minimum and maximum concentration or property limits.
- Optional: May be added up to maximum concentration or property limits.
- By agreement: May be added only with agreement of the user/purchaser within specified limits.

	JET A-1	Avgas 100LL
Mandatory	Antioxidant Conductivity Improver**	Antiknock
Optional	Metal Deactivator Corrosion Inhibitor/Lubricity Improver	Antioxidant Corrosion Inhibitor/Lubricity Improver Conductivity Improver
Agreement	Fuel System Icing Inhibitor (FSII)	Fuel System Icing Inhibitor (FSII)

** Optional in QAV-1

Table 3: Additives in Turbine Aviation Fuels and Aviation Gasoline

When looking into the possibility to produce JET A-1 and Avgas at decentralized manufacturing sites there is a high probability to waive most of the above-mentioned additives. Regarding JET A-1 the mandatory use of an antioxidant with the production and use of Fischer-Tropsch SPK has to be carefully evaluated with the relevantauthorities. With regard to Avgas the optional use of a corrosion inhibitor/ lubricity improver (CI/LI) has to be discussed with involved aircraft/engine OEMs. Potential replacement possibilities for the toxic antiknock additive Tetraethyl Lead could be

- The replacement by another metal-organic additive,
- blending with other high-octane fuel components,
- producing of a lower octane Avgas product for selected aircraft types or
- producing ethanol for the use of selected ethanol engine equipped airplanes

and need to be investigated thoroughly.

The latter option has to be considered separately herein. Ethanol is not included in the normal product range of Fischer-Tropsch Synthetic Paraffinic Kerosene (FT-SPK). In theory, it could be generated by severe cracking of the FT-SPK products to obtain a certain amount of ethylene, which then could be transferred to ethanol in a subsequent reaction path. Cracking can only be achieved by the implementation of a dedicated hydrocracking unit. Such a process is uneconomic. A second pathway to manufacture ethanol is a relatively new chemical route developed by LanzaTech. A part of the Synthesis Gas can be used to react with water catalyzed by special enzymes ($6\ CO + 3\ H_2O \rightarrow C_2H_5OH + 4\ CO_2$). This would entail the implementation of an additional chemical plant which has to be operated in parallel. All in all, a decentralized production of ethanol using Synthesis Gas as a feedstock is rather complex and expensive.

The most promising option for a decentralized self-sufficient lead-free Avgas production on the basis of Fischer-Tropsch technology seems to be the manufacture of lower octane Avgas for the use in selected aircraft types.

4 Telemetry

Telemetry opens the door to a modern and optimized way of technical fuel analyses. It has the potential to facilitate decentralized operations and to increase flexibility of quality control in the field. This chapter covers the question if telemetric tools, devices and procedures are available and can be used for a more sophisticated and optimized landscape of the certification of aviation fuels which are produced locally at decentralized manufacturing sites. It also comprises some specific initial proposals of how a development and an introduction of telemetric fuel analysis in Brazil can be initiated and achieved.

All physical and chemical parameters mentioned in chapters **2.1** and **2.2** are currently tested and evaluated based on actual aviation fuel samples being taken and analyzed at a laboratory on-site or at an external, certified analytical laboratory. Online aviation fuel qualifications and certifications devices are not yet available in the market. Thus, such an innovative approach of a certification concept is somehow challenging but also worthwhile to explore, develop, and approve.

Some ideas and possibilities for the introduction of (partial) telemetric tools and processes are discussed below.

- Nowadays, smaller and larger analytics companies who are specialized in fuels analyses and certifications are in the stage of developing analytical devices which can be used for online analytics and control. Some of them are even already offering final products and/or collaborations in order to develop tailor-made solutions with the customer. It is recommended to identify a couple of renowned companies and start a detailed status analysis based on the requirements for a decentralized production site. As a positive side effect, this approach offers the opportunity to find out which parameters can be detected and controlled already online today and which parameters need further R&D efforts.

- The project JETSCREEN, funded by the European Union's Horizon 2020 Research and Innovation Program, offers some interesting and use indications for the development and implementation of modern aviation fuel quality and specification assessments as well as fuel approvals. JETSCREEN gathers 15 partners from five European countries under the leadership of the German Aerospace Center (DLR) and collaborates with the US funded aviation project ASCENT. Some aspects of both projects which might be relevant for the development of telemetry within ProQR are listed here:

    - track fuel properties of fuels in use (processing, supply, end use) to improve quality control in fuel production and supply
    - data access for airports and airlines to demonstrate safe usage of synthetic alternative aviation fuel components
    - facilitate airport fuel analysis reporting
    - track fuel supply information in real-time
    - global fuel dataset for conventional, alternative and blended fuel

These two main proposals were discussed in a workshop between GIZ, ANP, PLURAL and AFPC at Brasilia-DF on August 29th, 2019. This discussion has been the starting point for additional and more specific contact proposals by ANP how to proceed with Brazilian companies. The following companies were mentioned:

- Fundacao Certi / Certi Sapientia (Florianópolis) Fundacao Certi / Certi Sapientia (Florianópolis)

- Squitter Metrologia e Hidrologia (Sao José dos Campos)
- Projetando Solucoes (Brasilia)

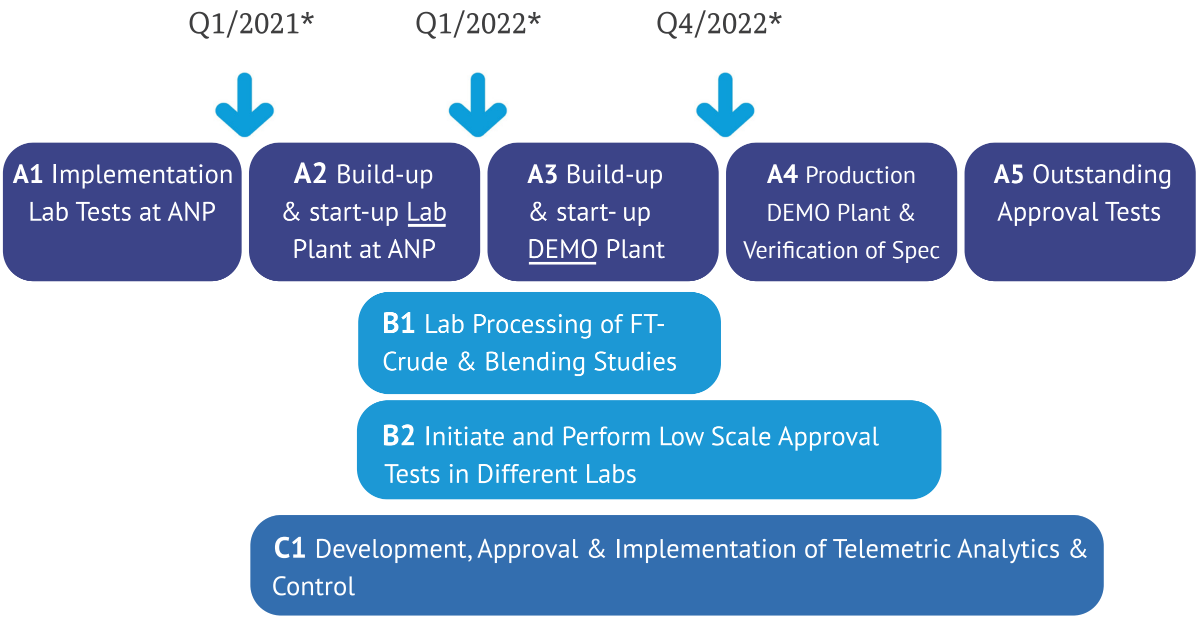
The company Hytron is another suitable Brazilian industry partner to support the introduction of telemetric tools.

All proposed approaches entail the potential to conceive a new, innovative concept for telemetric fuel certification. It must be noted that the whole development and implementation including the approval by relevant aviation authorities seems to be a long-term project with some uncertainties.

Therefore, it is recommended to initiate a dedicated subproject "Tailor-made Telemetry" early enough i.e. in parallel to the start-up of the ANP laboratory plant. It is further recommended to have a detailed discussion with the German Aerospace Center (DLR) about JETSCREEN prior to the start of such a subproject in order to prepare it in the most efficient and successful way.

5 Roadmap for the introduction of QAV-S

This chapter outlines a possible and practicable route – developed within the ProQR project – along a timeline to introduce a new national aviation fuel specification including its approval by Brazilian authorities. Furthermore, it comprises some main development, approval and implementation aspects of a future telemetric aviation fuel certification.



A1 – As a first step, ANP has to finish the implementation of all laboratory equipment including a training for employees in order to conduct ASTM D1655 and ASTM D7566 analyses for the certification of turbine aviation fuels of QAV-1 type. The completion of that task is scheduled for the end of Q1/2020. It is recommended to also include all necessary analyses related to ASTM D910 for the certification of Avgas.

A2 – In a next step, ANP will build up - or have access to - a laboratory plant with a capacity of a few liters per day for the synthesis of a) synthesis gas from carbon dioxide and water and b) a subsequent Fischer-Tropsch conversion to produce a crude mixture of synthetic paraffins called 'FT-Crude'. A successful installation and start-up of such a laboratory plant is scheduled for Q1/2021*. This is a key parameter in order to work out important technical and analytical details for all subsequent production and approval related requirements. But it definitely requires the realization of a successful internal or external treatment of the FT-Crude product to dedicated QAV-S aviation fuel components so that relevant approval and telemetry related tasks can be initiated and performed in an efficient way (**B1**, **B2** & **C1**).

B1 – It is recommended to facilitate further laboratory and/or pilot plant work either at ANP or 3rd party laboratories where the ANP FT-Crude product is transferred into aviation fuel components using e.g. hydrocracking, hydroisomerization and fractionation. Such synthetic fuel components can already be used for first blending studies. Under these circumstances it is possible to draft a first new aviation fuel specification for QAV-S (including the use of additives) and to start with a number of important

*Dates are subject to changes for reasons of force majeure.

approval tests (**B2**). In this way the time until completion of the first demonstration plant (**A3**) can be used in an optimal way while gathering already valuable information.

B2 – It is also recommended to perform some first approval related tests with representative samples. Therefore, it might be interesting to partner with Força Aérea Brasileira (FAB) right from the beginning of this task as FAB can conduct testing and experimental flights relatively easy. It even may be that other relevant OEMs have to be included at a quite early stage (like e.g. Embraer, Boeing, Airbus). Their guidance is needed for an effective approval work in cooperation with ANP. Such kind of approval tests should focus on selected so-called Tier 1 and Tier 2 tests which comprise of fuel specification properties and fit-for-purpose properties testing. The main part of potentially required approval tests should be performed with fuel samples from the demonstration plant (ref. to **A3**).

A3 – It is planned to build up a demonstration plant for the production of **QAV-S** with a capacity of 500–1000 liters/day until Q1/2022*. The location has still to be determined and depends inter alia on the future selection of the test aircraft and test route for a continuous use of **QAV-S**. Such a real-world demonstration will be a strong support for a future technology and product launch.

A4 – A successful start-up of the demonstration plant to produce **QAV-S** is the good proof of concept for the ProQR project. It now opens the door to manufacture considerable and representative volumes of **QAV-S** which ideally can be used a) to verify the new Brazilian aviation fuel specification with ANP and b) to perform all outstanding approval tests with the relevant partners (ref. to **A5**).

A5 – This task is the most difficult to define accurately as well as to predict precisely its time need. It contains possibly a number of unforeseen questions which will come up by the OEMs who are involved in that process.

Even without a dedicated establishing of QAV-S, the product can be blended and is imediately usable for complying fully to the ASTM D7566 Standard.

GIZ and Hytron met with Embraer on September 5th, 2019. Embraer and Hytron concluded that a direct cooperation with the Forca Aérea Brasileira (FAB) seems to be the most promising approach to approve **QAV-S** in an efficient way for the use in a demonstration campaign. A suitable aircraft candidate could be the EMBRAER TUCANO single engine aircraft which is powered by a Pratt & Whitney turbo prop engine. FAB could be an ideal partner for a (limited) approval of **QAV-S** because of two reasons: they have the power and network to bring all relevant stakeholders together in a timely manner and they would benefit from a successful outcome because they could drastically reduce their fuel supply to the Amazon region in the future. Therefore, it is important to involve FAB at a quite early stage (ref. to **B2**) in order to discuss first specification and approval related test results from ANP. Thus, the right approval test matrix can always be set up and updated with all parties involved. And all necessary OEM partners and relevant laboratories are identified on time.

At a later stage it is important to already use representative samples from the demonstration plant to perform larger approval rig tests which might be probably required (A4 and A5 partly in parallel). In this context it is important to note that the manufacturing technology and the quality of the resulting synthetic fuel samples of the ANP laboratory and the demonstration plant have to be comparable for the whole approval process. Furthermore, cooperation with 3rd party institutions like I.A.E./CTA and DCTA should be sought in order to support the approval work with valuable rig tests. (Note: As performing some approval test requirements is only possible in one or maximum two organizations world-wide, AFPC can give guidance and support to find the right partner and to establish contacts in the future.)

C1 – With reference to chapter **4. Telemetry** it is recommended to initiate a respective R&D project relatively soon, i.e. in mid of 2020 latest. It will take an adequate time to

- Identify the right industry partners and to start cooperating with them,
- develop a couple of individual analyses,
- approve the technical solutions with all relevant authorities and
- implement the telemetric analytical tools and verify the whole concept.

Finally, some further general observations are made and recommendations are given:

- In case of using single engine EMBRAER TUCANO in the flight demonstration campaign a useful differentiation between QAV-S and standard type QAV-1 under flight operation conditions is not possible anymore. If this is an important aspect to investigate and to consider, a suitable twin engine A/C with two separated fuel tank systems should be identified.

- It is recommended that QAV-S is first specified, approved and certified nationwide (if possible) before any international initiatives – e.g. via ASTM – will be started. Such an approach enables Brazil to collect important and useful experiences with a game-changing new technology on the basis of limited and regional trials.

Por ordem do

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da República Federal da Alemanha

Por meio da:

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