Bulletin No. 75 **April 2015**

Guidance on Changes to ASTM D1655 and Def Stan 91-91 to Increase Allowable FAME Limits to 50 mg/kg

The latest revisions to the two major western jet fuel specifications, ASTM D1655-15 (primarily used in North America) and Defence Standard 91-91 Issue 7 Amendment 3 (implementation date 2nd May 2015) have recently been published and both contain the revision to the maximum permissible level of Fatty Acid Methyl Ester (FAME), as an identified incidental contaminant; raising it from less than 5 mg/kg to 50 mg/kg. This has allowed JIG Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS) Checklist to also be changed so that Issue 28 now reflects this higher FAME maximum limit of 50 mg/kg.

This is intended to be an interim position ahead of an industry move to approve 100 mg/kg: a move intended to occur in 2017, should there be no FAME-related aircraft / engine maintenance issues in the interim.

This new limit follows extensive approval work by the industry and recognises the challenge of moving jet fuel in an environment where there is increasing frequency and levels of FAME in diesel fuel. As such this revised limit should improve operational flexibility to manage FAME contamination; however, **procedural safeguards and assurances for jet fuel supply shall remain in place**.

In the past, the less than 5 mg/kg limit was based on the limit of detection using, principally, a complex and expensive GC-MS analytical method (IP585) and as a result the availability of test equipment and access to testing results was not as convenient as might otherwise be the case. For this reason, many supply chains relied on procedures to limit FAME contamination to below 5 mg/kg. This remains a valid method of working.

However, the revised 50 mg/kg limit not only increases the FAME limit, but also allows access to a wider range of test methods. This includes the IP583 / ASTM D7797 Solid Phase Extraction and Fourier Transform Infra-Red (SPE-FTIR) Spectroscopy method. These rapid screening methods have lower test equipment cost compared to IP585 and allow near-immediate results to be obtained in the field. This should greatly improve the availability of testing and improve the supply chain's ability to control FAME levels.

The intent of both specifications is to only measure FAME where there is a risk of FAME being present. This means that, should Jet fuel be in dedicated systems with positive segregation from FAME containing fuels, or where robust control procedures are in place to ensure FAME is less than 5 mg/kg, then FAME testing is not mandatory. This logic holds for both the point of manufacture and in the supply chain.

However, there remains a need to support the technical case to move to 100 mg/kg FAME in jet fuel and this will require collection of data from the field to be able to monitor FAME levels and correlate them with any impact on aircraft / engine maintenance intervals. **This, combined with the improved availability and access to test equipment, will result in FAME testing being required on recertification of jet fuel where there is the chance of FAME being present in the jet fuel at levels of 5 mg/kg or greater.**

Supply chains where FAME may come into contact with Jet fuel shall still be subject to a Management of Change procedure to minimise the exposure and ensure it remains controlled within the specification limits. Where these MOC assessments suggest the FAME

could be above 5 mg/kg, or where assurance cannot be obtained, then FAME testing shall be carried out and reported. Particular consideration needs to be given to supply chains where procedures have not changed, but the FAME content of the incoming jet fuel may now be at a higher level than the historical norm.

Note that despite the relaxation of FAME contamination limits in ASTM D1655-15 and Def Stan 91-91 Issue 7 Amendment 3, **many pipeline owners may still apply the 5 mg/kg limit**. As rapid screening methods can have a lower detection limit of 20 mg/kg, it is not appropriate for use where <5 mg/kg limits exist. The lower detection limit takes into account the known fuel-to-fuel biases unique to this approach that is not reflected in the precision statement. Where FAME testing has been determined to be necessary prior to issuance of either Def Stan 91-91 Issue 7 Amendment 3 or ASTM D1655-15, it will still be required to be conducted by IP585, IP590 or IP599 for supply into systems requiring a less than 5 mg/kg limit, especially when considering incoming fuel may only be released up to the new 50 mg/kg specification limit.

Summary of Testing Requirements

The new requirement for testing of FAME and the new limits will come into place immediately for ASTM D1655 and by 02nd May 2015 for fuels released to Def Stan 91-91.

Scenarios Where FAME Testing is NOT Required

Where documented assessments indicate adequate controls are in place to keep FAME levels below 5 mg/kg.

- In systems where FAME contamination is physically prevented then there is no requirement for FAME testing. Examples are at the refinery where jet is positively segregated and isolated from FAME containing components, and in jet dedicated supply systems (including recertification testing). The 50 mg/kg max FAME requirement is met by a risk based assessments without the need to test. The RCQ / COQ shall state “Not measured - Risk Assessed in accordance with JIG Bulletin 75”. ” against the FAME result in the specification requirement.
- If FAME testing was not previously required because **robust** quality assurance procedures were introduced to mitigate risk to **assure** compliance to less than 5 mg/kg, **and** no additional risk of FAME contamination has been created through the implementation of the current issue of Def Stan 91-91 or ASTM D1655 in the supply chain, then testing is still not required as the risk assessment approach satisfies the specification requirement.

  Note: Procedures and control of jet fuel into the supply system shall be robust and any changes in supply or controls shall be assessed through adequate and documented Management of Change procedures.

  Note: FAME levels, where known, will still need to be calculated and recorded as additional information on recertification. See Q2 in the Frequently Asked Questions for more details.

Scenarios Where FAME Testing IS Required

These are based on locations which may be subject to increased uncertainty in FAME levels in supply with the implementation of the new specification changes. Risk based testing shall be conducted:

- If FAME testing was not required previously because quality assurance procedures were introduced to mitigate risk to assure compliance to less than 5 mg/kg, but the risks of FAME contamination in supply is now elevated after the implementation of Def Stan 91-91 Issue 7 Amendment 3 / ASTM D1655-15.
- If FAME testing was required previously because quality assurance procedures were unable to mitigate risk to assure compliance to less than 5 mg/kg then FAME testing shall be conducted as part of recertification or at the point at which the jet enters a dedicated supply chain upstream of an airport. The continuation of testing is required considering that the risks are only likely to increase with the adoption of the new FAME limits, but furthermore the test results are required by the industry to support a potential future 100 mg/kg approval.

Storage Tank Testing

Generally FAME testing will be required for Certificate of Analysis and Recertification Testing whenever jet is moved in non-dedicated systems carrying diesel/gasoil. This testing is necessary prior to delivery to an airport to ensure that FAME content is at acceptable levels. Refer to the table below for specific examples.

Testing FAME concentration of jet is not required for storage locations that receive and deliver jet via dedicated systems.

Storage Tank Type	**Context**	**FAME testing required on Jet RCQ / COA / Recertification Test (RT)**
Refinery Production Batch Tank	For refineries which have jet fuel systems which are positively segregated and isolated from products containing FAME.	No
Refinery Import tank	Refinery to refinery transfers where there is direct knowledge that any diesel on board that interfaced with the jet is B0[1] and the vessel has not carried biodiesel within the last three loads. Also refer to Marine Testing Requirements in this Bulletin	No
Refinery Import tank	Refinery to refinery transfers where there is incomplete knowledge or direct knowledge that any diesel on board that interfaced with the jet contained biodiesel and/or the vessel has carried biodiesel within the last three loads	Yes
Marine Terminal Receipt Tank	Confirmed no FAME in marine supply system, and where direct knowledge that any diesel on board or having any interface with the jet is B0 and the vessel has not carried biodiesel within the last three loads may be exempted from testing.	No
Marine Terminal Receipt Tank	In systems where diesel is confirmed to be >B0 or unknown FAME content. Also refer to Marine Testing Requirements in this Bulletin	Yes
Multi-product Terminal Receipt Tank	Biodiesel confirmed present or unknown in multiproduct system delivering to the terminal.	Yes

[1] Gas Oil (diesel fuel) may be referred to as B0 or “FAME-free” if the FAME content measured per test method EN 14078 (*Liquid petroleum products - Determination of fatty acid methyl esters (FAME) in middle distillates - Infrared spectroscopy method)* is less than 0.05 % (v/v) or 500 ppm.

Multi-product Terminal Receipt Tank	FAME is confirmed and controlled to not be present. FAME must be restricted and controlled by multi-product system operator (e.g. FAME content of all fuels coming into the multi-product system).	No
Airport Tanks – Non Dedicated Supply	Testing is required when receiving via non-dedicated transportation mode or supply terminal cannot confirm that FAME content is less than the specification limit	Yes
Airport Tanks – Dedicated Supply	When in a dedicated supply system and the supplying terminals confirm the FAME content is below the specification limit.	No

Recommended Marine Vessel Cleaning/Testing

The table below captured recommended vessel cleaning for change of grade and testing requirements to monitor FAME contamination from FAME. It is the charters/ship owners' responsibility to prepare the vessel in a condition that is acceptable to load the nominated cargo but the tank preparation that was conducted should be reviewed prior to loading. In all circumstances, history of the last three cargos carried shall be checked and cleaning and testing requirements applied accordingly. In instances where there are conflicting recommendations, the more stringent, testing and cleaning should be applied.

Diesel/Gasoil FAME content discharged	**Cleaning Recommendations (As captured in EI HM 50 3rd edition)**	**FAME testing required on COA / Recertification Test (RT) after jet loading or prior to discharge**
B15-B100	A minimum of 3 zero FAME intermediate cargoes between B15-B100 and aviation jet fuel.	Yes
B5-B15	Requires a stringent hot water wash, including flushing pumps and lines followed by draining.. For further information refer to Energy Institute HM50 Guidelines.	Yes
<B5	Requires a hot water wash, including flushing pumps and lines followed by draining	Yes
Confirmed >B0 or unknown FAME content	Follow B5-15 cleaning.	Yes
B0 confirmed for last for four voyages		No

Frequently Asked Questions

Q1: As the FAME limit appears in Table 1 of Def Stan 91-91, does the new version Def Stan 91-91 require FAME testing, even at the point of manufacture?

ASTM D1655-15 Section 6.3 makes it clear that FAME testing is only required where there is a risk of contamination exceeding 50 mg/kg.

The wording in Def Stan 91-91 Issue 7 Amd 3 is currently more ambiguous and requires some clarification. Note 20 and Annex G4 are intended to reflect that FAME is also tested only when there is a risk of contamination, but Annex J1.2.1 states that all properties in Table 1 are listed in the Refinery Certificate of Quality.

For refineries which have jet fuel systems which are segregated and isolated from products containing FAME, then FAME testing is not necessary as its absence can be assured through procedures and therefore can be declared as 'Not measured - Risk Assessed in accordance with JIG Bulletin 75".' on the RCQ.

Q2: Does Def Stan 91-91 and ASTM D1655 now require FAME testing, even if a risk assessment and controls determine that the FAME level is below 50 mg/kg?

For the supply chain downstream of manufacture, the intent of Def Stan 91-91 and ASTM D1655 specifications is that FAME **testing is required if Jet fuel is exposed to a multi-product system which contains FAME** and the procedural controls cannot guarantee a level of FAME below 5 mg/kg in the jet. In this case testing shall be conducted and the actual results shall be declared on the Recertification Test results or Certificate of Analysis.

Once Jet fuel is in dedicated jet fuel systems, or supply chains that do not contain FAME[2], there is no need to continue to test for FAME as further contamination is prevented by physical separation.

In multi-product systems not containing FAME, or where a complete risk assessment determines that FAME contamination is not possible, the FAME testing may be omitted when conducting recertification testing.

In supply systems where FAME testing is not required, there is still a need to capture and record the FAME content of the jet as it transits the system. An example might be when jet fuel batches coming into a FAME-free system are known to have a pre-existing, measured FAME content. In such cases, when recertifying the fuel, or when comingling batches in a dedicated system, the FAME content of the jet shall be calculated based on the previously declared FAME content of the constituent component batches.

To achieve this, the volume weighted average FAME content shall be calculated and declared as the 'Calculated FAME Content' in a footnote or comment on the Recertification Test Certificate or Certificate of Analysis and shall also be included on quality certificates at airport depots. This volume weighted average shall be the arithmetic mean FAME content,

[2] Gas Oil (diesel fuel) may be referred to as B0 or "FAME-free" if the FAME content measured per test method EN 14078 (*Liquid petroleum products - Determination of fatty acid methyl esters (FAME) in middle distillates - Infrared spectroscopy method)* is less than 0.05 % (v/v) or 500 ppm.

based on the individual FAME contents and respective volumes of the constituent batches (including the tank heel) that are being comingled.

To facilitate this calculation, the FAME content of the constituent jet fuel volumes shall be either the measured value or the declared calculated content in cases where the FAME content is not measured in accordance with the controls of this Bulletin. For constituent volumes for which FAME content is not measured in accordance with this Bulletin and there is no calculated value declared - as may be the case from an entirely dedicated system from a refinery for example - then for the purposes of the calculation this portion of the fuel composition will be assumed to have a zero FAME content (0 mg/kg).

This process of tracking FAME content is necessary not only to meet the specification requirements, but also recognizes that industry needs to collect data about FAME levels in jet fuel in order to support the case for the move to 100 mg/kg in the future. This is referred to in Def Stan 91-91 Issue 7 Amd 3, Annex G.4.4.

Q3: If testing is not mandatory, can we, without testing, assure that any import will be suitable for pipeline transport whilst pipelines continue to stipulate a 5 mg/kg limit? This may lead to a reduction in supply or significant risk exposure in the case of a contamination between 5 and 50 mg/kg FAME.

If pipeline supply limits continue to be less than 5 mg/kg, it is clear that either procedural controls to assure less than 5 mg/kg, or testing, will continue to be required as was the case in previous versions of ASTM D1655 and / or Def Stan 91-91. The reason is that, if jet parcels supplied to the pipeline are only released as conforming to Def Stan 91-91 Issue 7 Amd 3 and / or ASTM D1655-15, then it will not be possible to use this as an adequate control for a less than 5 mg/kg requirement.

Not only are the allowable FAME limits different, but also not all of the test methods allowed by the recent Jet fuel specification changes allow sufficient control of FAME down to 5 mg/kg. Specifically, determination of FAME level using the rapid screening method, IP583 / ASTM D7797 has a lower detection limit of, at best, 20 mg/kg and so is not precise enough to determine FAME levels down to and below 5 mg/kg.

Where testing to a limit of 5 mg/kg is required, IP585, IP590 or IP599 shall continue to be used, with IP585 being the referee method.

Q4: The implementation date of Def Stan 91-91 Issue 7 Amd 3 is listed as 02nd May 2015. If we have a jet fuel incident which is above 5 mg/kg but below 50 mg/kg before the implementation date, is it possible to release the fuel under the higher FAME limits contained in Def Stan 91-91 Issue 7 Amd 3?

Yes it is possible, should the supply contracts allow it (attention needs to be paid to pipeline specs if they remain out of step with the new FAME limits).

The compliance date in the Defence Standard is intended to indicate a date by which the specification becomes mandated. A compliance date later than the issue date is intended to give suppliers sufficient time to risk-assess their supply chains and to purchase test equipment where it is needed. However, it does not mean that product cannot be released to Issue 7 Amd 3 prior to this date. Although it would be conventional to continue to issue fuel

against the earlier specification standards until the compliance date of the new standard, the issue date of Def Stan 91-91 Issue 7 Amd 3 is 02nd Feb 2015 and so this makes Issue 7 Amd 3 a current specification and it therefore can be used for release should it be necessary.

Q5: What about FAME limits in other jet fuel specifications, such as the Canadian CAN-CGSB 3.23?

CGSB report that they intend to adopt the 50 mg/kg FAME limit in their jet fuel specifications now that ASTM D1655-15 has been issued. However, revisions have not yet been issued and so at the time of writing CAN-CGSB 3.23-2012 Amendment 1 is current, which requires less than 5 mg/kg FAME. The next meeting to revise the CAN-CGSB specifications is planned for May 2015.