

IS MEASURING JET FUEL VISCOSITY MORE ACCURATE THAN FREEZING POINT?

During their 2008 meeting in Shanghai, China, the International Air Transport Association (IATA) asked the Coordinating Research Council (CRC) to investigate the possibility of finding a replacement for the currently used freezing point methods. This request arose from the work of IATA's Freezing Point Harmonization Group, whose goal was to explore the viability of using a single grade of commercial jet fuel throughout the world, with respect to freezing point.¹ The thought was that using a single grade of commercial jet fuel globally would have economic and fuel production benefits.

The group investigated a number of options, focusing on freezing points around Jet A and Jet A-1 limits. Although several options were presented and further study was suggested, the group's work also indicated that the engine original equipment manufacturers (OEMs) were more concerned about the fuel viscosity at the engine intake rather than the freezing point of the fuel in the tanks. The report concluded that "it is a generally accepted fact that the freezing point test is not an effective test for predicting fuel flow behavior in the aircraft at low temperatures."²

From this request came a comprehensive CRC report that evaluated the current state of the OEM fuel systems, available testing methods, and research into jet fuel low temperature properties.³ One of the conclusions from the CRC report was that viscosity may be a more accurate predictor of pumpability from an aircraft fuel tank than freezing point.

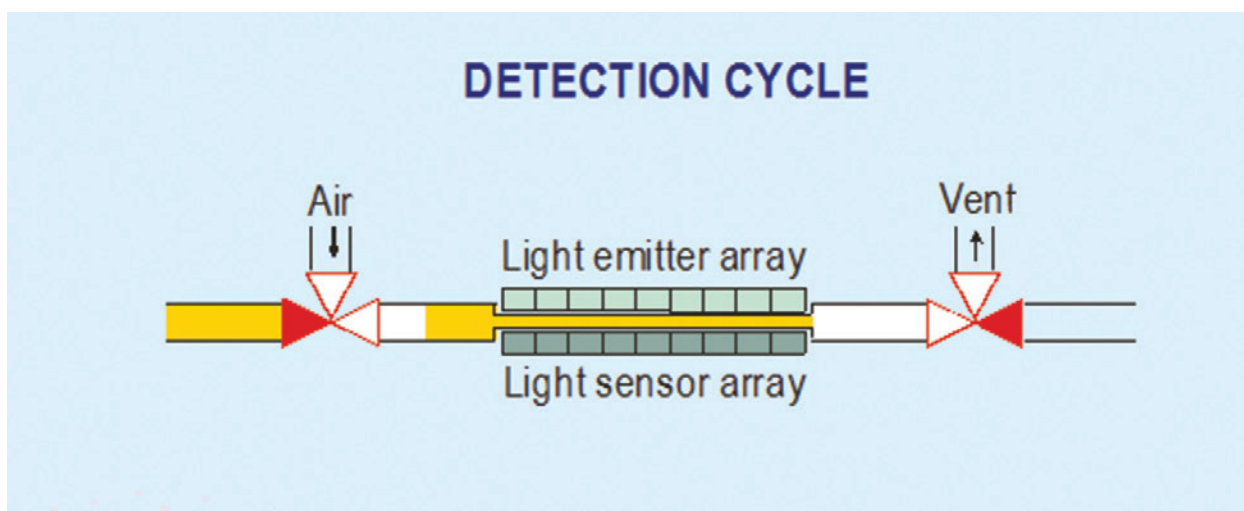
The report recommended four specific actions:

- Develop and assess a suitable low temperature scanning viscometer to accurately predict low temperature pumpability
- Identify a viscosity equivalent limit for specification purposes
- Quantify any likely small chemistry changes to viscosity
- Evaluate OEM support for replacing freezing point with viscosity

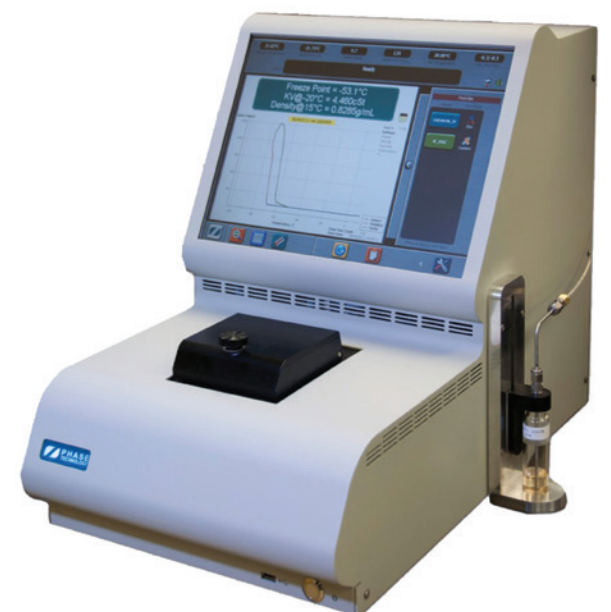
A promising new instrument for simultaneously measuring freezing point, viscosity and density, which is approved for jet fuel certification, is the Phase JFA-70Xi. This instrument combines a well-established freezing point test method (ASTM D5972/IP435) and a recently-developed viscosity test method (ASTM D7945) into a single instrument. The JFA-70Xi is capable of determining the kinematic viscosities of jet fuels at both -20°C and -40°C. It also measures the density of the fuel.

D7945 utilizes a horizontal capillary and calibrated air pressure to drive a column of test sample. Under the Hagen-Poiseuille principle, the times of transit across multiple calibrated timing segments are directly correlated to the viscosity of the fuel.

A 2016 ASTM ILS⁴ with current jet fuel types, including Jet A, jet A1 (both satisfying D1655), renewables (satisfying D7566) and 50/50 blends, has demonstrated that D7945 exceeds the precision of both D445 and D7042, two other viscosity test methods. The repeatability of D7945 at -20°C is 0.011 mm²/s and the reproducibility is 0.021 mm²/s. This is more than four times better



The working principle of D7945, in which a fixed volume of test fuel is driven by a calibrated air pressure force across timed segments of a horizontal capillary tube. The times of transit of the sample can then be used to calculate its viscosity according to the Hagen-Poiseuille law.



JFA-70Xi, the world's first 3-in-1 Jet Fuel Analyzer



than the precision of D445. In addition, a precision statement has also been developed for D7945 at -40°C. To date, D7945 is the only viscosity test method for jet fuels with an approved precision at -40°C. Measurement of viscosity at the lower temperatures of -40°C is considered to be more representative of pumpability.

In addition to viscosity, the JFA-70Xi also calculates the temperature at which the fuel reaches 12.0 mm²/s using ASTM D341 and the afore-measured viscosities at -20°C and -40°C. The 12 mm²/s metric is considered essential in the operation of the APU (auxiliary power unit) during ETOPS (Extended Twin (Engine) Operations). Furthermore, by comparing this 12 mm²/s temperature with the resultant freezing point also measured, i.e. whether colder or warmer, the JFA-70Xi further assess which of the two temperatures is the more critical during low temperatures flight operation.

As illustrated by the two figures at the right, the calculated 12 mm²/s temperature may or may not be meaningful depending on whether it is warmer or colder than the freezing point.

By combining freezing point and viscosity in a single instrument at the current specified temperature of -20°C and also at the potentially more useful temperature of -40°C, and lastly the temperature at which the fuel would reach 12 mm²/s, the JFA-70Xi represents the state-of-the-art in delivering the most comprehensive measure of the pumpability of jet fuels at cold temperatures.

Phase Technology was recently acquired by PAC. This makes PAC-Phase the number one provider of Jet Fuel analysis solutions. PAC's portfolio includes: the world renowned JFTOT, the new OptiReader, OptiFZP and the Intelligent Heater Tubes used by labs worldwide.

References

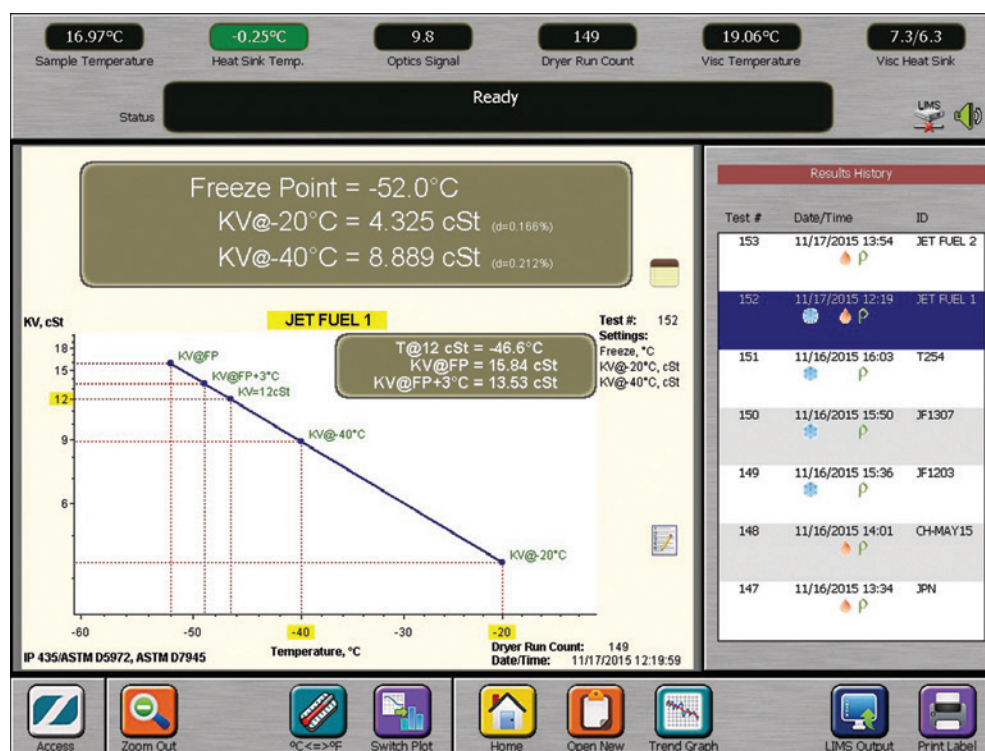
1. Fuel Freezing Point Harmonization, Final Report, February 2008, IATA Technical Fuel Group (TFG) Task Force.
2. Ibid
3. CRC Project AV-11-09, "Develop an Aviation Fuel Cold Flowability Test to Replace Freezing Point Measurement", G. Richard, 2010.
4. 2016 ASTM Research Report RR D02-1833, "Interlaboratory Study to establish statements for measuring the kinematic viscosity at -20°C and -40°C, and then calculating the temperature when the sample would reach 12 mm²/s using ASTM D341."

Author Details

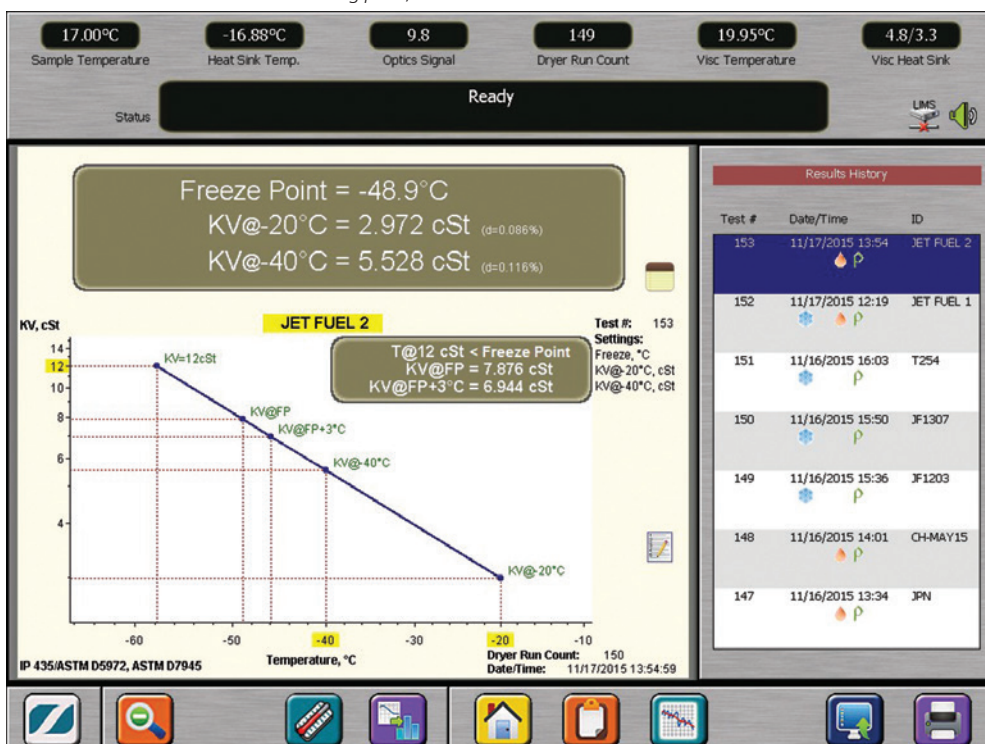
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An illustrative output of the JFA-70Xi test screen showing various results. In particular, the 12 mm²/s temperature is reported if it is found to be warmer than the freezing point, since the fuel is free of solids when 12 mm²/s is reached.



An illustrative plot when the 12 mm²/s temperature is calculated to be colder than the freezing point. In this instance, the calculated 12 mm²/s temperature will not be reported as the fuel will be in a two-phase regime, rendering the calculation rationale of D341 unsuitable.