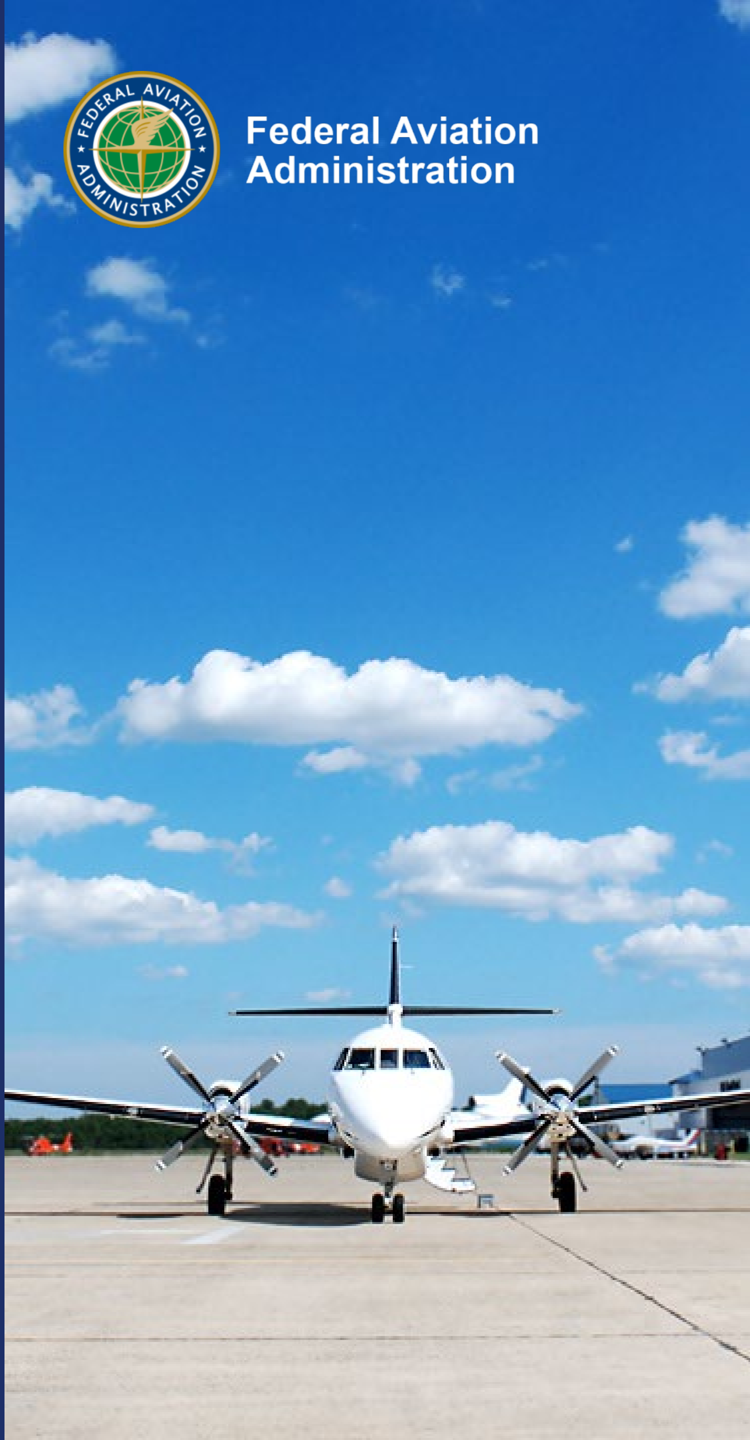
Attachment VI

Rolls-Royce Diesel Exhaust Fluid and Apple Jelly Contamination Report



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Presentation Contents

1. Introduction to Diesel Exhaust Fluid (DEF) contamination in Jet-A fuel.
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3. Introduction to Apple Jelly contamination of Jet-A fuel.
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6. Experimental results and analyses.
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Introduction to Diesel Exhaust Fluid Contamination

- **Definition of Diesel Exhaust Fluid (DEF):**

  (1). Diesel Exhaust Fluid is an aqueous solution consists of urea (CH_4N_2O) & water (H_2O).

  (2). DEF is used to reduce nitrogen oxides (NO, NO_2 & NO_x) in an exhaust gas from a diesel engine into nitrogen gas (N_2) .

  (3). The purpose of this process called Selective Catalytic Reduction (SCR) is to reduce NO_x emission to meet EPA standards in 2010.

  (4). DEF stored in an airport can mistakenly be used as a Fuel System Icing Inhibitor (FSII) to be added into airplane fuel tanks causing DEF contamination.

- **Characterizations of DEF contamination in a Jet-A fuel sample:**

  (1). Formation of urea crystals when the fuel sample is evaporated.

  (2). A high water content in comparison with a DEF-free Jet-A fuel sample.

  (3). A high nitrogen content in comparison with a DEF-free Jet-A fuel sample.

Introduction to "Apple Jelly" Contamination

- **Definition of "Apple Jelly" from a Jet-A Fuel distribution system:**

  (1). "Apple Jelly" in a fuel distribution system or in a Jet-A fuel sample refers to a complex mixture of dark colored, gelatinous & moderately viscous hydrocarbons/materials.

  (2). "Apple Jelly" can be a precursor of a fuel gum. When "Apple Jelly" contamination in a fuel sample is high its gum content is also at a higher level.

  (3). "Apple Jelly" in a fuel system can lead to more frequent changes of filter, separator elements and increase workloads for fuels personnel.

- **Characterizations of "Apple Jelly" contamination in a Jet-A fuel:**

  (1). "Apple Jelly", according to Southwest Research Institute (SwRI), is formed via the interaction of diethylene glycol monomethyl ether (DiEGME), a fuel system icing inhibitor (FSII), with water and other fuel system contaminants.

  (2). DiEGME is an anti-icing inhibitor added to JP-8 jet fuel to prevent free water in a fuel system from freezing at high altitudes.

  (3). Higher density and viscosity.

Rolls Royce Jet-A Fuel Sample Information

Aviation Fuels Research Lab (AFRL) received six (6) RR Jet-A fuel samples taken from different locations in a fuel system from the Rolls Royce Corporation. AFRL obtained a 1,000 mL fresh Jet-A fuel from the Atlantic City International Airport (ACY) as a reference sample. The following table lists the detailed information of these fuel samples:

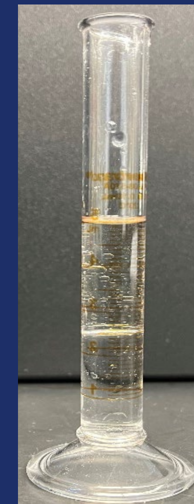
Jet-A Sample	Description (Sample Location)	Date	Volume & Color
ACY Jet-A	Reference Fuel from A Fixed-Base Operator (FBO) at ACY.	07/15/2023	1,000 mL/Clear
RR Jet-A A	Engine Fuel Pump Filter (N61KH)	12/06/2022	~60 mL/Slightly Yellow
RR Jet-A B	AF Fuel Filter Drain	11/06/2022	~15 mL/Clear
RR Jet-A C	AF Fuel Filter Bowl (N61KH)	12/06/2022	~100 mL/Clear
RR Jet-A D	Aircraft Filter 12:16 p.m. (N61KH)	11/03/2022	~150 mL/Clear
RR Jet-A E	Airport Tank Gun 11:15 a.m. (N61KH)	11/03/2022	~75 mL/Clear
RR Jet-A F	Airport Tank Filter 11:10 a.m. (N61KH)	11/03/2022	~60 mL/Clear

DEF Test Results (1) – Water Reaction

- **Purpose:** To investigate the free water contents in Jet-A samples.
- **Procedure-1:** Based on ASTM D1094 (Standard Test Method for Water Reaction of Aviation Fuels), mixing 2.5 mL Jet-A samples with 2.5 mL buffer solution (pH = 7.0) & shaking for 2.0 minuets.
- **Procedure-2:** After setting down for two hours, observe the interfaces of the fuel & water.
- **Results:** For the six (6) samples the interfaces remain at 2.5 mL levels, indicating that free water contents in these samples are insignificant.

ACY

RR C



RR E

RR A

RR D

RR F

DEF Test Results (2) – Water Contents & Freezing Points

- **Purpose:** To determine the dissolved water in seven (7) Jet-A samples.
- **Method:** ASTM D6304-20 (Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration).
- Fuel freezing point tests use an automatic freezing point tester (ASTM D5972-23).
- Water contents & freezing points for the seven (7) Jet-A samples are summarized below:

Water (ppm)	ACY	RR A	RR B	RR C	RR D	RR E	RR F
1st Testing	33.50	46.60	42.40	49.45	47.56	48.68	45.41
2nd Testing	33.06	46.75		46.37	50.13	47.09	41.07
Average	33.28	46.68	42.40	47.91	48.85	47.89	43.24
Freezing Point (°C)	-52.9	-48.9	**-10.1**[*]	-49.3	-49.3	-49.0	-48.7

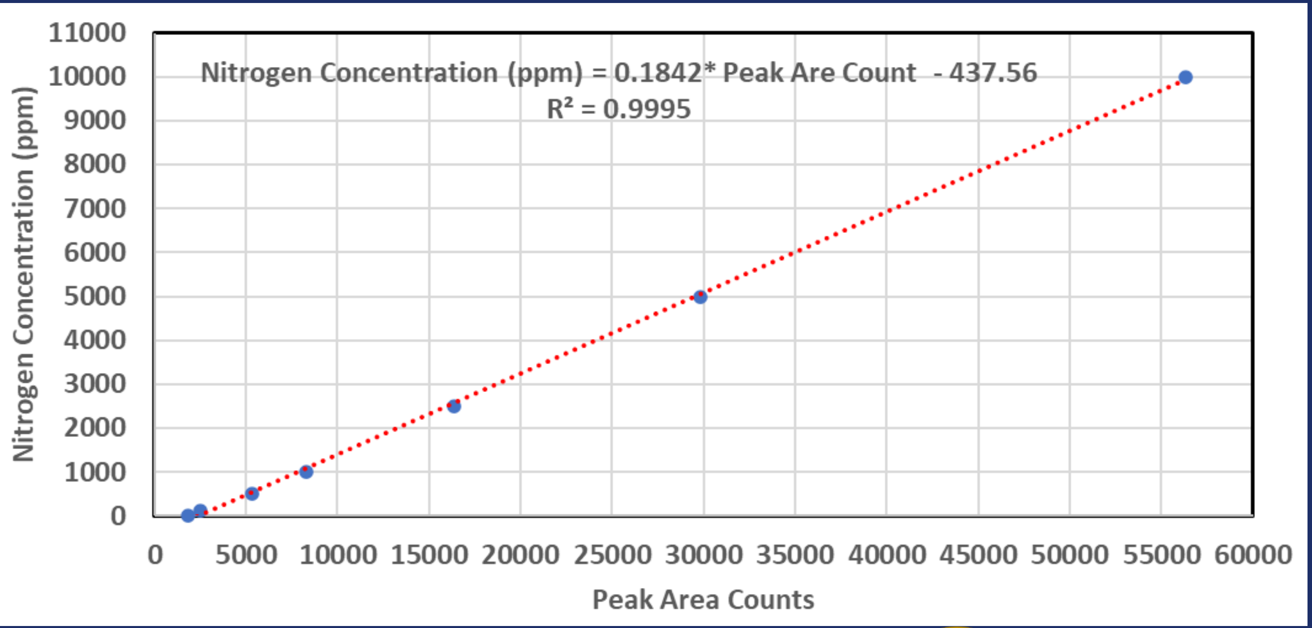
[*]This data is the average of three tests. The tailing on the phase transformation plot from the auto-freezing point tester represents a significant amount heavy & high boiling point materials in the fuel. This result may indicate the presence of impurities in the fuel sample. More detailed analysis is recommended for the future work.

DEF Test Results (3) – Nitrogen Content Measurements

- **Purpose:** To determine the nitrogen contents in the seven (7) Jet-A samples.
- **Method:** ASTM D5291-21 (Standard Test Methods for Instrumental Determination of Carbon (C), Hydrogen (H), Nitrogen (N), Sulfur (S) & Oxygen (O) in Petroleum Products and Lubricants).
- **Instrument:** Flash 2000 Elemental Analyzer for Carbon (C), Hydrogen (H), Nitrogen (N), Sulfur (S) & Oxygen (O), equipped with a recently purchased liquid automatic injection system (Thermo Fisher Scientific).
- **Injection volume:** 1.0 to 5.0 µL.
- **Carrier & Reactant Gases**: High purity helium & oxygen.

DEF Test Results (4) – Instrument Calibration & Detection Limit of Nitrogen Concentration

- ❖ **Purpose:** To determine the nitrogen detection limit of the instrument & nitrogen concentration as a function of peak area counts from the Thermal Conductivity Detector of the instrument.
- ❖ **Calibration Standards:** Analytical Grade m-toluidine (C_7H_9N) in toluene ($C_6H_5CH_3$) solutions with known nitrogen concentrations of 10,000, 5,000, 2,500, 1,000, 500 & 131 ppm N by mass. The detection limit is about 100 ppm.
- ❖ **Injection Volume & Measurements:** 3.0 µL & two (2) measurements.



DEF Test Results (5) – Nitrogen Contents for Jet-A Fuels

- Nitrogen (N) as a function of Peak Area Count:

  Nitrogen (ppm) = 0.1842*Area Count – 437.6 (ppm)

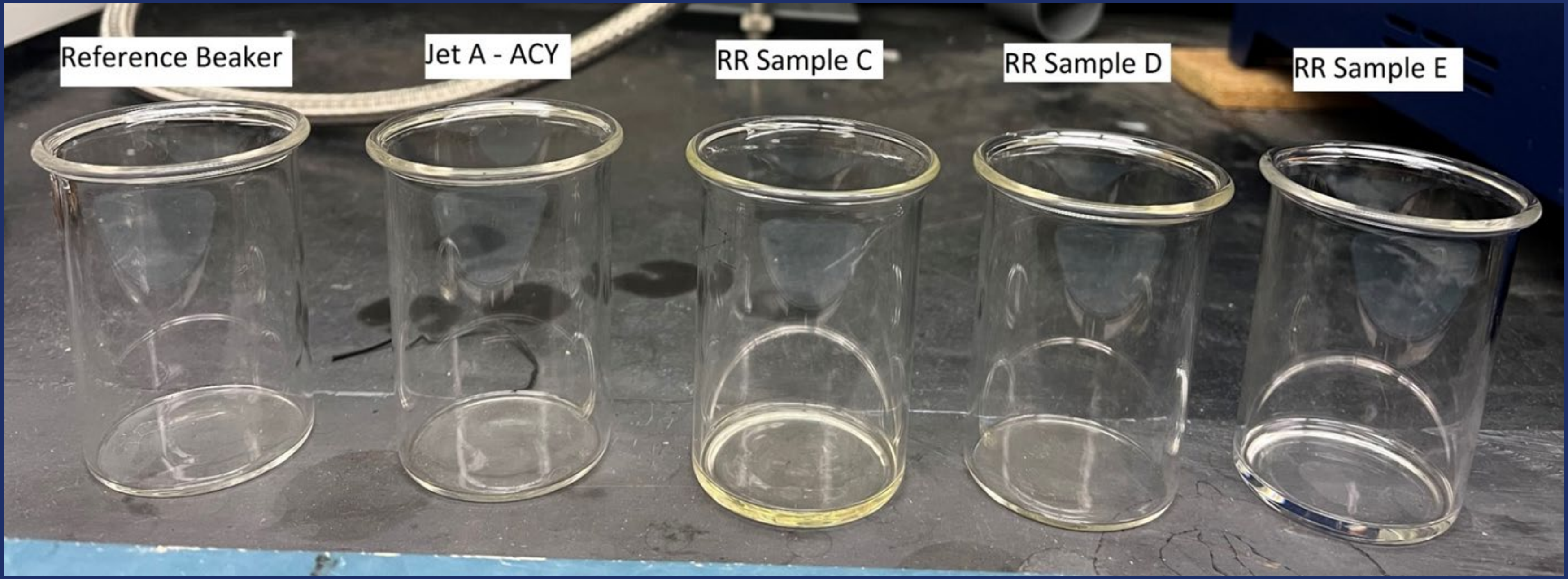
Eliminating the baseline error: **Nitrogen (ppm) = 0.1842*Area Count**

- The nitrogen concentrations of six (6) RR Jet-A fuel samples are at the ppm level closing to that of the ACY Jet-A sample. The very accurate results require a nitrogen detector in gas chromatogram.
- Results: Based on nitrogen concentration of Jet-A (ACY), we can conclude that no additional Nitrogen contents have been found for RR Jet-A samples.
- Very low nitrogen concentrations, low level water & no white particles (urea CH_4N_2O) formed during gum tests for five (5) Rolls Royce fuels indicate that these fuels may not be contaminated with Diesel Exhaust Fluid (DEF).

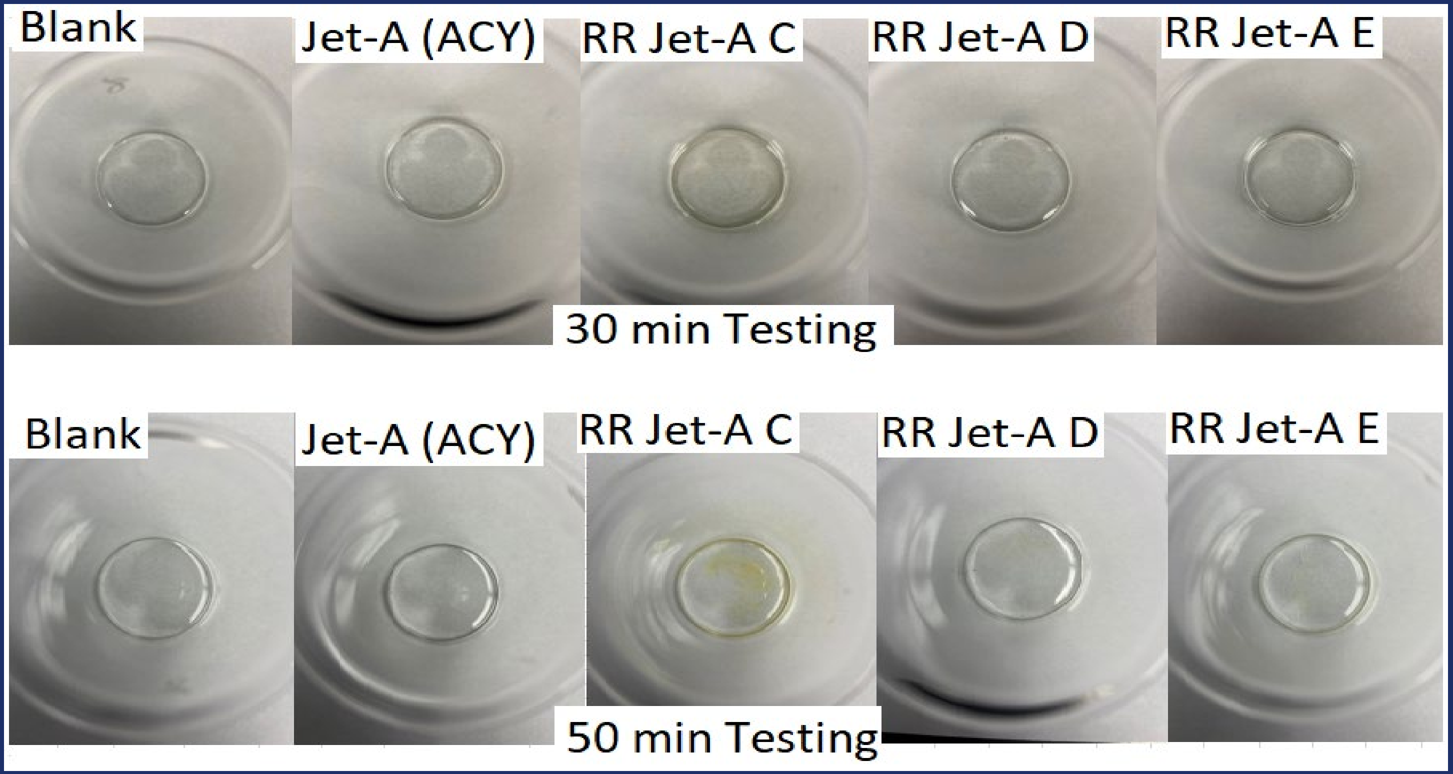
Nitrogen (ppm)	ACY	RR A	RR C	RR D	RR E	RR F
1st Measurement	373	259	289	315	243	256
2nd Measurement	302	240	296	319	244	222
Average	**337**	**250**	**293**	**317**	**243**	**239**

Apple Jelly Test Results – Fuel Existent Gum Testing-1

- **Instrument:** A solid state heater & a jet air evaporator.
- **Method:** ASTM D381-22 (Standard Test Method for Gum Content in Fuels by Jet Evaporation).
- **Sample Volume:** 50 mL.
- **Testing conditions:** T = 164 ^{o}C, t = 30 ~ 50 min with airflow.
- **Observations:** No solid particles have been observed.



Apple Jelly Test Results – Existent Gum Testing-2



Top views of existent gum testing beakers for Jet-A(ACY) & RR Jet-A samples have shown that no significant gum deposits nor white urea particles have been formed. (Note: there are not sufficient volumes (50 mL) of RR Jet-A A, B & F samples for this testing).

Apple Jelly Test Results – Fuel Existent Gum Testing-3

Existent Gum Testing (50 mL) for RR Jet-A samples:

1. In both 30 min and 50 min tests, existent gum contents of RR Jet-A fuels C, D & are much higher than that of Jet-A (ACY) fuel.
2. The higher gum contents in RR Jet-A fuels may mainly result from the extended time of storage (Please refer to the fuel sampling dates (Slide 5)).
3. As there is no significant color changes for RR fuel samples in both 30 min and 50 min tests, it appears that no significant apple jelly contamination has been identified.
4. Jet-A ACY contains much less gum than those in RR Jet-A C D & E samples.
5. No gum information is available for RR Jet-A A, B & F samples as there is not enough samples to run existent gum tests.
6. *The tests started from adding sample beakers to the oven when they are still at room temp. In an Existent Gum Test, time starts when fuel temp. = 164 ^{o}C.

Gum (mg/100 mL fuel)	Jet-A ACY	RR Jet-A C	RR Jet-A D	RR Jet-A E
30 min Testing*	95.2	2939	14.2	3356
50 min Testing*	0.60	87.20	2.20	78.20

Apple Jelly Test Results – Fuel Density & Viscosity

Fuel Density:

- Fuel density linearly increases as fuel temperature decreases.

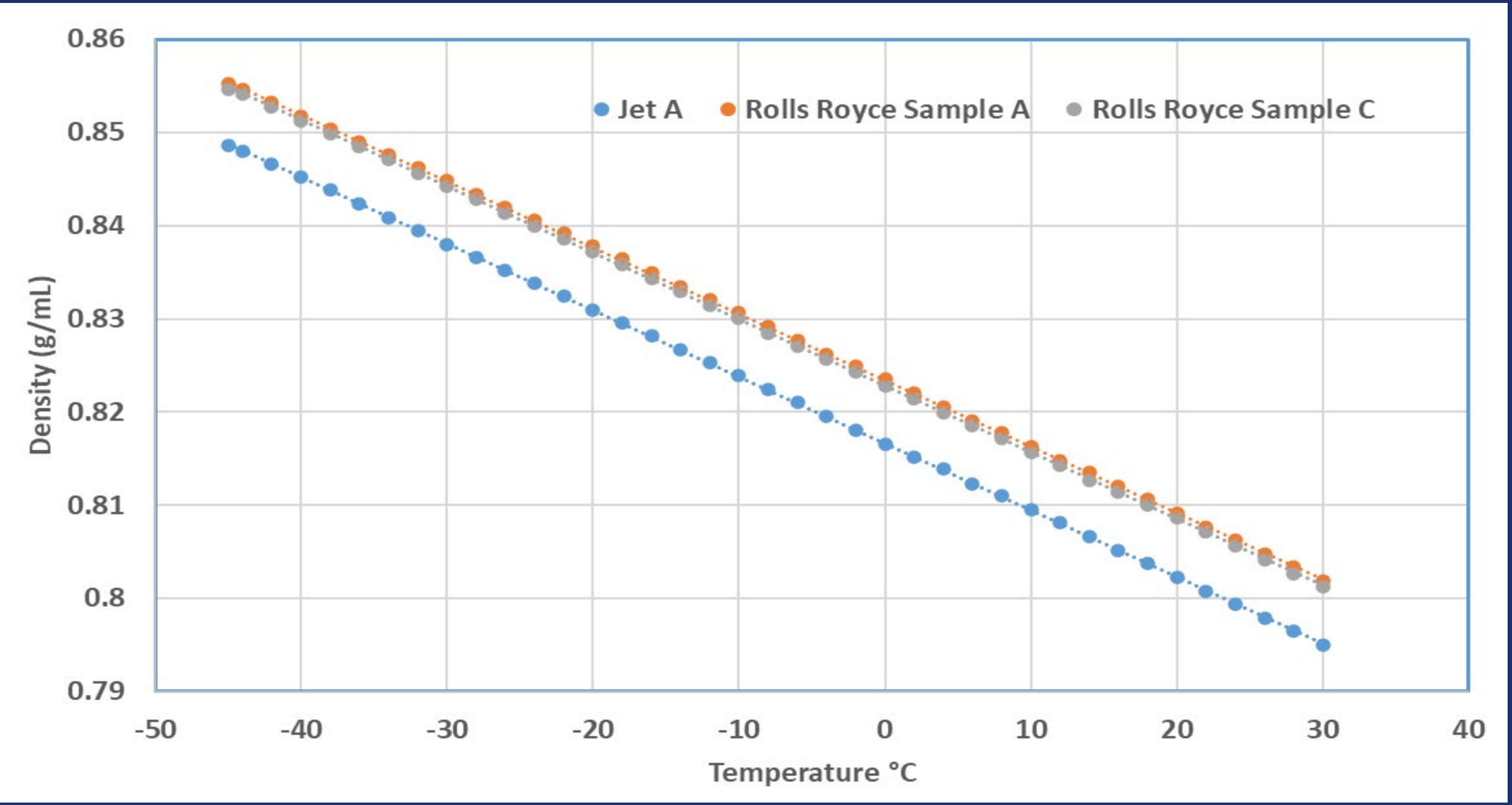
Fuel Viscosity:

- Fuel Viscosity: Energy/force is required to drive a fuel flow. Fuel viscosity is a measure of fuel flow resistance.
- Viscosity & Temperature: Viscosity is a strong function of temperature. Viscosity increases as fuel temperature decreases.
- Dynamic Viscosity: A fuel pressure (Pascal) needed to generate one (1) Newton (N) of shear stress at 1.0 m/sec flow rate for the fuel.
- Kinematic Viscosity: The amount of energy requirement for a 1.0 m/sec fuel flow ((Joule/kg)*s)).
- Kinematic Viscosity = Dynamic Viscosity/Fuel Density.

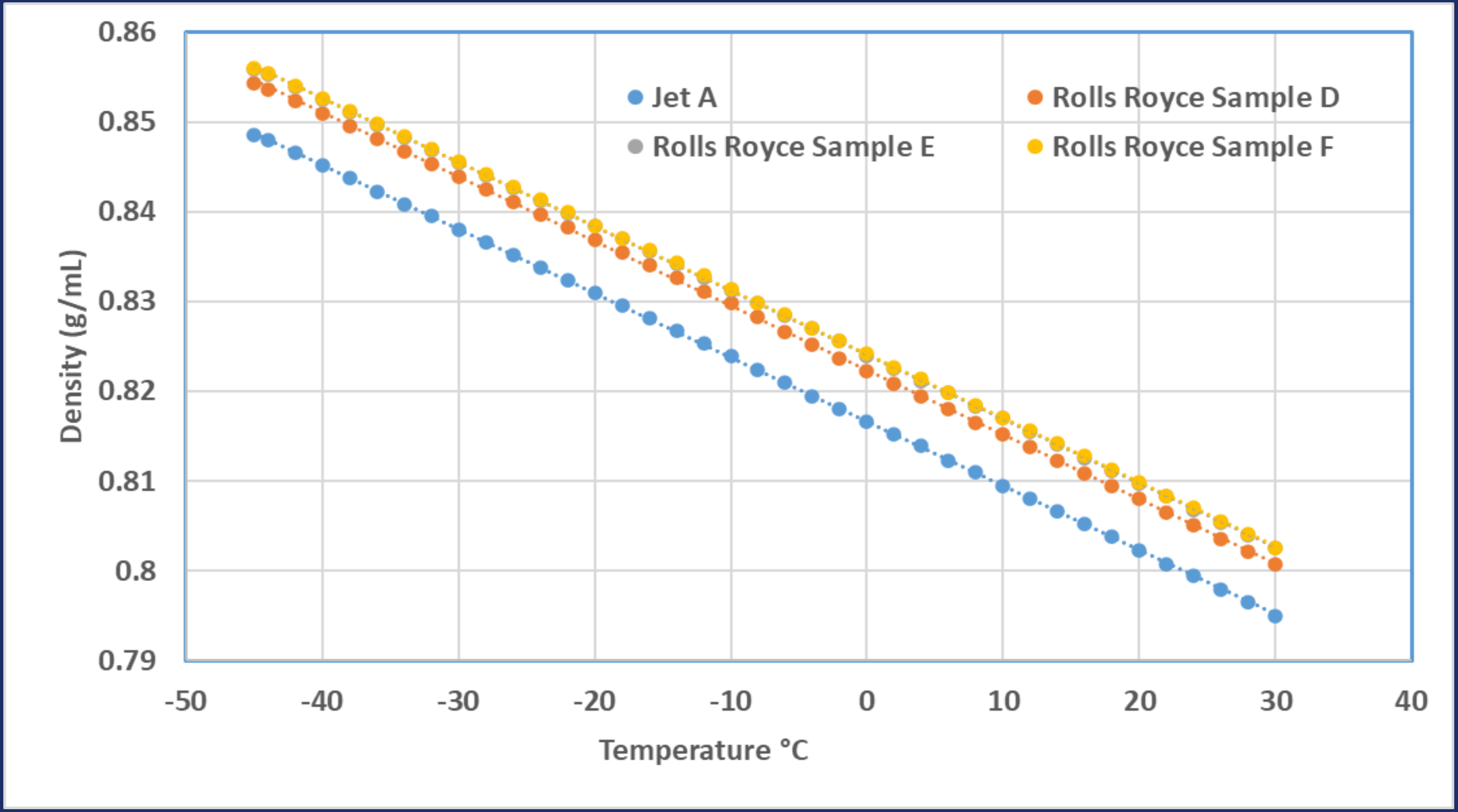
Measurements of Fuel Density & Density:

- AFRL uses an Anton Paar SVM 3000 Stabinger Viscometer allowing continuous measurements of viscosity & density at given temperatures.
- The method used for viscosity and density determination: ASTM D7042 (Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer & the Calculation of Kinematic Viscosity).

Apple Jelly Test Results – Fuel Density-1



Apple Jelly Test Results – Fuel Density-2



Apple Jelly Test Results – Fuel Density-3

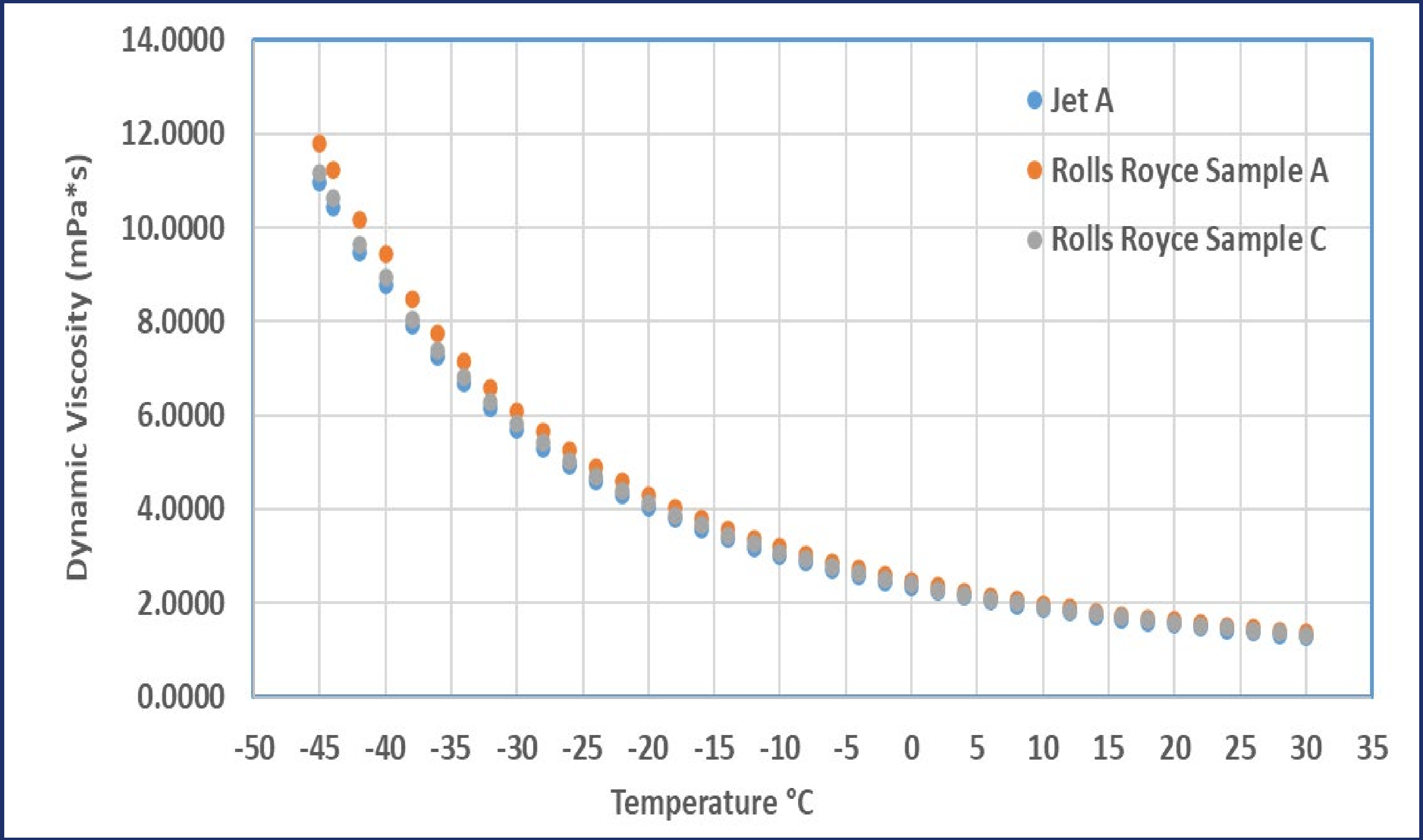
Jet-A fuel density is linearly related to the fuel temperature (°C):

Fuel Density (g/mL) = 0.0007*Temp(°C) + Fuel Density (g/mL) at 0.0 °C

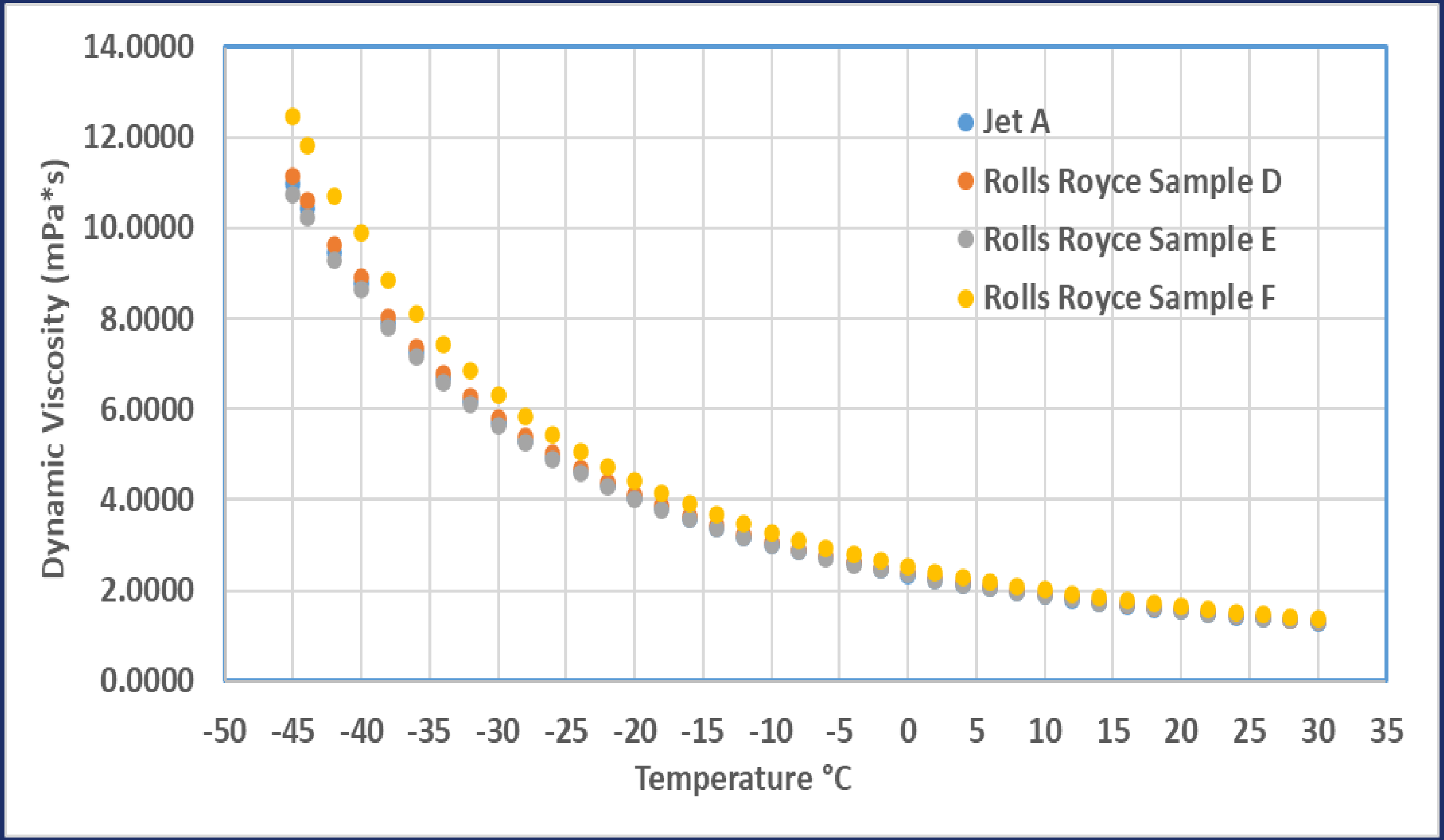
The densities at 0.0 °C for RR Jet-A fuel samples are slightly higher than that of Jet-A(ACY) fuel. A higher fuel density indicates the existence of higher existent gum or “Apple Jelly” contents due to fuels’ evaporation, aging or contamination.

Jet-A Sample	Fuel Density (g/mL) as a Function of Temperature (°C)	Fuel Density at 0.0 °C	Linear Fitting R^2 Value
ACY	Density = 0.0007*Temp + 0.8166	0.8166	1.0000
RR A	Density = 0.0007*Temp + 0.8234	0.8234	1.0000
RR B	(Insufficient sample to run this test.)		
RR C	Density = 0.0007*Temp + 0.8228	0.8228	1.0000
RR D	Density = 0.0007*Temp + 0.8224	0.8224	1.0000
RR E	Density = 0.0007*Temp + 0.8241	0.8241	1.0000
RR F	Density = 0.0007*Temp + 0.8242	0.8224	1.0000

Apple Jelly Test Results – Dynamic Viscosity-1



Apply Jelly Test Results – Dynamic Viscosity-2



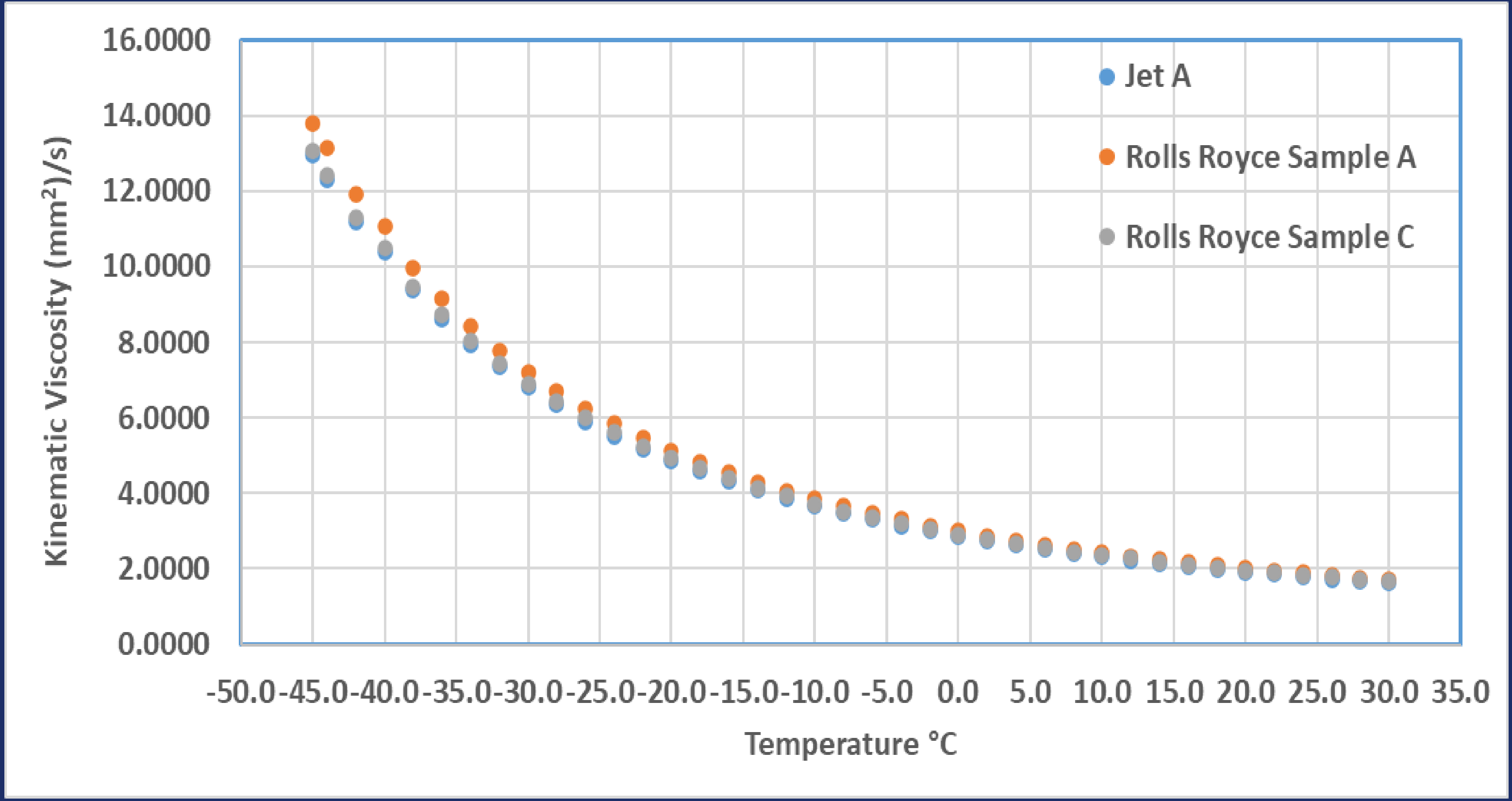
Federal Aviation Administration

Apple Jelly Test Results – Summary of Dynamic Viscosity-3

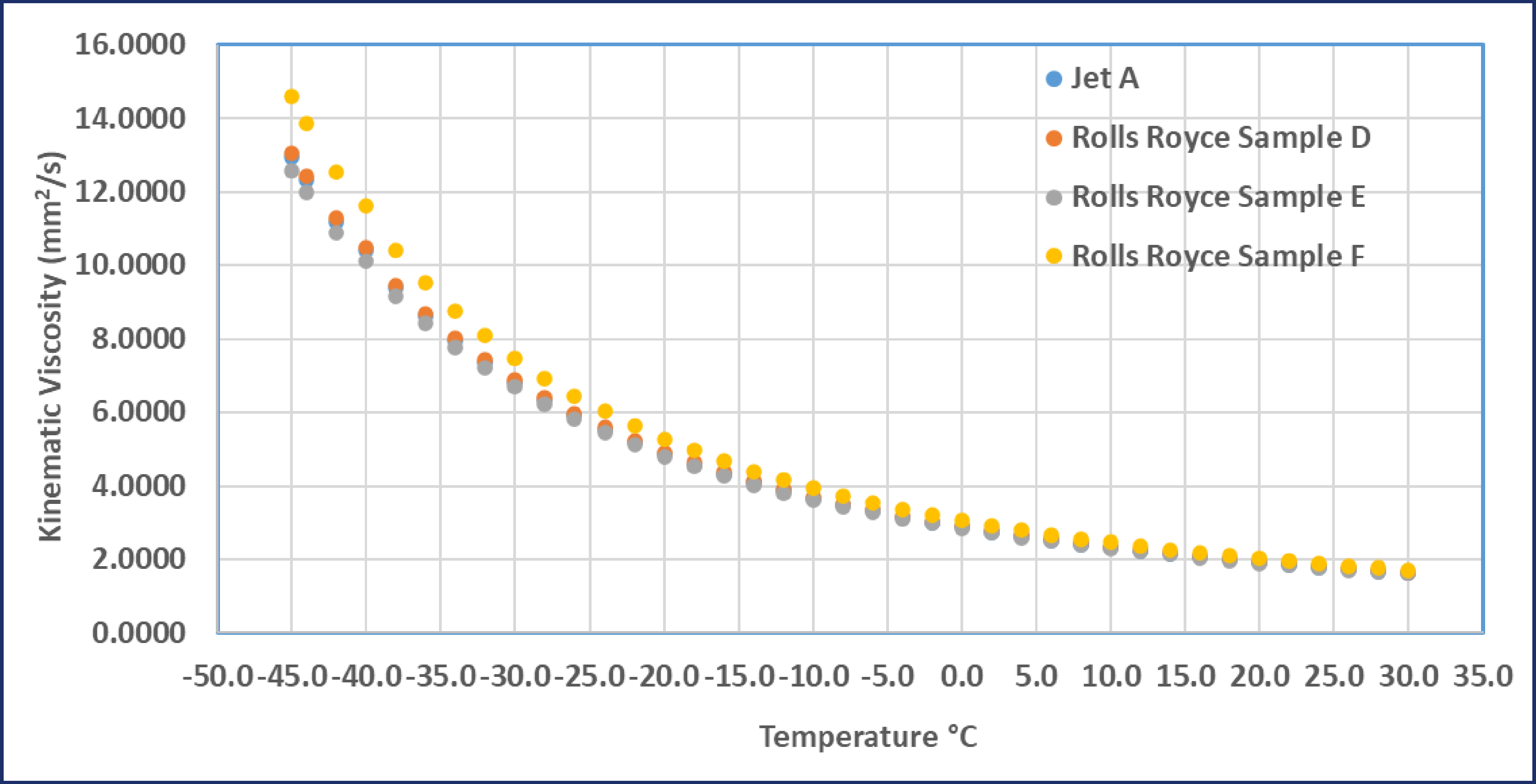
- The following table lists some dynamic viscosities (mPa*s) of Jet-A fuels at selected temperatures. At various temperatures, RR Jet-A E sample has similar dynamic viscosities in comparison with those of Jet-A(ACY) fuel. RR F sample has shown highest viscosities among six (6) samples.
- At temperature above 0.0 °C, the differences of dynamic viscosities for the six (6) samples are less than 0.2000 mPa*s.
- At low temperatures, the dynamic viscosity has shown slightly greater differences for the six (6) samples.

Sample	30/°C	20/°C	10/°C	0/°C	-10/°C	-20/°C	-30/°C	-45/°C
ACY	1.2857	1.5386	1.8751	2.3418	3.0167	4.0438	5.7104	10.9820
RR A	1.3668	1.6331	1.9831	2.4758	3.1973	4.2987	6.0945	11.8090
RR C	1.3286	1.5840	1.9248	2.3987	3.0876	4.1308	5.8323	11.1640
RR D	1.3184	1.5709	1.9134	2.3887	3.0760	4.1161	5.8132	11.1520
RR E	1.2972	1.5454	1.8803	2.3429	3.0100	4.0226	5.6550	10.7570
RR F	1.3742	1.6436	2.0111	2.5244	3.2733	4.4249	6.3216	12.4840

Apple Jelly Test Results – Kinematic Viscosity-1



Apply Jelly Test Results – Kinematic Viscosity-2



Apple Jelly Test Results – Summary of Kinematic Viscosity-3

- Some kinematic viscosities of Jet-A fuel samples at selected temperatures are listed in the following table. At various temperatures, RR Jet-A E sample has similar kinematic viscosities in comparison with those of Jet-A (ACY) fuel. The RR F has shown the highest viscosity of six (6) samples.
- At temperature above 0.0 ^{o}C, the differences of kinematic viscosities for the six (6) samples are less than ~0.3000 m^2/s.
- At low temperatures, the differences of kinematic viscosities for six (6) samples have shown slightly greater differences.

Sample	30/^{o}C	20/^{o}C	10/^{o}C	0/^{o}C	-10/^{o}C	-20/^{o}C	-30/^{o}C	-45/^{o}C
ACY	1.6172	1.9177	2.3163	2.8677	3.6616	4.8663	6.8141	12.942
RR A	1.7045	2.0183	2.4292	3.0064	3.8491	5.1312	7.2141	13.808
RR C	1.6582	1.9590	2.3596	2.9153	3.7197	4.9344	6.9083	13.063
RR D	1.6467	1.9442	2.3471	2.9050	3.7071	4.9185	6.8883	13.054
RR E	1.6165	1.9085	2.3015	2.8432	3.6208	4.7979	6.6884	12.568
RR F	1.7122	2.0293	2.4613	3.0631	3.9369	5.2769	7.4760	14.585

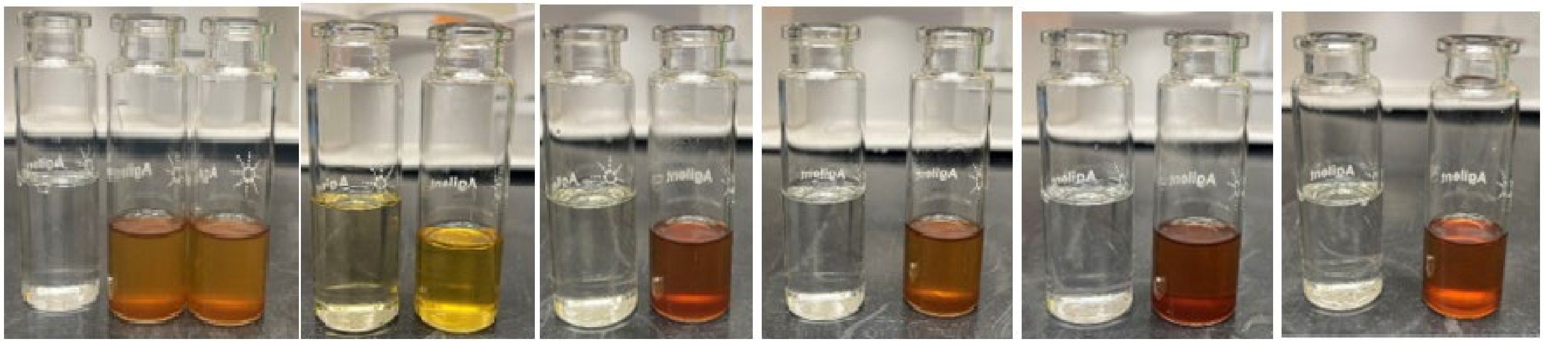
Summary of Apple Jelly Contamination Testing Results

1. No visible amount of “Apple Jelly” have been observed during fuel existent gum tests for RR Jet-A fuels.
2. The slightly greater densities of the five (5) Rolls Royce Jet-A fuels than that of Jet-A (ACY) fuel may result from fuel aging & vaporization.
3. No significant differences of the dynamic & kinematic viscosities of the five (5) Rolls Royce Jet-A samples in comparison with those of Jet-A (ACY) fuel at temperature higher than -20 ^{o}C.
4. When Temperature is lower than -20 ^{o}C, RR Jet-A F fuel taken from the Airport Tank Filter shows highest viscosities among the five (5) fuel samples. The higher dynamic & kinematic viscosities may result from the higher water content, existent gum or small amount of apple jelly contamination.
5. Both dynamic and kinematic viscosities for RR E fuel are very close to those of Jet-A (ACY) fuel from room temperature to -45 ^{o}C, indicating that RR Jet-A E taken from the Airport Tank Gun is most unlikely having significant apple jelly contamination.

Discussion on Apple Jelly Formation - Purpose (1)

1. **Mechanism of Apple Jelly Formation**: Literature survey has revealed that apple jelly in a Jet-A fuel is the products of fuel system icing inhibitor (FSII) (diethylene glycol monomethyl ether $C_5H_{12}O_3$ (DiEGME) reacts with water. This can be a major mechanism for the apple jelly formation. However, apple jelly is a complex mixture of hydrocarbons & there should have many other pathways for its formation.
2. **Purpose:** To investigate potential formation conditions & pathways of apple jelly. The understanding of Apple Jelly formation can help us to prevent apply jelly contamination when we are handling aviation turbine fuels.
3. **Materials**: the five (5) Rolls Royce Jet-A samples & Jet-A (ACY) fuel.

Discussion on Apple Jelly Formation – Color Change (2)



Simulation for Apple Jelly Formation
(Before (Left) & After (Right) Samples for 165 °C 13 hours' Heating)

After 13 hours' aging at 165 °C & under ambient pressure, the color of the two Jet-A (ACY) & five (5) Rolls Royce fuel samples have turned to dark brown, the color after aging is close to those of fuel apple jelly reported in literature. Brown colored precipitation has been found for all six fuels. (Note: the color of aged RR Jet-A A sample appears slightly lighter than others. AFRL has repeated the test & found that the fuel color is similar with those of other samples.)

Discussion on Apple Jelly Formation – Mass Loss (3)

	Mass/Before (g)	Mass/After (g)	Loss (g)	Loss (%)
Jet-A (ACY)	8.023	5.4259	2.6062	32.48
RR A	8.091	5.4930	2.5980	32.11
RR C	8.086	5.3023	2.7837	34.43
RR D	8.080	5.2256	2.8544	35.33
RR E	8.097	5.4218	2.6752	33.04
RR F	8.099	5.4786	2.6204	32.35

- ❖ When a fuel sample is volatile, the mass loss% can be high after aging.
- ❖ When it is contaminated with heavy Apple Jelly or others, the loss% will be low.
- ❖ The mass loss percents for the five (5) Rolls Royce fuels after 13 hours' aging at 165 ^{o}C & 1 atm are higher or similar to that of Jet-A (ACY) fuel, indicating the fuels do not have heavy Apple Jelly contaminants.
- ❖ The data for the Jet-A (ACY) fuel is the average of two samples.

Discussion on Apple Jelly Formation – Water Content (4)

	1st Test (ppm)	2nd Test (ppm)	Average (ppm)
Jet-A (ACY)	67.80	60.20	64.00 (Two samples)
RR A	76.27	79.36	77.82
RR C	54.11	63.60	58.86
RR D	55.57	48.82	52.20
RR E	79.25	71.64	75.45
RR F	73.92	71.75	72.84

- ❖ The water contents for five (5) Rolls Royce and two (2) Jet-A (ACY) samples after 13 hours' aging at 165 ^{o}C & 1 atm are still at ppm levels.
- ❖ No significant water content increases have been observed.
- ❖ This result indicates that fuel's apple jelly formation may not require water participation, instead, the apple jelly in a fuel is mainly resulted from its oxidation (aging).

Discussion on Apple Jelly Formation – Density Increase (5)

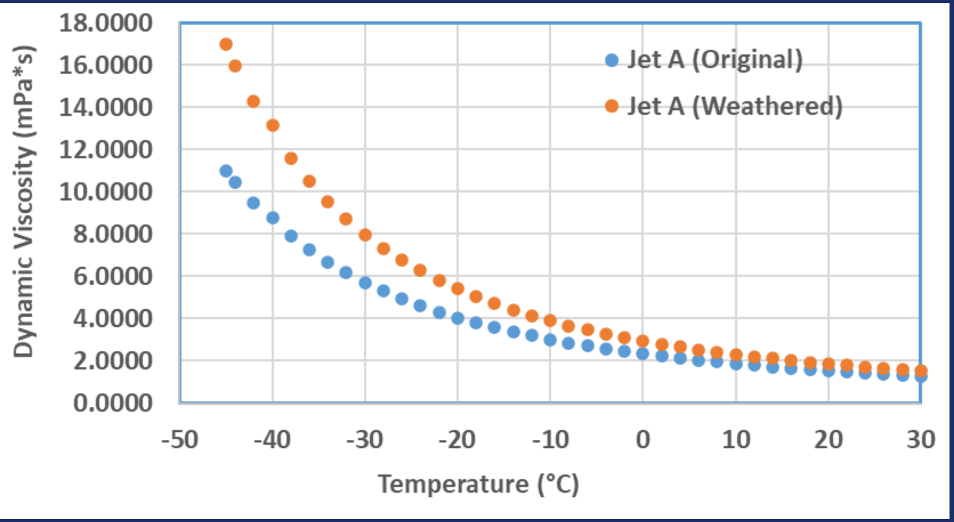
The density of all six (6) Jet-A fuel samples after aging is still following the linear relationship with the fuel temperature (°C) with $R^2 = 1.0000$:

Fuel Density (g/mL) = 0.0007*Temp(°C) + Fuel Density (g/mL) at 0.0 °C

After aging at 165 °C for 13 hours, the densities at 0.0 °C for six (6) Jet-A fuels are slightly higher than those of the original samples with density gained less than 1.8%. Compared to Jet-A (ACY) fuel, RR fuels show higher density increase.

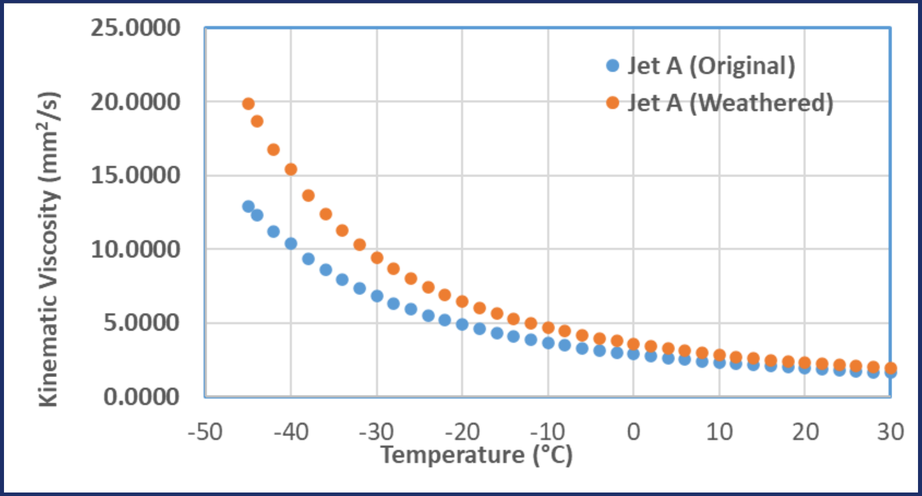
Jet-A Sample	Fuel Density @ 0.0 °C (Original Fuel)	Fuel Density @ 0.0 °C (Aged Fuel)	Density Gained (%)
ACY	0.8166	0.8232	0.8082
RR A	0.8234	0.8349	1.3966
RR B	N/A	N/A	N/A
RR C	0.8228	0.8347	1.4463
RR D	0.8224	0.8343	1.4470
RR E	0.8241	0.8365	1.5047
RR F	0.8224	0.8365	1.7145

Discussion on Apple Jelly Formation – Dynamic & Kinematic Viscosity Increase (6)

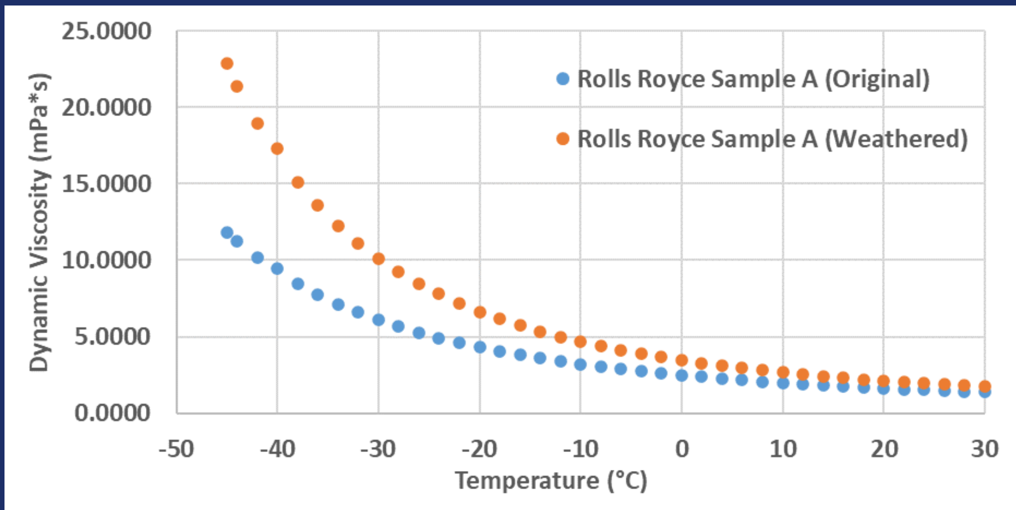


After aging at 165 °C & 1 atm for 13 hours, dynamic viscosity for Jet-A (ACY) significantly increases in comparison with original fuel (Left Figure).

The kinematic viscosity increase in comparison with that of original fuel indicates the formation of apple jelly or fuel gum in the fuel (Right Figure).

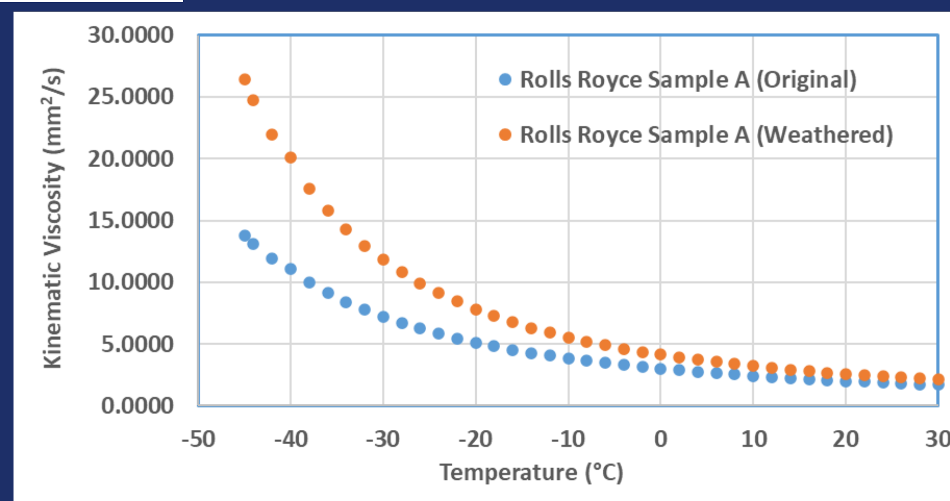


Discussion on Apple Jelly Formation – Dynamitic/Kinematic Viscosity Increase for RR Jet-A A Fuel (7)

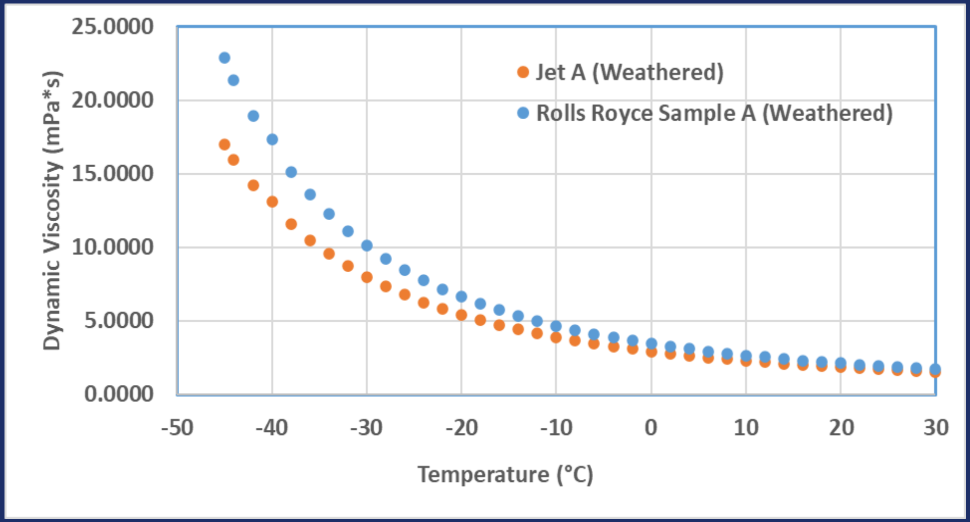


After aging at 165 °C for 13 hours, both dynamic and kinematic viscosities for RR Jet-A A fuel significantly increase.

The viscosity increase for aged RR A fuel in comparison with that of original fuel indicates the formation of apply jelly or fuel gum in the fuel.

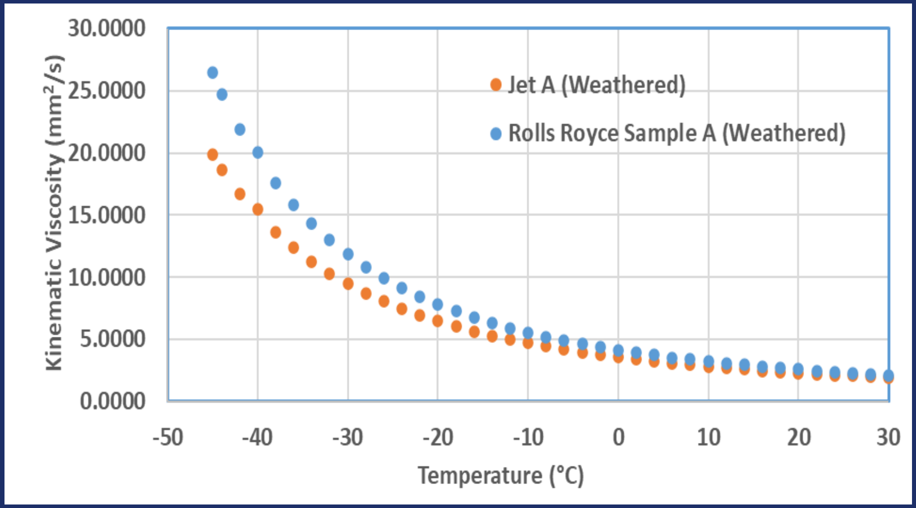


Discussion on Apple Jelly Formation – Comparison of Viscosity Increase for aged ACY & RR A Fuels (8)

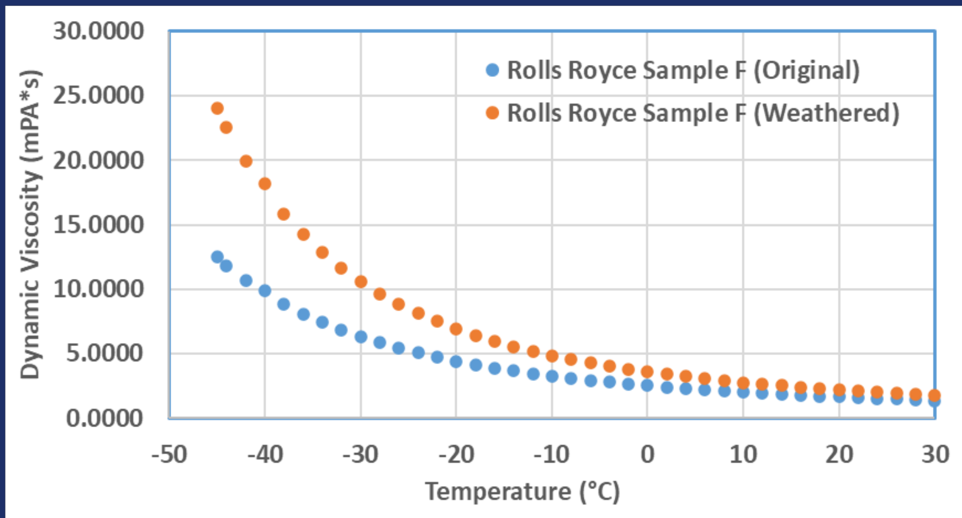


The dynamic viscosity for aged RR Jet-A A fuel is higher than those for Jet-A (ACY) fuel at a given T as RR A original sample contain more oxidation products.

The kinematic viscosity increase with temp. for aged RR Jet-A A fuel is more significant than that for aged Jet-A (ACY) fuel, indicating more apply jelly/fuel gums formed in RR Jet-A A fuel.

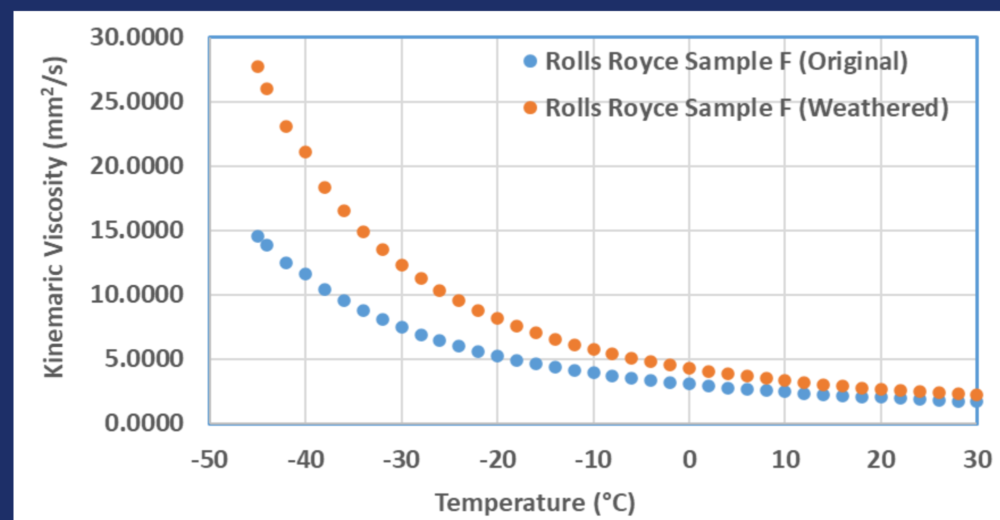


Discussion on Apple Jelly Formation – Dynamic/Kinematic Viscosity Increase for RR Jet-A F Fuel (9)

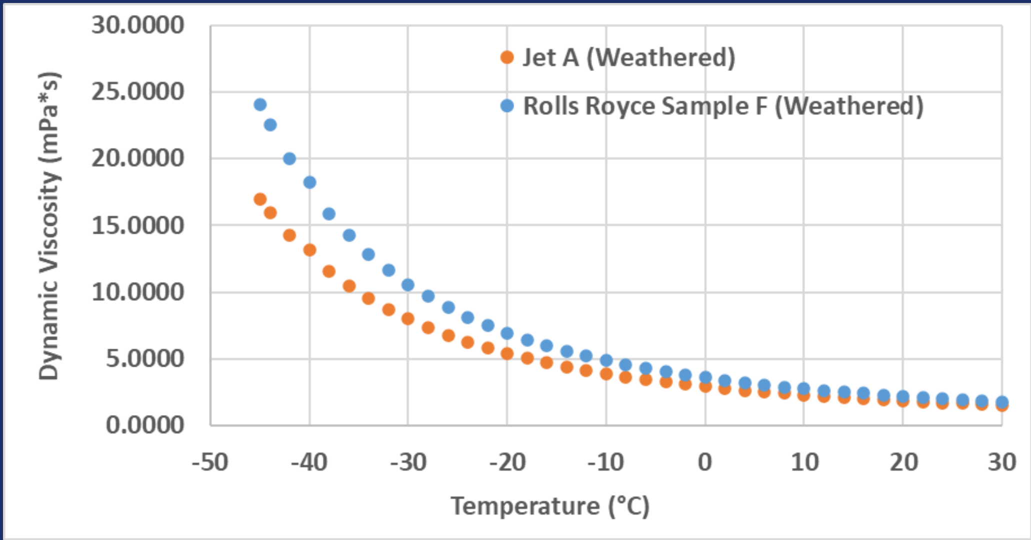


After aging at 165 ^{o}C & 1 atm for 13 hours, both dynamic and kinematic viscosities for RR Jet-A F fuel significantly increase.

The viscosity increase for aged RR Jet-A F fuel in comparison with that of original fuel indicates the formation of apply jelly or fuel gum in the fuel.

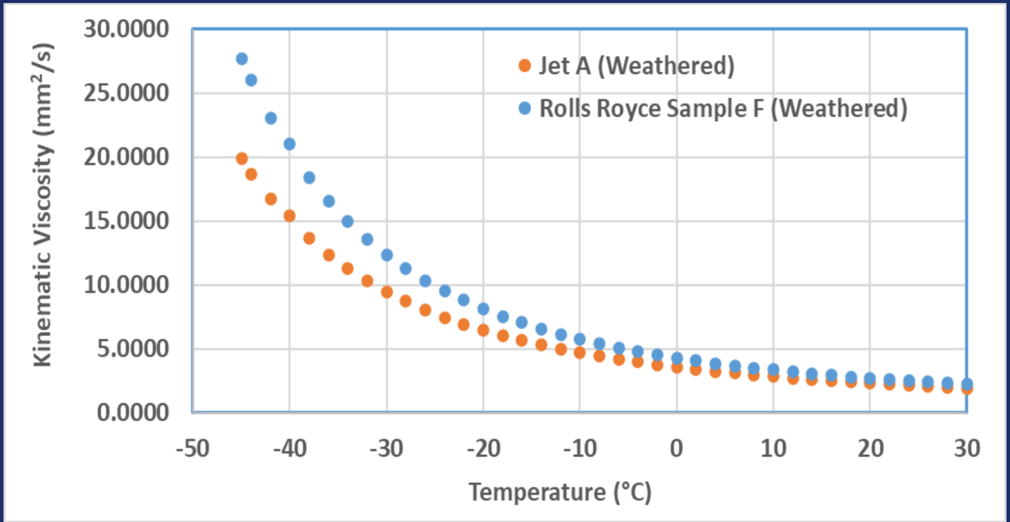


Discussion on Apple Jelly Formation – Comparison of Dynamic Viscosity Increase for ACY & RR F Fuels (10)



The dynamic viscosities for aged RR Jet-A F fuel are higher than those for Jet-A (ACY) fuel at a given T as RR F original sample contain more oxidation products.

The kinematic viscosity increase with temp. for aged RR Jet-A F fuel is more significant than that for aged Jet-A (ACY) fuel indicating more apple jelly or fuel gum were formed in the fuel.



Discussion on Apple Jelly Formation – Summary (11)

1. Apple Jelly in a Jet-A fuel sample can form from contamination in a fuel system as well as from the fuel's aging/oxidation.
2. Apple Jelly formation during Jet-A fuel oxidation requires elevated temperature & prolonged time. At room temperature, apple jelly formation requires much longer time than at higher temperatures.
3. Aged Jet-A fuels have a darker color & higher viscosities in comparison with original fuels.
4. The water contents in aged Jet-A fuels do not significantly increase in comparison with original fuels.
5. Aged Jet-A fuels formed brown colored precipitates in all fuel samples. Those particles may be heavy polycyclic aromatic hydrocarbons (PAHs). ("Development of a practical reaction model of polycyclic aromatic hydrocarbon (PAH) formation and oxidation for diesel surrogate fuel", *Fuel*, vol. 267, May 01, 2020, 117159.)

Conclusions of the DEF & Apple Jelly in Jet-A Fuels

1. No significant (greater than ppm levels) Diesel Exhaust Fluid (DEF) contamination has been detected for Rolls Royce Jet-A fuel samples.
2. Rolls Royce Jet-A fuels contain higher existent gums than that in a fresh Jet-A fuel as RR Jet-A fuels have been aged for more than eight (8) months.
3. No significant Apple Jelly contamination has been identified for Rolls Royce fuel samples.
4. Experimental results have indicated that Apple Jelly in a Jet-A fuel can be formed during fuel aging at elevated temperature under ambient pressure.
5. Apple Jelly contaminated Jet-A fuels exhibit higher density & dynamic/kinematic viscosities in comparison with original Jet-A fuel.

Recommendations

1. Detailed chromatographic analyses including GC/MS & GCxGC/MS are highly recommended for the characterizations of DEF & Apple Jelly contamination.
2. More volume (at least 300 mL) of Rolls Royce Jet-A B sample is recommended for the analyses of Apple Jelly contamination for this fuel sample.
3. To eliminate the influence of existent gum with Apple Jelly contamination fresh sample is needed for future testing.
4. Scan Electron Microscope (SEM) or ICP (Inductively Coupled Plasma) Spectroscopy can be used to identify the solid precipitates of Apple Jelly contaminated fuel samples.
5. More detailed testing & analyses are needed for us to better understand Jet-A fuel Apple Jelly contamination & formation mechanisms.
6. Fuel distillation & potential gum tests are highly recommended for us to understand the fuel vaporization behavior & the resistance for apple jelly formation when there are more volumes of samples available.

References

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