World Jet Fuel Survey
Project 090

Lead investigator: Zachary West, University of Dayton
Project manager: Ana Gabrielian, FAA

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Alexandria, VA

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University of Dayton

University of Dayton Research Institute

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World Jet Fuel Survey (WJFS)

University of Dayton Research Institute

PI: Zachary West

PM: Ana Gabrielian

Cost Share Partners: Global Bioenergies, ASG, Marathon, Boeing, Shell, IHI, Neste, GE Aviation, NRC Canada, LanzaTech, and University of Dayton

Objective:
- Coordinate a worldwide survey of current aviation turbine fuels to support the development of a jet fuel technical property database

Project Benefits:
- Allow faster, data driven decisions regarding safety and operability of alternative fuels
  - Provide a snapshot of physicochemical and performance properties of current jet fuels on the world market
  - Establish a baseline of fuel properties for comparison to candidate synthetic fuels
- Become a reference benchmark of property data for designers, operators, producers, researchers, and other fuel practitioners

Research Approach:
- Procure fuel samples from diverse, global production locations
- Coordinate and conduct fuel sample testing and evaluation
  - Specification and fit-for-purpose testing
- Manage data collection and distribution
- Anonymize samples
- Publish results regularly/annually through partnerships with the Coordinating Research Council (CRC) and the Volpe Center
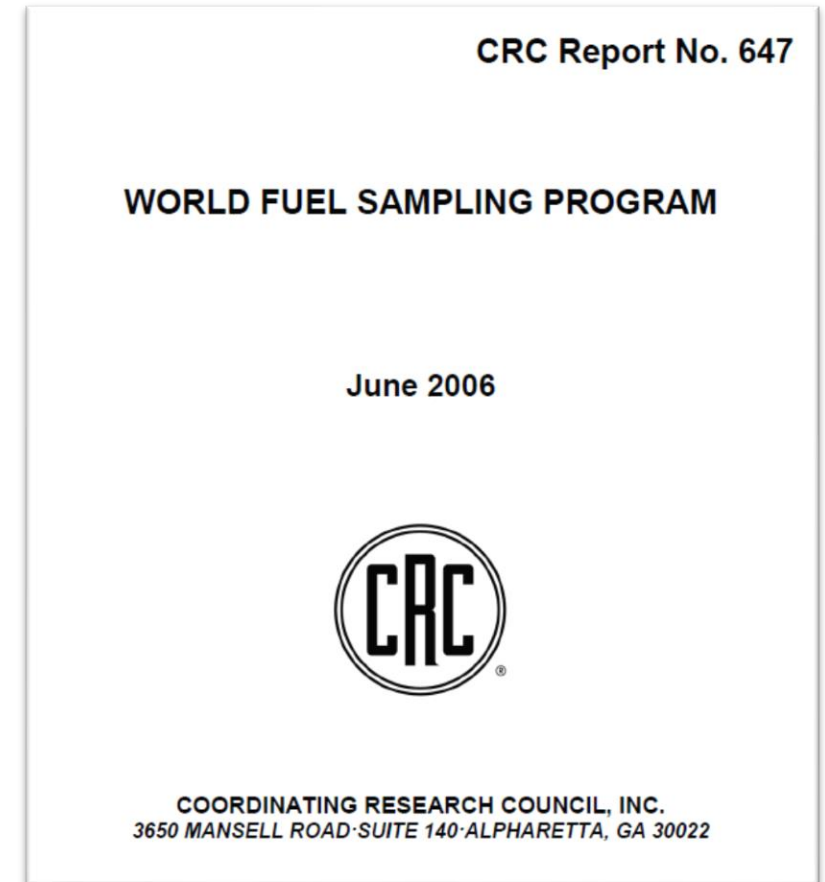
Major Accomplishments (to date):
- Presented preliminary findings:
  - FAA/ASTM Original Equipment Manufacturers (OEM) panel, UK Ministry of Defence (MOD) Aviation Fuels Committee (AFC) meeting, ASTM International, IASH 2024 conference, and the Energy Institute (EI)
- Solidified partnerships with Coordinating Research Council (CRC) members and individual refiners/fuel producers
- Secured partnership with CONCAWE to procure samples from European refineries
- Received 53 samples representing over 148,000,000 US Gallons of product
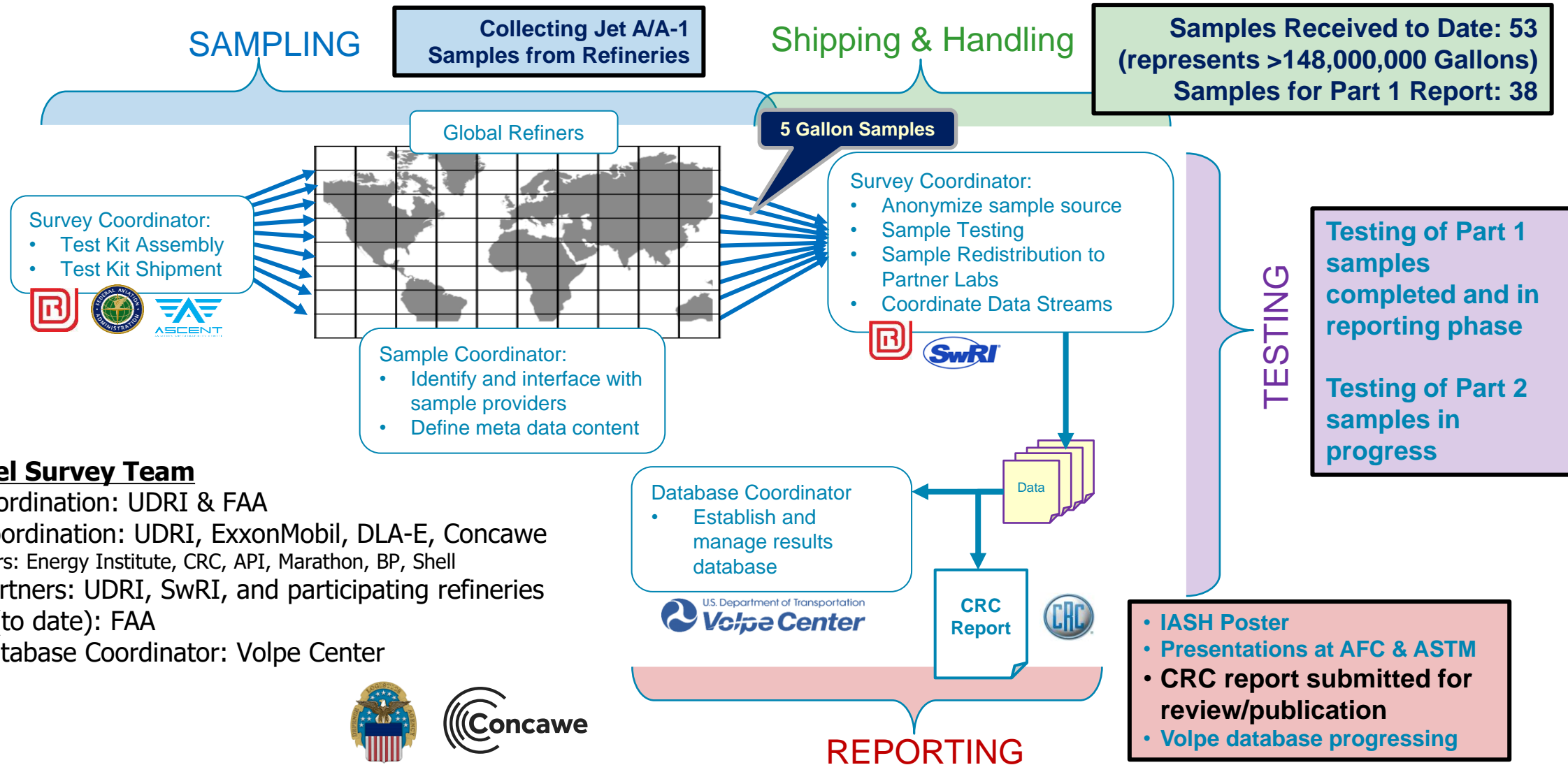
Future Work / Schedule:
- Publish 2023-2024 (part 1) data report NLT Dec 2025
- Continue to collect samples & data for 2024-2025 (part 2)

Background

- CRC World Fuel Sampling Program conducted in early 2000's
  - CRC Report No. 647, 2006

- Data relied on by industry for:
  - **ASTM D4054 Evaluation of Synthetic Aviation Turbine Fuel (SATF)—Real fuels data needed to make informed, technical decisions regarding safety and reliability**
  - Other Research or Investigations
  - Aircraft/Engine Design

- Industry needs updated survey to:
  - Expand data to include Fit-for-Purpose properties
 - Update data to reflect current trends in jet fuel properties and production methods

CRC Report No. 647

WORLD FUEL SAMPLING PROGRAM

June 2006

CRC

COORDINATING RESEARCH COUNCIL, INC.
3650 MANSELL ROAD·SUITE 140·ALPHARETTA, GA 30022

WJFS: Approach, Team, & Recent Status

SAMPLING

Collecting Jet A/A-1 Samples from Refineries

Shipping & Handling

Samples Received to Date: 53 (represents >148,000,000 Gallons) Samples for Part 1 Report: 38

Global Refiners

5 Gallon Samples

Survey Coordinator:
- Test Kit Assembly
- Test Kit Shipment

Survey Coordinator:
- Anonymize sample source
- Sample Testing
- Sample Redistribution to Partner Labs
- Coordinate Data Streams

SwRI

TESTING

Testing of Part 1 samples completed and in reporting phase

Testing of Part 2 samples in progress

Sample Coordinator:
- Identify and interface with sample providers
- Define meta data content

Data

Database Coordinator:
- Establish and manage results database

World Jet Fuel Survey Team
- Survey Coordination: UDRI & FAA
- Sample Coordination: UDRI, ExxonMobil, DLA-E, Concawe
  – Partners: Energy Institute, CRC, API, Marathon, BP, Shell
- Testing Partners: UDRI, SwRI, and participating refineries
- Sponsors (to date): FAA
- Results Database Coordinator: Volpe Center

U.S. Department of Transportation **Volpe Center**

CRC Report

- IASH Poster
- **Presentations at AFC & ASTM**
- **CRC report submitted for review/publication**
- Volpe database progressing

REPORTING

Concawe

Sample Data Collection

- Initial focus on Jet A/A-1 fuels (ASTM D1655 & DEF STAN 91-091)

- Use data from Refiner's Certificate of Quality (RCQ) document
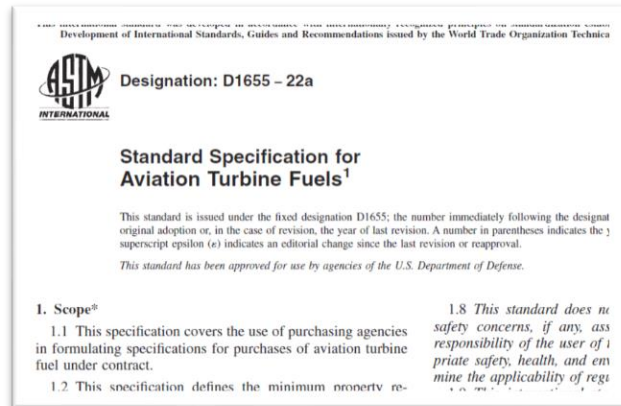
- Over 300 Fit-for-purpose data points collected via 24 test methods per sample (in addition to RCQ data)

Fit-For-Purpose Testing

Property	Test Method
COMPOSITION	
Detailed Hydrocarbon Type (GCxGC)	UDRI FCM-101
Olefins	D1319
Hydrogen Content	D3701
Polar Organics (SPE-GCxGC)	UDRI FCM-102
Total Nitrogen	D4629
Trace Metals	UDRI FCM-107
BULK PHYSICAL AND PERFORMANCE PROPERTIES	
Distillation	D86
Simulated Distillation	D2887
Thermal Stability, Breakpoint	D3241
Lubricity	D5001
Viscosity (-40 to 100°C)	D7042
Density (-40 to 100°C)	D4052
Specific Heat (-40 to 140°C)	E2716
Surface Tension (-10, 25, 40°C)	D1331
Isentropic Bulk Modulus (35 to 75°C) v. Pressure	D6793
Thermal Conductivity (0 to 50°C)	D7896
Refractive Index	D1218
Water Solubility (0 to 50°C)	D6304
Air Solubility (oxygen/nitrogen)	UDRI FCM-103
True Vapor Pressure (0 to 120°C)	D6378
Dielectric Constant vs. Density	IP 638
Autoignition Temperature	E659
Hot Surface/Manifold Ignition Temperature	ISO 20823
Derived Cetane Number (DCN)	D6890

Status

CRC REPORT AV-33-22

CRC AV-33-22—WJFS (Part 1) Report: **Status**

- Submitted report: CRC AV-33-22, *World Jet Fuel Survey Part 1: 2023-2024* to CRC for final technical reviews/approval
  - Anticipate publication by or before December 2025

- Report structure:
  - Introduction
  - Refiners Certificate of Quality Data
  - Fit-for-purpose Data
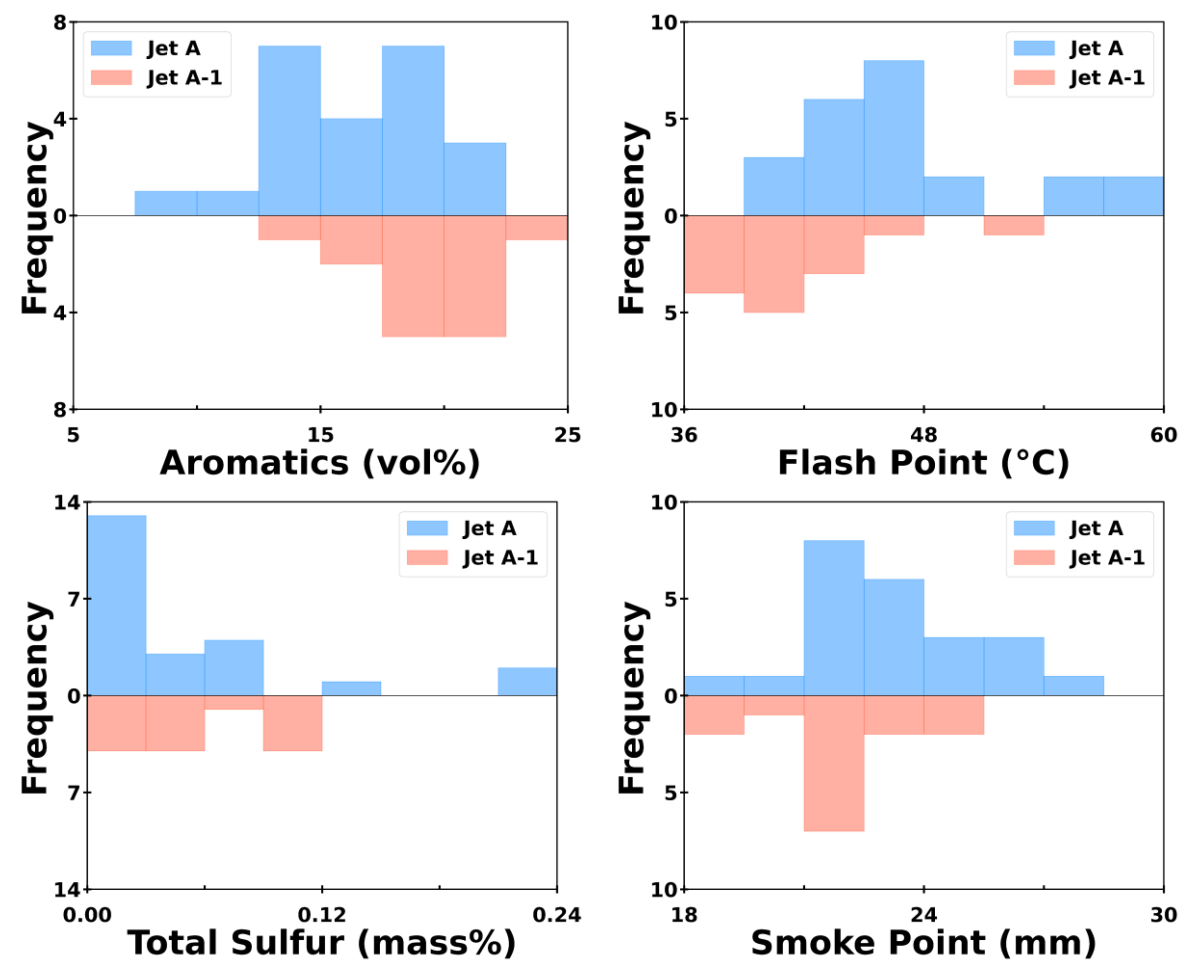 - Composition-to-property Modeling
  - References & Appendices

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- Reported by grade, e.g., Jet A and Jet A-1; tabulated statistics and histograms for comparison

Table 2. Statistics for Jet A CoA data compared to specification limits from ASTM D1655.

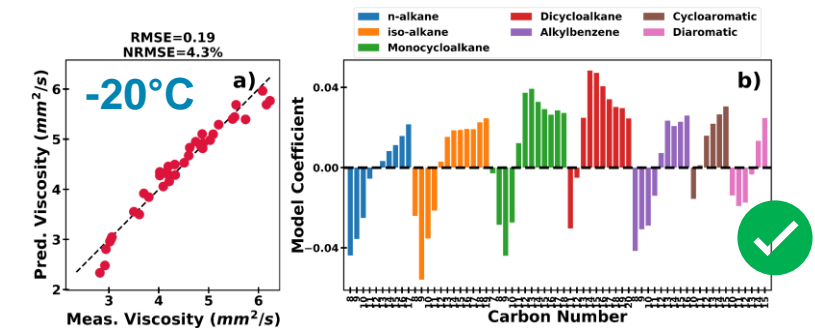| Property	Specification Limits		Jet A CoA Data				
	Min	Max	Min	Max	Mean	Weighted Mean	Count
Acidity (mg KOH/g)	N/A	0.10	0.00	0.02	0.00	0.00	23
Aromatics (vol%)	N/A	25	10	22	16	17	23
Mercaptan Sulfur (mass%)	N/A	0.003	0.000	0.003	0.001	0.001	17
Total Sulfur (mass%)	N/A	0.30	0.00	0.21	0.05	0.06	23
10 vol% Recovered (°C)	N/A	205	158	196	176	175	23
50 vol% Recovered (°C)	Report		192	220	207	208	22
90 vol% Recovered (°C)	Report		221	286	250	250	23
Final Boiling Point (°C)	N/A	300	249	330	276	276	23
Residue (%)	N/A	1.5	0.8	1.3	1.1	1.2	14
Loss (%)	N/A	1.5	0.0	1.3	0.5	0.5	14
Flash Point (°C)	38	N/A	41	58	47	45	23
Density at 15°C (kg/m^3)	775	840	793	816	805	806	15
Freezing Point (°C)	N/A	-40	-62	-40	-50	-49	23
Viscosity at -20°C (mm^2/s)	N/A	8.0	3.6	6.2	4.8	4.8	22
Net Heat of Combustion (MJ/kg)	42.8	N/A	43.0	43.5	43.2	43.2	23
Smoke Point (mm)	18.0 or 25.0	N/A	18.9	28.1	23.1	23.0	23
Naphthalenes (vol%)	N/A	3.0	0.2	2.0	1.0	1.1	23
Thermal Stability Filter Pressure Drop (mmHg)[1]	N/A	25	0	3	0	0	23
Existent Gum (mg/100 mL)	N/A	7	1	4	2	1	23
Microseparometer Rating Without Electrical Conductivity Additive	85	N/A	99	99	99	99	1
Microseparometer Rating With Electrical Conductivity Additive	70	N/A	94	100	98	98	21
Electrical Conductivity (pS/m)[2]	50	600	0	292	87	24	10

- Comparisons by survey (when available); tabulated, split violin, histogram, & box plots

- 10 new/updated FFP property data collected

- Models trained using partial least squares (PLS) regression
  - Demonstrate a quantitative composition-property relationship (QCPR)

- Identify correlations between properties and composition
  - Good model performance → model coefficients provide insight into fuel chemistry
  - Poor model performance → experimental method development and/or more advanced modeling techniques are required
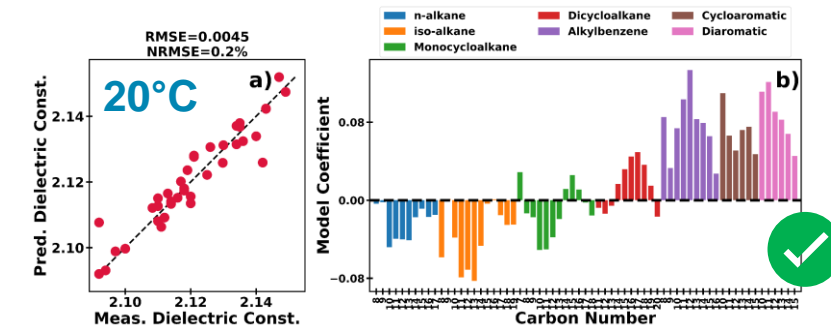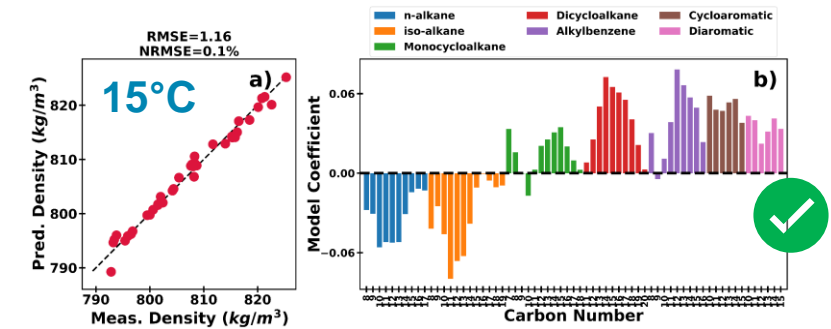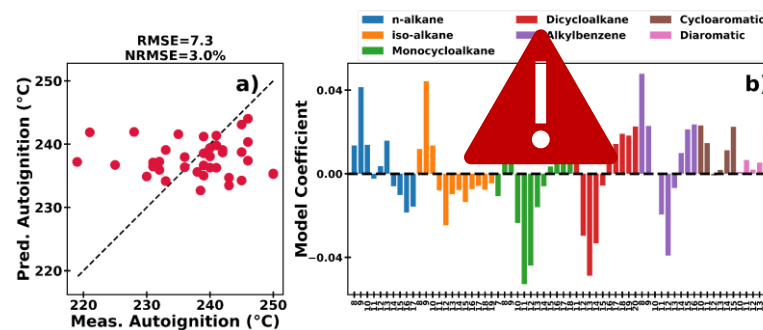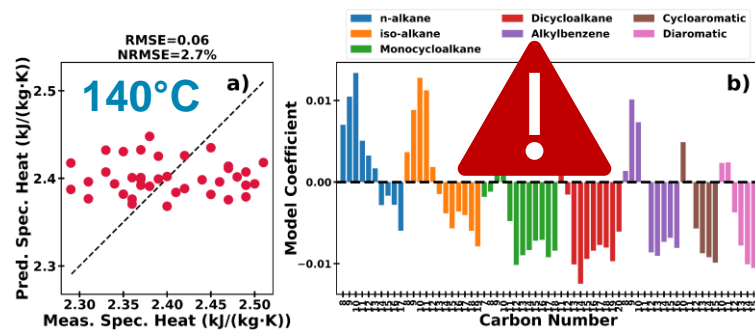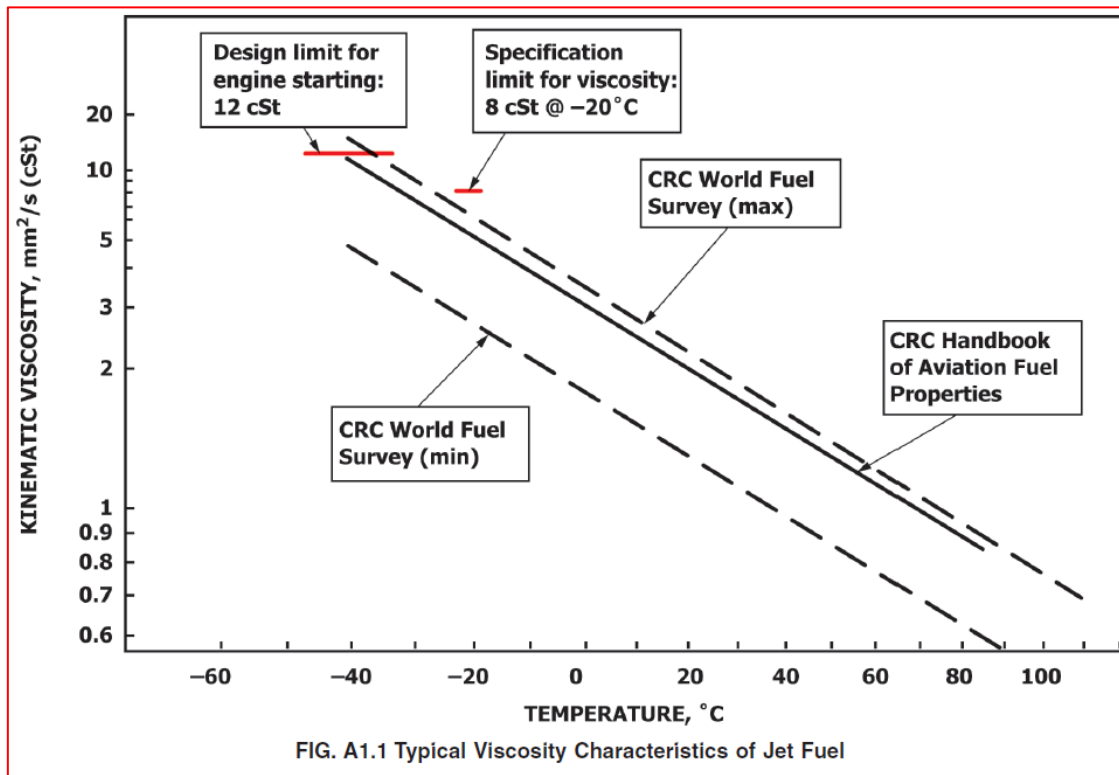
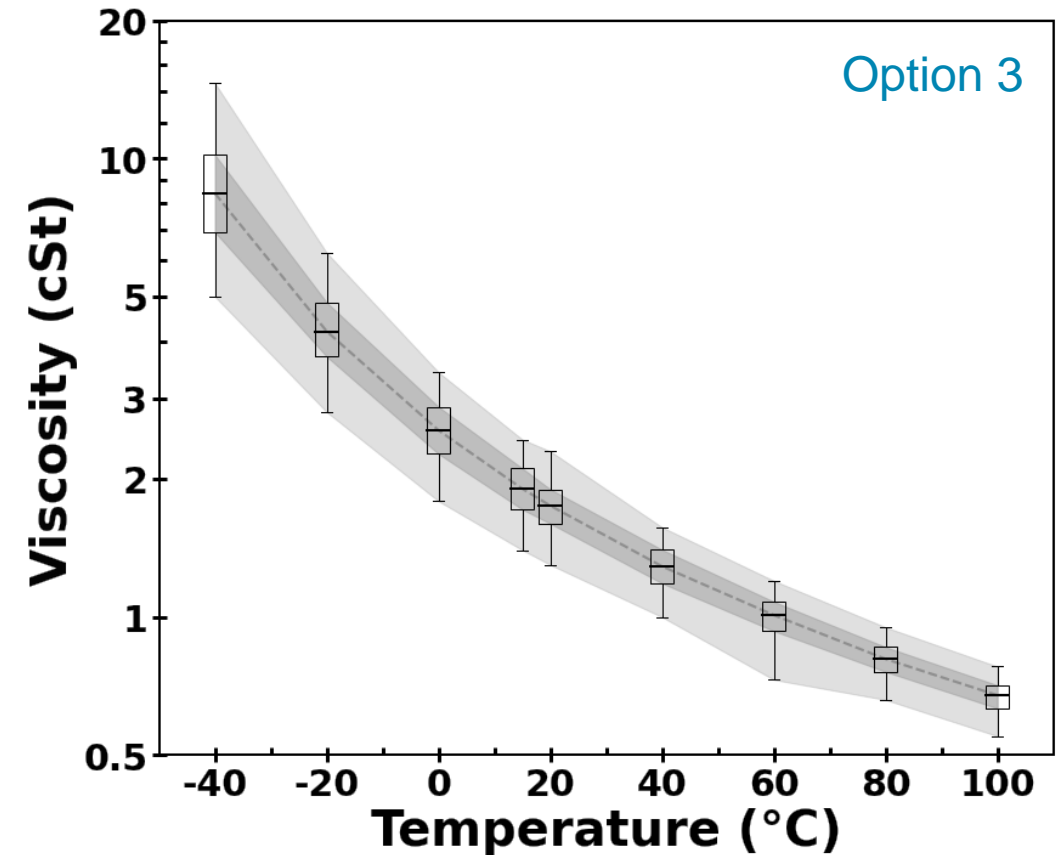Updated ASTM D4054 "Basis of Experience"

CONTRIBUTION TO INDUSTRY

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Contribution to Industry: Update "Basis of Experience" (Viscosity)

Current Figure in ASTM D4054

FIG. A1.1 Typical Viscosity Characteristics of Jet Fuel
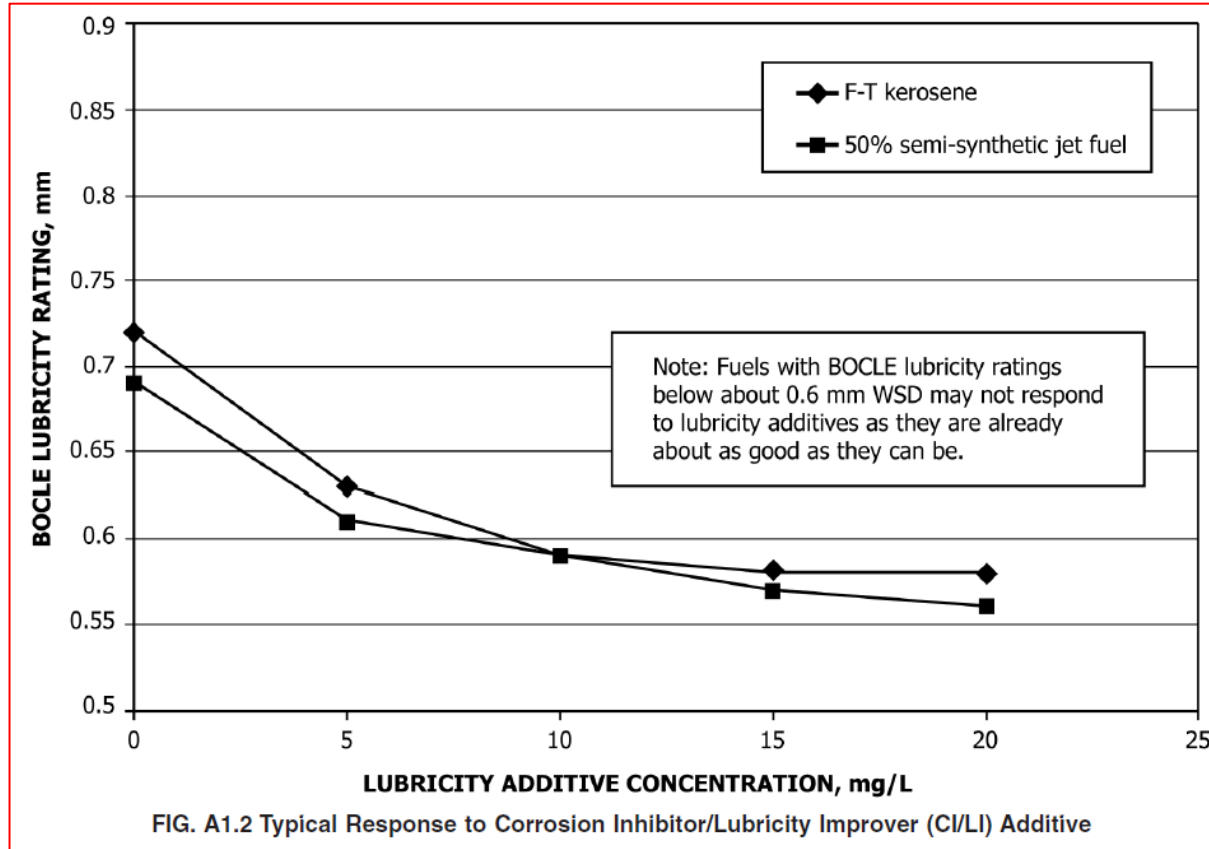
Proposed Update

Option 3

- Replaced CRC Report 647 (2006) max/min and CRC Handbook (nominal) values with statistical distribution from combined CRC Report 647 (2006) AND CRC AV-33-22 (2025) surveys

- CRC Report 647 only reported viscosity at -40, -20, and 20°C; CRC AV-33-22 reports at -40, -20, 0, 15, 20, 40, 60, 80, and 100 °C
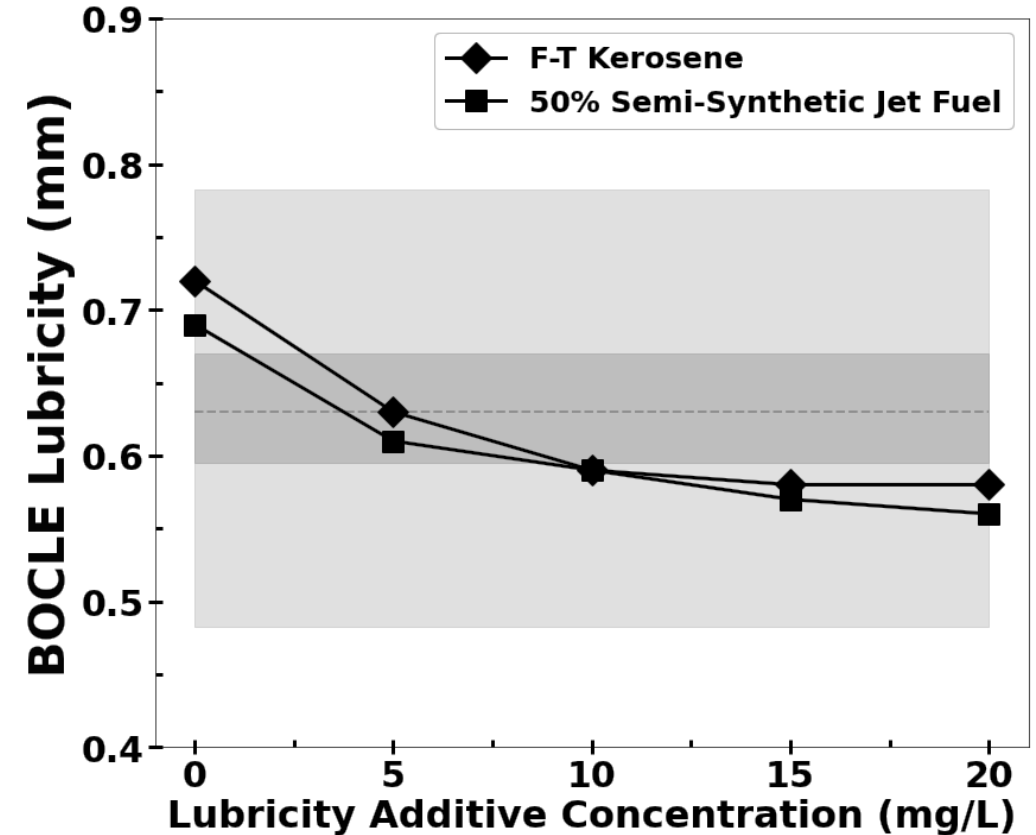
Contribution to Industry: Update "Basis of Experience" (Lubricity)

Current Figure in ASTM D4054

Proposed Update

FIG. A1.2 Typical Response to Corrosion Inhibitor/Lubricity Improver (CI/LI) Additive

- Typical response to CI/LI retained, augmented with measured lubricity range (via ASTM D5001) for fuels in both CRC Report 647 + CRC AV-33-22
  - Additive amounts in fuels measured unknown – shaded region simply demonstrating range measured for survey fuels
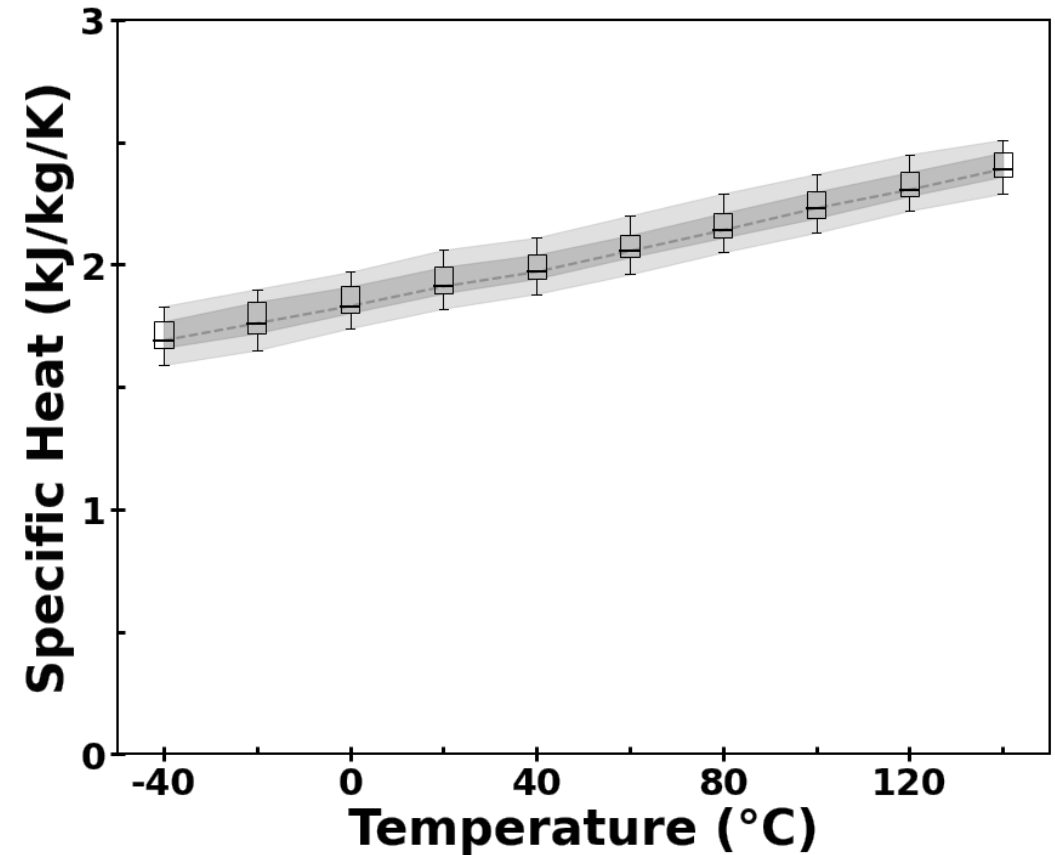
Contribution to Industry: Update "Basis of Experience" (Specific Heat)

Current Figure in ASTM D4054

FIG. A1.3 Typical Specific Heat Characteristics of Jet Fuel
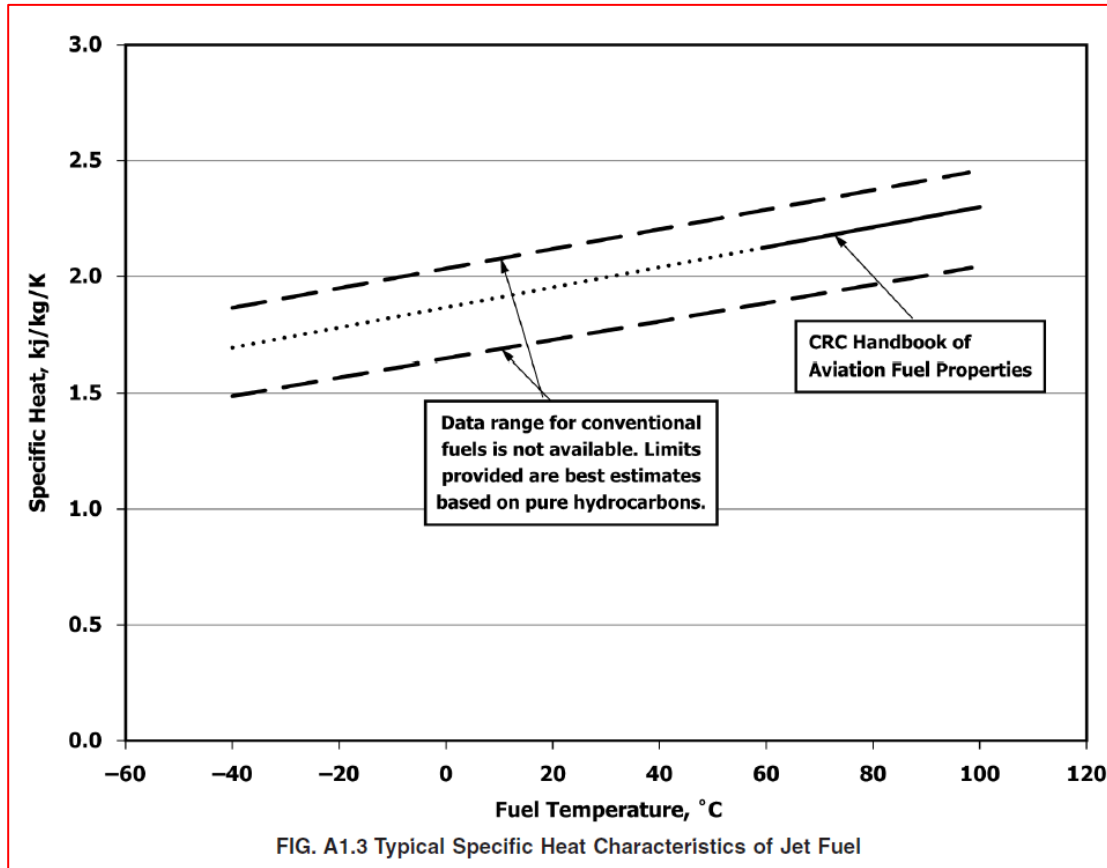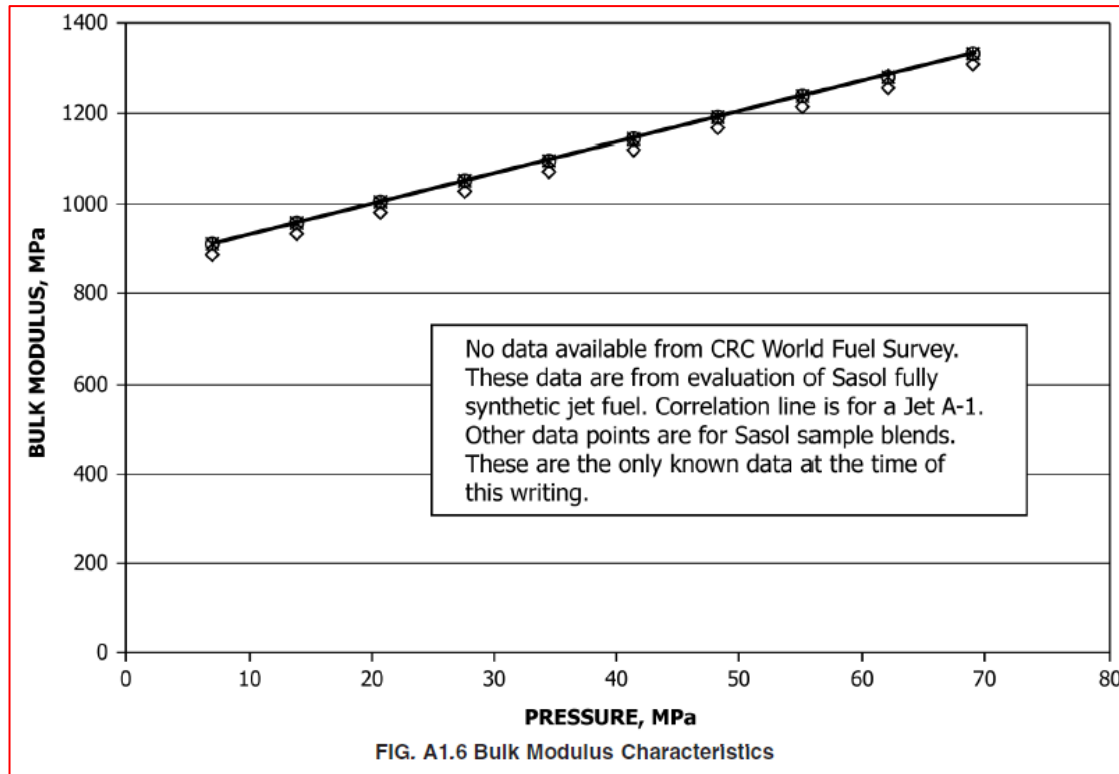
Proposed Update

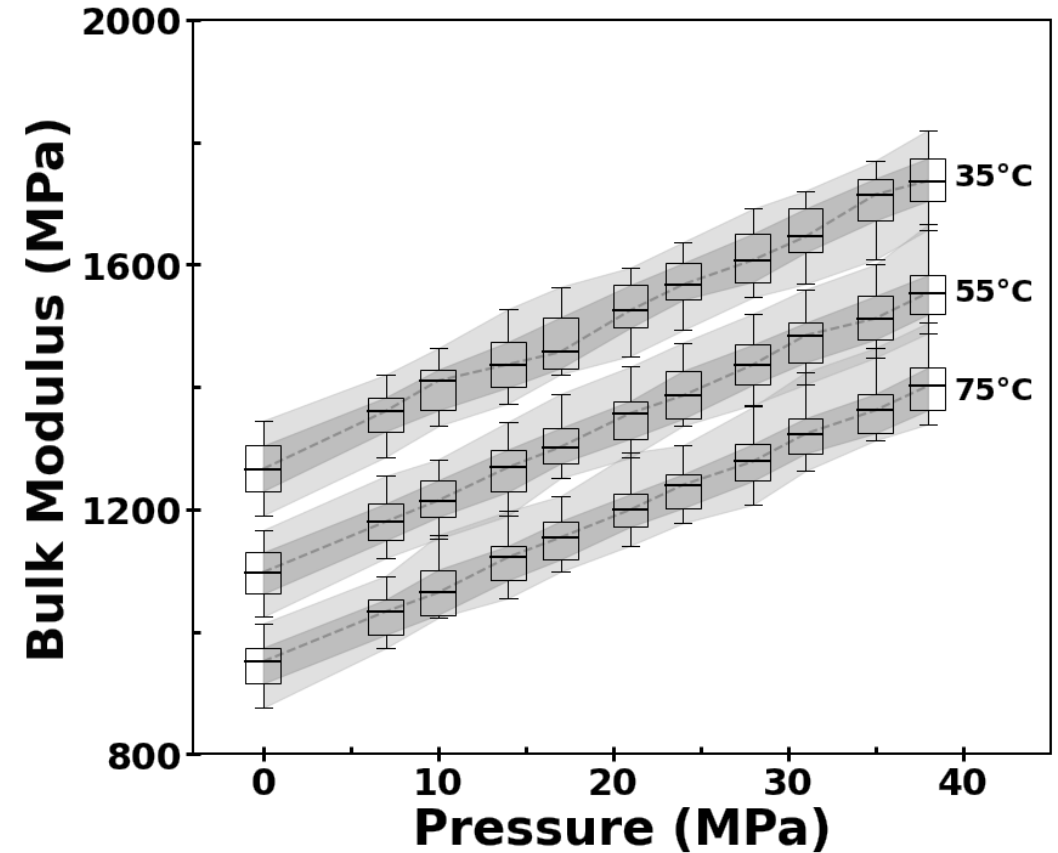- Original estimated limits (based on pure hydrocarbons) replaced by measurements; however, ranges are very similar!

Contribution to Industry: Update "Basis of Experience" (Bulk Modulus)

Current Figure in ASTM D4054

No data available from CRC World Fuel Survey. These data are from evaluation of Sasol fully synthetic jet fuel. Correlation line is for a Jet A-1. Other data points are for Sasol sample blends. These are the only known data at the time of this writing.

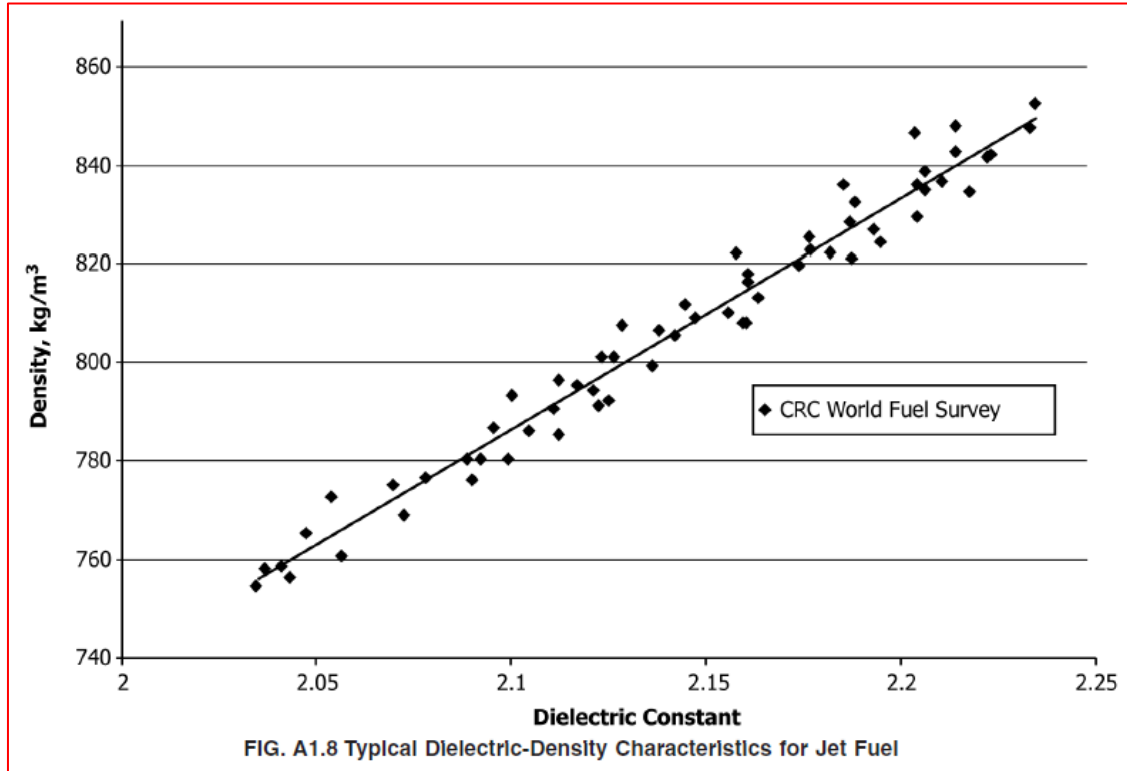FIG. A1.6 Bulk Modulus Characteristics

Proposed Update

- Large increase in data availability since original publication of D4054 Annex A1
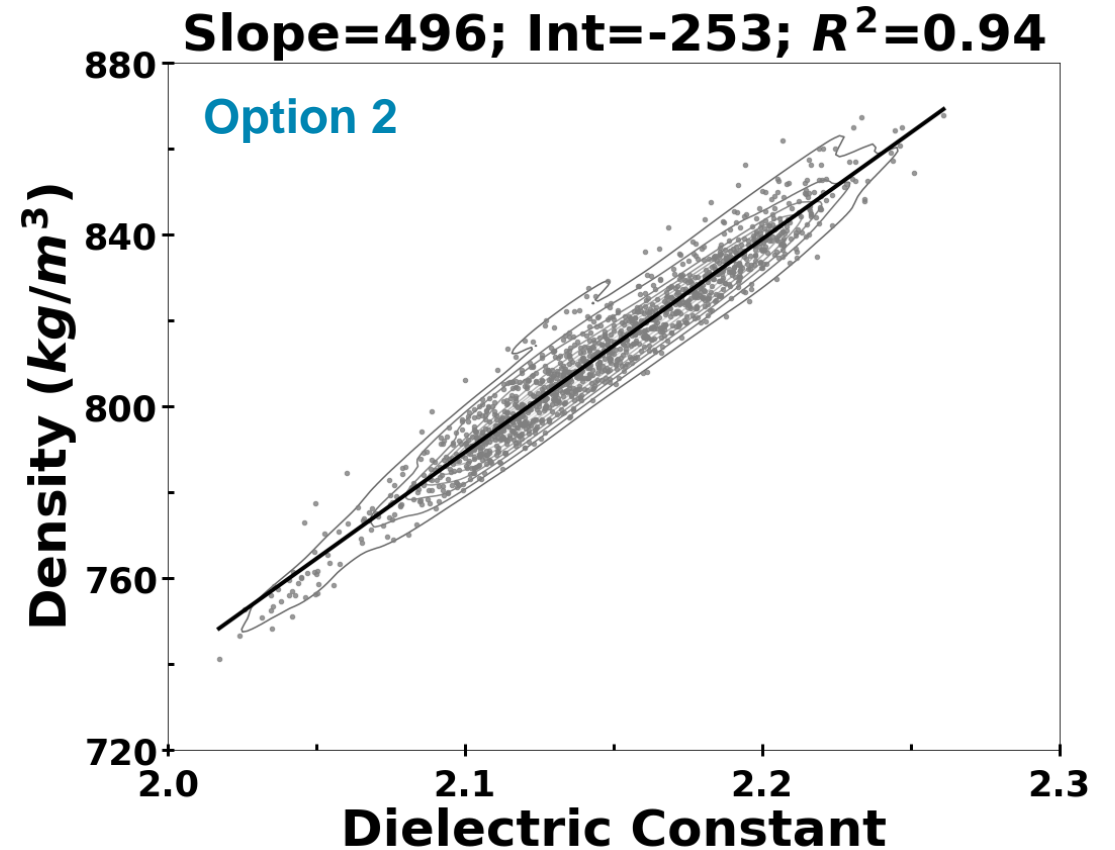
- Included temperature dependence

Contribution to Industry: Update "Basis of Experience" (Dielectric Constant)

Current Figure in ASTM D4054

FIG. A1.8 Typical Dielectric-Density Characteristics for Jet Fuel

Proposed Update

Slope=496; Int=-253; R^2=0.94

Option 2

- Option 1: data only from CRC AV-33-22 (temperature range 10 to 30°C, probability density between 5-100%)

- Option 2: data from ARINC 611 (-46 to 26°C), CRC Report 647 (-39 to 71°C), and CRC AV-33-22 (10 to 30°C)

Summary

- Summary statement
  - First tranche of data is incipient

- Next steps?
  - Update ASTM D4054
  - Continue with fuel/data collection (increase knowledge base to improve understanding of nominal & extremes)

- Future direction
  - What would you like the Advisory Board to help you with or provide comment on?
    - How should we best display/use this data going forward?
    - Would it be worthwhile to expand survey SBCs on the market?

Acknowledgements

- FAA AEE for sponsorship—E. Anders C., Ana G., Anna O., et al.

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- Volpe Center for Database Development—Jeff Cegan, Kristin Lewis, Kirby Ledvina, Mindy Liu

- Southwest Research Institute—Valerie Rios

Participants

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FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

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