Database Capture of Jet Fuel Properties

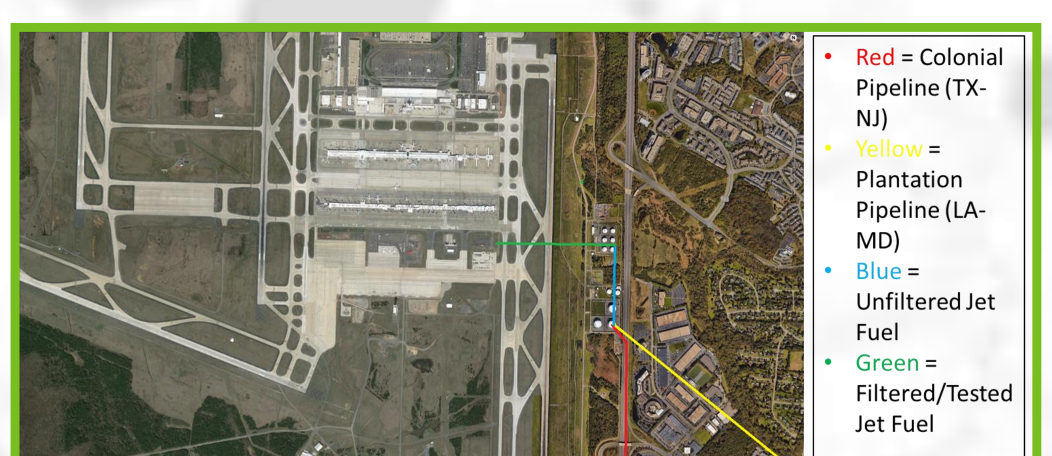
Motivation and Objectives

- Precursor project (Advanced Jet Fuel Quality Performance Control Research & Development Study) focused on developing a jet fuel properties database as part of a study on alternative aviation fuels.
  - Supported by FAA CLEEN, the John A. Volpe National Transportation Systems Center, and the Commercial Aviation Alternative Fuels Initiative (CAAFI).
- After completion of precursor project, further development and refinement of the jet fuel properties database was requested by FAA CLEEN. **Primary goals have been to:**
  - Strengthen fuel quality control processes via better tracking of key fuel properties.
  - Analyze significant differences in fuel properties between airports.
  - Support the planned introduction of alternative fuels into the current fuel distribution system by ensuring that fuel consistently meets ASTM D1655 specification.
- Consulted with Defense Logistics Agency (DLA) to learn of their experience in creating, modifying, and maintaining their Petroleum Quality Information System (PQIS) database that tracks jet fuel properties across the world.
  - PQIS tracks and analyzes many of the same properties tracked by ASTM D-1655 (DoD approved) and DEFSTAN 91-91 (UK specification).
  - We adopted the DLA's Petroleum Administration of Defense Districts (PADDs) as a standard location descriptor to use to group airports by geographic region for analytical and other purposes.

Current set of airports for which COAs are received

Methods and Materials

- Once background research described above was underway, we began requesting COAs from participating airports/fuel farms/labs.
- Initially received COAs from eight airports, and the list has grown over time.
  - Central U.S. airports are underrepresented by the current set, while coastal airports are overrepresented.
  - Primarily received initial COAs from Swissport and Inspectorate, with other labs (Nobil, ASIG, etc.) providing data later in the process.
- Initial research approach focused on understanding the current fuel distribution system and where the data that is being received fits within that distribution system. This consisted of strengthening three primary areas of understanding:
  - The jet fuel transportation system itself, from the refinery to the wing of the aircraft.
  - Specifications, regulations, and procedures associated with jet fuel transportation and distribution.
  - The Certificate of Analysis (COA) documentation that accompanies each shipment of jet fuel downstream of the refinery.
- Subsequent research centered on understanding the specifications associated with fuel receipts and fuel servicing, including any potential regulatory requirements, fuel testing procedures and quality control best practices.
  - ATA-103 is the primary U.S. industry specification addressing jet fuel quality control practices.
  - NFPA-407 is the National Fire Protection Association's standard for aircraft fuel servicing.
  - ASTM D-1655 is the primary industry specification addressing fuel testing procedures.
- As we had previously received COAs for the precursor project, we were familiar with the various formats and structures of COAs across the country. However, where we had previously been simply capturing the data from the COAs, we now needed to understand if the information we were receiving constituted a full ASTM D-1655 specification, and what was actually being captured (if not the full specification).
- We visited San Francisco Int'l Airport (as part of the precursor project) and the ASIG fuel farm at Washington Dulles Int'l Airport to better understand the very different fuel distribution systems feeding two large international airports.

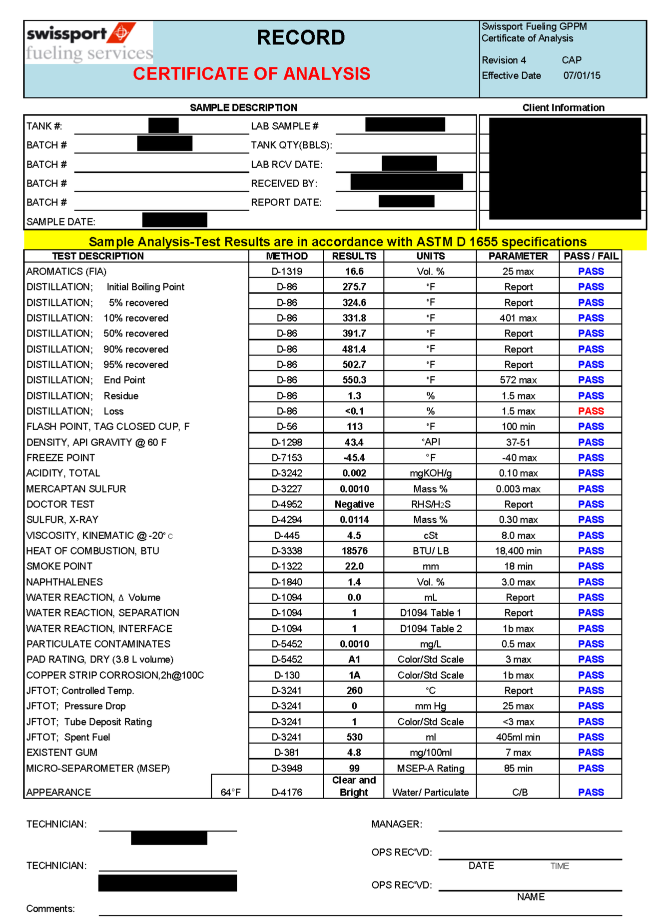


Fuel distribution system diagram – Washington Dulles Int'l Airport

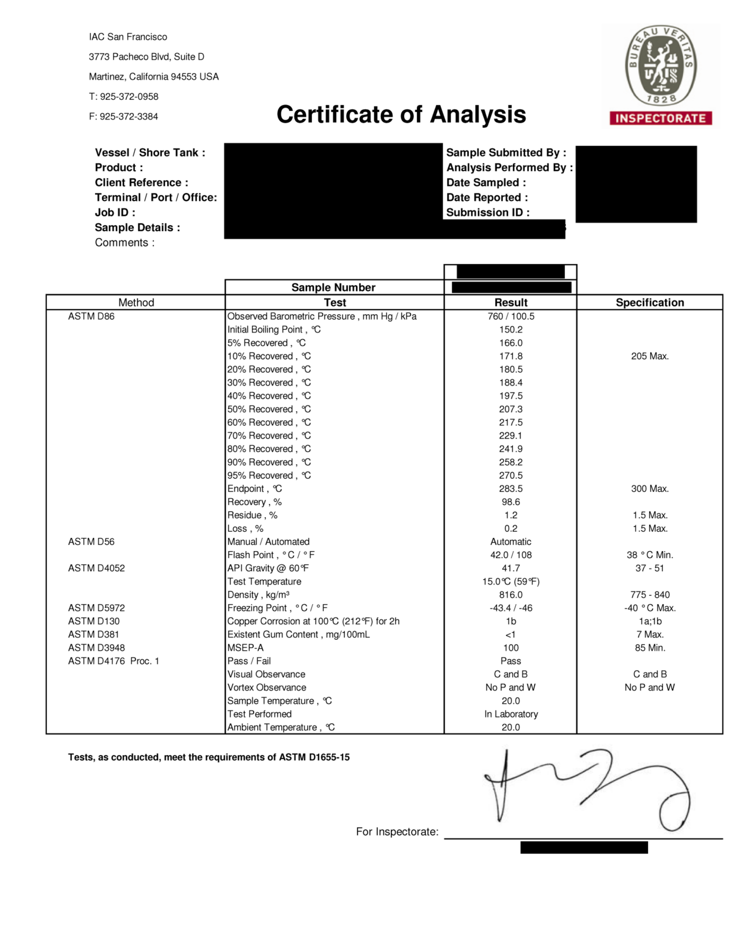
Summary

- While the ASTM D-1655 specification includes a set of required and a smaller set of optional tests, some COAs we have received do not consistently include the set of tests that comprises the full specification, due to a variety of factors:
  - ASTM D-1655 is not regulatory in the U.S. – no entity requires that tests associated with the specification are completed.
  - As a result, the fuel buyer and fuel seller decide on the specific set of tests that are required to be completed for each COA.
  - A portion of the selected tests are often not part of the D-1655 specification.
  - Some laboratories also do not possess the equipment to complete all of the tests associated with D-1655.
- COA data quality is a major issue and affects the specific set of airports for which we can capture and analyze data.
  - The majority of labs send COA data in Microsoft Excel (.xls or .xlsx) format, which is parsable and fairly easy to work with.
  - Other labs send scanned copies of COA data, which is not parsable.
- Data that is received in Microsoft Excel format is run through an extract-transform-load (ETL) process that captures the data and inserts it into the database.
- Data that is received in scanned PDF or other non-parsable formats is simply stored at this time. Some of the data is organized well enough that OCR data parsing may be a future possibility for this dataset.
- The table to the right shows COAs received as of April 1, 2016.

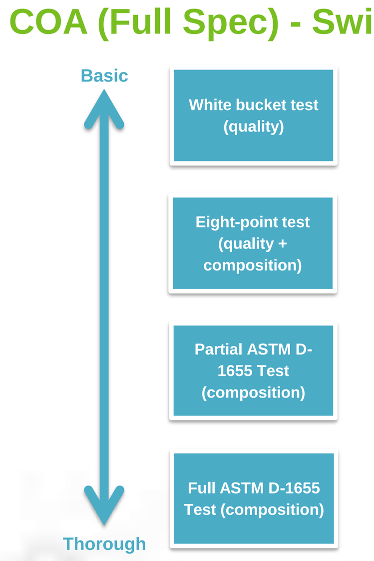
Airport	COAs received (April 1, 2016)	Full Spec?	Electronic?
BOS	74	No	No
DTW	152 (145 PDF, 7 XLS)	Yes	No
EWR	26	Yes	Yes
IAD	4	Yes	No
JFK	24	Yes	Yes
LAS	240	No	Yes
MSP	82	Yes	No
OAK	42	No	Yes
PDX	139	Yes	Yes
RNO	38	Yes	Yes
RSW	52	Yes	No
SAN	78	No	Yes
SEA	75	Yes	Yes
SFO	258	Yes	Yes
SMF	36	No	Yes



D-1655 COA (Full Spec) - Swissport



D-1655 COA (Partial Spec) - Inspectorate



Three primary types of fuel quality and composition tests done along the supply chain:

- **White bucket test** – simplest test involving checking for free water and visible contaminants by placing a sample of jet fuel in a white bucket.
- **Eight-point test** – the eight-point test is a common check done along the supply chain that includes the white bucket test and seven other specific tests that correlate tightly with fuel composition and quality.
- **ASTM D-1655 testing** – testing of a full set or subset of the tests specified under ASTM D-1655. The results of this testing are reported to the customer via COA.

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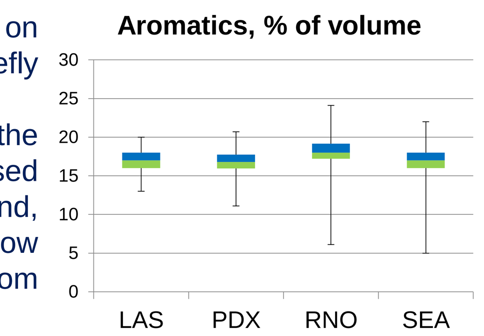
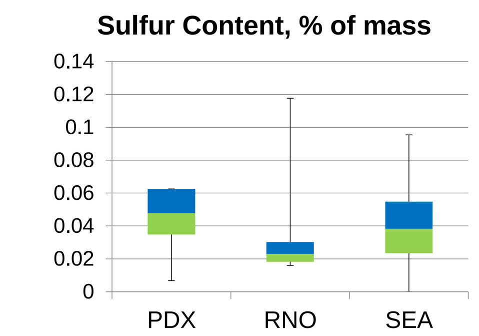
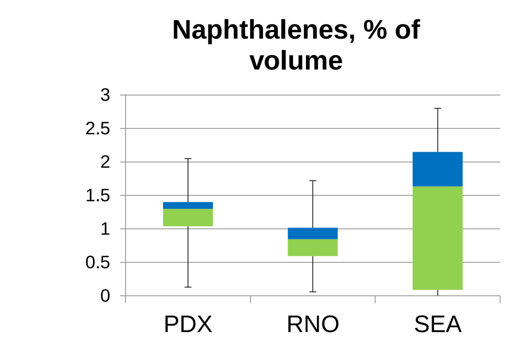
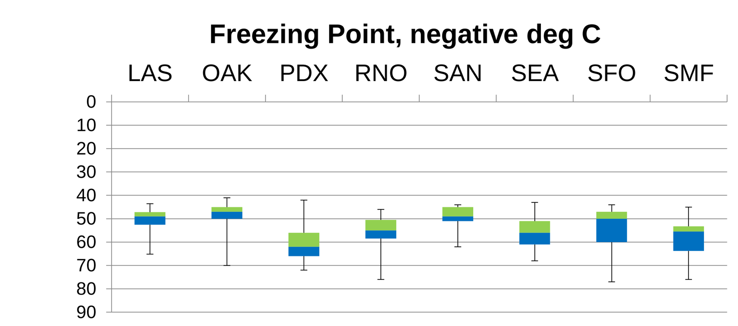
Results and Discussion

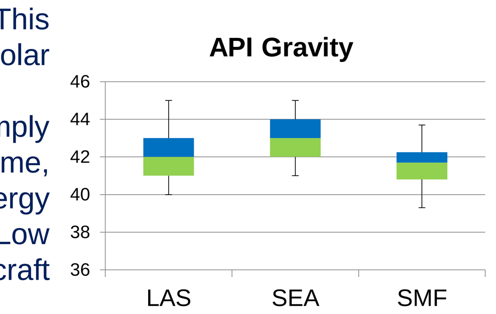
- Six specific tests of note were selected based on potential operational impact and are briefly described below:
  - **Aromatics** – these provide lubricity to the fuel and cause elastomer-based components of jet fuel system to expand, causing a desired sealing effect. Low levels of aromatics can result in leaks from those same components.
  - **Mercaptan sulfur** – these generic sulfur compounds are highly toxic, corrosive, and odoriferous and cause environmental and performance issues when present in high quantities.
  - **Sulfur content** – this metric is important because sulfur is the primary ingredient in the production of sulfur dioxide, a major human and environmental irritant and a prime component of acid rain formation.
  - **Naphthalenes** – organic, possibly carcinogenic hydrocarbon compounds that contribute to the production of soot, smoke, and thermal radiation. High naphthalene fuel does not burn cleanly and contributes to higher levels of emissions than would otherwise be expected.
  - **Freezing point** – the temperature at which jet fuel molecules begin to solidify. This property is particularly important for polar route planning purposes.
  - **Density (including API Gravity)** – simply a measure of mass per unit of fuel volume, and can be used to determine the energy density of a specific volume of jet fuel. Low fuel energy density can decrease aircraft efficiency relative to expected levels.

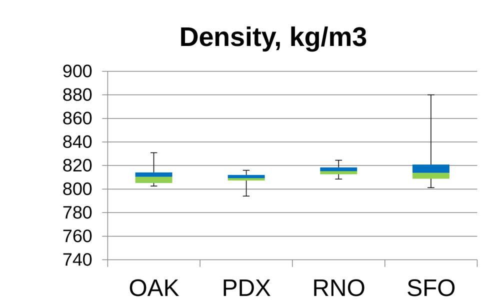






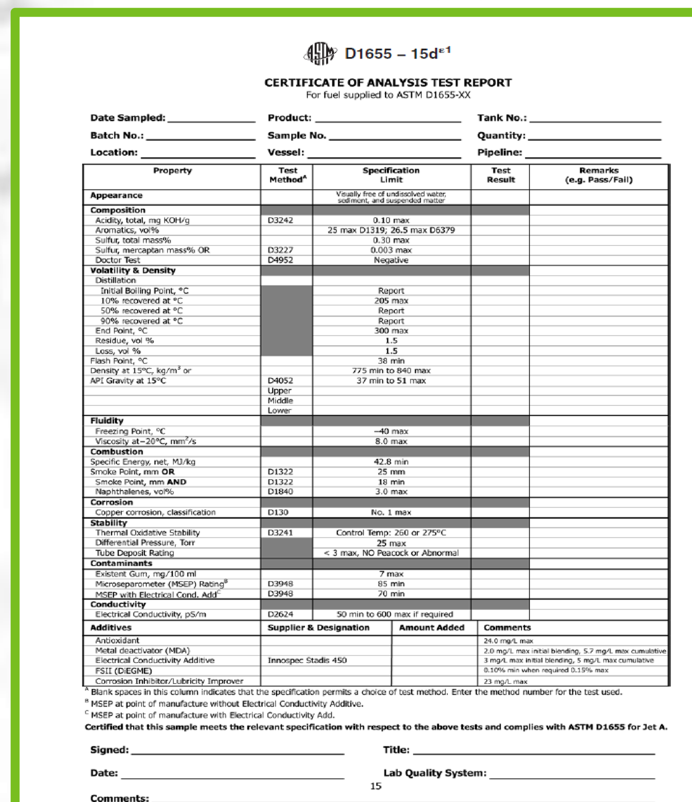






Conclusions and Next Steps

- Develop action plan to encourage COA input data standardization in conjunction with the FAA and A4A.
  - This would enable better metrics tracking and quality assurance for all stakeholders within the jet fuel distribution system.
- Continue to add data from new airports, laboratories, and fuel farms for analysis.
  - Increase the geographic distribution of collected airports (add airports in PADD 3 and PADD 4).
- Continue to refine the extract-transform-load (ETL) process.
  - Increase command-line level data validation.
  - Construct improved parsing routines for variable COA data.
- Enhance data quality metrics tracking and reporting.
- Continue to add support for new COA formats within current set of airports.
- Add optical character recognition (OCR) capability to capture data from printed PDF files for those airports for which it is feasible
- Continue to identify additional stakeholders with interest in fuel properties data.



Example of a standardized COA format – ASTM International

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