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Comparing Methods to Determine Cetane Ratings of Fuel Blends

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Report Documentation Page

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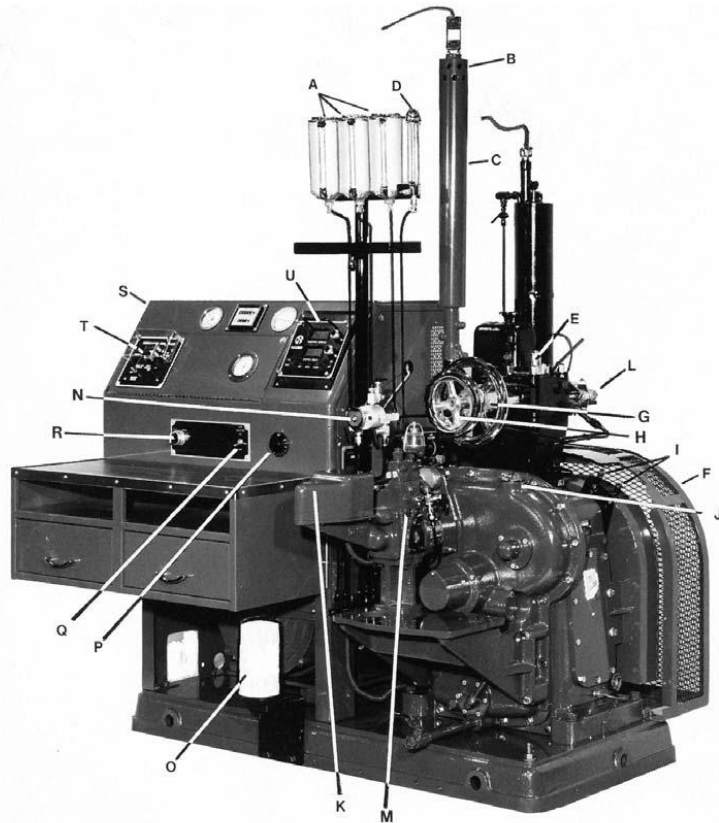
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- **Introduction**
 - What is a Cetane Rating?
 - How is it currently determined?
- **Methodology**
 - Engine method
 - Traditional laboratory method
 - Newer laboratory method
- **Comparison test**
 - Fuels used
 - Results
- **Recommendations**

- **Cetane rating is a measure of the speed at which a given fuel combusts**
 - There is a delay between the time the fuel is injected and it begins to combust; this is known as the ignition delay time
 - During this ignition delay time, the fuel will volatilize and disperse into the compressed air in the combustion chamber
 - When the conditions are “right”, the fuel will spontaneously begin to combust
 - The ignition delay time can vary from fuel to fuel depending on fuel composition, as well as engine design and operational parameters
- **“Low cetane” fuels have a long ignition delay time**
- **“High cetane” fuels have a short ignition delay time**

- **The original method to determine cetane rating uses a research engine**
 - This test is lengthy and expensive
 - It requires expert technicians to operate the engine
 - ASTM D613
- **Subsequent laboratory methods were developed to improve response time**
 - Two-variable test method
 - Uses API gravity and T_{50} temperature
 - ASTM D976
 - Four-variable test method
 - Uses density, and the T_{10} , T_{50} , and T_{90} temperatures
 - ASTM D4737



- Requires the user to adjust the compression ratio of the test engine while in operation per ASTM D613
- Uses two reference fuels as limits
- User interpolates subject fuel between the brackets
- Directly measures the Cetane Number of a diesel oil fuel

Reprinted, with permission, from D613-08 Standard Test Method for Cetane Number of Diesel Fuel Oil, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM (www.astm.org).

- **Two-variable method**

- ASTM D976
- Uses the API Gravity of the fuel along with the mid-boiling point (T_{50})
- Uses a simple calculation that has been refined over many years of petroleum-based fuel testing
- Insensitive to the addition of cetane-improving additives, pure hydrocarbons, and synthetic fuels
- Has a correlated range of 30 – 60 Cetane Number

- **Four-variable method**

- ASTM D4737
- Uses the fuel density and three boiling point temperatures (T_{10} , T_{50} , and T_{90})
- Uses a simple calculation that has been refined over many years of petroleum-based fuel testing
- Has a correlated range of 32.5 – 56.5 Cetane Number



- **Ignition Quality Tester (IQT)**
 - Automated lab test covers conventional diesel fuel, oil sands fuel, fuel blends, etc.
 - Is applicable for fuels with cetane-improving additives
 - Yields the Derived Cetane Number (DCN) per the ASTM D6890 test method

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- **Test fuels**

- Five base fuels: Biodiesel (FAME), JP-8, Synthetic Paraffinic Kerosene (SPK), GTL diesel fuel, and Ultra-Low Sulfur Diesel (ULSD)
- Blends were created
 - Various ratios of base fuels (binary blends and tertiary blends)
 - With and without cetane improver (two levels of treat rate)

- **Test fuels subjected to all four methods of cetane evaluation**

- DCN obtained from an additional laboratory as a Round Robin test

- **Results from laboratory methods compared back to research engine method results**

Research Engine method (ASTM D613) → Cetane Number

2- and 4-Variable methods (ASTM D976 and D4737) → Cetane Index

IQT method (ASTM D6890) → Derived Cetane Number



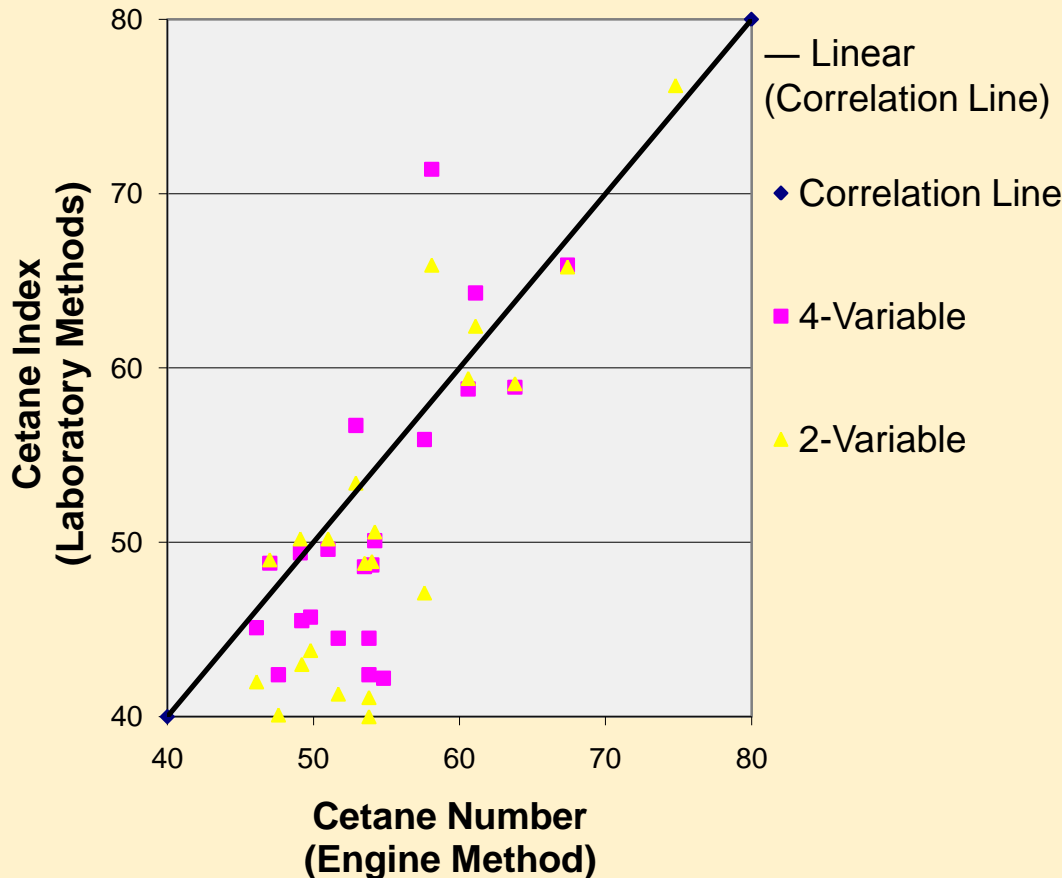
Data Table of Test Results



Fuel	Traditional Laboratory Methods		Engine Method	Newer Laboratory Method	
	CETANE INDEX		CETANE NO.	DERIVED CETANE NO.	
	D4737	D976	D613	D6890 (Lab #1)	D6890 (Lab #2)
Biodiesel	55.9	47.1	57.6	59.0	57.6
JP-8	45.1	42.0	46.1	45.2	46.7
SPK	71.4	65.9	58.1	60.2	56.5
GTL diesel fuel	82.2	76.2	74.8	79.9	71.8
ULSD	48.8	49.0	47.0	43.4	43.4
JP-8 : Biodiesel (4:1)	42.4	40.1	47.6	49.9	51.4
JP-8 : Biodiesel (4:1) + Cetane Improver (max treat rate)	42.2	39.8	54.8	56.7	57.0
JP-8 : Biodiesel (4:1) + Cetane Improver (min treat rate)	42.4	40.0	53.8	54.1	54.4
JP-8 : GTL fuel (1:1)	58.9	59.1	63.8	62.2	62.0
JP-8 : GTL diesel fuel : Biodiesel (2:2:1)	58.8	59.4	60.6	63.7	63.5
JP-8 : GTL diesel fuel : Biodiesel (8:1:1)	45.7	43.8	49.8	52.1	52.2
JP-8 + Cetane Improver (max treat rate)	44.5	41.1	53.8	56.6	56.3
JP-8 + Cetane Improver (min treat rate)	44.5	41.3	51.7	53.6	54.3
SPK : JP-8 (1:1)	56.7	53.4	52.9	52.4	52.8
SPK : JP-8 : Biodiesel (1:8:1)	45.5	43.0	49.2	48.5	51.4
SPK : JP-8 : Biodiesel (2:2:1)	50.1	50.6	54.2	54.7	56.0
SPK : JP-8 : GTL diesel fuel (1:1:2)	65.9	65.8	67.4	68.0	64.5
SPK : JP-8 : GTL diesel fuel (1:2:1)	49.6	50.2	51.0	48.9	54.7
SPK : JP-8 : GTL diesel fuel (2:1:1)	64.3	62.4	61.1	62.6	59.5
ULSD : Biodiesel (4:1)	49.4	50.2	49.1	48.8	49.0
ULSD + Cetane Improver (max treat rate)	48.6	48.8	53.5	54.3	54.3
ULSD + Cetane Improver (min treat rate)	48.7	48.9	54.0	51.6	46.9

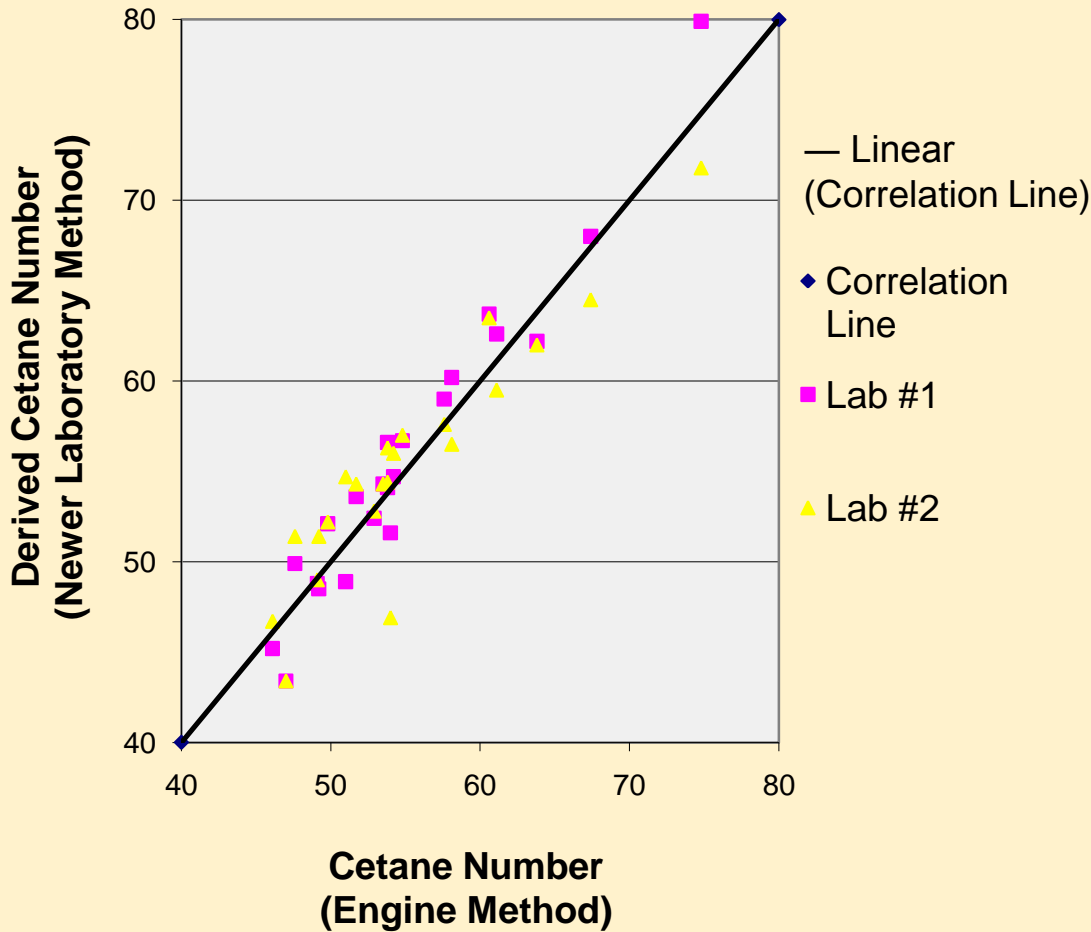
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Cetane Rating Comparison: Cetane Number vs. Cetane Index



- Most fuel blends do not correlate well with engine test
- Especially true at Cetane Rating = 50 +/- 5

Cetane Rating Comparison: Cetane No. vs. Derived Cetane No.



- Results from DCN testing correlate very well with research engine results
- Lab #1 and Lab #2 also in good agreement

- **Traditional laboratory methods for determining Cetane Index**
 - Based on TARDEC test results, these methods are not suitable for use with fuel blends, including synthetic fuel blends, and fuels or fuel blends additized with Cetane improvers
 - Results do not correlate well to engine testing
 - Includes 2- and 4-variable methods (ASTM D976, D4737)
- **Newer laboratory method for determining Derived Cetane No.**
 - Based on TARDEC test results, this method is suitable for use with fuel blends, including synthetic fuel blends, and fuels or fuel blends additized with Cetane improvers
 - Results correlate well to engine testing

- **In the future, we will be handling unconventional fuels and fuel blends**
- **Some or all of these fuels may have synthetic components**
- **Future fuel evaluations should**
 - Disregard 2- and 4-variable methods (ASTM D976 and D4737) to determine a fuel's Cetane Index because of the poor correlation of these methods with the research engine method
 - Incorporate the IQT method (ASTM D6890) to determine a fuel's Derived Cetane Number because of the very good correlation of this method with the research engine method
- **Future standards and specifications should be changed to reflect this method change**

Back-up Slides

- 2- and 4-variable methods are insensitive to biodiesel addition and/or Cetane improver addition
- Engine and IQT methods track very closely with each other

