RESEARCH LABORATORIES, INC.

6209 DISCOUNT DRIVE, FORT WAYNE, INDIANA 46818 (260) 489-2551 www.researchlaboratoriesinc.com

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Introduction

Most fuel buyers assume the diesel fuels they purchase meet the established (**ASTM – American Society for Testing and Materials**) specification requirements. Whether diesel fuels are sourced from major producers or independent suppliers, there is absolutely NO guarantee this always happens.

Additionally, what is not always published is the fact that the petroleum producers (refiners), diesel fuel distributors and fuel suppliers heavily inundate every ASTM Division and Committee including the Diesel Fuel D-2 Committee which actually writes the specifications for diesel fuels sold in America.

Accordingly, the approved diesel fuel quality specifications generally sway more in favor of fuel productions rather than specifically in the direction of optimum engine performance. This is not to say the engine manufacturers (and fuel users) do not have any say in the diesel fuel quality specifications.

ASTM allows all qualified Committee Members to voice an opinion on any specification or any recommended change to a specification. But over the years, many Committee Members' compromises between fuel producers and equipment manufacturers have been resolved in the direction of fuel producers rather than fuel users.

Therefore, the current **ASTM D-975 Specifications for Distillate (Diesel) Fuels** is very broad and contains only limited requirements for achieving optimum engine performance. Nearly all diesel fuel productions today meet the broad specification requirement regardless of crude source, refinery process or final product blending techniques used in making and supplying the finished diesel fuels.

Although the diesel engine tends to be very tolerable of different quality diesel fuels, the diesel fuel buyer generally understands that diesel fuels not meeting all of the recognized parameters of the **ASTM D-975 Specifications for Distillate (Diesel) Fuels** will negatively impact the performance of their equipment. The extent to which performance is affected can be debated, but that discussion is not part of this article.

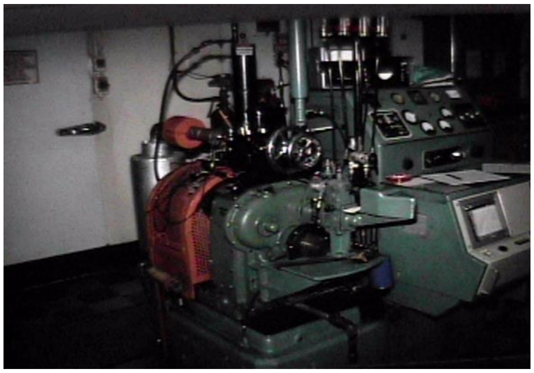
This article encourages readers to take a proactive approach to their diesel fuel purchases through regular and consistent laboratory analysis in order "***to determine the actual delivered quality***" and not leave this to the fuel supplier. This action will not necessarily guarantee quality diesel fuels are always purchased, but it will provide the fuel buyer the knowledge needed to make an effective choice when sourcing better quality diesel fuels.

Research Laboratories, Inc is an independent full service petroleum analytical laboratory incorporated in 1983 and headquartered in Fort Wayne, Indiana. The past thirty years of operation and experience testing numerous diesel fuels and fuel oils from across North America has demonstrated the significant and frequent variations seen in these delivered distillate fuels.

This article includes factual documentation of several of the diesel fuels analyzed during the past twelve months from major refiners, independent refiners and various fuel distributors and suppliers. Test data on each of the major performance parameters including Cetane Engine Number, Lubrication Value, Detergency Content, Distillation Temperature Range, Viscosity, API Gravity, Cold Flow Properties (CFPP, Pour Point, Cloud Point and 'Real World' Cold Room), Conductivity and Fuel Density will be shown and discussed.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Cetane Engine Number is a laboratory determination of the ***ignition delay*** quality of a diesel fuel. This number is determined by physically running the diesel fuel in a Cetane Engine Test Engine. The result indicates the microseconds of time between liquid fuel injection into the cylinder and ignition of the atomized fuel droplets.



Cetane Engine Test Apparatus

The Cetane Engine Test apparatus is a diesel engine with an adjustable (moveable) head cylinder head assembly. This allows the compression ratio of the test engine to be manually changed during the test engine operation. With the test engine operating, the compression ratio is systematically changed until knocking occurs.

The test engine compression ratio is then readjusted until the knocking is no longer heard. Readings are taken at each adjustment and compared to the known values for a chosen base combustion fluid. The Cetane Engine Number for the diesel fuel is arrived at through calculations of the test results.

A higher number (50+) represents a shorter time delay in ignition which permits more complete burning of the fuel/air mixture and more complete heat release (conversion of the BTU content into horsepower production) during the power stroke cycle.

A lower number indicates a longer time delay (the lower the number below 50, the longer the ignition delay) which results in later fuel/air mixture ignition, more "incomplete" burning and less power produced during the power stroke cycle.

The net effects of using lower Cetane Engine Number diesel fuels is poor starting, more smoke emissions, more fuel combustion noise (engine knock during start up and idle operations), poor burning of the fuel consumed, increased fuel related engine deposits and ultimately much lower fuel efficiency/economy (MPG). ***The lower the Cetane Engine Number, the worse the actual fuel economy***.

Following are engine laboratory test results achieved on several different delivered diesel fuels from various providers across North America. The laboratory tests were conducted by a cooperative laboratory in Texas.

Sample Date	**Sample Location**	**Delivered Cetane Engine Number**	**Additive Treated * Cetane Engine Number**	**2-EHN Cetane Improver Treated ***
12/17/12	Palm Beach, Florida	**44.7**	**52.5**	2200ppm
12/04/12	South Bend, Indiana	**42.3**	**50.1**	2000ppm
12/04/12	Romulus, Michigan	**46.3**	**51.3**	1500ppm
01/14/13	St. Paul, Minnesota	**41.4**	**48.0**	2300ppm
02/28/13	Perrysburg, Ohio	**41.9**	**49.7**	2100ppm
02/28/13	Cedar Rapids, Iowa	**39.1**	**47.0**	2400ppm
03/20/13	Des Plaines, Illinois	**44.2**	**50.4**	1800ppm

*** The fuels were treated by the lab and tested to verify the ability to correct the Fuel Cetane Engine Number deficiencies.**

There can be no doubt that the above diesel fuels with low Cetane Engine Number deficiencies did not deliver optimum operating performance. This reduced performance translates into higher fuel costs and increased long term maintenance costs for the diesel equipment operators.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Cetane Engine Number (cont)

Unfortunately, the current **ASTM D-975 Specifications for Distillate (Diesel) Fuels** requires a Cetane Engine Number of only **40 minimum**. The diesel fuel refiners do not typically need to add much if any Cetane Improver Additives to their diesel productions to achieve this minimum requirement. The task of increasing diesel fuel Cetane Engine Number beyond the requirement is left to the fuel terminals or fuel distributors (suppliers).

But, adding Cetane Improver Additive to a diesel fuel is generally done only IF the diesel fuel buyer requests his fuel supplier to incorporate appropriate 2-ethylhexal nitrates (2-EHN) additives in order to increase the Cetane Engine Number to a higher level.

The diesel fuel terminals or fuel distributor (suppliers) do not generally test their diesel fuels for Cetane Engine Number. The diesel fuel buyer MUST test the prospective diesel fuels in order to determine which diesel fuels need to be enhanced with a Cetane Improver Additive.

Fuel Lubrication Value (***Fuel Lubricity***) is a measure of how well the diesel fuel provides the necessary lubrication to the moving parts of the diesel fuel injection system. The most commonly used ASTM specified laboratory test for determining fuel lubricity is the **HFRR (High Frequency Reciprocating Rig) Test**.

HFRR Lubricity Test Apparatus

The HFRR (high frequency reciprocating rig) Lubricity Test Stand incorporates a steel ball that is subjected to a 200 gram load (downward pressure) while it reciprocates with a 1 millimeter stroke length at 50 Hz for 75 minutes on a highly polished disk. Both ball and disk are immersed continually during the test in a measured amount of diesel fuel kept at a constant humidity and temperature.

The ball and disk are removed from the apparatus after 75 minutes and the length and depth of wear scar on the ball is measured by viewing under a microscope.

The length and depth measurement of the wear scar is averaged by adding the wear scar length and depth together and dividing by 2 and the result is reported as the fuel HFRR lubrication value in µm (micrometers) of wear.

A "higher" HFRR fuel lubricity number indicates a 'poorer' lubrication value which will increase fuel system wear (pump, injector, etc.). Higher HFRR fuel lubricity number results can also add to deposit buildup in the fuel delivery system particularly with the new Common Rail Fuel Injector Systems.

Poor fuel lubricity will be most often noticed by increased fuel injector 'chatter' (noise) especially during engine startup, increased fuel injector operational issues and ultimately over time will result in complete fuel injector seizure.

Higher (poor) fuel lubricity numbers can also cause premature fuel island pump failures and increased fuel storage deposits.

Poor fuel lubricity will exacerbate improper fuel spray patterns in the cylinders and contribute to decrease fuel combustibility efficiencies. This decreases fuel economy and increases fuel costs.

Fuel Lubrication Value (cont)

The current **ASTM D-975 Specifications for Distillate (Diesel) Fuels** mandates Fuel Lubrication Value tested by **HFRR to be 520µm or less**. Some engine manufacturers have advocated for a more stringent fuel lubricity approaching the European specification of 400µm or less. This author agrees with the European Fuel Lubrication Value requirement because many new vehicles are being imported from Europe with engines that require a lower HFRR lubricity rating.

All of the current fuel lubricity chemical additives are severely restricted from incorporation into the petroleum pipeline systems because of a potential adverse effect on the jet fuel water test method. Accordingly, although there is a government mandate for a specific fuel lubrication value for diesel fuels sold in America, the fuel refiners do not generally add fuel lubricity chemistries to their diesel fuel productions. This compliance task is most commonly done by the fuel terminals or fuel distributor (suppliers) networks providing the diesel fuels.

Following are HFRR laboratory test results achieved on several different delivered diesel fuels from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	Sample Location	Delivered Fuel HFRR Number	Additive Treated * HFRR Number	Additive Treat Rate Used
12/11/12	Salem, Illinois	**600µm**	**420µm**	75ppm
12/11/12	Clear Lake, Iowa	**729µm**	**400µm**	125ppm
12/11/12	Knoxville, Tennessee	**715µm**	**415µm**	100ppm
01/07/13	Salt Lake City, Utah	**565µm**	**395µm**	65ppm
02/28/13	Stoughton, Wisconsin	**615µm**	**425µm**	90ppm
02/28/13	Romulus, Michigan	**815µm**	**445µm**	165ppm
03/12/13	Woodland, Pennsylvania	**630µm**	**400µm**	85ppm

*** The diesel fuels were treated by the lab and tested to verify the ability to correct the Fuel Lubricity Value deficiencies.**

None of the above delivered diesel fuel lubricity values reflect optimum lubrication values for the diesel engines using these fuels. These diesel fuels will not protect the diesel fuel delivery systems and will result in less than expected life of the fuel injector components. This less than adequate lubricity performance will translate into higher fuel costs and increased long term maintenance costs for diesel equipment operators.

Fuel Detergency determines whether or not the fuel delivery system, combustion area and post combustion components are kept clean and free of deposits. While fuel detergency would add only a very small amount to the overall cost of a diesel fuel, unfortunately, there is **no required ASTM specification** for Fuel Detergency in the **ASTM D-975 Specifications for Distillate (Diesel) Fuels**.

Generally, the diesel fuel producers (refiners) do not add any Fuel Detergents to their diesel fuel productions. Although diesel Fuel Detergents could be incorporated at the fuel terminal distribution point, the task of adding detergency to diesel fuels is almost always left to the fuel purchaser.

Additionally, there is no recognized consensus on a test method for determining Fuel Detergency in a diesel fuel. This makes the task nearly impossible for the diesel fuel buyer to determine whether or not a diesel fuel needs or already contains adequate fuel detergency for his equipment.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Detergency (cont)

However, **Research Laboratories, Inc** has developed a unique laboratory test procedure for accurately determining the precise amount of detergent present in any diesel fuel. This proprietary test method can be used for all types of diesel fuels, fuel oils and biodiesel fuel products.

Photospectometer Test Apparatus

The proprietary diesel fuel Detergent Content Test measures the amount of diesel detergent in a diesel fuel using a laboratory photospectometer unit calibrated to the specific available diesel fuel detergent additives.

Reagent chemicals are combined to react to the chemistries in the diesel detergents and compared photographically to the known colors generated by the individual diesel fuel detergent additives.

This process is repeated several times in order to more precisely determent the parts per million of diesel detergent additive present in the diesel fuel sample.

Following are Fuel Detergency laboratory test results achieved on several different delivered diesel fuels from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	**Sample Location**	**Delivered Fuel Detergency Value**	**Additive To Treat For IDID Detergency Value ***	**Detergent Additive Required ***
12/04/12	Tomah, Wisconsin	**None Detected**	**250ppm**	**250ppm**
12/11/12	West Fargo, N. Dakota	**None Detected**	**250ppm**	**250ppm**
12/11/12	Fridley, Minnesota	**None Detected**	**250ppm**	**250ppm**
02/06/13	Erie, Pennsylvania	**None Detected**	**250ppm**	**250ppm**
02/06/13	Albany, New York	**None Detected**	**250ppm**	**250ppm**
02/28/13	Freemont, Indiana	**None Detected**	**250ppm**	**250ppm**

*** The diesel fuels are shown treated with Detergent (ppm) necessary to correct the Fuel Detergency Value deficiencies.**

The above results indicate very little if any adequate detergency in these delivered diesel fuels. While the diesel equipment operator may not immediately detect the absence of appropriate fuel detergency, he will experience higher maintenance costs associated with poor detergency. He will also see higher fuel costs as a result of poorer combustion resulting from the less than optimum operation of the diesel fuel delivery system equipment.

These are hidden costs, but they are there and they are significant costs that can be dramatically reduced if the 'right' action is taken to determine the detergency value and correct it on a continual basis.

Fuel Distillation Temperature Range is a laboratory determination of a diesel fuel's boiling temperatures from IBP (Initial Boiling Point) to EP (End Point). Analyzing the diesel Fuel Distillation Temperature Range (using a laboratory distilling apparatus) allows the fuel buyer to assess whether the diesel fuel has an adequate path for appropriate combustion during the power stroke of the engine cycle.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Distillation Temperature Range (cont)

As a diesel fuel ignites and burns, each part of the fuel must combust to a temperature level that will evenly release its energy (BTU Content) so the next temperature level of the fuel can ignite and burn. How the diesel fuel is compounded (constructed) will be demonstrated by determining the Fuel Distillation Temperature Range.

Distillation Test Apparatus

The automatic Distillation Temperature Machine is a laboratory apparatus that vaporizes 100ml of the liquid diesel fuel while measuring the temperatures required to vaporize each 10 % of the liquid.

The vaporized materials is then cooled in order to reliquify the vapors and liquid volumes are collected in a separate cylinder and measured to verify the exact Distillation Temperature Points.

If the Fuel Distillation Temperature Range is very compact (narrow range), the fuel will burn too quickly to produce optimum horsepower and low engine power will result. If the Fuel Distillation Temperature Range is too long (broad range), the fuel will burn too slowly, not combust completely and the engine will smoke more and create excessive unburned hydrocarbon deposits and emissions.

A low IBP distillation temperature indicates contamination of lighter materials (such as gasoline or alcohol or similar product). This will cause pre-ignition before TDC (Top Dead Center) of the compression stroke. Pre-ignition puts extreme twisting pressure on the crankshaft of each cylinder as the piston cylinder pressure tries to push the piston back down before TDC is reached and those cylinders effectively try to "run the engine backwards". This condition is also noted by severe knocking.

A higher EP distillation temperature indicates heavier components in the fuel that will be difficult to combust and burn completely. This condition increases smoke and unburned hydrocarbon emissions and greatly increases the chances for excessive fuel related combustion area deposits and increased deposits in post combustion areas such as EGR Valves, Diesel Particulate Filters and other exhaust system components. Unfortunately, there is **no** set requirement for the other important distillation temperature points. Following are Fuel Distillation Temperature Range test results achieved on several different delivered diesel fuels from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	**Sample Location**	**Delivered Fuel Distillation Range**				**Additive Treated * Distillation Range**	**Additive Treat Rate Used**
		IBP	**50%**	**90%**	**EP**		
12/04/12	Des Plaines, Illinois	358	**509**	623	674	None	na
12/04/12	Romulus, Michigan	342	491	579	629	None	na
12/11/12	Fridley, Minnesota	336	523	629	**680**	None	na
01/07/13	Shelby, Iowa	**339**	**410**	522	587	None	na
01/07/13	Salt Lake City, Utah	331	490	587	636	None	na
01/07/13	Plover, Wisconsin	332	508	**632**	695	None	na
02/28/13	Tomah, Wisconsin	342	439	**514**	**565**	None	na
02/28/13	Perrysburg, Ohio	351	494	572	627	None	na
02/28/13	Cedar Rapids, Iowa	**381**	508	604	667	None	na

*** The diesel fuels were not tested for Fuel Distillation deficiencies. Fuel additives cannot change the distillation temperatures, but the 'right' fuel additives can counteract the negative effects of fuels with Distillation deficiencies.**

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Distillation Temperature Range (cont)

How can any diesel fuel user expect his diesel engine fleet to perform the same when the Fuel Distillation Temperatures (**highs to lows**) vary so much from one location (fuel supplier) to the next?

A diesel fuel buyer who ignores the Fuel's Distillation Temperature Range will likely find himself using diesel fuels that do not provide the correct amount of BTU Content (heat energy) for his application. This will lead to extensively higher operating and maintenance costs for the fleet and yield less than optimum fuel economy.

ASTM D-975 Specifications for Distillate (Diesel) Fuels includes only a **90% point temperature (282C to 338C = 540F to 640F)** requirement.

Defining a proper Fuel Distillation Temperature Range for the diesel fuels purchased will allow the fuel buyer to acquire diesel fuels that can deliver the best possible combustion efficiency and ultimately the best possible fuel economy for the fuel dollars spent.

Fuel Viscosity is a measure how viscous (thick or thin) the diesel fuel is at a standard temperature (usually 60 degrees F). This parameter determines whether or not the diesel fuel flows through the fuel injector and properly disperses (atomizes) in the compressed air in the cylinder when injected.

The Fuel Viscosity has become of paramount importance because of the new common rail fuel injection systems. These new fuel injection systems operate at extremely high pressures and much higher temperatures with extremely small tolerances. Any change in Fuel Viscosity will significantly affect how these systems perform.

Ubbelohde Viscosity Test Tube

The viscosity (kinematic viscosity) of a diesel fuel ASTM D-445 is a measurement of the time required for a specified volume of liquid to flow through a give size opening (calibrated glass capillary viscometer) under gravity at a specific temperature. This laboratory test result represents the thickness of the fuel at the given temperature (100 degrees F for diesel fuels) and determines how well or how poorly a diesel fuel can be injected during normal and varying engine power productions.

Fuel Viscosity can be precisely tested in specific laboratory equipment to determine whether or not the diesel fuel meets the current **ASTM D-975 Specifications for Distillate (Diesel) Fuels** requirement of **1.9 to 4.1 cSt (32.6 to 40.1 SUS) or at 100 degrees F**.

If the Fuel Viscosity is too low (thin), the fuel injectors may leak when closed causing raw fuel to be dumped into the engine cylinders at the wrong combustion cycle times. This will cause engine damage and excessive fuel consumption (poor fuel economy).

If the Fuel Viscosity is too high (thick), the fuel may not inject properly out of the inject tips and may not atomize correctly with the compressed air in the cylinders. This will cause poor combustion, increased deposits, and reduce fuel economy.

Fuel Viscosity (cont)

Following are Fuel Viscosity laboratory test results achieved on several different delivered diesel fuels from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	Sample Location	Delivered Fuel Viscosity	Additive Treated * Viscosity	Additive Treat Rate Used
12/11/12	Fridley, Minnesota	37.07	None	na
12/11/12	Rock Island, Illinois	36.93	None	na
01/07/13	Shelby, Iowa	**31.71**	None	na
02/06/13	Plainfield, Indiana	37.24	None	na
02/06/12	Erie, Pennsylvania	34.91	None	na
02/28/13	Tomah, Wisconsin	32.61	None	na
02/28/13	Des Plaines, Illinois	37.37	None	na
03/12/13	Albany, New York	**37.96**	None	na

*** The diesel fuels were not tested by the lab for Fuel Viscosity deficiencies. Fuel additives cannot change the Fuel Viscosity, but the 'right' fuel additives can counteract the negative effects of fuel usage related to Fuel Viscosity deficiencies.**

The above Fuel Viscosities show significant variation between the **highs and lows** which is caused primarily by the crude oils used to produce the diesel fuels. While these variations are typical of different deliveries from different fuel suppliers in North America, there is no possibility the same fleet of diesel powered equipment would achieve the same operability performance burning these different viscosity diesel fuels.

Fuel API Gravity and Fuel Density are measurements of the weight of the diesel fuel which determines the BTU Content (heat energy) in the diesel fuel. Fuel API Gravity and Fuel Density work opposite of each other in that as one increases, the other decreases. The same relationship occurs with BTU Content.

Hydrometer and Test Tube

API Gravity of a diesel fuel is a measurement of the weight of the liquid at a specific temperature (60 degrees F). The measurement is determined using a hydrometer and the result is standardized throughout the petroleum industry using an accepted series of calculations and international standard tables.

Density (or Relative Density) of a diesel fuel also depicts the petroleum industry standardized weight of a diesel fuel as it compares to the BTU Content present in the liquid.

Changes in the API Gravity or Density of a diesel fuel will correspond to equal changes in the energy content (BTU Content) of the diesel fuel which affects the horsepower potential of the diesel fuel tested.

As the Fuel API Gravity increases, the Fuel Density decreases and as the Fuel API Gravity decreases, the Fuel Density increases. The same is true for each test parameter regarding the BTU Content (i.e. as the Fuel API Gravity increases the BTU Content decreases and as the Fuel API Gravity decreases, the BTU Content increases). The current **ASTM D-975 Specifications for Distillate (Diesel) Fuels** does not contain a requirement for Fuel API Gravity or Fuel Density.

Fuel API Gravity and Fuel Density (cont)

Following are Fuel API Gravity and Fuel Density laboratory test results achieved on several different delivered diesel fuels from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	Sample Location	Delivered Fuel API Gravity	Delivered Fuel Density	Additive Treated * API Gravity & Fuel Density	Additive Treat Rate Used
12/04/12	South Bend, Indiana	32.7	0.8602	na	na
12/04/12	Romulus, Michigan	37.4	0.8363	na	na
12/11/12	Fridley, Minnesota	32.2	0.8629	na	na
01/07/13	Salt Lake City, Utah	37.7	0.8348	na	na
02/06/13	Cadillac, Michigan	37.0	0.8383	na	na
02/28/13	Perrysburg, Ohio	33.2	0.8576	na	na
02/28/13	Cedar Rapids, Iowa	**30.9**	**0.8698**	na	na
02/28/13	Tomah, Wisconsin	**38.7**	**0.8299**	na	na

*** The diesel fuels were not tested by the lab for Fuel API Gravity and Fuel Density deficiencies. Fuel additives cannot change the Fuel API Gravity, but the 'right' fuel additives can counteract the negative effects of fuel usage related to Fuel API Gravity and Fuel Density deficiencies.**

The differences between the **low and high** Fuel API Gravities (high and low Fuel Densities) reflect the actual BTU Content (energy content) in the diesel fuels which determines the maximum horsepower than can be produced from the diesel fuels when consumed.

Although the differences between the various numbers may seem small, these differences will result in significant variations in diesel engine fuel efficiency (MPG - fuel economy). Those differences will directly affect the bottom line of the operation.

Fuel Cold Flow Properties (CFPP, Pour Point, Cloud Point and 'Real World' Cold Room results) determine how well or how poorly the diesel fuel will perform during cold weather operations. The current **ASTM D-975 Specifications for Distillate (Diesel) Fuels** specifies Fuel Cloud Point temperatures based on 10^{th} percentile expected ambient temperatures in a given region. Fuel Pour Point is not specified and neither of these parameters are a good predictor of winter operability. The Fuel Cloud Point temperature is much too conservative and the Fuel Pour Point temperature over estimates operability.

Cloud & Pour Test Unit

The diesel fuel Cloud Point is the temperature at which the paraffin content in the fuel first changes to a measureable amount of solid wax crystals. This fuel temperature is the first potential for fuel filter plugging to occur. However, if the wax crystals are kept small, they may travel through the fuel filter media (depending on the micron size of the media) until a lower temperature is reached.

The diesel fuel Pour Point is the temperature at which all of the paraffin content in the fuel has changed to a solid wax and the fuel will no longer pour out of a container. Fuel flow to the diesel engine will be normally be severely restricted and the engine will shut down well before the fuel Pour Point temperature is reached.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Cold Flow Properties (cont)

The Fuel CFPP (Cold Filter Plugging Point) temperature has been used successfully for many decades in Europe and the United States in order to predict diesel fuel operability. However, changes in crude oil sources, fuel refinery processes and diesel engine equipment design over the last decade have made this parameter somewhat over optimistic in certain diesel fuels.

CFPP Test Apparatus

A diesel fuel CFPP (Cold Filter Plugging Point) is the diesel fuel temperature at which sufficient liquid paraffin content has changed to solid wax crystals in an amount that fuel flow through the fuel filter is restricted enough to cause the engine to stop running.

The fuel CFPP temperature can be lowered and engine operability improved by making the wax crystals small enough to flow through the fuel filter and by preventing wax crystals accumulations in the area of the fuel draw line (tank bottom).

While CFPP is a more accurate indication of engine operability potential during cold weather, it should not be used as the ultimate indicator of true low temperature operability (see Cold Room Testing for ultimate 'real world' operability test results).

Research Laboratories, Inc has developed a unique '***Real World***' ***Cold Room Test Method*** for precisely determining the temperature at which a diesel fuel will fail during cold weather operations. This ***exclusive*** test method involves the use of OEM (original equipment manufacturer) fuel pumps to flow diesel fuel through OEM fuel filters at fuel temperatures down to -30 degrees F. The testing method is accurate and undeniably yields the precise winter operability temperature for any diesel fuel.

Following are **Fuel Cold Flow Property** laboratory test results achieved on several different delivered diesel fuels from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	Sample Location	Delivered Fuel Cloud, Pour & CFPP Temperatures (F)			Additive Treated * Fuel Cloud, Pour & CFPP Temperatures (F)			Additive Treat Rate Used
		Cloud	Pour	CFPP	Cloud	Pour	CFPP	
12/04/12	Woodland, Pennsylvania	+ 12.0	- 14	**+ 4**	+ 10.3	- 50	**- 31**	2000ppm
12/11/12	Keokuk, Iowa	+ 11.4	- 8	**+ 7**	+ 10.9	- 48	**- 36**	2000ppm
12/11/12	Fargo, North Dakota	+ 3.6	- 40	**+ 3**	+ 1.0	- 82	**- 37**	2000ppm
12/11/12	Knoxville, Tennessee	+ 9.0	- 14	**+ 6**	+ 9.0	- 50	**- 28**	2000ppm
01/07/13	Plover, Wisconsin	+ 9.1	- 28	**+ 5**	+ 7.0	- 74	**- 31**	2000ppm
01/07/13	Salt Lake City, Utah	+ 8.1	- 36	**- 4**	+ 6.1	- 50	**- 35**	2000ppm
02/06/13	Cadillac, Michigan	+ 4.7	- 22	**+ 4**	+ 4.9	- 50	**- 33**	2000ppm
03/12/13	Albany, New York	+ 10.1	- 10	**+ 7**	+ 9.0	- 54	**- 38**	2000ppm

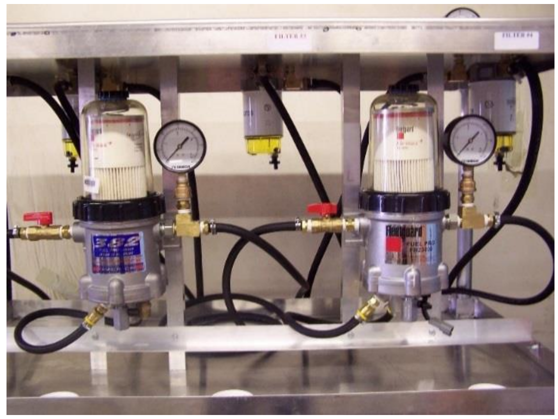
*** The diesel fuels are shown treated with Cold Flow Improver Additive in the necessary amount to correct the Fuel Cold Flow Property deficiencies. The 'right' fuel additives can counteract the negative winter effects of fuel usage related to Fuel Cold Flow deficiencies.**

The **Research Laboratories, Inc Fuel Cold Room Testing** yields results defining the temperature at which fuel pressure was first documented on the inlet side of the fuel filter and the percentage of fuel flow lost through the fuel filter at that temperature. The specific amount of inlet pressure and percentage of fuel flow loss is only important for determining the test temperature at which both occurred.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Cold Flow Properties (cont)

Cold Room Test Cell



Cold Room Test Cart Filter Assembly

The computer Cold Room is programed to lower the temperature of the fuel samples at a constant rate per hour from 50 degree F ambient to the first test temperature (fuel Cloud Point) over a 16 hour period. This temperature reduction simulates typical 'overnight' fuel temperature drops that might occur in a vehicle fuel tank during winter.

Fuel samples of 2.5-gallon or 5-gallons are flowed through individual 2µm, 5µm, 7µm or 10µm fuel filters at each test temperature. Inlet fuel pressure and flow through the filters are recorded at each fuel test temperature. Any inlet fuel pressure accompanied with a fuel flow loss is considered the failure temperature of the fuel being tested.

Following are **Fuel Cold Room Test** results achieved on the same delivered diesel fuels shown above from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	Sample Location	Delivered Fuel Cold Room Temperatures (F)	Additive Treated * Cold Room Temperatures (F)	Additive Treat Rate Used
12/04/12	Woodland, Pennsylvania	3# - 18% loss @ **+ 8.5 F**	5# - 20% loss @ **- 14.4 F**	2000ppm
12/11/12	Keokuk, Iowa	1# - 5% loss @ **+ 11.4 F**	4# - 5% loos @ **- 15.1 F**	2000ppm
12/11/12	Fargo, North Dakota	1# - 8% loss @ **+ 3.2 F**	3# - 9% loss @ **- 16.9 F**	2000ppm
12/11/12	Knoxville, Tennessee	3# - 10% loss @ **+ 6.4 F**	5# - 15% loss @ **- 15.4 F**	2000ppm
01/07/13	Plover, Wisconsin	2# - 10% loss @ **+ 4.7 F**	4# - 9% loss @ **- 15.5 F**	2000ppm
01/07/13	Salt Lake City, Utah	2# - 8% loss @ **- 0.9 F**	3# - 5% loss @ **- 17.3 F**	2000ppm
02/06/13	Cadillac, Michigan	3# - 20% loss @ **+ 3.9 F**	4# - 18% loss @ **- 15.3 F**	2000ppm
03/12/13	Albany, New York	3# - 5% loss @ **+ 6.8 F**	3# - 9% loss @ **- 15.6 F**	2000ppm

*** The diesel fuels are shown treated with Cold Flow Improver Additive in the necessary amount to correct the Fuel Cold Room Test deficiencies. The 'right' fuel additives can counteract the negative winter effects of fuel usage related to Fuel Cold Room Test deficiencies.**

Since the **Fuel Cold Room Test** results are achieved by flowing diesel fuel through the fuel filters at specific fuel temperature readings, the above **Fuel Cold Room Test** results clearly show that the laboratory tested CFPP temperature results may be '*overly optimistic*' in predicting winter time operability for these diesel fuels. Although the current **ASTM D-975 Specifications for Distillate (Diesel) Fuels** does not contain any requirement for **Fuel Cold Room Testing**, **Research Laboratories, Inc** believes this testing is the most accurate and most effective means to precisely determine how well or how poorly a diesel fuel will perform during cold weather.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Fuel Conductivity is a measure of a diesel fuel's ability to dissipate a static electric charge. A good Fuel Conductivity (high number) will allow the diesel fuel to rapidly dissipate the static buildup and eliminate a potential fire hazard from a static discharge spark.

Conductivity Test Meter

The electrical Conductivity of a diesel fuel can be determined by measuring the static charge potential in picosiemens per meter.

Various portable meters for field or laboratory measurements are available as well as in-line constant measurement meters for determining this measurement.

It should be noted that while absolute numbers are given in petroleum product (diesel fuel) specifications, there are few long-term studies to verify the acceptability of these absolute numbers.

A minimum **25pS/m2 Fuel Conductivity** requirement was recently added to the current **ASTM D-975 Specifications for Distillate (Diesel) Fuels**. While it is good to have a requirement, **Research Laboratories, Inc** believes this minimum requirement should be increased to 100pS/m2 minimum in order to guarantee optimum protection from the diesel fuels and equipment.

Following are **Fuel Conductivity Test** results achieved on the same delivered diesel fuels shown above from various providers across North America. These tests were performed by **Research Laboratories, Inc**.

Sample Date	Sample Location	Delivered Fuel Conductivity (pS/m2)	Additive Treated * Conductivity (pS/m2)	Additive Treat Rate Used
12/04/12	Des Plaines, Illinois	**76**	**124**	5ppm
12/11/12	Knoxville, Tennessee	**59**	**124**	10ppm
01/07/13	King of Prussia, Pennsylvania	**53**	**115**	8ppm
02/06/13	Riverton, Illinois	**59**	**147**	10ppm
02/28/13	Stoughton, Wisconsin	**32**	**126**	10ppm
02/28/13	Perrysburg, Ohio	**20**	**128**	10ppm
02/28/13	Romulus, Michigan	**21**	**102**	8ppm
03/20/13	Tomah, Wisconsin	**31**	**121**	10ppm

*** The diesel fuels are shown treated with Conductivity Improver Additive in the necessary amount to correct the Fuel Conductivity Test deficiencies. The 'right' fuel additives can counteract the negative winter effects of fuel usage related to Fuel Conductivity Test deficiencies.**

As indicated above, correcting Diesel Fuel Conductivity can be accomplished quite easily with only a very small amount of chemical treatment. The diesel fuel buyer should be aware of the handling and potential fire dangers associated with Fuel Conductivity and specify protection adequate for the application of the diesel fuel.

RESEARCH LABORATORIES, INC.

Do You Know The "Quality" Of Diesel Fuel You Are Buying?

Summary and Conclusion

This article is not drafted to say that all delivered diesel fuels are bad or even that most do not meet the required ASTM D-975 Specifications. This article was written not to offer a solution to diesel fuel quality, but rather to document the test results of several real diesel fuels actually delivered to unsuspecting customers.

These fuel buyers believed they were buying compliant diesel fuels that would provide the best performance for their respective diesel powered equipment. Because of the deficiencies discovered, these fuels did not provide the most optimal performance possible for the buyers.

This article points out that the "Buyer Should Beware" and "Test His Diesel Fuel Purchases" with a qualified independent laboratory IF the buyer truly wants to receive the most for the money he spends on today's diesel fuels.

Energy costs account for the largest single (non-labor) expense of every business in North America. The diesel equipment operator must take action to insure those dollars are well spent and he gets the most for his money. This will guarantee lower costs and maximize the diesel fuel costs expended.

Submitted by:

Gary G. Pipenger, Consultant

Testing by Matt Alt, Manager
RESEARCH LABORATORIES, INC.
6209 Discount Drive
Fort Wayne, Indiana 46818
www.researchlaboratoriesinc.com

Note: The diesel fuel additives used in the testing were supplied by Amalgamated, Inc (260-489-2549) www.amalgamatedinc.com