NCWM Premium Diesel Definition

Informal Focus Group Recommendation and Report

September 2017

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Objective:
Update the NCWM premium diesel definition to align fuels with current requirements of the engines and injection equipment.

Background:
The National Conference on Weights and Measures (NCWM) Objective is to develop meaningful model language for Laws and Regulations concerning "regular" and "premium" diesel fuel so that these fuels can be identified accurately and clearly through dispenser labeling and other means.

Current Properties:

- Cetane Number, ASTM D613: 47 Minimum
- Lubricity Wear Scar Diameter, ASTM D6079: 520 Micron
- Low Temperature Operability: Requiring the ASTM D975 Guideline Using the Tougher LTFT Method
- Stability, ASTM D6468: 80% Reflectance, 180-Minute Test

Proposed New Properties:

- Cetane Number, ASTM D613: 47 minimum
  ~~Although~~ ASTM D613 ~~test method~~ ~~should be~~ is the referee method; however, the following methods may be used to determine cetane number: ~~new test methods can be used~~:
  - *D6890 (IQT)*
  - *D7170*
  - *D7668*
- Corrosion, NACE TM0172-2015: B+ rating minimum
- Filter Blocking Tendency, ASTM D2068, procedure B: 1.6 maximum
- Injector Deposit, CEC DW-10 B: 2 % maximum power loss
- Low Temperature Operability, Cloud Point, LTFT, or a restricted CFPP: ASTM D975 Guideline
  - *CFPP should be limited to a maximum of 6 C below the cloud point of the fuel.*
- Lubricity Wear Scar Diameter, ASTM D6079: 460-micron maximum.

Proposed Amendment

Proposed Changes to 2.2.1 Statement on Premium Diesel Fuel:
2.2.1. Premium Diesel Fuel. -- All diesel fuels identified on retail dispensers~~, bills of lading, invoices, shipping papers, or other documentation~~ with ~~terms such as premium, super, supreme, plus, or premier~~ **an additional term incorporated directly in the product or grade name that differentiates the fuel and implies the fuel provides properties that exceed minimum specification limits or performance properties** must conform to the following **minimum** requirements.

EXCEPTION NOTE: It is permissible to include a clearly-defined fuel property that has a functional benefit, established test method, and a level, if stated as such. Example is winterized diesel which provides an operability benefit and is discussed in detail in ASTM D975 as a recommended guideline.

(a) Cetane Number. - A minimum cetane number of 47.0 as determined by the latest version of ASTM D613, "Standard Test Method for Cetane Number of Diesel Fuel Oil."

NOTE: ***ASTM D613 is the referee method; however, the following methods can be used to determine cetane number: D6890 (IQT); D7170 D7668***

(b) **Low Temperature Operability.** – A cold flow performance measurement which meets the latest version of ASTM D975, "Standard Specification for Diesel Fuel Oils," tenth percentile minimum ambient air temperature charts and maps by either ASTM Standard Test Method D2500 (Cloud Point) or the latest version of ASTM Standard D4539, "Low Temperature Flow Test, LTFT." **ASTM Standard Test Method D6371 may be used when the test results are a maximum of 6 ºC below the Cloud Point.** Low temperature operability is only applicable October 1 to March 31 of each year.

~~(c) **Thermal Stability.** – A minimum reflectance measurement of 80 % as determined by the latest version of ASTM Standard Test Method D6468 (180 min, 150 °C).~~

(d) **Lubricity.** – A maximum wear scar diameter of ~~520~~ **460** micrometers as determined by the latest version ASTM D6079, "Standard Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR)." ~~If an enforcement jurisdiction's single test of more than 560 micrometers is determined, a second test shall be conducted. If the average of the two tests is more than 560 micrometers, the sample does not conform to the requirements of this part.~~

(e) Corrosion. – A minimum rating of B+ as determined by the most recent NACE TM0172.

(f) Filter Blocking Tendency (FBT) – A maximum of 1.6 by ASTM D2068 Standard Test Method for Determining FilterBlocking Tendency, following procedure B.

(g) <u>Injector Deposit Control. – Maximum power loss in keep-clean mode of 2 % by the most recent CEC DW-10.</u>

Focus Group Members:

Randy Jennings	TN Dept. of Agriculture
Manuch Nikanjam	Chevron
Hind Abi-Akar	Caterpillar
Joan Axelrod	ExxonMobil
Paul Biggerstaff	Baker Hughes
Shawn Broughton	Marathon Petroleum
Jim Bush	Lubrizol
Rick Chapman	Innospec
Jennifer Draper	Motiva
Scott Fenwick`	NBB
Roger Gault	EMA
Barbara Goodrich	John Deere
Garry Gunter	Phillips 66
Ron Hayes	Missouri Dept. of Agriculture
Dennis Hess	Infineum
Cal Hodge	Neste
Stuart Johnson	Volkswagen
Alex Kulinowski	Afton Chemical
Tom Livingston	Bosch
Shailesh Lopes	GM
Chuck Richardson	Ford
Prasad Tumati	J Haltermann

Process Guidelines:

- Properties should have
  - A functional benefit (with supporting technical data)
  - A standard test method (ASTM or other)
  - Statistically significant difference, if a minimum ASTM specification exists, at least by the reproducibility of the test method
- Group decisions are made by consensus.
- This group makes a recommendation only, States make the final decision through their established process.

Initial identification of potential performance categories:
Group members met on October 12, 2016 in Nashville to identify all possible performance categories for discussion, further research, and consideration as a part of the new definition. A leader was identified for each category to form a small team to study the property and to provide a recommendation to the group. Eleven teams were formed as follows:

- Aromatics; *Hind Abi-Akar*
- Cetane Number; *Shawn Broughton*
- Cleanliness; *Roger Gault*
- Corrosion; *Rick Chapman*
- Energy Content; *Joan Axelrod*
- Filter Blocking Tendency; *Hind Abi-Akar*
- Injector Deposit; *Joan Axelrod*
- Low Temperature Operability; *Dennis Hess*
- Lubricity; *Paul Biggerstaff*
- Metals; *Shailesh Lopes*
- Stability; *Scott Fenwick*

Each category and the related group recommendation is discussed below. Minority opinion also included, if one was raised.

Aromatics:
Higher aromatics level can result in higher soot emissions. Very low aromatics can affect elastomer failures in older equipment with aged gaskets and O rings. Lower aromatics results in lower energy content which affects fuel economy.

Controlling fuel aromatics in the market is not practical because diesel fuel is fungible, there is no additive solution to adjusting it. Once at the fuel terminal, the aromatics level is fixed.

The group is not in favor of including it in the proposed definition.

Cetane Number:
Benefits were demonstrated in the previous effort leading to the current definition. Keep the existing minimum 47 requirement. Although ASTM D613 test method should be the referee method, we recognize that new test methods are available and can be used. These are:

- D6890 (IQT)
- D7170
- D7668

Cleanliness:
Control of water and particulate levels in diesel fuel is important. However, we are not recommending this category at this point because definitive technical supporting data to quantify maximum levels do not exist. Also, many believe that once data becomes available, it should apply to all diesel fuels through specifications in ASTM D975.

Corrosion:
Vehicle manufacturers report corrosion as one of their concerns and claim that they continue to experience corrosion in their diesel fuel systems. OEM's generally believe that the NACE TM-0172 test suits their needs at a B+ or better rating. Fuel steel corrosion should be a part of the revised NCWM Premium Diesel Specification NACE TM0172-2015, "Determining Corrosive Properties of Cargoes in Petroleum Product Pipelines" is the de facto petroleum industry test and the method preferred by most vehicle manufacturers. Suggested B+ rating corresponds to nearly no corrosion short of being perfect.

> Minority Report by Garry Gunter
> WG recommends NACE TM0172 (pipeline corrosion test) B+ rating or better (less than 5% of test surface corroded). I do not agree that this needs to be included because fuels already meet these criteria according to pipeline specifications. Also, there was no data shown to support the proposed limit. We believe the test is likely inappropriate for vehicle fuel systems because they have different metallurgy than mild carbon steel in pipelines at 100°F, which is the basis of the NACE test.

Energy Content:
Energy content affects fuel economy. However, it cannot be adjusted at the terminal and in a fungible system, it is not practical to control. With conventional diesel fuel, it can be estimated by density but increasing use of biodiesel, renewable diesel, and GTL introduce complications. At this time, we do not recommend adopting this fuel property.

Filter Blocking Tendency:
This test has been developed recently and can be effective in reducing premature vehicle filter plugging occurrence. It supports injector performance and durability. It has the potential to aid reducing frequent dispensing filter changes as the final dispensing point.

ASTM D2068, procedure B is the appropriate test method.

Proposed limit is a maximum of 1.6.

> Minority Report by Garry Gunter
> WG recommends ASTM D2068 procedure B (using premanufactured filter instead of lab-assembled filter), limit 1.6 max. I do not agree because no data was provided to support the recommendation. With no data to support limits, this is a very unscientific way to set a specification.

Injector Deposit:
Deposit free injectors help to prevent power loss and to maintain combustion efficiency. Clean injectors reduce deterioration in exhaust gas and particulate emissions. They help to prevent premature hardware failure and drivability issues.

Current industry-accepted test method is the CEC DW-10B. It is designed to show the effect of additives.

In this category and for premium diesel, injectors must be sufficiently free of deposits to avoid power loss. However, since most agree that test variability is around 2 %, the required level should be power loss < 2 %.

Additive use can be used as enforcement because routine performance of the DW-10B is expensive, time consuming, and requires a large fuel sample.

> Minority Report by Garry Gunter
> WG recommends CEC DW-10B <2% power loss. I strongly object to this requirement many reasons. 1) No data was shown that this translates to a real benefit. 2) The test is European-based test, not available in US. We have no influence over the test method procedure (unlike ASTM). 3) This is an expensive, time-consuming test requiring hundreds of gallons of fuel, weeks to months to complete, and costing up to $20,000. 4) We are not convinced that the test measures anything relevant to real injector fouling since the procedure involves spiking the fuel with metal contaminants (copper) to induce fouling, then mitigating the fouling with antifoulant additive. This test does not demonstrate that the original fuel had a fouling problem to begin with, and even if it did, it does not demonstrate that the antifoulant is effective in the absence of copper. So the test does not seem relevant to "real world" fouling.

Low Temperature Operability:
This is one of the most important properties of diesel fuel. Unfortunately, ASTM D975 does not have a specification. It has a suggested guideline that many fuel suppliers follow. This is a part of the current definition. It is recommended to continue.

Current definition requires the ASTM D975 guidelines. Only Cloud Point and Low Temperature Flow Test (LTFT) are acceptable as test methods. Base on research and knowledge since the original definition, we recommend that we also add a restricted Cold Filter Plugging Point (CFPP) as an acceptable test method option. CFPP should be limited to a maximum of 6 C below the cloud point of the fuel. Operability can be achieved at a lower temperature than the cloud point if proper additives are used. LTFT and CFPP, therefore, are useful indicators of operability for additized fuels.

> Minority Report by Garry Gunter
> WG recommends to continue requirement of CP and LTFT and add "restricted CFPP" (CP-CFPP) <= 6°C. I do not agree because I think it adds little value. The technical reasons for including it are sound, the test methods are good, and data shows it helps certain older vehicles. But OEMS have been improving vehicle low temperature operability, so I think it is unnecessary and less relevant to newer vehicles.

Lubricity:
It is well known that fuel lubricity is an important property to protect fuel injection equipment such as pumps and injectors from excessive wear. It was included as a requirement in the current definition at a time when ASTM D975 did not specify it. Since that time, ASTM has adopted it as a part of diesel fuel specifications.

The group had a choice to keep the existing requirement, to drop the requirement, or to make it more stringent. Majority were in favor of increasing fuel lubricity by lowering the High Frequency Reciprocating Rig (HFRR), ASTM D6079 wear scar diameter (WSD) from the current 520-micron

maximum (with a 560-micron conformance allowance per ASTM 3224) to a 460-micron maximum.

Minority Report by Manuch Nikanjam, Joan Axelrod, Garry Gunter
Lubricity is an important diesel property that prevents excessive wear of pumps and injectors' metal parts sliding and rotating with small clearances.

NCWM's current definition includes a maximum 520-micorn wear scar diameter (WSD). This was adopted at a time when we had supporting data that the level protected the equipment but had not required it for all fuels in the ASTM D975 diesel specifications.

Many experts conducted equipment research to support the level. Results were shared broadly and globally with all interested parties such as injection equipment, engine, and auto manufacturers and fuel suppliers. Based on advice by the injection equipment manufacturers and auto makers, the current level was adopted. They stated that they could market equipment that could tolerate less fuel lubricity, as they have done for artic pumps and airplane applications dealing with jet fuel, but we needed the higher lubricity level (520 micron) to protect millions of exiting equipment that were in use and had designed based on the better lubricity of previous higher sulfur diesel fuels.

Based on the same science and agreement among all relevant parties, and with a great deal of effort and collaboration, the same NCWM protective level eventually was adopted at ASTM.

At the time the precision of the High Frequency Reciprocating Rig (HFRR) was poor. NCWM added additional statistical requirements to ensure protecting the injection equipment. Later injection equipment and engine manufacturers demanded that we either improve the test method precision or change the fuel specification. The ASTM task force conducted a workshop, round robin testing, and a significant effort and was successful in improving the precision significantly (almost to half of it original value).

As such the current ASTM D975 is sufficient to protect equipment. There are no reports of premature excessive wear and no request by users to change the requirement. As such it is time to drop this requirement, especially since those who may use premium fuel do not own specific vehicles designed to run on premium fuel only (unlike the gasoline ones).

Adopting an unnecessary more stringent lubricity requirement will result is much higher use of additives, some of which may result in harmful side effects. As with medicine, we must use additive but no more than needed. Since the introduction of S15 in 2006, and due to requirements such as conductivity, lubricity, stability for biodiesel, etc., we have benefitted from use of several additives in numbers and quantities higher than before. Suppliers have done a great job to ensure compatibility. Increasing the number and the concentration results in more challenges.

Also, to make the NCWM premium diesel definition more practical for a fuel supplier to market it, it is important to limit the number of requirement and to those that have a clear functional benefit beyond the ASTM D975 requirements.

Metals:
Lower metals in the fuel protect the catalyst and reduce injector deposits. After treatment systems are designed anticipating certain efficiency loss due to low levels of metal exposure. Fuel with metal levels below detectable limits will not translate to customer benefit.

Any metal limits if require by the OEMs should be part of the ASTM specifications. Therefore, the group does not recommend metals as a requirement for premium diesel.

Stability:
This is an important parameter but cannot be included until technical supporting document is produced through a number of research project in progress or initialed in the near future through industry efforts at Coordinating Research Council (CRC) and/or others.

Proper fuel stability provides benefit in storage and shelf life. It prevents formation of insoluble compounds and polymers.

The current NCWM premium diesel definition includes a stability requirement but with recent 15-ppm sulfur fuel, nearly all fuels meet the high standard and such the method and the level is outdated. Additionally, much higher of different forms of diesel fuel, such as biodiesel are in use. They require more relevant test methods and levels for fuel stability.

Group Consensus Position:
A summary of the recommendations by the group and a record of the votes are as follows:
(number refer to: yes/no/abstain)

Include in the new definition

- Cetane Number 18/0/1
- Corrosion 16/0/2
- Deposit 17/1/1
- Low Temperature Operability 17/0/1
- Lubricity
  - Drop 2/14/2
  - Keep the same 2/13/3
  - Change to 460 microns 13/4/2
- Filter Blocking Tendency 9/7/2

Do not include at this time

- Aromatics
- Cleanliness
- Energy Content
- Metals
- Stability

Recommend change to NIST Handbook 130, 2.2.1:
The group also discussed various terms that should be an indication of premium diesel, therefore, requiring compliance with the NCWM definition. Also, exceptions to be considered if a specific fuel property is of value and is clearly defined.

Current text in Handbook 130 is as follows:

2.2.1. Premium Diesel Fuel. - All diesel fuel identified on retail dispensers, bills of lading, invoices, shipping papers, or other documentations with terms such as premium, super, supreme, plus, or premier must conform to the following requirements.

Recommended new language is:

2.2.1. Premium Diesel Fuel. -- All diesel fuels identified on retail dispensers, ~~bills of lading, invoices, shipping papers, or other documentation~~ with ~~terms such as premium, super, supreme, plus, or premier~~ **an additional term incorporated directly in the product or grade name that differentiates the fuel and implies the fuel provides properties that exceed minimum specification limits or performance properties** must conform to the following **minimum** requirements:

EXCEPTION NOTE: It is permissible to include a clearly-defined fuel property that has a functional benefit, established test method, and a level, if stated as such. Example is winterized diesel which provides an operability benefit and is discussed in detail in ASTM D975 as a recommended guideline.

Supporting Material & References for Individual Properties/Teams

- Aromatics; *Hind Abi-Akar*


Aromatics Abi-Akar
NCWM Preiium Dies

- Cetane Number; *Shawn Broughton*


Cetane Number
Broughton NCWM F

- Cleanliness; *Roger Gault*


Cleanliness Gault
NCWM Preiium Dies

- Corrosion; *Rick Chapman*

Corrosion
Chapman NCWM Pr

- Energy Content; *Joan Axelrod*

Energy Content
Axelrod NCWM Pren

- Filter Blocking Tendency; *Hind Abi-Akar*

Filter Blocking
Tendency Abi-Akar

- Injector Deposit; *Joan Axelrod*

Injector Deposit
Axelrod NCWM Pren

Injector Deposit
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- Low Temperature Operability; *Dennis Hess*

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- Lubricity; *Paul Biggerstaff*

Lubricity
Biggerstaff NCWM F

- Metals; *Shailesh Lopes*

Metals Lopes
MCWM Premium Die

- Stability; *Scott Fenwick*

Stability Fenwick
NCWM Premium Die