ASTM INTERNATIONAL
Helping our world work better

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**COMMITTEE D02 on PETROLEUM PRODUCTS, LIQUID FUELS, AND LUBRICANTS**



Issued: September 16, 2020
Reply to: Dan Worcester

Southwest Research Institute
6220 Culebra Rd.
San Antonio, TX 78238
Phone: 210.522.2405
Email: dworcester@swri.org

These are the unapproved minutes of the 09.08.2020 Sequence VI Conference Calls.



The meeting was called to order at 9:03 AM Central Time by Chair Andrew Stevens.

1.0 The Agenda is Attachment 1.
2.0 Roll Call. Attendance is Attachment 2. There were no member changes.

3.0 Old Business

MOTION: Approve minutes from the 08.25.2020 conference call.
Andrew, Ben second. Approval was unanimous.

4.0 New Business

4.1 There was a review of the fuel analysis done for lab run tanks. See Attachments 3 and 4. Note that 3 labs used the same company for their analysis.

4.1.1 Comparison was made to the analysis done by Todd Dvorak. There were parameters that Todd highlighted that showed statistical response. The concern noted is variation in results based on labs and repeatability/reproducibility of the test itself. It was noted that the greatest variation is labs and the test selected. This applies in particular to D240. Data is comingled and there are too many assumptions. See Attachment 5.

4.1.2 Jeff really wanted to reinforce that the industry would be heading down a rabbit hole. Potential variation could cause a reversal in a pass or fail of a borderline oil.

4.1.3 Based on these comments, the decision was made to move forward and re-check results two years from now. A DOE was suggested but this would be very expensive and may not be possible at the current level of testing. The recommendation was made to begin to gather data for later review.

MOTION: Effective 09.08.2020, labs will take a sample every quarter and tie to the first reference in that quarter. Sample will be taken at fuel rail before starting the reference test. Tests will be run for Net Heating Value [D3338], RVP and Distillation Curve. All samples will be measured at the same lab [Saybolt]. If possible include residence time for the fuel in the tank.

Ben, Adrian second. There were 9 yes and 7 waives. The motion carried.

4.2 Rich added a discussion item that D8114 had an incorrect equation for FEI2 engine hours.

MOTION: Generate an Information Letter to correct the equation for engine hours for FEI2. Rich, Adrian The motion passed unanimous.

4.3 There is a goal now to get the alternate fuel supplier process moving forward.

The meeting adjourned at 10:34 AM.

# Sequence VI Surveillance Panel Call Meeting Agenda
# September 8, 2020 @ 10:00-11:30 EST

**Webex Meeting Details Below Agenda**

## 1. Roll Call (start 10:05 EST)

*1.1. SP Membership changes and additions*

## 2. Old Business

| | | |
|---|---|---|
| 2.1 | Approve Minutes from 8/25 call | Andrew Stevens |

## 3. New Business

| | | |
|---|---|---|
| 3.1 | Alternative Fuel Discussion<br>- Correlation b/w Todd's Work & Round Robin Data<br>- Decisions for "at-risk" parameters<br>- What does additional fuel property testing look like?<br>- What do we do when something is out of spec? | Panel |

## 4. Next Meeting

*4.1. SP Meeting: TBD*

## 5. Meeting Adjourned

## APPENDIX

**ASTM SEQUENCE VI**

| Name | Email | Company | Attend |
|---|---|---|---|

## VOTING MEMBERS

| | | | |
|---|---|---|---|
| Ben Maddock | Ben.Maddock@AftonChemical.com | Afton | ATTEND |
| Brianne Hockkeppel | Brianne.Hockkeppel@bp.com | BP | |
| Kevin Brodwater | KBrodwater@chevron.com | Chevron | ROBERT |
| Haiying Tang | HT146@Chrysler.com | Chrysler | |
| Tracey King | TKing@h-c-s-group.com | CS Group | ATTEND |
| Ron Romano | rromano@ford.com | Ford | ATTEND |
| Paul Rubas | paul.j.rubas@exxonmobil.com | ExxonMobil | ATTEND |
| Jim Carter | jcarter@gageproducts.com | Gage | ATTEND |
| Aleise Gauer | aleise.gauer@gm.com | GM | MIKE |
| Prasad Tumati | ptumati@jhaltermann.com | Haltermann | ATTEND |
| Andy Ritchie | Andrew.Ritchie@infineum.com | Infineum | ATTEND |
| Adrian Alfonso | Adrian.Alfonso@intertek.com | Intertek | ATTEND |
| Andrew Stevens | andrew.stevens@Lubrizol.com | Lubrizol | ATTEND |
| Jason Bowden | jhbowden@ohtech.com | OHT | ATTEND |
| Jeff Hsu | j.hsu@shell.com | Shell | ATTEND |
| Dan Worcester | Dan.Worcester@swri.org | SwRI | ATTEND |
| Dan Lanctot | dlanctot@tei-net.com | TEI | ATTEND |
| Rich Grundza | reg@astmtmc.cmu.edu | TMC | ATTEND |
| Teri Kowalski | Teri.Kowalski@tema.toyota.com | Toyota | |
| Amol Savant | acsavant@valvoline.com | Valvoline | ATTEND |

**ASTM SEQUENCE VI**

| Name | Email | Company | Attend |
|---|---|---|---|
| Ed Altman | Ed.Altman@aftonchemical.com | Afton | |
| Bill Anderson | Bill.anderson@aftonchemical.com | Afton | |
| Bob Campbell | Bob.Campbell@aftonchemical.com | Afton | ATTEND |
| Lisa Dingwell | Lisa.Dingwell@AftonChemical.com | Afton | |
| Todd Dvorak | Todd.Dvorak@aftonchemical.com | Afton | |
| Terry Hoffman | Terry.Hoffman@aftonchemical.com | Afton | |
| Christian Porter | Christian.Porter@aftonchemical.com | Afton | |
| Jeremy Styer | Jeremy.Styer@aftonchemical.com | Afton | |
| Clifford Salvesen | Clifford.R.Salvesen@exxonmobil.com | EM | |
| Jonathan VanScoyoc | VANSCJ@cpchem.com | CPChem | ATTEND |
| Mike Deegan | mdeegan@ford.com | Ford | |
| Bob Patzelt | bpatzelt@gageproducts.com | Gage | ATTEND |
| Veronica Akers | veronica.akers@gm.com | GM | |
| Tim Cushing | timothy.cushing@gm.com | GM | |
| Meryn Hopp | Meryn.Hopp@GM.com | GM | |
| Michael Raney | Michael.p.Raney@gm.com | GM | ATTEND |
| Charles VanCamp | charles.vancamp@gm.com | GM | |
| Ed Hennessy | ehennessy@jhaltermann.com | Haltermann | |
| Indresh Mathur | imathur@jhaltermann.com | Haltermann | |
| Doyle Boese | Doyle.Boese@infineum.com | Infineum | ATTEND |
| Charlie Leverett | Charlie.Leverett@yahoo.com | Infineum | ATTEND |
| William Buscher | William.Buscher@intertek.com | Intertek | |
| Martin Chadwick | Martin.Chadwick@intertek.com | Intertek | |
| Al Lopez | Al.Lopez@intertek.com | Intertek | |
| Scott Rajala | srajala@ILAcorp.com | Idemitsu | |
| Dave Passmore | dpassmore@imtsind.com | IMTS | |
| Stuart Bartley | stuart.bartley@lubrizol.com | Lubrizol | |
| Jerry Brys | Jerome.Brys@lubrizol.com | Lubrizol | |
| Tony Jang | Tony Jang@Lubrizol.com | Lubrizol | |
| Joe Gleason | Jog1@lubrizol.com | Lubrizol | |
| James Matasik | James.Matasic@lubrizol.com | Lubrizol | |
| Will O'Ryan | William.ORyan@Lubrizol.com | Lubrizol | |
| Chris Castanien | Chris.Castanien@neste.com | Neste | |
| Dwight Bowden | dhbowden@ohtech.com | OHT | |
| Matt Bowden | mjbowden@ohtech.com | OHT | |
| Ricardo Affinito | affinito@chevron.com | Oronite | |
| Ian Elliot | IanElliott@chevron.com | Oronite | |
| Jo Martinez | jogm@chevron.com | Oronite | |
| Kirsten Runyan | | Oronite | ATTEND |
| Robert Stockwell | rsto@chevron.com | Oronite | |

**ASTM SEQUENCE VI**

| Name | Email | Company | Attend |
|---|---|---|---|
| Dan Engstrom | daniel.engstrom@swRI.org | SwRI | ATTEND |
| Travis Kostan | Travis.Kostan@swRI.org | SwRI | ATTEND |
| Patrick Lang | Patrick.Lang@swRI.org | SwRI | ATTEND |
| Michael Lochte | mlochte@swri.org | SwRI | ATTEND |
| | | | |
| Karen Haumann | Karen.Haumann@shell.com | Shell | |
| Sean Moyer | sam@astmtmc.cmu.edu | TMC | |
| Jeff Clark | jac@astmtmc.cmu.edu | TMC | |
| Hirano Satoshi | Satoshi_Hirano_aa@mail.toyota.co.jp | Toyota | |
| Mark Adams | mark@tribologytesting.com | Tribology Testing | |
| Timothy Caudill | Tlcaudill@valvoline.com | Valvoline | |
| Chris Taylor | Chris.Taylor@vpracingfuels.com | VP Racing Fuels | |
| Richard Blakely | | | |
| | | | |
| | | | |
| | | | |

**ASTM SEQUENCE VI**

| Name | Email | Company | Attend |
|---|---|---|---|

| MOTION: | FUEL BATCH ANALYSIS | | | |
|---|---|---|---|---|
| Ben Maddock | APPROVE | | | |
| Brianne Hockkeppel | | | | |
| Robert Stockwell | APPROVE | | | |
| Haiying Tang | | | | |
| Tracey King | WAIVE | | | |
| Ron Romano | APPROVE | | | |
| Paul Rubas | | | | |
| Jim Carter | WAIVE | | | |
| Mike Raney | APPROVE | | | |
| Prasad Tumati | WAIVE | | | |
| Andy Ritchie | APPROVE | | | |
| Adrian Alfonso | APPROVE | | | |
| Andrew Stevens | APPROVE | | | |
| Jason Bowden | WAIVE | | | |
| Jeff Hsu | WAIVE | | | |
| Dan Worcester | APPROVE | | | |
| Dan Lanctot | WAIVE | | | |
| Rich Grundza | APPROVE | | | |
| Teri Kowalski | | | | |
| Amol Savant | WAIVE | | | |
| | 9 Y, 7 WAIVE | | | |

**ASTM SEQUENCE VI**

| Name | Email | Company | Attend |
|---|---|---|---|

| **MOTION:** | | | | |
|---|---|---|---|---|
| Ben Maddock | | | | |
| Brianne Hockkeppel | | | | |
| Kevin Brodwater | | | | |
| Haiying Tang | | | | |
| Tracey King | | | | |
| Ron Romano | | | | |
| Paul Rubas | | | | |
| Jim Carter | | | | |
| Aleise Gauer | | | | |
| Prasad Tumati | | | | |
| Andy Ritchie | | | | |
| Adrian Alfonso | | | | |
| Andrew Stevens | | | | |
| Jason Bowden | | | | |
| Jeff Hsu | | | | |
| Dan Worcester | | | | |
| Dan Lanctot | | | | |
| Rich Grundza | | | | |
| Teri Kowalski | | | | |
| Amol Savant | | | | |
| | | | | |

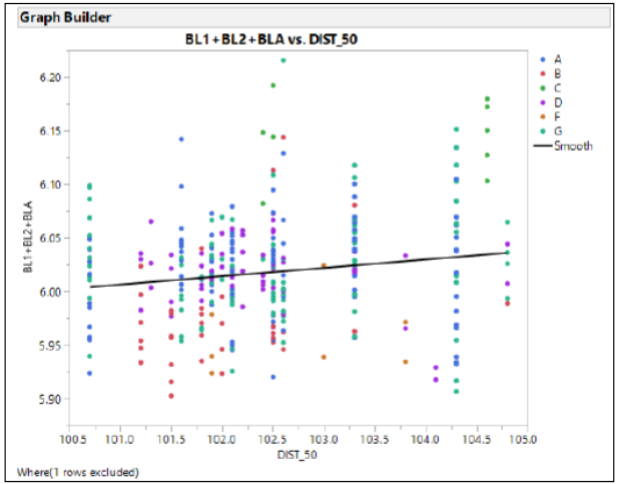
# Seq VI Alternative Fuel Round Robin Results

**Data Comparisons for Discussion**

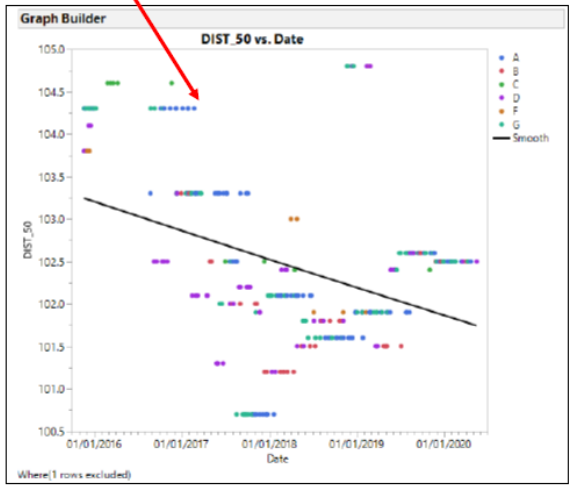
9/8/2020

# Fuel Consumed: Distillation @ 50

- **Plots of significant variables – Dist_T50**
  - Range of Dist_T50: 100.7 – 104.8
  - Dist_T50 exhibits some relationship with calendar date




Dist_T50 vs. BLB1+BLB2+BLA

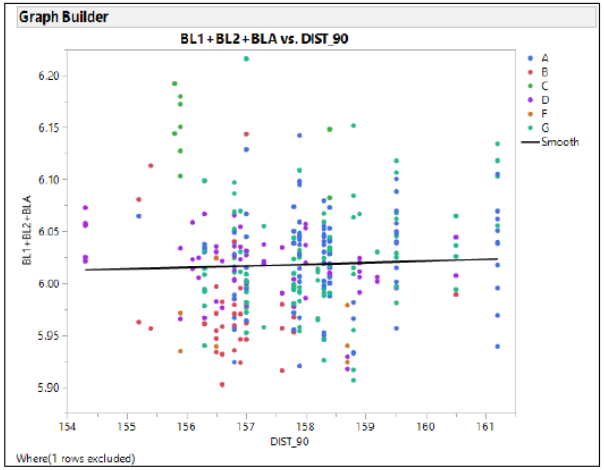



Dist_T50 vs. Date

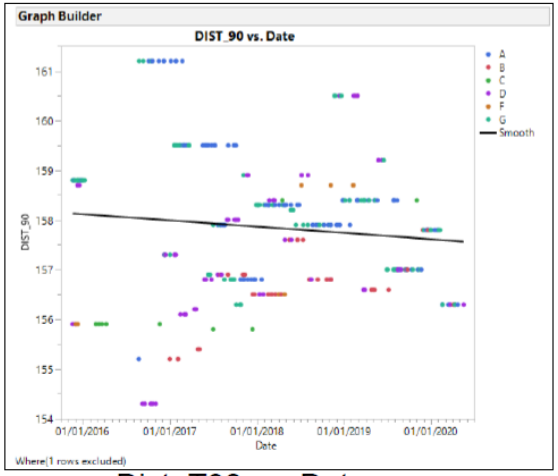
| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek - 70 | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| Distillation - 50% | 102 | 103.1 | 102.2 | 103.277778 | 103.5 | 101.8889 | 103.2 | 101.9 | Distillation - 50% | 102.7 | 101.8889 | 103 | 102 | 102.4444 | 102.2 |

# Fuel Consumed: Distillation @ 90

- **Plots of significant variables – Dist_T90**
  - Range of Dist_T90: 154.3 – 161.2




Dist_T90 vs. BLB1+BLB2+BLA



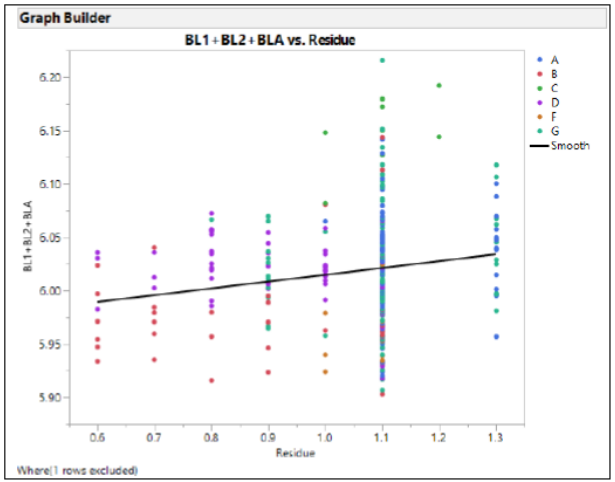

Dist_T90 vs. Date

| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek - 70 | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| Distillation - 90% | 157.7 | 157.1 | 156.1 | 158.222222 | 158.44444 | 157.1111 | 157.7 | 157.6 | Distillation - 90% | 157.3 | 155.4444 | 158 | 157.7 | 156.9444 | 156.1 |

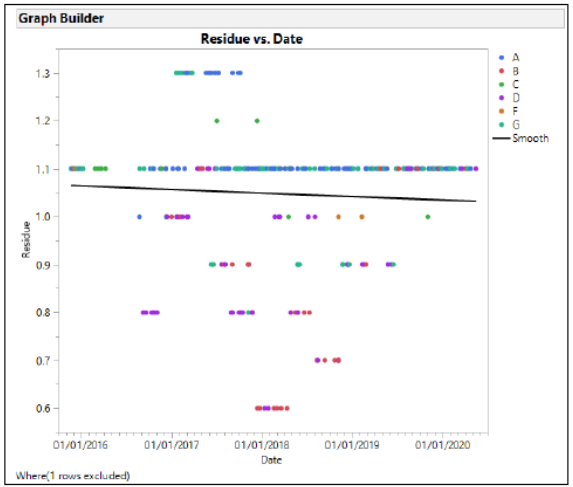
# Fuel Consumed: Residue

## Plots of significant variables – Residue

- Range of Residue: 0.6 – 1.3




Residue vs. BLB1+BLB2+BLA



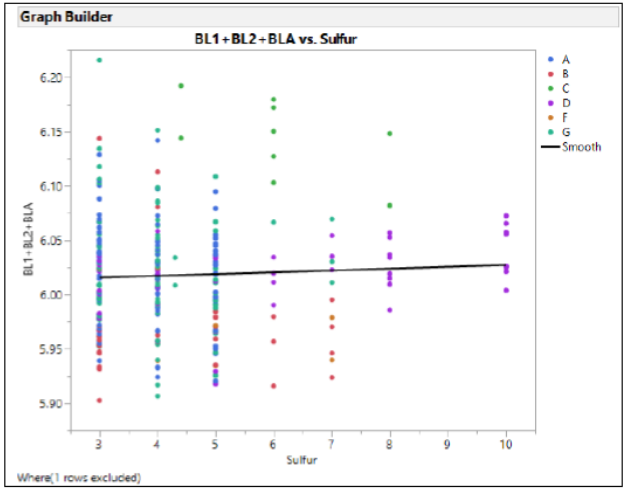

Residue vs. Date

| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek - 70 | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| Residue | 1.1 | 0.7 | 0.6 | 0.7 | 0.9 | 1 | 0.8000 | 0.9000 | Residue | 1.1 | 1.1 | 1 | 1.1 | 0.7 | 0.6 |

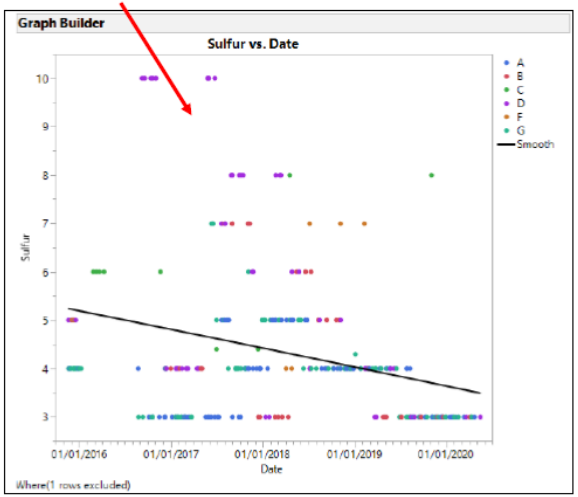
# Fuel Consumed: Sulfur

## Plots of significant variables – Sulfur

- Range of Sulfur: 3 – 10
- Sulfur exhibits some relationship with calendar date




Sulfur vs. BLB1+BLB2+BLA




Sulfur vs. Date

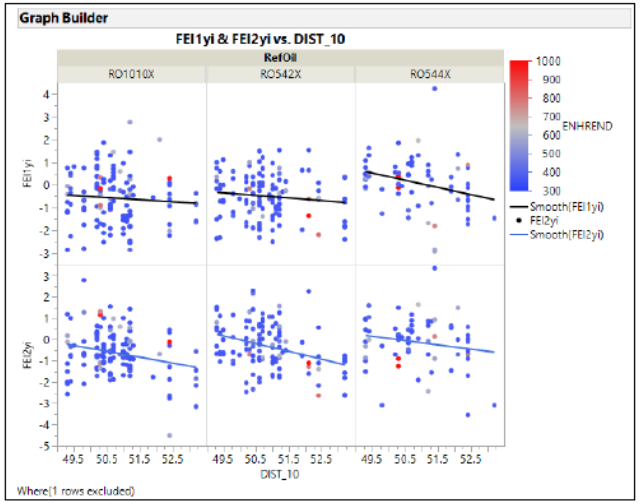
| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| Sulfur | | 7.8 | 4.2 | 2.32 | 2.49 | 2.4 | 2.8 | 2.7 | Sulfur | 3 | 2.3 | 2.9 | | 2.47**** | 2.3 |

**** Sulfur by UV D5453

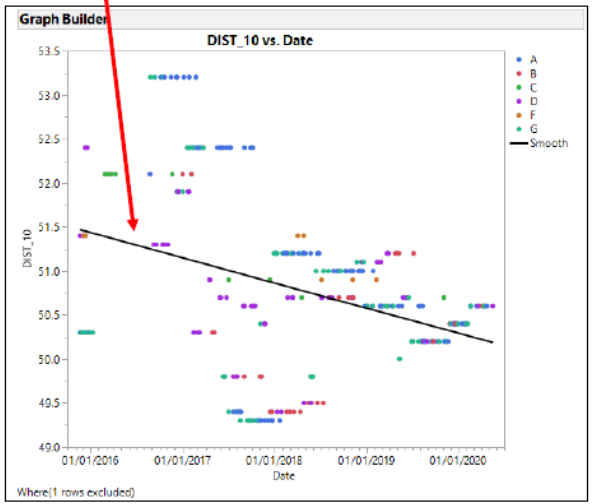
# FEI1 & FEI2: Distillation @10

## Plots of significant variable – Dist_T10

- Range of Dist_T10: 49.3 – 53.6
- Dist_T10 exhibits some relationship with calendar date




Dist10 vs. FEIYi



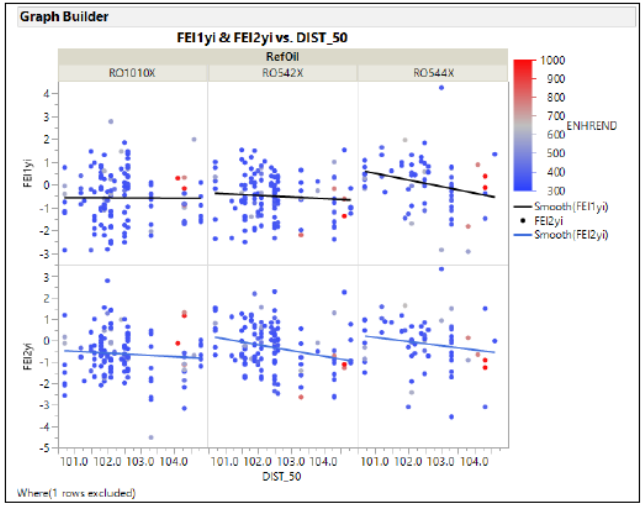

Dist10 vs. Date

| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek - 70 | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| Distillation - 10% | 50.9 | 51.1 | 50.6 | 52.2222222 | 52.166667 | 49.83333 | 51.8 | 50.5 | Distillation - 10% | 50.3 | 50.11111 | 51 | 50.9 | 50.61111 | 50.6 |

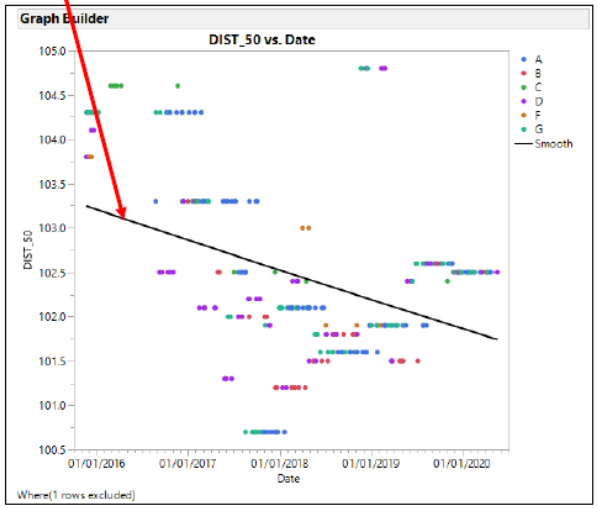
# FEI1 & FEI2: Distillation @50

## Plots of significant variable – Dist_T50

- Range of Dist_T50: 100.7 – 104.8
- Dist_T50 exhibits some relationship with calendar date




Dist_T50 vs. FEIYi



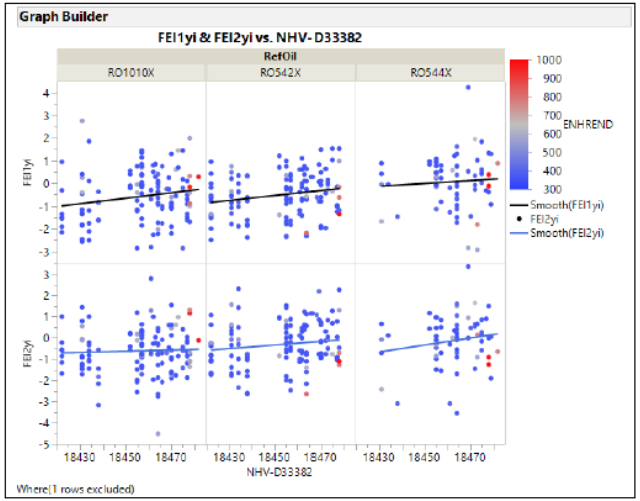

Dist_T50 vs. Date

| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek - 70 | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| Distillation - 50% | 102 | 103.1 | 102.2 | 103.277778 | 103.5 | 101.8889 | 103.2 | 101.9 | Distillation - 50% | 102.7 | 101.8889 | 103 | 102 | 102.4444 | 102.2 |

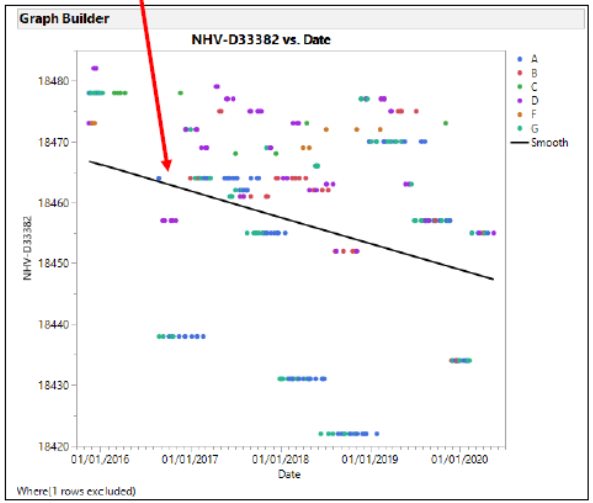
# FEI1 & FEI2: NHV – D3338

## Plots of significant variable – NHV-D33382

- Range of NHV-D33382 : 18422 – 18482
- NHV-D33382 exhibits some relationship with calendar date




NHV-D33382 vs. FEIYi



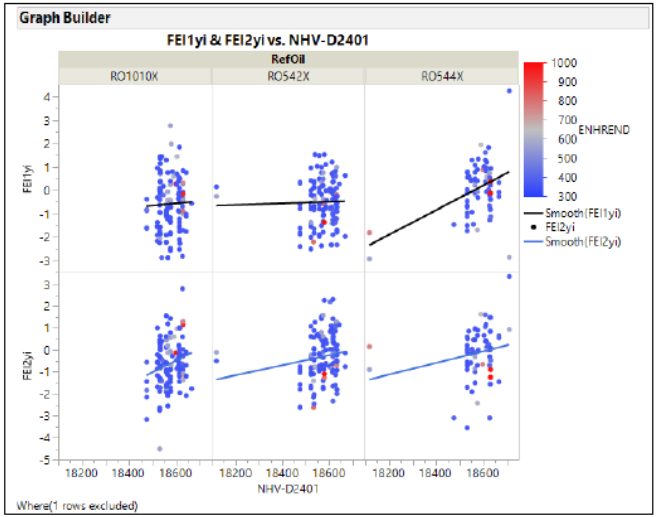

NHV-D33382 vs. Date

| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| NHV D3338 | | | 18488.36 | | | 18492.16 | | | Net Heating Value | | | | | | 18359 |

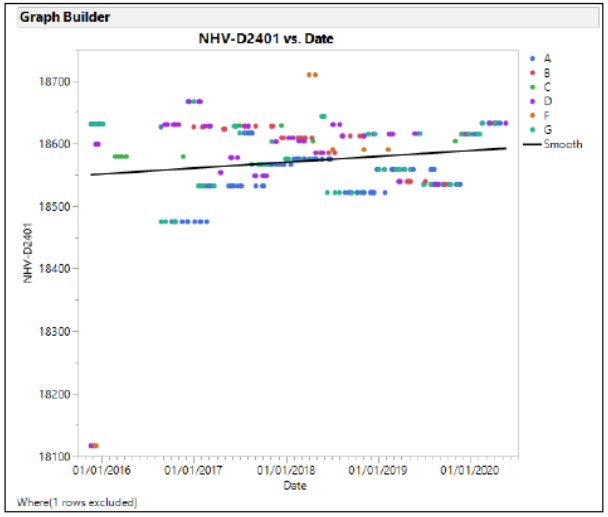
# FEI1 & FEI2: NHV – D240

## Plots of significant variable – NHV-D2401

- Range of NHV-D2401: 18117 – 18710




NHV-D2401 vs. FEIYi



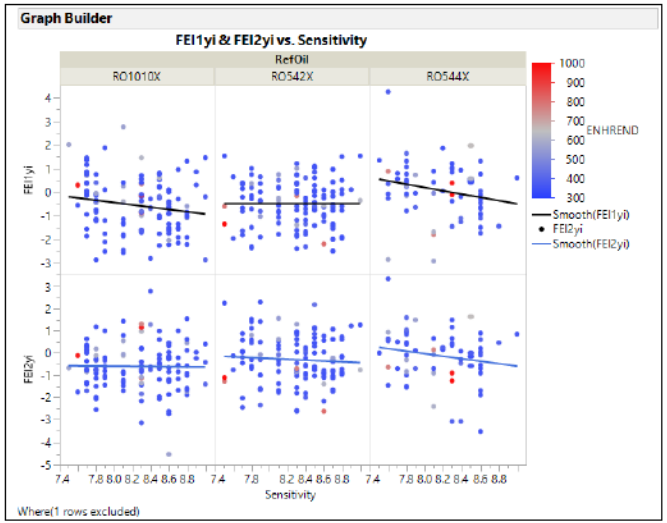

NHV-D2401 vs. Date

| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| NHV D240 | | 18590 | 18590 | 18602 | 18562 | 18523 | 18726 | 18799 | NHV D2401 | 18565 | 18537 | 18965 | | 18570 | 18639 |

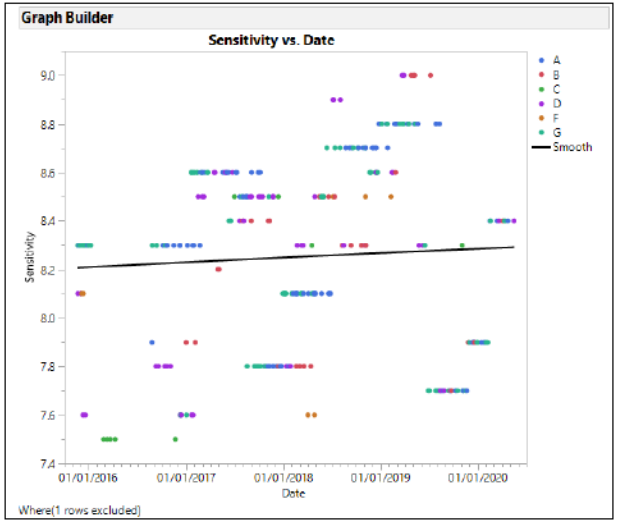
# FEI1 & FEI2: Sensitivity

## Plots of significant variable – Sensitivity (RON-MON)

- Range of Sensitivity : 7.5 – 9.0




Sensitivity vs. FEIYi




Sensitivity vs. Date

| Tanks | | | | | | | | | Haltermann Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labs/Tanks | | | | | | | | | Labs | | | | | |
| Parameter | Lubrizol | Ashland | ExMo | SwRI - 180A | SwRI 180-B | Afton | Intertek | Intertek | Parameter | Haltermann | Afton | Intertek | Lubrizol | SwRI | ExMo |
| Sensitivity | | | 7.986563 | | | 8.5 | | | Sensitivity | | | | | | |

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**Seq. VI Lube Certification Fuel**

| TEST | METHOD | UNITS | Seq. VI Specs | | | Haltermann |
|---|---|---|---|---|---|---|
| | | | MIN | TARGET | MAX | |
| Distillation - IBP | ASTM D86 | °C | 23.9 | | 35.0 | 29.9 |
| 5% | | °C | | | | 43.5 |
| 10% | | °C | 48.9 | | 57.2 | 50.3 |
| 20% | | °C | | | | 60.4 |
| 30% | | °C | | | | 72.1 |
| 40% | | °C | | | | 87.7 |
| 50% | | °C | 93.3 | | 110.0 | 102.7 |
| 60% | | °C | | | | 110.8 |
| 70% | | °C | | | | 116.9 |
| 80% | | °C | | | | 127.1 |
| 90% | | °C | 151.7 | | 162.8 | 157.3 |
| 95% | | °C | | | | 171.1 |
| Distillation - EP | | °C | | | 212.8 | 198.2 |
| Recovery | | vol % | | Report | | 97.9 |
| Residue | | vol % | | Report | | 1.1 |
| Loss | | vol % | | Report | | 1.0 |
| Gravity @ 60°F/60°F | ASTM D4052 | °API | 58.7 | | **61.2** | 59.5 |
| Density @ 15° C | ASTM D4052 | kg/l | 0.734 | | 0.744 | 0.740 |
| Reid Vapor Pressure | ASTM D5191 | kPa | 60.1 | | 63.4 | 60.7 |
| Carbon | ASTM D3343 | wt fraction | | Report | | |
| Carbon | ASTM D5291 | wt fraction | | Report | | |
| Hydrogen | ASTM D5291 | wt fraction | | Report | | |
| Hydrogen/Carbon ratio | ASTM D5291 | mole/mole | | Report | | |
| Oxygen* | ASTM D4815 | wt % | | | 0.05 | <0.01 |
| Oxygenates Ethanol | ASTM D4815 | % | | Report | | |
| MTBE | | % | | Report | | |
| ETBE | | % | | Report | | |
| Methanol | | % | | Report | | |
| Sulfur | ASTM D5453 | mg/kg | 3 | | 15 | 3 |
| Benzene | ASTM D3606 | vol % | | | 1.00 | |
| **Composition, aromatics** | **ASTM D5769** | **vol %** | **(32.5) 26** | | **(34.5) 32.5** | 32.2 |
| **C6 aromatics (benzene)** | **ASTM D5769** | **vol %** | | | **1.00** | 0.1 |
| **C7 aromatics (toluene)** | **ASTM D5769** | **vol %** | | **Report** | | 19.4 |
| **C8 aromatics** | **ASTM D5769** | **vol %** | | **Report** | | 1.5 |
| **C9 aromatics** | **ASTM D5769** | **vol %** | | **Report** | | 9.1 |
| **C10+ aromatics** | **ASTM D5769** | **vol %** | | **Report** | | 2.2 |
| **Composition, olefins** | **ASTM D6550** | **wt%** | | | **2.0** | 0.5 |
| Lead* | ASTM D3237 | mg/l | | | 2.6 | |
| Manganese* | ASTM D3831 | g/gal | | | 0.01 | |
| Phosphorus* | ASTM D3231 | mg/l | | | 1.3 | |
| Silicon * | ASTM D5185 | mg/kg | | | 4 | |
| Particulate matter | ASTM D5452 | mg/l | | | 1 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Oxidation Stability | ASTM D525 | minutes | 1000 | | | |
| Copper Corrosion | ASTM D130 | | | | 1 | 1A |
| Gum content, washed | ASTM D381 | mg/100mls | | | 5.0 | |
| Gum content, unwashed | ASTM D381 | mg/100mls | 7.0 | | 20.0 | |
| Research Octane Number | ASTM D2699 | | 96.0 | | | |
| Motor Octane Number | ASTM D2700 | | | Report | | |
| R+M/2 | D2699/2700 | | | Report | | |
| Sensitivity | | | 7.5 | | | |
| Net Heating Value, btu/lb | ASTM D3338 | btu/lb | | Report | | |
| Gross Heating Value, btu/ | ASTM D240 | btu/lb | | Report | | |
| Net Heating Value, btu/lb | ASTM D240 | btu/lb | | Report | | 18565 |
| Water and Sediment | ASTM D2709 | vol% | | | 0.01 | |
| Color ** | VISUAL | 1.75 ptb | | Red | | |
| Top Tier Additive*** | | 69.3 ptb | | Report | | |

BLANK VALUES WERE NOT REPORTED

**IAR Method for Distillation D2887

** IAR used ICP

*** Reported Dry Vapor

**** Sulfur by UV D5453

| (outsourced) Afton | Intertek | Lubrizol | Swri | (outsourced) ExxonMobil |
|---|---|---|---|---|
| 30.1 | 34 | 29.5 | 31 | 32.2 |
| 43.3 | 43 | 44.5 | 44 | 43.9 |
| 50.1 | 51 | 50.9 | 51 | 50.6 |
| 60.4 | 62 | 60.7 | 61 | 60.6 |
| 72.0 | 73 | 72.2 | 72 | 71.7 |
| 87.5 | 89 | 87.6 | 88 | 87.2 |
| 101.9 | 103 | 102 | 102 | 102.2 |
| 110.1 | 111 | 109.8 | 111 | 110.6 |
| 116.1 | 117 | 115.9 | 117 | 116.7 |
| 126.4 | 127 | 126.3 | 126 | 126.7 |
| 155.4 | 158 | 157.7 | 157 | 156.1 |
| 170.2 | 171 | 169.8 | 170 | 169.4 |
| 196.8 | 199 | 196.9 | 195 | 196.1 |
| 97.9 | 95.9 | 98.7 | 98.5 | 98.3 |
| 1.1 | 1 | 1.1 | 0.7 | 0.6 |
| 1.0 | 3.1 | 0.2 | 0.8 | 1.1 |
| 59.6 | 59.0900 | 59.6 | 59.5 | 59.4 |
| 0.7404 | 0.74213 | 0.7402 | 0.7406 | 0.7408 |
| 61.8 | 62.40 | 8.88*** | 63 | 56.52*** |
| | | | 86.37 | Not Avail |
| 86.6 | | | 86.72 | 86.90 |
| 13.2 | | | 13.59 | 13.58 |
| 1.815 | | | 6.500 | 1.862 |
| <0.02 | <0.20 | | <0.2 | <0.2 |
| <0.1 | <0.20 | | <0.2 | < 0.2 |
| <0.1 | <0.20 | | <0.2 | < 0.2 |
| <0.1 | <0.20 | | <0.2 | <0.2 |
| <0.1 | <0.20 | | <0.2 | < 0.2 |
| 2.3 | 2.9 | | 2.47**** | 2.3 |
| | | | | |
| 31.6 | | | 30.51 | 31.16 |
| 0.0 | | | 0.02 | 0.05 |
| 19.4 | | | 18.1 | 18.82 |
| | | | 1.4 | 1.3 |
| | | | 8.9 | 8.93 |
| | | | 1.2 | 2.06 |
| <1.0 | | | not availab | 0.04 |
| <0.1 g/USG | <0.0001** | | <0.001 | < 0.264 |
| <0.0009 | <0.0001** | | <0.2 | < 0.00076 |
| <0.211 | <0.0001** | | <0.2 | <0.2 |
| <0.20 | <0.0001** | | | Not Avail |
| 0.2 | | | 1 | 0.8 |

| | | | | |
|---|---|---|---|---|
| 960+ | >1000 | | 1440 | 1440 |
| 1A | 1A | 1a | 1 | 1a |
| <0.5 | 0 | <0.5 | <0.5 | <0.5 |
| 12.0 | 12.6 | 11 | 11 | 11 |
| 96.6 | 97.0000 | | 96.7 | 96.7 |
| 88.5 | 88.7000 | | 88.2 | 88 |
| 92.6 | 92.85 | | 92.4 | 92.4 |
| | | | 8.5 | |
| | | | | 18359 |
| 19740.0 | 19761 | | 18570 | 19858 |
| 18537.0 | 18965 | | 0.7406 | 18639 |
| <0.01 | | | <0.005 | <0.005 |
| | CLEAR | L3.0 | clear no color | Clear |

**PRODUCT:** **Sequence VI-E W/DCA**

**PRODUCT CODE:** **HF2003**

| | Lubrizol | Valvoline | ExxonMobil |
|---|---|---|---|
| **Batch No.:** | | | |
| **TMO No.:** | | outsourced | Out sourced |
| **Tank No.:** | | | |
| **Analysis Date:** | | | |
| **Sample Date:** | | | |

| TEST | METHOD | UNITS | HALTERMANN Specs MIN | TARGET | MAX | RESULTS | RESULTS | RESULTS |
|---|---|---|---|---|---|---|---|---|
| Distillation - IBP | ASTM D86 | °C | 23.9 | | 35.0 | 29.5 | 30.4 | 32.2 |
| 5% | | °C | | | | 44.5 | 43.9 | 43.9 |
| 10% | | °C | 48.9 | | 57.2 | 50.9 | 51.1 | 50.6 |
| 20% | | °C | | | | 60.7 | 60.9 | 60.6 |
| 30% | | °C | | | | 72.2 | 72.9 | 71.7 |
| 40% | | °C | | | | 87.6 | 88.7 | 87.2 |
| 50% | | °C | 93.3 | | 110.0 | 102 | 103.1 | 102.2 |
| 60% | | °C | | | | 109.8 | 110.4 | 110.6 |
| 70% | | °C | | | | 115.9 | 116.6 | 116.7 |
| 80% | | °C | | | | 126.3 | 126.3 | 126.7 |
| 90% | | °C | 151.7 | | 162.8 | 157.7 | 157.1 | 156.1 |
| 95% | | °C | | | | 169.8 | 170.9 | 169.4 |
| Distillation - EP | | °C | | | 212.8 | 196.9 | 202.3 | 196.1 |
| Recovery | | vol % | | Report | | 98.7 | 98.6 | 98.3 |
| Residue | | vol % | | Report | | 1.1 | 0.7 | 0.6 |
| Loss | | vol % | | Report | | 0.2 | 0.7 | 1.1 |
| Gravity @ 60°F/60°F | ASTM D4052 | °API | 58.7 | | 61.2 | 59.6 | 59.0 | 59.4 |
| Density @ 15° C | ASTM D4052 | kg/l | 0.734 | | 0.744 | 0.7402 | 0.7429 | 0.7408 |
| Reid Vapor Pressure | ASTM D5191 | kPa | 60.1 | | 63.4 | 8.88 | 9.0300 | 56.52 |
| Carbon | ASTM D3343 | wt fraction | | Report | | | | Not Avail |
| Carbon | ASTM D5291 | wt fraction | | Report | | | 86.76 | 86.90 |
| Hydrogen | ASTM D5291 | wt fraction | | Report | | | 13.41 | 13.58 |
| Hydrogen/Carbon ratio | ASTM D5291 | mole/mole | | Report | | | | 1.862 |
| Oxygen | ASTM D4815 | wt % | | | 0.05 | | <0.2 | <0.01 |
| Sulfur | ASTM D5453 | mg/kg | 3 | | 15 | | 7.8 | 4 |
| Lead | ASTM D3237 | mg/l | | | 2.6 | | <0.001 | <1 |
| Phosphorous | ASTM D3231 | mg/l | | | 1.3 | | <0.05 | <0.05 |
| Composition, aromatics | ASTM D1319 | vol % | 26.0 | | 32.5 | | | |
| Composition, olefins | ASTM D1319 | vol % | | | 10.0 | | | |
| Composition, saturates | ASTM D1319 | vol % | | Report | | | 71.8 | 71.8 |
| Composition, aromatics | ASTM D5769 | vol % | 31 | | 34 | | 33.3 | 30.44 |
| C6 aromatics (benzene) | ASTM D5769 | Vol% | | | | | | 0.06 |
| C7 aromatics (toluene) | ASTM D5769 | Vol% | | | | | | 18.46 |
| C8 aromatics | ASTM D5769 | Vol% | | | | | | 1.27 |
| C9 aromatics | ASTM D5769 | Vol% | | | | | | 8.66 |
| C10+ aromatics | ASTM D5769 | Vol% | | | | | | 2.01 |
| Olefins | D6550 | wt % | | | 1 | | <1 | |
| Particulate matter | ASTM D5452 | mg/l | | | 1 | | 0.5 | 0.5 |
| Oxidation Stability | ASTM D525 | minutes | 1000 | | | 1000+ | 1440 | 1000+ |
| Copper Corrosion | ASTM D130 | | | | 1 | 1a | 1a | 1a |
| Gum content, washed | ASTM D381 | mg/100mls | | | 5.0 | <0.5 | <0.5 | <0.5 |
| Gum content, unwashed | | | 7 | | 20.0 | 11.0 | 13.0 | 10.0 |
| Fuel Economy Numerator/C Density | ASTM D5291 | | 2401 | | 2441 | | | |
| C Factor | ASTM D5291 | | | Report | | | | 0.9991 |
| Research Octane Number | ASTM D2699 | | 96.0 | | | | 97.4 | 96.4 |
| Motor Octane Number | ASTM D2700 | | | Report | | | 88.9 | 88.4 |
| Sensitivity | | | 7.5 | | | | | 8.0 |
| Net Heating Value, btu/lb | ASTM D3338 | btu/lb | | Report | | | | 18488 |
| Net Heating Value, btu/lb | ASTM D240 | btu/lb | | Report | | | 18590 | 18590 |
| Color | VISUAL | 1.75 ptb | | Red | | L3.0 | Red | Red |
| Top Tier Additive | | 69.3 ptb | | Report | | Added at Top Tier Rate | Added at Top Tier Rate | Added at Top Tier Rate |
| Other | | | | | | | | |
| Methanol (MeOH) | | vol% | | | | | <0.2 | <0.2 |
| Ethanol (EtOH) | | vol% | | | | | <0.2 | <0.2 |
| Isopropanol (iPA) | | vol% | | | | | <0.2 | <0.2 |
| tert-Butanol (tBA) | | vol% | | | | | <0.2 | <0.2 |
| n-Propanol (nPA) | | vol% | | | | | <0.2 | <0.2 |
| Methyl tert-butylether (MTBE) | | vol% | | | | | <0.2 | <0.2 |
| sec-Butanol (sBA) | | vol% | | | | | <0.2 | <0.2 |
| Diisopropylether (DIPE) | | vol% | | | | | <0.2 | <0.2 |
| Isobutanol (iBA) | | vol% | | | | | <0.2 | <0.2 |
| Ethyl tert-butylether (ETBE) | | vol% | | | | | <0.2 | <0.2 |
| tert-Pentanol (tPA) | | vol% | | | | | <0.2 | <0.2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| n-Butanol (nBA) | | vol% | | | <0.2 | <0.2 |
| tert-amyl methylether (TAME) | | vol% | | | <0.2 | <0.2 |
| Total Oxygen | | WT% | | | <0.2 | <0.2 |
| | | | | | | |
| Aromatics by GCMS | | | | | | |
| Benzene | | Vol% | | | <0.1 | <0.1 |
| Toluene | | Vol% | | | 21.9 | 21.9 |
| Total Aromatics | | Vol% | | | 33.3 | 33.3 |
| Ethylbenzene | | Vol% | | | <0.1 | <0.1 |
| m p-Xylene | | Vol% | | | 0.1 | 0.1 |
| Oxylene | | Vol% | | | 0.4 | 0.4 |
| Iso-propylbenzene | | Vol% | | | <0.1 | <0.1 |
| n-Propylbenzene | | Vol% | | | 0.6 | 0.6 |
| 1-Methyl-3-Ethylbenzene | | Vol% | | | 1.9 | 1.9 |
| 1-Methyl-4-Ethylbenzene | | Vol% | | | 0.9 | 0.9 |
| 1,3,5-Trimethylbenzene | | Vol% | | | 0.8 | 0.8 |
| 1-Methyl-2-Ethylbenzene | | Vol% | | | 0.9 | 0.9 |
| 1,2,4-Trimethylbenzene | | Vol% | | | 3.6 | 3.6 |
| 1,2,3-Trimethylbenzene | | Vol% | | | 0.7 | 0.7 |
| Indan | | Vol% | | | 0.1 | 0.1 |
| 1,4 Diethylbenzene | | Vol% | | | 0.3 | 0.3 |
| *n* -Butylbenzene | | Vol% | | | <0.1 | <0.1 |
| 1,2-Diethylbenzene | | Vol% | | | <0.1 | <0.1 |
| 1,2,4,5-Trimethylbenzene | | Vol% | | | <0.1 | <0.1 |
| 1,2,3,5-Trimethylbenzene | | Vol% | | | <0.1 | <0.1 |
| Napthalene | | Vol% | | | 0.1 | 0.1 |
| Pentamethylbenzene | | Vol% | | | <0.1 | <0.1 |
| 2-Methyl-napthalene | | Vol% | | | 0.2 | 0.2 |
| 1-Methyl-napthalene | | Vol% | | | 0.1 | 0.1 |
| C10-Benzenes | | Vol% | | | 0.6 | 0.6 |
| C11-Benzenes | | Vol% | | | <0.1 | <0.1 |
| C12-Benzenes | | Vol% | | | <0.1 | <0.1 |
| Alkyl Indans | | Vol% | | | <0.1 | <0.1 |
| **Composition, aromatics** | | **vol %** | | | | |
| **C6 aromatics (benzene)** | | **vol %** | | | | 0.06 |
| **C7 aromatics (toluene)** | | **vol %** | | | | 18.46 |
| **C8 aromatics** | | **vol %** | | | | 1.27 |
| **C9 aromatics** | | **vol %** | | | | 8.66 |
| **C10+ aromatics** | | **vol %** | | | 0.6 | 2.01 |
| **Composition, olefins** | | **wt%** | | | <1 | 0.05 |
| | | | | | | |

**PRODUCT:** **Sequence VI-E W/DCA**

**PRODUCT CODE:** **HF2003**

**Batch No.:** SwRI
**TMO No.:** 180A
**Tank No.:**
**Analysis Date:**
**Sample Date:**

| TEST | METHOD | UNITS | HALTERMANN Specs MIN | TARGET | MAX | RESULTS |
|---|---|---|---|---|---|---|
| Distillation - IBP | ASTM D86 | °C | 23.9 | | 35.0 | 32 |
| 5% | | °C | | | | 46 |
| 10% | | °C | 48.9 | | 57.2 | 52 |
| 20% | | °C | | | | 62 |
| 30% | | °C | | | | 74 |
| 40% | | °C | | | | 89 |
| 50% | | °C | 93.3 | | 110.0 | 103 |
| 60% | | °C | | | | 111 |
| 70% | | °C | | | | 117 |
| 80% | | °C | | | | 127 |
| 90% | | °C | 151.7 | | 162.8 | 158 |
| 95% | | °C | | | | 170 |
| Distillation - EP | | °C | | | 212.8 | 197 |
| Recovery | | vol % | | Report | | 98.5 |
| Residue | | vol % | | Report | | 0.7 |
| Loss | | vol % | | Report | | 0.8 |
| Gravity @ 60°F/60°F | ASTM D4052 | °API | 58.7 | | 61.2 | 59.2 |
| Density @ 15° C | ASTM D4052 | kg/l | 0.734 | | 0.744 | 0.7419 |
| Reid Vapor Pressure | ASTM D5191 | kPa | 60.1 | | 63.4 | 61.0 |
| Carbon | ASTM D3343 | wt fraction | | Report | | 86.41 |
| Carbon | ASTM D5291 | wt fraction | | Report | | 86.38 |
| Hydrogen | ASTM D5291 | wt fraction | | Report | | 13.26 |
| Hydrogen/Carbon ratio | ASTM D5291 | mole/mole | | Report | | 6.5 |
| Oxygen | ASTM D4815 | wt % | | | 0.05 | <0.2 |
| Sulfur | ASTM D5453 | mg/kg | 3 | | 15 | 2.32 |
| Lead | ASTM D3237 | mg/l | | | 2.6 | <0.001 |
| Phosphorous | ASTM D3231 | mg/l | | | 1.3 | <0.2 |
| Composition, aromatics | ASTM D1319 | vol % | 26.0 | | 32.5 | |
| Composition, olefins | ASTM D1319 | vol % | | | 10.0 | |
| Composition, saturates | ASTM D1319 | vol % | | Report | | |
| Composition, aromatics | ASTM D5769 | vol % | 31 | | 34 | 31.23 |
| C6 aromatics (benzene) | ASTM D5769 | Vol% | | | | 0.02 |
| C7 aromatics (toluene) | ASTM D5769 | Vol% | | | | 18.6 |
| C8 aromatics | ASTM D5769 | Vol% | | | | 1.4 |
| C9 aromatics | ASTM D5769 | Vol% | | | | 9.1 |
| C10+ aromatics | ASTM D5769 | Vol% | | | | 2.1 |
| Olefins | D6550 | wt % | | | 1 | |
| Particulate matter | ASTM D5452 | mg/l | | | 1 | 1.1 |
| Oxidation Stability | ASTM D525 | minutes | 1000 | | | 1440.0 |
| Copper Corrosion | ASTM D130 | | | | 1 | 1 |
| Gum content, washed | ASTM D381 | mg/100mls | | | 5.0 | <0.5 |
| Gum content, unwashed | | | 7 | | 20.0 | 12.0 |
| Fuel Economy Numerator/C Density | ASTM D5291 | | 2401 | | 2441 | |
| C Factor | ASTM D5291 | | | Report | | 0.9991 |
| Research Octane Number | ASTM D2699 | | 96.0 | | | 96.9 |
| Motor Octane Number | ASTM D2700 | | | Report | | 88.0 |
| Sensitivity | | | 7.5 | | | 8.9 |
| Net Heating Value, btu/lb | ASTM D3338 | btu/lb | | Report | | 59.2 |
| Net Heating Value, btu/lb | ASTM D240 | btu/lb | | Report | | 18602 |
| Color | VISUAL | 1.75 ptb | | Red | | Red |
| Top Tier Additive | | 69.3 ptb | | Report | | Added at Top Tier Rate |
| Other | | | | | | |
| Methanol (MeOH) | | vol% | | | | <0.2 |
| Ethanol (EtOH) | | vol% | | | | <0.2 |
| Isopropanol (iPA) | | vol% | | | | |
| tert-Butanol (tBA) | | vol% | | | | |
| n-Propanol (nPA) | | vol% | | | | |
| Methyl tert-butylether (MTBE) | | vol% | | | | <0.2 |
| sec-Butanol (sBA) | | vol% | | | | |
| Diisopropylether (DIPE) | | vol% | | | | |
| Isobutanol (iBA) | | vol% | | | | |
| Ethyl tert-butylether (ETBE) | | vol% | | | | <0.2 |
| tert-Pentanol (tPA) | | vol% | | | | |

| | | | | |
|---|---|---|---|---|
| n-Butanol (nBA) | | vol% | | |
| tert-amyl methylether (TAME) | | vol% | | |
| Total Oxygen | | WT% | | |
| | | | | |
| Aromatics by GCMS | | | | |
| Benzene | | Vol% | | |
| Toluene | | Vol% | | |
| Total Aromatics | | Vol% | | |
| Ethylbenzene | | Vol% | | |
| m p-Xylene | | Vol% | | |
| Oxylene | | Vol% | | |
| Iso-propylbenzene | | Vol% | | |
| n-Propylbenzene | | Vol% | | |
| 1-Methyl-3-Ethylbenzene | | Vol% | | |
| 1-Methyl-4-Ethylbenzene | | Vol% | | |
| 1,3,5-Trimethylbenzene | | Vol% | | |
| 1-Methyl-2-Ethylbenzene | | Vol% | | |
| 1,2,4-Trimethylbenzene | | Vol% | | |
| 1,2,3-Trimethylbenzene | | Vol% | | |
| Indan | | Vol% | | |
| 1,4 Diethylbenzene | | Vol% | | |
| *n* -Butylbenzene | | Vol% | | |
| 1,2-Diethylbenzene | | Vol% | | |
| 1,2,4,5-Trimethylbenzene | | Vol% | | |
| 1,2,3,5-Trimethylbenzene | | Vol% | | |
| Napthalene | | Vol% | | |
| Pentamethylbenzene | | Vol% | | |
| 2-Methyl-napthalene | | Vol% | | |
| 1-Methyl-napthalene | | Vol% | | |
| C10-Benzenes | | Vol% | | |
| C11-Benzenes | | Vol% | | |
| C12-Benzenes | | Vol% | | |
| Alkyl Indans | | Vol% | | |
| **Composition, aromatics** | | **vol %** | | |
| **C6 aromatics (benzene)** | | **vol %** | | 0.02 |
| **C7 aromatics (toluene)** | | **vol %** | | 18.6 |
| **C8 aromatics** | | **vol %** | | 1.4 |
| **C9 aromatics** | | **vol %** | | 9.1 |
| **C10+ aromatics** | | **vol %** | | 2.1 |
| **Composition, olefins** | | **wt%** | | |
| | | | | |