Introduction to Re-Refined Vacuum Tower Asphalt Extenders (VTAEs)

Presented to: OHMPA Road Show
April/May 2015
Purpose of Presentation

- Provide a basic understanding of the characteristics of VTAEs
- Where do VTAEs come from
- How are they (or how “should they” be) used
- Discuss research completed to date
- Provide overview of ongoing research
Agenda

- Oil refining basics
- Crude refinery vs used oil re-refinery
- Statistics
- Research
- Discuss future of VTAEs
VTAEs

- Also known as…
  - REOB – Re-refined engine oil bottoms
  - RHVTB – Re-refined heavy vacuum tower bottoms
  - RMO – Re-refined motor oil
  - WEO – waste engine oil
  - Others as well…some not so flattering

- NORA has established VTAE as the standard for our industry
The Crude Oil Refinery
Asphalt Comes From Vacuum Tower Bottoms
Simplified Schematic – Crude Refinery

Crude Oil → Atmospheric Pressure

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<th>Atmospheric Pressure</th>
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<tbody>
<tr>
<td>LPG</td>
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<tr>
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<tr>
<td>LVGO</td>
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<tr>
<td>HVGO</td>
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<td>Or VTBs</td>
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<td>~800°F</td>
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Asphalt and Lube Oil Production

HVGO

VTBs

Bright Stock Feed

Solvent
De-Asphalting

PDA
Bottoms
or Pitch

Solvent
Extraction

Raffinate

Aromatic
Extract

De-Waxing

Asphalt

Wax-Free
Oils

Wax

*
What Determines Asphalt Grade?

- Crude oil feedstock
  - Heavy Crude: More Asphalt
  - Light Crude: Less Asphalt

- Type of refinery
  - Not all produce the same product slate

- How a given refinery is run
  - Based solely on economics
  - Spread in light vs heavy fraction profitability
  - Asphalt used as Coker feed?

- Lots of blending happens to make asphalt of a given grade
Distillation Process

A portion of the HVGO may be blended back into bitumen to make desired PG grade.

Lubricating Oil Production

De-Waxing

Wax-Free Oils

Hydrotreating and Fractionating

Greases

Low Viscosity Lubes

Medium Viscosity Lubes

High Viscosity Lubes

Wax Free Oils Can Be Further Refined
Wax Free Oils

- Additives are used to enhance oil properties
  - Anti-wear additives
  - Friction reducers
  - Antioxidants

- Why do you change your oil?
  - Additives wear out
  - Wear metals from the engine
  - The base oils (wax-free oils) remain mostly unchanged

- We recycle the recovered oils to refine out the “base oils”
Oil Collection Process

- Oil collectors are required under used oil regulations strictly enforced by EPA to check the oil for contaminants that should not be in the crankcase oil
  - PCB’s from old transformers
  - Water
  - Glycols from coolants
  - Chlorinated compounds such as solvents

- The EPA has determined that oil collected in this way is non-hazardous
Typically, this process results in more lighter oil in the VTAE.
Lube Production – Group II VTAEs

Typically, this process results in less lighter oil in the VTAE

Flash = 550F+
The Oil Re-Refinery

This is the “Real Deal” …a true refinery!
Re-Refined Oils Breakdown

- **~13%**
  - Other Light Fractions (Including Losses)
  - Water, Glycol, Fuels, Light Hydrocarbons

- **~75%**
  - Base Oils For Lubricant Production
  - VGOs

- **~12%**
  - Asphalt Extenders (VTAEs)
  - HVGOs
VTAEs – What is this stuff?

- **Definition**
  - The non-distilled fraction from the vacuum tower of re-refined lubricating oils

“Loosely” Equal To AC-1 Viscosity
Makeup of VTAEs

- Heavy Vacuum Gas Oils (HVGOs)
  - Higher viscosity lubricants
  - From industrial lubricants
    » Locomotives, Heavy Trucks, Generators etc.
  - Higher boiling point than base oils for standard motor oils

- Wear metals from engines, gears etc.

- Additives from motor oils
  - Polymers (synthetic oils)
  - Anti-friction additives (molybdenum)
  - Anti-wear (zinc)
  - Viscosity modifiers
Why Is VTAE Used In Paving Grade Asphalts?

- Used to modify viscosity
  - Crude refiners don’t always produce soft asphalt
  - Low viscosity binder reduces cracking potential

- More RAP/RAS requires softer base asphalt
  - Softer binders need to be engineered
  - Hard base asphalt needs to be blended with a cutter
The Bottom Line

- VTAEs have been used in paving applications for over 30 years in NA as a soft asphalt component to enhance low temperature and aging properties of binders.

- Approximately 160KT of VTAEs are produced in NA: that is ~0.5% of total asphalt and less than ~0.4% of the paving asphalt.
  - Generally it is used between 2% and 6% by weight of binder making up less than 0.2% by weight of total mix.
  - Mix in NA may contain 10-20 times more recycled binder than VTAEs!
  - More recycled asphalt requires softer virgin binder for blending.

\[
\text{Total AC in Mix} = 5.0\%
\text{30\% Recycle replacement} = 1.5\%
\text{Virgin Binder} = 3.5\%
\text{4\% VTAE by weight of Virgin} = 0.14\%
\frac{1.5}{.14} = \sim 11 \text{ times more recycled asphalt}
\]
Myth: Used Engine Oil Is Added Into Asphalt

- Used Engine Oil (UMO) is dehydrated and screened (like crude oil)
- If it is not used as feed for a re-refinery it goes into the marine fuel oil market where it commands significantly higher price than wholesale asphalt
- Since it contains fuel (diesel and gasoline) it is combustible and cannot be used in hot mix plants
- Putting UMO into asphalt would be like pouring a heavy crude oil into asphalt
- Used Engine Oil is NEVER added to asphalt
Use In Paving Binders

- **Benefits** (Dosage Dependent and when used properly)
  - Improve Cold Temperature Properties
    » PG (PAV Properties), Fraass, Low Temperature Pens
  - Reduce Viscosity
  - Improves Resistance to Aging
  - Extends Conventional Asphalt
  - Reduces Carbon Footprint
  - Compatible with Nearly All Asphalts
  - Long History of Use
Where Are We Today?

- ASTM Specification Being Developed
  - NORA, National Oil Recyclers Association
  - Industry specification to be issued

- Technical Studies Starting or In-Progress
  - University of Illinois, Illinois DOT
  - University of MA at Dartmouth, 8 NE States, MA DOT

- Ontario, Canada (Future study as of 4-2015)
  - NE type of study with University of Waterloo
  - Binder and mix testing
  - With and without RAP

- Many other studies by a variety of entities
Proposed Specification (Draft)

- Flash Temperature, COC °F
  - Group I VTAEs for **Paving**: 450 min
  - Group II VTAEs for **Roofing**: 550 min

- RTFO Mass Loss, %
  - Both Groups: <1

- Solubility in TCE, %
  - Both Groups: >98

- Absolute Viscosity, 60°C, P
  - Both Groups: <50
Conclusions

- VTAE is a highly refined product with a set of desirable properties:
  - It is non-toxic and non-carcinogenic
  - It is extremely consistent product with a well defined history
  - Its primary components are non-waxy bright stock and its derivatives as well as polymers
  - It is generally used at levels between 2% and 6% to enhance low temperature and intermediate temperature properties and not used at levels exceeding 15% as advertised in some references
This Process defines VTAEs

VTAEs

VACUUM TOWER ASPHALT EXTENDER

RE-REFINED OIL BASE STOCKS

INDUSTRIAL FUELS

DEHYDRATION

FUEL STRIPPING

VACUUM DISTILLATION

HYDROTREATING
This Process defines VTAEs

THIS IS VTAE!
This Process defines VTAEs

This is NOT VTAE!

This is VTAE!
More Information

- Asphalt Institute Task Force
  - Under “Engineering” tab at their home page
    - http://www.asphaltinstitute.org/re-refined-engine-oil-bottom-residue/
Testing Data

- Several studies completed to date
  - That data can be shared if desired

THANK YOU!