ExxonMobil Phosphorus Volatility Studies – 2/22/07 Update

ESCIT

February 22, 2007

Presentation Overview

- **Review previous ExxonMobil phosphorus volatility studies (9/28 ESCIT meeting)**
  - Phosphorus volatility characteristics of a LMW 2°ZDDP vs a HMW 1°ZDDP
- **Update using $PEI_{165\text{-}16}$**
- **$PEI_{165\text{-}16}$ methodology**

XOM Phosphorus Volatilization Conclusions – 9/28

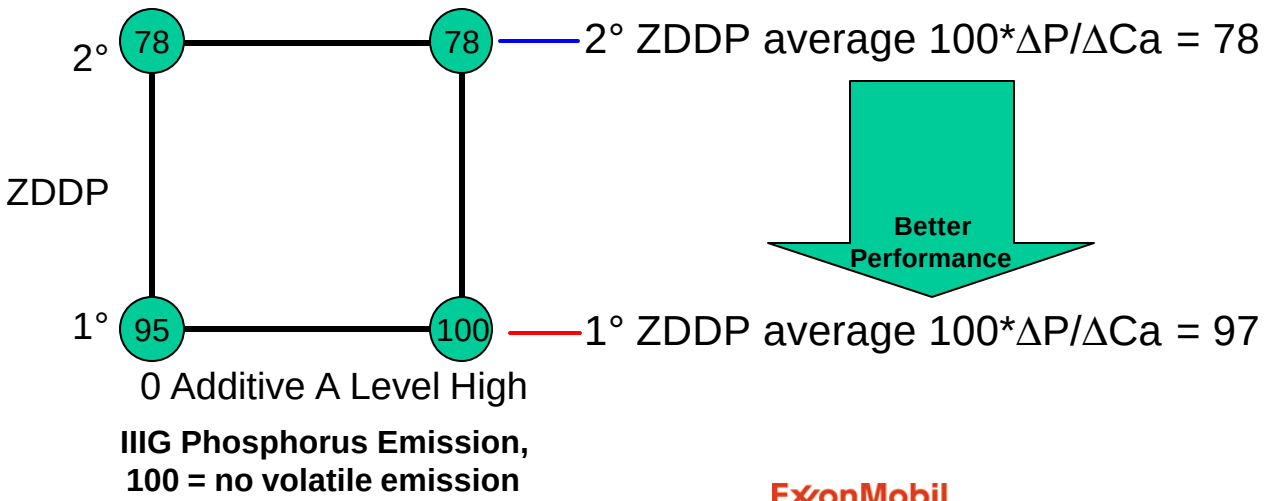
- **Impact of HMW 1° & LMW 2° ZDDP on phosphorus volatilization in several tests was studied**
- **Literature, TGA, IIIG, VIB, Bulk oxidation test, & the ROBO test indicate that the LMW 2° ZDDP volatilizes more P than the HMW 1° ZDDP**
  - Magnitude of Phosphorus loss varies for each test
- **$PEI_{250\text{-}1}$ ranking did not agree with other tests**
  - $PEI_{250\text{-}1}$ results found more P volatilized from the HMW 1° ZDDP than LMW 2° ZDDP

ExxonMobil Phosphorus Volatility 2/22 Update

- **4 Oils previously reported with IIIG data were tested in the $PEI_{165\text{-}16}$ test**
  - 0W-30 formulations
  - 0.075% P
  - 2 oils contain HMW 1° ZDDP
  - 2 oils contain LMW 2° ZDDP

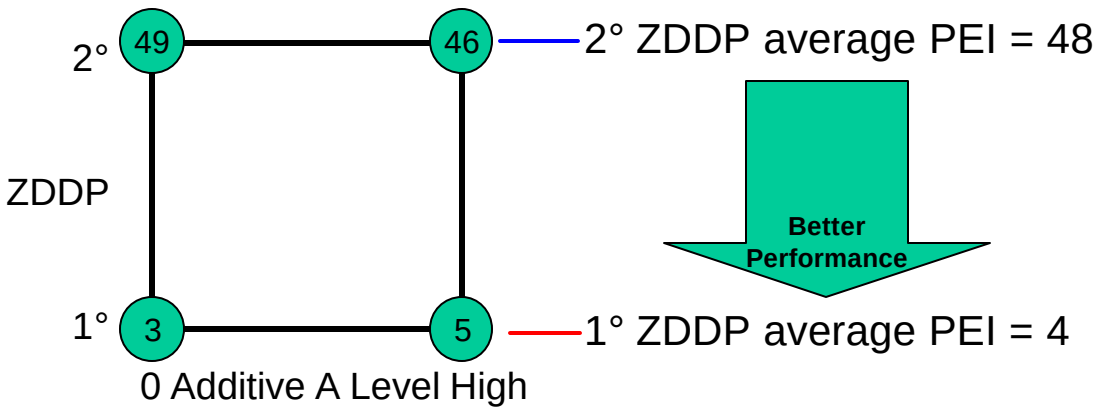
Phosphorus Volatility - IIIG Data

- **IIIG oils studied**
  - 0W-30 formulations
  - 0.075% P
  - 2 oils contain HMW 1° ZDDP
  - 2 oils contain LMW 2° ZDDP
- **EOT sump oil analyzed**
- **Ca increase used as a marker**
- **Measure retained phosphorus [ΔP/ΔCa]*100**
  - +100 = no phosphorus emissions (higher number is better)
- **1° ZDDP has significant P emission benefit over 2° ZDDP in the IIIG**



Phosphorus Volatility – $PEI_{165\text{-}16}$ Data

- **IIIG oils studied**
  - 0W-30 formulations
  - 0.075% P
  - 2 oils contain High Molecular Weight (HMW) 1° ZDDP
  - 2 oils contain Low Molecular Weight (LMW) 2° ZDDP
- **Phosphorus Emission Index (PEI) details**
  - Conditions = 165°C, 16 hours
  - Units = (mg P volatilized) • (855/65) (lower number is better)
- **1° ZDDP has significant P emission benefit over 2° ZDDP**

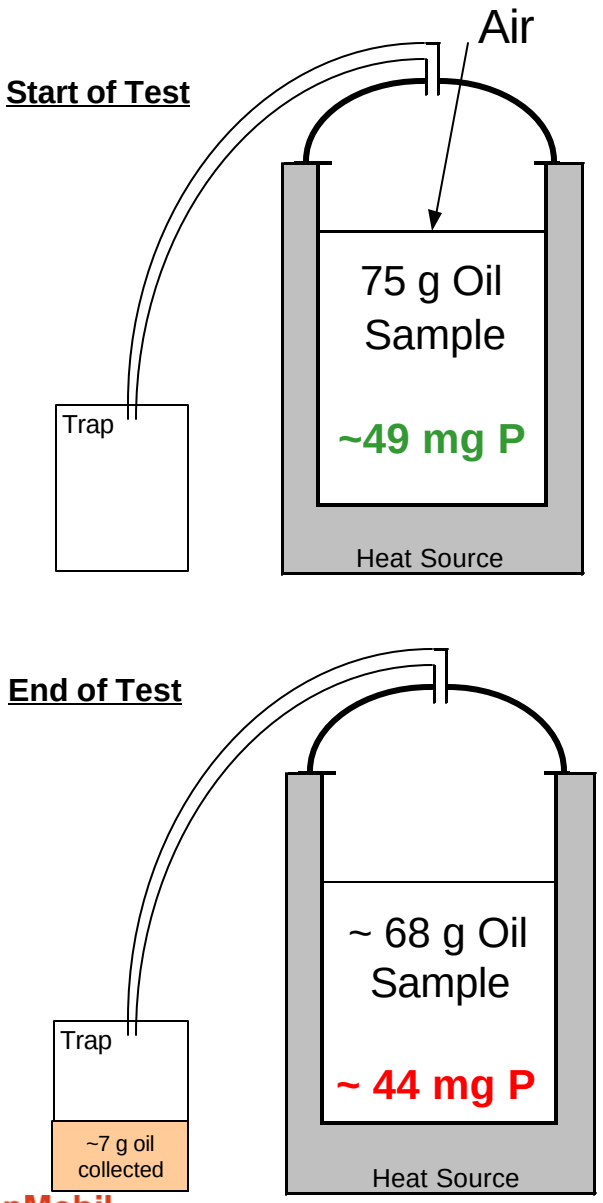


ExxonMobil Phosphorus Volatility Conclusions

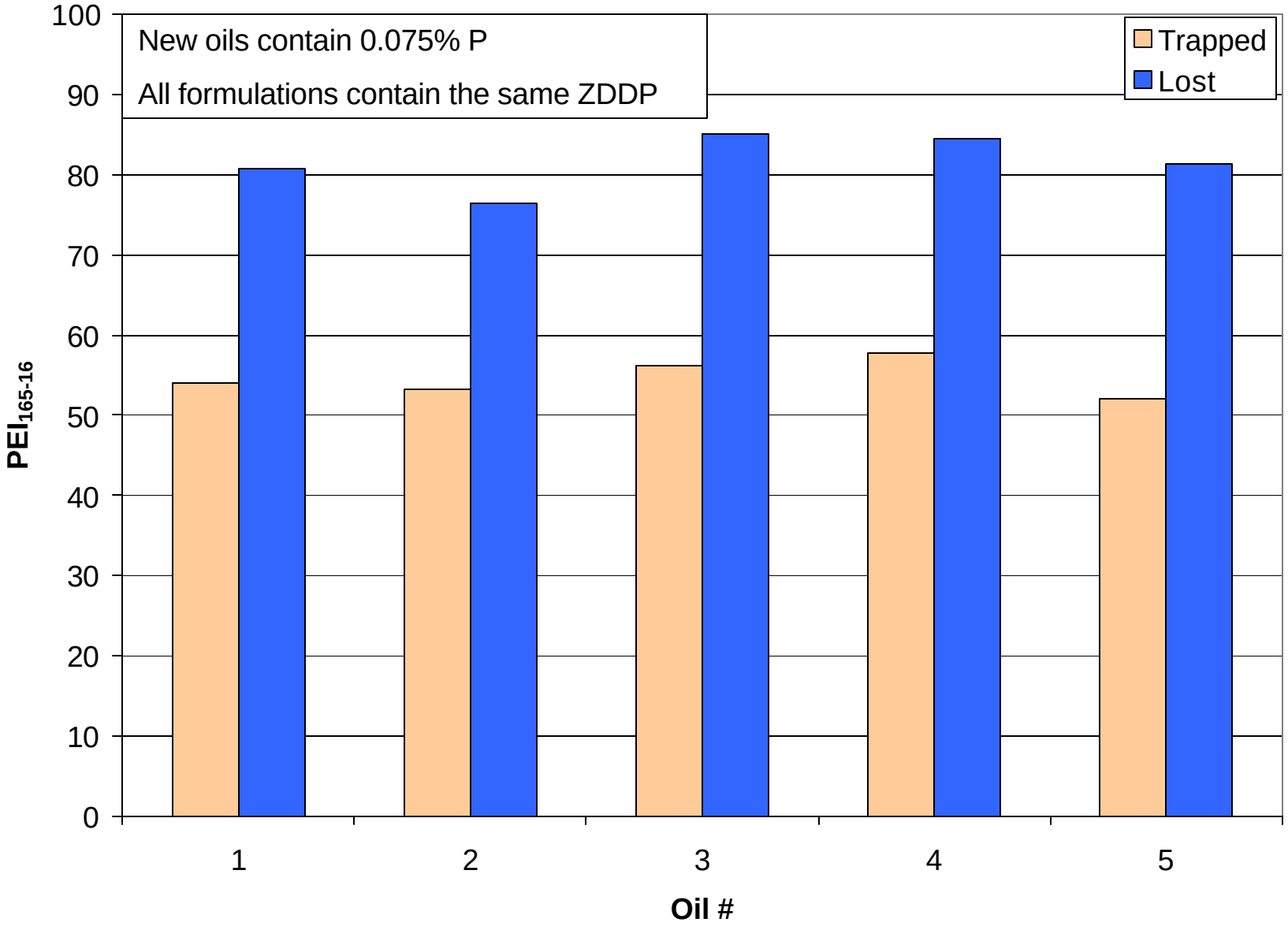
- **A HMW 1° ZDDP was found to volatilize less than a LMW 2° ZDDP in several bench & engine tests**
  - IIIG
  - VIB (9/28 data)
  - ROBO (9/28 data)
  - ExxonMobil bulk oxidation test (165°C) (9/28 data)
- **PEI testing at 250°C for 1 hour indicated that the HMW 1° ZDDP volatilizes more than a LMW 2° ZDDP**
- **PEI testing at 165°C for 16 hours indicated that the HMW 1° ZDDP volatilizes less than a LMW 2° ZDDP**
- **While additional studies are needed, the $PEI_{165\text{-}16}$ volatility ranking agrees with the IIIG, VIB, ROBO, & Bulk oxidation test**
- **Discrimination of phosphorus volatiles is possible with either a bench or an engine test**
- **These findings support the use of performance based tests to quantify the impact of phosphorus volatiles on TWCs**

$PEI_{165\text{-}16}$ Methodology Considerations

- **Current $PEI_{165\text{-}16}$ measures trapped phosphorus volatiles**
  - How rigorous is the trap?
- **Alternate approach is measuring lost phosphorus**
  - Lost P = (Fresh oil P – non-volatile P)
  - propagation of errors is a concern



Volatile Phosphorus Measurement Technique



$PEI_{165\text{-}16}$ Methodology Conclusions

- **Limited $PEI_{165\text{-}16}$ data indicates**
  - Strong correlation between Trapped P & Lost P
  - Lost P values are ~40% higher
  - Trap may not capture all P volatilized
  - Additional studies are needed