

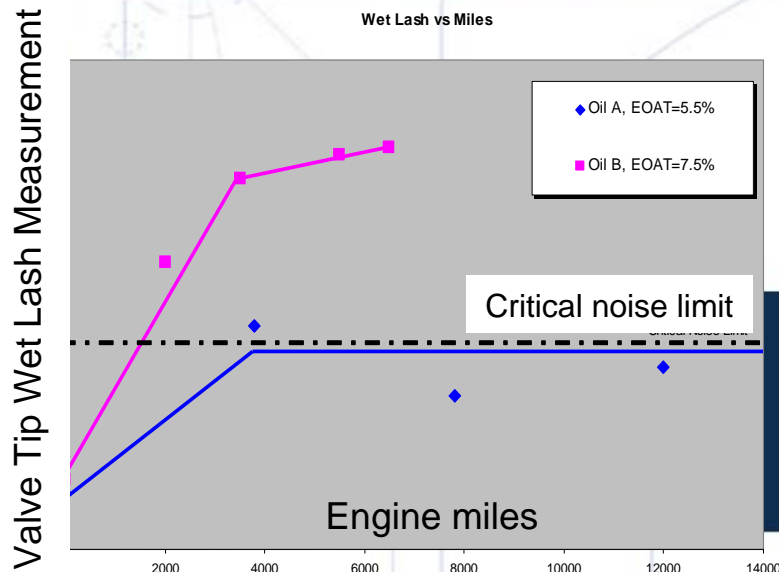
| Used Oil Aeration Control for GF-5



Petroleum Additives Panel

Background

- Aeration protection is included in the draft ILSAC GF-5 specification with HEUI proposed as the test
- GM showed a 2-oil correlation between oil performance and performance
 - Blue line is acceptable
 - >2000 miles to show difference
- HEUI ranks these two oils in the correct order
 - 8% max. is the latest proposed limit
- The objective was claimed to “maintain GF-4 level performance”



Literature

- Aeration in Lubricating Oils – Tribology International
 - Development of ASTM D3427 – Air Release Properties of Petroleum Oils
 - Many factors influencing air release
 - Air bubble size, viscosity, temperature, aromatic content, density and surface tension
 - Si FI's (foam inhibitor) most effective at short residence conditions but never truly soluble (high concentration of Si not stable)
 - ASTM D3427 test not the best for short residence time conditions
- Dennis Broderick-1995
 - Used Sequence IV Foam Test as Screener
 - Dow Si (DC200), Fluorosilicone (Dow), Phenyl-methyl Silicones (Alltech), Acrylid polymers (Ultra Additives),
 - FI vis grades ranged from 10,000 cSt to 100,000 cSt
 - TMC 1004/ECA13112/Exxon Grp I blended to 15W-40
 - Results
 - Seq IV Foam responded to increased concentration of FI up to 20 ppm
 - A few of the other Si FI's performed AS WELL as DC200, but none were better and several were worse
 - Higher concentrations (40-80 ppm) showed instability in the form of fish eyes
- Hydraulic fluids usually use different antifoam (not as effective as Si in AEO) and at higher treat rate (less stable at this higher treat rate)

CEC IL-061 Studies

- CEC IL-061 (Engine Oil Foaming and Air Entrainment Working Group chaired by A. Harlow) was formed at ACEA's request in 1995 in association with CEC ELTC (Engine Lubricant Technical Committee)
 - Foaming effect, Air release effect, Air content effect
- DKA Foam Study Group (E. Holthusen chair) started in March, 1996 in association with IL-061
 - BMW reported the need to keep air entrainment below 10% in its test (to protect hydraulic lift adjuster) though no field problems were reported
 - Audi reported engine designs have a big effect on air entrainment; also indicated oil aging process and blowby composition as factors
 - A subgroup including Audi, BMW, IAVF, KST, FEV, ISP, APL and Shell formed to run CEC reference oils in a number of engine tests
 - BMW 1.8L, VW 1.6L, TU3M, MB M111

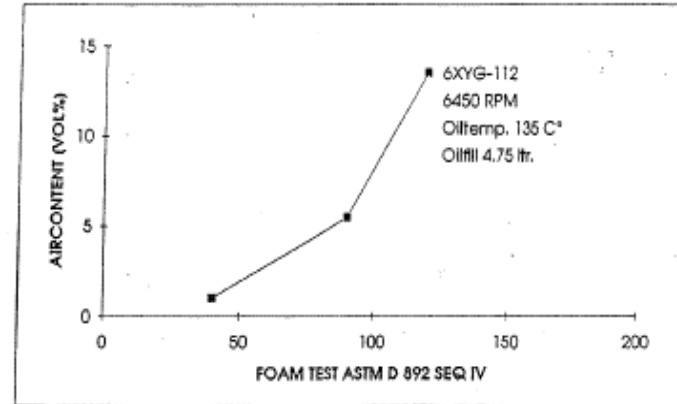
CEC IL-061 Studies cont.

- DKA found all labs (different engine types and oil aging) ranked the three CEC reference oils the same way
 - 189 (best) > 177 (better) > 178 (178 failed the BMW requirement)
- DKA concluded high temperature foam test ranked the oils correctly

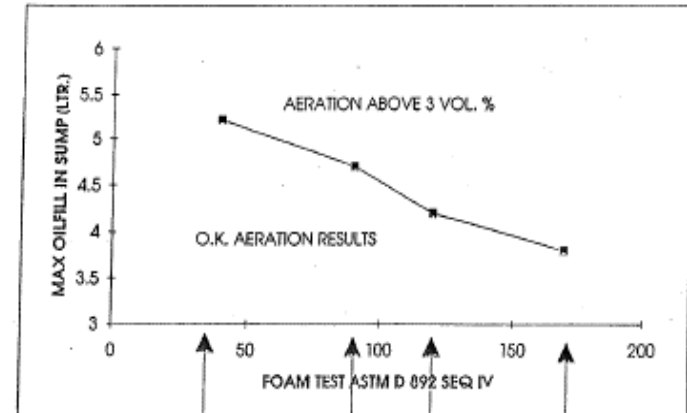
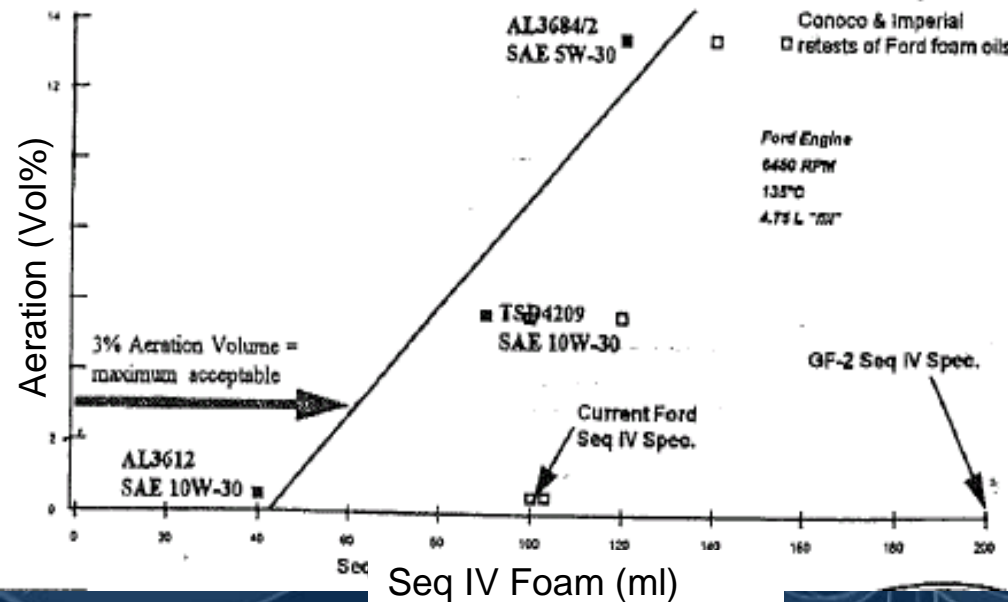
Ford Europe Supports The Use of High Temperature Foam

- Ford stated that 3% of gas entrainment gives “problem tappets”
- Ford’s measurement using radioactive tracer correlates with Seq IV foam test

CORRELATION AERATION / FOAM TEST



Sequence IV Performance correlates with air content in engines



Tests Evaluated (that showed no response)

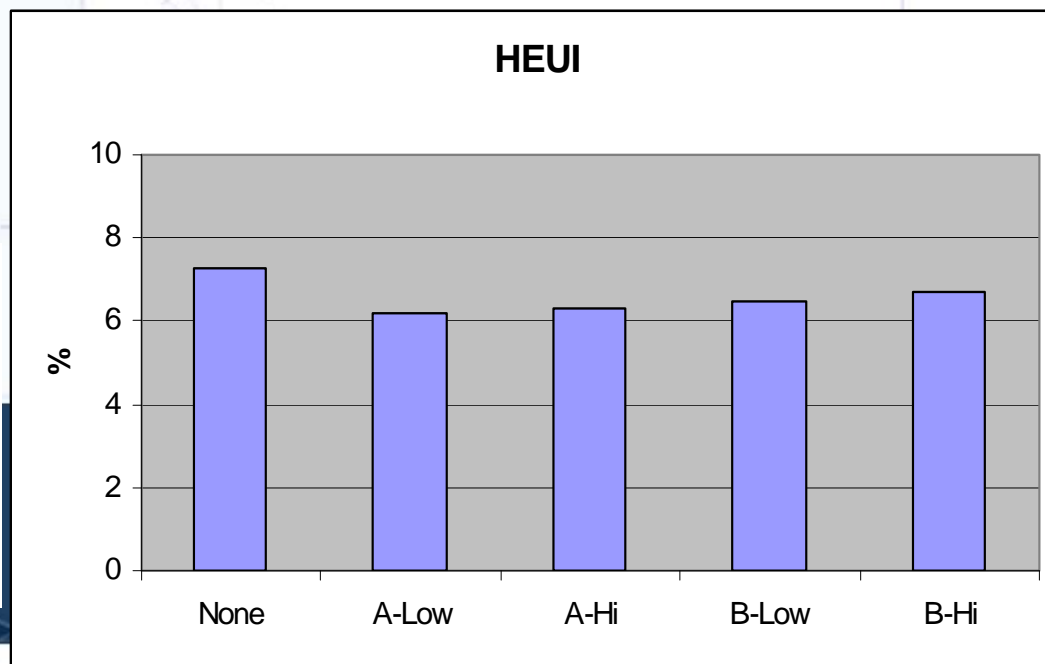
- Eight oils from HEUI database have been chosen to represent different performance and to represent the two “GM ref oils”
- D3427, Seq I, II, III Foam tests and Seq IV High Temp Foam test
- Oxidized (to age oil) in Universal Oxidation Test and then run in D3427 and Seq I, II, III, IV Foam tests.
- The Bosch Shear Test (to age oil) then ran in Seq I, II, III, IV Foam tests
- Surface tension
- Used oil from IIIG too dark to evaluate accurately
- Limited data from GM GEOS A aeration test

HEUI Assessment

- HEUI is a HD engine with correlation to HD oil
- Adopting HEUI creates serious logistic issues
 - Only one stand available and hardware production/support has ended in 2006
 - EMA members are questioning the performance of this stand
 - no BOI/VGRA coverage for PCMO which further aggravates the stand availability issue
 - Durability of this engine running on PCMO viscosity grades is also questionable
- HEUI, with 20-hour duration, does not represent the desired “used oil aeration” performance (GM showed transition between 2000 ~ 4000 miles)

HEUI Assessment cont.

- HEUI limit as proposed (8%) will not screen out any oil
- HEUI limit as previously proposed (6%) will screen out all oils
- HEUI precision does not support further separation of performance between 6~8%
- HEUI does not respond to PCMO formulations
 - Oil without antifoam performs similar to those treated
 - GM commented that “an oil without antifoam performed the best in its vehicle”
 - No response to antifoam type or treat rate



All oils run once.

FI Hi=7xLow

Precision per D6894 is
0.67% i.p. (~1 std
dev.)

Recommendation

- HEUI is not a suitable or sustainable test for used oil aeration control in GF-5
- High temperature foam test at the GF-4 limits will maintain equivalent aeration protection for use in GF-5
 - Supported by literature and CEC studies