

EXPO 2007-Open Technology Forum

Understanding emulsified water filtration from diesel fuels

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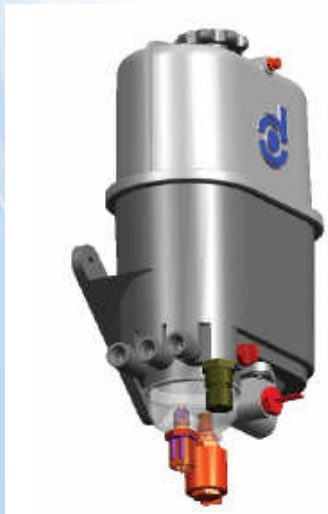
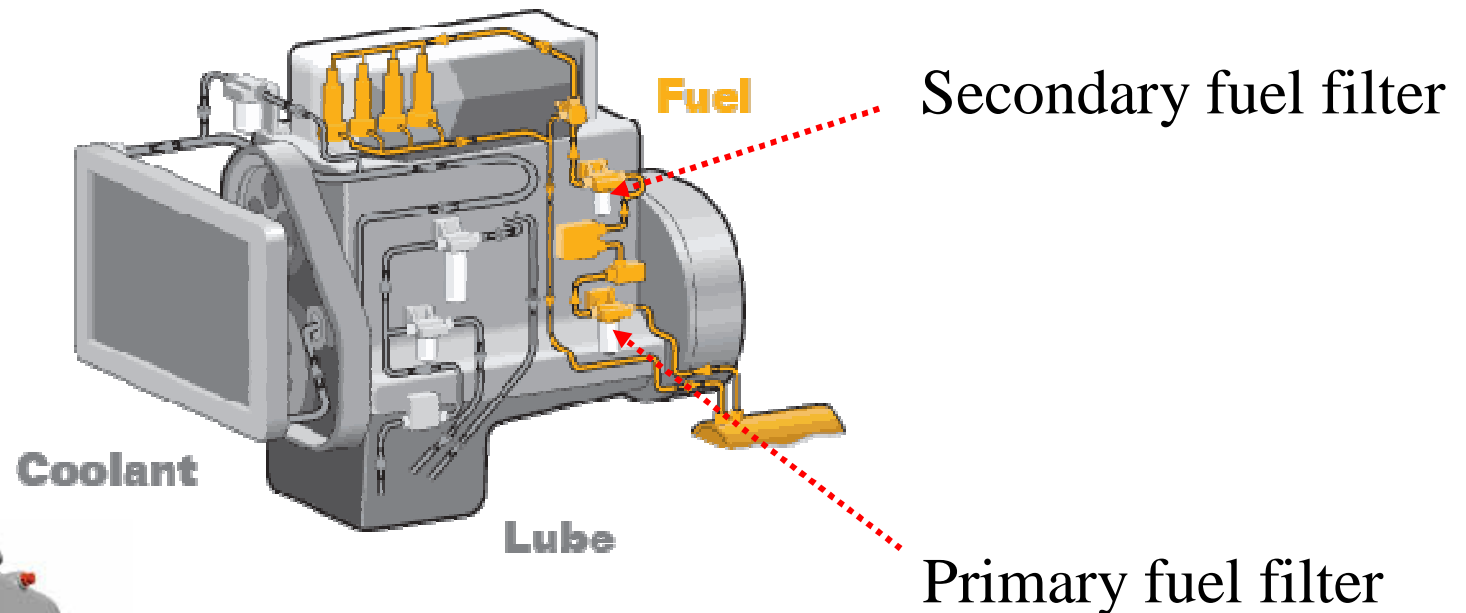
Outline

- Background
- Indirect determination of emulsion stability- IFT, MSEP & drop sizing & its correlation with media performance
- Affect of flow and water concentration
- Test standard issues
- Conclusions

Different forms of fuel/water separator & particulate filters



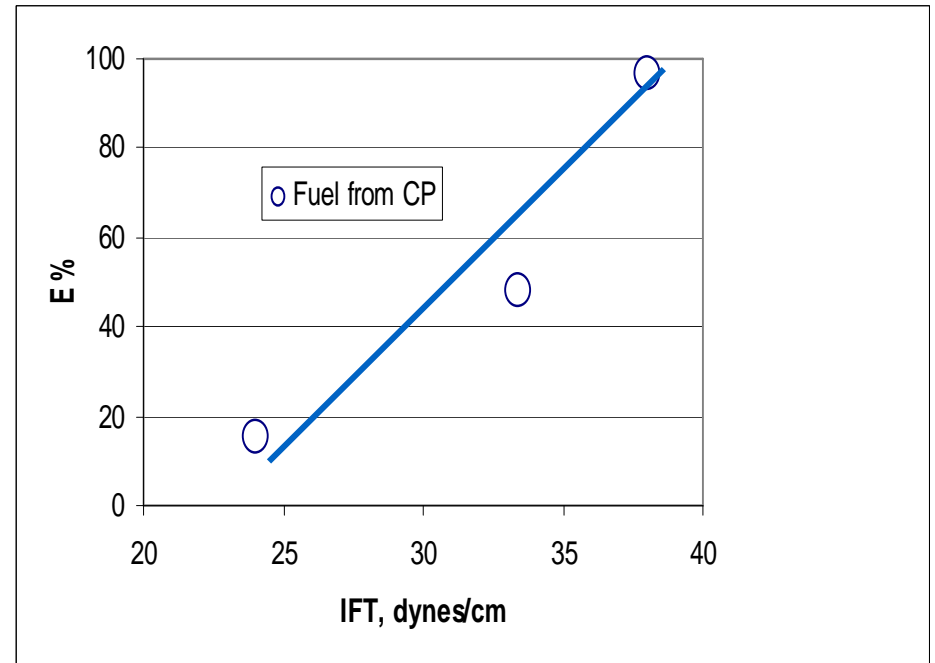
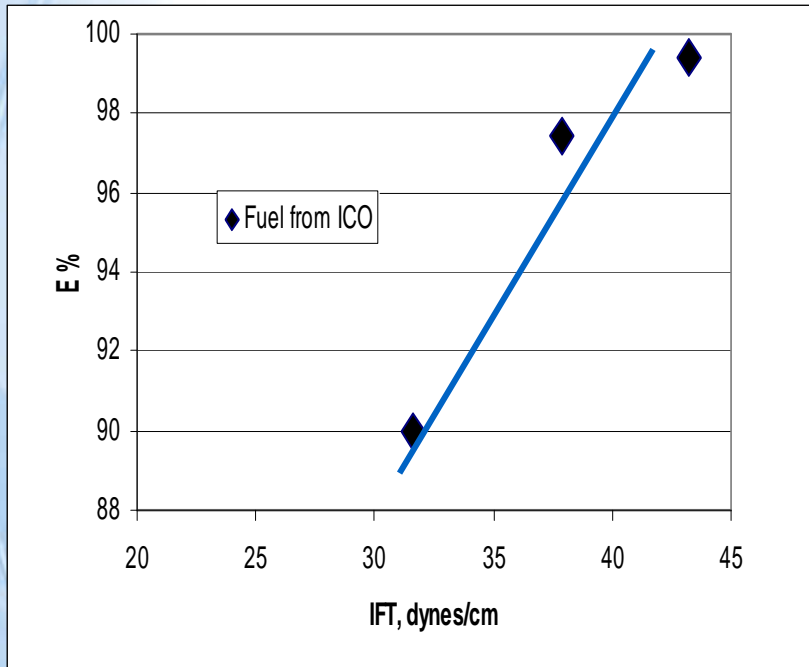
Engine Liquid Filtration



What is in the housing determines the extent of engine protection

Dual fuel filter & fuel/water separator

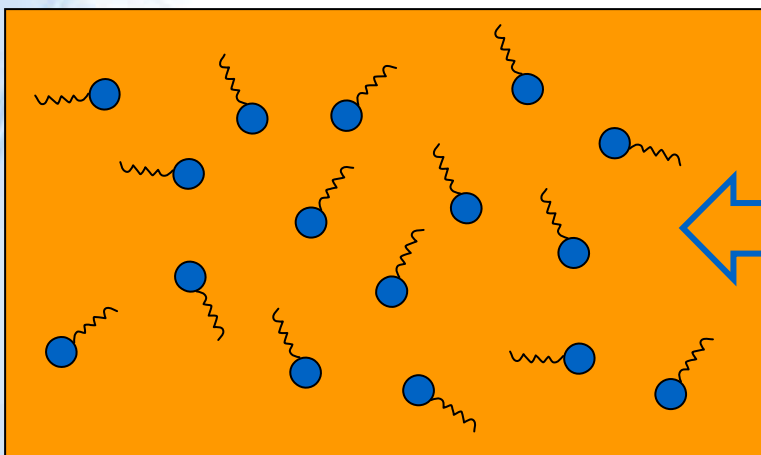
Emulsified water filtration efficiency per SAE J1488



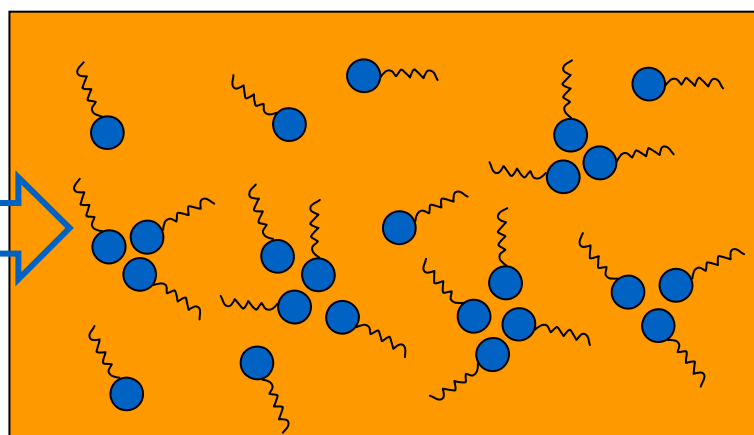
What is the problem?

Fuel physical chemical properties significantly affect a fuel/water filter's performance, especially when surface active agents are present.

Behavior of surfactant



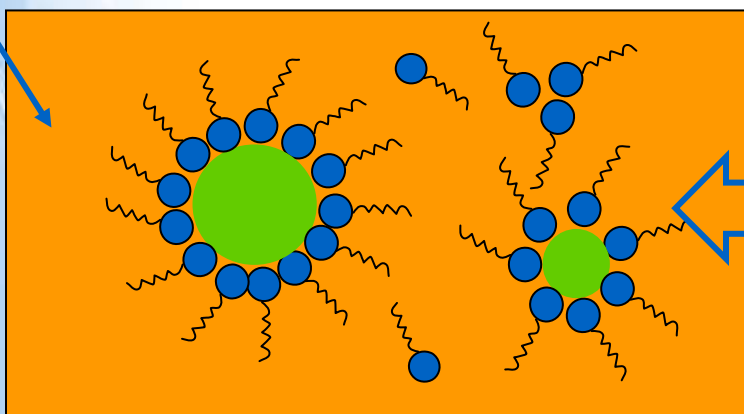
Random motion



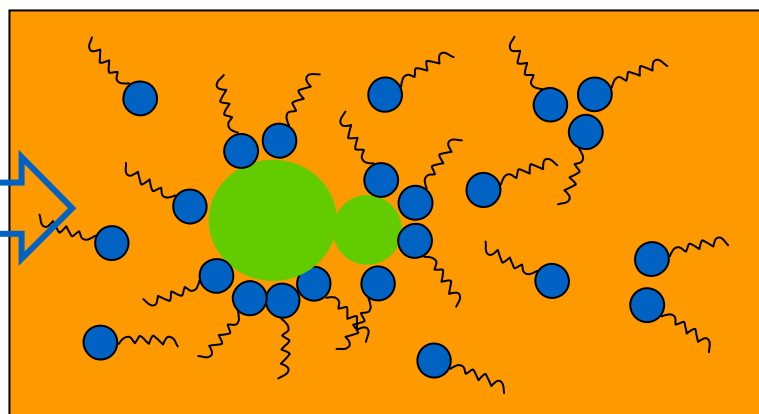
Self-assembly

H₂O

E



Water pool formation

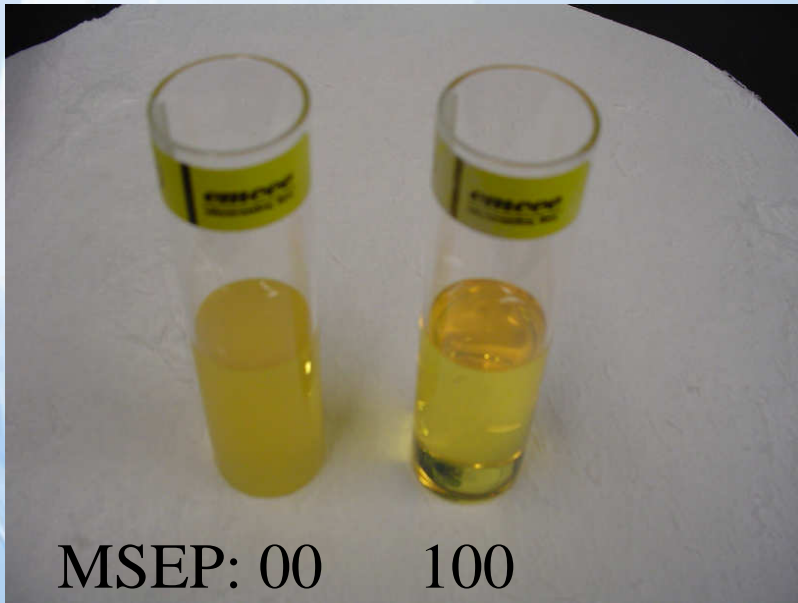


Mass exchange

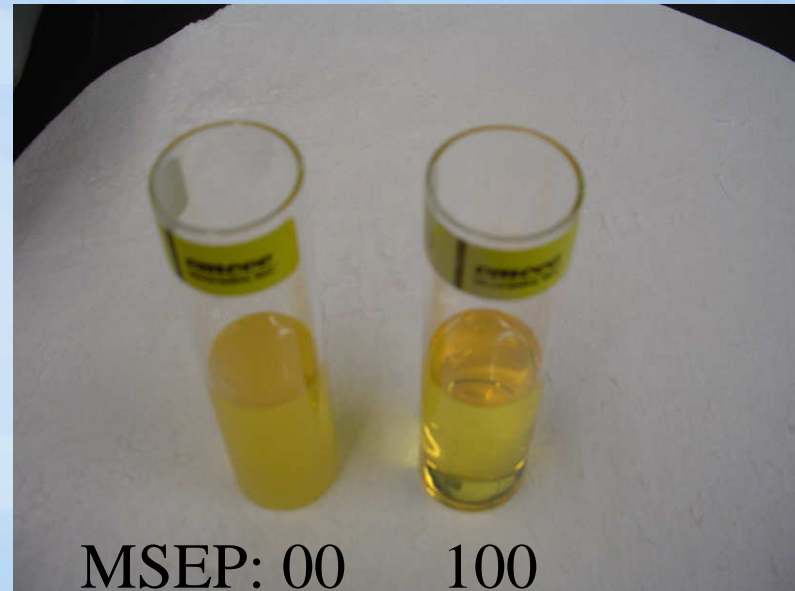
Surfactancy & MSEP

- **Surfactancy:** The amount and type of surfactant(s) in a liquid that cause liquid property change such as reduced surface tension and IFT, increased or decreased viscosity, stable liquid dispersion formation and so on.
- **Microseparator** rating (MSEP): an indicator of fuel surfactancy by measuring the fuel turbidity after the formed water-in-fuel emulsion is filtered through a standard coalescence material. It ranges from 00 to 100, the higher the number, the clearer the filtered fuel because of the faster settling of coalesced water droplets.

Emulsion stability is a function of fuel IFT and MSEP



15 min

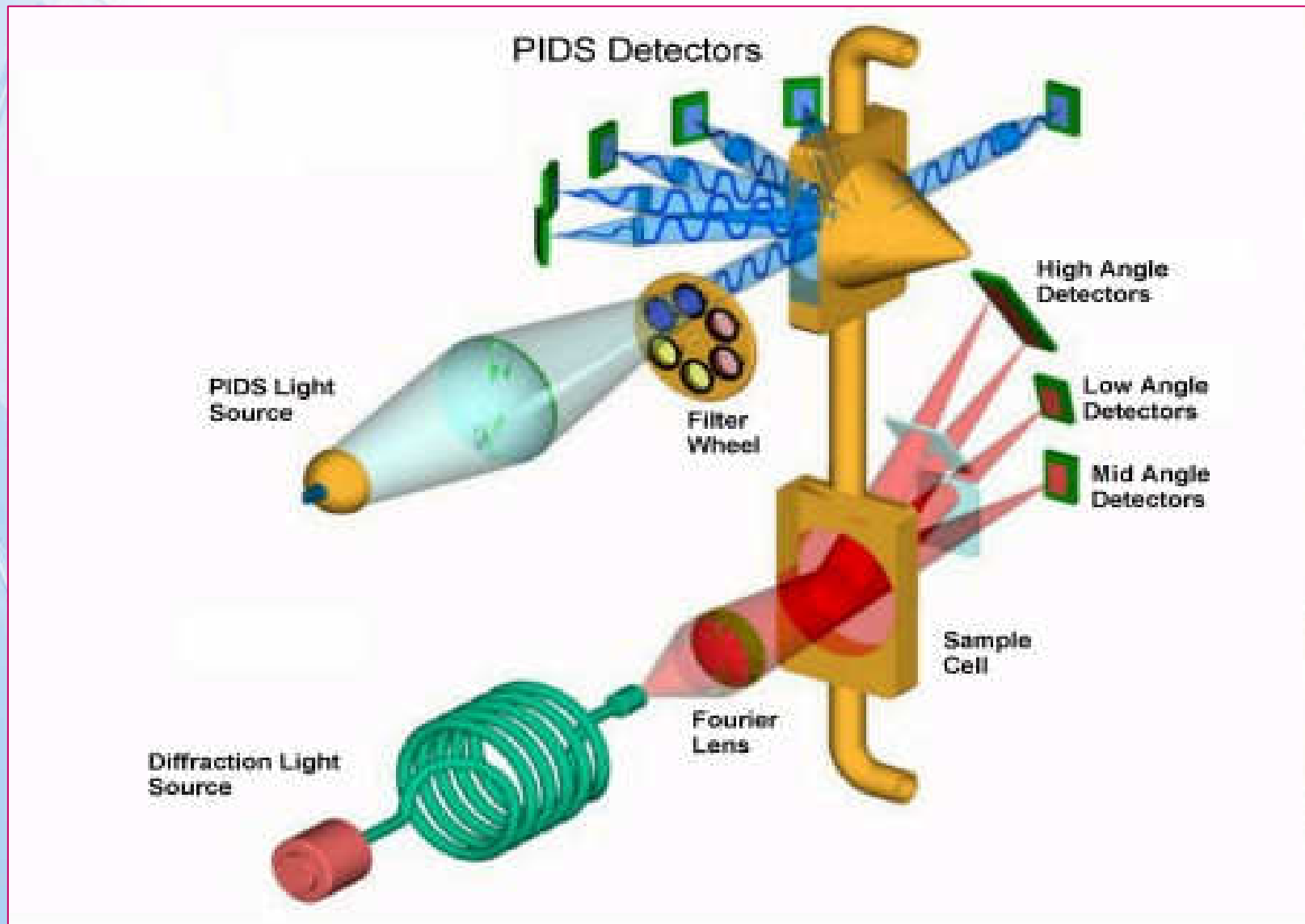


130 min

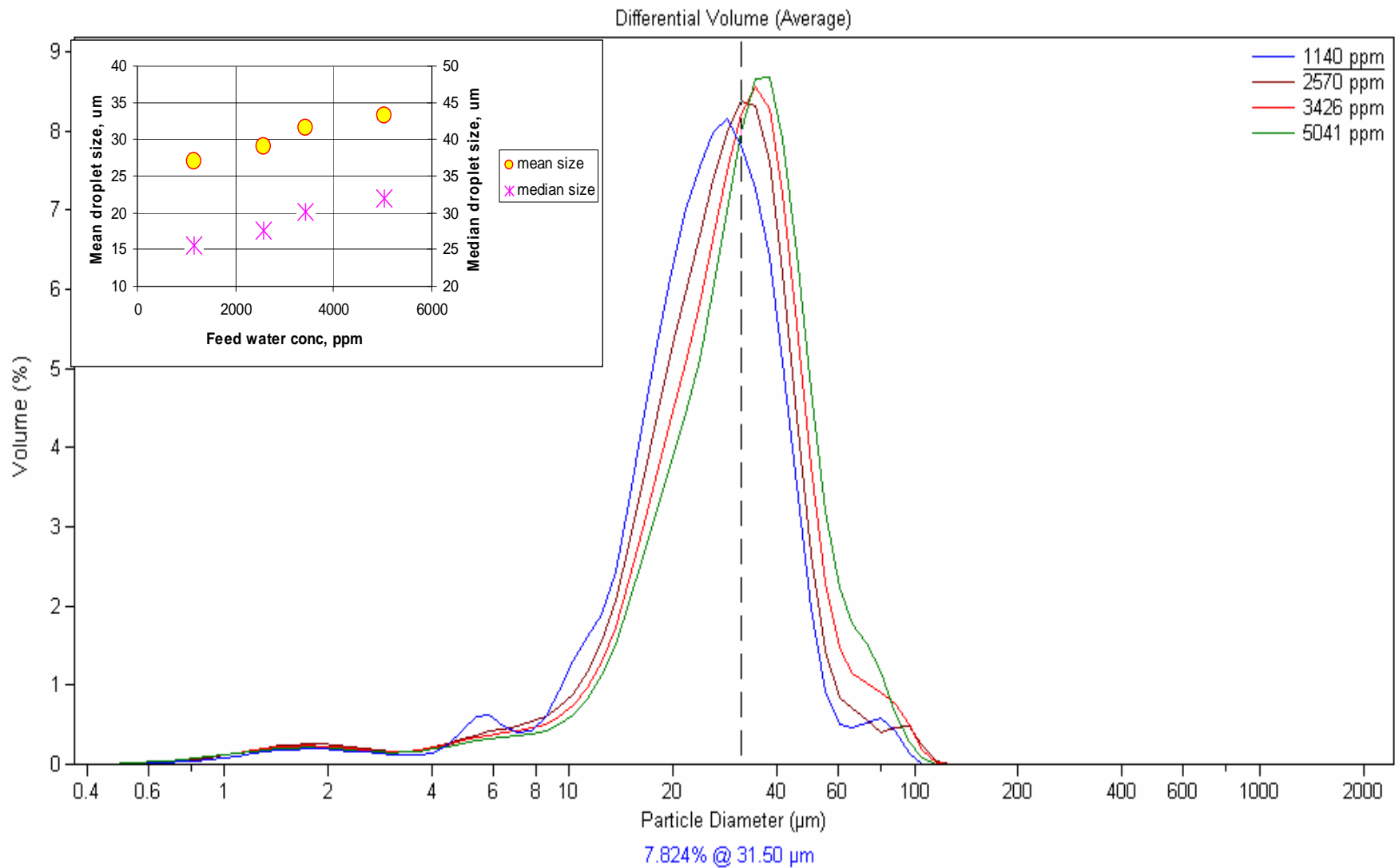
IFT=20.9 dynes/cm

Laser diffraction particle size analyzer optical system

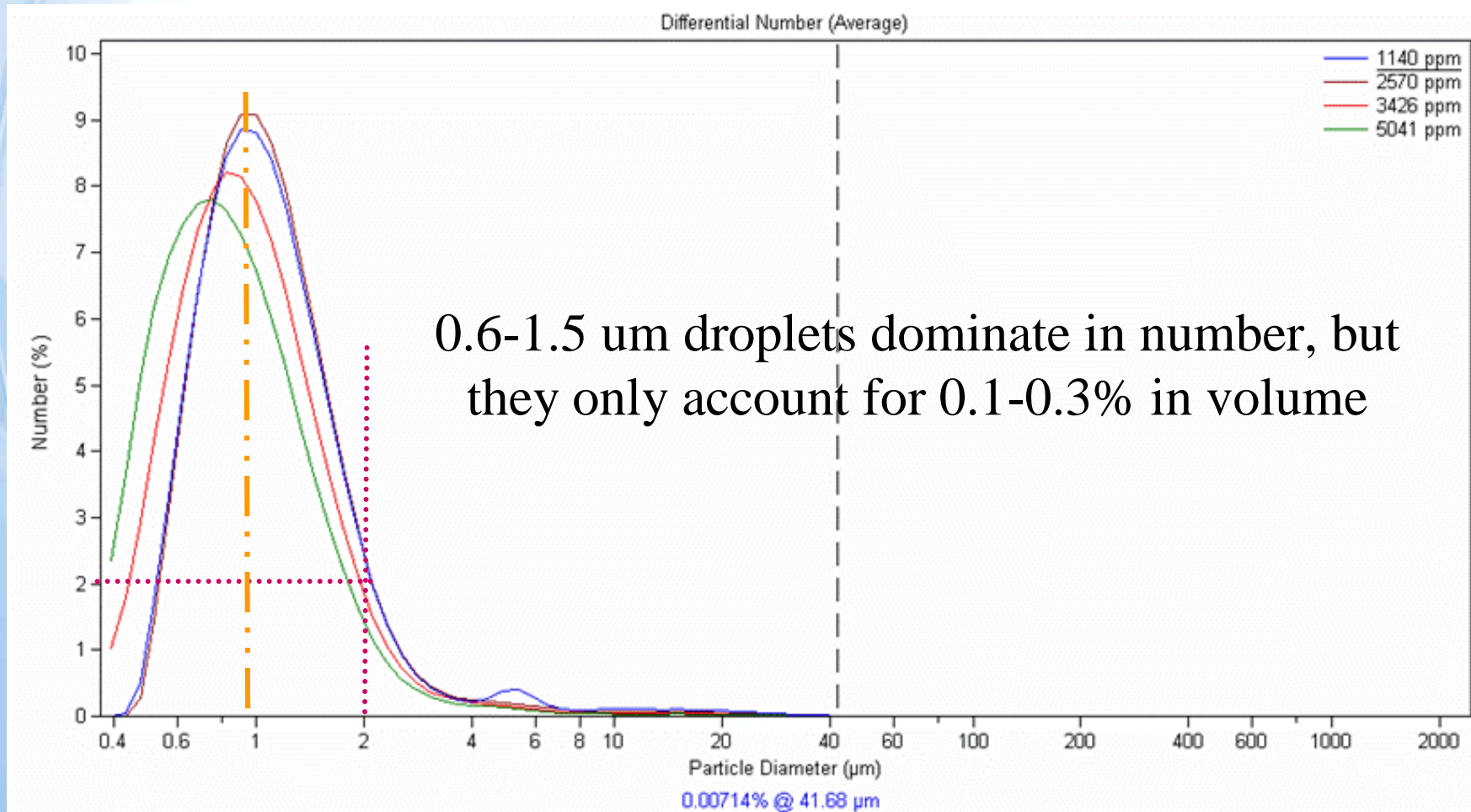
PIDS-polarization intensity differential scattering



Water droplet size volume distribution in original #2 diesel fuel (IFT = 32 dynes/cm). Inset shows the mean and median size vs. feed water concentration

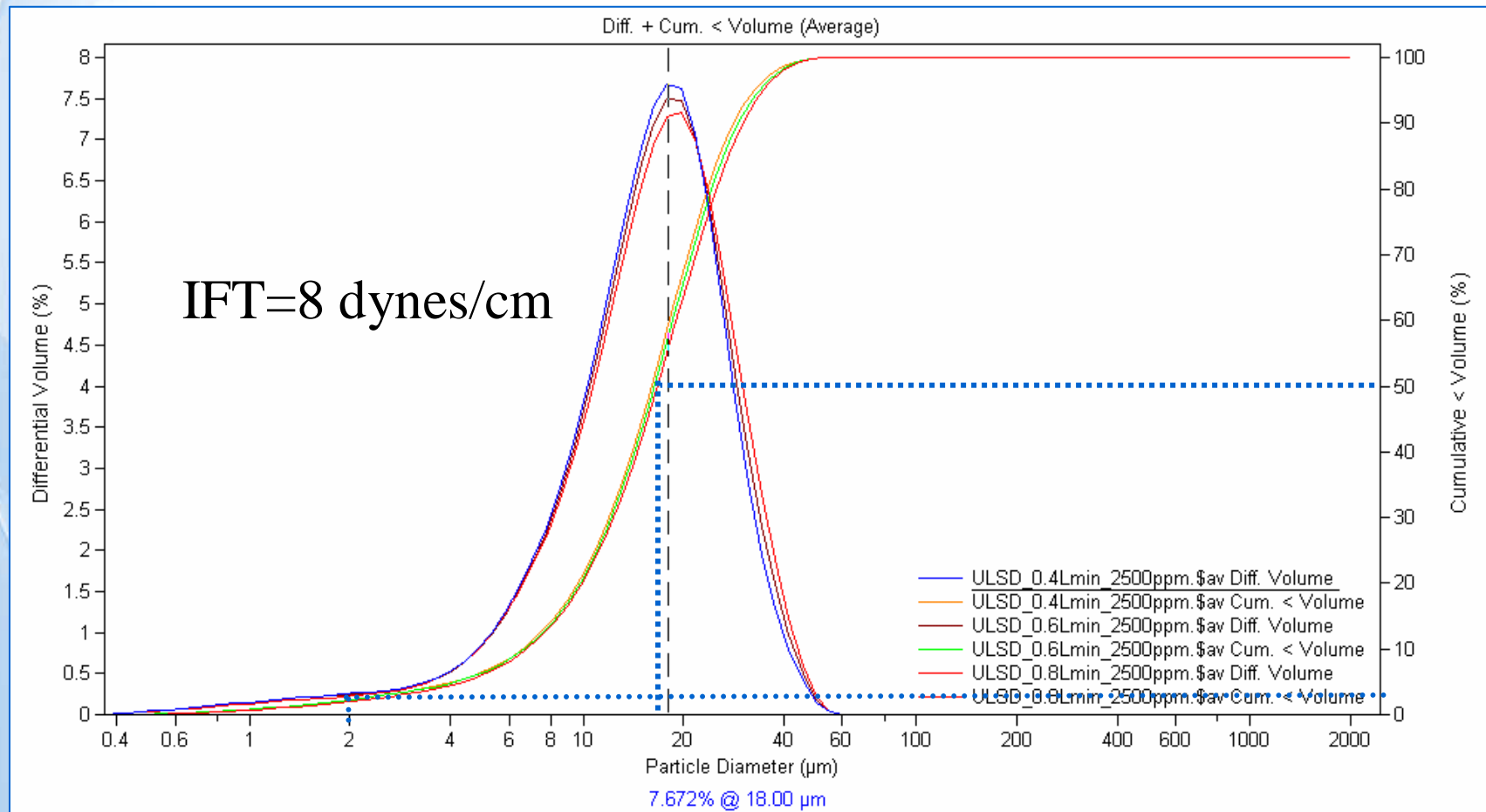


Water droplet size number distribution (original # 2 diesel fuel, IFT 32 dynes/cm)

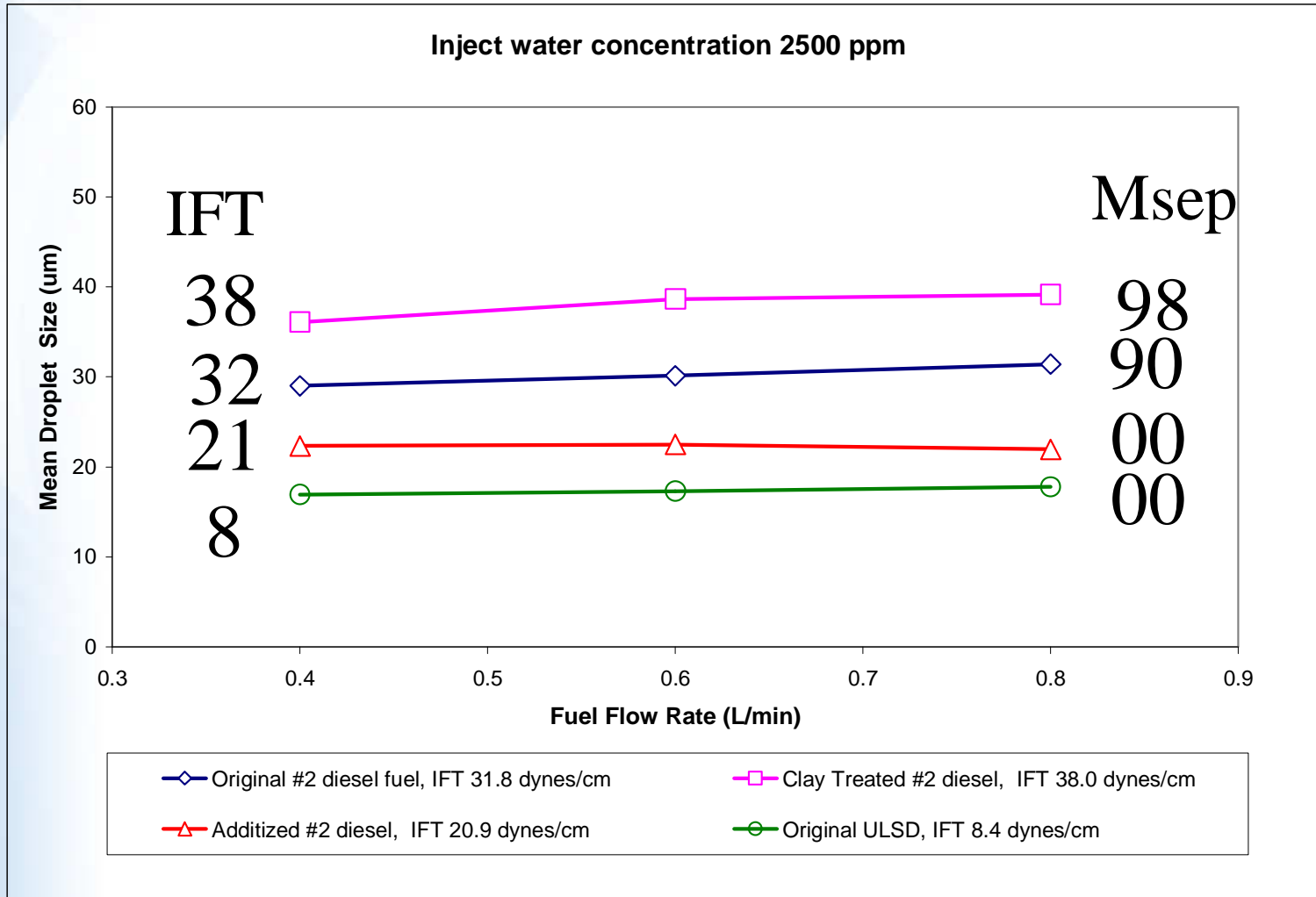


Higher emulsion stability in ULSD

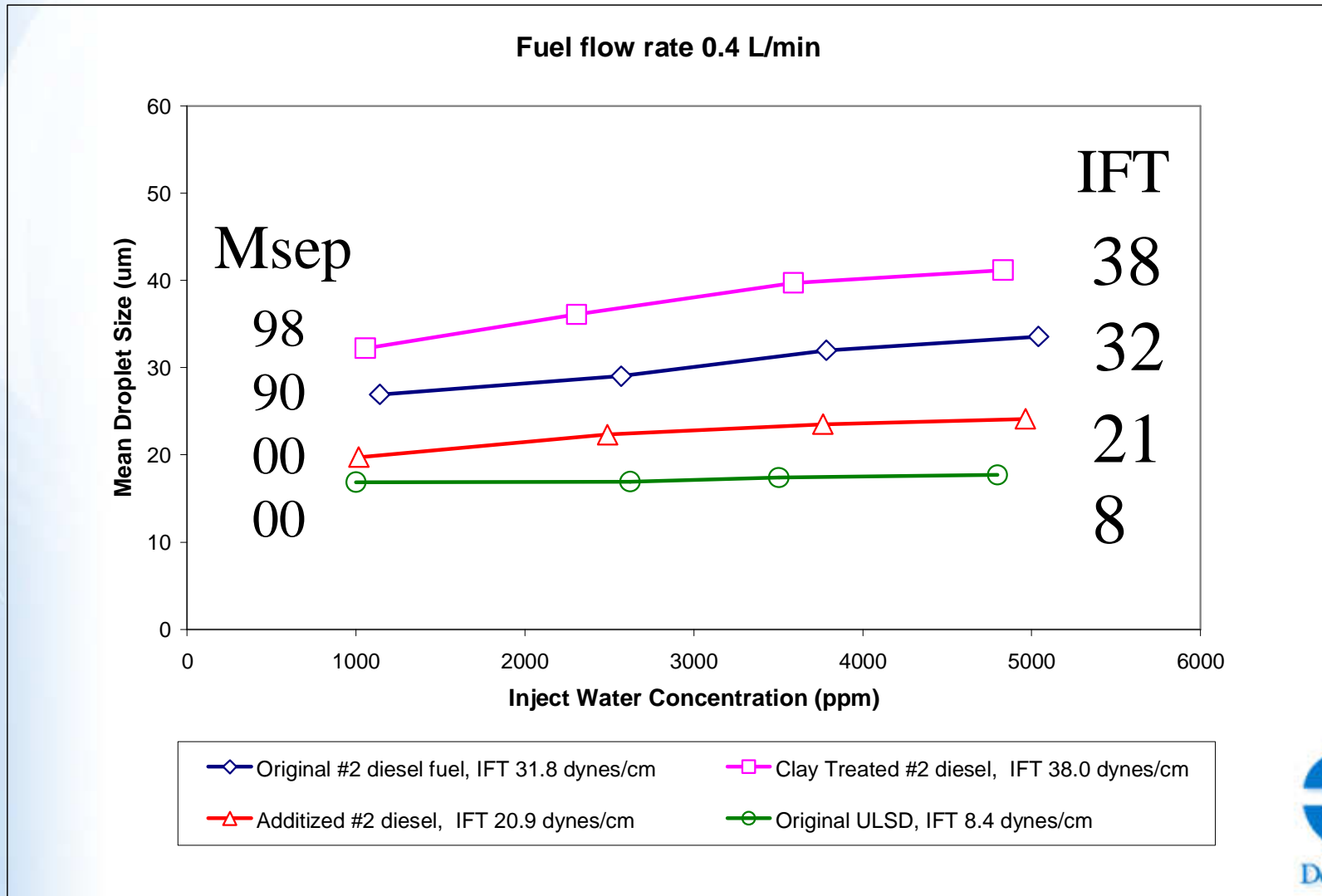
Decrease in IFT reduces mean volume size



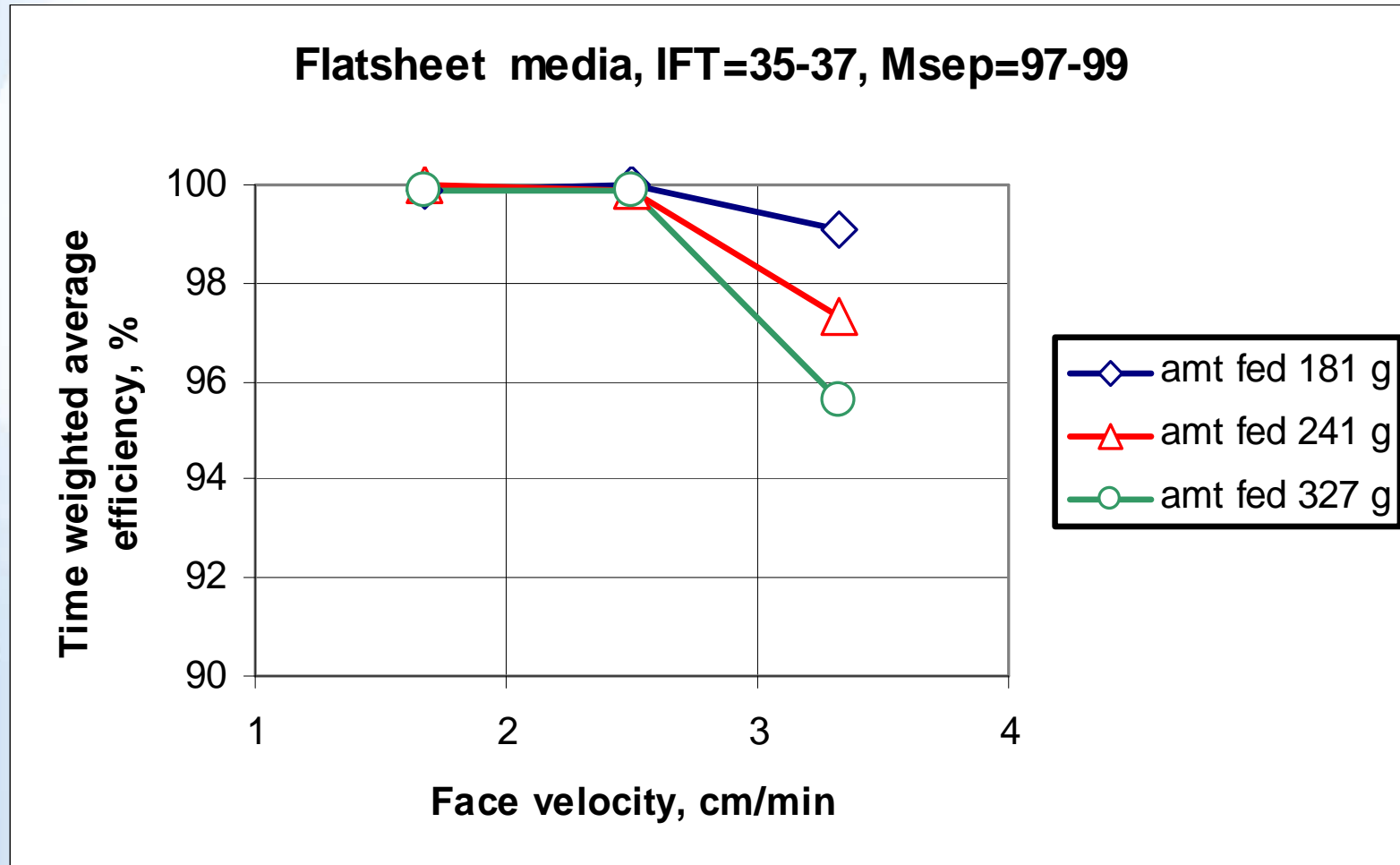
Drop size vs. flow rate. (IFT & MSEP affect relationship)



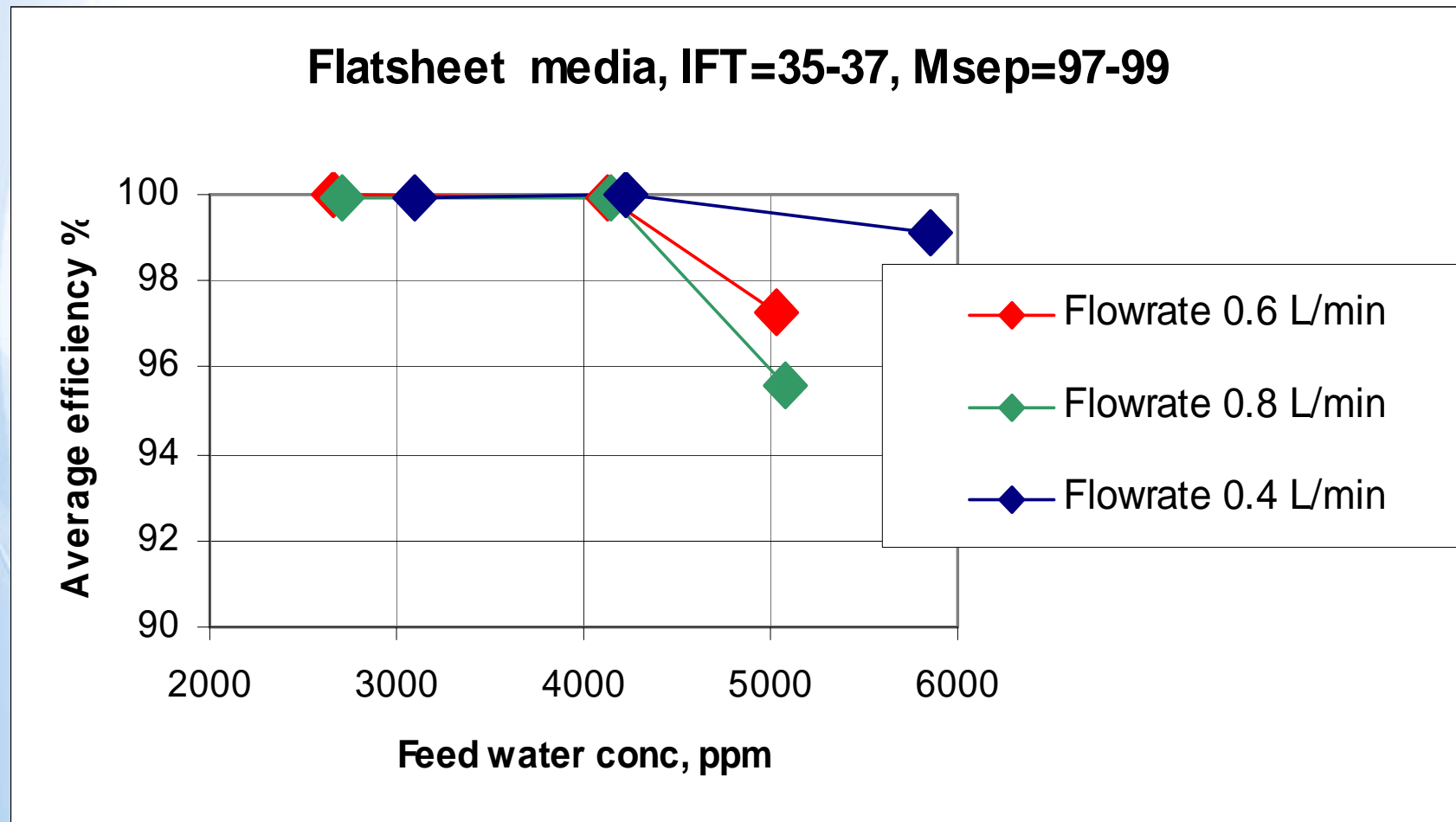
Droplet size vs. injection water concentration (IFT & MSEP affect relationship)



Efficiency vs. face velocity (High IFT & MSEP fuels)

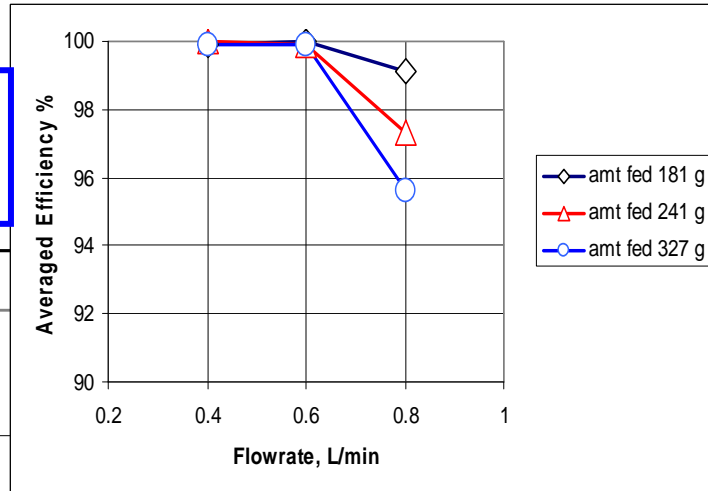
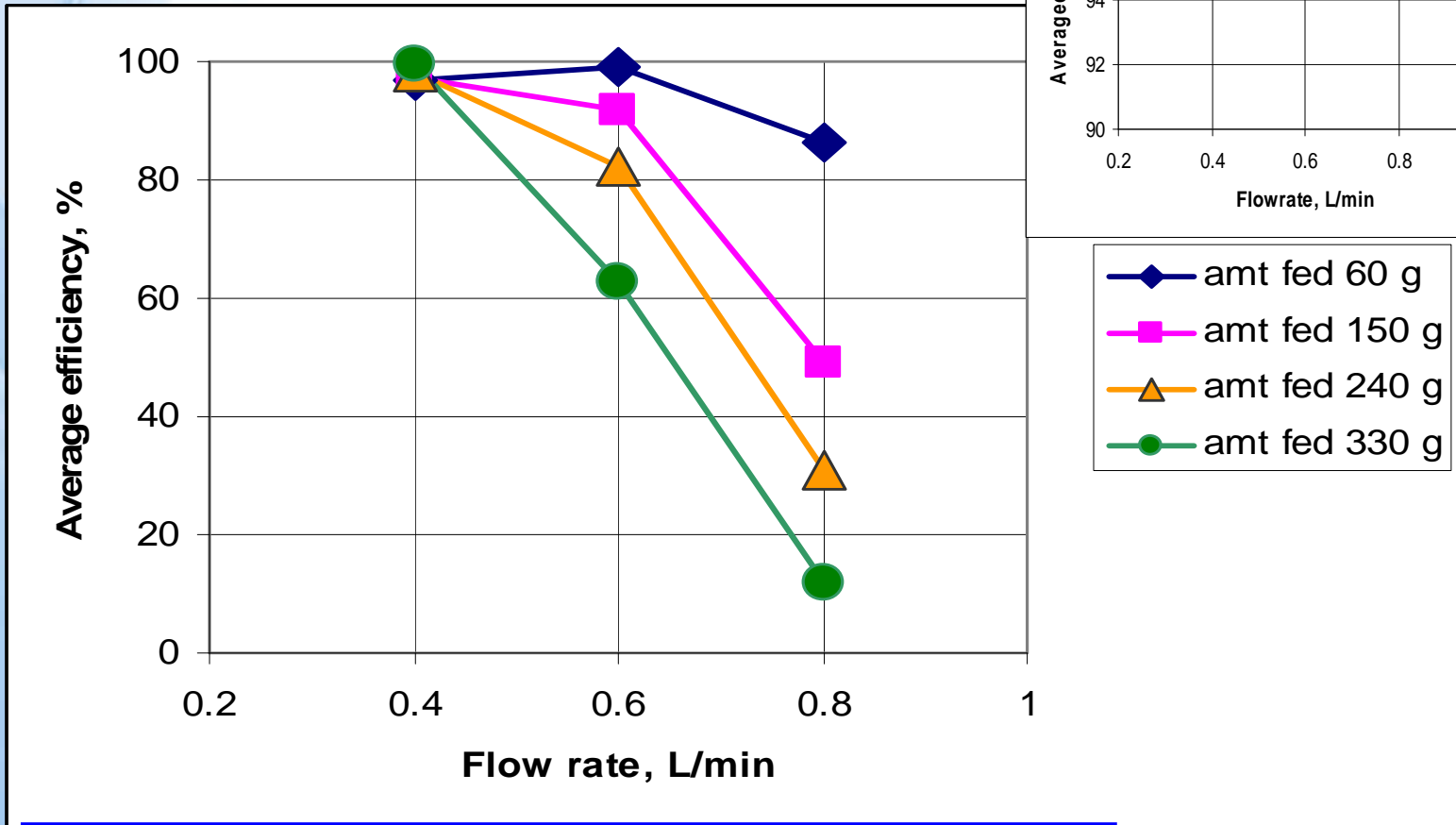


Efficiency vs. challenge water concentration (High IFT & MSEP fuels)



Comparison of efficiency vs. flow rate for high & low IFT/MSEP fuels

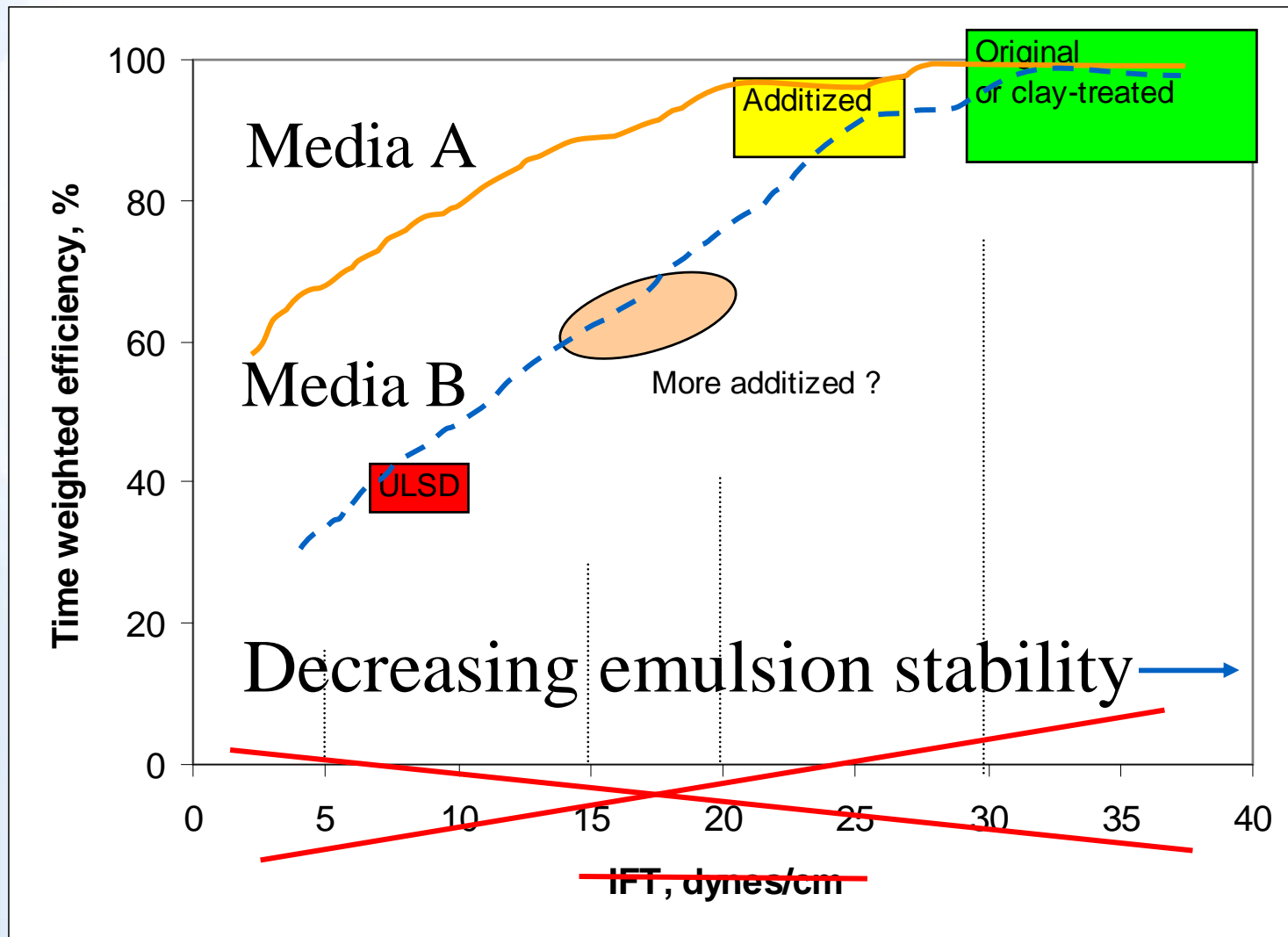
Clay-treated fuel,
IFT=36, MSEP=99



Additized fuel, IFT=20-25, MSEP=00-50



What really matters is the emulsion stability



Percent emulsified water filtration efficiency in different ULSD

Filter ID	Fuel-1	Fuel-2	Fuel-3
	IFT 30, Msep 100	IFT 10, Msep 80	IFT 10, Msep 0-50
A	99.4	82.7	29.6
B	98.0	93.1	52.4
C	96.8	95.5	96.5
D	99.1	70.2	38.4
E	/	/	38.6

SAE standard needs to be modified for ULSD

Test standard	SAEJ1839	SAEJ1488	ISO4020	ISO/ TS16332
Water type	coarse	Emulsified	Emulsified (?)	Emuls. or coarse
IFT dynes/cm	25-30	25-30	25-30	15±3
Drop size um	180-260	undefined	undefined	60 or 300
Water conc ppm	2500	2500	20,000	1500- 20,000
Pump	Not specified	3500 rpm centrifugal	diaphragm	Pump w/o pulsation

Conclusions

- **Emulsified water filtration becomes more difficult in fuels with low IFT and MSEP. However, IFT is not the sole factor. MSEP can be used as an indicator of a fuel's surfactancy that relates to the emulsion stability.**
- **ULSD with low IFT and MSEP also has smaller water droplet size, which translates to greater emulsion stability that determines a fuel/water filter's performance.**
- **Emulsified water filtration efficiency depends on media face velocity and the challenge water concentration. This is especially the case for fuels having higher surfactancy.**

Conclusions-cond

- **Due to the variety of fuel additives and fuel suppliers, even a well designed media may not satisfy all the fuels.**
- **Test standards need to be modified to reflect the impact of fuel variability by specifying both IFT, MSEP and possibly the emulsion droplet size.**
- **Other interfacial phenomena such as interfacial viscosity, rigidity and surface charge could be the real reasons that a fuel/water separator underperforms.**