MARAD – Shipboard Energy Technologies Workshop

MV Sine Maersk Emission Measurements
&
Retrofit Control Technology Discussion

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Content

MV Sine Maersk Emission Measurements

- Project status
- Results: constant load, transients (, FTIR species)
- (Set-up, procedures and test schedule)

Retrofit Control Technology Discussion

- Slide valves
- Water-in-fuel emulsion (vs SCR)
- Comments on HFO vs low-S DO

MV Sine Maersk – Emission Measurements

Purpose

to obtain actual emissions data in the harbor-coastal area

Project Status

testing finished successfully mid February 2004

preliminary report ready to be submitted

gaseous emission and tot. PM calculated

particulate filters still being analyzed at GL

Participants

A.P. Moller – Maersk Group

The City of Los Angeles Harbor Department (Port of LA)

California Air Resources Board (CARB)

United States Maritime Administration (MARAD)

University of California, Riverside

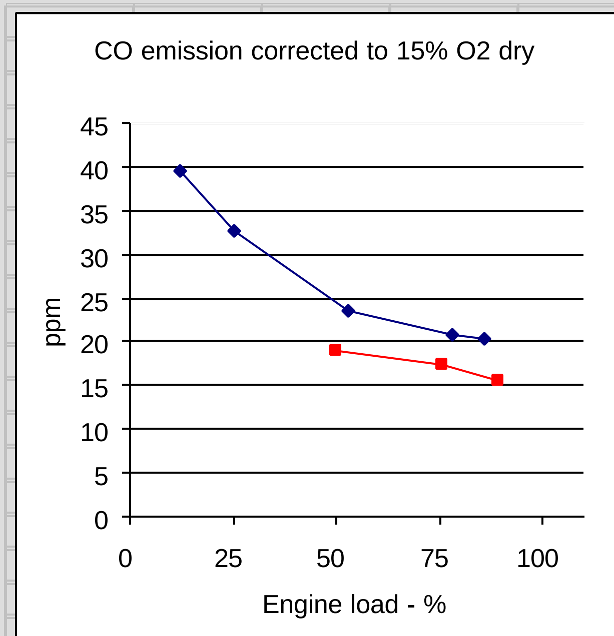
MAN B&W Diesel A/S

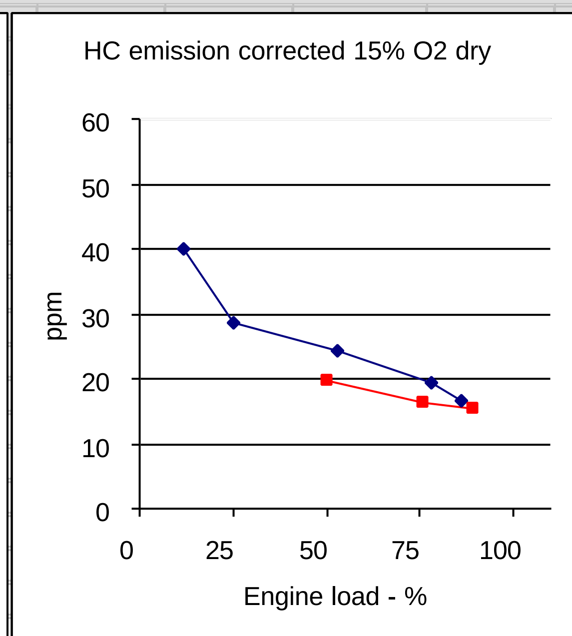
Results 12K90MC

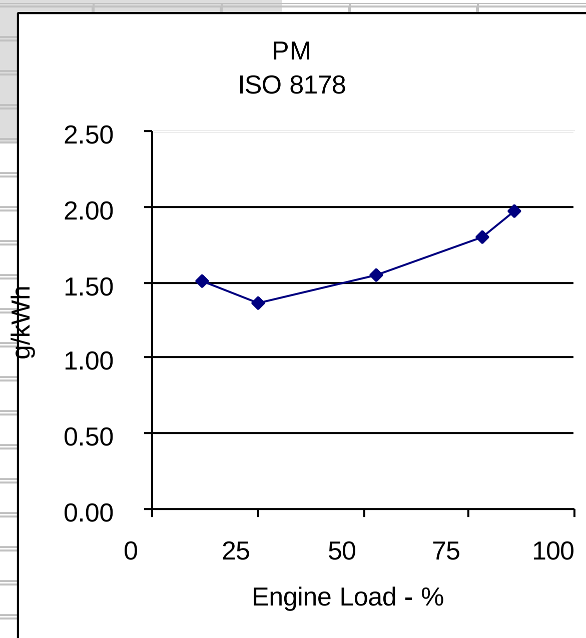
Main Engine 12K90MC (Fuel: 2.4% S, 0.48% N)	Engine load - %					
	85 (86)	75 (78)	50 (53)	25	12 knots (12) **	E3 IMO value *
NOx emission g/kWh	20.7	20.3	20.4	23.1	24.2	20.6
Particulates g/kWh (ISO 8178)	1.97	1.80	1.55	1.36	1.51	-

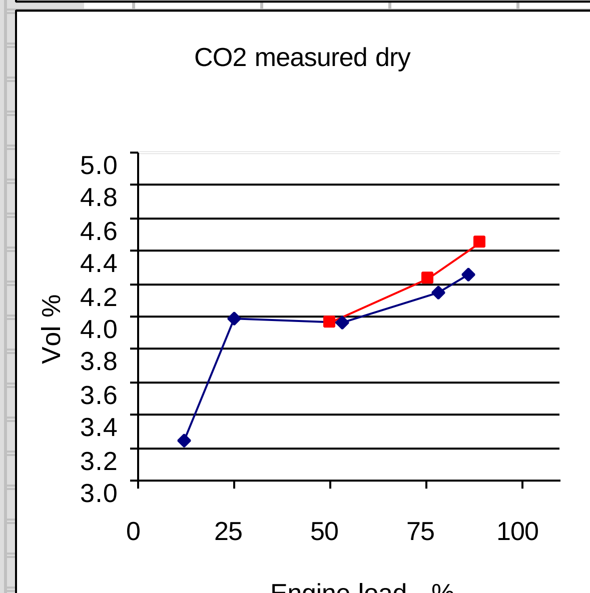
( ) Actual load - %.
*** Estimated IMO NOx value.**
****Load not a part of the IMO E3 cycle.**

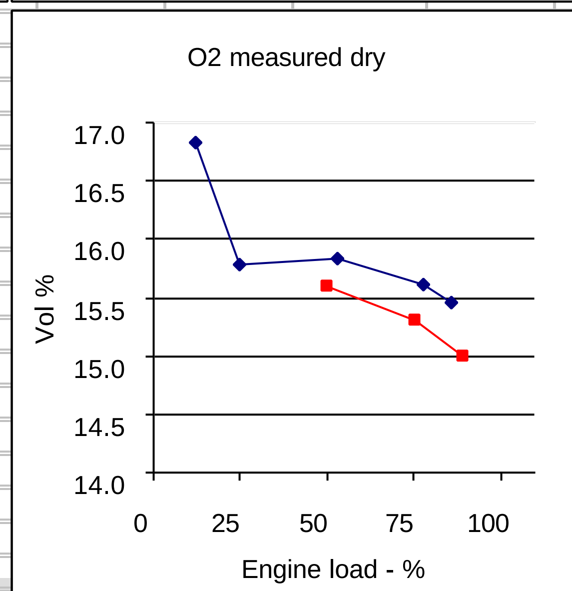
Sine Maersk - Emissions

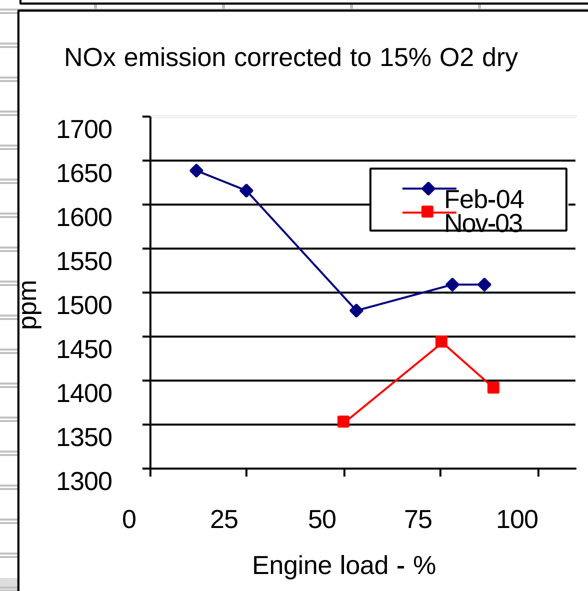




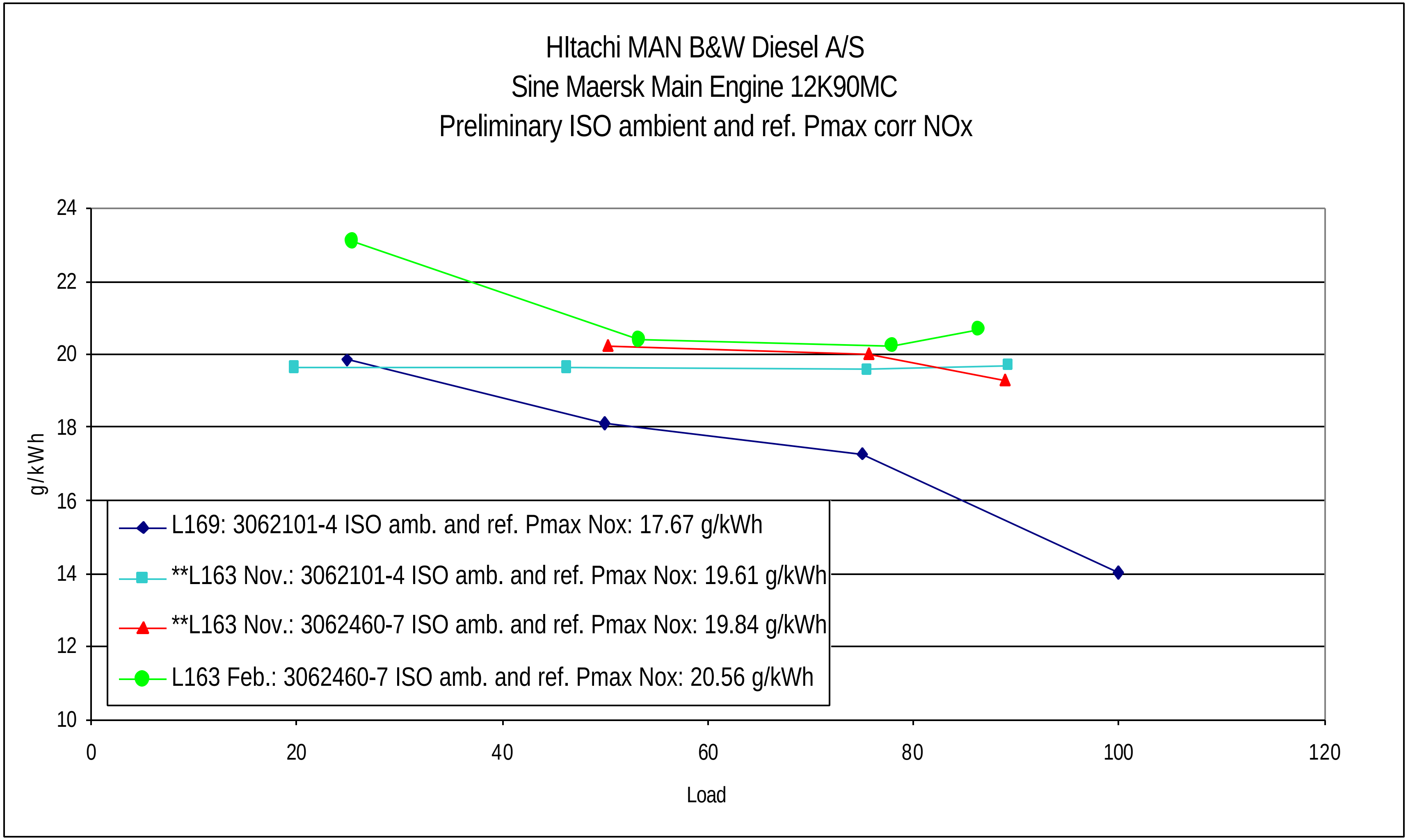




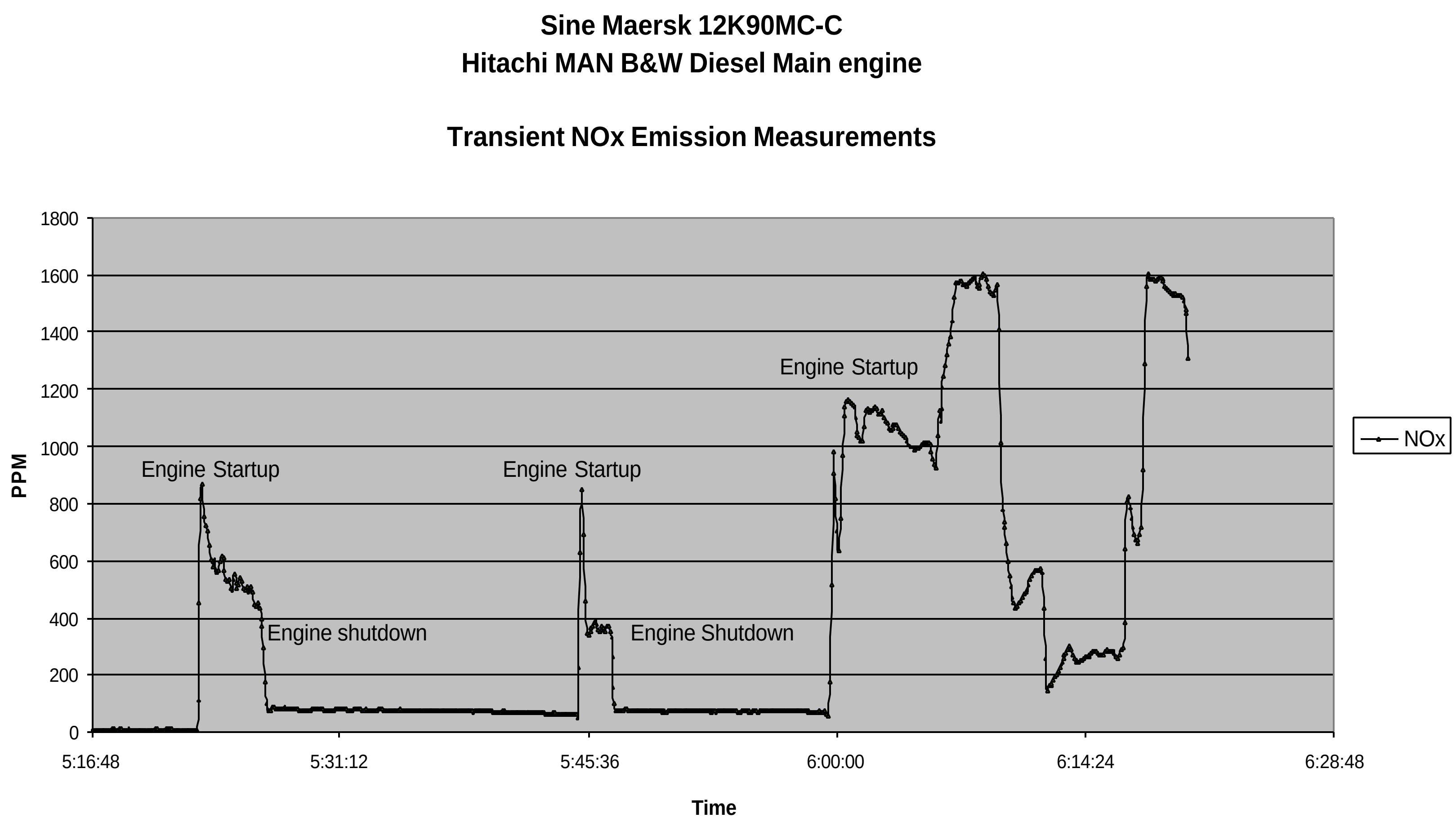




IMO NOx emission

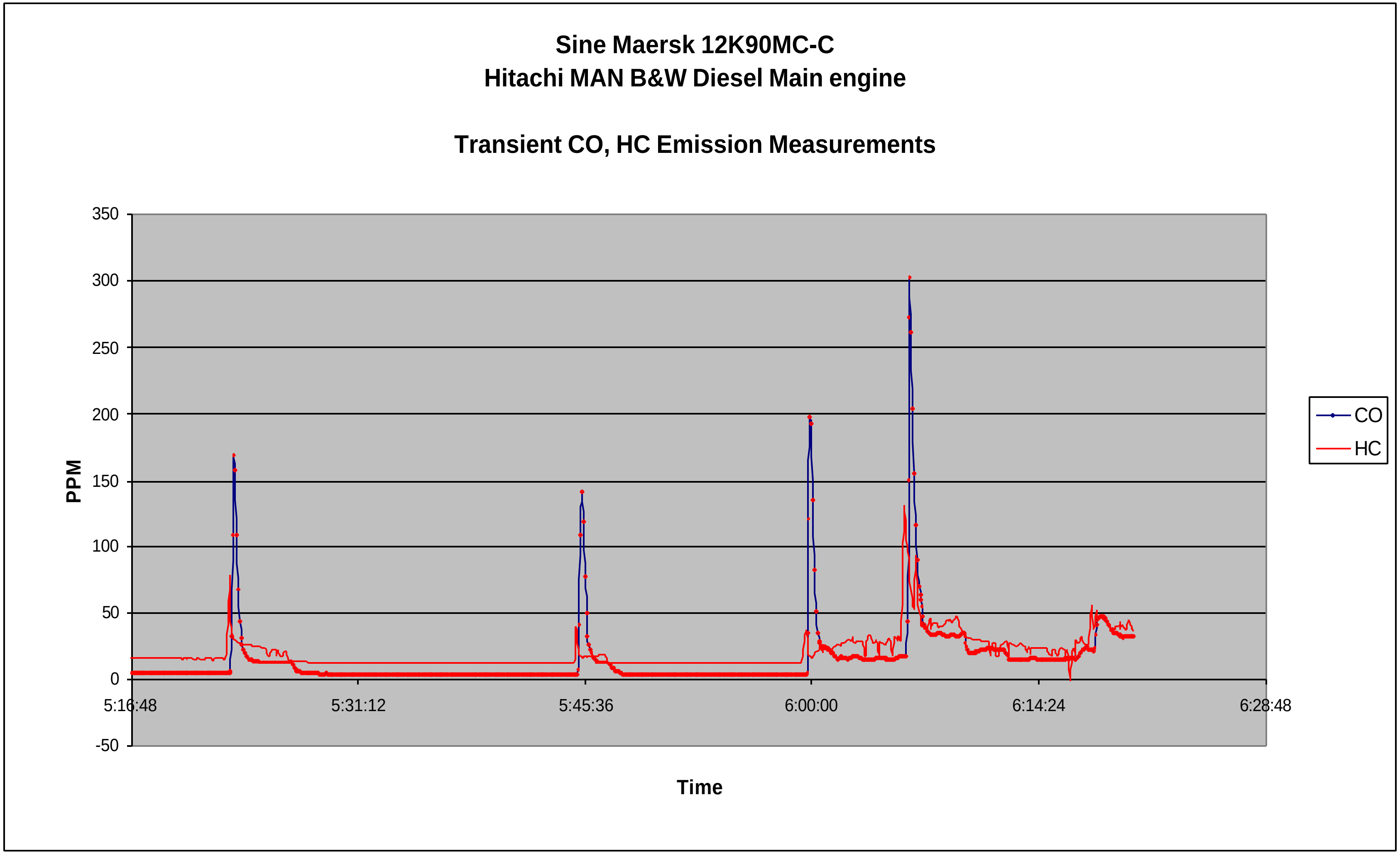


Transient NOx measurements

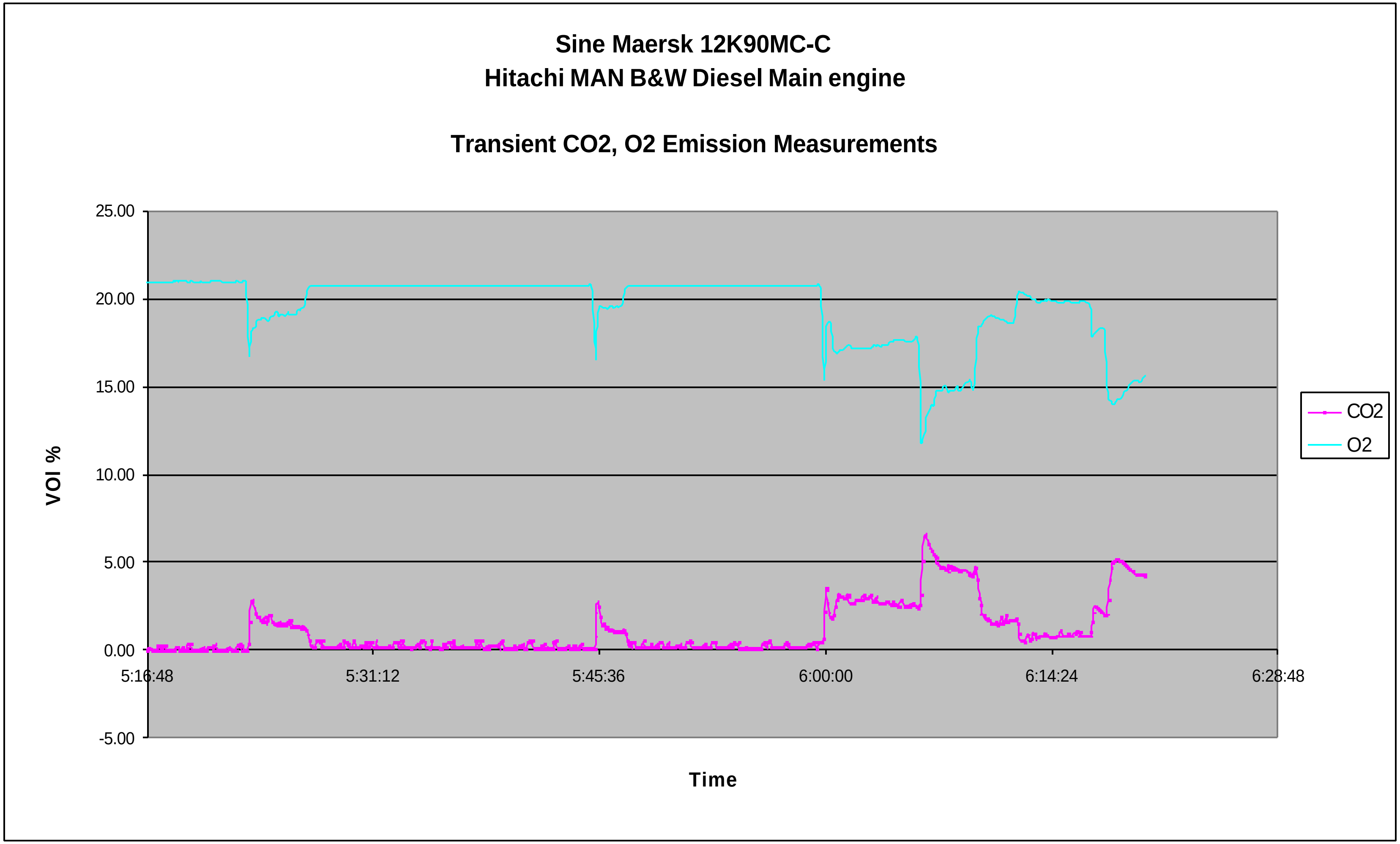


(--------------------------Manouvering---------------------)

Transient CO & HC Measurements



Transient CO2 & O2 Measurements



Retrofit Control Technology Discussion

Introduction (emission reduction methods)

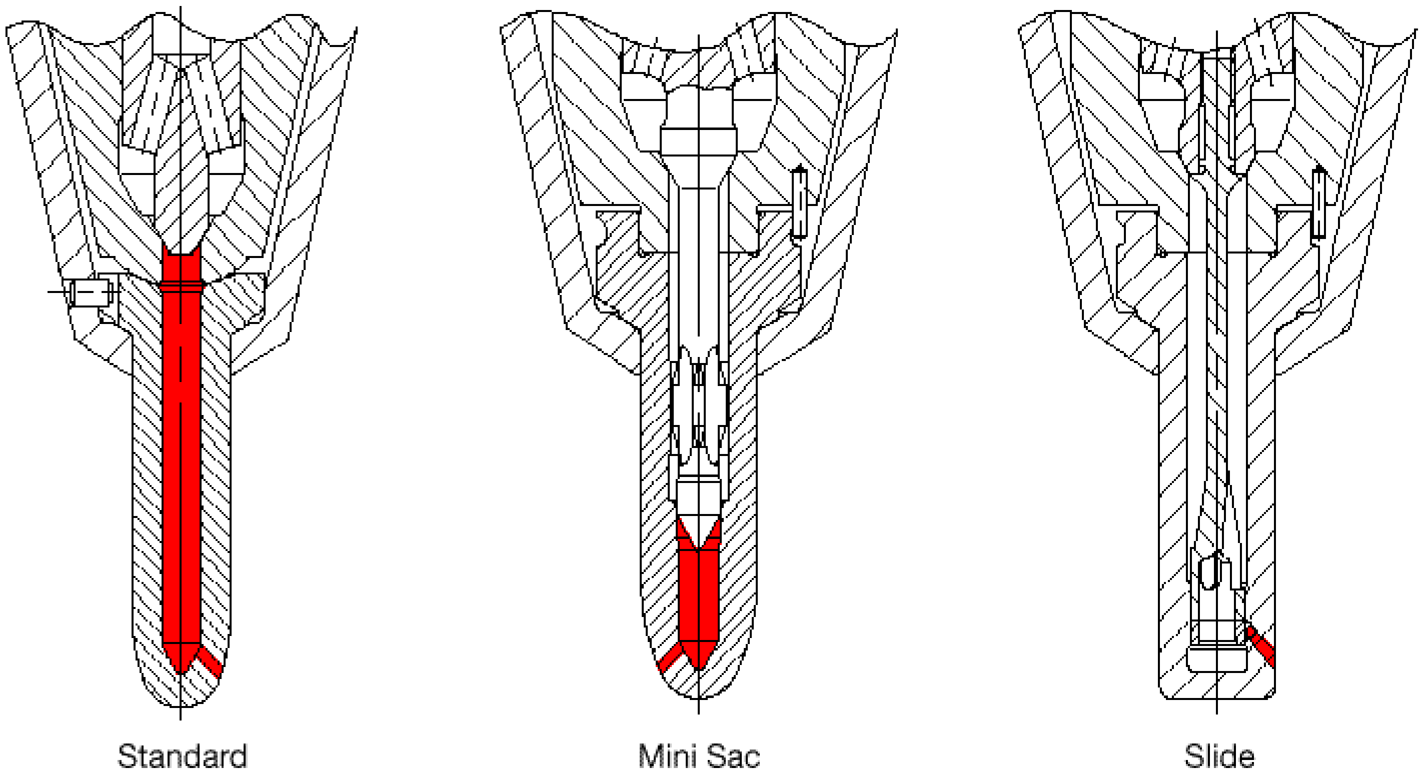
Slide type fuel valves

Water-in-fuel emulsion (vs SCR)

Comments on HFO vs low-S DO

Slide Valve Design

Cross sections of fuel-valve nozzle tips



Slide Valve Characteristics

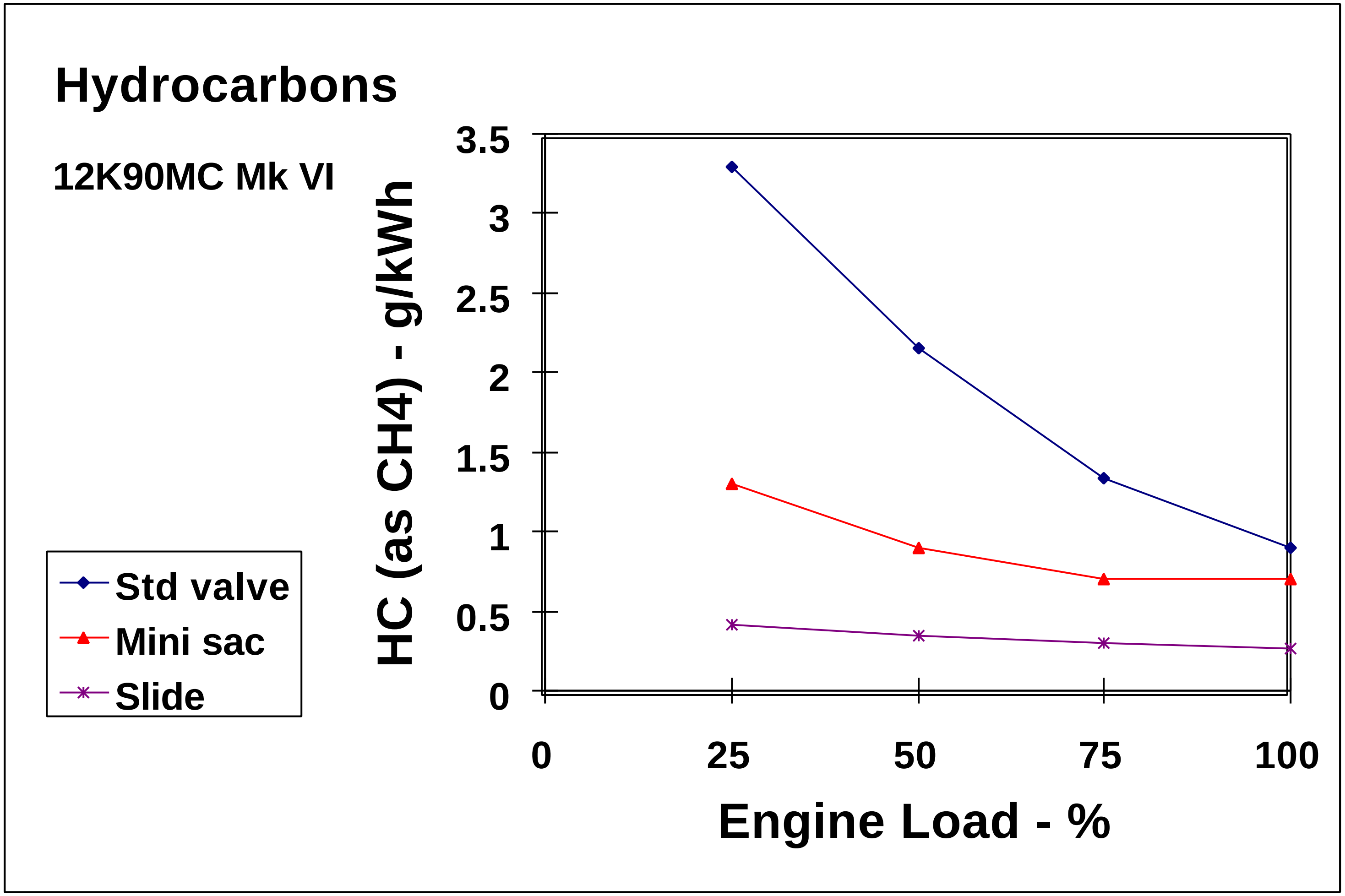
Minimal sac volume – no ’dripping’

* Lower HC and particulate emissions
* Less smoke formation
* Reduce fouling of gas ways and exhaust gas boiler
* Reduce fouling of piston topland and cylinder liner

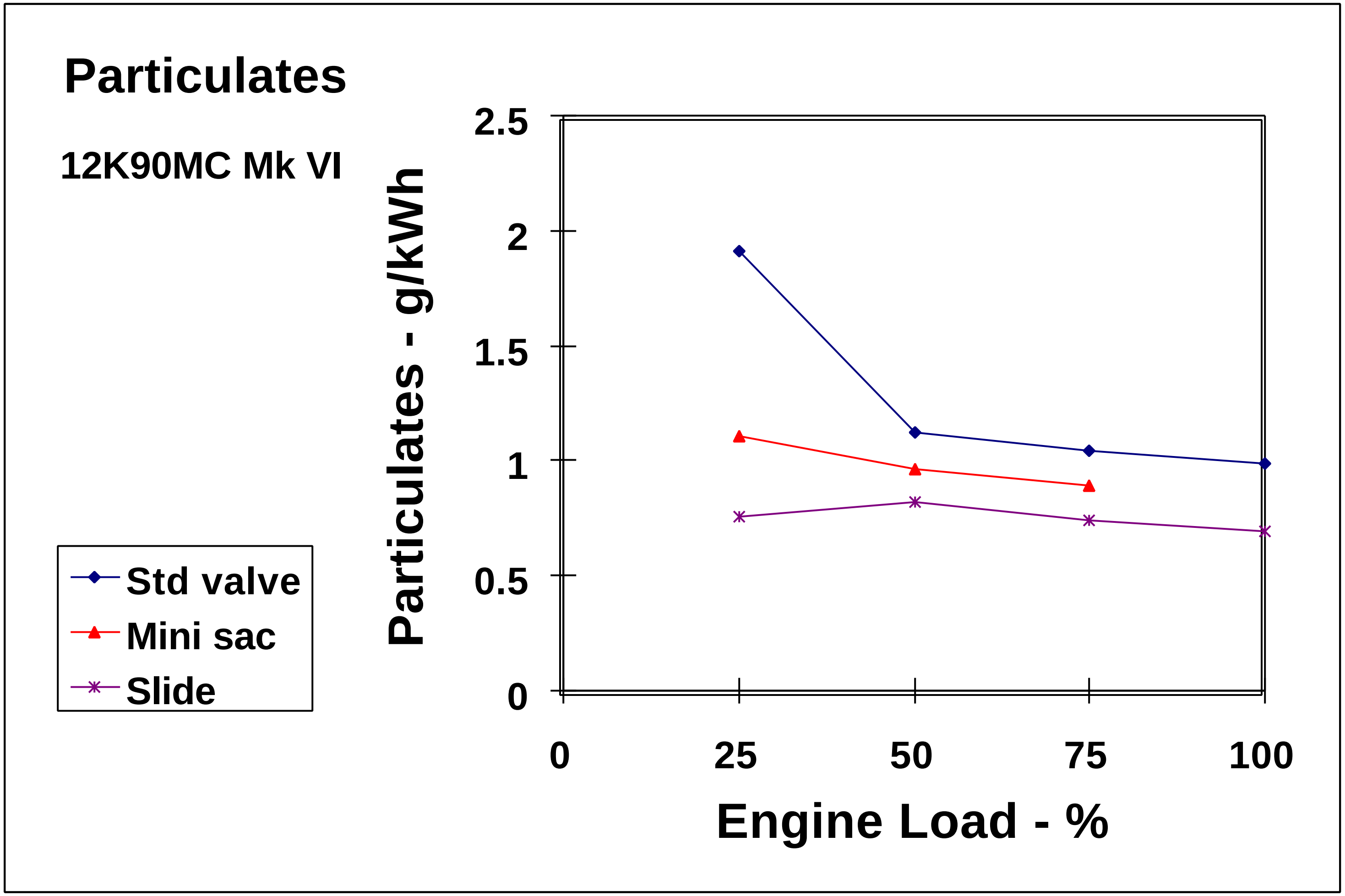
Usually combined with low-NOx behavior

Easy to retrofit

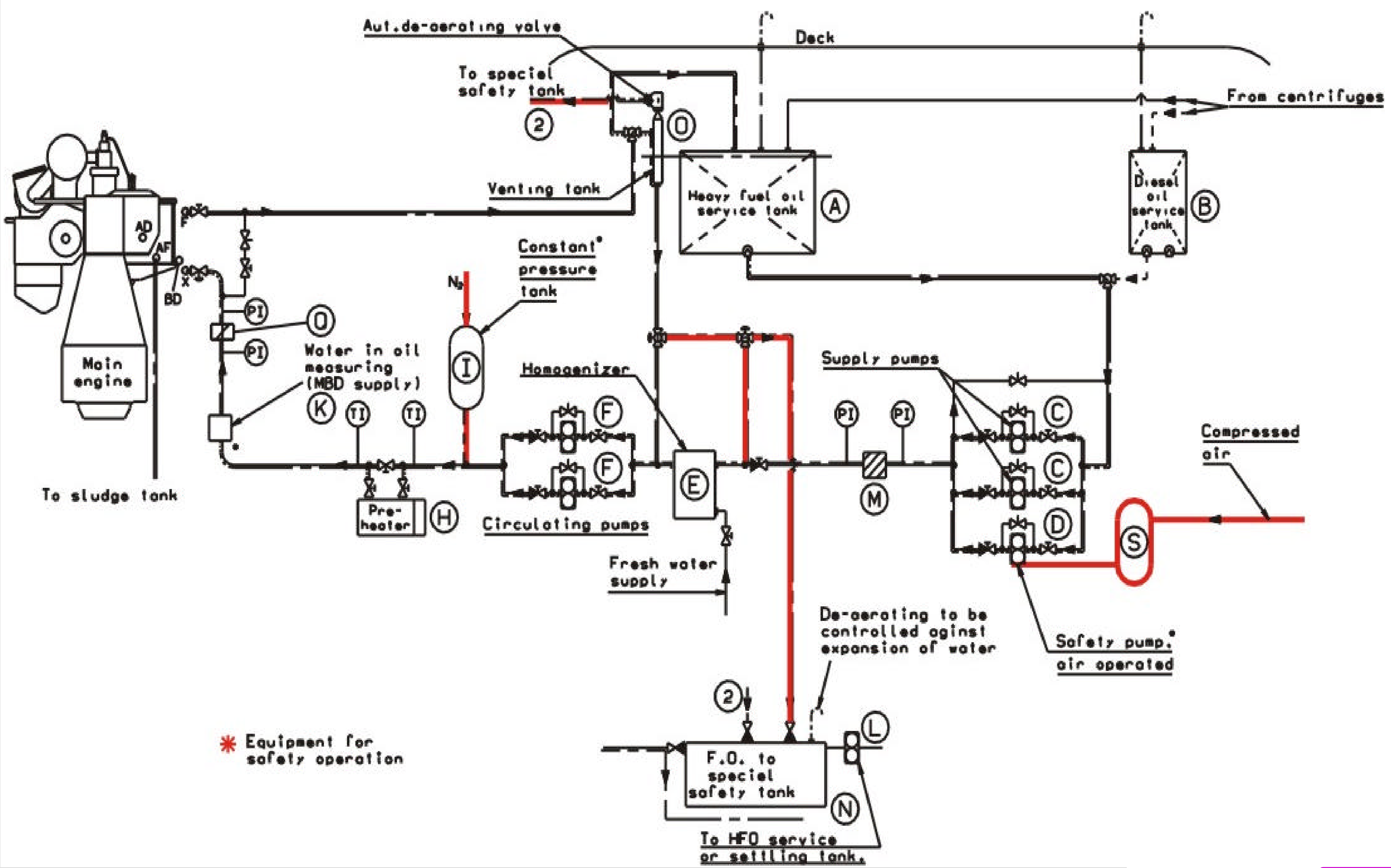
Example – HC Reduction



Example – PM Reduction



Water Emulsification System



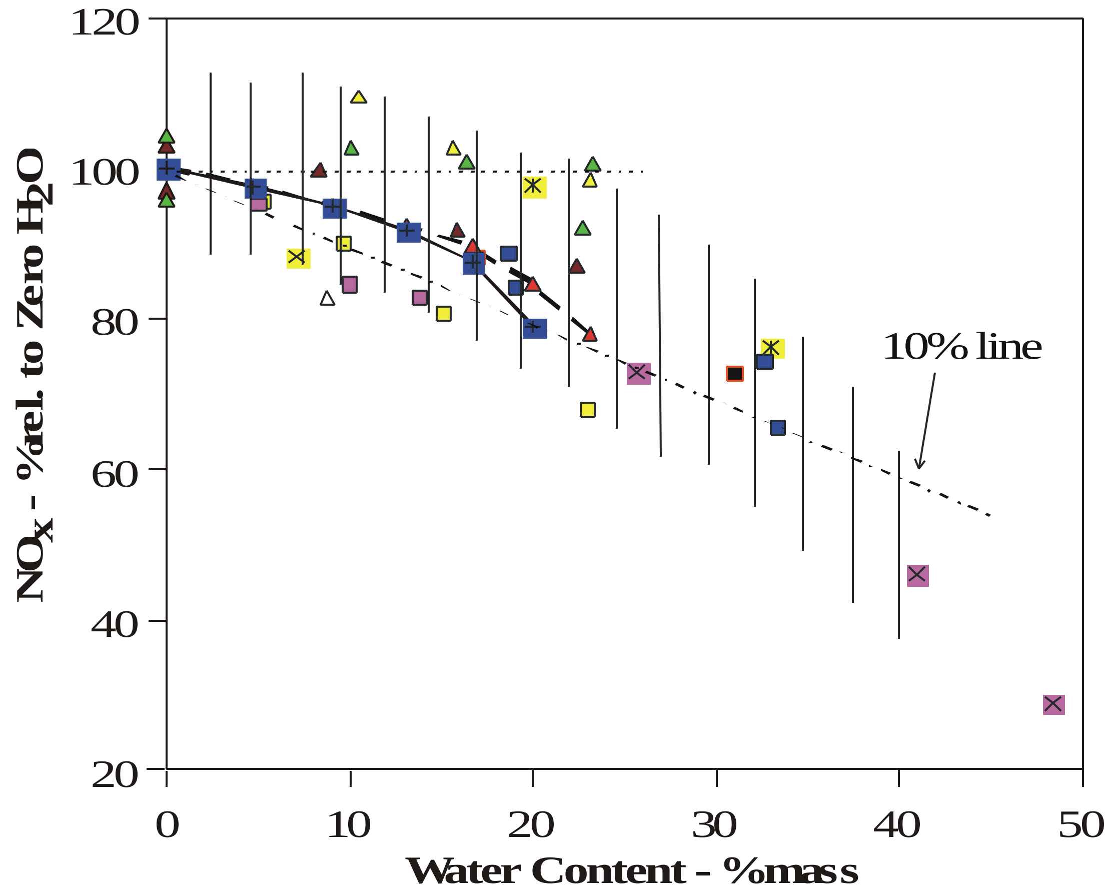
Water Emulsification – System Additions

External Fuel Oil Supply System (New Items)

- Homogeniser unit
- Water Supply System
- Closed dumping tank for fuel and water mixture
- Air driven emergency fuel oil supply pump or
  Other means for maintaining the fuel oil system pressurised
- Meter for measuring ”water content in fuel oil”

Water Emulsion – NO_x Reduction

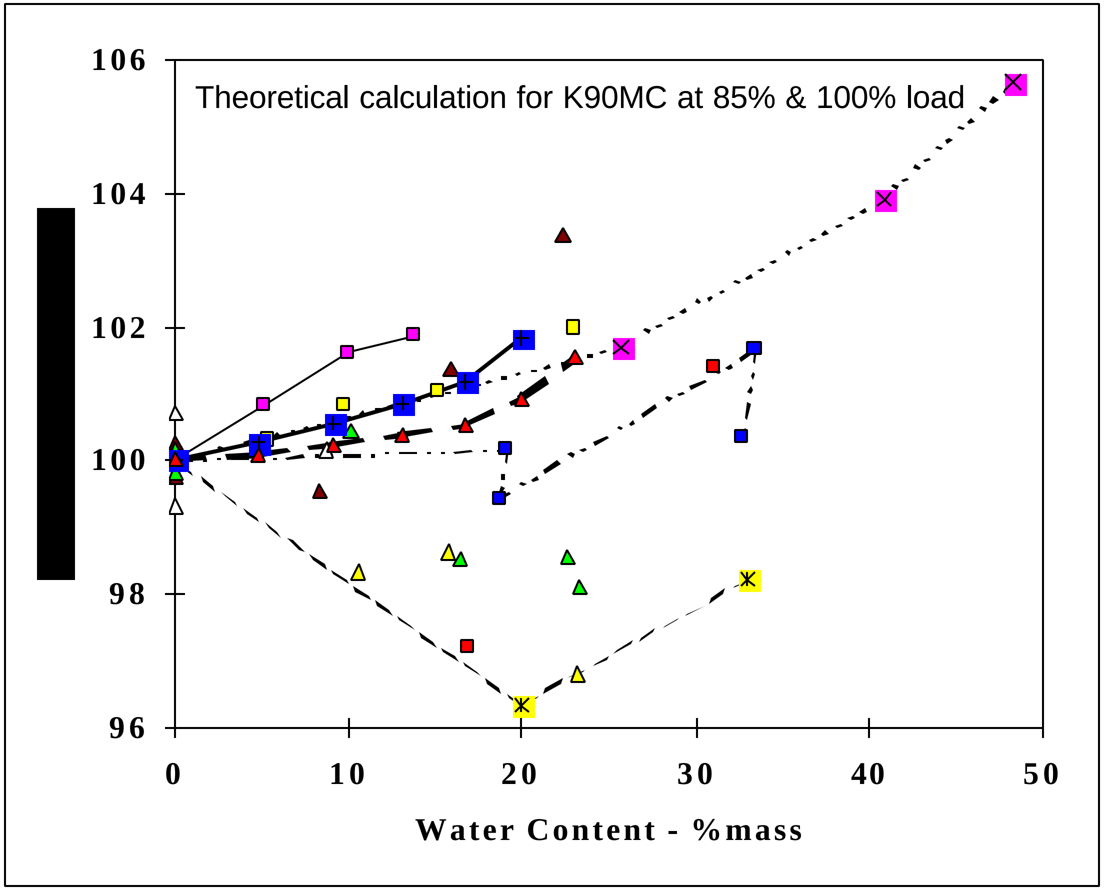
NO_x range for miscellaneous water-emulsion tests



Comment:
Heavy lines are theoretical calculations for K90MC at 85% and 100% load.

Water Emulsion – SFOC effects

sfoc range for miscellaneous water-emulsion tests



Comment:
Heavy lines are theoretical calculations for K90MC at 85% and 100% load.

Comments – Water Emulsification

The effect of water emulsion on NOx is known (a rough guideline gives 1% NOx reduction per % water content)

Large water amounts or changing FIE require MAN B&W involvement for evaluation of engine safety

The control system/governor needs to be designed for safe operation in case of emergencies/failures

FIE (pump-valve-nozzle) to be optimized for NOx reduction requirement and best sfoc & emissions trade-off

Changing the ’standard’ FIE has consequences for sfoc and emissions when running without water

Running on DO requires additive for stabilizing the emulsion

The fresh water supply to be considered

IMO requirements to be considered

MAN B&W can evaluate/propose systems on a case to case basis

Example – Stationary Application, Cost

Evaluation of NO_x reduction methods and costs for a new 12K80MC engine

Assumptions:

Engine type:	12K80MC
Shaft power:	40.680 kW at 104 r/min
Initial NO_x level:	1.500 ppm at 15% O_2

Means:	Reduction level:	Investment:	Consumption:
Primary means			
Emission optimised fuel nozzles and valves	0-25%	25.000 USD	Fuel increase up to 2%
Emulsification			
Incl. homogenizator, larger fuel pumps and NOx optimised nozzles and valves	0-50%	400.000 USD	Fuel increase up to 5% fresh water
Selective catalytic reduction			
Incl. control equipment, mixer NH_3 handling equipment but excl. piping between SCR catalyst, engine, Ammonia tank and mixer	0-98%	1.500.000 USD	NH_3 6-7g/kWh at 95% NO_x reduction

Comments on HFO vs low-S DO

Low-Sulfur distillate fuel as HFO alternative (the vessel still to operate on HFO elsewhere)

lube oil	**additive package adjustment to optimize for liner corrosion**
low lubricity	**fuel pump failures**
low Sulfur DO	**liner lacquering depn. on TBN or incompatibility with HFO**
low aromatic HC content	**fuel filter clogging**