

---

|  |                     |             |
|--|---------------------|-------------|
| <b>Subject</b>   |                     | <b>Page</b> |
| Test report after tests of emulsified fuel oil and water mixture on engine |                     | 1 of 3      |
| <b>Issued by</b>   | <b>Department</b>   | <b>Date</b> |
| Lars Bo Andersen   | Test Centre Aalborg | 17 Jan 2024 |

---

## Test of FOWE ECO Solutions in Alfa Laval Test & Training Centre, Aalborg, Denmark

### Introduction:

This report describes the learnings from 12% emulsified fuel oil and water mixture test on the axillary engine in Alfa Laval Test & Training Centre Aalborg, Denmark.

### Overall test goal

The test-run was requested by FOWE to verify performance and emissions of engine when combusting emulsified fuel oil (eFO) prepared by FOWE CAVITECH device. The engine should be kept, if possible, in "as-is" conditions to simulate an existing system.

### Executive summary

2 tests were run on the MAN 9L28/32 fourstroke medium speed engine. A base test with std. FO from bunker company (without water content) and test with FOWE emulsified fuel with 12% water content measured by FOWE Flowmeters. Each test was run at 50% and 100% load. Measurements by 3. Party (Norsk Analyse) and Alfa Laval instruments at each load point and comparison between base and emulsion test run was made.

Highlights from test on MAN 9L L28/32H Engine:

- eFO with 12% water content: Power output set as base test. Test for fuel saving and emission reduction.
  - Fuel index inline or a little higher on eFO compared to FO on both 50% and 100% load. Minor fluctuations are seen but it seems to stabilize over time.
  - Fuel consumption saving seen on both 50% and 100% load.
- NOx emissions lower on eFO than on FO in both load scenarios comparing the NO and NO2 emission curves in Appendix 1.
- CO, CO2 and SOx reduction observed, as outlined in Appendix 2.

### Short conclusion:

Expectation from FOWE was that fuel saving and emissions reduction would be seen during the test. The gathered test data indicates potential for fuel savings of 8.7% at 50% load and 6% at 100% load on engine based on FOWE flowmeter equipment readings during eFO preparation. NOx emissions are lower on all load scenarios compared to base test with a 1.6% reduction at 50% load and 8.0% reduction at 100% load.

**Main equipment used:**

Flex separation systems, S-separators 805/815

- 4-stroke MAN 9L L28/32H engine connected to generator and electrical grid in DK
- FOWE CAVITECH controlled cavitation emulsifier installed to prepare the test oil.
- FOWE Flowmeter Bellflow-systems BFU-100 RF clamp-on on oil flow measurement
- FOWE Flowmeter Massflow Online – Magnetic Inductive flow Sensor MVM-060-PA measurement on water flow measurement
- Fuel Oil: 180 cSt VLSFO 0,5% delivered by BunkerOne.
- 25m<sup>3</sup> heated double walled HFO tank,
- 25m<sup>3</sup> heated double walled stainless-steel tank,
- 2 m<sup>3</sup> heated double walled day-tank.
- HFO Separator ALCAP S805
- Alfa Laval Fuel Condition Module, TC version
- Detailed engine performance scheme with flows, pressures, temperature, density, cSt. with more - measured during test.,
- NOx, CO<sub>2</sub> measurement in exhaust gas by Norsk Analyse

**Preparation for test**

The VLSFO was run through separator from and to HFO/ALT tank 2 times prior to each test. All systems were inspected and cleaning of relevant components in the fuel system was executed before the test run (e.g., FO filter, Nozzles, and valves)

Preparation of the eFO was made using the FOWE CAVITEC solution connected to the fuel tank system in the Test Centre. Various equipment was added e.g., booster pump with VFD, tracing and insulation of pumps with more to ensure a trouble-free operation.

**Test program for test on Engine**

- **Day 1 - Test Plan - FOWE HFO Base Test 1:**
  - Base Test run on VLSFO 0,5% without water content to set baseline.
  - Run 80% load and start-up on DO and changeover to VLSFO.
  - Run 50% Load until stable run is observed.
  - Run 75% Load until stable run is observed.
  - Run 100% Load until stable run is observed.
  - Run 80% Load and change over to DO and shutdown
- **Day 2 - Test Plan - FOWE Emulsion Test 2 - 12%**
  - Run on VLSFO 0,5% with 12% water content based on FOWE flowmeters measurements.
  - Run 80% load and start-up on DO and changeover to emulsified FO.
  - Run 50% Load until stable run is observed.
  - Run 100% Load until stable run is observed.
  - Run 80% Load and change over to DO and shutdown.

## Learning/observation during test

### Disclaimer:

The learnings/observations during test can be interpreted in various ways depending on the measurement equipment used. Whenever indications are based upon a specific measurement device, the report will indicate this. Alfa Laval has facilitated a test in its test centre and does not warrant or take any responsibility in relation to the test results or the interpretation hereof. Particularly, Alfa Laval cannot and does not warrant any indicated fuel savings or emissions reduction stated in this report.

### FOWE HFO Base Test 1

- Test was conducted according to test plan. A pre-run prior to base test run indicated all systems ready to go.
- Engine performed normally under base test run and measurement for comparison against the 12% emulsified FO was gathered.

### FOWE Emulsion Test 2 - 12%

- Test was conducted according to test plan but shorter test time was executed on eFO compared to base oil on 50% load.
- The Fuel index measurement is in line or slightly higher on eFO compared to FO in both load scenarios.
- The Fuel consumption measurements indicate potential fuel saving at 50% and 100% load on eFO when compared with the FO base test.
- NOx emissions are lower on eFO than on FO in both load scenarios comparing the NO and NO2 emission curves.
- Engine performed normally under the test run on eFO though measurement of fuel consumption seems slightly blurred at 50% load. While preparing the graphs in Appendix 1, this was accounted for.

### Overall status of test

In general, the test scenarios were executed as agreed. Minor modification to the test plan was made to accommodate wishes from FOWE and prevent unintended shutdown of the engine.

## Conclusion

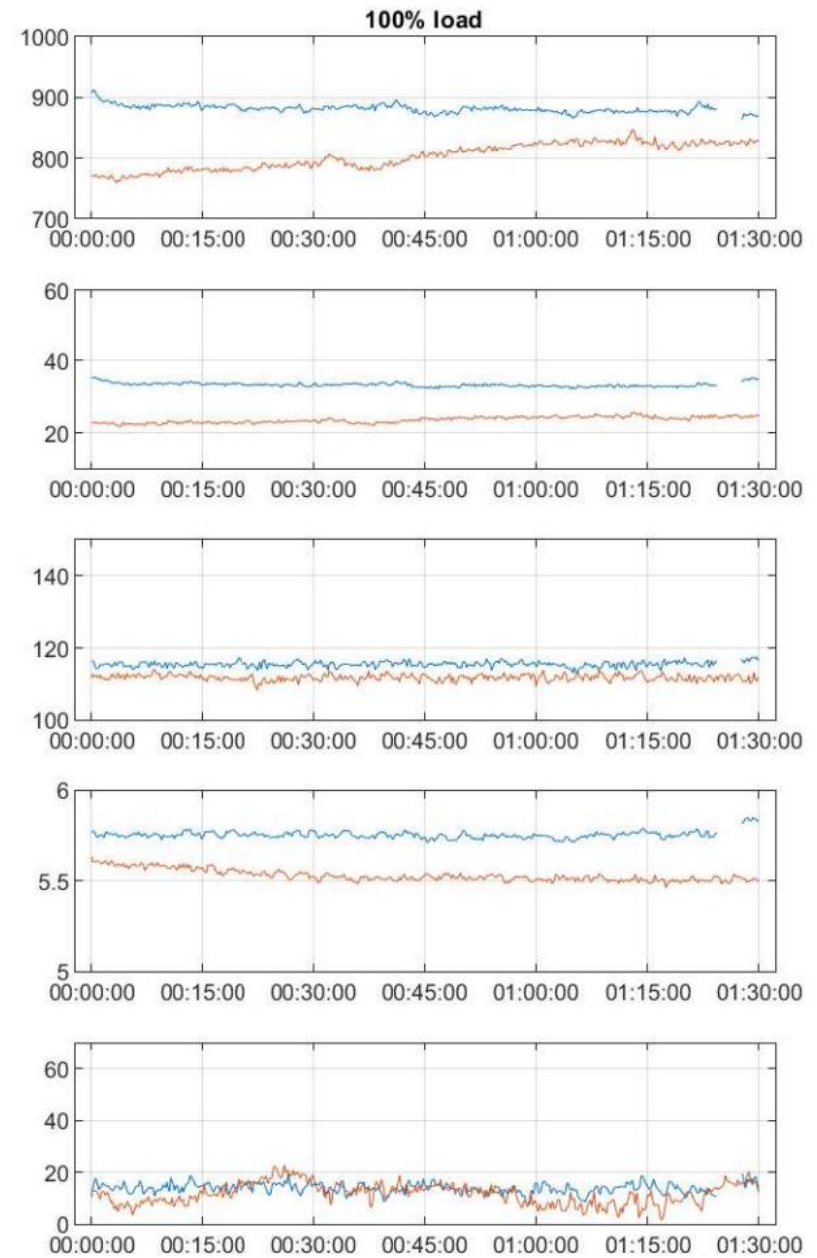
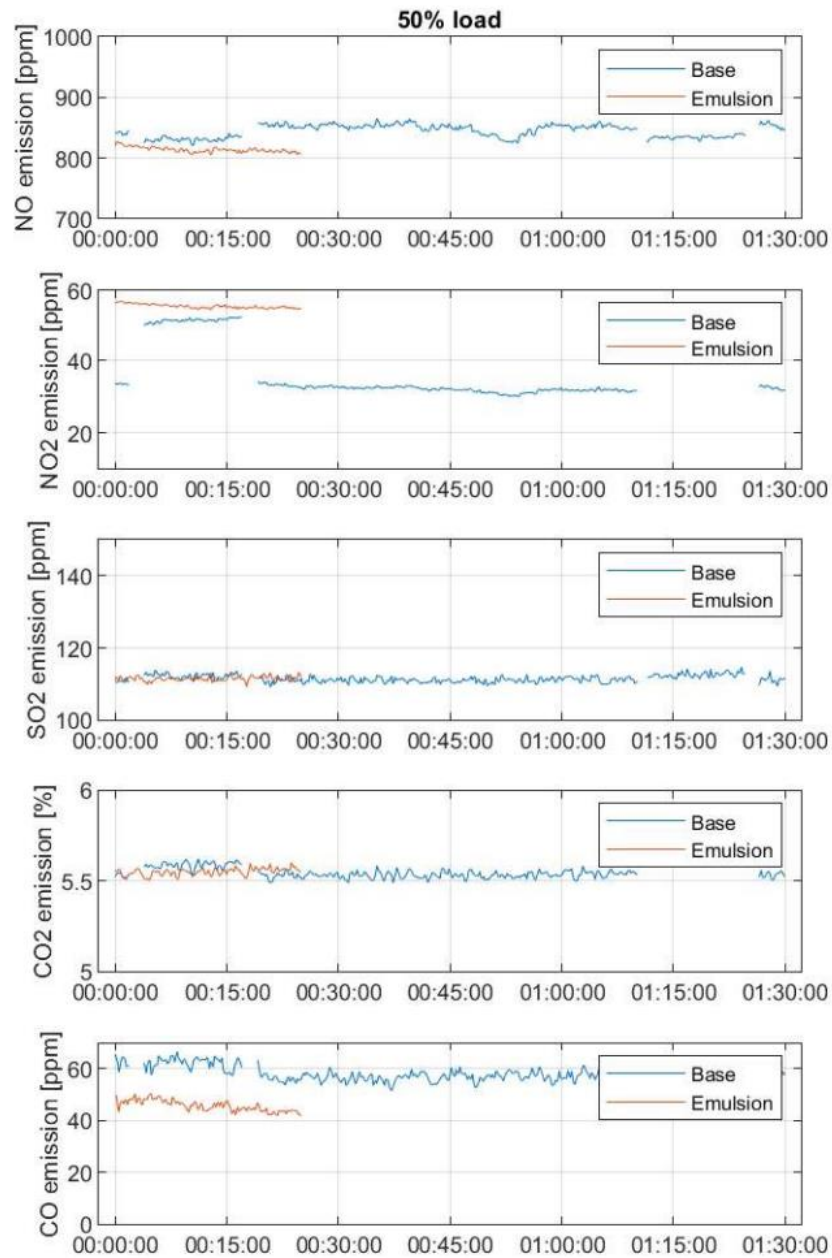
It seems possible to combust the emulsified fuel oil and water mixture on a 4-stroke MAN 9L L28/32H auxiliary engine without modification of auxiliary systems and engine layout.

A potential fuel reduction might be obtainable on 50% and 100% engine load, when FOWE flowmeter equipment reading is used during eFO preparation.

Emission test measurement indicates a reduction in NOx emissions when running on eFO.

The engine test has been running only shortly in a, to some extent, controlled environment. The few running hours obtained during test, cannot be used to conclude longtime behaviour of the engine running eFO continuously.

# Appendix 2: Emissions measurement, Norsk Analyse



# Appendix 1: Fuel consumption and NOx emissions

## Avg. from AL datalog and Norsk Analyse

