PERFORMANCE AND BEHAVIOUR OF DUAL-FUEL ENGINES IN SHIPS

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Content for the presentation

- Wärtsilä DF engines
- Loading performance
- Engine testing
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<table>
<thead>
<tr>
<th>Engine Size</th>
<th>Model</th>
<th>Power (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wärtsilä 20DF</td>
<td>6L20DF</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>8L20DF</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>9L20DF</td>
<td>1.6</td>
</tr>
<tr>
<td>Wärtsilä 34DF</td>
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<td>2.7</td>
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<td>9L34DF</td>
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<td>Wärtsilä 50DF</td>
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<td>16V50DF</td>
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<tr>
<td></td>
<td>18V50DF</td>
<td>17.55</td>
</tr>
</tbody>
</table>
Wärtsilä Dual Fuel engine performance

- A Wärtsilä dual fuel engine has the same loading ability as a diesel engine.
- Load acceptance in gas mode is restricted on low load by the turbo charging ability in principle the same way as a diesel engine. On higher load the restriction is set by the knocking.
Load acceptance comparison test in diesel mode and gas mode.

Wärtsilä 50DF
W34DF Loading 0 – 100%, Gas Operation
W34DF Loading 0 – 100%, Gas + Diesel Operation

- Engine load [%]
- Gas fuel injection dur. [time]
- TC speed [revs]
- Engine speed [rpm]
Mechanical drive – operating area

W34DF CPP Application Operating Area

- Max BMEP 20.5bar (nominal 19.8bar)
- Overload area for temporary use only (5% speed drop)
- Idling/Clutch-in speed range 60-65% of nominal speed
- Min. speed 375rpm 50% of nominal speed
- IMO E2-cycle points for CPP-applic. (4% speed droop)

Engine load [%] vs. Engine speed [rpm]

- MCR
- CSR
- 110% / 774rpm

February 2, 2012
Propeller curve loading Wärtsilä 6L50DF in gas mode

Bermeo 13.05.2010

- Engine load [kW]
- Engine speed [rpm*10]
- Charge air pressure [mbar]

Speed, load, pressure

Time [s]

45 seconds
Single main engine

- Redundancy
  - The DF design is by its design inherently redundant.
  - Gas fuel redundancy: Diesel mode
  - Pilot fuel redundancy: Backup mode
  - Control system redundancy: Limp mode (mechanical backup governor)
Ramping of load, gas

Max load rate: 7%/10s

Max unload rate: 50%/10s
Max instant load steps

Running at this load

Allows this big instant step
Load ramp up

This ramp defines the max allowed ramp rate when loading over the whole load range. I.e. loading from 30% to 85% in 80s is guaranteed. Practically same rules exist in diesel mode (and corresponding diesel engines of same size).

The restriction is mainly to avoid mechanical stress due to heating up of the big mass of an engine.
Load ramp down

Crash stop of LNG tanker. 85%-7% load in 7s.

Crash stop in gas mode

PT601
PT901
Pgas-Prec
Engine speed [drpm]
Engine load [mbar]
MFI duration [us]
Instant loading

Laboratory tests: Wave simulations

Wave loading results, W6L50DF, Gas mode

Wave loading results, W6L50DF, Gas mode
Example:

At 40% load a 20% instant step is possible. However if there are possibilities to make the load change by ramping it towards the new load, a higher "load step" is achievable. These kind of tests have not been done and no exact figures can be given.
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Gas engine testing

Engine Testing

Vasa, Finland
- W6L34 SG
- W9L20DF
- W16V34SG
- W6L20DF

Bermeo, Spain
- W6L34 DF
- W6L50SG
- W6L50DF

Trieste, Italy
- W6L34 DF
- W6L50 SG

Rig and Automation Testing

Fuel Injection
- UNIC

Rig Testing Mechanical
- UNIC

Single Cylinder Engine
- HALT

Engine Automation Testing

Wärtsilä