Influence of filtration on component lifetime of common rail injection systems
Agenda

- Abrasive particles limiting the lifetime of CR injectors
- Experiences with different filtration levels
- Filtration technology which overcomes the problem
- Conclusions
Target of the development

Safe operation of common rail injection system exceeding 8,000 running hrs with heavy fuel oil
Target of the development
Injector shut-off valves worn-out dramatically in very short time

typical wear on the tip of a control pin
after 500 running hrs

Source: Wärtsilä
Abrasive particles in the heavy fuel

Catfines
Abrasive particles in the heavy fuel

Catfines

chemical composition: \( \text{AL}_2\text{O}_3, \text{Si} \text{O}_2 \)

size (raw cat fine): \( 20 - 80 \mu m \)

mechanical: hard, abrasive
Fuel treatment system

Fuel cleaning system

Fuel conditioning system

Legend
1. Settling tank
2. Separator feed pumps
3. Fuel oil pre-heaters
4. Centrifugal separators
5. Service tank
6. Fuel oil supply pumps
7. Main filter
8. Bypass filter
9. Flow meter
10. Mixing tube
11. Circulation pumps
12. Heaters
13. Viscosity transmitter
14. Duplex safety filter
15. Constant pressure valves
16. Sludge tank
17. Feed pump to sludge separator
18. Sludge heater
19. Sludge separator
20. Concentrated sludge tank
21. Recovered fuel oil tank
22. Bilge water tank

Source: CIMAC Recommendation No. 25, May 2006
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**Abrasive particles in the heavy fuel**

**Catfines downstream separation**

*No. of Catfines found in Cylinder Liner Replicas*

- **Based on 133 cases with 167 - 5978 counted cat fines particles**
- **103 cases include size distribution**

Source: MAN, CIMAC WG7 Fuel, April 2013

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*Cat fines size distribution, µm*

- 0-5: 44%
- 5-10: 36%
- 10-15: 14%
- 15-20: 2%
- 20-25: 0.5%
- >30: 0.1%
Abrasive particles in the heavy fuel

Catfines

Most of the catfines broken bits are smaller than 5 micron. Separation is not efficient at this size but each particle itself, small or big, has got grinding properties on a surface!
**Abrasive particles in the heavy fuel**

**Catfines**

In order to reduce abrasion
You do not have to reject big particles only
But you have to catch as many particles possible
Fuel conditioning system

Option A

Option B

Supply system

Booster system
conventional fuel filters are equipped with 34 or 25 micron „absolute“
Abrasive particles in the heavy fuel

Catfines

With conventional filtration grades of 25 or 34 micron the uppermost amount of catfines passes the filter.
Experiences during lifetime testing

Typical wear with 34 micron mesh filtration on the tip of a control pin after 500 running hrs

All tests at rail pressures more than 1.500 bar (150 MPa).

➢ The injection becomes unefficient very soon and common rail is wasting fuel!

Source: Wärtsilä
Field experience with 10 micron mesh

Filter type: 6.64 DN125
Grade of filtration: 10 µm absolut
Sample: HFO
Sampling point: STENA BRITANNICA, booster system before and after automatic filter
Sampling date: 19.09.2011
Laboratory: DNV Petroleum Service Pte. Ltd., Singapore
Screening conditions: 0.50 g of sample was filtered through a 2 micron filter

Source: MAN / Boll&Kirch
Experiences during lifetime testing

Typical wear with 10 micron mesh filtration on the tip of a control pin

➢ Abrasion is starting at 500 running hours.

Source: Wärtsilä
Experiences during lifetime testing

Typical wear with 10 micron mesh filtration on the tip of a control pin after 1.200 running hrs.

After 1.200 running hours first score marks became visible.
➢ Thus lifetime is still limited!
Experiences during lifetime testing

Adoption from hydraulic oil filtration: metal fleece

10 micron „absolute“ woven mesh
6 micron „absolute“ metal fibre fleece

Source: CIMAC Congress 2007, paper no. 253, Stefan Schmitz
Experiences during lifetime testing

Typical wear with 6 micron metal fleece

NO score marks after 3,000 running hrs!
Experiences during lifetime testing

Summary

500 h on rig, 34 micron mesh

500 h on rig, 10 micron mesh

3000 h on field engine, “6” micron fleece

Seat area at control pin in excellent condition

Seat area in excellent condition

Source: Wärtsilä
Filtration technology

Automatic backflushing with compressed air
3-dimensional metal fleece requires high impulse for proper cleaning

6 micron fleece after 5,400 flushing processes, 2,700 running hrs
Filtration technology

Automatic backflushing with compressed air
3-dimensional metal fleece requires high impulse for proper cleaning

Cleaning impulse generated by compressed air
Sea trials

Tanker „Excello“ running mainly on heavy fuel

Differential pressure after ~ 1.000 running hours with 6 micron

Timer setting for backflushing 1 per hour.

Source: Wärtsilä

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Sea trials

Tanker Excello

Change of flushing timer setting from 60 to 30 minutes

Source: Wärtsilä

Target

Source: Wärtsilä

differential pressure (bar) over time
Tanker “Excello“ running mainly on heavy fuel
Coincidental blocking-up disappeared

Automatic filter recovered and proves its reliability!

Source: Wärtsilä
Sea trials

M/T Excello more than 7,500 running hours

Source: Wärtsilä
Sea trials

Superspeed 1  more than 13,000 running hours
Axel Maersk  more than 5,000 running hours

Source: Wärtsilä
Sea trials

MV Princesse Benedikte
Scandlines Ferry, Baltic Sea

Automatic filter type 6.72 DN65 in booster system

Engine: MAN 6L32/44 CR

Start with 10 µm: 07.05.2010
Start with 6 µm: 29.04.2011
Fuel: HFO 380
Booster pressure: 5,5 bar
Booster temperature: 130 °C
Flow rate: 7,5 m³/h (four engines)
Sea trials

FS Princesse Benedicte  more than 10,000 running hours
FS Schleswig Holstein  more than 17,000 running hours
Future potentials

Automatic backflushing with compressed air
even finer metal fleece variations than 6 micron are on test today
Conclusions

Automatic filtration with impulse backflushing

- metal fleece 6 micron requires more energy for cleaning than conventional filter meshes

- impulse backflushing with 6 micron is validated in marine application

- 6 micron both in feeder and booster systems

6 micron is applicable in the standard impulse back-flushing filters without any additional technology!
## Conclusions

### Wärtsilä 2-stroke engines recommendation

<table>
<thead>
<tr>
<th>Engine delivery date</th>
<th>mesh-size absolute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before summer 2005</td>
<td>50 micron</td>
</tr>
<tr>
<td>After summer 2005</td>
<td>34 micron</td>
</tr>
<tr>
<td>After spring 2012</td>
<td>10 micron</td>
</tr>
</tbody>
</table>

Wärtsilä released and specified 6 micron for future common rail generation.
Thank you very much for your kind attention!

BOLL Filtrator
TYP 8.64/8.72
BOLLFILTER Automatik
TYP 6.64/6.72