

Part 2

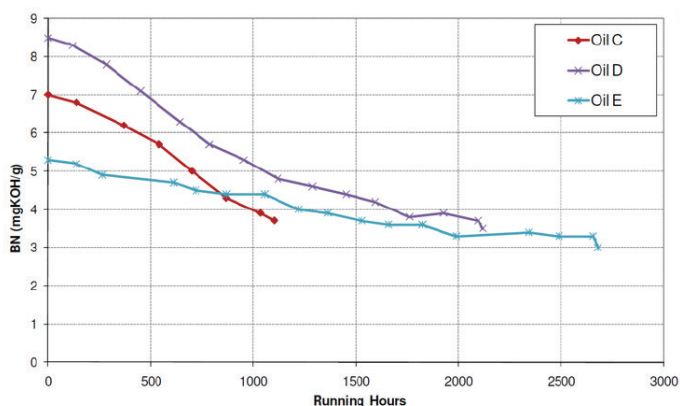


Figure 5. BN depletion trends of three candidate oils.

The chart in figure 5 clearly demonstrates that these three different candidate oils have very different BN depletion rates. Oil C and Oil D consume their BN much faster than Oil E.

Oil C depletes BN so fast that after only 800 running hours the BN is below that of oil E, even if its initial BN was 1.8 points higher than oil E. The BN of oil D does not cross the BN of Oil E, but after 2000 running hours the BN of both oils is almost equal. The chemistries used in Oil C and Oil D, although very different, both provide a less durable type of BN than the chemistry of Oil E.

In figure 6 the BN control limits for the three candidate oils have been entered in the chart, which helps to demonstrate how the different BN depletion rates translate into life. The oil control limit for BN is at 50% of the fresh oil BN.

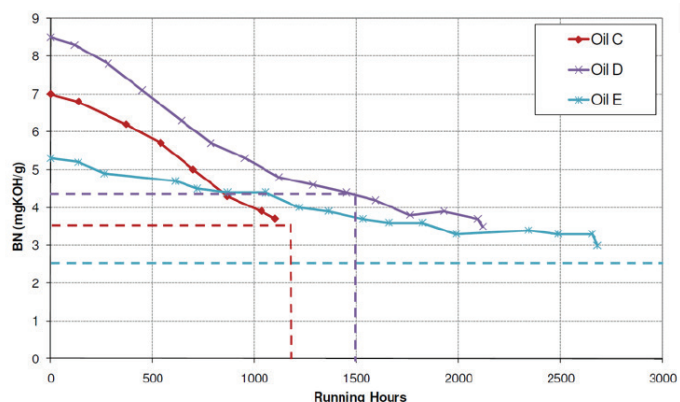


Figure 6. BN limits and achievable oil life for three candidate oils.

This chart demonstrates clearly that the rapid BN depletion of oils C and D results in shorter oil life than oil E, despite their higher initial BN value. With Oil C the oil drain interval has to be set at 1200 running hours only, for Oil D the oil drain interval would have to be set at 1500 hours. Oil E however, despite its relatively low initial BN, has demonstrated to safely reach 2680 running hours, and extrapolation of the oil condition trends predicts that it could safely reach 3000 running hours.

If the BN rejection limit would not have been a function of fresh oil BN, but a fixed number of e.g. 2.0, then also Oil D would have provided a longer life. From a physical and chemical perspective, Oil D can safely run longer than the 1500 hours that is the limit according current operational practice.

5.2. Oil life comparison of candidates with benchmark

The internal benchmark, Shell Mysella S3 S has been used at this site before the candidate oils were tested. There are good statistics available of this oil at this site. A handicap however is that the customer used to change the oil well before it had reached rejection limits. Therefore in order to allow comparison of Shell Mysella S3 S with the candidate oils, the trends had to be extrapolated. The results are as follows:

	Benchmark oil	Oil C	Oil D	Oil E
Actual oil drain interval	800 rh	1100 rh	2120 rh	2650 rh
Achievable oil drain interval	1600 rh	1200 rh	1500 rh	3000 rh

Table 2. Comparison of oil life of benchmark and candidate oils.

Only oil E, despite its low initial BN, provides significantly longer oil life than the benchmark. This is thanks to its high resistance to oxidation, in combination with the relatively mild acidity of the fuel gas. If the fuel gas had a high content of aggressive acidic compounds, then a slow rate of oxidation would not contribute to the extension of oil life. Instead the alkalinity reserve would dominate, i.e. the availability of durable and useful BN. In such case, Shell Mysella S3 S would provide longer oil life than all of the candidate oils, including Oil E, thanks to its higher buffer of durable alkaline additives.

Many OEMs however do not support the use of medium ash oils such as Shell Mysella S3 S, and recommend the use of low ash oil such as Oil E even for aggressive landfill gases. In such cases Oil E is expected to provide longer oil life than traditional low ash oils, because its slow rate of oxidation leaves more BN available for acid neutralization.

To confirm the good results of Oil E and to get more experience the field test was further prolonged with 2 more oil drain intervals (see appendix 2). After running in a kind of equilibrium (more than 5400 running hours with Oil E) the field test was stopped without exceeding any limits.

5.3. Engine condition

For engines running on landfill gas, the condition of components is not only a function of running hours, it is also strongly dependant on fuel characteristics. Acid compounds have been discussed above, and can be reasonably well abated with the help of a good lubricating oil in combination with oil condition monitoring. Another important effect is however the formation of hard deposits as a result of siloxanes in the fuel. Here the influence of the lubricating oil is limited since the deposits are formed directly during the combustion of the fuel with minimal interference of the lubricating oil.