AN ANALYSIS OF HYDRAULIC FLUID WEAR PERFORMANCE DISCRIMINATION BASED ON A STATISTICAL EVALUATION OF A STANDARD VANE PUMP TEST

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ABSTRACT

This paper discusses recent work at Shell Global Solutions’ laboratory to investigate the factors affecting vane pump test wear measurements made using mineral oil hydraulic fluids.

INTRODUCTION

Standard test vane pumps are well known within the industry, for example: the Eaton(Vickers) V104C, Eaton(Vickers) 35VQ25 and Denison T6C. Around these standard test pumps several standard test methods have also been developed. The primary purpose of vane pump testing is to determine steel-on-steel wear. Yellow metal wear is commonly assessed using piston pump testing. Vane pump testing commonly shows that the majority of the wear, typically greater than seventy-five percent occurs on the cam ring as opposed to the vane tip. It is common however to consider ring, vane and total wear when assessing performance.

The Eaton(Vickers) V104C vane pump test has been a standard wear test since the 1970’s. The test is relatively quick to run, 250h, and many laboratories have accumulated large datasets with wear as a function of formulation. The test is also cited in well-recognised industry standards such as the DIN 51524 standard.

Examination of the written methods utilising the V104C test pump, ASTM D2882, ASTM D7043, IP 281, ISO 20763, unfortunately indicates that little published statistical data available is on the repeatability of the test, although it may be that laboratories have developed their own data, as shown by the authors in this paper, to further the understanding of such tests. The authors feel it is an appropriate time to initiate discussion of such data given that the industry is currently facing issues in sourcing parts other than the original Eaton(Vickers) manufactured V104C parts. In assessing the suitability of alternative parts the statistical data on the original and new parts should be presented. It is the authors’ opinion that it is up to the companies actively marketing parts as alternatives to provide data on their products. Where a lubricant marketer is considering using parts it has selected as potential alternatives then the lubricant test house should satisfy itself as to the suitability and performance of the parts. Adoption of parts as replacements without the provision of such data is poor scientific practice and could result in products not meeting the requirements of the lubricant end-user, or claimed standards and specifications.

Currently at Shell Global Solutions tests are run using a stock of original Eaton(Vickers) V104C components. However a supplier in Japan (Tokimec) was identified who was able to supply parts that are potential replacements for future tests. In the work undertaken we assessed the equivalence of these parts. The authors’ laboratory has over twenty years experience with running the V104C test, and being able to continue to run this test to compare products with historic performance would be valuable.

TEST METHODOLOGY

At Shell Global Solutions UK the tests reported were run according to IP 281. This method specifies the test to be run at

To summarise the commonly accepted pass/fail criteria within the industry:

- Eaton(Vickers) I-286-S 50 max mg total weight loss (ASTM D2882 Vane V104C test) 2000 psi, 1200 rpm, 100 hours.
- DIN 51 524 Part 2 150 max mg total weight loss (2030 psi; 1440 rpm, 250 hours)

The test operator is given little guidance in the published methods as to test repeatability, and yet absolute limits exist against which to compare results.

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140 bar, 1440 rpm for 250 hour at a temperature to give a bulk fluid viscosity of 13 mm²/s at the pump inlet.

The Statistics Department at Shell Global Solutions UK was asked to advise on a test matrix using the three oils and cartridges from both suppliers Vickers and Tokimec. It was recommended that the tests be run in a randomised order in duplicate on the same rig (rig number 32) by the same rig technician. A limitation of the work is the diminishing stock of original components available, limiting the number of runs that could be accommodated. The aims of the work were to look at test repeatability and to determine if the two sets of test parts were equivalent.

MATERIALS
Three oils that were expected to cover the full range in weight loss were selected. The oils represent: Oil A - a leading 21st century technology, Oil B - a 1990’s technology and Oil C - a 1980’s technology fluid not optimised for wear performance. All three fluids used zinc based antiwear additives. Oil A is the high reference, that is it gives low wear and Oil C the low reference, that is it gives high wear. All three oils were ISO VG 32 fluids of VI 95.

RESULTS
The data from the study have been used to generate the following plot, Figure 1. This graph was drawn using the quantitative definition of repeatability in ISO4259, so the spacing between the two lines is the difference expected between two single test results with a probability of 95%.

Using this plot, if the first wear reading is 100 mg, the second one can only be said to be distinguishable from the first if it is smaller than about 20 mg or larger than about 240 mg. For single results, if both readings are less than about 60 mg they are indistinguishable. Clearly the precision of this test method is not very good when using single tests. In its current form, single test measurements are incapable of distinguishing between a top-performing oil with a wear measurement of around 20 mg after 250 hours and any oil producing wear less than 100 mg after 250 hours. In order to improve the quoted repeatability of a result for a particular fluid it is clearly necessary to perform more than one test. Figure 2 summarises the data in a simple format, enabling the quick determination, from a single test result of whether the limit of 150 mg total wear can be claimed with certainty.

Based on the dataset it was concluded that the two sets of test parts, Eaton (Vickers) manufactured and Tokimec manufactured, were equivalent.

CONCLUSIONS
Good scientific practice dictates the need to perform repeat tests and run reference oils to be assured of conclusions drawn from data; these concepts are reinforced by the study presented here.

Good scientific practice also dictates the need to test the equivalence of test parts when variations occur; for example parts sourced from different manufacturers, it is our opinion that this information needs to be readily available from those actively marketing such parts. Such data ideally should be generated with sufficient test parts in stock to allow comparison.

Scientific methods should ideally be published with sufficient information to allow users to judge the repeatability and reproducibility of their data. In the absence of such data there will be varying approaches taken by different parties, leaving the end customer of the fluids potentially in the dark about how to compare product performance. Performing multiple tests will help improve discrimination in tests with inherently poor repeatability.

Current test limits in specifications need to be reconsidered with regard to the data presented. The widely adopted and quoted DIN 51 524 limit of 150 mg total wear did not take into account the variability of single test results. To be confident a fluid did pass this criterion it would need to have a total reported wear of less than 90 mg for a single run. A new suggested acceptance limit is therefore 90 mg total wear. The historic Eaton I-286-S specification of 50 mg was close to the limit of determinability between results found in this study, namely that below about 60 mg total wear it is impossible to distinguish based on single results. Given the potential variability between the ASTM D2882 and IP 281 methods this was a good recommended limit.

From automotive lubricant wear testing; where international databases are maintained, test stand severity established, single test results not always permitted; the testing of industrial lubricants could adopt some best practices

![Figure 1: Chart for comparing single wear results](chart.png)

![Figure 2: comparison with the specification - single samples](chart2.png)

Figure 1: Chart for comparing single wear results

Figure 2: comparison with the specification - single samples. The Pass Level is denoted by the dotted line on the chart.

ACKNOWLEDGEMENTS
The authors thank Shell Global Solutions for the opportunity to publish this work.