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Effect of conductivity on multipass testing as per ISO 4548-12:2017

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Foreword

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This document was prepared by Technical Committee ISO/TC 70, *Internal combustion engines* Subcommittee SC 7, *Tests for lubricating oil filters*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

ISO 4548-12 (2000 and 2017 editions) states that oil (MIL-PRF-5606, AIR 3520 and other suitable fluids) conductivity is to be set to “at least 1 000 pS/m” prior to conducting a lubricating oil filter, with a recommended level of “1 500 pS/m +/- 500 pS/m.” Prior to the revision of ISO 4548-12:2000 (started in 2016), fluid conductivity had received increasing attention. Some labs reported issues with maintaining fluid conductivity during these tests and discussed the effects conductivity can have on filter capacity results. Testing showed the fluid conductivity can decrease during a test, which corresponded to an increase in filter capacity. A task force was established within ISO/TC70/SC7/WG2 to investigate this issue. Findings from this work are summarized in this document. The root cause of the fluid conductivity problem was not discovered and most labs did not report any issues with maintaining conductivity during ISO 4548-12 testing.

Experiments were conducted by one laboratory, oil was examined by two laboratories, and survey results were sent from nine laboratories. Three sets of experiments were conducted including testing with flat sheet samples and commercially available filters to examine the effect of fluid conductivity change. Fresh and aged oil were examined to see if any components of the fluid were depleted during normal use.

Effect of conductivity on multipass testing as per ISO 4548-12:2017

1 Scope

This document outlines the importance of conductivity in multi-pass filter testing per ISO 4548-12. This information also applies to filters tested per other multi-pass filter test standards, such as ISO 16889 and ISO 19438. Filters tested according to each method can experience similar changes in performance during the fluid conductivity changes outlined within this document.

The objectives of this document are to clarify the following issues:

— Examine how conductivity affects filter capacity test results when filters are tested per ISO 4548-12:2017.

— Compare findings to ISO 4548-12:2017 operating parameters.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4548-1, *Methods of test for full-flow lubricating oil filters for internal combustion engines — Part 1: Differential pressure/flow characteristics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4548-1 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

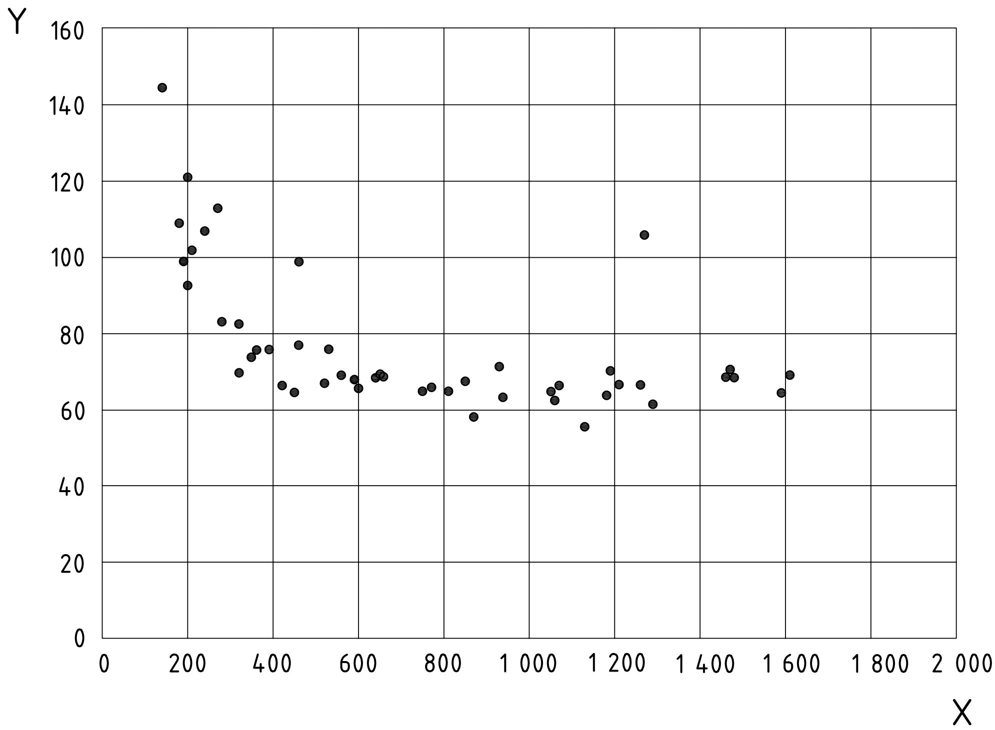
— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Reference filter testing

This issue was first reported after a lab used “reference filters” to monitor the consistency of their multi-pass test system. These are typical production spin-on filters, but specifically manufactured to limit filter-to-filter variation. These reference filters are constructed with synthetic media and a media area of 3 039 cm^2. These filters are typically used as hydraulic/transmission oil filters on heavy-duty diesel engines for off-road equipment.

From 2012 to 2015, this lab gathered data from periodic testing of these reference filters per ISO 16889:2008 (Figure 1). Initial and final conductivity were logged during this testing. Test technicians noticed final conductivity would significantly drop during some tests, corresponding with a higher than expected capacity. Specific parameters of this testing are shown below.



Key

X final conductivity (pS/m)

Y retained capacity (g)

Flow Rate: 75 lpm

BUGL: 10 mg/l of A3 dust per ISO 12103-1:2016

Terminal dP: 345 kPa

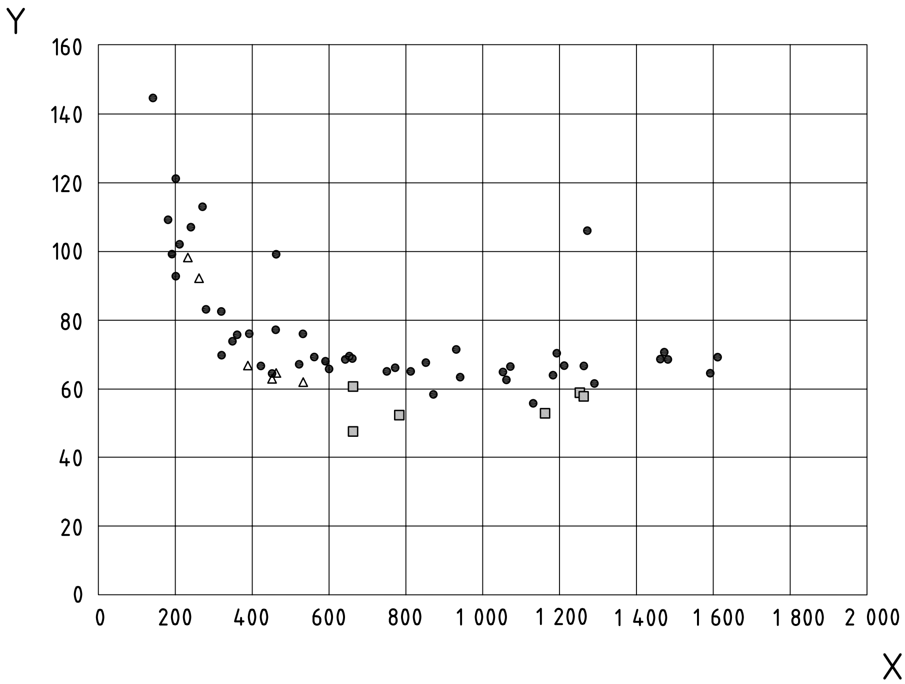
Expected capacity: 60 – 70 g

Expected performance: β200 = 14 µm(c) / β1,000 = 19 µm(c)

Figure 1 — Reference filter capacity versus final conductivity

When a reference filter test results were outside of the expected results (tolerance), the fluid in the test system would be changed. This fixed the issue and allowed the reference filter to test within expected results. Reference filter testing has continued at this lab, but in 2015 more attention was paid to fluid change-outs of the test system. Reference filters were tested in old oil (used for some time and ready to be changed) and new oil, at different levels of initial conductivity (results shown in Figure 2). Figure 2 also shows the results from testing reference filters throughout 2015 as “Historical Data.” This is normal lab practice for monitoring the status of the test system and fluid.

The 2016 Study conducted with old and new oil was done at initial conductivity levels of 1 000 pS/m, 1 500 pS/m, and 2 000 pS/m. The reference filter capacity results were significantly higher than historical results when tested with the old fluid, signifying the need for the fluid to be changed. This old fluid was left in the test system for the 2016 study. The new fluid was a fresh batch of oil, removed from the drum, added to the test system, and additized with conductivity improving fluid to establish the initial conductivity level(s).



Key

X final conductivity (pS/m)

Y retained capacity (g)

● historical data (conductivity was not actively maintained)

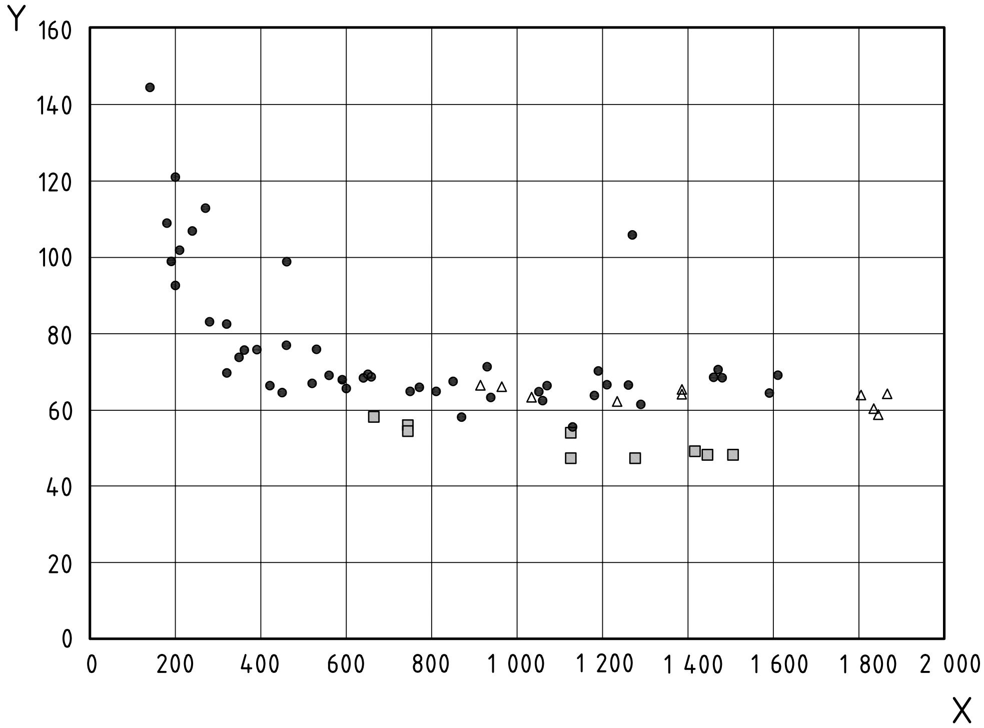
□ new oil, 2016 study (conductivity was not actively maintained)

△ old oil, 2016 study (conductivity was not actively maintained)

Figure 2 — Reference filter capacity vs final conductivity from 2016 Study when conductivity was not maintained and historical data.

A method (conductivity dosing system) for maintaining oil conductivity was developed and tested in 2016 to see how maintaining the conductivity would affect reference filter performance. Conductivity improving/increasing fluid (Stadis 450[1)]) was continuously added in small doses during each multi-pass test (up to 50 ml) to not significantly affect the fluid level of the main tank. This dosing was consistent throughout each test as the conductivity was actively controlled. Conductivity was monitored with an in-line conductivity sensor that provided real-time feedback. Initial and final conductivity measurements were also taken with a hand-held conductivity meter in the main tank, as specified in ISO 4548-12. All conductivity data presented in this report was measured in the main tank with a hand-held conductivity sensor. This method was effective at maintaining an oil conductivity within ± 200 pS/m of the initial conductivity during each test. The new oil was not actively maintained because the final conductivity did not decrease significantly during the current work testing. Testing with the “new” oil was conducted over the course of one (1) week. The results are shown below in Figure 3.

1) Stadis 450 is the trademark of a product supplied by Innospec. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.



Key

X final conductivity (pS/m)

Y retained capacity (g)

• historical data (conductivity was not actively maintained)

□ new oil, 2016 study (conductivity was not actively maintained)

△ old oil, 2016 study (conductivity was actively maintained)

Figure 3 — Reference filter capacity vs final conductivity 2016 Study when conductivity was maintained and historical data.

Figure 2 and 3 show the importance of maintaining conductivity for obtaining consistent and reliable test results in multi-pass testing (such as ISO 4548-12). Figure 2 shows that when conductivity decreases during the test (which can occur in older / heavily used oil), the final conductivity can reach a level that allows the filter to reach a much higher capacity compared to when conductivity is maintained.

In the new oil, the reference filters tested at a lower capacity than historical results. The root cause of this was not investigated because shortly after completing the 2016 study the reference filters began testing within their expected range. This could have been due to the lack of a dust cake on the test system clean-up filters, which would lower their efficiency, especially for smaller particles (less than 4 um). This could have lowered the capacity of tested filters until adequate dust cake was deposited on the new test system clean-up filters.

5 Flat sheet media study

In 2015, conductivity related effects during filter testing were evaluated further through flat sheet testing at different levels of oil conductivity. This testing was conducted using a Single-pass system to avoid any changes in fluid conductivity. Testing was conducted at fluid conductivity levels of 1 500 and 6 000 pS/m with ISO Medium test dust (ISO 12103-1:2016, A3 dust) in MIL-PRF-5606 hydraulic oil. Flat sheet holder media area was 6,1 in^2 (39 cm^2). Flow rate through the media was maintained at 300 ml/min. Temperature was maintained at 25 °C. The media used in this testing was typical, production-level, engine liquid filter media. Samples were tested to 172 kPa terminal differential pressure.