TECHNICAL REPORT

ISO CONTAMINATION STANDARDS CHANGES AND THEIR IMPACT ON FILTER TESTING AND PARTICLE COUNTING

1.0 INTRODUCTION

For several decades, AC Fine Test Dust (ACFTD) has been utilized for a number of purposes in the area of hydraulic and lubrication contamination control. It was used for primary calibration of liquid automatic particle counters, for filter testing, and for component contamination sensitivity testing. ACFTD was originally sold by AC Spark Plug Division of General Motors Corporation, but is no longer being produced. The obsolescence of ACFTD has led to the adoption of a new test dust and four new or revised ISO fluid power standards that affect filter performance testing, particle counting and the reporting of data.

2.0 CHANGES IN THE ISO STANDARDS

2.1 New Test Dust

The International Organization for Standardization (ISO) and Society of Automotive Engineers (SAE) have worked to find dusts to replace ACFTD. This has resulted in a new ISO Standard: ISO 12103-1 with four different grades of dust listed in Table 1. ISO Medium Test Dust (ISO MTD), having a particle size distribution close to ACFTD, has been selected as the replacement dust for calibration and testing purposes. However, although similar to ACFTD, ISO MTD produces test results that are somewhat different than ACFTD.

Therefore, results of both laboratory filter performance test (including filter efficiency and dirt holding capacity) and automatic particle counting can be significantly affected. This is an artifact of the testing only; filter performance and actual contamination levels in the field will remain the same as before.

Table 1
New and Replacement ISO Test Dusts

ISO Designation	Common Name	Other Names
ISO 12103-A1	ISO Ultrafine Test Dust (ISO UFTD)	PTI* 0-10 µm Test Dust
ISO 12103-A2	ISO Fine Test Dust (ISO FTD)	PTI* Fine Test Dust SAE Fine Test Dust
ISO 12103-A3	ISO Medium Test Dust (ISO MTD)	PTI* 5-80µm Test Dust SAE 5-80µm Test Dust
ISO 12103-A4	ISO Coarse Test Dust (ISO CTD)	PTI* Coarse Test Dust SAE Coarse Test Dust

2.2 NIST Certification of the ISO MTD Particle Size Distribution

The US National Institute of Standards and Technology (NIST) undertook a project to certify the particle size distribution of ISO MTD. NIST determined that for particle sizes below 10µm, the actual particle size is greater than previously measured using an automatic particle counter (APC) calibrated with ACFTD. Particle sizes reported based on the NIST determination are represented as X µm(c), with "(c)" referring to "certified" calibration and sizes traceable to NIST.

Therefore, the new definition of particle size (see Table 2) will have an effect on filter performance data and fluid cleanliness measurements.

Table 2
Comparing APC Measured Particle Sizes
(ACFTD vs. NIST Calibration)

An ACFTD Calibrated Size (µm) of : (ISO 4402)	Corresponds to a NIST Calibrated Size µm (c) of: (ISO 11171)
0.8	4.0
1.0	4.2
2.0	4.6
2.7	5.0
3.0	5.1
4.3	6.0
5.0	6.4
7.0	7.7
10.0	9.8
12.0	11.3
15.0	13.6
15.5	14.0
20.0	17.5
25.0	21.2
30.0	24.9
40.0	31.7
50.0	38.2

2.3 New Automatic Particle Counter Calibration

The ISO Technical Committee updated the old APC calibration procedure, ISO 4402, to a new procedure, **ISO 11171.** The new procedure incorporates the new ISO MTD test dust, NIST particle size and particle count determinations as well as a number of other enhancements to ensure better accuracy, reproducibility, and repeatability of the APC. In addition ISO developed a new procedure, **ISO 11943,** for calibration and verification of on-line automatic particle counters.

Because APCs are used for Multi-pass filter performance testing and fluid contamination measurements, these will affect reported results.

2.4 New ISO Cleanliness Code

ISO adopted a revised procedure for reporting fluid cleanliness measurements resulting from ACPs calibrated with the new NIST traceable method. The revised procedure, **ISO 4406**, uses three code numbers, corresponding to concentration of particles large than 4µm(c), 6µm(c), and 14µm(c) using the new calibration method. The 6µm(c) and 14µm(c) sizes correspond closely to the 5µm and 15µm sizes respectively used in the old ISO 4406 coding system which specifies the ISO 4402-ACFTD calibration procedure. The new 4µm(c) size, however, corresponds to about 0.8 µm old size using the ACFTD calibration procedure. This will result in somewhat higher values in the first ISO code digit when compared to the current 3-digit codes that reference particles larger than 2µm using the old ACFTD calibration method. For example, a specification of 19/17/13 based on 2, 5 and 15 µm (ACFTD Calibration) will change to ISO 20/17/13 based on 4, 6 and 14µm(c) (NIST Calibration)

2.5 Filter Performance Testing

There are a number of substantial changes made to the old Multi-pass test procedure, ISO 4572. These changes are intended to produce more repeatable, reproducible test results. The new method, **ISO 16889**, incorporated ISO MTD test dust and the NIST traceable APC calibration procedure. Beta ratios derived form the test when using the new ISO procedure will be designated using the symbol “(c)” to signify they were measured in accordance with the ISO 16889 procedure using NIST traceable calibration. For example a Beta ratio of 200 at 5µm(c) would be designated as $\beta_{5(c)}=200$.

3.0 IMPACT OF THE CHANGES ON FILTER TESTING

3.1 Filter Efficiency

Revisions to the Multi-pass test method and its inclusion of both ISO MTD and the new APC calibration procedure (ISO 11171) will dramatically affect reported filter element Beta ratios. The effect will vary for different filters, depending on the influence of the test dust and the degree of change in the particle size at the filter's rating. Generally, fine filters will appear coarser or less efficient, and coarse filters will appear finer or more efficient. Tests have been performed on standard filter media using the new Multi-pass test method, ISO 16889. Comparisons to results obtained form the previous ISO 4572 methods are shown in Table 3. Table 4 shows a summary of the new ratings, µm(c), at Beta= 2, 10, 75, 100, 200, and 1000.

It should be noted that the filter's performance in the field has not been changed at all. The filter is no more or less efficient at removing harmful particles. The reported results are merely an artifact of the new procedures and methods.

Table 3
Comparing Laboratory Filter Ratings

	Micron Rating for Beta value	
	Using ISO 4572	Using ISO 11171
Pall Filter ID	$\beta_X = 200$	$\beta_{X(C)} = 200$
F01	<1	2.0
F03	3	3.8
F06	6	5.7
F12	12	9.7
F25	25	18.2

Table 4
New Filter Ratings for using ISO 16889

	µm (c) rating for Beta value					
Filter ID	β =2	β = 10	β =75	β = 100	β = 200	β = 1000
F01	-	-	-	-	2.0	2.5
F03	-	-	3.1	3.3	3.8	5
F06	2.1	3.4	5.0	5.2	5.7	7
F12	3.2	5.5	8.3	8.7	9.7	12
F25	7.2	11.0	15.8	16.5	18.2	22

3.2 Filter Dirt Holding Capacity

The replacement of ACFTD with ISO MTD in the Multi-pass test also affects retained dirt capacity values for filter elements. Capacity may be somewhat higher or lower with the new dust, depending on the specific filter being tested; however, most filters evaluated have exhibited an increase in dirt capacity of about 10% to 40% when using ISO MTD over values measured with ACFTD. Because each type of filter performs differently with ISO MTD, no general factor can be given to convert ACFTD capacities to ISO MTD capacities.

It should be noted that a dirt capacity increase or decrease with ISO MTD does not imply that the filter will have a longer or shorter actual service life. In fact, there will not be a change in field service life. This reinforces the fact that dirt capacity should not be used as an indicator of field service life.

4.0 IMPACT OF THE CHANGES ON PARTICLE COUNTING

The changes discussed in the previous sections will not affect the actual cleanliness of fluids in the fields. However, for those operators reporting data using particle counts, the changes in APC calibration will affect laboratory particle counts for system fluids and those obtained using portable particle counts for system fluids and those obtained using portable particle counters calibrated to the new standards (see Table 5).

Those operators reporting data using the ISO cleanliness codes will notice less effect. The adoption of a cleanliness code with 3 digits should not have any appreciable impact as 3-digit codes have been used throughout the industry for a number of years. In addition, the change from the 5µm and 15µm sizes to 6µm(c) and 14µm(c) will not show an appreciable change in fluid contamination levels. The primary change will come form the adoption of the 4µm(c) size. This is a new addition to the ISO standard, although a third digit at 2µm using ACFTD has been widely used throughout industry. Since the new 4µm(c) size equates to about 0.8µm using ACFTD, particle counts on fluid samples will show a typical increase on one to two levels for the first digit of the code because there are typically more particles in the fluid at smaller particle sizes.

The changes in ISO cleanliness code is illustrated in the following example:

Old 2-digit ISO Code	**Old 3-digit ISO Code**	**New 3-digit ISO Code**
14 / 12	16 / 14 / 12	17 / 14/ 12
5µm / 15µm	2µm / 5µm / 15µm	4µm(c) / 6µm(c) / 14µm(c)

Remember: regardless of the calibration method or ISO cleanliness code version used, the fluid is no dirtier or cleaner than before.

Table 5

Typical Effect of New Calibration on Particle Counts

Particle Size, µm (old count) µm(c) (new count)	Old Count (ACFTD) (particles/mL)	New Count (NIST) (particles/mL)
2	4,170	24,900
5	1,870	3,400
15	179	105
25	40	14

5.0 CONCLUSION

A replacement dust for ACFTD has been chosen because ACFTD is no longer being manufactured. To gain better resolution, accuracy, repeatability, and reproducibility, four new or revised ISO standards have been adopted. These changes will impact automatic particle counter calibration, particle size definition, and laboratory reporting of filter performance both in particle removal efficiency (fine filters will appear coarser and coarse filters finer) and dirt holding capacity (capacity will likely increase). The changes will also impact laboratory reporting on system fluid cleanliness (typically a higher contamination level at smaller particle sizes). Although this will undoubtedly cause confusion, it should be remembered that this impact is merely an artifact of the testing. Actual filter performance and field fluid contamination levels will remain the same as before.

To obtain copies of the new ISO standards contact the National Fluid Power Association (NFPA) at: 414-778-3353 or www.nfpa.com

References for this document include Fluid Technologies, Inc., National Fluid Power Association and Dr. Leonard Bensch of Pall Corporation.