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'Providing Tribological Solutions'

TECHNICAL NOTE
PENETRATION

1. Introduction: In this test the consistency (stiffness) of a grease sample is determined by how far a specially shaped cone penetrates into a sample. But there are different ASTM methods depending on the size of the sample and the expected consistency. Tests include; ASTM D217 'Test Methods for Cone Penetration of Lubricating Grease', ASTM 4301 'Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment', and D937 'Test Method for Cone Penetration of Petrolatum'.

D217 also gives the penetration ranges for the various NLGI consistency numbers from 000 to 6. Plus it notes that ¼ and ½ scale tests are reportedly only applicable to NLGI 0 to 4 and "only where the size of the sample prevents the use of Test Method D 217".

2. Concerns: Because of the various tests individual labs might find differences between their results and the "typical" values given in the MOV Long Life data sheets and/or in the COA (certificate of analysis) for that batch. Some differences are to be expected given the precision of the test itself and the different tests. It should not necessarily reflect on the QA (quality assurance) of the grease.

Each batch is tested for penetration at least twice before release; once during production and then a second time by the QA lab. In addition, the full scale penetration test used by the manufacturer has much better precision than the quarter and half scale tests that might be used by other labs for acceptance testing. Their only advantage is that they require less grease. As a guide to sample size a full scale test requires 400 cc of grease while the ¼-scale only about 15 cc and the ½-scale about 40 cc. But the precision suffers.

Testing for worked penetration requires a grease worker. After working, care has to be taken to remove air pockets by 'jarring' the cup. Generally 3 sets of results are required with the average given. For worked results these can be obtained from the same grease sample in the cup. The worked grease that was scraped off to give the right profile in the cup, or comes out during a test, is returned to the cup after each test. In addition it is stated in the test that full-scale penetration values derived from ¼ and ½-scale may differ and that parties may use modified conversion equations when mutually agreed.

3. Test Precision: For ASTM D217 the penetration reproducibility is said to be 20 units which is the penetration in mm divided by 10. For ASTM D1403 the ¼ or ½-scale penetration precision statements for reproducibility of the worked penetration in unconverted units are 7 & 10. In converted units as used in ASTM D217 this would correspond to ±50 and ±25 units respectively. In addition when checking results from labs it is important to compare how their previous results compared with the COA numbers. To reduce problems it could also be very advantageous if the labs being used participate in round robin testing such as that offered by the ASTM D2 Crosscheck program for greases or the Alberta Research Council. Then it is known, that at least for that operator, that the results are likely acceptable.

4. Sampling: The concern is that a little oil separation is common during shipping and storage. Further some greases are worse than others and while the calcium sulphonate greases are generally very good, any significant separated oil has to taken into account. If sending a full tube this likely taken out with a spatula so that the oil could be more likely mixed back in. However, for a sample being taken at a station is from a pail or keg or drum, the results are not valid unless any separated oil is mixed back in fully (down to the bottom of the container). You can not just mix back in the top few inches because it will affect the results. If the sample was taken from a 'dry' area the reported consistency might be low and if from a 'wet' area with more oil then the consistency might be higher.

5. Limits: There are two issues. First is the grease the right NLGI Grade and secondly is it what was represented by the COA. For both the test precision limits have to be taken into account. Given below are the limits[1] for MOV Long Life Grades 0 to 2;

	Manufacturing			**Reject 3rd Party**		
	Acceptance	**Typical**	**Reject**	**¼ Scale**	**½ Scale**	**Full Scale**
Grade 0	355-385	370	<355 or >385	<305 or >435	<330 or >410	<335 or >405
Grade 1	310-340	325	<310 or >340	<260 or >390	<285 or >365	<290 or >360
Grade 2	265-295	280	<265 or >295	<215 or >345	<240 or >320	<245 or >315

1. Full Scale Worked Penetration at 25°C.

The above is based on the reproducibility precision statements for the expected variation between the same samples tested at different operators working in different laboratories. The differences can exceed these values in only one case in twenty. As an example if the COA had a value of 325 other labs can report a value of 305 to 345 if they did the full scale test, 300 to 350 if the 1/2-scale test and 275 to 375 if using the 1/4 –scale and still be within the test precision statements.

5. Summary

Results can be both higher and lower than the "typical" value and the Certificate of Analysis value. A lower value does not necessarily represent a quality issue any more than a higher value. The most likely cause is likely with the test procedure. The NLGI consistency system is for full scale test results and if there was oil separation, sampling can also be a factor.

It is suggested that acceptance limits include the precision statements for the tests being used and that they also have to take into account the results for previous testing by the lab being used.

In addition, for acceptance testing the purpose is to determine if the correct grease was sent. Penetration of new greases is generally only an indication of the NLGI Grade.

If more information is required please call.