Variation in test results between laboratories from different parts of the world

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ABSTRACT: In order to ensure the quality of a geosynthetic product, some European countries have created their own national quality system in addition to the simple CE marking procedure. During the certification process with continuous surveillance and regular controls, a selection of characteristics is tested. The accuracy and reliability of the tests are of primary importance for all the entities engaged in the process: the producers, the certifying body and the final users. The economic consequences of a defective test result might be significant: by losing the certification of a product, a producer can suffer important economic losses. However, previous experience showed that even when obeying the standards, the results between similar tests performed in different conditions can demonstrate important variations. A study is carried out in order to compare the results of Round Robin tests on different nonwoven geosynthetics. The tests are performed by two different organizations: NorGeoSpec (Norway) certification body, within the frame of the continuous surveillance of the certified products; and an independent company, DuPont (Luxembourg). Three main origins are pointed out:

- Lack of precision in some standards, which allow a high degree of freedom in the interpretation
- Deviations from the test method described in the standard.
- Product variation

Finally, some recommendations are suggested in order to improve the quality of the testing procedure.

1 PRESENTATION OF THE STUDY

1.1 *Background*

In order to ensure the quality of a geosynthetic product, some European countries have created their own national quality system in addition to the simple CE marking procedure (e.g. NorGeoSpec in Norway and Asqual in France). Indeed, the CE mark although often considered on the market as a quality label, is in fact only attesting the accordance of a product with the harmonized European application standards. During the certification process with continuous surveillance and regular controls, a selection of characteristics is tested. The tests are usually performed in EN ISO 17025 certified laboratories. The accuracy and reliability of the tests are of primary importance for all the entities engaged in the process: the producers, the certifying body and the final users. The economic consequences of a defective test result might be significant: by losing the certification of a product, a producer can suffer important economic losses. However, it could be noticed that the tests can show important variations in their results, depending on the laboratory where they are performed, and on the specific conditions in which they are run. The following sections present the results of a study carried out in order to assess these differences. Round Robin tests are used as a base for the comparison of the results. The tests are performed by two different organizations: NorGeoSpec (Norway) certification body, within the frame of the continuous surveillance of the certified products; and an independent company, DuPont (Luxembourg).

1.2 *The NorGeoSpec 2002 system*

The NorGeoSpec 2002 system is a Nordic system used for the specification and the control of geotextiles intended for roads and other trafficked areas. Within a certification period of two years, a product should be tested at least twice. Therefore the continuous surveillance includes the regular sampling and testing of the certified products. As agreed in the certification process, these samplings should be used, among other purposes, for a continuous round

robin test performed by several laboratories. The participating laboratories are independent from the NorGeoSpec certification body and are not owned by the same company or the same holding company.

1.3 *Procedure for the tests performed within the frame of the NorGeo study*

The procedure for these Round Robin tests is now described.

From a given roll, two samples (5m x 5m) are taken, and respectively called A1 and A1.1. In order to assess the possible variations in the results, the tests are performed in two different laboratories. In the so-called laboratory A, all the characteristics mentioned in the NorGeoSpec requirements have been tested, while only a selection of tests have been conducted in parallel in other laboratories (the so-called laboratory B.). As the tests shall be carried out according to the test standards, no additional instructions for preparing the specimens are defined for the comparison tests. In order to enable a better comparison of the tests results, the mass per unit area is measured in all laboratories. The results of laboratory A are the ones used for certification and specification of the product. In the Round Robin test program all the 5 laboratories involved in the NorGeoSpec system are included. The following test methods have been performed for comparison (Table 1).

Table 1. Tested properties

Standard	**Content**
EN ISO 9864	Mass per unit area
EN ISO 10319	Wide width tensile test
EN ISO 13433	Dynamic perforation resistance
EN ISO 11058	Permeability normal to the plane without load
EN ISO 12956	Characteristic opening size

1.4 *Test program for the DuPont study on opening size*

From previous participation in several certification systems, the company DuPont could experience that unacceptable differences were obtained in the different laboratories on the same samples, thus increasing the risk of losing a certificate only due to gaps in the procedure. The highest variation was usually observed on the opening size test. In some cases, only the fact that an appeal was allowed by different certification systems allowed to obtain or maintain the certificate for a product. During an appeal the same sample that was refused due to results being outside of the tolerances, measured by a first laboratory is tested in a second laboratory that often found completely different values. A special program has been launched to investigate the reason for this high variation.

1.5 *Preparation of the samples for the opening size study*

In order to perform the tests, different samples have been specially produced. These samples are manufactured by using the same process conditions but by varying the mass per unit area. In order to reduce the product variation, the width of the sample rolls is limited to 44 cm. From each roll, samples were sent to the participating laboratories.

The participating laboratories are all accredited for this test. A few additional laboratories joined the program later on some selected items only.

Table 2. Tested samples for opening size tests

Test Item	Area Weight (g/m²)
1	90
2	95
3	100
4	115
5	125

1.6 *Room of interpretation for the test method and apparatus*

All the tests are performed following the harmonized European test standards. The 10 years' experience on the running of these tests clearly shows that the application of the standards still leaves room for a broad range of interpretation of both the test methods and apparatus, as suggested in the table below (Table 3).

Table 3. Possible gaps in the standards

Name of the standard test	**Possible gaps in running the tests/interpretation**
EN ISO 10319 Wide width tensile tests	Use of capstan clamps or hydraulic clamps
	Various sizes of clamping area (no size specification in the standard)
	Method for applying the preload
	Method for measuring elongation
EN ISO 13433 Dynamic perforation resistance	Way to clamp the specimen (not properly described in the standard)
	Free fall or controlled fall of the cone
	Pre-tension of samples during clamping
EN ISO 11058 Permeability normal to the plane without load	Use of falling head versus constant head procedure
	Size of the testing surface (only a minimal size is specified in the standard)
EN ISO 12956 Characteristic opening size	Nature of the soil used to perform the test (possible variations between soil distribution curves)
	Size of the testing surface (only a minimum size is specified in the standard)

2 RESULTS OF NORGEO ROUND ROBIN TEST

The tests are carried out on nonwoven products coming from different producers and tested in five laboratories participating in the NorGeoSpec system. The evaluations give an overview of the test results from the different laboratories. Deviations of the product itself are visible when considering the mass per unit area measured for each product. At this stage of the round robin procedure, the evaluation enforces no need for a statistical approach. The focus on the continuously round robin tests is rather orientated on seeing the tendencies of single laboratories to deviation when compared with other laboratories. The results on the A1 samples, used for the certification and specification of the products by NorGeoSpec, are used as references. The other results are shown in percentage of the results of the A1 samples.

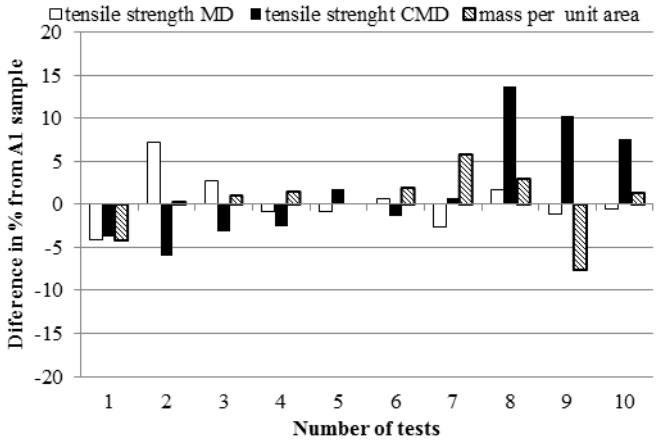

Figure 1. EN ISO 10319 Wide width tensile tests (Tensile strength in MD Machine Direction and CMD Cross Machine Direction)

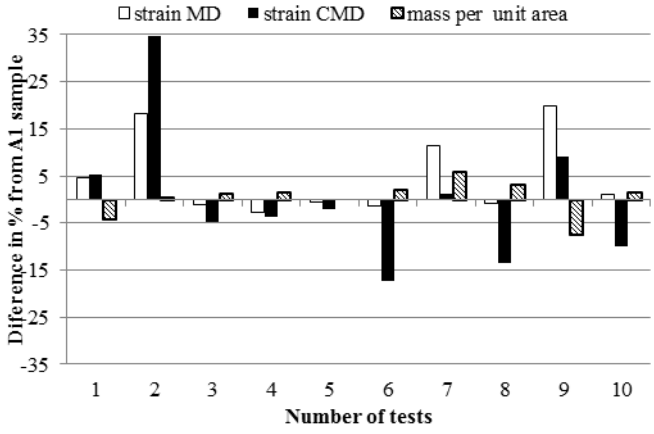

Figure 2. EN ISO 10319 Wide width tensile tests (Strain at maximum load in MD machine direction and CMD cross machine direction)

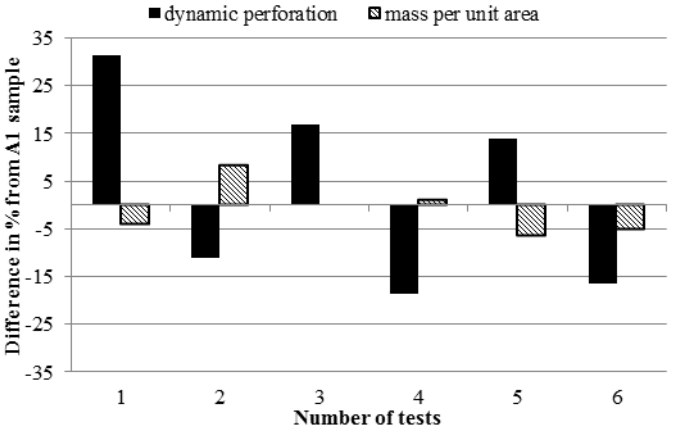

Figure 3. EN ISO 13433 Dynamic perforation resistance

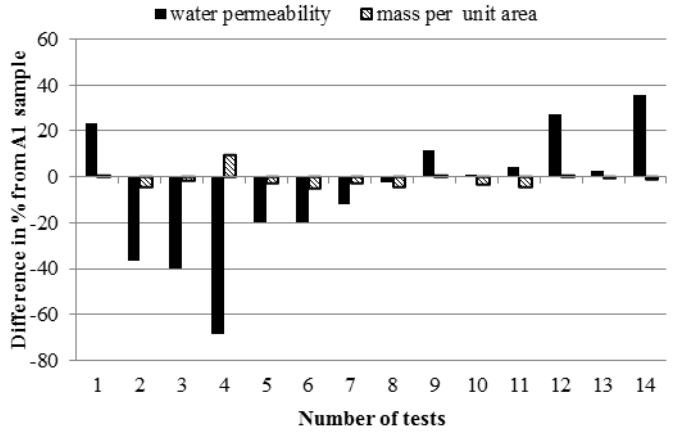

Figure 4. EN ISO 11058 Permeability normal to the plane without load

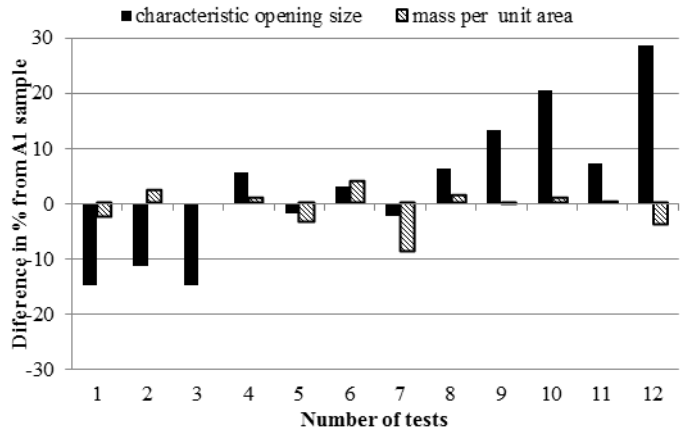

Figure 5. EN ISO 12956 Characteristic opening size

The results of tensile strength (Figure 1) on 10 different products tested in 4 of the 5 NorGeoSpec laboratories. With a quality concern, and in order to ensure a safe distance to the tolerances given in the NorGeoSpec guideline; a variation between the laboratories of maximum +/- half of the NorGeoSpec tolerance should be ensured. In this case, it can be seen that 5 tests have a difference (MD or CMD direction) of more than 5% from the test results of the A1 test and are consequently out of the half tolerance rule (10% for tensile strength). The reasons for those deviations could originate from the test method (handling the specimen, interpretation of the standard, test speed) or product variation. Indeed, when the product is not uniform, meaning that the

mass per unit area is not the same over the test area; it is logical that the material exhibits different properties (e.g. for the tensile strength).

In Figure 2, showing the results of wide tensile tests, one test is out of the tolerance (20% for tensile strain at maximum load), whereas 5 out of the 10 tests show deviations over the 10% tolerance. These differences could be influenced by the system used to measure the elongation (e.g. laser or video systems) and by the error accompanying the different marking used for the strain measurement.

Five of six test results are out of half the NorGeoSpec tolerance of 20% for the test on Dynamic Perforation Resistance (Figure 3). The reason for the high number of differences could be due to different test equipment used by the labs (Free falling or controlled fall of the cone), difference in clamping (tension of the specimen) and product deviations (see the difference in mass per unit area).

The obtained values on permeability normal to the plan (Figure 4) show that 4 tests are out of the tolerance of 30% and that 8 of the 14 tested products are out of half of the tolerance. The results of these tests clearly indicate that the test procedure is critical and sensitive to differences in handling the specimen and carrying out the tests.

Finally, in the case of the characteristic opening size (Figure 5), two tests are out of half the tolerance of 30% and two further tests (no 1 and 3) are close to that limit. The reason here could come from differences in the soil distribution curves of the soils which were used for this test. However in this precise case, the standard is not ambiguous: different soil distribution curves are authorized.

3 RESULTS ON OPENING SIZE – DUPONT ROUND ROBIN TEST

3.1 *Test results on opening size – first round*

Table 3 and Figure 6 show the results after the first round of comparison test. The difference between the lowest and the highest value for each sample is very high and completely out of the range of most commonly used certification tolerance of +/- 30 %. A first investigation showed that there were major differences in the soil used by the laboratories. One of the problems occurred due to the fact that in the norm EN ISO 12956, different required zones of the cumulative percentage of size distribution of the granular material are given (Figure 7). Some labs used the graph given in the informative annex of the norm which had a higher upper limit on particle size than the one in the normative part. For example: the maximum d_{20} in the normative part is 50 µm while in the informative part the d_{20} is given as 90 µm.

Table 3. Opening Size O_{90} results – First Round

	Opening size (µm)				
Lab.	Item 1	Item 2	Item 3	Item 4	Item 5
A	81	74	65	63	61
B	134	131	127	92	72
C	67	63	60	57	49
D	113		85	79	75
E	167		107	110	88
F	89		87	67	47
G	122		87	79	79
H	201		201	185	199
I	111	91	101	81	72
Min Value	67	63	60	57	49
Max Value	201	131	201	185	199

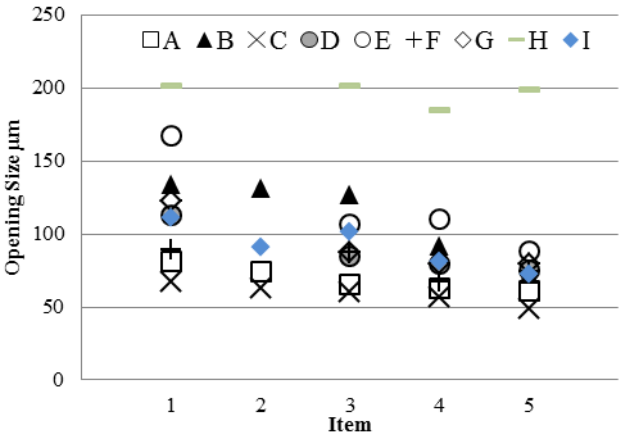

Figure 6. Round Robin Tests – First Round

3.1 *Improvement of the distribution curve of the soils*

Based on the results of the first round, some of the laboratories changed their soil according to the normative part and repeated the tests. Laboratory B that had changed his soil some months ago first repeated the tests with previously used soil and in a second step further improved the result by making a new soil that was completely within the tolerances of the normative part. Laboratory D having a soil outside the normative tolerance changed the soil accordingly. The results are presented in Table 4 and Figure 8. For both laboratories, the amount of fine particles had to be increased and finally the O_{90} results became lower and were comparable to the results of other laboratories with similar soil.

Table 4. Lab. B and D: Additional tests with new soil

	Opening size (µm)				
Lab.	Item 1	Item 2	Item 3	Item 4	Item 5
B Initial	134	131	127	92	72
B. Repeat (old soil)	113	98	80	74	
B. New improved soil		88		71	
D. Initial	113		85	79	75
D. New improved soil	93		74	70	63

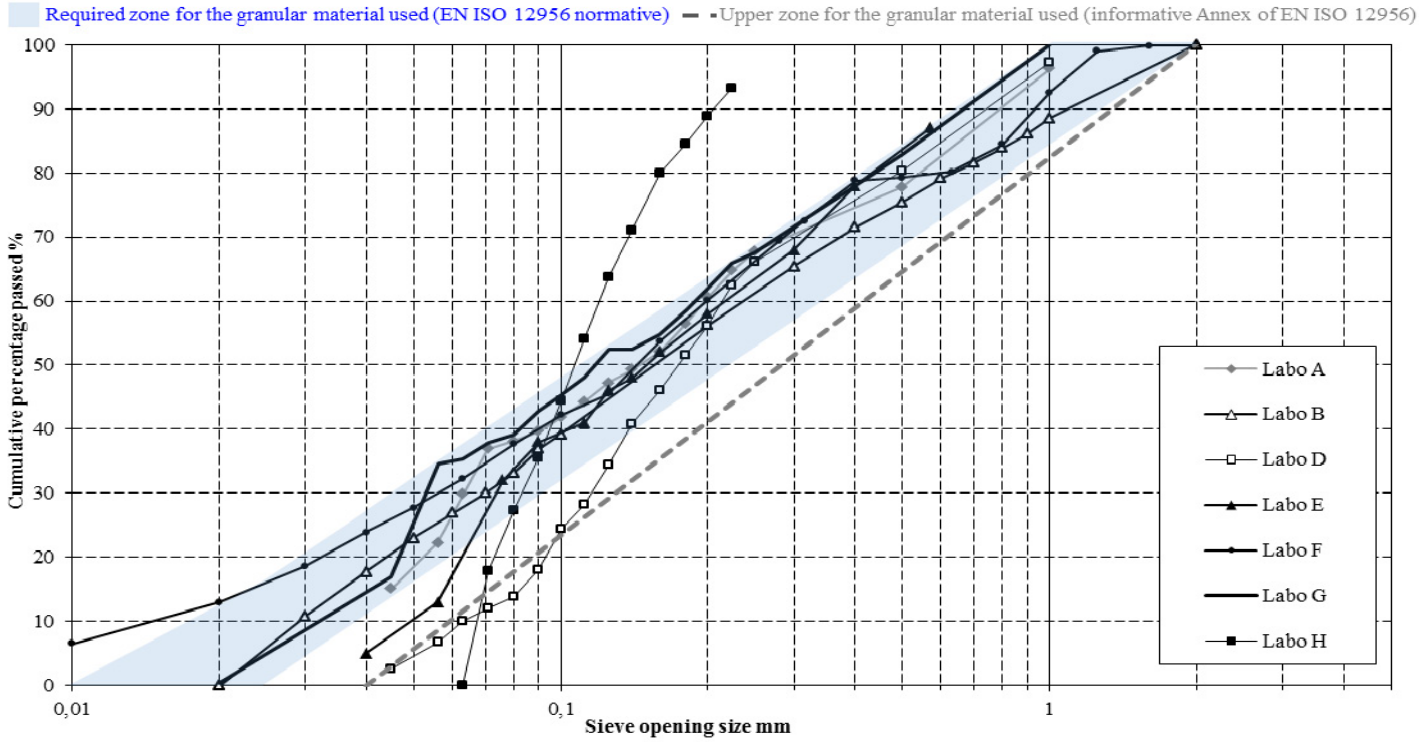

Figure 7. Round Robin Tests – Granular Distribution Curves (first round)

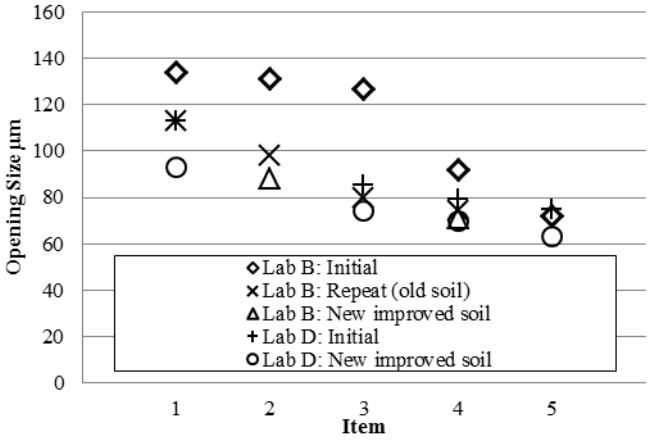

Figure 8. Lab B and D: Additional tests with new soil

4 CONCLUSIONS

The Round Robin tests constitute an important tool in the ongoing process to ensure the quality and the reliability of the tests. These tests are organized by laboratories, certification bodies, standardization committees and manufacturers. The results of all these Round Robin tests show basically similar high variations. The present study on the Round Robin test, conducted within the NorGeoSpec system and a test program organized by a geosynthetic producer confirms these large variations between the involved participants. The variations in test results between laboratories can come from various reasons. Three main origins could be identified.

First of all, the lack of precision in some standards, which allows a high degree of freedom in the interpretation. Although harmonized standards do exist for all tests, for some of these tests, there is still too much room for interpretation. For example, the water permeability test according to EN ISO 11058 allows using different test procedures: falling head or constant head procedure. Depending on the product, these two procedures could lead to different results. Some of the tests (e.g. the determination of the characteristic opening size test) might be complicated and difficult to perform in an accurate and repeatable way. Some standards need to be updated and such Round Robin tests should be discussed in the different standardization committees to further improve the standards for the next revision.

The second source of error comes from deviations from the test method described in the standard. Indeed, it has been found that some laboratories do not fulfill the standard completely or perform the test procedures in a different way. This fact is inadmissible and should exclude these laboratories from further tests if they are not willing to change their operating procedure.

Finally, another origin for differences in the results is the product variation. This has to be carefully considered when organizing Round Robin tests and sample selection and a good organization to reduce variation and increase repeatability is very important.

A solution should be found on how to better document these tests so that the test standard and/or laboratory procedures can be improved. Both, laboratories and manufacturers should work together to find operating procedures that eliminate as much as possible the different sources of possible errors.