Power Industry

Technical bulletin

T&D low temperature testing

AMORIM
CORK COMPOSITES

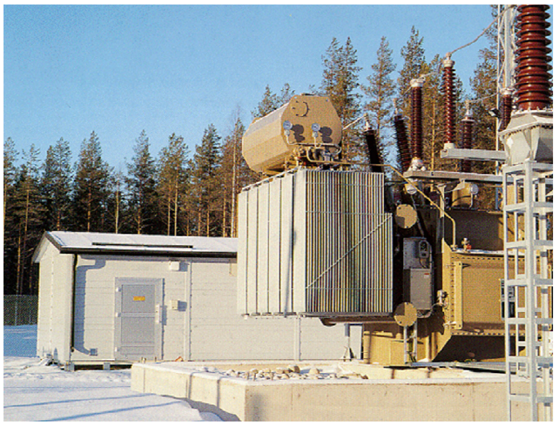
TD1310 low temperature performance

The low-temperature properties of cork rubber materials are important when used in applications in colder climates, or, in environments that have low temperature requirements. There are a number of test methods in use.

When cooled, elastomeric compounds start to lose their elasticity, and at very low temperatures they harden and have glasslike brittleness. When the temperature rises they regain their original properties – i.e., the condition is fully reversible.

Cork rubber materials with good cold flexibility are amongst others specially compounded Nitrile (NBR) - TD1310.

Most low temperature tests are designed to indicate the brittleness point of a material, instead of the beginning of the elastic behaviour region.



Most common test methods for low temperature testing

ASTM
D1329
Evaluating rubber property: retraction at lower temperatures (TR test).

ASTM
E1640
Assignment of glass transition temperature by dynamic mechanical analysis.

ASTM
F147
Low temperature flexibility; modified.

ASTM
D2137
Rubber property: brittleness point of flexible polymers and coated fabrics.
(Will not be discussed)

Low temperature testing test description

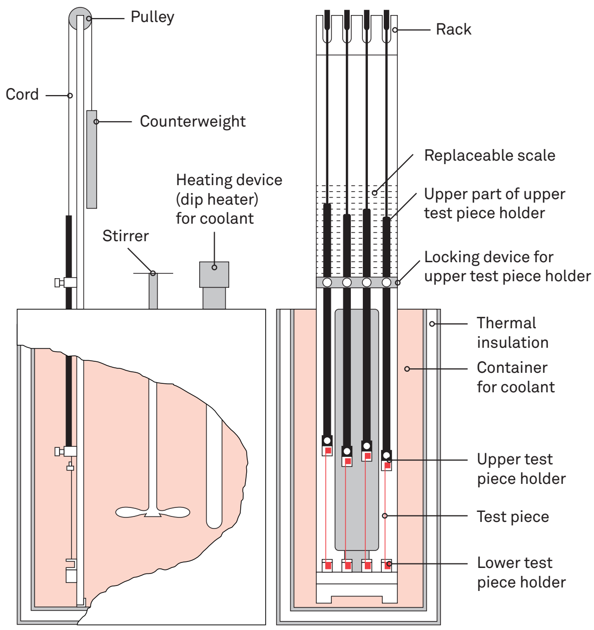
ASTM D1329 - Evaluating rubber property: Retraction at lower temperatures (TR Test)

The “TR”, or “time-to-return” or Retraction Temperature Test uses samples that are stretched to 50% extension in a sample rack and then locked. The samples are then cooled to a low temperature and allowed to reach equilibrium (-70°C).

The frozen samples are then released from the rack and allowed to retract freely, while the temperature is raised at a uniform rate of 1°C/minute.

Measurements of the sample length are taken at regular temperature intervals as the sample recovers. When a 10% retraction in the sample length is obtained it is recorded as TR10.

There is a certain relation between TR10 and brittleness point, wherein the brittleness point is lower than the TR10 temperature.



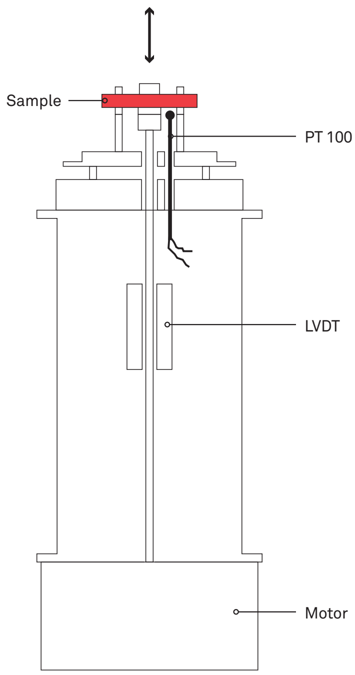
ASTM E 1640 - Assignment of glass transition temperature by dynamic mechanical analysis

DMTA characterizes the viscoelastic nature of polymers. An oscillating force is applied to a sample of the material, the resulting displacement of the sample is measured.

A force (stress) is applied to the sample, through the motor. The stress is transmitted through the drive shaft onto the sample which is mounted in a clamping mechanism. As the sample deforms, the amount of displacement is measured by the LVDT positional sensor. The strain can be calculated from the displacement. The force (or stress) is applied sinusoidally with a defined frequency of 1 Hz, varying the temperature from -80°C to 60°C at a rate of 1°C/minute.

On this basis, the sample stiffness can be determined, and the sample modulus can be calculated. By measuring the time lag in the displacement compared to the applied force it is possible to determine the damping properties of the material.

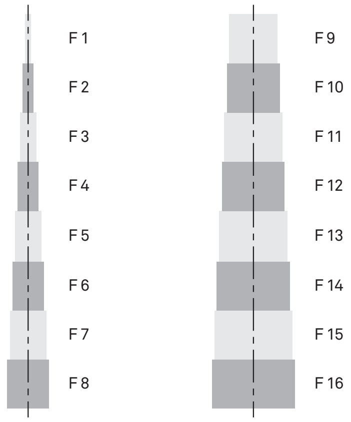
By scanning the temperature during a DMT A experiment, the change of state can be observed and the glass transition temperature (Tg) can be determined.



ASTM F147 - Low temperature flexibility; modified.

During the test the samples are put in a freezer at a low temperature 50$_{-2}$°C for a time period of 2,0$^{+0,1}$ hours. After 2 hours the samples are bent at an angle of 90±5° at the same test temperature.

Visual inspection is performed, and samples are considered as PASS with a specific flexibility factor (which depends on sample thickness and mandrill diameter) if no surface cracks are present.

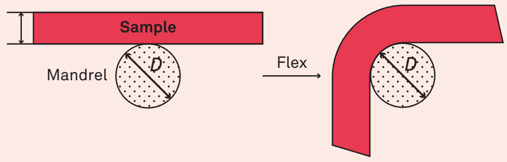


$$\text{Flexibility Factor} = \frac{\text{Minimum Mandril Ø}}{\text{Material Thickness}}$$

When a sample with thickness of **δ** is put around a mandrill with a diameter of ***D***, the outside of the sample is stretched, and the inside is compressed. The centre of sample is not stretched or compressed.

If the Elongation of the Sample material is **ε**, it can be correlated to the diameter of the mandrel and the Thickness of the sample.

The value of ***D*** gives an idea of the flexibility of the material, and shows its dependence with the sample thickness under test. The smaller the value of ***D***, the better the flexibility. So, if the sample thickness **δ** is thinner, the value of ***D*** is smaller, consequently the flexibility is better. If the elongation of the material is greater, the value of ***D*** is smaller, consequently the flexibility is better.



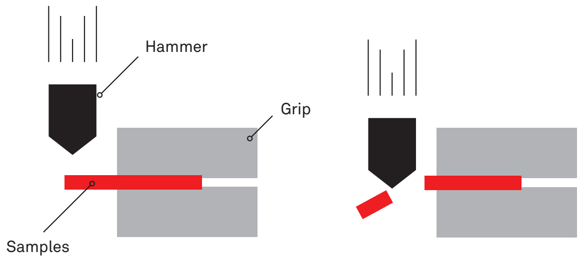
$$D = \frac{(1-\varepsilon)}{\varepsilon} \times \delta$$

δ Sample thickness
D Mandrel diameter
ε Material elongation

ASTM D2137 - rubber property: brittleness point of flexible polymers and coated fabrics.

Brittleness point, means the lowest temperature at which rubber materials exhibit brittle failure when impacted under specified conditions. When testing, test pieces in the form of strips are clamped as shown, and then immersed for 5 min in a cold bath. After 5 min they are subjected to a single impact blow, then examined to see if they show any cracks.

If they have failed, new test pieces are tested at a temperature 2°C higher. The test is then repeated at higher temperatures until no failure is observed. This temperature is recorded as the temperature limit for brittleness.

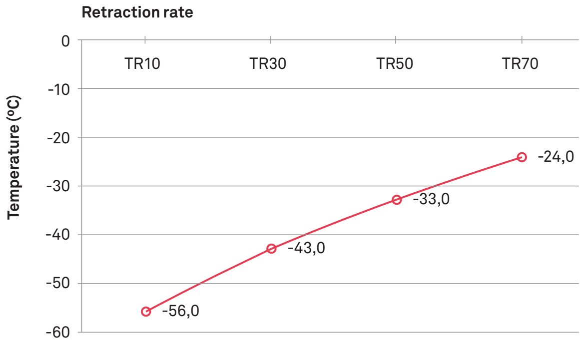


TD1310 - Low temperature nitrile, cork rubber

Retraction at Lower temperatures- TR Test

The TR test was performed in a well-known independent rubber testing laboratory (Akron Rubber Development Laboratory).

The results show that TR10 is achieved at -56°C.
At this point the material regains its rubbery behaviour, this temperature is higher than the brittleness point.

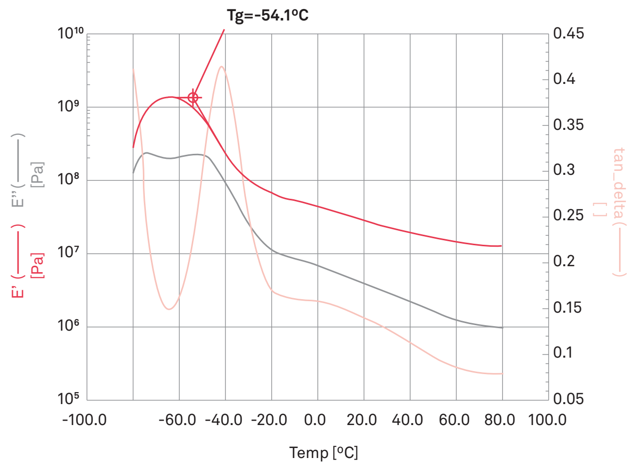


ASTM D1329

Tg- Glass Transition Temperature by DMTA

DMTA Tg testing performed internally shows correlation to TR10 test values, a decrease in É modulus (Elastic) at -54°C. This is designated its Tg temperature.

These results confirm that these two test methods are aligned with the forecast material low temperature performance.

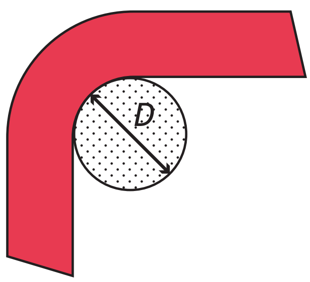


ASTM E1640

Low Temperature Flexibility- Modified

The Low Temperature Flexibility test was performed in a well-known independent rubber testing laboratory (Akron Rubber Development Laboratory).

The results show that this test method also seem to have some correlation to the above. But when thinking about the application, this test method can only be used as a comparative method, due to the strong dependence on the tested thickness.



No cracks
PASS @ -50°C

Sample thickness
3,14mm

Flexibility Factor
1,57

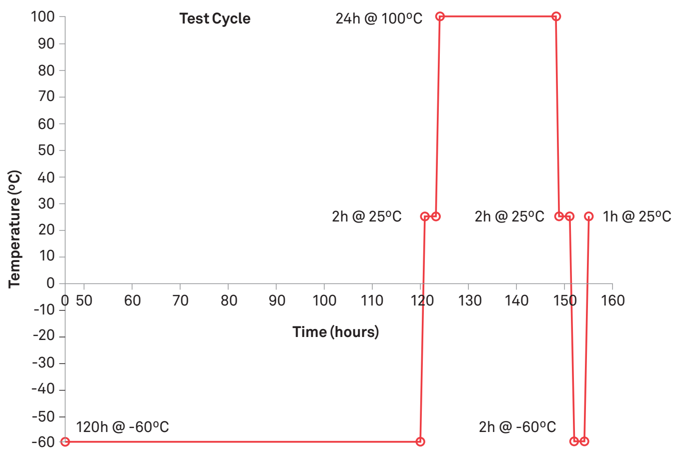
D (Diameter)
5mm => F2 Flexibility

ASTM F147

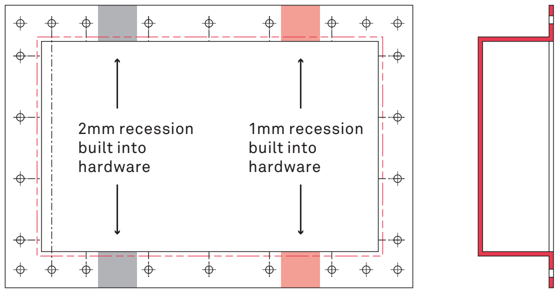
TD1310 - Low temperature application testing

Functional performance of TD1310 low temperature Nitrile material at -60°C.
Objective is to simulate the storage/transport of the transformers in extreme cold conditions.

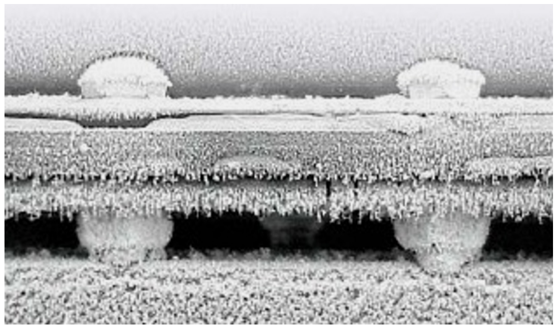
Thermal Cycle with observation steps at 25°C.



No leakages were observed at any point during the entire thermal cycle. Material responds to the temperature gradient of -60°C to 100°C, even though the lower limit temperature is stated at -50°C.



Test fixture with 1 and 2 mm recesses, was assembled with TD1310 @ 9mm thick and filled with Mineral Transformer Oil. Load was applied through a 49N.m torque.



TD1310 Grade under artic conditions

Conclusion

Comparative testing shows that there is correlation between the low temperature testing methods, although care must be taken when extrapolating to the application. In short, the various methods proposed for evaluation of low temperature properties apply to a limited set of conditions:

- In case of low temperature compression or elongation (TR test) tests, if the initial compression or elongation applied is not adjusted to the materials' compressibility or elongation working curve, results can be shifted from the materials' real life operating conditions

- Low Temperature Flexibility tests are highly operator dependant, and sometimes typical material properties can be interpreted as cracks.

- Measurements performed by DMTA for Tg value significantly diminishes the impact of the test conditions, by measuring the response of the materials elastic and visco-elastic properties. This makes this test a reliable and relevant source of information.

Application testing under extreme temperature conditions corroborate the results obtained through TD1310 material tests, making it suitable for -50°C operating temperatures.

AMORIM CORK COMPOSITES
Rua de Meladas, 260 - P.O. Box 1
4536-902 Mozelos - VFR
Portugal
T. +351 22 747 5300
F. +351 22 747 5301
E. acc@amorim.com

www.amorimcorkcomposites.com