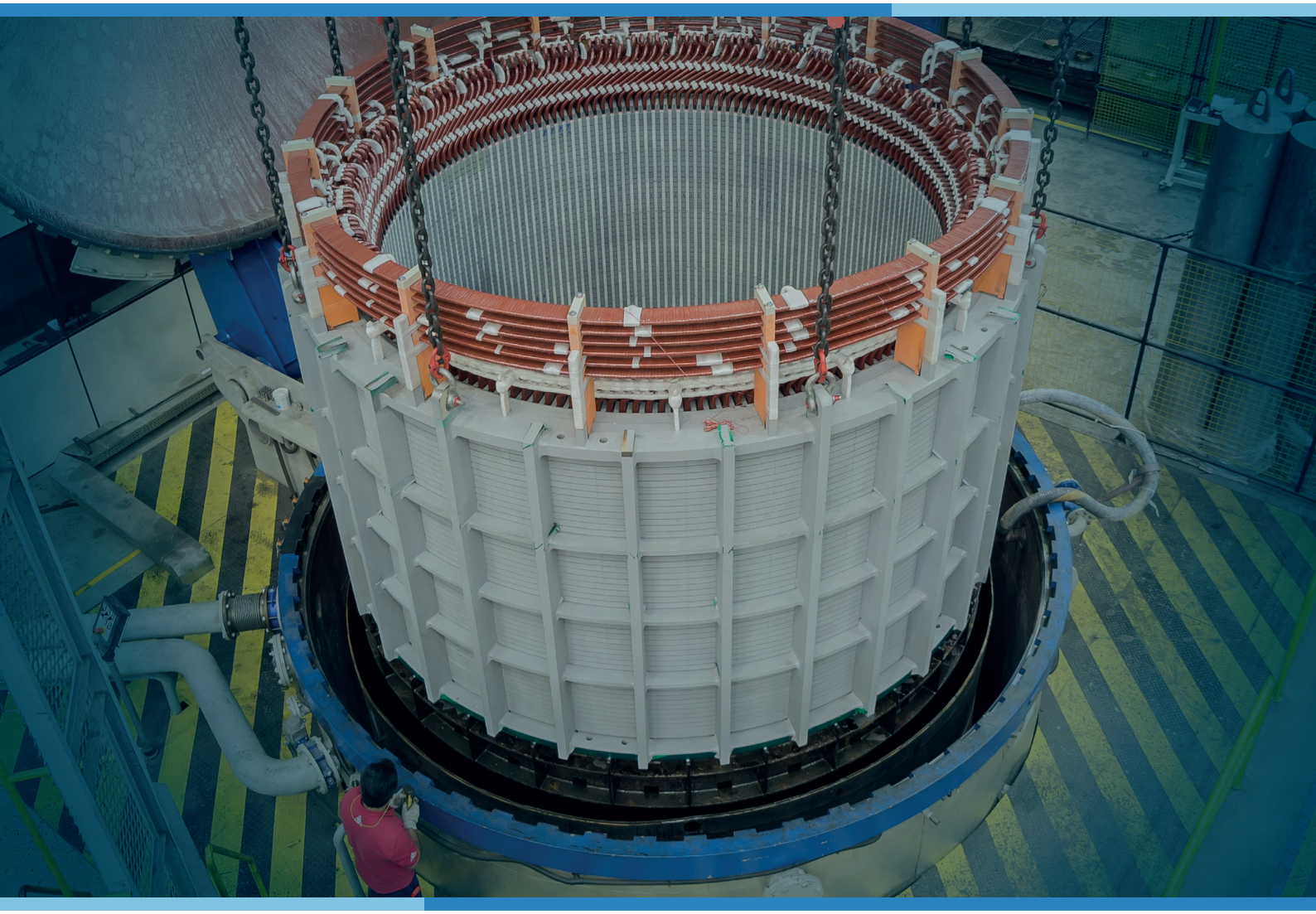
# WEG INSULATION SYSTEM – MICATHERM

Reliability for multiple applications



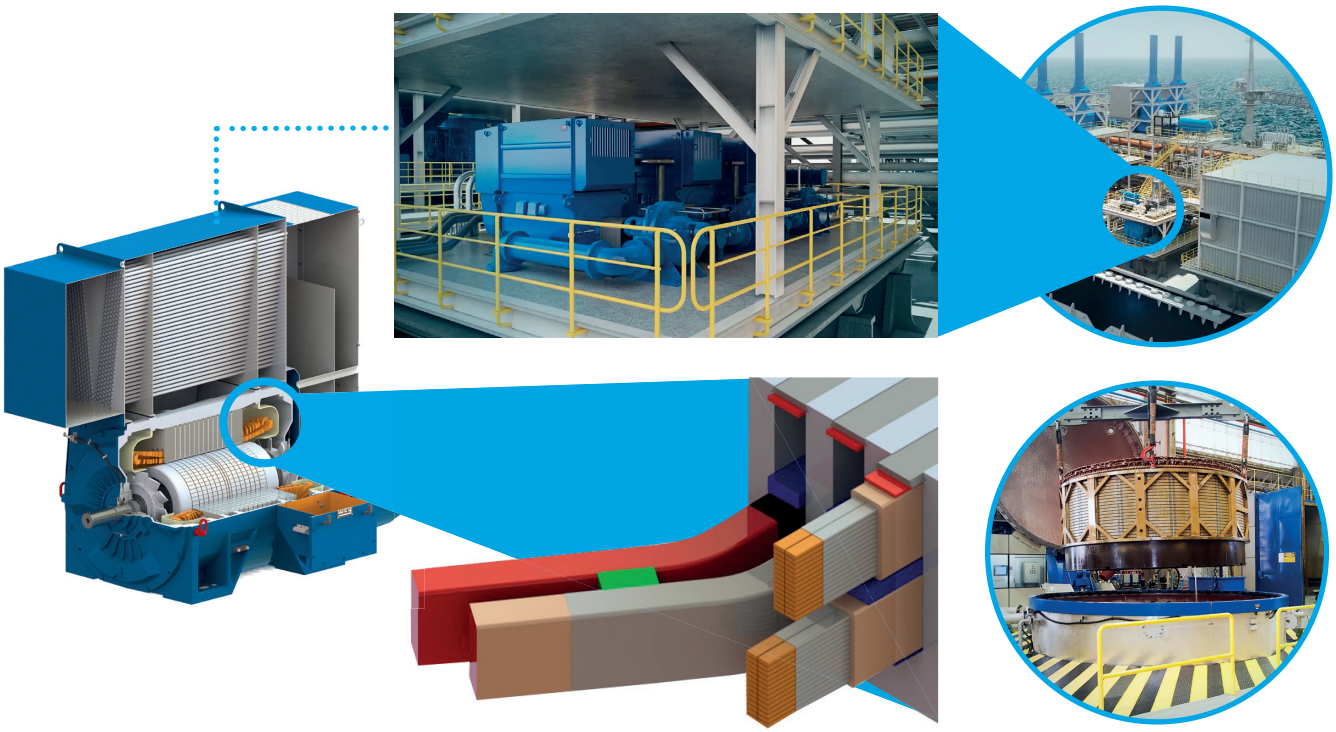
Motors | Automation | Energy | Transmission & Distribution | Coatings

# WEG Insulation System for Medium Voltage Rotating Electrical Machines – Micatherm

Rotating electrical machines must ensure delivery of the output power, either mechanical or electrical, required by the various existing applications. All types of industrial businesses are somehow dependent on the operation of those machines.

The insulation system is an essential part of a rotating electrical machine! Its durability is a key factor, directly affecting the equipment lifetime and, therefore, the availability and reliability of the processes.

WEG studies, defines and continually improves its insulation system, named as Micatherm, in accordance with diversified market demands and recognized technical standards, keeping the focus on ensuring availability of the machines produced and the flexibility of customization and adaptation to a wide variety of market demands.

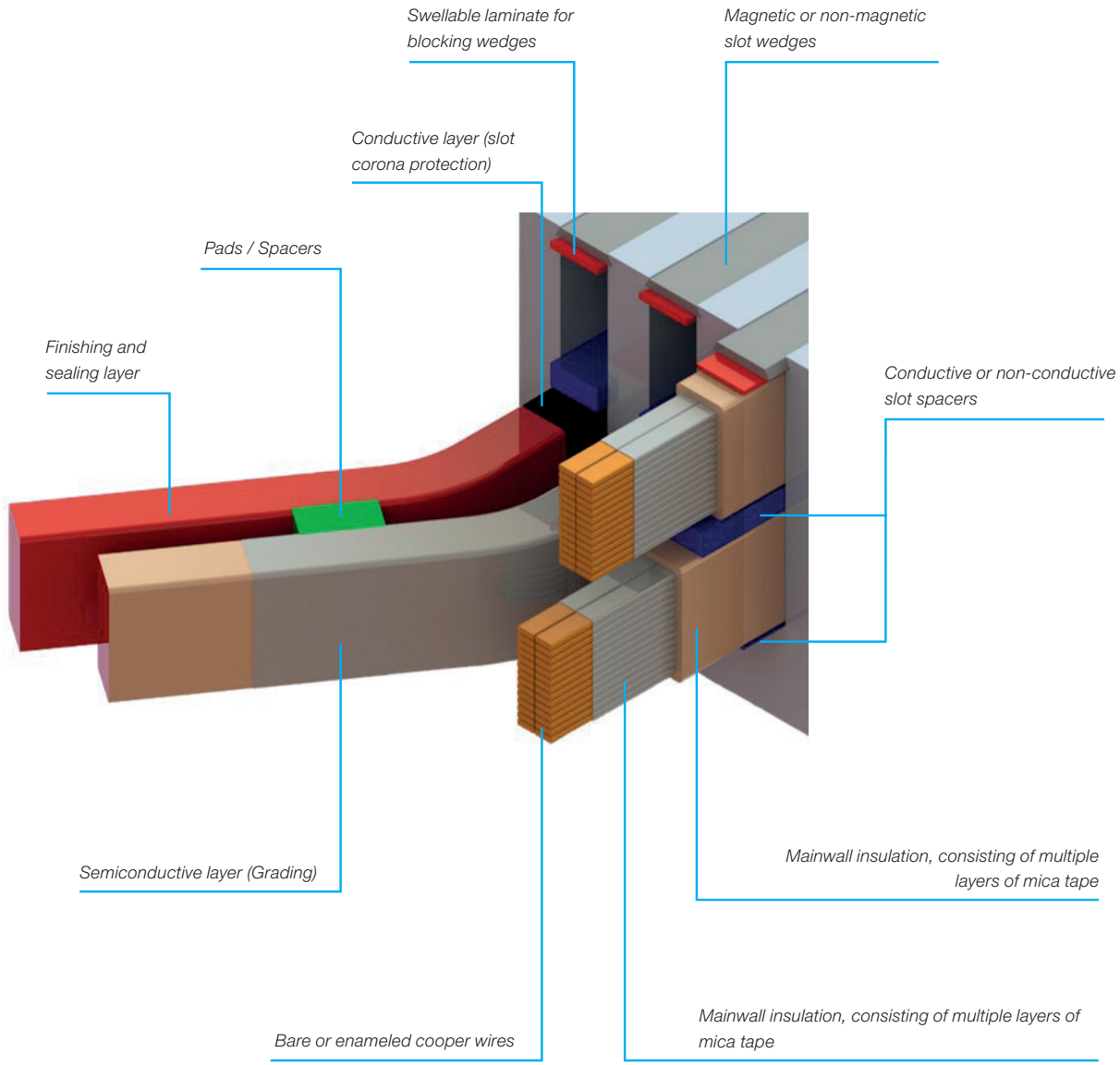


The Micatherm system is a combination of materials and industrial practices recognized worldwide. It is a reliable solution, proven in service over almost three decades of application on thousands of machines, which are successfully operating all over the world.

From the most usual class F insulation (155 °C), applied in both safe and hazardous areas, to the most demanding class H insulation (180 °C), applied, for example, on the restricted nuclear energy applications, the Micatherm system and its variations guarantee the reliability and the security required at critical operating conditions.

# Insulation System Description

An insulation system is a combination of materials and knowledge, which applied under design, processes and control parameters will deliver a dielectric solution, suitable for the expected service life of the machines.
The Micatherm system is available to the market in two versions, defined according to the required insulation class: F (155 °C) or H (180 °C). Specific materials are used on each version.
Thousands of motors and generators, with voltage classes that can vary from 380 V to 15,000 V, have been successfully operating since 1993, when this system was introduced at WEG. Since then, improvements and tests have been continually performed to ensure insulation durability and the availability of the equipment for duty.
The picture below shows one of the possible Micatherm System configurations.



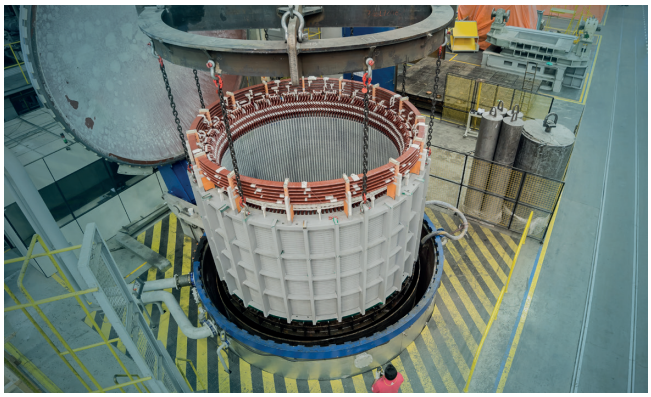
# Impregnation

For the Micatherm system, WEG uses the GVPI (Global Vacuum and Pressure Impregnation) process, where stators, wound rotors and other components, with the winding completed, are placed entirely in an autoclave. This process is able to ensure significant homogeneity, repeatability, reliability and robustness to the product.

The GVPI process consists of removing the air from the insulation, as well as any residual moisture, followed by the filling of the empty spaces with specific resin. In addition, the impregnation ensures that the coils are properly fixed into the slots, and acquire suitable electrical and mechanical properties, which are required for reliable operation.

The resin used has already been substantially tested and proven, under the most diverse and severe conditions. It is a low viscosity and highly stable thermosetting epoxy system, which combined with different materials, components of the insulation system, provide a technical solution, suitable for several applications. Special features are available uppon request.

*Vacuum and pressure impregnation system*



*80-ton stator impregnation in Global VPI, voltage class: 15 kV*

# Highlights and Special Features

### Corona Protection

Corona protection plays a fundamental role in the durability of an insulation system. When certain electric field magnitudes are exceeded, partial discharges cannot be avoided at specific points, as well as the ionization of the air surrounding the surface of the insulation, even away from the slots. For this reason (mainly, but not limited to that), corona protection is applied. It is a combination of materials, where electrical properties are not similar to those of insulating materials.

### Sealed Winding

Humid environments, where condensation may occur on the winding, demand special care to guarantee the dielectric characteristics throughout the equipment lifetime. The same solution can be applied to other critical environments. It is a combination of precautionary measures, leading to an optimal result.
After being impregnated and cured, upon prior request, the winding can be tested as per NEMA MG 1, part 20.18 (Spray Test), among others.

### VFD (Variable Frequency Drives)

Many of the variable frequency drives available in the market require special winding insulation. Over the years, WEG has developed its own insulation criteria, for operation with many VFDs available in the market. It is important to evaluate case by case, depending on the characteristics of the VFD, in order to specify the adequate insulation.
Ageing test equipment were developed in house, in order to simulate the stresses across the insulation in service, caused by the different types of VFD's.

### Proper Endwinding Bracing

The bracing of the endwindings are a very important part of the system. Despite not having a direct dielectric function, the bracing ensures that the insulation will remain intact throughout motor lifetime, regarding the consequences of possible mechanical stresses, whether in the normal operating condition, during starts or under sudden load transitions.
Specific applications demand high supportability to mechanical efforts. Several solutions are available to ensure the winding insulation integrity.

# Control and Inspections

The manufacture of a wound stator includes several checking points during the process. Even before impregnation, when the insulation is not yet completed, tests are carried out, to ensure product integrity.

Criteria based on international standards are used whenever available. Other criteria and parameters are defined by WEG, based on experience, often resulting from long-term tests in laboratories and on the needs of the product. In addition to the tests carried out regularly, any additional tests can be discussed, whether on the wound stator itself, on the stator coils or on spare coils, necessary when destructive or overly aggressive tests are required. Even long-term tests are available, as described below.

### Material Incoming Inspections

- Inspection plans defined based on Brazilian and International standards, such as ISO 2859, ANSI/ASQ Z1.4-2003, NF06-022, BS 6001, DIN 40080, and NBR 5426

### Routine

- Visual and dimensional inspection
- Ohmic resistance
- Insulation resistance (Reference: IEEE Std 43)
- Hi-Pot (Reference: IEC 60034-1)
- Surge-test (Reference: IEEE std 522 / IEC 60034-15)
- Check-up of RTDs

### Additional (Wound Stator)

- Darkroom test – Visual corona test (IEEE Std 1799)
- Dissipation factor and capacitance (IEEE std 286 and IEC 60034-27-3)
- Spray-test (NEMA MG 1 20.18)
- Partial discharges (IEEE Std 1434 / IEC 60034-27-1 / IEC 60270 / IEC 60034-27-2)
- DC hi-pot, Ramp test and Step-voltage test (IEEE Std 95)

### Additional (Spare Coils)

- Breakdown voltage test
- Impulse voltage test (IEC 60034-15)
- Electrical aging – VET (IEEE Std 1043 / IEEE Std 1553 / IEC 60034-18-32 / IEC 60034-18-33)
- Thermal cycling (IEEE Std 1310 / IEC 60034-18-34)

# R&D Tests and Certifications

The main standards and documents, guidelines for the R&D and long-term tests, are listed below:

IEC - International Electrotechnical Commission
60085; 60505; 60034-15; 60034-1; 60034-18-1; 60034-18-21; 60034-18-31; 60034-18-32; 60034-18-33TS; 60034-18-34; 60034-18-41; 60034-18-42; 60034-27-1; 60034-27-2TS; 60034-27-3; 60034-27-4; 60270; 60216-1; 60216-2; 60216-3; 60216-4-1; 60216-4-2; 60216-4-3; 60216-5; 60216-6; 60216-7TS; 60216-7-2TR; 60216-8; 61858-1; 61858-2.

IEEE – Institute of Electrical and Electronic Engineers
Std 43, Std 95, Std 1310, Std 1043; Std 1434; Std 1553; Std 1776; Std 1799; Std 286; Std 522; Std 99.

It is relevant to highlight the long-term tests, such as the Voltage Endurance Test (Power frequency or with impulsive voltages, which simulate applications with VFDs), the Thermal Cycling Test and Thermomechanical Cycling Test. The Thermomechanical Cycling test, when evaluating an insulation system, is the sequence of tests that allows the effective system classification. These are long-term tests, where the insulation systems are exposed to extreme conditions, usually more critical than those found under regular service.

Several types of samples are used, from simple metallic bars, for comparative tests, to replicas of coils, "*formettes*", and even wound stators, whether they are complete or only representative pieces.

Development tests follow methodologies that are globally disseminated and accepted, in addition to methods and procedures developed internally, when there are no international references. The results are interpreted and treated based on statistical tools, to guarantee reliability.

A team of experts is responsible for leading the insulation system development. It is a multidisciplinary team, consisting of qualified and well-trained professionals in terms of logistics, procurement and engineering. This group operates globally, based on different WEG production facilities.

# Laboratories

WEG counts on a large testing facility, such as laboratories dedicated to product development, each one to a specific purpose, in different competences, such as chemical, mechanical, electrical, among others.
Focused on medium voltage insulation systems, but not limited to, the laboratory described below deserves special highlights.

## Insulation Systems Laboratory

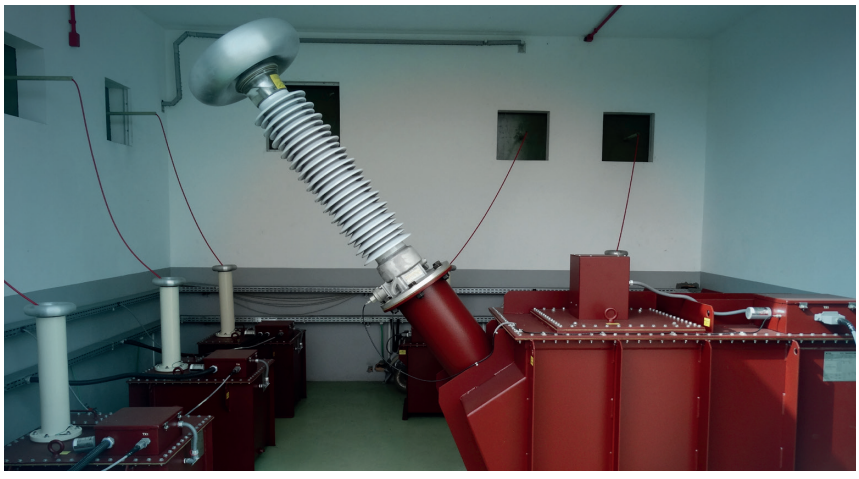
The Laboratory of Insulation Systems (LIS) is an evidence of WEG's commitment to the reliability and durability of the insulation systems. It is an infrastructure dedicated to research, development and innovation, where the most relevant tests of materials and systems can be performed, in accordance with international standards and other usual practices. This laboratory is duly equipped with dedicated equipment, and by cooperating with many partners, internal (among different WEG's Business Units) or external (third parties), allows WEG to perform any tests related to insulation systems.

*Control room - Insulation Systems Laboratory*

A lab-scale impregnation plant is dedicated to R&D. Resins, varnishes and emulsions of different types can be used, combined with a wide range of processes variations, which can be easily simulated.

*LIS impregnation plant*

High voltage sources (hi-pot testers) up to 150 kV ac and 120 kV dc are available, to be used for aging, diagnosis and breakdown tests, among others. For the thermal cycling test, a modular rectifier with a capacity of up to 9,000 A is used.



*High voltage sources (up to 150 kV ac)*

# Laboratories

## Endurance Tests

Through the application of electrical stress on the insulation system, combined or not with thermal stress, electrical endurance tests (TEA – Thermal Electrical Endurance or VET – Voltage Endurance Test) are performed. Dedicated and customized systems monitor full time the execution of the tests.

*Examples of tests performed*

For thermal cycling tests, a rectifier is used to supply current to the (resistive) heating of the samples, while an air blower cools the samples by forced air circulation through a distribution and homogenization chamber. A control system ensures the application of cyclical stress, while a customized system records the quantities involved. Samples are cyclically heated and cooled in a controlled manner, causing different expansion coefficients on the materials involved, to result in mechanical stress over the insulation.

Thermomechanical cycling tests are the most complete tests, based on international standards, to qualify and classify an insulation system. Ovens are used to apply thermal stress on the samples, while a shaking table provides proper mechanical stress. Additionally, a specific chamber creates a saturated environment with moisture, with visible condensation on the samples. The electrical endurance-testing infrastructure, previously detailed, is used to apply electrical stress. Sub-cycles of diagnosys are used to identify the end of the lifetime of samples.


*Saturated humidity chamber*

*Ovens for thermal aging and shaking table*

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Cod: 50105432 | Rev: 00 | Date (m/a): 02/2021.