SAVER SPA
W: savercompositi.com - e: sales@savercompositi.com
I-20067 Tribiano (MI) Via Pasubio 1
I-226017 Trescore Cremasco (CR) Via Soncino snc

TEST CERTIFICATE

REFERENCES

Subject **DESIGN TEST REPORT** *Date* **15.11.2017**
Number **DTR** *Rev* **2a** *Pages* **2**

MANUFACTURER , TEST METHOD AND STANDARDS

Manufacturer **SAVER SPA**
I-20097 Tribiano (MI)
1, via Pasubio

Description **Hollow Core Composite Insulator design tests and customer's and/or manufacturer specific test for design class insulators**

Remarks **---**

PERFORMED TESTS and Applicable Standards:

- **Tests on interfaces and connections of end fittings**
  Acc. to IEC 61462 § 7.2 and IEC 62217 §9.2
- **Hardness test**
  Acc. to IEC 61462 § 7.3.1 and IEC 62217 §9.3.1
- **Accelerated weathering test**
  Acc. to IEC 61462 § 7.3.2 and IEC 62217 §9.3.2
- **Tracking and erosion test**
  Acc. to IEC 61462 § 7.3.3 and IEC 62217 §9.3.3
- **Flammability test**
  Acc. to IEC 61462 § 7.3.4 and IEC 62217 §9.3.4
- **Dye penetration**
  Acc. to IEC 61462 § 7.4.1 and IEC 62217 §9.4.1
- **Water diffusion test**
  Acc. to IEC 61462 § 7.4.2 and IEC 62217 §9.4.2
- **Thermal cycles stability test**
  Acc. to NT802
- **Thermal ageing under internal pressure**
  Acc. to NT802
- **Arc Resistance test**
  Acc. to IEC 62039 § 3.10
- **Erosion resistance test, inclined plane method**
  Acc. to IEC 60587
- **Hydrophobicity test (wettability test)**
  Acc. to IEC 62073
- **Silicone breakdown field strength**
  Acc. to IEC62039 § 3.7
- **Silicone volume resistivity**
  Acc. to IEC62037 § 3.6

Original Test Certificate

- **Salty fog test (Pollution test) with 80 g/l and 112 g/l salinity**
  Acc. to IEC60507
- **5000 hours multi-stress test**
  Acc. to IEC 61109
- **Silicone Fingerprinting FTIP by ATR reflection range 400-4000cm^{-1}**
  n/a
- **Validation of usage of composite insulators at temperatures down to -60°C**
  Acc. to IEC 61462 §7.2.4, 7.2.3 and Saver test method
- **Validation of usage of LSR at temperatures down to -60°C**
  Acc. to Saver test method
- **Low temperature storage test**
  Acc. to Saver test method
- **Resistance to products of decomposition of SF_6**
  Acc. to PPS-0063 rev E
- **DC Test resistance to tracking and erosion**
  Acc. to INS AA S 01 (Terna Italia), IEC 60587, ASTM D2303

LOCATIONS AND RESULTS

Tested by

Saver SpA – Headquarter laboratory, Tribiano (MI), Italy

Saver SpA - High Voltage Division, Siziano (PV), Italy

Wacker Chemie, Burghausen, Germany

FGH, Mannheim , Germany

OMECO Srl, Monza (MB), Italy

CESI, Milan, Italy

ARC Laboratory, Villerbanne, France

STRI, Ludvika, Sweden

Marterial Research Division, Pennsylvania (USA)

University of Applied Sciences, Zittau/Gorliz (FH),

Test results

ALL HERE ABOVE DESIGN TESTS AND CUSTOMER OR MANUFACTURER DESIGN CLASS INSULATOR TESTS HAVE BEEN SUCCESFULLY PASSED

Saver High Voltage Division - Controlled and APPROVED - SAVER

Original Test Certificate

1 - Scope and object

Composite hollow insulators consist of an insulating tube bearing the mechanical load protected by an elastomeric housing, the loads being transmitted to the tube by metal fittings.
Successfully passed tests grant to match the insulator requirements, in order to ensure a satisfactory lifetime under normal service conditions.
Standards distinguish between design tests and type tests because several general characteristics of a specific design and specific combinations of materials do not vary for different insulator types.
In these cases results from design tests can be adopted for different insulator types.
Pollution tests according to IEC 60507 are not applicable as such pollution tests performed on insulators made of non-ceramic materials do not correlate with experience obtained from service.

2 - Classification of tests acc. to IEC 61462 § 7

Composite insulators tests are divided into four groups as follows:

- design test:
- type test:
- sample test:
- routine test:

2.1 - Design tests acc. to IEC 61461 § 7.1

These tests are intended to verify the suitability of the design, materials and manufacturing technology.
A composite hollow insulator design is defined by :

- materials and design of the tube, housing and manufacturing method,
- material of the end fittings, their design and method of attachment,
- layer thickness of the housing over the tube.

Results from design tests can be adopted for different insulator types belonging to the same design class. These tests consist of three parts:

⇒ Tests on interfaces and connections of end fittings (IEC 61462 § 7.2)

⇒ Tests on shed and housing material (IEC 61462 § 7.3) which includes:

- Hardness test (IEC 61462 § 7.3.1)
- Accelerated weathering test (IEC 61462 § 7.3.2)
- Tracking and erosion test (IEC 61462 § 7.3.3)
- Flammability test (IEC 61462 § 7.3.4)

⇒ Tests on the tube material (IEC 61462 § 7.4)

- Dye penetration (IEC 61462 § 7.4.1)
- Water diffusion test (IEC 61462 § 7.4.2)

2.1.1 *Definition of design class for composite insulators*

Composite insulators are considered belonging to the same design class if the followings are respected:

- Same shed and housing material (specific silicon type)
- Same housing profile (within the limits given IEC 61462)
- Same tube material (matrix, reinforcement)
- Same tube design (liner and winding angle)
- Same manufacturing process for the housing (i.e. injection moulding)
- Same manufacturing process for the tube (wet filament winding)
- Same end fitting material (same metal)
- Same type of load on the tube (i.e. combination of inner pressure and bending due to outer forces)
- Same tube-housing-end fittings interface design (i.e. injection mould housing/sheds)

Diameters and/or lengths are not matter of design tests since their details and their influences are covered by the type tests.

Basing on the above, **the present insulator and insulator used for test on "Tests on interfaces and connections of end fittings" are considered belonging to the same *design class* and related results have to be considered valid also for this insulator.**

2.2 - Type tests acc. to IEC 61461 § 7.2

These tests are intended to verify the mechanical characteristics of a composite hollow insulator which depends mainly on its tube and end fittings. Type tests shall be applied to the class of composite hollow insulators which have passed the design tests.
The type test shall be repeated only when the type or the material or the manufacturing process of the composite hollow insulator is changed.

The type tests **are only mechanical tests** and consist of a pressure test, for pressurized insulators only, and a bending test a follows:

⇒ Internal pressure test (IEC 61462 § 8.4) performed in 3 stages:

- Stage 1: test at 2,0 × maximum service pressure
- Stage 2: test at 4,0 × maximum service pressure
- Stage 3: test at specified internal pressure level

⇒ Bending test (IEC 61462 § 8.5) performed in 4 stages:

- Stage 1: test at maximum mechanical load
- Stage 2: test at 1,5 × maximum mechanical load
- Stage 3: test at 2,5 × maximum mechanical load
- Stage 4: test to failure (optional)

These tests are therefore not included in the present folder.

2.3 - Sample tests acc. to IEC 61461 § 7.3

These tests are for the purpose of verifying the characteristics of composite hollow insulators which depend on the manufacturing quality and the material used.
They shall be made on insulators randomly taken from batches offered for acceptance and their number depends from batches of production.
These tests are therefore not included in the present folder.

2.4 - Routine tests acc. to IEC 61461 § 7.4

These tests are for the purpose of eliminating composite hollow insulators with manufacturing defects.
These tests are not included in the present folder

2.5 – Customer – Manufacturer design class insulator tests

These tests are performed according to Customer Standards or Manufacturer internal Standards in order to evaluate in a better way the properties of used material as well and the manufacturer technology or the behavior in field of the composite insulators or its ageing. Usually no IEC standards are applicable and, if any, are not requested or mandatory from relevant IEC 61462 Standards

3 – Design Test reports and Customer / Manufacturer design class insulators test reports

3.1 - Tests on interfaces and connections of end fittings (IEC 61462 § 7.2)

Tests on interfaces and connections of end fittings

Scope:	Test is performed in order to evaluate the electrical behavior of the insulator and its silicon housing (material and manufacturing technology) when artificially aged
Location:	FGH Engineering & Test GmbH, Mannheim, Germany
Acceptable Criteria:	No cracks, puncture of any part of the insulator occur during steep-front impulse voltage test or dry power frequency voltage test flashover voltage during dry power frequency voltage test must be greater than 90% of the reference flashover voltage no remarkable temperature rise during The leakage rate is not more than volume fraction of 0,5% per year No leakage during water leakage test
Result:	**TEST SUCCESFULLY PASSED**

3.2 - Tests on shed and housing material

3.2.1 - Hardness test (IEC 61462 § 7.3.1)

Scope:	The scope is to qualify the silicon housing material and its water absorption
Location:	Germany Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	The hardness shall not change from the pre-boiled value by more than ±20%.
Result:	**TEST SUCCESFULLY PASSED- Hardness shore A 31-32**

3.2.2 - Accelerated weathering test (IEC 61462 § 7.3.2)

Scope:	The scope is to evaluate the UV resistance of silicon housing
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	markings on shed or housing material shall be legible; surface degradations such as cracks and raised areas are not permitted.
Result:	**TEST SUCCESFULLY PASSED**

3.2.3 - Tracking and erosion test or 1000h salty fog test (IEC 61462 § 7.3.3)

Scope:	The scope is to evaluate the hydrophobicity of the silicon housing and its resistance to erosion in service under electrical field stress
Location:	FGH Engineering & Test GmbH, Mannheim, Germany
Acceptable Criteria:	no tracking occurs and no shed, housing or interface is punctured for composite insulators, erosion depth, if any, is less than 3 mm and does not reach the core, if applicable;
Result:	**TEST SUCCESFULLY PASSED**

3.2.4 - Flammability test (IEC 61462 § 7.3.4)

Scope:	The scope of the test is to evaluate the ignition and self-extinguishing properties of silicon
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	category V0 (HB40 category is not applicable)
Result:	**TEST SUCCESFULLY PASSED – FLAMMABILITY CLASS V0**

3.3 - Tests on shed and housing material

3.3.1 - Dye penetration test (IEC 61462 § 7.4.1)

Scope:	The scope is to evaluate the performance of the impregnation of glass fibers with resin and check possible air bubbles
Location:	Saver's headquarter laboratory, Tribiano (MI), Italy
Acceptable Criteria:	time taken for the dye to rise through the specimens greater than 15 min
Result:	**TEST SUCCESFULLY PASSED**

3.3.2 - Water diffusion test (IEC 61462 § 7.3.2)

Scope:	The scope is to evaluate the performance of core material (resin and glass fibers) against water penetration or absorption
Location:	Saver's headquarter laboratory, Tribiano (MI), Italy
Acceptable Criteria:	no puncture or surface flashover shall occur during test; the current during the whole test shall not exceed 1 mA (r.m.s.).
Result:	**TEST SUCCESFULLY PASSED**

3.4 - Other tests

3.4.1 - Thermal Cycles stability test (NT802)

Scope:	The scope is to evaluate the quality of material and manufacturing technology and simulate thermal ageing under service load
Location:	ARC Laboratory, Villerbanne, France
Test Method:	Insulator is pressurized at MSP and subjected to 10 cycles (24 each) between Tmin and Tmax
Acceptable Criteria:	No crack, failure, gas leakage or dimensional deviation and bending breakdown above 80% of unstressed insulator
Result:	**TEST SUCCESFULLY PASSED**

3.4.2 - Thermal ageing under internal pressure test (NT802)

Scope:	The scope is to evaluate the quality of material and manufacturing technology and simulate artificial ageing under service loads
Location:	ARC Laboratory, Villerbanne, France
Test Method:	2000 hours at Tmax under MSP
Acceptable Criteria:	No crack, failure, gas leakage or dimensional deviation and bending breakdown above 80% of unstressed insulator
Result:	**TEST SUCCESFULLY PASSED**

3.4.3 - Arc resistance test (IEC 62039 § 3.10)

Scope:	The scope is to evaluate the arc resistance for the outdoor insulation material
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	Minimum time: 180s
Result:	**TEST SUCCESFULLY PASSED – RESISTANCE CLASS HL3**

3.4.4 - Erosion resistance test, inclined plane method (IEC 60587)

Scope:	The scope is the differentiation between insulating materials in AC application with respect to the resistance of electrical insulating materials against erosion and tracking.
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	Minimum class: 1A 3.5
Result:	**TEST SUCCESFULLY PASSED – TRACKING CLASS 1 A 4.5**

3.4.5 - Hydrophobicity test (IEC 62073)

Scope:	The scope is to evaluate the hydrophobicity or hydrophillicity properties of silicon housing
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	n/a
Result:	**TEST SUCCESFULLY PERFORMED – WETTABILITY CLASS WC1**

3.4.6 – Silicone breakdown field strength (IEC 62039 § 3.7)

Scope:	The scope is to evaluate field strength withstand of silicon
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	n/a
Result:	**TEST SUCCESFULLY PASSED – BREAKDOWN STRENGTH 15kV/mm**

3.4.7 – Silicone volume resistivity (IEC 62039 § 3.6)

Scope:	The scope is to evaluate volume resistivity of silicon
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	n/a
Result:	**TEST SUCCESFULLY PASSED – RESISTIVITY: 15 x 10^{15} Ω/CM**

3.4.8 - Salty fog test or artificial pollution test (IEC 60507)

Scope:	The scope is to test the withstand of LSR and shed profile to a specified voltage stress and salinity
Location:	STRI, Ludvika, Sweden
Acceptable Criteria:	No puncture on sheds or flashover
Result:	**TEST SUCCESFULLY PASSED**

3.4.9 - 5000 hours multi-stress test (IEC 61109)

Scope:	The scope is to evaluate the behavior of the insulator when aged in severe ambient condition and to predict the minimum lifetime in service
Location:	CESI, Milan, Italy
Acceptable Criteria:	No discharge, tracking, erosion or shed puncture
Result:	**TEST SUCCESFULLY PASSED**

3.4.10 - Fingerprinting FTIR by ATR reflection of silicon housing

Scope:	The scope is to identify a fingerprinting of the silicon housing
Location:	Wacker Chemie, Burghausen, Germany
Acceptable Criteria:	n/a
Result:	**TEST SUCCESFULLY PERFORMED**

3.4.11 - Validation of usage of composite insulators at temperatures down to -60°C (IEC 61262 §7.2.4 and § 7.2.3 and SAVER test method)

Scope:	The scope is to evaluate the usage of composite insulators in severe low temperature ambient condition with artificially aged insulators
Location:	Saver SpA - HV Division, Siziano (PV), Italy; OMECO Srl, Monza (MB), Italy
Test Method	Saver procedure
Acceptable Criteria:	No gas leakage, crack, failure and, when applicable, tube in elastic phase
Result:	**TEST SUCCESFULLY PERFORMED**

3.4.12 - Validation of usage of LSR at temperatures down to -60° (SAVER test method)

Scope:	The scope is to evaluate the usage of LSR in severe low temperature ambient condition with new specimens and artificially aged ones
Location:	Wacker Chemie, Burghausen, Germany
Test Method	Saver test method (Comparison of mechanical / electrical properties)
Acceptable Criteria:	n/a
Result:	**TEST SUCCESFULLY PERFORMED**

3.4.13 – Low temperature storage test (SAVER test method)

Scope:	The scope is to evaluate the usage of LSR in severe low temperature ambient condition with new specimens and artificially aged ones and to see the different performances when aged, if any
Location:	Wacker Chemie, Burghausen, Germany
Test Method	Saver test method (Comparison of mechanical / electrical properties)
Acceptable Criteria:	n/a
Result:	**TEST SUCCESFULLY PERFORMED**

3.4.14 – Resistance to products od decomposition of SF_6 (Cust. Test method)

Scope:	The scope is to evaluate resistance of inner liner of a FRP tube to product of decomposition of SF_6
Location:	Modern industries Inc., Pennsylvania, USA
Test Method	PPS-00063
Acceptable Criteria:	Surface resistance ≥ 10 MΩ, no scratch marks of erosion
Result:	**TEST SUCCESFULLY PERFORMED**

3.4.15 – DC Erosion resistance test, inclined plane method (IEC 60587)

Scope:	The scope is the differentiation between insulating materials in DC application with respect to the resistance of electrical insulating materials against erosion and tracking.
Location:	University of Applied Sciences Zittau/Görlitz, Germany
Acceptable Criteria:	Initial tracking voltage : DC+ >2.90kV; DC- >4.40kV
Result:	**TEST SUCCESFULLY PASSED**