Atmospheric Corrosion Tests

The Trends in Advanced Cyclic Climate Tests

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EUROPEAN RELIABILITY AND ENVIRONMENTAL TESTING CONNECTED

Chemical Factors Influencing the Corrosion

Atmospheric corrosion

The atmospheric corrosion strongly depends on the quality of the surrounding air and therefore it differs between various countries as well as between various environments within one country (urban, industrial and marine).

Humidity

The air humidity has the strongest influence on the atmospheric corrosion. The threshold is around 60-70% relative humidity.

Especially critical is the formation of a condensation which is mixed with the impurities from the air.

Big temperature, respectively humidity changes result in a continuous forming and drying of dew drops on a surface. This strongly benefits the corrosion.

Source: SurTec Deutschland GmbH – Korrosionsarten und deren Beeinflussung

Main Drives Behind Corrosion Testing

- Meet increased customer requirements concerning resistance of various products and components to corrosion
- Research of new materials, coatings and manufacturing processes and test their behaviour under different climate conditions
- Optimisation of production, energy saving and coating material by maintaining the corrosion resistance
- Quality assurance, global sourcing
- Legislation re product reliability, environmental regulation, REACH regulation
- Consolidation of business with key customers

The Basic Test Procedures

- Salt spray test

according to DIN EN ISO 9227 NSS, ESS, CASS

- Condensation test

according to DIN EN ISO 6270-2, CH, AT, AHT

Application of the Salt Spray Test

Neutral salt spray test (NSS)

- Metals and their alloys, metal coatings; Conversion coatings; Anodic oxide coatings and organic coatings on metallic materials.

Acetic acid salt spray test (AASS, acetic acid salt spray)

- Check decorative coatings of copper + nickel + chromium + nickel or chromium and of anodic coatings on aluminium.

Copper accelerated acetic acid salt spray test (CASS)

- Check decorative coatings of copper + nickel + chromium + nickel or chrome and anodic coatings on aluminium.

Source: DIN EN ISO 9227

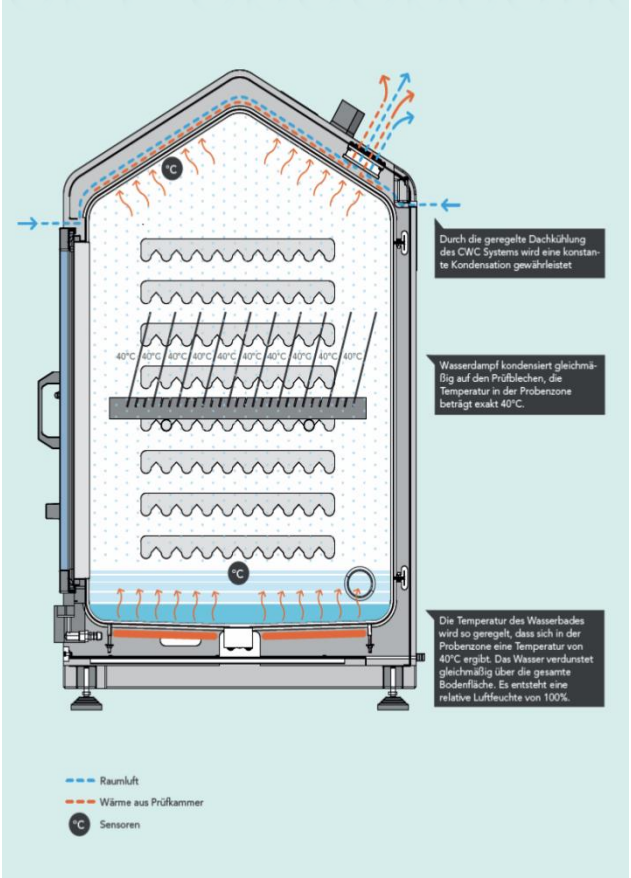
Controlled Water Condensation (CWC)

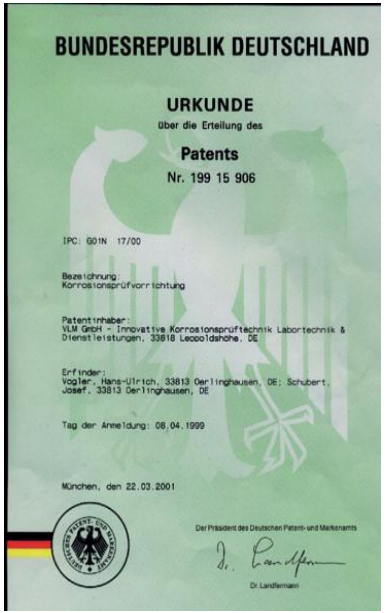
Patented system for Controlled Water Condensation (CWC).

The innovative roof cooling system keeps the roof temperature exactly 1 °C less than the floor temperature. This ensures the best results for water condensation process.

Water vapour condenses evenly on the test panels, the temperature in the sample zone is exactly 40°C.

The temperature of the water bath is controlled so that in the sample zone results in a temperature of 40°C. The water evaporates uniformly over the entire floor area. The relative humidity is kept at of 100%

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URKUNDE

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Patents

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VLM GmbH - Innovative Korrosionsprüftechnik Labortechnik & Dienstleistungen, 33818 Leopoldshöhe, DE

Erfinder:
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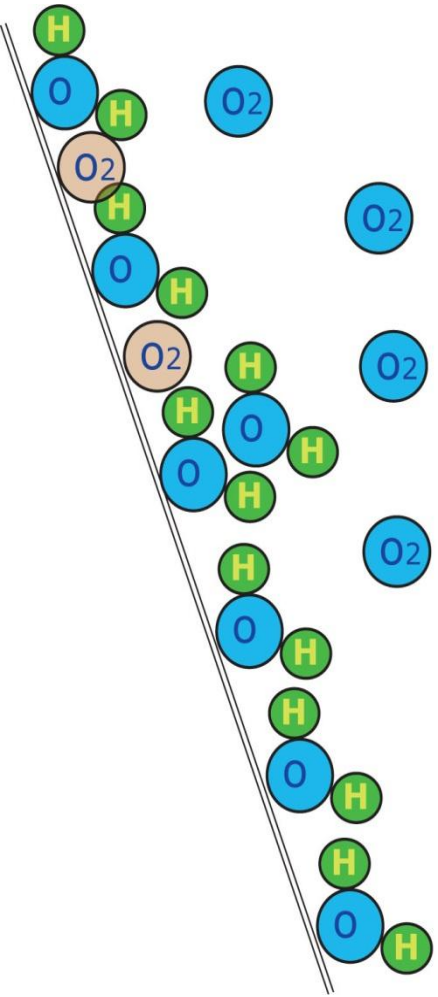
Der Präsident des Deutschen Patent- und Markenamts

Dr. Landfermann

Air Ventilation



The importance of ventilation on the corrosion is frequently underestimated.

Besides:

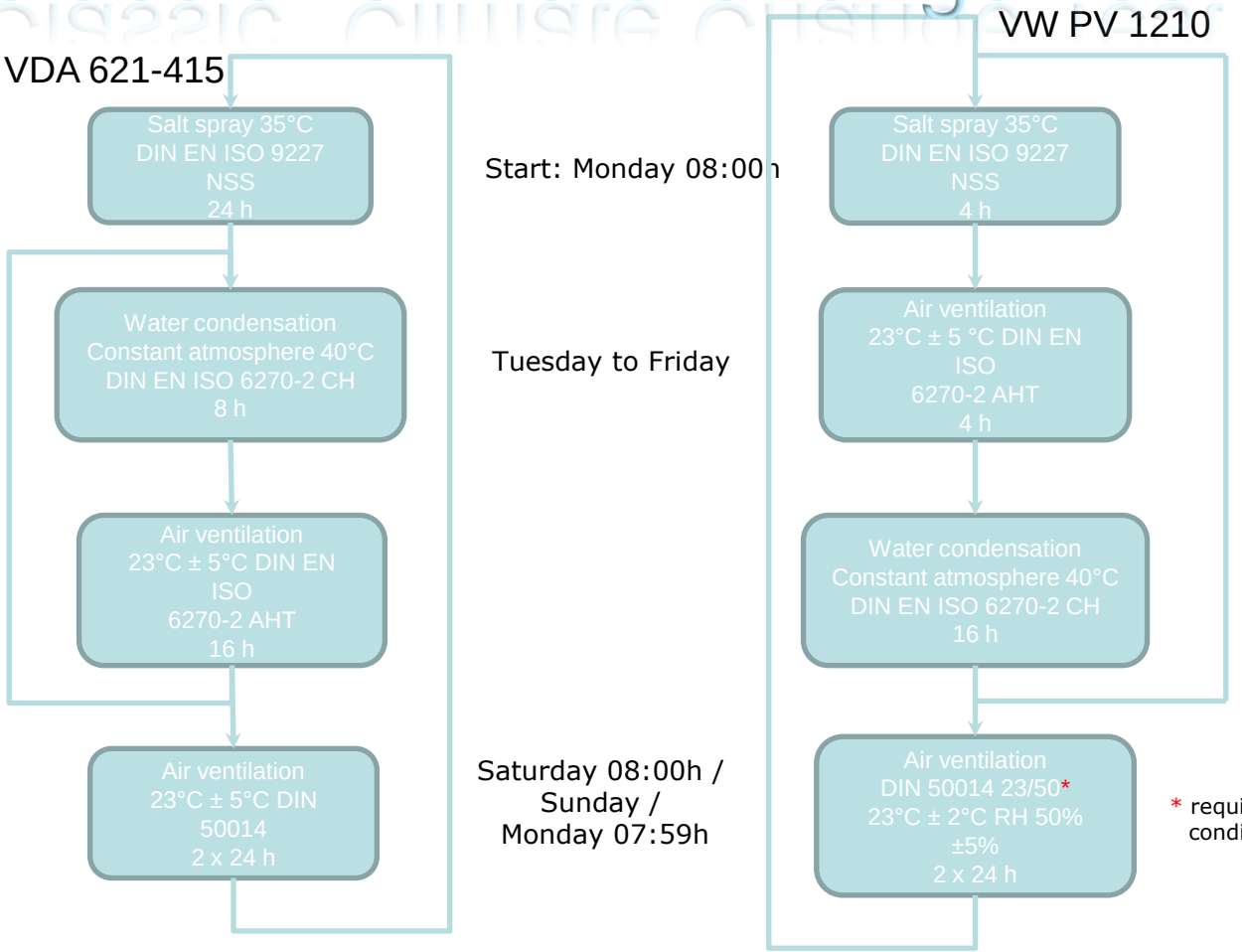
Pay attention to the quality of the environmental air (outside the test chamber), which can vary significantly from location to location. Specifically:

- Air temperatures
- Air humidity (tropical countries)
- high levels of pollutants (e.g. SO_2)

“Classic” Climate Change Test

The “Classic” Climate Change Test

The tests which were previously conducted in separated test chambers are after the introduction of the flow control performed in a single and technically advanced salt test chamber. However there are still questions related to the comparability of the test conditions.

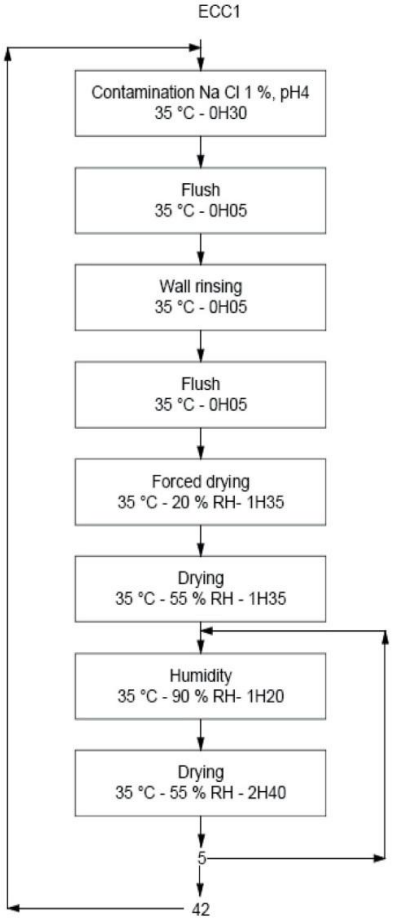


Way Accelerating the Corrosion Tests?

- increase the temperature in the test room in order to increase the speed of the reaction
- use stronger reagents, shift the pH value
- increase the rate of change of climatic conditions

Shortening of test cycles increases the need for accurate control of the test conditions in order to increase the repeatability of results. Only in this case it is possible to compare the test results obtained at different locations.

Renault ECC1 Test



This cycle shall be performed 42 times, i.e. in all **6** weeks of testing.

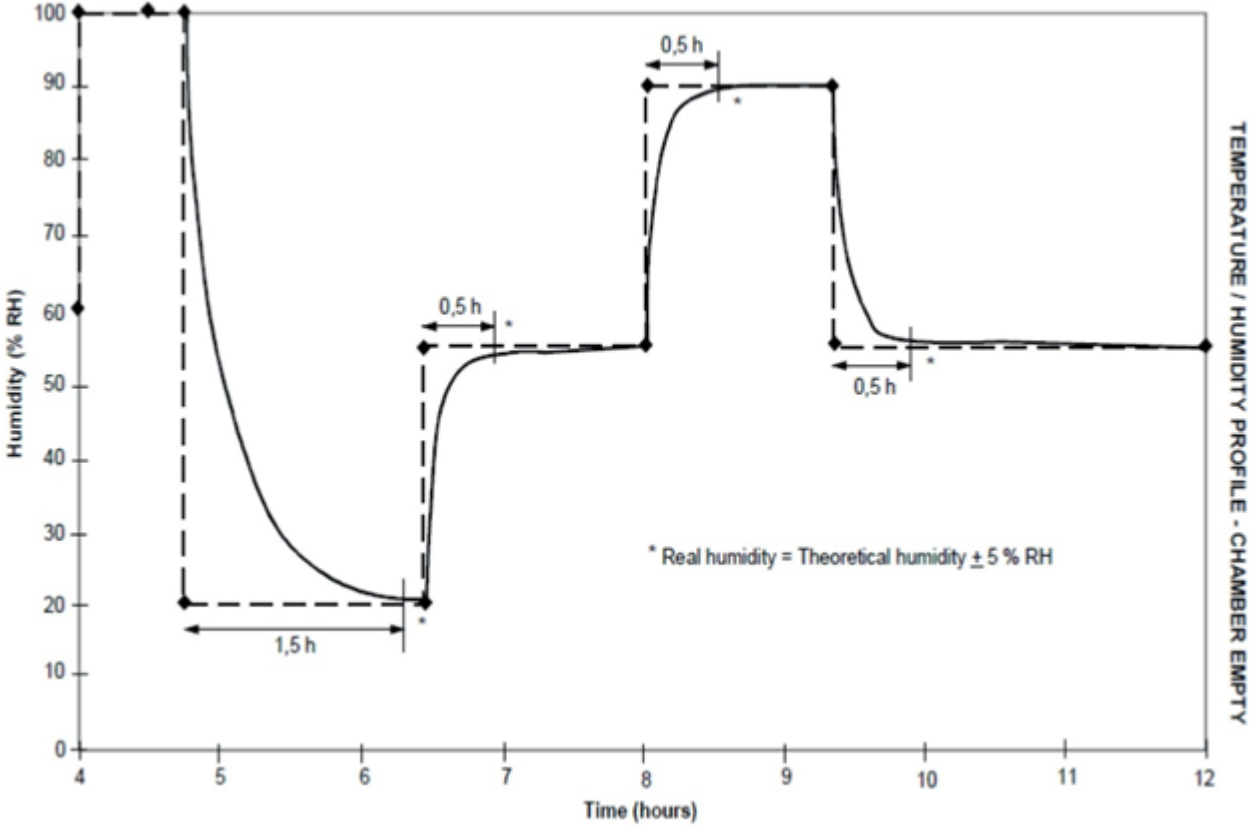
Annex 3 indicates the test profile, chamber unloaded.

Quelle: Renault ECC1 Standard

- NaCl concentration 1%
- pH 4
- Precipitation Rate 5 ± 1 ml/h
- humidity ±3%
- Wall washing
- automatic blowing out of the salt spray
- temperature inside the test chamber 35 °C ±0,8 °C
- forced drying at 35 °C < 20% relative humidity (RH)
- defined transition periods

Due to the moisture in the existing air in the test chamber it is not possible to achieve <20% RH at 35°C only by heating the air. Therefore the air in the test chamber must first be dehydrated with a climate module and only after that warmed up to 35°C.

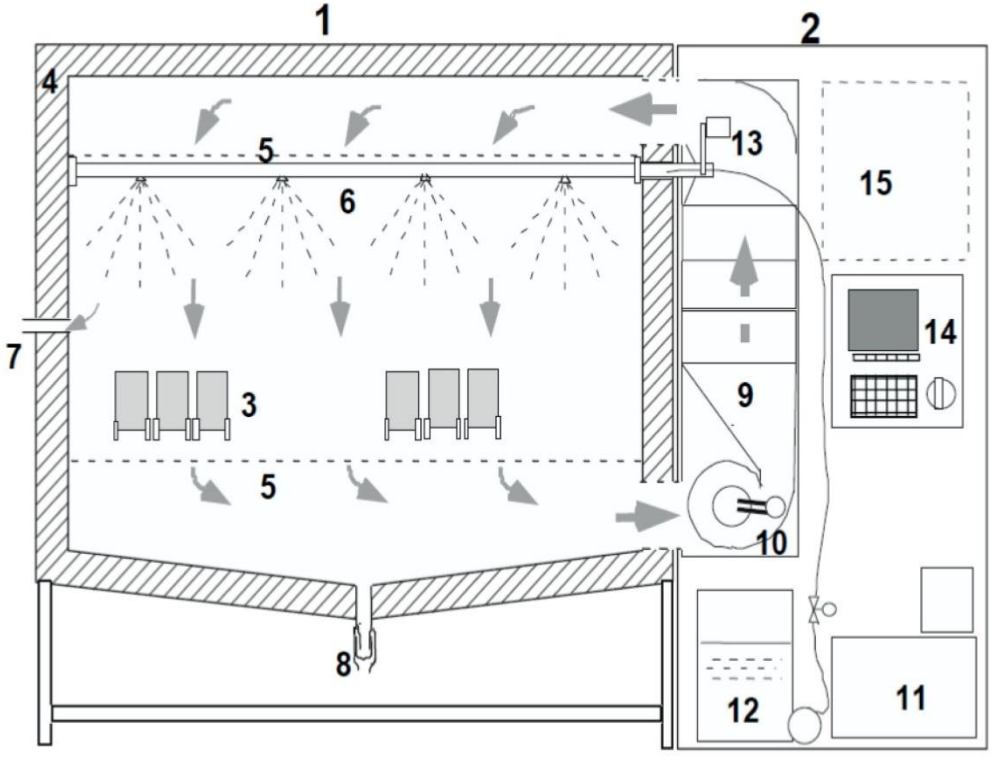
Renault ECC1 Test (II)



Example of Test Acceleration

"Humidity ramp times between the ambient and wet condition and between the wet and dry conditions can have a significant effect on acceleration test (because corrosion rates are highest during these transition periods).“

"These ramp times can be adjusted to increase or decrease acceleration test in order to meet targeted mass loss.“



Klim

1 Test chamber
2 Machinery unit
3 Test object area
4 Well insulated walls/lid
5 Air distribution plate
6 Swaying tube/member with spraying nozzles
7 Air purge outlet
8 Outlet
9 Climatization unit (cooling/heating/humidification)
10 Wet and dry Pt100 sensors (psychrometric sensor)
11 Cooling machine
12 Vessel with salt solution + pressurizing pump
13 Motor and link arms for swaying motion of precipitation tube/member
14 Control unit
15 Electronics and regulatory devices

This design for the spraying of salt solution without compressed air is an example of a device that was developed exclusively for this test.

Quelle: VOLVO VS 1027 Standard

Volvo

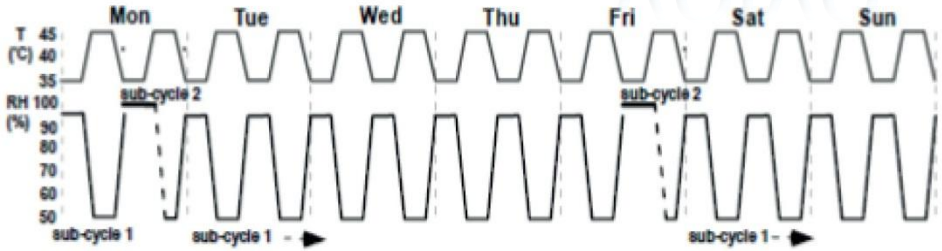


Fig. 3a

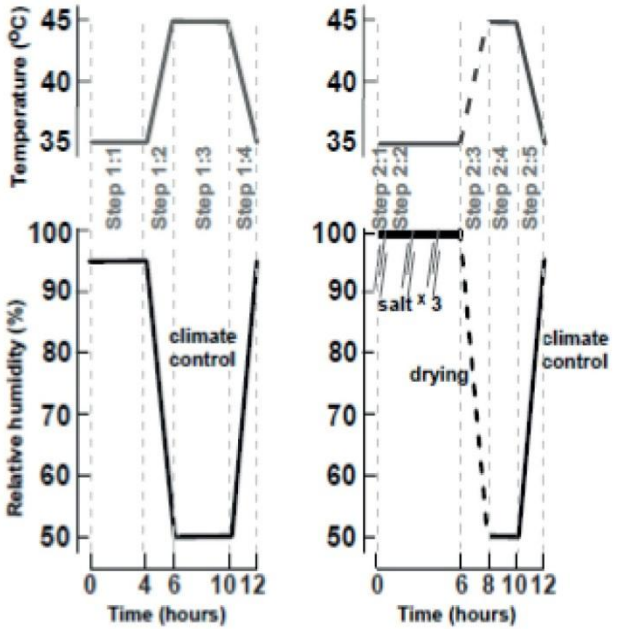


Fig. 3b

Fig. 3c

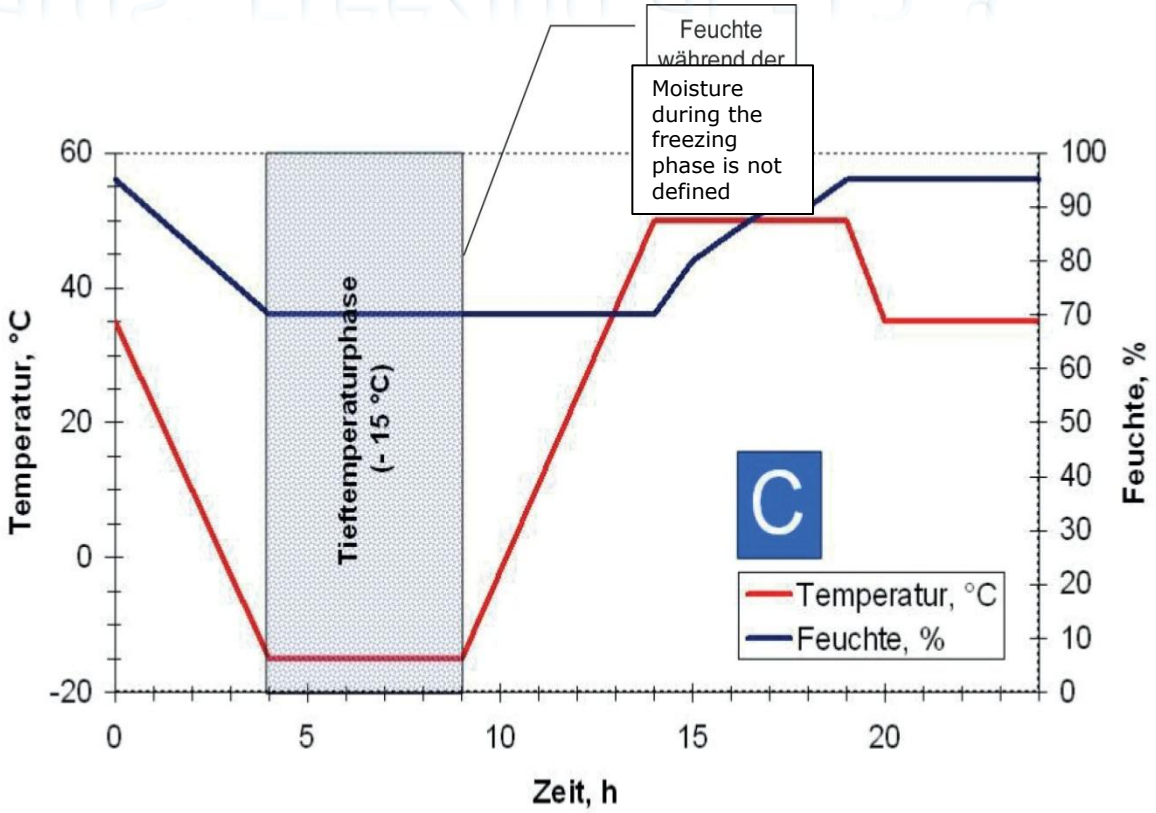
This test procedure is defined for rapid change of temperature and humidity. A simple climate change control can not be used due to a variety of driving conditions simulated during the test. For this reason a powerful process control is required.

Quelle: VOLVO VS 1027 Standard

PLATFORM OMGEVINGSTECHNOLOGIE

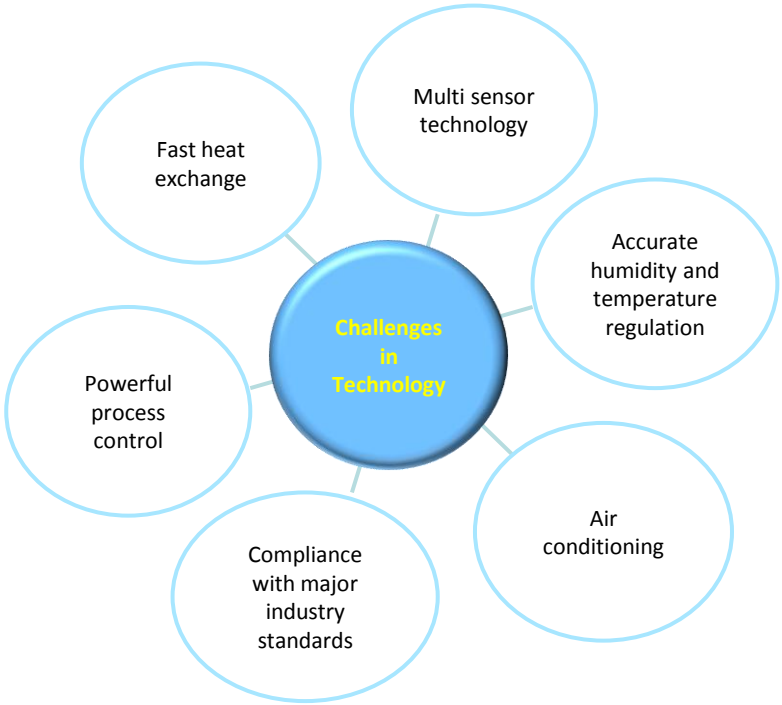
The "New" VDA Test Sets New Standards: Freezing at -15 °C

Test Cycle C (graph)

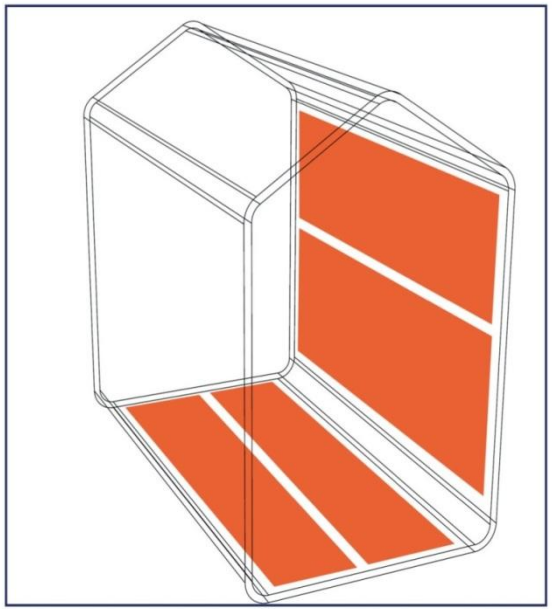


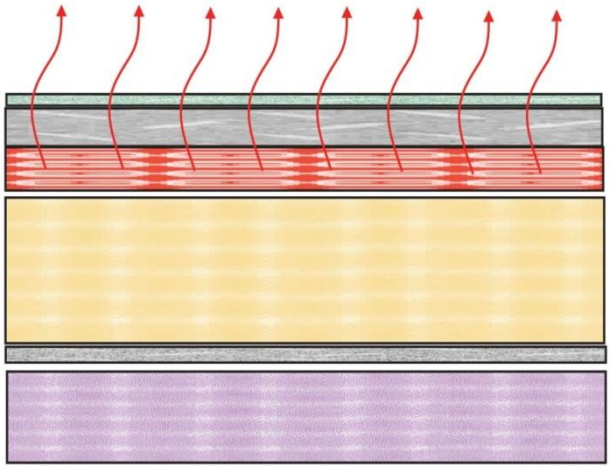
Quelle: VDA Neu

Requirements for the Modern Corrosion Test Chambers



Fast Heat Transfer - Optimal Temperature Control





ECTFE coating
Stainless Steel
Micanite heating

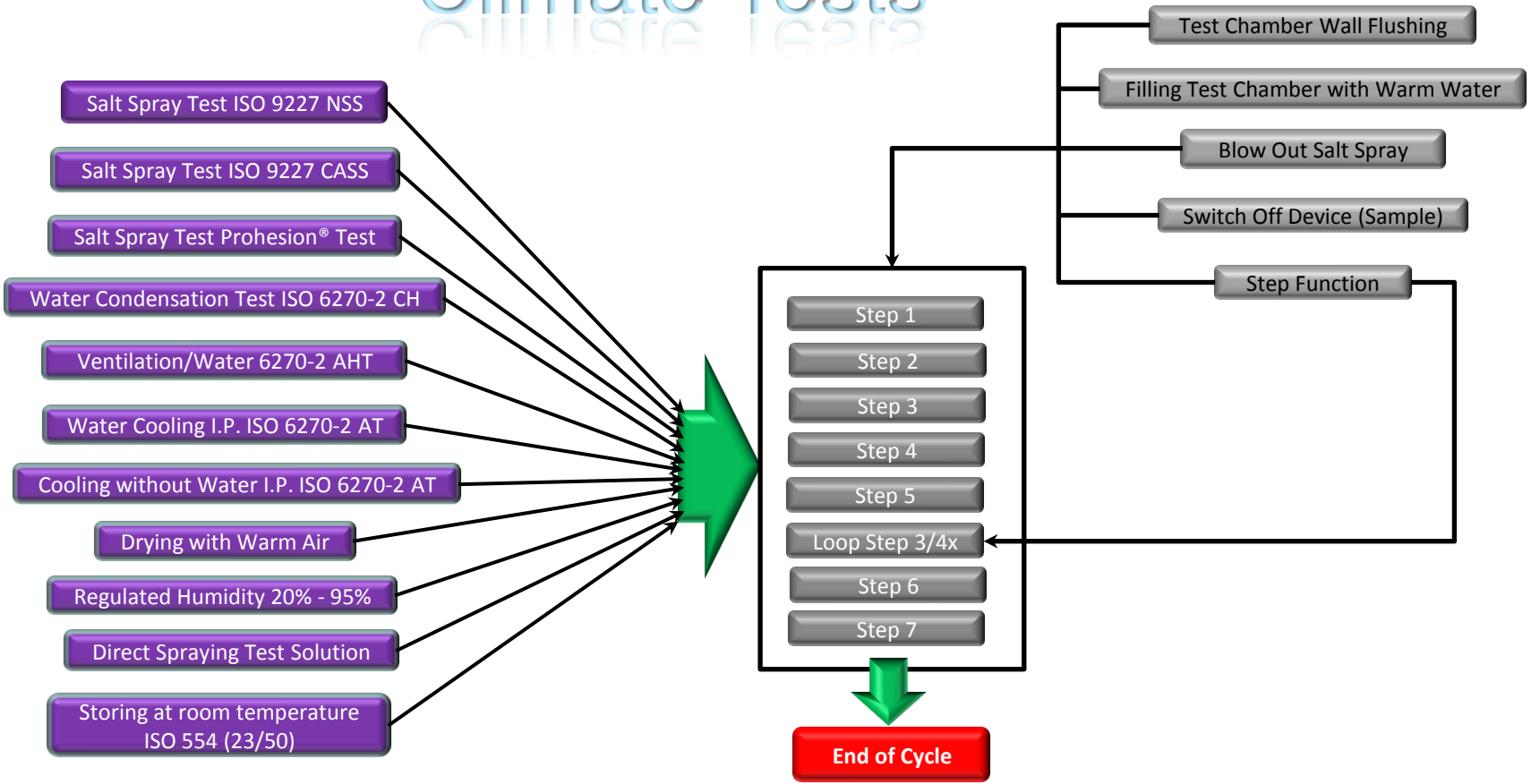
Soft insulation

Aluminium cover plate

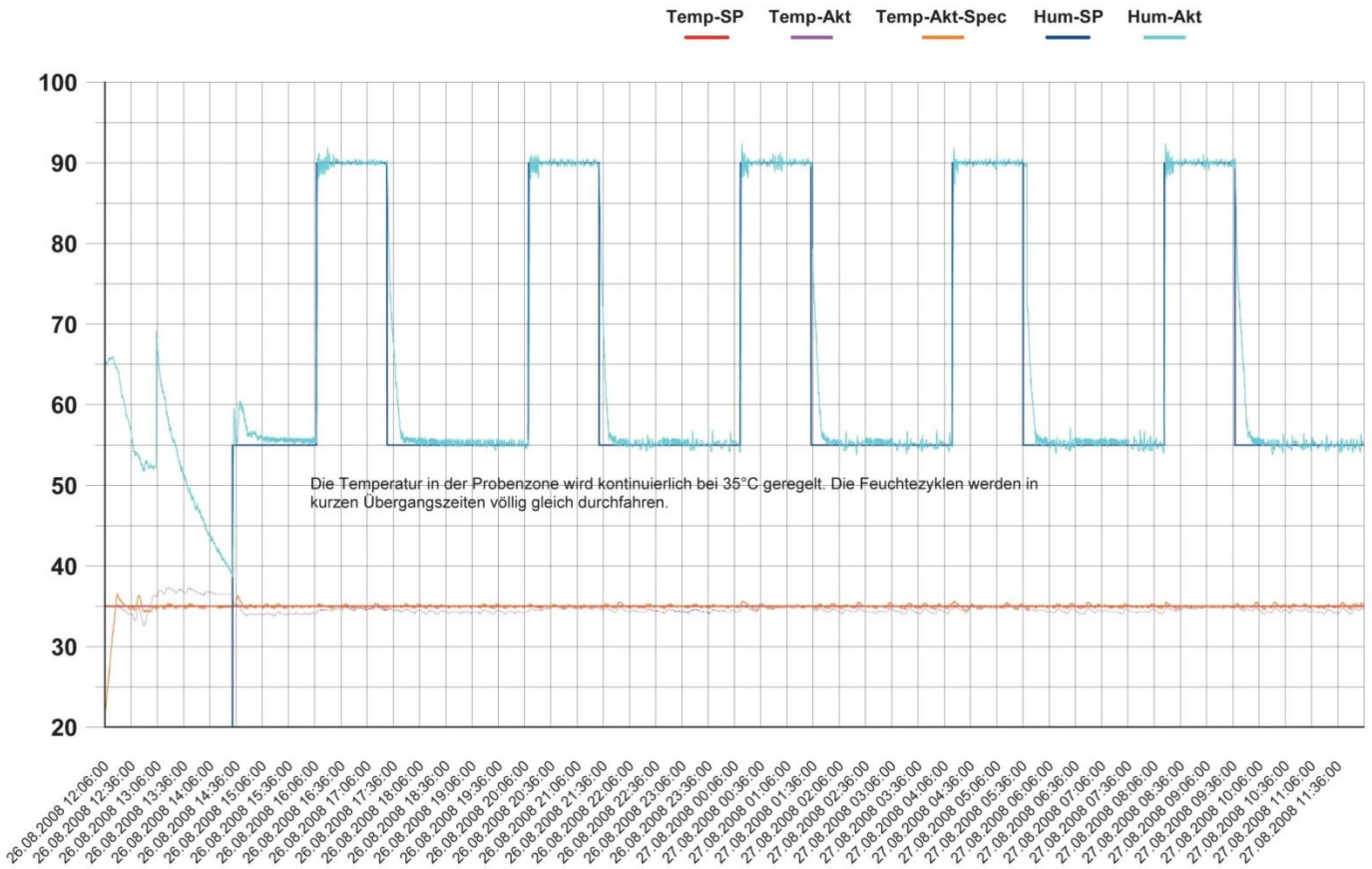
Foam insulation

- Floor, back wall and roof Back made of stainless steel, coated with ECTFE (fluoro polymer)
- High heat conductivity combined with chemical resistance
- Mica surface heating under the floor and behind the back wall allows even and rapid heating of the test chamber

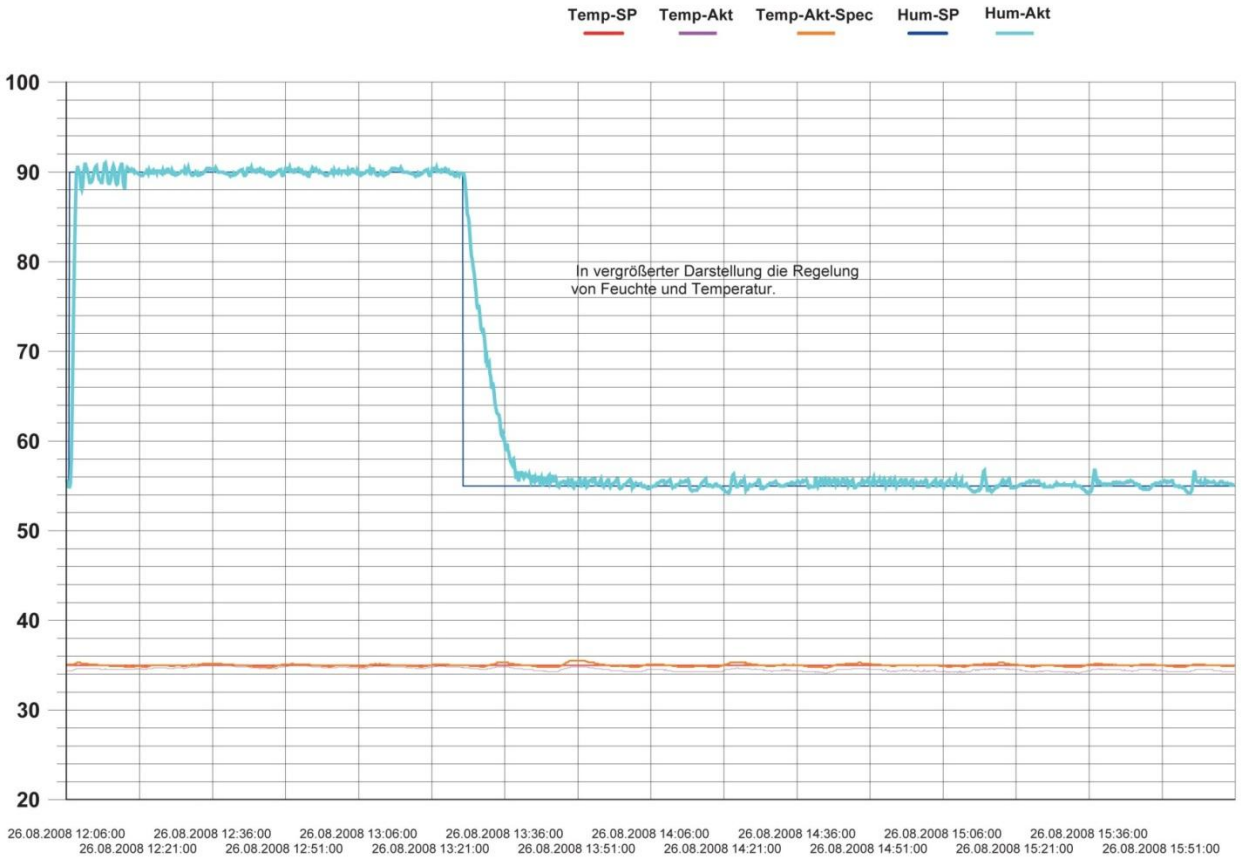
The Combination of Cyclic Climate Tests



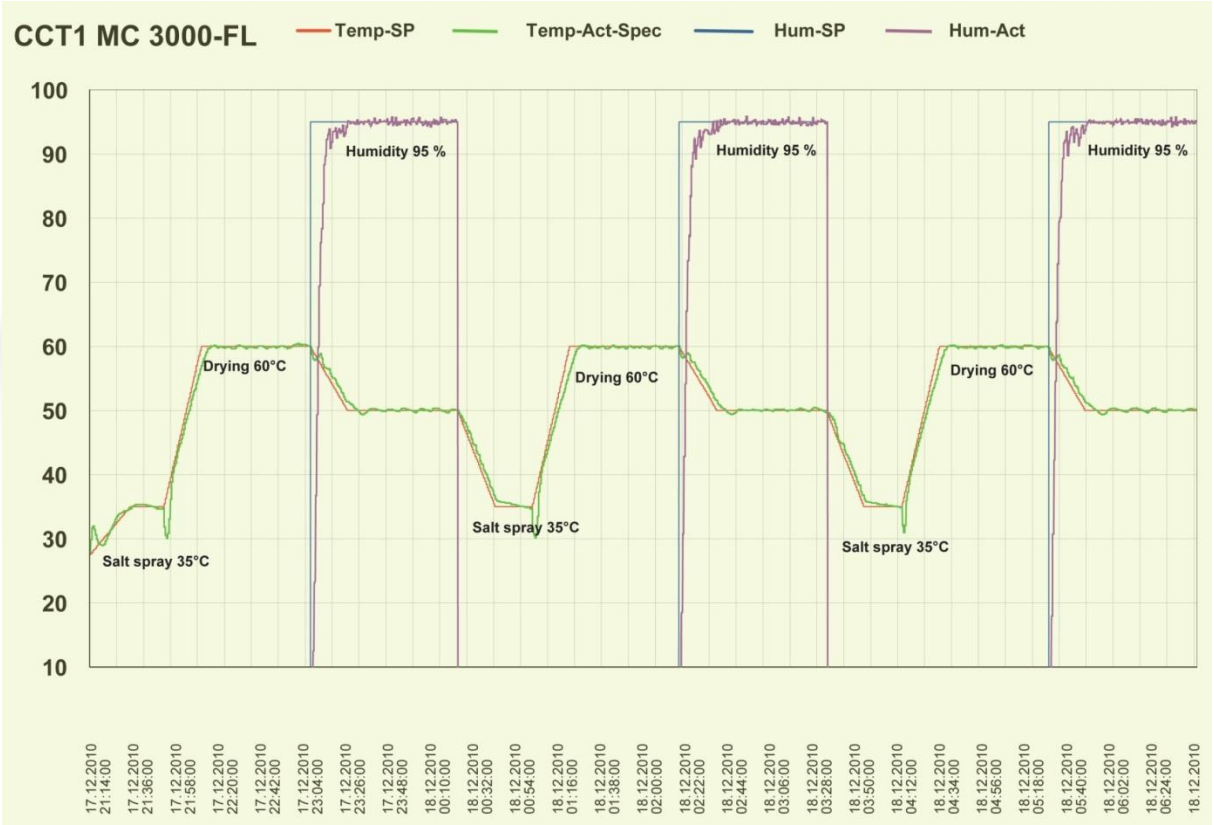
Renault ECC1



Renault ECC1



Test Results of the 3000L Test Chamber



Summary

- Remember: Corrosion = Chemistry
- The question "What happens with the test specimen?" must guide the development of test methods and the design of test equipment.
- The device technology and the proper implementation of the corrosion tests should increase the reliability and repetivity of the test results.
- There is a considerable gap between the "traditional" climate-change tests and modern (complex) tests.

Thank you for your attention

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Annexes

Salt Spray Test (ISO 9227:2006)

Relevant Standards:
ISO 9227
DIN EN ISO 9227 NSS, ESS, CASS
DIN 50942, DIN 53 167
ASTM B 117-73
ASTM B 287-74
ASTM B 368-68
ISO 7253 ISO 3678BS 1224, BS 2011, BS3900 F4, BS 3900 F12,
BS 5466 Part I
BS 5466 Parts 2 + 3
NFX 41002,
AS 21331 Section 3.1
SIS 1841190
JIS Z 2371

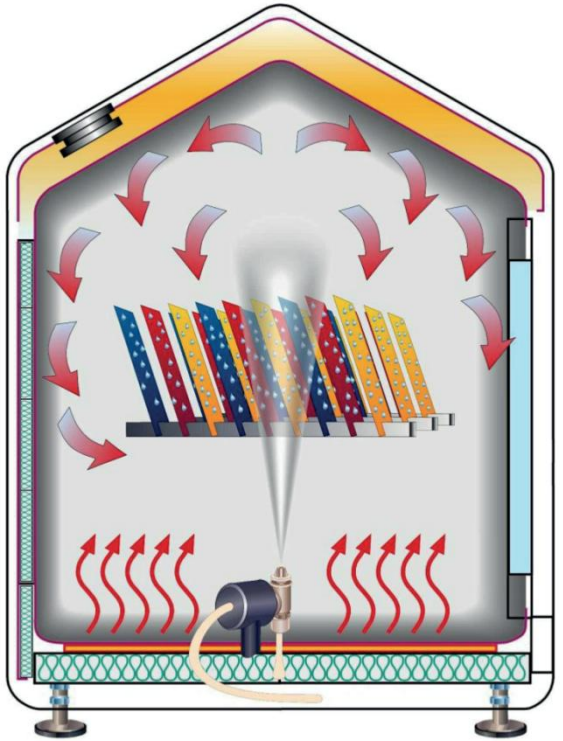
Examples of corporate standards:
VW, GM 44, AUDI, BMW,
Toyota, Nissan, Honda,
Jaguar, Rover,

Literature:

These standards are available at:

Beuth Verlag GmbH,
Burggrafenstr. 6,
10787 Berlin

ASTM International, 100 Barr Harbor Drive,
PO Box C700, West Conshohocken,
PA 19428-2959
United States
Annual Book of ASTM Standards Vol 03.02



The process principle:
5% sodium chloride solution is saturated with moisture and injected in the test chamber through a spray nozzle.
The test room has a constant temperature of 35 °C ± 2 °C

Salt Spray Test – Test Conditions

Test Procedure	Neutral Salt spray test (NSS)	Acetic acid Salt spray test (AASS)	Copper-Accelerated Acetic acid salt spray test (CASS)
Temperature	(35 ± 2) °C	(35 ± 2) °C	(50 ± 2) °C
Average Quantity collected / 80cm ²	1.5 ± 0.5 ml/h		
Sodium chloride Concentration (collected solution)	(50 ± 5) g/l		
pH (collected Solution)	6.5 to 7.2	3.1 to 3.3	3.1 to 3.3

Source: DIN EN ISO 9227

Salt Spray Test – Test ASTM G 85

Annex	Test name	Temperature	pH-value	Salt concentration	Procedure
Annex A1	acetic acid-salt spray test, continuous	35 + 1,1 or -1,7) °C	3,1-3,3	5 % NaCl	***Continuous***
Annex A2	cyclic acidified salt spray test	(49 + 1,1 or -1,7) °C	2,8-3,0	5 % NaCl	***6 h cycles:*** ¾ h salt spray /wet bottom 2 h purge/ drying 3¼ h soak/high humidity 65-95% rH
Annex A3	seawater acidified test, cyclic (SWAAT)	49°C Al-alloys 35°C (Org.Coat.)	2,8-3,0	42 g synth. sea salt/l	***Cyclic:*** 1/2 h salt spray/wet bottom 1½ h soak/high humidity 98% rH
Annex A4	SO2 salt spray test, cyclic	(35 ± 2)°C	2,5-3,2	5 % NaCl or 42 g synth. sea salt/l	6 h cycles salt spray /wet bottom SO2 introduction last 1 hour
Annex A5	dilute elctrolyte cyclic fog dry test	(24 ± 3)°C rH < 75 % (35 ± 3)°C	5,0-5,4	0,05 % NaCl 0,35 % $NH4)_2SO_4$	**2 h wet /dry cycle:** 1 h wet 1 h dry off

Relevant Standards

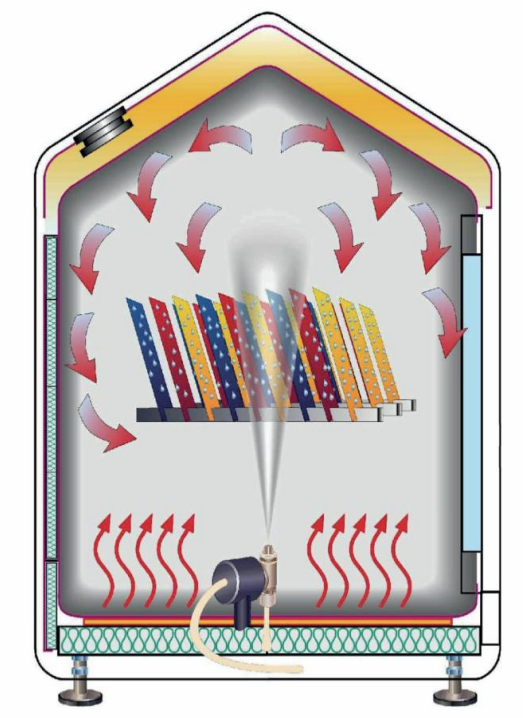
DIN EN ISO 6270-2
DIN 50017 KK, KTW KFW,
DIN 50014
BS 3900F2, BS 3900 F15,
ASTM D2247

- Water Condensation - Constant Climate CH
- Water Condensation – Alternating Humidity and Temperature AHT
- Water Condensation – Alternating Temperature AT

ASTM G 87-02

Prüfklima Benennung		Kurzzeichen	Dauer eines Zyklus		Bedinungen für den Nutzraum nach Erreichen des Gleichgewichtszustandes	
			Gesamt	1. Prüfabschnitt 2. Prüfabschnitt	Luft-temperatur	relative Luftfeuchte
Kondenswasser-Konstantklima		CH (KK)		vom Anwärmen bis Ende Beanspruchung	40 ±3 °C	etwa 100 % mit Betauung der Proben
Kondens-wasser-Wechselklima	mit Wechsel von Luftfeuchte und -temperatur	AHT (KFW)	24 h	8 h einschließlich Anwärmen	40 ±3 °C	etwa 100 % mit Betauung der Proben
				16 h einschließlich Abkühlen (Klimakammer geöffnet bzw. belüftet)	18 - 28 °C	< 100%
	Mit Wechsel von Lufttemperatur	AT (KTW)	24 h	8 h einschließlich Anwärmen	40 ±3 °C	etwa 100 % mit Betauung der Proben
				16 h einschließlich Abkühlen (Klimakammer geschlossen)	18 - 28 °C	Ca. 100 %

The CWC –System in the Cyclic Climate Test



During the salt spray phase the double shell cover acts as a heat insulator.

In the water condensation phase the insulating effect of the double shell cover is not effective when the heat from the test chamber is transferred up along the chamber walls and removed from the test chamber by the stream of external fresh air.

VOLVO

The accelerated laboratory corrosion test applies to:

- metals and their alloys
- metallic coatings
- chemical conversion coatings
- organic coatings on metals

The method is suitable for comparative testing in the optimization of surface treatment systems for test panels, specially designed specimens and components.

2 Apparatus

2.1 Temperature and humidity control

The climate chamber shall be designed so that the following test conditions can be obtained, controlled and monitored during the test.

During a period of constant climate conditions an accuracy of ±3% RH for the mean value in relative humidity shall apply, corresponding to a minimum temperature accuracy requirement of in this case ±0,6 °C. For the instantaneous maximum deviation from set relative humidity a value of ±5% RH in the range from 50% RH to 95% RH at 40 °C shall apply.

The climate chamber must be designed so that the relative humidity may be changed linearly with respect to time, from 95% RH to 50% RH within 2 h. In figure 1 a suitable design of a climate chamber is shown.

To meet the temperature and humidity accuracy requirements, the climate chamber should be equipped with means to provide evenly distributed efficient circulation of air to secure small temperature and humidity variations in the chamber. Sufficient insulation of the chamber walls and lids is required in order to avoid excessive condensation on these surfaces.

The humidity and temperature levels of the climate chamber during a test cycle shall be continuously monitored. The humidity and temperature sensors should reflect the climate conditions in the very test area.

For measurement of the relative humidity use a hygrometer designed for measurements at high humidity levels, e.g. a high-quality psychrometric sensor or a gold mirror dewpoint meter. For temperature measurements, the use of a resistance thermometer is required.

2.2 Application of salt solution

It is advisable to install a spraying device for salt application inside the climate chamber.

2.2.1 Spraying device

The spraying device shall be capable of producing a finely distributed, uniform spray falling on the test objects with a flow corresponding to a downfall of 15 mm/h ±5 mm/h.

When using spray the solution must not be reused.

The device for salt spraying shall preferably be made of a number of flat spraying nozzles mounted in series on a rail or tube in such a way that their spray patterns are partly overlapping, see figure 2. A swaying mode of the tube member must be implemented in order to distribute the salt solution uniformly over the complete test area.
The spraying device shall be made of, or lined with, materials resistant to corrosion by the salt solution. The use of plastics material is recommended.

Recommended nozzle type: Spraying Systems Uni Jet 800050VP. C/C mounting of nozzles on supporting tube 50-60 cm (if approx. 1m above test objects).

2.2 Applicering av saltlösning

Det rekommenderas att utrustning för spridning av saltlösning installeras i klimatkammaren.

2.2.1 Utrustning för spridning av saltlösning

Utrustningen för spridning av saltlösning skall klara av att producera en fint fördelad, enhetlig spray över provobjektet med ett flöde motsvarande en nederbörd av 15 mm/h ±5 mm/h.

Sprayad saltlösning får ej återanvändas.

Utrustningen för sprutning av saltlösning utgörs företrädesvis av ett antal flatstråledysor monterade i serie på en skena eller ett rör på sådant sätt att sprutbilderna delvis överlappar varandra, se figur 2. En fram- och återgående rörelse röret/skenan måste åstadkommas så att saltlösningen fördelas jämnt över provningsområdet.
Utrustningen för spridning av saltlösning skall bestå av, eller beklädas med, material beständiga mot korrosion från saltlösningen. Plastmaterial rekommenderas.

Rekommenderat munstycke: Spraying Systems Uni Jet 800050VP. C/C-montering av munstycken på bärtuben 50-60 cm (om ca 1 m ovanför provobjektet).

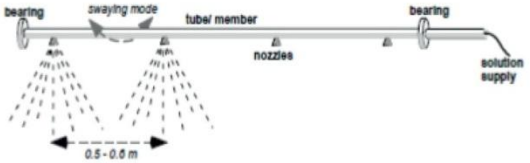


Fig 2

A suitable design of spraying device is shown in figure 2.

Figur 2 visar en lämplig konstruktion av utrustning för spridning av saltlösning.

Quelle: VOLVO VS 1027 Standard