RESOTECH-SALT SPRAY TEST CHAMBER Proposal

Professional Manufacturer of Test Equipment

ISO 9001:2008 CERTIFIED COMPANY

MAKE:-RESOTECH

MODEL NO. RESOTECHFLIX2-610

RESONANCE AUTOMATION AND MACHINES

MANUFACTURERS & SUPPLERS

SPECIAL PURPOSE MACHINE, MATERIAL TESTING MACHINE, LEAKAGE TESTING MACHINE, PACKIGING TESTING MACHINE, ENVIRONMENTAL TEST CHAMBER, ASSY. LINE EQUIPMENT, SOLUTION FOR ELECTRONIC AUTOMATION AND PRODUCT DEVELOPMENT, COMPUTERIZED CONTROL MACHINE , PLC HMI SCADA VISUAL BASIC SOFTWARE DEVELOPMENT SOLUTION AND OTHER SERVICES.

SALT SPRAY CHAMBER

DISCRIPTION

The **salt spray (or salt fog) test** is a standardized and popular corrosion test method, used to checkcorrosion resistance of materials and surface coatings. Usually, the materials to be tested
are metallic (although stone, ceramics, and polymers may also be tested) and finished with a surfacecoating which is intended to provide a degree of corrosion protection to the underlying metal. Salt spray testing is an accelerated corrosion test that produces a corrosive attack to coated samples in order to evaluate (mostly comparatively) the suitability of the coating for use as a protective finish.

The appearance of corrosion products (rust or other oxides) is evaluated after a pre-determined period of time. Test duration depends on the corrosion resistance of the coating; generally, the more corrosion resistant the coating is, the longer the period of testing before the appearance of corrosion/rust. The salt spray test is one of the most widespread and long established corrosion

tests. ASTM B117 was the first internationally recognized salt spray standard. Other importantrelevant standards are ISO9227, JIS Z 2371 and ASTM G85.

SPECIFICATION

RESONANCE AUTOMATION AND MACHINE® Salt Spray (Fog) Tester has been designed strictly as per the relevant standard to assess the ability of rust proofed components to withstand corrosiondue to atmospheric conditions. It is double walled with glass wool insulation.

o Temperature Range – Ambient to 45ºC

o Temperature Accuracy +/- 1ºC

o Temperature Control – Solid State Digital Programmable Temperature Controller cum Indicator with specialzero corrosion PT 100 Sensor

o Air Regulator: A moisture cum oil filter and air regulator ranging from 0 to 30 psi is provided.

o Construction: FRP–Fibre Reinforced Plastic

o Digital indicator

o Time and Temperature are settable

Related Standards: JIS Z 2371, ASTM B117 – 11, IS: 5528, IS: 6910 (R2003)SALT SPRAY CHANBER CAPACITY – 250 Ltr

The apparatus for testing consists of a closed testing cabinet/chamber, where a salt water (5%

NaCl) solution is atomized by means of spray nozzle(s) using pressurized air. This produces
a corrosive environment of dense salt water fog (also referred to as a mist or spray) in the chamber,so that test samples exposed to this environment are subjected to severely corrosive conditions.

Variations to the salt spray test solutions depend upon the materials to be tested. The most commontest for steel based materials is the Neutral Salt Spray test which reflects the fact that this type of test solution is prepared to a neutral pH of 6.5 to 7.2. Results are represented generally as testing hours of corrosion products.

Although the majority of salt spray tests are continuous, i.e.; the samples under test are exposed tothe continuous generation of salt fog for the entire duration of the test, a few do not require such exposure. Such tests are commonly referred to as modified salt spray tests. ASTM G85 is an example of a test standard which contains several modified salt spray tests which are variations to the basic salt spray test.

Standard Facilities

All models are equipped with Air purging, Regulators, Time totalizer, Cyclic Timer, Gauges andSpecimen racks
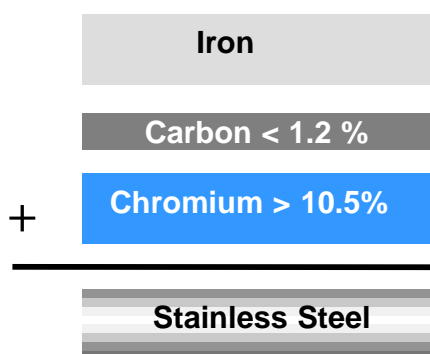
RESOTECH- BY SALT SPRAY TEST CHAMBER

Contents

1. What is the aim of this brief?

Due to its numerous properties and, specifically, its corrosion resistance, stainless steel is used for many applications in the Industrial, Automotive or Domestic sectors.

Stainless steel is steel with a chromium content of more than 10.5%.

Iron
Carbon < 1.2 %
Chromium > 10.5%

+

Stainless Steel

By adding various alloying elements it is possible to create a complete range of grades, which have different physical or chemical properties. The choice of grade must take into account several different parameters. Corrosion resistance will be one of them.

While this parameter is essential, the choice remains very difficult for designers or manufacturers who must

use stainless steels. Indeed, how can a user be sure of the life cycle of a grade if it is new or will be used for a new application in which the environment is not stable or perfectly known? How, for example, can the correct stainless steel grade for a device that will be located on the seafront be identified? The simplest solution would be an over-specified grade but, for economic reasons, this is obviously unacceptable.

For this reason, stainless steels are often characterized by performing accelerated corrosion tests. The media is selected to be not too far from real conditions, but a little more severe, tosimulate the life duration.

One of the most known accelerated corrosion test is the salt spray test. However, this test can unfortunately sometimes lead to the elimination of economic grades that could be suitable for an application. It can even lead to modification of the classification of grades, as a result of creating different mechanisms of corrosion.

This document will try to explain the limits in the use and interpretation of salt spray tests.

2. What is the salt spray test?

This accelerated laboratory test was invented at the beginning of the 20th century.

It provides a controlled corrosive environment and has been used toproduce relative corrosion-resistance information for specimens of metals and

coated metals exposed in a testchamber.

The classical salt spray (fog) test ASTM B117 consists of atomizing a salt solution into uniform droplets on specimens supported or suspendedbetween 15-30°from the vertical.
.

The salt solution is a solution of 5% (in weight) of NaCl, (more than sea water, which is only 1.8% to max 3%). The exposure zone of the salt spray chamber is maintained at 35°C.

The pH of the salt solution is such that when atomized at 35°C, the collected solution will be in a pH range from 6.5 to 7.2.

The test is continuous for the duration of the entire test period.

The period of exposure is mutually agreed upon between the purchaser and the seller. It can reach more than 1000H.

There exist other accelerated testing procedures – in ageing tests, quite often used in automotive industry. These tests are briefly described below. The most important corrosive element is moisture, which is applied in all ageing tests, supplemented by salt mist and/or changing temperature.

Testing procedure	Short description	Main impact
VDA 621-415 (VDA – Wechseltest)	Salt mist, condensed water, standard climate (18°C<__T ≤ 40°C)	Moisture, corrosion
VW P 1200	80°C/95% relative humidity/ - 40°C	Moisture, changing temperature conditions
VW P 1210	Salt mist, condensed water	Moisture, corrosion
VDA - KKT	3 weeks VDA 621-415, salt mist 1 week VW P 1200	Corrosion, moisture, changing temperature conditions
SCAB-test	60°C/-25°C, salt mist 60°C/ 85% relative humidity 30°C/60% relative humidity	Corrosion, moisture

The results are given rather in qualitative than quantitative form.

3. Why it is so popular? What are its advantages?

The salt spray test is the oldest "corrosion test" and the most widely used by users of highly corrosion- resistant material. It has become a "universal" test.

The reason is that the salt spray test offers numerous advantages.

One of the most interesting is that the test is multi-material.

For example, it is possible to test a bare material, a painted one and a noble or sacrificial coating [Figure 1].

The test duration is short compared to the natural environment, the cost is limited and a standardised material is required.

There is a limited number of standards dedicated to this technique, so the framework is widely known.

	Electro-galvanized carbon steel	AISI 441 type stainless steel
48h		
380h		

Figure 1: Electro-galvanized carbon steel and AISI 441 type stainless steel after shortand long salt spray test exposure.

The salt spray test can also be acombined test of material and surface finish, due to the fact that roughness and wettability play a considerable role in the final result.

Influence of the roughness and wettability of the surface on time of contact of the droplets.
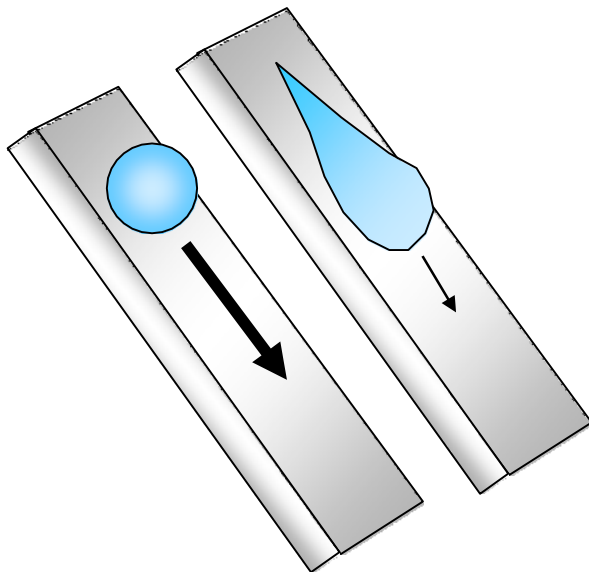
addition, we should not forget that the results provided by such tests are impressive and easy to comprehend.

The test is consequently appreciated for being useable in a commercial argument. On the other hand, systematic abuses are sometimes noted, especially when stainless steelsare tested.

As a first approach, it is sometimes found that the standard itself is not well enough known. In the next part, an in- depth reading is therefore suggested.

To conclude, the salt spray test unfortunately has serious drawbacks. It is a destructive test, very scattered and not correlated with actual performance.

Many users do not even hesitate to testshaped items or equipped parts. In

4. What is written in the Standard Practice for Operating Salt Spray(Fog) Apparatus: ASTM B117?

The standard ASTM B117 (or its equivalent CEI 60068-11) is used in this part to highlight specific points. It is to be remembered that the standard does not describe the type of samples, the exposure time for a given product or the procedure for interpretingthe results (Extract 1).

test environment. Suitable apparatus which may be used is described in Appendix X1.

1.2 This practice does not prescribe the type of test specimen or exposure periods to be used for a specific product, nor the interpretation to be given to the results.

1.3 The values stated in SI units are to be regarded as standard. The inch-pound units in parentheses are provided for

(Extract 1)

It is therefore necessary to present here the choices made by the laboratory, such as thetype of sample and its preparation (test duration and validation criteria should be

decided in agreement with the customer). We also highlight the risk of misinterpretationand suggestions for good practices deduced from reading the standard.

It is generally not possible to assess the behaviour of a material (especially for stainlesssteels) in a natural environment from the results of a salt spray test (Extract 2).

> resistance information for specimens of metals and coated metals exposed in a given test chamber.
> 3.2 Prediction of performance in natural environments has seldom been correlated with salt spray results when used as stand alone data.
> 3.2.1 Correlation and extrapolation of corrosion performance based on exposure to the test environment provided by

(Extract 2)

Numerous previous experiments confirm this fact (Extract 3) and we insist particularly onthe fact that there is no direct relation between resistance to the salt spray test and resistance in another environment.

> X2.2 The salt spray has been used to a considerable extent for the purpose of comparing different materials or finishes. It should be noted there is usually not a direct relation between salt spray (fog) resistance and resistance to corrosion in other media, because the chemistry of the reactions, including the formation of films and their protective value, frequently varies greatly with the precise conditions encountered. Informed personnel are aware of the erratic composition of basic alloys

(Extract 3)

In addition, reproducibility is highly dependent on the type of specimen (Extract 4) and isnot even good for similar samples (Extract 5).

> only in cases where appropriate corroborating long-term atmospheric exposures have been conducted.
> 3.3 The reproducibility of results in the salt spray exposure is highly dependent on the type of specimens tested and the evaluation criteria selected, as well as the control of the operating variables. In any testing program, sufficient repli-

(Extract 4)

> operating variables. In any testing program, sufficient repli-cates should be included to establish the variability of the results. Variability has been observed when similar specimens are tested in different fog chambers even though the testing conditions are nominally similar and within the ranges speci-fied in this practice.

(Extract 5)

In the absence of recommendations provided by the standard, it is nevertheless possible to deduce the type of sample from extract 6. It should be flat, since an angle from 15°to 30° from the vertical must be respected. This extract illustrates the difficulties in

interpretation of the salt spray test performed on shaped items with horizontal zones withretention. At the laboratory, rectangular samples (100mm x 150mm) are typically used.

> during the test shall be such that the following conditions are met:
> 7.1.1 Unless otherwise specified, the specimens shall be supported or suspended between 15 and 30° from the vertical

(Extract 6)

In addition to the sample-cleaning method recommended in the standard (laboratory procedure: ultrasound in an ethanol/acetone mixture, then rinsing with distilled water and finally drying), it is essential to suitably protect the edges. Regarding coated materials (which are finally the only ones for which the standard is useful, by highlighting possible porosity of the coating), the standard recommends protecting the cut edges and zones in contact with the support by paint, wax or suitable tape (Extract 7).

> defined in Test Method D 1654, unless otherwise agreed upon between the purchaser and the seller.
>
> 6.5 Unless otherwise specified, the cut edges of plated, coated, or duplex materials and areas containing identification marks or in contact with the racks or supports shall be protected with a suitable coating stable under the conditions of the practice.
>
> NOTE 1—Should it be desirable to cut test specimens from parts or from preplated, painted, or otherwise coated steel sheet, the cut edges shall be protected by coating them with paint, wax, tape, or other effective media so that the development of a galvanic effect between such edges and the adjacent plated or otherwise coated metal surfaces, is prevented.

(Extract 7)

5. What does this test do with stainless steels, what is happening inreality and what can go wrong?

The salt spray fog test puts materials in the very harsh environment of a high- chloride test medium.

The chloride concentration specified is more than hundredfold higher than in drinking water and even higher than in sea water (chloride concentrations of 3.0% for the test solution, 1.8% for sea water and max. 0.025% for drinking water according to the European drinking water directive).

So the salt spray test does not usually serve for reproducing real service conditions. Only occasionally it is used for a very rough simulation of high chloride environments to be met in, for example, marine service – and even in these cases it cannot really map the conditions and often leads to corrosion reactions and material rankings that are different from those in field exposure.

The salt spray test just generates a defined high-corrosive environment which is quite well reproducible, often just used for production and quality- control purposes. It can serve to detect unsuitable items or material samples in series of known behaviour.

If stainless steels are prone to corrosion in the salt spray test, no general thinning, but forms of localized attack are normally observed.

The prevalent types are pitting and crevice corrosion. With these corrosion forms, attack is normally confined to very small surface areas, while the surrounding surface shows no thinning and exhibits the original surface topography, more or less covered with rusty corrosion products.

Whereas pitting is also found on bare surface areas, crevice corrosion only occurs in case of crevice configuration. The corrosion morphology is characterized by pits that have a small diameter compared to their depth, in the case of pitting, and shallower forms   in the case of crevice corrosion (Fig. 1 and 1b). Pitting in the salt spray test often leads to localised or cloudy rust spots.
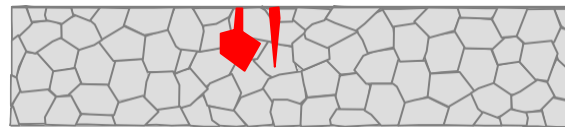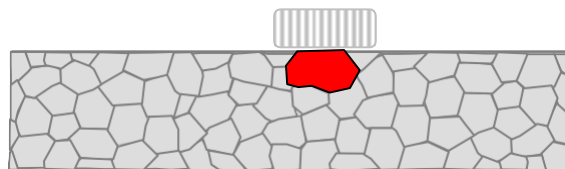

Fig 1: Diagram of pitting corrosion

Fig 1b: Diagram of crevice corrosion

Not only in this test but also in many actual applications, chloride salts are the most relevant corrosive species for stainless steels and pitting and crevice corrosion are the corrosion forms encountered. However, in terms of mapping reality, the salt spray test is not sufficient to simulate actual applicationenvironments.

The corrosive medium of the salt spray test impacts on stainless steel directly from the start of exposure, without any protection over time afforded by, for example, a coating.

There is therefore no long incubation time before a corrosion reaction occurs. It will be seen rather soon, after several hours or a few days when the steel is not resistant. Also, when the test continues further, the corrosion attack proceeds gradually and corrosion behaviour does not usually change abruptly, as can be seen with other materials.

Coated steels, for instance, which are also often evaluated by means of the salt spraytest, may remain free from any visual degradation for quite a long time, until the coating can no longer offer protection.

Then the behaviour of the material changes drastically and severe corrosion sets in (**Fig. 2**). So different types of materials exhibit completely different corrosion reactions in the salt spray test and therefore should not be compared by means of this test.
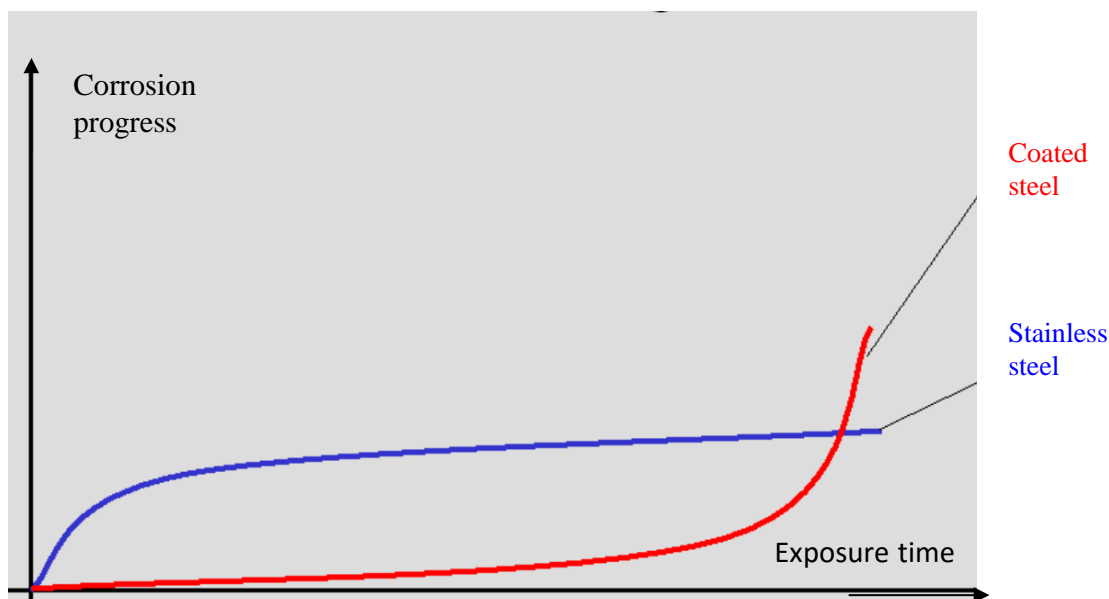
Fig. 2: Diagram of the corrosion progress of stainless steel (blue) and coated steel (red) when exposed to the salt spray test

Due to its very high chloride level, the salt spray test often induces corrosion in stainless steels that are resistant to the much lower chloride impact of actual applications. The salt spray test then changes the corrosion behaviour of stainless steels and can neither serve as an accelerating nor as a simulating test.

The salt spray test is also of rather limited use for comparing the corrosion resistance of different stainless steel grades and for establishing a ranking or
– even more ambitious – quantifying the differences in corrosion resistance.

The reason is that the corrosive conditions of the test are fixed and cannot be adjusted to the resistance of the steel grades to be tested.

This is completely different for other tests better suited to stainless steels, such as critical pitting potential or critical pitting temperature measurements in NaCl⁻ and FeCl⁻ solution respectively. In these tests, corrosivity is progressively increased by shifting continuously or

stepwise one test parameter (e.g. the potential or the temperature) until critical conditions are reached and corrosion initiates. The critical value of the variable test parameter where corrosion initiates then serves as a measure of the corrosion resistance of the material tested. Critical pitting potentials or temperatures of different materials can therefore be determined, serve as a quantitative measure of corrosion resistance and be compared.

With the salt spray test it is not possible to measure corrosion resistance in such a quantitative manner.

Because corrosion attack on stainless steels in the salt spray test proceeds as pitting and crevice corrosion, the factors

influencing these corrosion forms also determine the behaviour of stainlesssteels in this test.

In addition, features that influence the rinsing-off of the test medium from the samples are relevant for the resistance in this test. The sample shape and geometric effects are therefore important.

Chromium and molybdenum are the most important alloying elements of stainless steel in terms of corrosion resistance. The higher the content of these two metals, the more aggressive must the conditions be to initiate pitting and crevice corrosion.

Molybdenum is more effective than chromium, which is expressed by the so- called PRE-value:

$PRE = \%Cr + 3.3 \times \%Mo$

The PRE value is the resistance of astainless steel against pitting and crevice corrosion that can be expectedon the basis of its alloy composition.

Stainless steels with only 12% chromium, such as 1.4512, develop

severe rusting within only a few hours in a salt spray test.

12% chromium

Steels with ~18% chromium (1.4301 *etal*) are quite resistant for much longer. Higher-alloyed grades containing additional molybdenum, such as 1.4404, are quite resistant, even in more endangered areas such as crevices.


18% chromium + molybdenum

Besides the alloying elements chromium and molybdenum, nickel is beneficial for salt spray test behaviour. In contrast to chromium and molybdenum, nickel does not increase resistance to pitting and crevice corrosion initiation but it very effectively slows down the corrosion process once it has started. Thus nickel-austenitic grades oftenshow better salt spray test results, with much less rusting than low-nickel ferritic grades with similar PRE-values.

Nickel-austenitic grade

Ferritic grade without nickel

Same behaviour for low-nickel austenitic grades
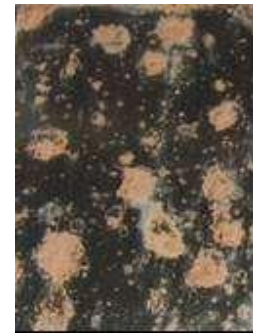
Since the salt spray test detects surface flaws and suboptimal surface states very sensitively, it is often used for comparing polished finishes. Smoother finishes tend to show better test behaviour but roughness is not the only influencing factor. More important is a coherent surface without micro-cracks and micro-crevices, for example in the form of material overlaps. Residues of the polishing material can be detrimental, contaminate low-alloyed steel, leading to very rapid rusting.

Heat tint colours resulting from heat treatments or welding operations reduce pitting and crevice corrosion resistance. In addition the oxides forming these colours can react in corrosive environments, transforming to brownish hydroxides. Heat tinted areas are therefore often prone to corrosion and rusting in salt spray tests (**Fig. 3**).
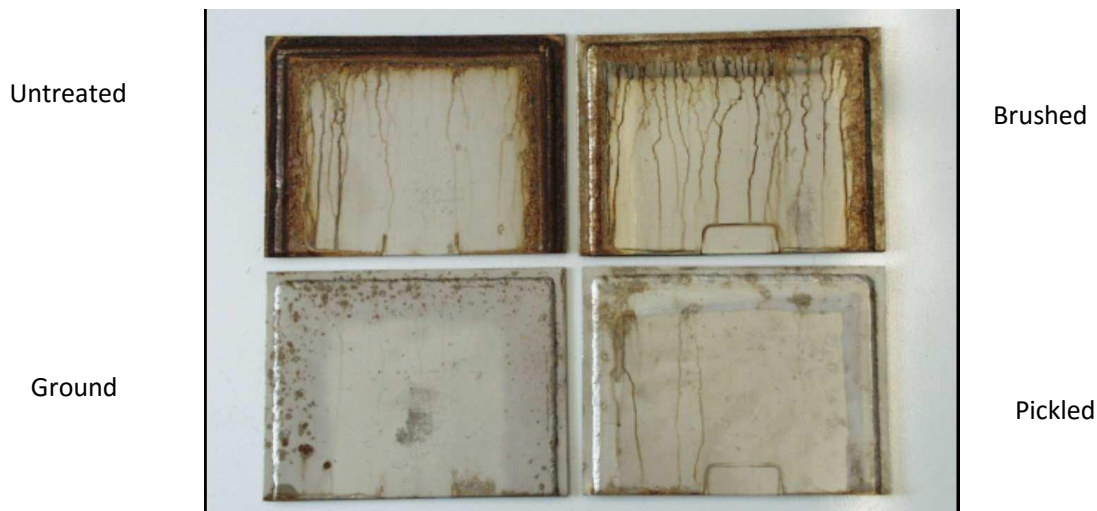

Untreated

Brushed

Ground

Pickled

Fig. 3: Effect of heat tint colours and weld cleaning operations on the salt spray testresistance of stainless steel 1.4301

Corrosion at the cut edges of the sample often makes the carrying out of a saltspray test and its evaluation more difficult, if corrosion products emergingat the upper and lateral edges spread out over the sample surface, masking large area fractions after longer testing times. The appearance of the sample is then governed by the corrosion behaviour of the cut edges, which is usually of less interest, while the corrosion behaviour of the rolled surfaces can no longer be adequately evaluated.

Corrosion of the cut edges and holes is often caused by ferrous contamination from drilling and cutting.
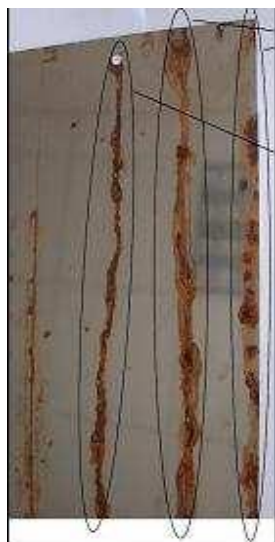
Hole edges canlead to corrosion

Corrosion of the cut edges can lead to considerable rust formation. The cross- sectional areas are not only slightly less corrosion resistant than the rolled surfaces. A fissured topography from the cutting operation and slower draining- off of the test medium makes cut edges even more susceptible and their corrosion behaviour rather irregular, so parallel samples can show quite different resistance.

Bad adhesive tape can lead to corrosion

To reduce these experimental shortcomings, cut edges can be masked with adhesive tape or prepared to obtain a smoother surface. The sample areas covered with corrosion products coming from the cut edges should be ignored when evaluation is performed.

Good adhesive tape can avoid corrosion

According to the test specification, the salt fog has to fall vertically. With flat samples standing inclined, according to the standard, the test medium does not stagnate on the surface but drains offrapidly and is continuously replenished.

If other sample layouts let the test medium stagnate in crevices, depressions or on horizontal sections, these areas are much more prone to corrosion and the positioning of the sample in relation to the falling direction of the salt has a considerable influence on test behaviour. It is therefore recommended to test only plane samples rather than constructional elements with complex geometries.

6. For which purpose can the salt spray test be used and for whichshould it not?

As shown in this document, the salt spray test has some serious drawbacks when used for stainless steel. It is a destructive test, which gives often quite scattered results that often do not correlate that well with the performance of the stainless steel grade in the final application. Nevertheless, testing stainless steels in salt spray chambers has its fields of use in material science and engineering, when performed with care by experts knowing and considering its above-discussed limitations.

Comparison of the corrosion resistance of different stainless steel grades is possible. But the test gives only a ranking of materials. A salt spray on its own cannot normally provide sufficient information for stainless steel grade selection, as the correlation between the test conditions and the application is often not sufficiently well known. Forthe same basic reason, it is also impossible to estimate the lifetime of the manufactured product from the salt spray test result of a stainless steel sample. It is also not possible to compare materials of different classes, such as stainless steel and painted carbon steel. The corrosion mechanisms for these two materials in this test are different, as will be the correlation between their test results and the real-life environment.

The received test results are only valid for the conditions of the test – namely atmospheric corrosion – since the material may behave differently when, for example, immersed continuously in a salt solution. Also, changes in the specimens, such as their shape, can lead to erroneous conclusions. Introducing welds or tensile stress in the specimens, for instance, may give a quite different material ranking.

One advantage of the salt spray test is that it not only tests the corrosion resistance of the base material but can also show the influence of surface preparation on the resistance of stainless steels to atmospheric corrosion. But as the correlation betweentest conditions and application are, as mentioned above, not normally well defined, the result is only a ranking of preparation methods, as described before for material comparisons. Therefore, it can only help choose the best surface finish. It cannot provide information to select a surface sufficiently good for the application.

Another advantage of the salt spray test is that it is possible to examine quite big samples, depending on the size of the salt spray chamber. Chambers are available in sizes that even allow the testing of a whole truck. When exposing fabricated products to a salt spray test, the product development engineer can gather valuable information on the performance of his product under conditions of accelerated atmospheric corrosion. When correctly planned and accurately performed, the test will identify details in the structure that will

probably show corrosion first, in the final application. Typically, this will include crevices, untreated weld seams and areas where dirt or water can collect later. Based on the test results, the engineer can improve these parts of the product.

It also must be pointed out here that the test will not show when or even if corrosion will occur in the real-life environment. Similarly, the salt spray test can help a quality control engineer identify steps in the manufacturing process that make the product more prone to corrosion, by highlighting areas where, for example, extraneous rust has come into contact with the stainless steel surface or where, for example, cut edges should be deburred. As the dependence of the test results on small differences in the base material is relatively low, the test cannot usually serve the quality engineer as an acceptance tool for different batches of final products.

A salt spray test is simple to perform and its results seem to be immediately understandable to everyone. This makes it an interesting tool also for marketing purposes. Since it is, however, important to construe the results of the test properly and since there are many ways to introduce mistakes into the test procedure, salt spray test results of stainless steel should be presented with care, knowledge and good faith. Also, those looking at marketing material containing the results of salt spray tests should be aware of the test method's above-described constraints, so as to avoid misinterpretationor misunderstanding.

7. What is the best practice for assessing the corrosion resistance of stainless steels?

As shown above, the salt spray test can serve only as accelerated ranking test for stainless steel samples under conditions of atmospheric corrosion. It is often impossible to make predictions on the service life of a product or decide about the acceptance of a product for a certain application based on the results of such a test. As it cannot be an acceptance or lifecycle prediction test, it is often not necessary to perform the salt spray test exactly according to the standardized method to get a ranking of sample differences. This means that the conditions of each single salt spray test can be optimized to reach the goal of the experiment as best as possible. For instance, it is absolutely reasonable to use intermediate spraying techniques with drying periods for testing of more corrosion resistant stainless steel grades. Alternatively, more aggressive conditions can be obtained by replacing the commonly applied sodium chloride solution by calcium chloride solution.

On the other hand, samples that are more prone to corrosion can be tested at lower temperatures or with diluted or even inhibited chloride solutions. This means also that it is often possible to stop a salt spray test when all stainless steel samples show at least the beginning stages of pitting corrosion.

For comparing different stainless steel grades, more methods that are not necessarily limited to pitting corrosion under the conditions of atmospheric corrosion are available to the corrosion engineer. Generally speaking, the corrosion test method of choice should represent the conditions in the final application as best as possible. On the other hand, it may take quite a long time to perform a corrosion test under real life conditions – which is usually denoted as 'field test' and gives, of course, the most reliable test results. In the case of applications that are often related to salt

spray tests, the selection of an unsuitable material, surface finish or manufacturing method often leads to initial small corrosion damage after a relatively short time of use. Therefore, a carefully performed field test, taking perhaps several months or sometimes a year, can be a very powerful alternative in many cases, where material substitution is the target of corrosion testing.

In order to overcome the problem that field tests may take quite some time, accelerated laboratory corrosion tests have been developed, which are often performed under conditions significantly different from the final application, leading sometimes even to different corrosion mechanisms. A suitable comparison method should therefore be expertly selected, taking into account the target application and the occurring corrosion mechanisms.

Suggested Alternative:

Measurement of the critical pitting temperature (CPT, see ASTM G48 or ASTM G150), which is the temperature necessary to induce pitting corrosion in stainless steel in given conditions, is often the better choice for higher alloyed-grades, since the salt spray test is usually not severe enough to cause corrosion damage. For austenitic and ferritic standard grades, the measurement of pitting potential, which is the electrochemical potential that is necessary to induce pitting corrosion under given conditions, is also a popular way of comparing their pitting corrosion resistance. When testing stainless steel for use under conditions that may also result in corrosion other than pitting corrosion, it is usually necessary to choose a special corrosion test and consult an expert.

Apart from laboratory and field tests, the simplest way to compare the pitting corrosion resistance of stainless steel grades is to use the Pitting Resistance Equivalent (PRE, see *various ISSF documents*), which is calculated on the basis of the composition of the grade and correlates to its (CPT). It takes the chromium, molybdenum and nitrogen content of the alloy into account and gives a handy measure to compare

stainless steel grades. Despite its simplicity, calculated PRE numbers often give results that are as reliable as salt spray tests for many real-life applications, without performing any experiment.

AUSTENITIC/FERRITIC PRE COMPARISON

$PREN = \%Cr = 3,3 \times \% Mo + 16 \times \% N$
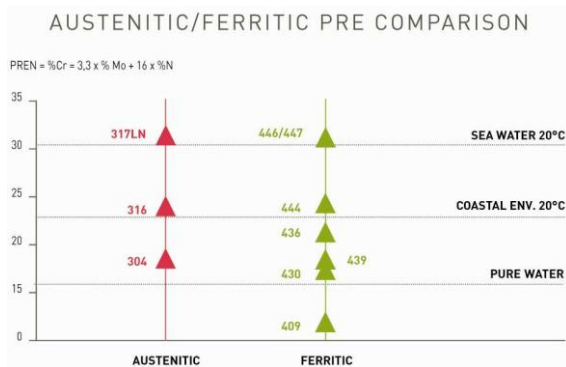
It must be pointed out, however, that the PRE number does not reflect the influence of the alloying element nickel, which plays an important role in repassivation of active pits and in pitting corrosion propagation, resulting often in higher amounts of red rust formed on low-nickel grades under the extreme conditions of the salt spray test.

The best way to estimate the lifetime of a given product is, of course, still to refer to the previous experience of other users of stainless steel. Surprisingly, much information is published and available through stainless steel producers and their national and international organizations, literature, commercial databases and even standards. For instance, for architectural applications, standard EN 1993-1-4, contains a simple but handy materials selection table, based on many years of experience.
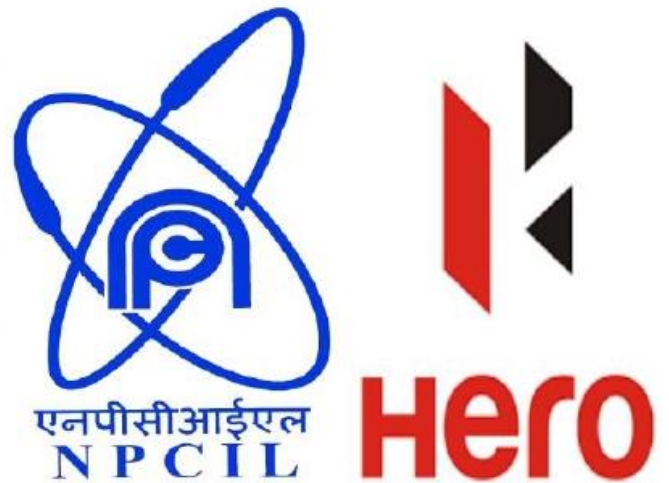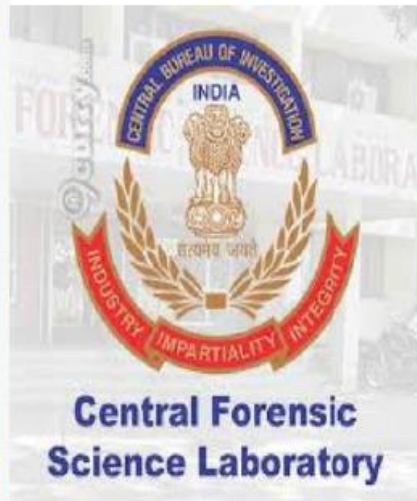
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