SURFACE VEHICLE RECOMMENDED PRACTICE

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Filiform Corrosion Test Procedure for Painted Aluminum Wheels and Painted Aluminum Wheel Trim

RATIONALE

This document has been updated to improve the procedure based on feedback from users. Clarity and process learning are incorporated. An example data sheet is provided as well as an example master panel to facilitate the use of image analysis to the measurement process.

TABLE OF CONTENTS

1. SCOPE

This test procedure defines a laboratory procedure for generating and evaluating filiform corrosion on painted aluminum wheels and painted aluminum wheel trim.

While this test was developed specifically for the testing of painted aluminum wheels and wheel trim, it may be applicable to other components. The application owner will need to assess if this test generates filiform similar to that found in the relevant usage to ensure it will provide accurate data for the application.

1.1 Purpose

To establish a uniform test method for the wheel and wheel trim industry when assessing the resistance of components to filiform corrosion. An objective is to reduce test procedure proliferation and thereby reduce costs for establishing and maintaining unique test facilities, test methods, measurement methods, laboratory accreditations, and operator training. The net effect is to reduce cost while improving the quality of the test data by adopting uniform and standardized test methods. The procedure does not establish performance standards for the components. Performance standards are to be established by the users of the test and/or their clients. The method and format for documenting proficiency is defined.

1.2 Overview

Filiform corrosion is generated by exposing a coated substrate to a warm, humid environment. This filiform test procedure utilizes the SAE J2634 scribing method to ensure consistent exposure of the sample substrate to the corrosion products. The test part is inoculated with corrosion products by using ASTM B368-97 (2003)[e1] followed by an immersion in de-ionized (DI) water to remove excess corrosion products and then placed in a temperature and humidity controlled test cabinet to initiate the formation of filiform corrosion. Posttest evaluations of length of filiform filament growth, density of filaments, and area of filiform growth can be assessed to evaluate the corrosion resistance of the component.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2634 Scribing of Coatings in Preparation for Testing of Wheels and Wheel Trim

SAE J2636 Corrosion Test Master Establishment

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B368-97 (2003)[e1] Standard Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)

ASTM D1193 Standard Specification for Reagent Water

3. DEFINITIONS

3.1 FILIFORM CORROSION

Filiform corrosion is type of corrosion that propagates across the metal surface underneath a coating. The corrosion is almost always initiated at discontinuities in the coating and propagates in the presence of oxygen and sufficient relative humidity. Filiform corrosion is characterized by thin "thread-like" corrosion filaments. Each filament has a "head" (the point of propagation of the corrosion growth) and a "tail" (the corrosion by products); see Figures 1 and 2, respectively.

3.2 FILIFORM FILAMENT

An individual thread like corrosion element that grows in length; see Figure 1.

3.3 DENSITY

The number of filiform filaments distributed within a specified length, such as along a scribe or wheel spoke edge. A filament may grow from a scribe and curve to return to the scribe. This is counted as one filament for frequency counts.

3.4 EQUALIZATION ADJUSTMENT FACTOR

A factor calculated to equalize the data from two or more different test laboratories or test chambers based on a proficiency analysis (see Table 2).

3.5 TEST MASTER SAMPLE

A sample used to assess the proficiency of a laboratory to conduct a filiform test and to allow calculation of a laboratory adjustment factor to permit the comparison of data from different laboratories on an equalized basis. A test master is also used in each test to confirm that the test has been performed correctly by comparing the master sample with the established data of the proficiency assessment. A significant variation may result in the test being disqualified.

4. TEST PROCEDURE

4.1 Cabinet Settings

Set and check the humidity cabinet for the temperature, humidity, airflow and exhaust vent settings. Correct any discrepancies from predetermined levels.

Humidity Cabinet Settings:

The cabinet should be capable of maintaining the following parameters:

Temperature 60 °C ± 1 °C

Humidity 85% Relative Humidity ± 3%

Air Flow 6 to 24 m/min (20 to 80 ft/min) in the test area

NOTE: Chamber air flow baffles may be required to manage the flow within the test chamber. Multiple areas within the chamber should be assessed (mapped) for air flow to ensure consistent air flow to achieve the required corrosion growth.

4.2 Sample Preparation

Visually examine the painted surface and record any adverse conditions, such as sags, paint film porosity, scratches, etc., and record. Photograph of the sample anomalies before testing to document the original sample condition in the test report is recommended. Do not mark on the candidate test area unless the intent is to disqualify an area from evaluation. Measure the paint film thickness over the area to be scribed, and record on a schematic drawing of the part and in the required proficiency data sheets (the paint film thickness measured at a specific control point should be correlated with cross-sectional analysis for the entire part geometry). Prepare a master test sample in a similar manner.

4.3 Scribing

Scribe the test piece to the base metal with a carbide tip-scribing tool per SAE J2634. The scribe should be as long as practical (recommended 100 mm) but must be least 40 mm long (the measuring length shall be at least 30 mm; no data is to be measured for the first 5 mm from the scribe ends). A laboratory scribing fixture as described in SAE J2634 should be utilized to make a straight scribe line. Scribes made free-hand will not allow acceptable gage repeatability and reproducibility measurements. On a machined wheel, the scribe should be made perpendicular to the machining lines.

Check the scribe with a multimeter for electrical continuity from end to end, to assure that the scribe has exposed the base metal. There must be electrical continuity down the full length of the scribe. If continuity is an issue anywhere along the scribe, a fresh scribe must be made. This may be done on the same sample if there is at least 20 mm separation from the old scribe and/or from a parallel edge. Electrical continuity is checked to assure that the scribe exposes the base metal. Particular care must be taken to scribe through multiple layers of paint.

NOTE: In some cases where multiple coatings are used, it may not be possible to scribe to the base metal. These coatings may be such that filiform is not a failure mechanism due to a robust coating and multiple coating layers and their thicknesses. If this occurs, then this is to be noted and the scribing data is to be provided demonstrating no penetration of the scribe to the base metal layer and the test disqualified.

4.4 Test Part Corrosion Inoculation

Place the scribed parts in CASS per ASTM B368-97 (2003)e1 such that the test surfaces are at an angle of approximately 45 degrees to the horizontal on a suitable nonmetallic rack. It is a good policy to photograph the parts at this stage to document which surface(s) are at appropriate test angles.

NOTE: The location of the test sample within the chamber may affect the repeatability of the test. Mapping of the test locations in the chamber is recommended to ensure consistent results. Measuring the weight loss on nickel panels at different locations within the chamber is recommended to verify the consistency of the corrosion within the chamber.

4.5 Exposure Conditions

Expose the parts 6 hours in the CASS cabinet as described in ASTM B368-97 (2003)e1. When the CASS exposure is near completion, prepare a container at least 5 gallons in size with a slow but constant flow of DI water that meets ASTM D1193 (Type 4).

4.6 Post-Inoculation Rinsing

Dip the test samples and the master test sample into deionized water that meets ASTM D1193 (Type 4). The parts should be dipped slowly in a vertical direction, slowly turned 90 degrees and back to the original position then removed using the same vertical direction. The dip should be for about 3 seconds. The objective is to remove only the excess CASS solution. The DI water should enter the bottom of the container to promote flushing of any contamination out of the container with the overflowing water. Flow rate should be dependent on the number of samples being dipped at one time. After approximately 25 samples (dipped one at a time) have been dipped, the water in the container shall be dumped prior to proceeding with the sample rinsing procedure.

4.7 Part Test

Place the parts directly into the humidity cabinet described in 4.1. Position the samples such that the droplets of moisture will run off of the part, approximately 45 degrees. Expose the test samples for a duration of 672 hours. Review and assess the growth of the filiform once every 168 hours to evaluate if there are any test anomalies. Check the filiform growth on the master test sample for consistency with that of the master test samples from prior test lots. The test samples must not be kept out of the humidity chamber for more than 15 minutes per measurement. Should the growth not be consistent or if there appear to be test anomalies, the test may be terminated, or the test set up and operating parameters can be assessed and adjusted to conform to the prescribed setting. Should this occur, the action taken must be noted in the comments section of the report.

4.8 Test Master Samples

Test master samples, which have been qualified as per SAE J2636 and have a known filiform growth, must be run with the test samples. The measurements taken on the test master samples must be consistent within the normal variation of the control limits. Periodically, but no less than twice per year, a master sample shall be run inside a cardboard box to evaluate the effect of chamber air flow on the master sample results. These results shall be added to the ongoing filiform control chart. Discrepancies in the results in the chamber and the cardboard box should be addressed in the continuous improvement process for the test procedure. Testing inside a cardboard box could be required in order to obtain acceptable proficiency test data.

5. FILIFORM EVALUATION

5.1 Post-Exposure Measurement and Data Reporting

Consult the customer's requirements for what types of data are required. Measure the corrosion on the master test sample as described in 6.1, at completion of the test duration. Enter the data into the data sheet; see Table 2 for the test master samples and determine if the sample performance is within the control limits established. If the sample is within the control limits, continue. If the sample is outside the control limits, the test is invalidated and corrective action may be required. Measure the data from the remaining test samples and record data on the data sheet.

5.2 Filiform Length Measurements

Linear measurements. Measurements shall be taken perpendicular to the scribe or the test edge and not at the angle from the scribe edge that the filiform corrosion may have grown. Measurements must be taken from the edge/scribe of the scribe to avoid including the scribe; see Figure 1. Record the data with two significant figures.

5.3 Filiform Length Data

Measure the longest filament from either side of the scribe/edge and record as maximum filiform length. After measuring the maximum filiform length, the data can be equalized with respect to the latest proficiency results. Record the result. All data must be clearly recorded as "raw" and "equalized."

5.4 Filament Distribution Data

Measure the length of each filament from either side of the scribe and record in a table of filament lengths. After measuring the filament lengths, equalize the data with the latest proficiency results based upon the maximum filament length measurement; see Figure 1. Record the results. All data must be clearly recorded as "raw" or "equalized." These data can be used to establish the statistical distribution of filament lengths for the part.

5.5 Filament Area Data

Area measurements can be done at the request of the customer. The total area in square millimeters of filiform corrosion as measured using an automated image analyzer or equivalent techniques, e.g., manual grid technique, perimeter, etc. If the area of the scribe is included in the measurement, as in the case of the image analyzer, it should be subtracted from the total area measurement (see Figure 4).

5.6 Acceptance Criteria

Consult the customer’s current acceptance specification for part performance and or internal specification for part performance.

5.7 Data Recording

Photograph the test parts and control samples within 96 hours to document the filiform at the end of test (filiform will continue to grow at room temperature). See example photographs in Figures 3 and 4. Any sample data not documented by photography or actual area and length measurements within 96 hours of completion of humidity exposure shall be considered void. Include a metric scale in the picture to permit the auditing of the results. The picture should be taken perpendicular to the surface and labeled with the sample ID or Master Test Number. The image is to be entered into the data sheet as a “jpg” file.

6. FILIFORM TEST MASTER SAMPLE

6.1 Master Samples

Master test samples (see Figure 5) are be included in every test to assure that the test conditions are operating within the limits to generate consistent test results. Refer to SAE J2636 for the method to establish and qualify test master samples. An overlap of the testing of old and new batches of master test samples is required to permit direct assessment of the batch-to-batch consistency of corrosion and variation within the batches. Control limits for the test master’s samples are to be calculated and maintained on an ongoing basis.

SAE J2636 also provides the method for establishing inter-laboratory comparisons and the method for establishing adjustment factors for laboratory data between laboratories. See Figure 5 for an example master sample panel.

7. PROFICIENCY REQUIREMENTS

Proficiency requirements for this test are defined in SAE J2636. SAE J2636 defines the method for qualifying a test master batch and for establishing inter-laboratory comparisons. The procedure defines a method for test data adjustment factors for comparison of data between laboratories.

Each laboratory must maintain correlation to another laboratory, either through cooperative round-robin testing or by utilization of industry standards. A method of utilizing proficiency results to “equalize” data should be documented. This methodology should be approved by the end user of the data. Refer to SAE J2636. The inter-laboratory comparisons are to be based on the maximum filament length measurements. Lab proficiency assessments are documented per Table 2. Data for area and frequency measurements may invalidate the results should they be outside of reasonable limits when compared to the Test Master performance.

Table 1 - Filiform testing best practices

Humidity Chambers - Best Practices
a. Start-up of a new chamber
b. Calibration of a chamber
c. Maintenance of a chamber

a. Initial Start Up

Upon receipt of a new test cabinet, it is recommended the cabinet interior be washed down with a 10% solution of HNO_3. This is to clean off oils and other contaminants from the interior surfaces. The cabinet interior should be constructed from stainless 304L or 316L grades. The preferred grade is 316L for higher corrosion resistance and, thus, longer cabinet life. The steam generator may contain a corrosion inhibitor. In case it does, metal filings can be used to condition the cabinet such that the corrosion inhibitor does not affect the long-term performance of the cabinet.

Seasoning of the interior cabinet could be necessary prior to before running parts or tests samples. The idea is to condition the interior environment so that it simulates the “equilibrium” conditions of long-term running of parts. Bare aluminum and steel samples should be placed into the cabinet and run for a period of time to “normalize” the environment. Exposing the parts to a salt spray environment before placing them into the chamber is recommended. This step might not be necessary for cabinets that have been used previously for corrosion testing. A caution is noted that if an electric humidity sensor is utilized in the cabinet, then seasoning with steel surfaces could lessen the life of the sensor. This should not affect a wet bulb-type system.

It is recommended that the temperature gage and humidity gages be ordered already calibrated to a NIST (National Institute of Standards and Testing) source.

The typical chamber has a vent. To maintain the internal conditions consistently, this vent needs to be kept closed to seal the cabinet. The measurement of the airflow within the chamber should be performed with the door closed. This is achieved using an anemometer. It is recommended that the anemometer not be a blade (vane) type. Use a probe type! The measurements need to be taken after the chamber has stabilized its internal conditions. This will vary by chamber size and make, but a minimum of 30 minutes is typical. The airflow throughout the chamber needs to be recorded. The operating range may vary from 20 to 80 ft/min. The airflow may be regulated several ways. One is to utilize a variable speed control on the fan motor. A second is to baffle the shelves within the chamber. It is typical for the top shelf in a large unit to be baffled and not used for test samples. The intent of the baffle is to diffuse the airflow and slow it down so that the airflow is more gradual.

The number of shelves and their placement can have an effect on the quantity of parts that can be tested and the calibration of the sample’s performance. The performance of each location needs to be assessed. The number of parts on test can have an effect on the airflow within the chamber also. This needs to be assessed also. An alarm for possible power loss during off hours, nights, and weekends is recommended. This can be audible and a light. A chart recorder that documents the humidity over time is recommended. Running the chamber for a minimum of 24 hours is recommended prior to any test work or setup.

b. Calibration-Correlation

Test masters are required to assess correlation and calibration analysis to be performed to assess a chambers performance versus others within the industry. When airflow is high, low filiform lengths are typical. It is recommended that samples be tested inside a cardboard box. The cardboard type is not critical, but it should not have any sealant on it. The box can be set up to cover the sample on the shelf with the box positioned over it upside down. An alternate is to place the sample in the box with the top not completely closed and not sealed closed. If samples test with longer filiform lengths inside the box, then airflow is above an incubation level and could be lowered to achieve better correlation. The scribing of samples should not be done with a free hand. Studies performed by this committee found this to be a significant source of variability. Refer to the scribing procedure SAE J2634 (see Figure 1).

Inoculation and rinsing of samples can have significant effects on correlation. Variables that should be controlled are: (1) the rinsing of the sample, (2) blocked nozzles, (3) chamber size, (4) sample positioning, (5) sample spacing, and (6) 45-degree angle placement, etc.

It is recommended to continuously run the CASS cabinet for stability. The solution does not need to be running when there are no samples in the cabinet. The liner condition and temperature need to be monitored as these can highlight maintenance issues. If the CASS solution is not within the required range, it is recommended to make a new solution.

Nickel panels are used as a method to assess calibration. It is recommended that panels that have been calibrated in another setup or at another time be used for first-time setups of cabinets.

c. Maintenance

The fan impeller is an item that often requires replacement due to corrosion on certain cabinet models. Possible solutions such as plastic or stainless impellers may help. Replacement within 6 months is not atypical. A noise or vibration from the unit is typically an indication that the impeller is about to expire. The blower motor is another component that sometimes requires replacement. The operator should closely monitor the quality of the seals on the doors. The chambers must maintain an “Incubation” environment with low air flow. The seals can be ineffective even if the door is out of adjustment. Sometimes the seals harden over time and become ineffective. Replacement of the seal is recommended if this occurs. Leaks from the seals can be detected by condensation around the door. Another indication of a bad seal is when you can feel airflow around the door when the blower is running. Another method is to utilize a smoke bomb to trace leaks in the seals to all the locations. Shielding the test sample from the air flow can be done by placing the part into a cardboard box. If a part is tested inside and outside of a cardboard box, differences in the end results could be an indication of an air flow issue.

The vent may not seal if it is corroded. It might be necessary to block or permanently seal the vent. The humidity and temperature gages and the condition of the sensors should be checked regularly. It is recommended that the actual conditions in the chamber be checked rather than always relying on the controller.

Review the work instructions and confirm the operator is qualified and approved to conduct the test. Operator training and or an audit of another labs testing may contribute to training and or continuous improvement of the testing. Sometimes the heater elements of the unit may need attention. Draining the unit and refilling can help extend the unit life and stability of the test conditions. It is not recommended that the interior of the cabinets be cleaned. This could disturb the test chamber conditions. Cleaning should be restricted to removing loose pieces and debris.

8. NOTES

8.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

Table 2 - Filiform proficiency data sheet updated adding calculations for area and frequency assessments (filiform master SAE J2635 form.xls)

SAE J 2635, Filiform Proficiency Test Data 2017 Master Panel

Laboratory Identification		ecification Number :	SAE J 2635	pecification Revision Level :	
Test Apparatus Identification :		ecification Number :		pecification Revision Level :	
Test Operator :		Test Purpose :	Proficiency Test	Test Part Description :	Master Panel
Test Master Description:					
Reference Laboratory Name & Location:	Various				
Comments, Remarks :					

Laboratory Data For Comparison									Reference Laboratory Data						
Master Lot #	Master Test Date			Master Paint Total Film Thickness mils	Master Measured Maximum Length Scribe (mm)	Filament frequency within 30 mm length # of filaments per 30mm length	Filiform area within 30 mm length area mm²	Master Reference photo - jpg name	Master Lot #	Master Test Date		Master Paint Total Film Thickness mils	Master Measured Maximum Length Scribe (mm)	Filament frequency within 30 mm length # of filaments per 30mm length	Filiform area within 30 mm length area mm²
SAE 2017					2.2	31.0	101.0		SAE 2017	6/1/3017	1L	2.3	3.0	32.0	103.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	1R	2.3	3.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	2L	2.76	2.5	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	2R	2.76	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	3L	2.48	3.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	3R	2.48	3.5	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	4L	2.35	2.5	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	4R	2.35	3.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	5L	2.1	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	6/1/3017	5R	2.1	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	1L	≈65-92 μm	2.2	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	1R	"	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	2L	≈53-62 μm	2.4	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	2R	"	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	3L	≈52-58 μm	2.4	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	3R	"	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	4L	≈55-60 μm	1.9	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	4R	"	1.5	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	5L	≈58-63 μm	2.7	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	5R	"	1.9	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	1L	≈52-61 μm	1.9	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	1R	"	2.1	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	2L	≈58-60 μm	1.4	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	2R	"	1.4	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	3L	[illegible]	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	3R	"	2.0	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	4L	≈47-63 μm	1.9	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	4R	"	2.2	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	5L	≈55-58 μm	2.1	30.0	101.0
SAE 2017					2.0	30.0	100.0		SAE 2017	2017/3/29	5R	"	2.0	30.0	101.0

Master Proficiency Analysis			
Comparison Lab Samples, n =	30	Reference Lab Samples, n =	30
Proficiency Assessment for **Length** Measurement			
Standard Deviation	0.04	Standard Deviation	0.50
Average Length Comparison -	2.01	Average Length Reference -	2.22
Comparison Master UCL -	2.08	Reference Master UCL-	3.22
Comparison Master LCL -	1.93	Reference Master LCL -	1.22
Comparison Laboratory Adjustment Factor			1.1
E_n =	-0.42	Z score =	-0.42
Proficiency Assessment for **Frequency** Measurement			
Standard Deviation	0.18	Standard Deviation	0.37
Average Frequency Comparison	30.03	Average Frequency	30.07
Comparison Master UCL -	30.40	Reference Master UCL-	30.80
Comparison Master LCL -	-29.67	Reference Master LCL -	-29.34
Comparison Laboratory Adjustment Factor =			1.0
E_n =	-0.08	Z score =	-0.09
Proficiency Assessment for **Area** Measurement			
Standard Deviation	0.18	Standard Deviation	0.37
Average Area Comparison -	30.03	Average Area Reference -	30.07
Comparison Master UCL -	30.40	Reference Master UCL-	30.80
Comparison Master LCL -	-29.67	Reference Master LCL -	-29.34
Comparison Laboratory Adjustment Factor =			1.0
E_n =	-0.08	Z score =	-0.09
En =		$\lvert E_n \rvert \le 1$ =	
		$\lvert E_n \rvert > 1$ =	
Z score =		$\lvert Z \rvert \le 2$ = satisfactory	
		$2 < \lvert Z \rvert < 3$ = questionable	
		$\lvert Z \rvert \ge 3$ = unsatisfactory	
Inter-Laboratory Proficiency is based on Filament Length			
Proficiency assessment is based on :	Z Score		
Proficiency is rated as :	$\lvert E_n \rvert \le 1$ = satisfactory		
The range for Adjustment Factors is limited to 0.5-1.5			
AREA CALIBRATION MEASUREMENT OF THE MASTER PANEL WHEN USING IMAGE ANLAYSIS			
Master area =		Area measured using Image analysis	
Measurng Error=		Measuring area error <10% is acceptable	
Test Panel used for calibation		Date of Calibartion	

Operator Approv	Date² :	Reviewed & Approved By :	Date² :

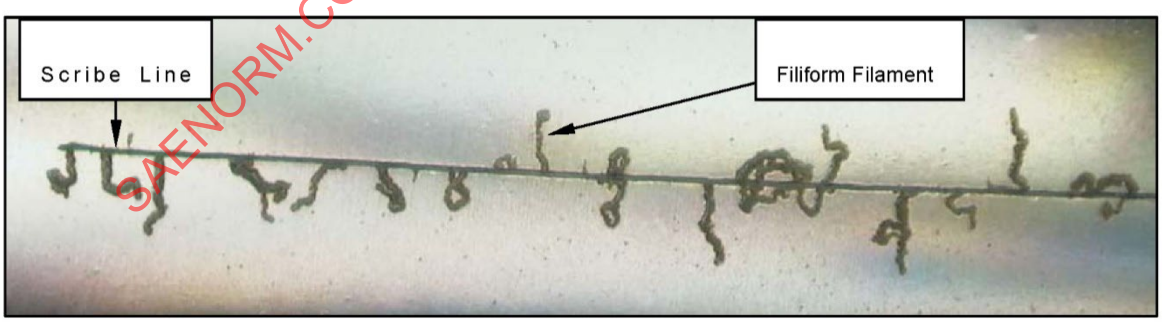

Figure 1 - Filiform corrosion test sample

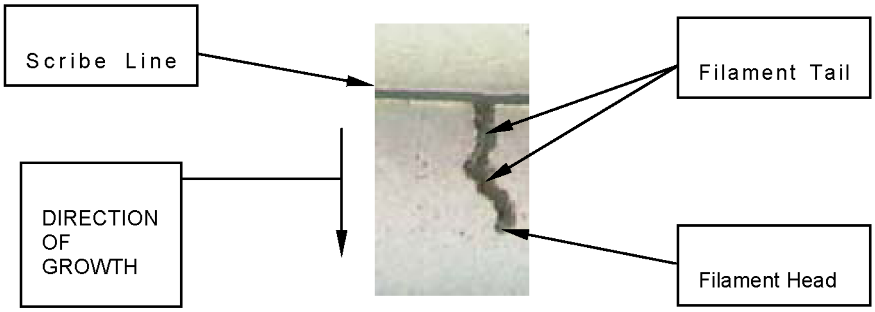

Figure 2 - Filiform corrosion, individual filament detail

Example filiform corrosion on an aluminum wheel spoke section. The section has been scribed.

Figure 3 - Filiform corrosion, test sample example