



Materials System Specification

09-SAMSS-107

22 May 2011

Qualification Requirements and Application
of Composite Fluoropolymer/Ceramic Coatings to Fasteners

Document Responsibility: Paints and Coatings Standards Committee

Saudi Aramco DeskTop Standards

Table of Contents

1	Scope.....	2
2	Conflicts and Deviations.....	2
3	References.....	2
4	Definitions.....	3
5	Processing Requirements.....	4
6	Coating Inspection and Testing.....	6
7	Inspection Responsibility.....	9
8	Handling, Storage and Preparation for Shipment.....	9
	Appendix A – Qualification Procedure for Initial Product/Coating Applicator Approval...	10

Previous Issue: 10 April 2011 Next Planned Update: 10 April 2016

Revised paragraphs are indicated in the right margin

Primary contact: [Mansour, Mana Hamad](#) on +966-3-8760264

Page 1 of 11

1 Scope

This Specification defines the minimum mandatory requirements for the shop application of Composite Fluoropolymer/Ceramic Coatings to threaded steel and stainless steel fasteners. This specification does not cover the requirements for the uncoated fasteners.

Commentary Note:

Fasteners are not characterized except as incidental to the application and evaluation of these coatings. It is presupposed that the fasteners to which these coatings are applied will be in compliance with applicable specifications and suitable for their intended use, and that thread tolerances are appropriate for subsequent coating.

2 Conflicts and Deviations

- 2.1 Any conflicts between this specification and other applicable Saudi Aramco Materials System Specifications (SAMSSs), Engineering Standards (SAESs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this specification in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

The selection and application of coatings covered by this specification shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*

Saudi Aramco Inspection Requirement

Form [175-092100](#)

*Application of Composite Fluoropolymer/Ceramic
Coatings to Fasteners*

Saudi Aramco Packing Specification

AS 8314-03 Packing Specification

SAMS Catalog description for the fasteners to be coated.

3.2 Industry Codes and Standards

Swedish Standards Institute

*SIS 05 59 00 Sa3 Pictorial Surface Preparation Standard for
Painting Steel Surfaces*

The Society for Protective Coatings

*SSPC SP5 Surface Preparation Specification Number White
Metal Blast Cleaning*

SSPC PA2 Measuring Dry Film Thickness

British Standards Institution

*BS 3900 Methods of Test for Paints Part E-6:
Cross-Cut Test (ISO 2409: 1992)*

American Society for Testing and Materials

ASTM B117 Standard Method of Salt Spray Testing

ASTM D512 Tests for Chloride Ion in Water and Waste Water

ASTM D516 Tests for Sulfate Ion in Water and Waste Water

4 Definitions

Responsible Unit Supervisor (RUS): The supervisor of Non-Metallic & Protective Coatings Unit who is designated by the Manager, Consulting Services Department in accordance with Material Supply Organization's instruction MI-350.020.

Saudi Aramco Inspector: The person or persons designated by the Saudi Aramco Inspection Department to inspect, monitor, and enforce the contract.

Vendor (Coating Applicator): The company responsible for the actual application of the coating.

Vendor's Inspector: The person or persons designated by the Vendor (Coating Applicator) to carry out the inspection duties required by this specification.

Manufacturer: The company which manufactures the required coatings.

5 Processing Requirements

5.1 Handling/Cleaning/Degreasing

5.1.1 Proper equipment for unloading, handling, and temporary storage of bare fasteners shall be used to avoid damaging them.

5.1.2 The substrate shall be thoroughly cleaned to remove all traces of grease and oil using a bake-out at 380-400°C for a minimum of 3 hours or a suitable degreasing system. Minimum requirements for degreasing shall be either hot alkali degreaser plus water wash, or chlorinated hydrocarbon solvent.

5.1.3 Acid pickling is not permissible as a cleaning method.

5.2 Abrasive Cleaning

After cleaning/degreasing, all fasteners shall be tumbled or dry blasted with a suitable media to ensure a clean, scale-free, chemically active surface. Minimum requirement is SIS 05 59 00 Sa3 quality (or SSPC SP5). Thread damage is not allowed.

5.2.1 Abrasive shall be chilled iron grit, aluminum oxide, garnet, or approved equal, sufficient to produce a minimum 5 micron surface profile.

5.2.2 The abrasive shall be clean and dry. It shall contain less than 50 ppm sulfates and less than 50 ppm chlorides when tested in accordance with ASTM D516, method B and ASTM D512 method A respectively. The Coating Applicator shall keep a record of the chemical analyses of all batches of abrasives used, verifying that these limits are not exceeded.

5.2.3 Subsequent processing shall be carried out before surface rusting begins to occur and in any case within two hours of abrasive cleaning.

5.3 Post-Cleaning

After abrasive cleaning, all fasteners shall be cleaned to remove traces of debris and dust prior to subsequent processing. Acceptable methods are air blast (using clean dry air), and/or solvent wash and dry.

5.4 Application of Composite Fluoropolymer/Ceramic Coating

All fasteners shall be coated with a suitable grade of composite fluoropolymer / ceramic coating to the following requirements:

5.4.1 Choice of Coating Material

See Appendix "A" for qualification of:

5.4.1.1 All coating materials shall be marked with the following information:

- a) The manufacturer's name.
- b) The material identification number.
- c) The batch number.
- d) Date of manufacturer.
- e) Product description
- f) Location of manufacturer
- g) The shelf life and storage temperature limits.

5.4.1.2 Coating materials shall be stored and handled in accordance with the coating manufacturer's recommendations, a copy of which shall be available for review by the Saudi Aramco Inspector.

5.4.1.3 Coating and surface preparation shall be allowed to proceed only when the surface temperature of the fastener is at least 3°C above the dew point

5.4.2 Number and Thickness of Coats

The primer shall be applied in one coat to a dry film thickness (DFT) of 20 to 30 microns.

The finish coat shall be applied to a DFT of 10 to 15 microns.

The total DFT shall be between 30 and 45 microns. (In the event that this range is more tightly limited by fit tolerance considerations, the acceptable range shall be agreed upon in writing prior to coating the fasteners).

5.4.3 Curing Cycles

Curing cycles shall be in accordance with the Manufacturer's Product Data Sheets, copies of which shall be available for review by the Saudi Aramco Inspector.

5.4.4 Determination of Metal Temperature

5.4.4.1 The temperatures in the curing cycles in paragraph 5.4.3 refer to metal temperature, not oven air temperature.

- 5.4.4.2 In order to ensure adequate cure, frequent metal temperature measurement checks must be carried out. At least one fastener per coating batch shall be checked.
- 5.4.4.3 A thermocouple shall be attached to the fastener in the batch either by drilling and inserting into the fastener, by clamping to the fastener, or by firmly attaching to an uncoated fastener of the same size and mass as those in the batch with heat resistant Kapton adhesive tape or equivalent.
- 5.4.4.4 Surface temperature of the metal shall be determined using an independent meter connected to the thermocouple to verify that the monitored fastener achieves the cure specified above.
- 5.4.4.5 In no case shall threaded steel fasteners be exposed to temperatures in excess of 400°C during any part of processing.

6 Coating Inspection and Testing

Fasteners coated to this specification are subject to verification by the Saudi Aramco Inspector per Saudi Aramco Inspection Requirement Form [175-092100](#), "Application of Composite Fluoropolymer/Ceramic Coatings to Fasteners", a copy of which shall be included with the purchase order. The Saudi Aramco Inspector may require at any time that the coating applicator prepare a set of test specimens as defined in Appendix A. These shall then be submitted to R&D Center or a third-party laboratory agreeable to Saudi Aramco and the payment charged to the vendor.

6.1 Non-Destructive Testing

Random samples of fasteners shall be taken from the production batch according to the sampling frequency designated in 6.1.1 below, and subjected to the non-destructive tests described in 6.1.2 to 6.1.5 below.

6.1.1 Sampling Frequency

Random sampling for non-destructive testing shall be carried out in accordance with the Table 1.

Table 1 – Sampling Frequency

Batch Size	Sample Size	Maximum Number of Rejects
2 Through 8	2	0
9 Through 15	3	0
16 Through 25	5	0
26 Through 50	8	0

51	Through	90	13	0
91	Through	150	20	0
151	Through	280	32	0
281	Through	500	50	0
501	Through	1200	80	1
1201	Through	3200	125	2
3201	Through	10000	200	3
10001	Through	35000	315	5
35001	Through	150000	500	7

If the maximum number of rejects exceeds the specified amount, two additional random samples, each of the original size, shall be pulled from the same batches in which failures occurred. The tests shall be re-run, each with the same accept/reject criteria.

If both the retest results are within acceptable limits, the defective pieces shall be removed and the rest of the batch is acceptable.

Should the reject rate from either retest of this same batch once again fall outside of the above set limits, the batch shall be rejected. It must either be reprocessed completely or each individual piece in the batch can be tested and accepted/rejected on a piece-by-piece basis. In addition, dual samples shall be tested on the next five batches produced.

If the test results from all five batches are all within acceptable limits, the sampling plan may return to normal. If any of the next five batches fail, production shall be stopped and the Saudi Aramco Inspector shall be notified. Production shall not resume until the Vendor can demonstrate that he has identified and corrected the problem.

6.1.2 Fit

Coated fasteners, including nuts, shall be a running fit. After coating, the dimensional characteristics of the bolt and nut must still be within the limits in the threads' governing specification. The finished fasteners shall allow installation of the nut without undue force or resultant damage of the coating. In cases where Saudi Aramco furnishes fasteners, the applicator retains the right to judge whether or not the thread tolerance is sufficient for coating. If judged unsuitable for coating, the Saudi Aramco organization placing the order shall be contacted for written instructions prior to proceeding.

6.1.3 Visual Inspection

Coated fasteners, including the interior surfaces of nuts, shall be visually

inspected for pinholes, runs, sags, blisters, foreign particles, or any other defects that could impair service performance. Any fasteners found to be defective shall be rejected.

6.1.4 Dry Film Thickness

Dry film coating thickness on flat surfaces shall be determined using a properly calibrated eddy current type coating thickness gauge that meets the requirements of SSPC PA2. Readings must be taken at the start and every hour during production.

6.1.5 Cure Test

The test shall be carried out to ensure that adequate cure (cross-linking) of the coating has been achieved.

The vendor shall propose a method to check the curing, which will be evaluated and approved for use by the RUS.

In the case of any fastener being found under cured, all fasteners in that batch shall be re-cured according to the recommended appropriate cure schedule in paragraphs 5.4.3 through 5.4.4.4 above and retested for cure.

Other coating manufacturers, who have an alternative cure test, must submit it to the RUS, whose written approval is required before the Coating Applicator can supply coated fasteners per this specification.

6.2 Adhesion Testing

6.2.1 For the adhesion test, one fastener shall be taken from each of two different batches in a production day, one in the morning and one in the late afternoon. If only one batch is run on any day, then one sample fastener from that batch is sufficient.

6.2.2 Coating shall pass the crosshatch and adhesive tape test according to BS 3900 or approved equal. It is preferable to conduct this test on actual fastener specimens when possible. If however, this is not possible, (as in the case with fasteners which are too small to have sufficient surface area on which to carry out the tests) a test panel of approximately the same total mass as that of the fasteners being coated, and which has undergone all processing along with the fasteners, may be used.

6.2.3 If any of the samples fail the adhesion test, the adhesion test shall be re-run on each of the affected batches (plus any batches that were coated that day but not previously tested for adhesion) using two fasteners from each batch. If all the fasteners pass the re-test, all the batches shall be

acceptable. If any of the re-tests fail, all the fasteners coated that day shall be set aside until the cause of the failures is identified and corrected to the satisfaction of the Saudi Aramco Inspector. Any eventual acceptance of fasteners coated on that day shall be on a batch-by-batch basis. In cases of disagreement between the manufacturer and the Inspector, the RUS shall determine whether the causes of failure have been properly identified and the appropriate corrective actions have been taken.

7 Inspection Responsibility

- 7.1 The coating applicator shall be responsible for all quality control checking and shall keep records on the results of all such inspection in a form suitable to Saudi Aramco. Only properly calibrated equipment shall be used.
- 7.2 The Saudi Aramco Inspector shall have access to each part of the process, and shall have the right and opportunity to monitor/witness any of the quality control tests.

8 Handling, Storage and Preparation for Shipment

- 8.1 Individual coated fasteners shall be placed inside an expanded polyethylene mesh sleeve (or shall have the threads protected by molded, plastic sleeves) and packaged in separated layers in strong cardboard cartons. Should Saudi Aramco find these boxes to be inadequate, then the fasteners shall be required to be packed in wooden boxes as per Saudi Aramco Packing Specification AS 8314-03.
- 8.2 Each box shall be identified by attaching inside the original mill tag (if available) for threaded steel fasteners. A coating applicator's label that fully identifies the following shall be attached on the outside of the box:
 - a) Saudi Aramco
 - b) Purchase Order Number
 - c) Stock number and item description
 - d) DPC number
 - e) Type of coating applied, date coated, and coating applicators name

Revision Summary

- 10 April 2011 Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor changes.
 - 22 May 2011 Editorial revision to change the document primary contact.
-

Appendix A – Qualification Procedure for Initial Product/Coating Applicator Approval

A1 General Requirements

- A1.1 In order to qualify a coating material and/or a potential Coating Applicator as acceptable under this Specification, the applicator of the coating material must submit the following certification in writing to the Responsible Unit Supervisor (RUS).
- a) Certification from an independent testing laboratory that they witnessed or performed the preparation and testing of the samples, and that all procedures were in accordance with this qualification procedure.
 - b) Certification by the Coating Applicator that the proposed coating has passed all the tests and met all the requirements of this qualification procedure.
 - c) A record of all test results.
- A1.2 Any and all initial qualification tests shall be carried out at no cost to Saudi Aramco. The RUS shall decide if the data presented by the Coating Applicator satisfy the requirements of the tests outlined below. Additional testing, including but not necessarily limited to full exposure tests in actual service conditions, may be required at the discretion of the RUS.
- A1.3 As part of the procedure for qualifying Coating Applicators, a written coating procedure must be prepared and submitted to the RUS for approval.

A2 Qualification Test Requirements

A2.1 Non-Destructive Tests

Ten randomly selected, coated fastener assemblies (two nuts, one washer, and one bolt per assembly) shall be tested in accordance with the following paragraphs in this specification 6.1.2 Fit, 6.1.3 Visual Inspection, 6.1.4 Dry Film Thickness, 6.1.5 Cure Test. The test assemblies shall come from at least two process batches.

A2.2 Destructive Testing

Five of the assemblies in A2.1 shall be tested and evaluated in accordance with paragraph 6.2 Adhesion Tests and five of them shall be tested and evaluated for salt spray resistance.

- A2.2.1 The salt spray test samples shall be chosen by the RUS and shall consist of a minimum of four fasteners coated in four different batches. Preferably, the earliest and the latest batches should be separated by two months or more.
- A2.2.2 Sample coated fasteners shall be subjected to ASTM B117 “Standard Method of Salt Spray Testing” at 95°F. The test specimen shall be a 4 inch long stud bolt with a UNC thread, with two nuts attached and tightened together (torque to 10 foot-pounds), separated by a coated washer that is positioned in the center of the threaded area of the bolt.
- A.2.2.3 The required test duration shall be 3000 hours. At the completion of the test, the test specimen shall be rinsed in potable water to remove salt deposits from the surface, and thoroughly dried. After de-clamping, there shall be no intercoat delamination, no visible (zero) corrosion on threads, the nuts or under the nuts, and the nuts shall turn easily over the entire threaded area of the bolt with no coating loss.
- A.2.2.4 If any of the samples fail the salt spray test, all locatable batches of fasteners coated on that day or later shall be segregated. Re-tests/additional tests shall be performed on duplicate samples from (a) each of the failed batches (b) samples from the most recent batch produced and (c) sufficient other batches produced in the interim so that the scope of the problem can be determined.

If all the retests/additional tests pass, all the batches shall be released. If any of the retests/additional tests fail, the RUS shall withdraw approval and request Standardization to take the appropriate action to place the manufacturer on hold. No additional purchases of coated fasteners shall be made until the problem has been completely identified and corrected to the satisfaction of the RUS, including (at his discretion) complete requalification of the coating.

A2.3 Continuing Qualification Requirement

For an approved Coating Applicator to maintain his approved status, he shall demonstrate at least once per year (and typically, not more than twice per year) that his fastener coatings meet or exceed the requirements of the tests set out in A2.2.1 through A2.2.4 above. The RUS shall determine when these retests shall be required.