SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS7109/5

REV. A

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Superseding AS7109/5

(R) Nadcap
Requirements for Coating Evaluation Laboratory Practices

1. SCOPE:

This SAE Aerospace Standard (AS) is to be used as a supplement to AS7109. In addition to the requirements contained in AS7109, the requirements contained herein shall apply to suppliers seeking Nadcap Coatings accreditation who are engaged in evaluation of coatings. Suppliers accredited to AS7101 that perform evaluations of coating shall demonstrate compliance to the applicable portions of the Standard as described in the Nadcap Auditor Handbook.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this standard to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Telephone: (724) 776-4841, Web address: http://www.sae.org.

AS7101	Nadcap - Requirements for Materials Testing Laboratories
AS7109	Nadcap - Requirements for Coatings
AMS 2750	Pyrometry

TO PLACE A DOCUMENT ORDER:
Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

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2.2 PRI Publications:

Available from PRI, 161 Thornhill Road, Warrendale, PA 15086-7527, Telephone: (724) 772-1616, Web address: http://www.pri.sae.org.

AC7101/4	Nadcap - Audit Criteria for Materials Testing Laboratories - Metallography and Microhardness
AC7101/5	Nadcap - Audit Criteria for Materials Testing Laboratories - Hardness
AC7109/5	Nadcap - Audit Criteria for Coating Evaluation Laboratory Practices

2.3 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, Telephone: (610) 832-9585, Web address: http://www.astm.org.

ASTM C 633	Standard Test Method for Adhesion or Cohesion Strength of Thermal Spray Coatings
ASTM E 4	Standard Practices for Force Verification of Testing Machines
ASTM E 1012	Standard Practice for Verification of Specimen Alignment Under Tensile Loading

3. PERSONNEL:

3.1 There shall be a training program for coatings evaluation personnel.

3.2 The supplier shall have the necessary trained personnel to perform the required tests: minimum of two laboratory personnel or one laboratory person with a subtiered laboratory Nadcap accredited to AS7109/5 or equivalent as approved by Nadcap Coatings Task Group, identified for coating evaluation in the absence of the laboratory person.

3.3 Personnel certification shall meet customer requirements.

4. PROCEDURES:

4.1 The supplier shall have the necessary procedures to perform the required tests.

4.2 The laboratory procedures shall be approved by the customer (and prime) if required.

4.3 Replaced tests, invalidated tests, nonconforming tests, and re-tests shall be logged and cross indexed, including explanations.

4.4 There shall be a policy/procedure for replacement testing and re-testing of failed or questionable samples including specific criteria.

4.5 Test result invalidation shall be permitted only when authorized (i.e., specification, contract, purchase order, etc.).

4.6 Provisions for replacement testing and re-testing shall comply with customer requirements.

5. EQUIPMENT AND FACILITIES:

5.1 The supplier shall have the necessary functional equipment and facilities to perform the required tests.

5.2 The testing environment shall be suitable for evaluations performed (i.e., external factors that can adversely affect test results).

6. ROUND ROBIN PROGRAMS:

6.1 The suppliers shall have an internal Round Robin plan that covers each coating family (as defined in Table 1 of AC7109/5), testing procedure, testing personnel, preparation personnel, preparation equipment, and testing equipment at least once every three years.

6.1.1 The Round Robin plan shall include all personnel who are certified to prepare and evaluate coatings for Nadcap accepting/mandating customers.

NOTE: If all personnel are not certified, then a system shall be in place that segregates the preparation and evaluation of hardware.

6.1.2 There shall be a separate Round Robin for each coating family (per Table 1 of AC7109/5) evaluated. If separate evaluation procedures are required for the “same” coating (e.g., different customers requiring different evaluation procedures), then each subsequent Round Robin shall use a different procedure.

6.1.3 All specimens of each coating family for the Round Robin shall be coated during the same coating run.

6.1.4 The Round Robin procedure shall define acceptance criteria of personnel participating.

6.1.5 All Round Robin test results are recorded and maintained for a minimum of four years.

6.1.6 The Round Robin results are used to identify and correct problems, and/or to initiate changes in testing methods or practices.

6.1.7 The Round Robin shall be conducted at a minimum of annually.

6.2 The laboratory shall participate in an external Round Robin program, if required by contract.

6.3 The laboratory shall participate in an external Round Robin program, if there is only one laboratory person.

7. HARDNESS TESTING:

7.1 If the supplier performs hardness/macrohardness testing, the applicable portions of PRI AC7101/5 shall be executed (reference Auditor Handbook for guidance) or the supplier shall be Nadcap accredited to AS7101.

7.2 If the supplier performs microhardness testing, the applicable portions of PRI AC7101/4 shall be executed (reference Auditor Handbook for guidance) or the supplier shall be Nadcap accredited to AS7101.

7.2.1 If values are calculated manually, conversion charts shall be available for all combinations of load and varied calibrated reticles.

7.2.2 The conversion shall be based upon millimeter or filar length.

7.2.3 There shall be procedures to indicate how the data are to be reported.

7.2.4 If indentations are found to be unacceptable, there shall be criteria to judge the impressions and the number of new indentations shall be defined.

7.2.5 Do the procedures for microhardness evaluation reflect the specification requirements for number and pattern of indentations?

8. METALLOGRAPHY AND THICKNESS:

8.1 Metallographic Preparation:

8.1.1 Calibration:

8.1.1.1 Filar eye-pieces used for dimensional measurement shall be calibrated against calibrated stage micrometers and calibrations shall be documented.

8.2 Standards:

8.2.1 Required metallographic comparison standards shall be convenient to the operator.

8.2.2 Photo standards shall be clear and legible or as provided by customer?

8.2.3 The lab shall maintain materials or specimens for operator training in preparation and interpretation.

NOTE: Coating samples from a round robin or other sources can be used.

8.2.4 When standards are not established by specification or part supplier, initial or supplemental standards shall be issued by the lab at the time the evaluation is performed.

8.3 General:

8.3.1 There shall be a procedure that covers metallographic preparation.

8.3.2 The following areas shall be covered in detail:

a. Sectioning.

b. Mounting.

c. Grinding and Polishing.

8.3.3 The sectioning procedure shall cover the following and there shall be reference to these parameters for specific coating types/families:

a. Wheel type, hardness, thickness, bonding, etc.

b. That coating shall be kept in compression as much as possible to reduce spalling delamination.

c. Use of coolant in cutting to reduce heat/damage.

d. Stipulation of pressure used.

e. 'Special' fixtures used for cut up of intricate parts when required.

f. Specimen sectioned per customer specification requirements.

8.3.4 The mounting procedure shall cover the following and there shall be reference to these parameters:

a. Proper cleaning of specimens before mounting.

b. The use of mounting materials in hot mount, cold mount, epoxies, etc.

c. Detailed steps in either using mounting equipment or mixing of epoxies, etc.

d. If heat, pressure or cooling is used in curing mounting material, appropriate controls shall be in place and followed.

e. If mixing is involved, appropriate controls shall be in place to assure preciseness of measuring the components for the mixture.

f. For vacuum or pressure impregnation, system variables, (vacuum, pressure, heat, etc.) shall be controlled and detailed to achieve consistent results.

8.3.5 The grinding/polishing procedures shall cover the following and there shall be references to these parameters.

a. Orientation of mounts in holder to achieve compression of coating against substrate during grinding/polishing.

NOTE: This may not be possible if coating is applied to both sides of the mounted section or if auto polishing is used.

b. Detailed step by step procedures for operation of the equipment.

c. Complimentary versus counter rotation of the head versus table noted in the procedure.

d. A minimum amount of metal removal noted for sample preparation.

e. This minimum amount of metal removal shall be periodically measured. (minimum frequency of once per month)

f. Pressure and rotational speeds noted and listed as important parameters.

g. The amount of lubricant applied shall be monitored (i.e., the frequency of application).

h. Monitoring of the amount of abrasive applied (i.e., the frequency of application).

i. Times fixed in the grinding steps for use of abrasive papers and the number of papers required.

8.3.5 (Continued):

j. If discs or abrasive wheels, etc. are used for material removal, criteria established for dressing of wheel and disposal after so many uses.

k. Varied polishing cloths dedicated to certain abrasive/lubricant combinations (prevent mixing).

l. If abrasive systems/slurries are mixed by the company, there shall be a procedure covering mixing proportions or dilution of premixed compounds.

8.4 Microscope Capabilities:

8.4.1 The microscope design shall facilitate interchange of magnification without moving the specimen which is to be examined (e.g., lenses in turret, preferably the same nominal focus).

8.4.2 The microscope design shall be sufficient for evaluation of aerospace coatings (e.g., adjustable light intensity, light filtration, etc.)

8.5 Metallographic Interpretation: General:

8.5.1 There shall be training/reference documents that clearly define coating features.

8.5.2 The technician shall examine the quality of the sample preparation before evaluation.

8.5.3 There shall be rules that cover the following:

a. Retesting/repolishing for metallography preparation-induced flaws.

b. A definition of flaws that may not be metallographically induced and no repolish is allowed.

8.6 Metallographic Interpretation: Part/Coatings Specific:

8.6.1 There shall be a procedure available which lists criteria for evaluation and the steps required for all coatings.

8.6.2 The procedure shall list the following:

a. Magnification required.

b. Specific area to be evaluated.

c. Acceptance criteria - predominant, minimum, maximum, photo standards, etc.

d. Data to be recorded.

8.6.3 The above shall comply with applicable customer requirements.

8.6.4 Required documents shall be easily accessible for the specific part, not difficult to locate, clear and concise.

8.6.5 If standards such as photos are used in the evaluation, there shall be system that controls the standards.

8.7 Metallographic Thickness Measurement:

8.7.1 There shall be guidelines for the measurement of coating thickness using the microscope.

8.7.2 The magnification shall be specified.

8.7.3 The method shall cover the following (as required by customer):

a. Average values.

b. Maximum versus minimum.

c. Predominant versus individual.

d. Only the high peaks.

e. Percentage of areas required.

8.7.4 The areas of required measurement shall be defined and areas not evaluated shall be identified, if required by the customer.

8.7.5 The number of measurements shall be specified.

8.8 Mechanical Thickness Measurement:

8.8.1 There shall be guidelines for measurement of coating thickness by mechanical means.

8.8.2 The methods shall be described:

8.8.3 The frequency of measurement shall be specified.

8.9 Photography:

8.9.1 Procedures shall be in place to verify that the photography represents the magnification indicated by the microscope.

8.10 Oxidation Layers:

8.10.1 Specimen preparation procedures shall ensure definition of surface layers to be evaluated.

8.10.2 Procedures shall specify whether examination is to be done in the etched and/or unetched condition.

8.10.3 Initial examination shall be done in the unetched condition. (Preferential etch attack may remove affected surface layer.)

8.10.4 Procedures shall cover selection of the specimen area(s) to be evaluated.

a. Surfaces shall be scanned at low magnification to locate areas of maximum attack; and these areas shall be examined at the required magnification.

b. Areas shall be selected at random for examination at the required magnification.

8.10.5 Procedures shall cover measurement technique(s) for oxidation/corrosion.

a. Report absolute maximum depth (affected surface to unaffected substrate) at any point.

b. Compare to photo standards.

8.11 Metallographic Test Report/Record:

8.11.1 In addition, to information required by the applicable specifications, the test report or record shall include the following:

a. Magnification used.

b. Specimen identification.

c. Recording of variable data.

d. Reference to established requirements (e.g., specification microstructure levels).

e. Disposition of recorded results.

f. Identity of individual performing and/or reporting test results.

9. MECHANICAL TESTING:

9.1 Document and Data Control:

9.1.1 The lab shall have copies of the most current revision of applicable testing specs and standards, including tensile and bend.

9.2 Calibration:

9.2.1 Load cells shall be calibrated annually (method of calibration per ASTM E 4 or other equivalent standard).

9.2.2 Alignment shall be performed after installation (per ASTM E 1012 or other equivalent standard) and when alignment is suspect (e.g., due to deterioration of test results).

10. CURING OF SPECIMENS:

10.1 Facilities and Equipment:

10.1.1 Furnaces/ovens shall be equipped with over-temperature sensors and recorders.

10.1.2 Furnaces/ovens shall be equipped with time/temperature recorders.

10.2 Thermocouples:

10.2.1 There shall be evidence that thermocouples which are in use are calibrated.

10.2.2 T/C shall be in intimate contact with specimen or fixture.

10.3 Furnace Calibration:

10.3.1 Calibration and maintenance records shall be available.

10.3.2 There shall be evidence of furnace calibration, including next survey date.

10.3.3 Temperature uniformity surveys shall be performed as appropriate in accordance with AMS 2750 or equivalent standard. (Surveys are required even though thermocouple is in intimate contact with speciment/fixture.)

10.3.4 Temperature uniformity in the working zone shall be ±25 °F (±14 °C).

10.4 Curing/Bonding Cycle:

10.4.1 Cure times and temperatures shall be specified with tolerances in procedures.

10.4.2 Cycle time shall be measured from the time the sample reaches the required temperature.

10.4.3 The lab shall have a procedure for determining cycle time (e.g., for light loads of a few well-spaced specimen blanks, time cycle might begin when the furnace recovers to temperature).

10.4.4 Times and temperatures shall be recorded.

10.5 Bonding of Specimens (Adhesives):

10.5.1 The types of adhesives used in bond testing of coatings shall be described.

10.5.2 A storage and shelf life procedure shall be in place to control the use of the adhesives.

10.5.3 The lot number control shall be traceable to the test report.

10.5.4 The use of adhesives shall be documented by specification and meet customer requirements.

11. BOND STRENGTH TESTING:

11.1 A print or drawing (such as from ASTM C 633) shall be used to document tolerances, etc., used in manufacture and control of specimens.

11.2 If buttons are used for tensile testing, they shall meet customer size and material requirements.

11.3 Samples shall be marked in a manner which identifies specimens (i.e., both ends of adaptor halves) through completion of testing and evaluation.

11.4 Specimen materials shall be in accordance with customer specification.

11.5 Bonding Fixtures:

11.5.1 Fixtures shall be available for bonding of specimens.

11.5.2 A procedure shall be available for the bonding process that details items such as alignment, pressure, etc.

11.5.3 When liquid epoxies are used, there shall be a procedure in place to ensure relatively consistent thickness on every sample (i.e., film epoxies are impregnated in cloth which dictate consistent thickness).

11.5.4 For gravity and pressure fixtures:

a. For gravity, fixtures shall be clean and free of adhesive remnants that might affect specimen alignment.

b. For gravity, the angle shall be at the proper value to prevent too much flow to one side.

c. For pressure, there shall be a means to verify that the proper pressure is applied consistently.

d. For pressure, the fixturing system shall prevent bowing of the specimens in the center (top plate used).

e. For both, the fixture design shall assist in producing a properly aligned concentric specimen.

11.6 Bonding Procedures:

11.6.1 A procedure shall exist detailing the steps used in bonding of specimens.

11.6.2 Fixtures/specimens shall be checked for proper function and dimensions (i.e., build-up of epoxy can affect alignment).

11.6.3 Buttons or tensile specimens shall be cleaned off with regards to over spray before bonding.

11.6.4 This method shall be documented as to not cause coating damage or metal removal on actual specimens.