COATINGS FOR AVIATION FUEL TANK INTERNAL LINING

Editorial Note – This version of the specification includes approval for use of unleaded petrol UL91 as substitute for AVGAS and clarification to the Existent gum acceptable limits.

1. SCOPE

a) This specification applies to coatings for the interior linings of storage tanks for aircraft fuels.

2. BACKGROUND

a) APAS Document D001 should be read to obtain a broad overview of the Australian Paint Approval Scheme (APAS).
b) Manufacturers who wish to participate in APAS within Australia should consult APAS documents D177.
c) APAS approval to this specification may be gained by compliance with the requirements detailed in this specification and those in document D192.
d) This specification has been produced in collaboration with the Australian Government’s Defence Science & Technology Group (DST).

3. DESCRIPTION & GUIDE FOR USERS

3.1 General product description

a) This specification Intended for the internal lining of tanks used for storing AVTUR containing FSII, AVCAT containing FSII and AVGAS aviation fuel, including tanks which also contain water, such as may collect on walls and in sump areas.
b) Finishing coats are generally white or off white with primers or intermediate coats being available in contrasting colours to aid application.
c) Intended generally for application by spray with brush or roller application only for small areas for patch repairs.
d) The coating system is expected to provide protection and withstand normal service conditions for a period of not less than 10 years.
e) These coatings meet Defence Department needs for the internal lining of bulk fuel storage tanks and ancillary equipment.
f) Products approved under this specification are accepted on the basis that they will continue to meet this specification when newly coated tank surfaces are washed down with a detergent solution followed by clean water rinse to remove any extractable surface organics and loose particulate matter prior to filling the tanks with fuel.

3.2 Technical basis of specification

a) This specification is not based on any known standard or specification.
b) Products approved under this specification do not comply with any PRN of AS/NZS 1580 Paints and related materials – methods of test.

3.3. Sub-classes

This specification is not divided into any sub-classes.

4. REFERENCED DOCUMENTS

This specification makes reference to the following documents;

a) AS/NZS 1580 Paints and related materials – methods of test
b) AS/NZS 2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings.
c) AS/NZS 2311 Guide to the painting of buildings

Australian standards are available on-line from SAI-Global at http://www.sai-global.com.au
e) APAS Document AP-D001 How APAS Operates
f) APAS Document AP-D177 How paint manufacturers participate in APAS
g) APAS Document AP-D192 The APAS Product Approval System

All APAS Documents may be downloaded from the APAS web site located at:

http://www.apas.gov.au

h) DEF (AUST) 52071 Turbine Fuel, Aviation (NATO Code F-44 AVCAT/FSII)
i) DEF (AUST) 52401 Turbine Fuel, Aviation (NATO Code F-34 AVTUR+FSII)
j) DEFSTAN 91-901 Gasoline, Aviation (UK (Joint Service UK Designation AVGAS 80, 100 or 100LL)
k) MIL-DTL-854701, Inhibitor, Icing, Fuel System, High Flash (NATO Code S-1745)

Note 1: the latest versions of these specifications must be used at all times.
5. COMPOSITIONAL REQUIREMENTS

5.1 Binder

a) The binder shall consist of epoxy or modified epoxy resin together with appropriate curing agents.
b) Other binders may be considered for certification but their acceptance or otherwise will be dependent on full test results and consideration and acceptance by DST.

5.2 Pigmentation

a) Although there are minimal restrictions placed on the type(s) of pigment used (see Note 2 below), they shall be non-toxic and anti-corrosive and comply with the requirements of the Uniform Paint Standard. Of primary importance is the compliance with the technical requirements detailed in Table 1 below.

Note 2: The coating shall not contain metallic zinc, aluminium, copper, copper alloys, lead or chromate based pigments.

5.3 Volatiles

a) Although there is no restriction placed on the type of volatiles used, typically the volatile portion shall principally be comprised of hydrocarbons.
b) VOC content restrictions (refer APAS Document D181) are not applied to these products.

Note 3: The coating shall not contain benzyl chlorinated compounds, ethylene based glycol ethers and their acetates.

5.4 Colour

a) Typically, products approved under this specification are normally available in white or an off-white colour.

6. PRODUCT APPROVAL REQUIREMENTS

6.1 General

a) The product and its application shall comply with all requirements of APAS Document D192 during the application process and the life of the approval.

6.2 Technical

a) Environmental conditions for application, curing and testing of these products are to be in accordance with AS 1580.101.5.
b) The product shall comply with all requirements detailed in Table 1 below.

c) Test panels shall be either of the following as appropriate:
- Tin plate panels shall be of minimum 0.3 mm thickness and maximum of 100 x 75mm in accordance with AS 1580.104.1. Prior to coating application, the panels are to be abraded and cleaned in accordance with AS 1580.105.2.
- Steel panels shall be of minimum 1.2 mm thickness and maximum of 100 x 75mm in accordance with AS 1580.104.1 (some tests have specific thickness requirements). Prior to coating application, panels are to be abrasive blast cleaned to Class 2.5 of AS 1627.4.

d) Other dimensions of the test panels shall be appropriate for the method.
e) Each product shall be applied to the relevant test panels in accordance with the manufacturer's recommendations and film thickness applied to each test panels shall be as detailed on the manufacturer's product data sheet unless otherwise stated.

6.3 Safety & environmental

a) The product shall comply with all requirements of clause 6.3 and 6.4 of APAS Document D192.
b) The manufacturer’s Safety Data Sheet (SDS) must be studied closely prior to using the product and complied with during use of the product.

APPENDIX A

DETERMINATION OF POT LIFE

A1. Scope

a) The pot life of each two-pack product in the coating system shall be confirmed using the following procedure

A2. Equipment

i) Rotothinner or Brookfield rotational viscometer

A3. Procedure

a) Condition the components of each product until their temperatures have been stabilised at 25±1°C.
b) Thoroughly mix the components in the ratio specified by the manufacturer to give a sample of 500 mL volume and allow to stand for 10 minutes.
c) Determine the consistency using a Rotothinner or Brookfield viscometer in accordance with AS 1580.214.4 or 214.5 respectively as recommended by the manufacturer.
d) Allow the mixed sample to stand for a period of at least 1.5 hours or for the manufacturer's recommended pot life time, whichever is greater, at 25±1°C and again determine consistency.

A4. Results & assessment

a) The consistency at the end of the standing period in A3d) shall not differ from the original value by more than 15% percent.
APPENDIX B
DETERMINATION OF CURE TIME

B1. Scope
a) This method details how the curing time of the mixed coating shall be determined.

B2. Materials & equipment
i) Metal panel complying with 6.2c) above
ii) Cotton wool
iii) Methyl ethyl ketone solvent
iv) Watch glass
v) Scratch tester complying with AS 1580.403.1 requirements with a load of 1500g on the needle.

B3. Procedure
a) One coat of the mixed paint shall be applied to a metal panel of appropriate size and cured for 7 days.
b) A wad of cotton wool soaked in methyl ethyl ketone shall be placed on the surface of the cured coating and covered by a watch glass.
c) After 10 minutes, the watch glass and cotton wool shall be removed, and the panel dried with a stream of dry clean air.
d) The test panel shall then be immediately subjected to a scratch test in accordance with AS 1580.403.1 ensuring that the scratch test is conducted across the area previously covered by the watch glass.

B4. Results & assessment
a) The coating shall be considered adequately cured provided that it withstands a scratch load of 1500g without penetration of the film through to the base metal.

APPENDIX C
DETERMINATION OF SCRATCH RESISTANCE

C1. Scope
a) This method details how the scratch resistance of the coating system shall be determined.

C2. Materials & equipment
i) Metal panel complying with 6.2c) above
ii) Scratch tester complying with AS 1580.403.1 requirements with a load of 2000g on the needle.

C3. Procedure
a) The complete coating system shall be applied in accordance with the manufacturer's instructions and at the recommended total film thickness to a steel test panel conforming to AS 1580.104.1 which has previously been abrasive blast cleaned to Class 2½ finish of AS 1627.4.
b) The first and intermediate coats of the system shall be allowed to cure for 24 hours and the final system to cure for 7 days.

D1. Scope
a) This method details how the impact resistance of the coating system shall be determined.

D2. Materials & equipment
i) Metal panel complying with 6.2c) above
ii) Impact tester complying with AS 1580.406.1 requirements.

D3. Procedure
a) The complete coating system shall be applied in accordance with the manufacturer's instructions and at the recommended total film thickness to a steel test panel conforming to AS 1580.104.1 which has previously been abrasive blast cleaned to Class 2½ finish of AS 1627.4.
b) The first and intermediate coats of the system shall be allowed to cure for 24 hours and the final system to cure for 7 days.

c) The coated test panel shall be tested in accordance with AS 1580.403.1 except that the load on the needle shall be adjusted to 2000g.
d) The scratch test is repeated in the same position with the 2000g load until penetration occurs or until 40 scratches have been completed.

d) The coated test panel shall be subjected to a direct impact of 1.5 Joule.
APPENDIX E

DETERMINATION OF ADHESION

E1. Scope
a) This method details how the adhesion of the coating system shall be determined.

E2. Materials & equipment
i) Metal panel complying with 6.2c) above
ii) apparatus and equipment complying with AS 1580.408.2 (Method B) requirements

E3. Procedure
a) The complete coating system shall be applied in accordance with the manufacturer's instructions and at the recommended total film thickness to a steel test panel conforming to AS 1580.104.1 which has previously been abrasive blast cleaned to Class 2½ finish of AS 1627.4.
b) The first and intermediate coats of the system shall be allowed to cure for 24 hours and the final system to cure for 7 days.
c) The coated test panel shall be tested in accordance with AS 1580.408.2 (Method B).

E4. Results & assessment
a) The coating system shall not show an adhesion rating of greater than 1, for both the coating to the substrate and between successive coats.

APPENDIX F

DETERMINATION OF RESISTANCE TO AVIATION FUELS

F1. Scope
a) This method details how the resistance of the coating system to aviation fuel immersion shall be determined.
b) The determination shall be carried out in triplicate.

F2. Materials & equipment
i) Test fuels AVCAT, AVTUR & AVGAS complying with Defence specifications described in 4 above. Standard Unleaded Petrol with a RON of 91 (UL91) is a suitable replacement for AVGAS. UL91 is defined in (UK) Defence Standard 91-090.
ii) Balance to 0.001g accuracy
iii) Suitable sealable containers to hold fuel & test panels
iv) Scratch resistance tester as per Appendix C above
v) Adhesion testing as per Appendix E above

F3. Procedure
a) For each type of fuel, prepare 3 steel panels for scratch resistance test (as in Appendix C) and 3 for adhesion test (as in Appendix E – total of 18 panels).
b) Apply the coating to both sides of all panels.
c) The first and intermediate coats of the system shall be allowed to cure for 24 hours and the final system to cure for 21 days. Clearly identify each panel.
d) Weigh the panels to be used for the adhesion tests and record the results.
e) Retain a reference sample of each of the test fuels in suitable individual, clean, sealable cans or jars for testing and comparison.
f) All of the tests shall be completed within the specified shelf life of the fuels.
g) Place 1 scratch and 1 adhesion test panel into a suitable container, cover completely with the specified fuel ensuring that the fuel has ready access to all parts of each panel.
h) Seal the container to prevent the loss of volatiles from the fuels. Repeat this procedure with the other 2 pairs of test panels and the same fuel.
i) Repeat g) & h) above for two additional containers with the same fuel type.
j) Repeat g) & h) above for the other two types of fuel. This will result in 9 containers of fuel each with 2 panels in them.
k) Prepare 3 additional containers as in g & h) above but containing fuel only to act as references.
l) Each of the 12 containers shall be stored in a secure and darkened area for 25 weeks. (The storage area shall be appropriate to the fuel being used with regards occupational health and safety requirements).
m) On completion of the immersion period, remove all test panels and allow to air dry. Transfer the fuel from each test container to suitable individual, clean, sealable cans or jars.

Note 4 - This test must be performed by a laboratory approved by DST for the conduct of this test. CSIRO (Clayton Victoria tel +613 9545-8774 Ms Money Arora) is such a DST-approved laboratory.
APPENDIX G

DETERMINATION OF EFFECT ON AVIATION FUELS

G1. Scope
a) It is important that the coating systems itself has no effect on the fuels that may adversely affect its performance. An example of a possible defect is gellation of the fuel.
b) This method details how the effect of the coating system on the fuels shall be determined.

G2. Materials & equipment
i) Fuels remaining from the test in Appendix F above.

G3. Procedure
a) On completion of the tests detailed in Appendix F above, examine the fuels in which the panels have been immersed.
b) Examine the test fuels and reference fuels as follows;
   i) DEF(AUST)5207 and DEF(AUST) 5240: Determine existent gum content in accordance with ASTM D381 / IP131, and thermal stability JFTOT in accordance with ASTM D3241 / IP323.
   ii) DEFSTAN 91-90: Determine existent gum content in accordance with ASTM D381 / IP131.

G4. Results & assessment
a) When compared to fresh unused fuels, the fuels used for the immersion tests shall not exhibit any observable gelling, polymerisation or other deterioration.
b) When compared to fresh unused fuels, the fuels used for the immersion tests shall not have an increase in existent gum content of greater than 3.0mg/100mL as defined in the specifications nominated in G3b)i) & ii) above.
c) The fuel used for the immersion tests shall remain within the respective specified limits of the specification with respect to thermal stability as defined in the specifications nominated in G3b)i) above.

Note 5 - This test must be performed by a laboratory approved by DST for the conduct of this test.

APPENDIX H

DETERMINATION OF RESISTANCE TO WATER

H1. Scope
a) This method details how the resistance of the coating system to immersion in water shall be determined.
b) Condensation water can build up on the cool, dark sides of the inside of fuel storage tanks.

H2. Materials & equipment
   i) Distilled water
   ii) Oven or other means of maintaining test samples at 50 ± 2°C for 21 days

H3. Procedure
a) The complete coating system shall be applied in accordance with the manufacturer's instructions and at the recommended total film thickness to a steel test panel conforming to AS 1580.104.1 and of minimum dimensions 100 x 100 x 3 mm which has previously been abrasive blast cleaned to Class 2 ½ finish of AS 1627.4.
b) Apply the coating system to both sides and all edges of the panel. The first and intermediate coats of the system shall be allowed to cure for 24 hours and the final system to cure for 21 days.
c) Immerse the panel in distilled water at 50 ± 2°C for 21 days. The container shall be sealed to prevent the loss of water.

H4. Results & assessment
a) At the end of the immersion period remove the panel, allow to dry and inspect. The coating system shall show no signs of blistering, cracking, corrosion or other integrity failure.
APPENDIX I
DETERMINATION OF RESISTANCE TO FSII
(FUEL SYSTEM ICING INHIBITOR)

I1. Scope
a) This method details how the resistance of the coating system to immersion in FSII shall be determined.
b) FSII is an additive to aviation fuels designed to prevent icing up of the fuel system during flight. It is essentially diethylene glycol monomethyl ether (DEGME).

I2. Materials & equipment
i) FSII complying with 4k) above
ii) Oven or other means of maintaining test samples at 40 ± 2°C for 10 weeks
iii) Suitable sealable containers to hold fuel & test panels

I3. Procedure
a) The complete coating system shall be applied in accordance with the manufacturer’s instructions and at the recommended total film thickness to a steel test panel conforming to AS 1580.104.1 and of minimum dimensions 100 x 100 x 3 mm which has previously been abrasive blast cleaned to Class 2 ½ finish of AS 1627.4.
b) Apply the coating system to both sides and all edges of the panel.
c) The first and intermediate coats of the system shall be allowed to cure for 24 hours and the final system to cure for 21 days.
d) On 1 panel, cut a cross (X) to base metal on one side of the panel. The cross shall be in the middle of the panel and each arm of the cross shall be approximately 30mm in length.
e) Immerse the panels in an aqueous solution of 40% FSII for 10 weeks at 40°C.
f) The container shall be sealed to prevent the loss of water and FSII.

I4. Results & assessment
a) At the end of the immersion period remove the panel, allow to dry and inspect. The coating system shall show no signs of blistering, cracking, corrosion or other integrity failure.
b) In addition, the panel with the cross cut through the coating shall exhibit no rusting beyond 1mm from the sides of the scratch.

Note 6 - This test must be performed by a laboratory approved by DST for the conduct of this test. CSIRO (Clayton Victoria tel +613 9545-8774 Ms Money Arora) is such a DST-approved laboratory.
7. TABLE 1 – PERFORMANCE PROPERTIES

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<tr>
<th>TEST</th>
<th>AS/NZS 1580 METHOD</th>
<th>REQUIREMENTS</th>
</tr>
</thead>
</table>

### 7.1 For each Component of the Coating System

#### A. Wet paint tests – each component of the system

<table>
<thead>
<tr>
<th>Preliminary examination</th>
<th>103.1</th>
<th>To be readily reincorporated. Shall be free of coarse particles, gel and foreign matter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity</td>
<td>214.x</td>
<td>To be recorded for the mixed product.</td>
</tr>
<tr>
<td>Pot life</td>
<td>Appendix A</td>
<td>Consistency shall not change by more than 15% after standing for the manufacturer's recommended pot life time which shall not be less than 1.5 hours.</td>
</tr>
<tr>
<td>Application properties</td>
<td>205.1</td>
<td>Shall be suitable for application by brush to small areas having satisfactory application properties and the dry film shall be free of defects. The presence of some brushmarks is acceptable.</td>
</tr>
<tr>
<td>Application properties</td>
<td>205.2 or 205.4</td>
<td>Shall be suitable for application by conventional air or airless spray with satisfactory application properties and the dry film shall be free of defects.</td>
</tr>
<tr>
<td>Recoating properties</td>
<td>404.1</td>
<td>When one coat is applied to a steel test panel and cured for 24 hours before application of a second coat of paint, the recoated panel shall not show any evidence of wrinkling, patchiness or lifting of the previous coat.</td>
</tr>
<tr>
<td>Reincorporation after</td>
<td>211.2</td>
<td>Each component shall comply with all the preceding requirements after 12 months storage at ambient temperature.</td>
</tr>
<tr>
<td>Degree of setting</td>
<td>211.1</td>
<td>Settling shall not fall below 6.</td>
</tr>
<tr>
<td>Aged application</td>
<td>205.2 or 205.4</td>
<td>In addition, the use of spray application shall produce a uniform finish typical of the un-aged product type.</td>
</tr>
<tr>
<td>VOC content</td>
<td></td>
<td>Theoretical calculation shall be recorded.</td>
</tr>
</tbody>
</table>

#### B. Additional wet paint tests – Topcoat only

| Non volatile content by volume (Volume solids) | 301.2 | Minimum 48% (Volume solids may be determined theoretically from raw material data except where solid constituents incorporate sealed air voids). |
| Fineness of grind | 204.1 | Maximum 40µm |

#### C. Dry paint film tests – each component of the system

| Surface dry condition | 401.1 | Maximum 9h |
| Hard dry condition (Mechanical thumb test) | 401.6 | Maximum 18h |
| Colour - Visual comparison | 601.1 | Approximate match |
| Specular gloss (60°) | 602.2 | To be recorded |
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<tr>
<th>TEST</th>
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<tbody>
<tr>
<td><strong>7.1 For each Component of the Coating System (cont’d)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Dry paint tests – each component of the system (cont’d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finish</td>
<td>603.1</td>
<td>Shall be free of coarse particles, wrinkling or orange peel and have a uniform colour and appearance.</td>
</tr>
<tr>
<td>Curing properties</td>
<td>Appendix B</td>
<td>Shall resist a scratch load of 1500g</td>
</tr>
<tr>
<td>Surface dry condition</td>
<td>401.1</td>
<td>Maximum 9 hours</td>
</tr>
<tr>
<td>Hard dry condition (Mechanical thumb test)</td>
<td>401.6</td>
<td>Maximum 18 hours</td>
</tr>
<tr>
<td><strong>D. Additional dry paint film tests – Topcoat only</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colour - Visual comparison</td>
<td>601.1</td>
<td>The finishing coat shall be an approximate match to AS2700 Y35 Off White.</td>
</tr>
<tr>
<td>Specular gloss</td>
<td>602.2</td>
<td>Minimum 20 units at 60° after 7 days curing</td>
</tr>
</tbody>
</table>

| **7.2 For the complete System** | | |
| A. Dry paint tests | | |
| Scratch resistance | Appendix C | No penetration to substrate after 40 passes |
| Impact resistance | Appendix D | The coating shall not display any cracking and shall remain firmly adherent when subjected to a direct impact of 1.5 Joule. |
| Adhesion | Appendix E | Adhesion rating ≤1 |
| Resistance to aviation fuels | Appendix F | No evidence of softening, cracking or blistering of the paint film. No loss of adhesion or reduction in scratch resistance. Mass increase not to exceed 15g/m². |
| Effect on aviation fuels | Appendix G | The coating system shall not cause any observable gelling, polymerisation or deterioration of the test fuels when compared with new fuel held for the duration of the testing (Appendix F) in identical containers. The fuel used for the immersion tests shall not increase existent gum content more than 3.0mg/100mL when compared with reference fuel held for the duration of the testing (Appendix F) in identical containers. The fuel used for the immersion tests shall remain within the respective specified limits of the specification with respect to the thermal stability as defined in the appendix. |
| Water resistance | Appendix H | No integrity failure |
| Resistance to icing inhibitor | Appendix I | No integrity failure. Minimal corrosion at cut. |