1 Purpose

This Specification covers Daimler Trucks North America LLC (DTNA) performance requirements for pretreatment primer and topcoat paint systems when used to coat metal surfaces.

2 Abstract

This Specification covers the performance requirements for paint finish systems applied to metal substrates. These coatings are primarily intended to provide optimal corrosion protection along with vehicle cosmetic appearance. This Specification is not intended to limit or specify the processes used for painting. Any process providing quality parts that meet this Specification will be approved.

3 Application

All drawings of metallic component parts and assemblies requiring paint shall specify the level of prime and/or topcoat performance, as identified in this Specification. In those cases where paint is not required or not desired, there shall be no reference to paint made on the drawing.

4 Responsibility

Suppliers of painted components to DTNA are responsible to ensure that all supplied components arrive at DTNA facilities in full compliance with the requirements of this Specification. All DTNA personnel involved with the design, review, procurement, manufacture or quality assurance of components and assemblies will ensure that the requirements of this Specification are implemented. Engineering is responsible for documenting the determination whether to paint or not and which paint requirement applies.

5 Conformance Requirements

5.1 All parts must be visually inspected and meet the appearance and color requirements cited in this document or on the engineering drawing.

5.2 The supplier shall demonstrate conformance with the performance requirements cited in this document for the finish specified.

5.3 All changes must be approved by DTNA Engineering prior to production implementation.

5.4 No changes may be made to the painting processes without prior written notification and approval from DTNA Manufacturing Engineering Coating and Technology Group.

5.5 Any significant change in the painting processes will require resubmission and requalification of the painting processes.

6 Specifications

6.1 Primer Paint Systems

Primer paint to be applied by suppliers or DTNA manufacturing plants. Components with these paint Specifications are always intended to be topcoated during final vehicle manufacture at a DTNA facility and therefore must be fully compatible with DTNA topcoat systems.

When applied correctly, primer paint serves a number of functions, including:

- Protection to pretreatment prior to topcoat finishing
- Corrosion protection
- Provides a uniform, level, and sealed surface for topcoat application.

Primer Paint Specifications:

49-00023-101	For cab decorative exterior components which are visible appearance items and require a high degree of corrosion and weathering resistance. This finish is intended for topcoat during vehicle assembly.
49-00023-102	For chassis and suspension components, non-decorative cab exterior parts requiring a high degree of corrosion and weathering resistance and for engine parts and those parts subject to oil exposure. This finish is intended for topcoat during vehicle assembly.
49-00023-103	For cab interior parts requiring minimal corrosion resistance where a good appearance, may or may not be essential. This finish is intended for topcoat during vehicle assembly.

6.2 Topcoat Paint Systems

Topcoat paint to be applied by suppliers or DTNA manufacturing plants. Components with these paint specifications may or may not be topcoated during final vehicle manufacture at a DTNA facility. Topcoat paint must provide both appearance and corrosion protection for the life of the vehicle.

When applied correctly, topcoat paint serves a number of functions, including:

- Class A surface appearance to meet new vehicle customer expectations
- Corrosion protection for the life of the vehicle

Topcoat Paint Specifications:

49-00023-201	For cab decorative exterior components, which are visible appearance items and require a high degree of corrosion and weathering resistance. This finish may be recoated during vehicle assembly and must be compatible with standard DTNA topcoats.
49-00023-202	For chassis and suspension components, or non-decorative cab exterior parts, requiring a high degree of corrosion and weathering resistance or for engines, engine parts and those parts subject to oil exposure. This finish may be recoated during vehicle assembly and must be compatible with standard DTNA topcoats.
49-00023-203	For cab interior parts requiring minimal corrosion resistance.
49-00023-204	For non-decorative, blackout appearance. Coating should provide robust rock chip resistance, high degree of corrosion resistance, and weathering resistance. This finish is NOT intended for recoat during vehicle assembly. Typical applications include: backside of chromed bumpers, non-decorative chassis and suspension components, and underside of cab. This coating must be black in color.

7 Performance Requirements

Results of performance testing shall be documented with individual performance ratings noted for each of the tests performed. Included with the results, the supplier shall provide detailed description of the coatings applied and processes used. Section 8 identifies specific information related to the materials and processes which must be documented.

7.1 Production Component Validation

7.1.1 The primary requirement for all painted components supplied to, or by, DTNA, is that they provide acceptable appearance and corrosion performance for the life of the vehicle. All components shall be fully coated (no voids allowed) with a uniform coating, unless specific non-coated areas are defined on the engineering drawing.

7.1.2 Testing shall be performed on finished parts processed through the entire intended production process. Processed parts shall represent the following applicable production processes to be used during normal series production:

- Material blanking/cutting (including laser and/or plasma cutting)
- Metal stamping with representative processing lubricants and draw compounds
- Mechanical surface treatment (rust./scale removal)
- Staging and support of component through the paint process
- Cleaning and rinsing as part of pretreatment
- Applicable pretreatment
- Application of primer and/or topcoats(s)

7.1.3 Component(s) shall meet the requirements identified in Table 1. Component(s) shall be scribed not less than 2 inches as per ASTM D1654 on a vertical surface as viewed with the component oriented in truck position. Components shall be oriented in truck position (+/-5°) throughout the salt spray test. Edges shall be left unprotected as they would be on vehicle.

7.1.4 Test methods are generally described in Sections 9 and 10 of this Specification.

The “A” rating refers to the corrosion creep back distance from the scribe line.

The “B” rating refers to corrosion spots/blisters allowed in the unsubscribed region of the part.

Table 1: Component Performance Requirements

Specification	49-00023-101 49-00023-201	49-00023-102 49-00023-202 49-00023-204	49-00023-103 49-00023-203
Tape Adhesion	5B	5B	5B
Salt Spray - Duration	500 hrs	240 hrs	96 hrs
Salt Spray - Scribe Rating	7A	7A	7A
Salt Spray - Edge Rating	Isolated rust spots or white corrosion on edges up to 5% No blistering or edge creep back allowed.		
Salt Spray - Unsubscribed Region (IE: Remainder of Part)	10B	9B	9B
Tape Adhesion after Salt Spray	5A	5A	5A

7.2 Paint and Process (System) Validation Requirements

Performance testing of pretreatment systems, paints and production paint system processes, using paint test coupons, is required any time a new pretreatment, paint or paint process (system) is considered in the coating of DTNA components. Testing identified in the Section is considered mandatory as part of the initial system validation and does not supersede the component performance requirements of Section 7.1. This testing shall be used as a means of validating that the proposed paint system(s) provide paint performance to DTNA requirements. It is important to note that this level of testing is conducted on standardized test coupons to enable comparison between systems. However this testing does not adequately validate various production manufacturing and material variants.

7.2.1 Testing shall be performed on test panels which represent the proposed production process as close as possible, or preferably on flat panels cut from representative production material.

7.2.2 Test plaques shall measure 4 inch x 8 inch or 4 inch x 12 inch (100 mm x 200 mm or 100 mm x 300 mm). The substrate shall be representative of the production material with respect to surface condition and base chemistry. Some standard test plaque configurations are listed below. These plaques may be purchased from ACT Test Panels LLC, 273 Industrial Drive, Hillsdale, MI 49242. (Other panel sizes may be considered upon approval by DTNA Product Validation Engineering.)

Test Plaque Configurations:

Material	Standard	Nominal Thickness	Coating
SAE 1010 CRS	ASTM D609, Method A	0.032”±0.005”	None
5052-H32 Aluminum	ASTM B209	0.050”±0.005”	None
6022-T4 Aluminum	ASTM B209	0.050”±0.005”	None
SAE 1010 CRS	ASTM D609, Method A	0.032”±0.005”	Electrolytic Zinc per 48-25025-120
SAE 1010 CRS	ASTM D609, Method A	0.032”±0.005”	Hot Dip Galvanized per 48-00719-120

Minimum number of test plaques needed to evaluate each Specification:

Specification	Minimum Number of Plaques
49-00023-101	24
49-00023-102	30
49-00023-103	21
49-00023-201	35
49-00023-202	32
49-00023-203	28
49-00023-204	24

7.2.3 Pretreatment/Surface Preparation

7.2.3.1 Prior to painting, test plaques are to be cleaned and pretreated per the proposed production process. This process must be capable of thoroughly cleaning and pretreating all surfaces. Any of the paint callouts defined in this Specification will require surface cleaning and chemical pretreatment as part of the process in order to provide the level of performance required by DTNA. Validation of this pretreatment is a key constituent of this Specification.

Cleaning	Removal of any accumulation of dirt, oil, grease and oxidation. After cleaning, the surfaces shall not contain any smut, and shall be water-break free. Acceptable cleaning methods include: hot alkaline cleaning, vapor degreasing, and grit or shot blasting. The cleaned components should be processed as soon as practical after cleaning to avoid any possibility of oxidation.
Acid Etch	Parts manufactured with laser cut edges may require an acid etch treatment in order to remove the oxidation scale form the cut edge. Paint adhesion to the laser cut edge is necessary and care should be taken to ensure the parts are prepped properly to ensure this.
Chemical Pretreatment	Required for all classes of finish. Acceptable chemical pretreatments include: microcrystalline zinc phosphate with a chrome sealer, acid wash primer, or an amorphous chromate conversion coating. It is recommended that a zinc phosphate be used on all zinc and steel substrates and a chromate conversion coating be used on all aluminum substrates. Non chrome pretreatments are preferred. Iron phosphate should only be considered for interior coatings and is not suitable for exterior paint applications.

7.2.3.2 Any test plaque protective wrapping used prior to cleaning/pretreatment shall not be reused. Panels shall be wrapped in a clean media suitable to protect them from damage during transport.

7.2.4 Primer

7.2.4.1 The primer system used must contain corrosion inhibitors in order to meet the requirements stated within this specification. A thermal cure epoxy based primer system is preferred, but any primer that meets the performance requirements cited herein is acceptable.

7.2.4.2 For parts specified as “prime only’, (49-00023-101, -102, and –103), it is the supplier’s responsibility to ensure the primer used is compatible with the topcoat systems used by DTNA. Additionally, the primed parts must have a surface finish capable of meeting the appearance requirements in Paragraph 7.2.6 after topcoat.

7.2.4.3 All primed parts must meet the requirements cited in Table 2. Deviations in dry film thickness may be considered as long as they are within paint manufacturer’s recommended thickness for the product and process. Dry film thickness in excess of those stated in Table 2 shall also be evaluated for detrimental effects on fastener tolerances and component fit-up and function.

7.2.5 Topcoat

7.2.5.1 Preferred topcoat chemistries are polyurethane enamel or acrylic polyester. Topcoats of different chemistries shall possess UV resistance comparable to that of an acrylic polyester or urethane when tested under identical conditions.

7.2.5.2 Topcoated parts shall meet the appearance requirements for their respective class as indicated in Section 7.2.6.

7.2.5.3 All topcoated parts must meet the requirements cited in Table 3. Deviations in dry film thickness may be considered as long as they are within paint manufacturer’s recommended thickness for the product and process. Dry film thickness in excess of those stated in Table 3 shall also be evaluated for detrimental effects on fastener tolerances and component fit-up and function.

7.2.5.4 49-00023-201 & 49-00023-202 color chassis black per spec 49-00091-022 unless otherwise specified on the drawing.

7.2.6 Appearance

7.2.6.1 Cab exterior or interior visible components requiring good appearance shall have a surface finish free from any runs, sags, pits, scratches, stains, blemishes, or any other visible defects which will detract from the overall appearance of the component. These conditions apply to both primed and primed/topcoated parts.

7.2.6.2 Part mating surfaces with all classes of finishes must be free from any runs or sags that may be detrimental to the function of the part or which would prevent a properly fastened joint from being achieved.

7.2.6.3 The standard primer color shall be black or dark gray unless specifically noted otherwise on the engineering drawing or purchase order.

7.2.7 Sample Conditioning

7.2.7.1 All test specimens must be aged 72 hours at 24 C ± 2° C and 50% ± 5% relative humidity prior to testing.

Table 2: Prime Only Performance Requirements

Test Description	49-00023-101	49-00023-102	49-00023-103
Gloss	< 60	< 60	< 60
Dry Film Thickness, mils Standard Primer Flexible Primer E-coat Powder Coat	 0.8 – 1.0 1.3 – 1.7 0.7 – 1.0 1.5 – 2.8	 0.8 – 1.0 1.3 – 1.7 0.7 – 1.0 1.5 – 2.8	 0.8 – 1.0 N/A 0.7 – 1.0 1.5 – 2.8
Tape Adhesion	5B	5B	5B
Solvent Wipe	0 or 1 after 5 double rubs	0 or 1 after 5 double rubs	0 or 1 after 5 double rubs
Pencil Hardness	H – 4H	H – 4H	H – 4H
Brittleness	no paint flaking beyond the furrow	no paint flaking beyond the furrow	no paint flaking beyond the furrow
Flexibility Impact 30 in-lbs for Aluminum 60 in-lbs for Steel	No Cracking	No Cracking	N/R
Cylindrical Mandrel Bend 23°C	Max of 4 uninterrupted line cracks	Max of 4 uninterrupted line cracks	N/R
Salt Spray X-cut Adhesion	7A/9B @ 500 hrs 5A	7A/9B @ 240 hrs 5A	7A/9B @ 96 hrs 5A
Humidity X-cut Adhesion	6A/9B @ 500 hrs 5A	6A/9B @ 240 hrs 5A	6A/9B @ 96 hrs 5A
Water Immersion X-cut Adhesion	6A/9B @ 500 hrs 5A	6A/9B @ 240 hrs 5A	6A/9B @ 96 hrs 5A
Ethylene Glycol – 96 hours Color Change (Yes/No)	N/R	9B None Allowed	N/R
Engine Oil – 24 hours Color Change (Yes/No) Hardness	N/R	9B None Allowed H – 4H	N/R

Table 2: Continued

Test Description	49-00023-101	49-00023-102	49-00023-103
Diesel Fuel – 96 hours Color Change (Yes/No) Hardness	N/R	9B None Allowed H – 4H	N/R
Cycle Scab	6A/9B @ 5 cycles	6A/9B @ 5 cycles	6A/9B @ 5 cycles
Weathering Exposure (12 month exposure)	Ratings of 8 or better on all visual inspection	Ratings of 8 or better on all visual inspection	Ratings of 8 or better on all visual inspection

Table 3: Topcoat Performance (Part 1 of 2) – Physical Requirements

Test Description	49-00023-201	49-00023-202	49-00023-203	49-00023-204
Gloss	Refer to 7.2.5.4	Refer to 7.2.5.4	Refer to 49-00091	< 60
Dry Film Thickness, mils Standard Primer Flexible Primer Topcoat *Flexible Primer Stand-alone Powder Coat	 0.8 – 1.0 1.3 – 1.7 1.8 – 2.2 1.5 – 1.9 1.8 – 2.8	 0.8 – 1.0 1.3 – 1.7 1.8 – 2.2 1.5 – 1.9 1.8 – 2.8	 0.8 – 1.0 N/R 1.8 – 2.2 1.5 – 1.9 1.8 – 2.8	 N/R N/R 1.8 – 2.2 N/R 1.8 – 2.8
Tape Adhesion	5B	5B	5B	5B
Gravelometer	5A6B no C or D size chips allowed	5A6B no C or D size chips allowed	N/R	5A6B no C or D size chips allowed
Solvent Wipe	0 or 1 after 10 double rubs	0 or 1 after 10 double rubs	0 or 1 after 10 double rubs	N/R
Cleaning Agents	N/R	N/R	0 or 1 after 25 double rubs	N/R
Pencil Hardness	H – 4H	H – 4H	H – 4H	N/R
Brittleness	no paint flaking beyond the furrow	no paint flaking beyond the furrow	no paint flaking beyond the furrow	no paint flaking beyond the furrow
Flexibility Impact 30 in-lbs for Aluminum 60 in-lbs for Steel	No Cracking	No Cracking	N/R	N/R
Cylindrical Mandrel Bend 23°C	Max of 4 uninterrupted line cracks	Max of 4 uninterrupted line cracks	N/R	Max of 4 uninterrupted line cracks
Abrasion Resistance	N/R	N/R	1500 cycles/mil DFT	N/R
Stain Resistance	N/R	N/R	No staining	N/R

* DuPont Flexible Primer is a weather-able primer developed for use on DTNA products. This product can be used as a “stand alone” coating which effectively acts as the topcoat. In such applications, the Flex Primer is to be considered a topcoat and evaluated as such.

Table 3: Topcoat Performance (Part 2 of 2) – Environmental Test Requirements

Test Description	49-00023-201	49-00023-202	49-00023-203	49-00023-204
Oven Aging X-cut Adhesion Gravelometer Humidity	No Visual Changes 5A 5A6B 7A/9B @ 1000 HRS	No Visual Changes 5A 5A6B 7A/9B @ 750 HRS	No Visual Changes 5A N/R 6A/9B @ 240 HRS	No Visual Changes 5A 5A6B 7A/9B @ 750 HRS
Salt Spray X-cut Adhesion	7A/9B @ 1000 HRS 5A	7A/9B @ 240 HRS 5A	7A/9B @ 96 HRS 5A	7A/9B @ 240 HRS 5A
Humidity X-cut Adhesion	7A/9B @ 1000 HRS 5A	7A/9B @ 750 HRS 5A	6A/9B @ 240 HRS 5A	7A/9B @ 750 HRS 5A
Water Immersion X-cut Adhesion	7A/9B @ 750 HRS 5A	6A/9B @ 500 HRS 5A	6A/9B @ 240 HRS 5A	6A/9B @ 500 HRS 5A
Filiform Corrosion	No filiform allowed	No filiform allowed	No filiform allowed	No filiform allowed
Ethylene Glycol – 96 hours Color Change (Yes/No)	9B None Allowed	9B None Allowed	N/R	9B None Allowed
Engine Oil – 24 hours Color Change (Yes/No) Hardness	9B None Allowed H – 4H	9B None Allowed H – 4H	N/R	9B None Allowed N/R
Diesel Fuel – 96 hours Color Change (Yes/No) Hardness	9B None Allowed H – 4H	9B None Allowed H – 4H	N/R	9B None Allowed N/R
Cycle Scab	7A/9B @ 10 cycles	6A/9B @ 10 cycles	6A/9B @ 10 cycles	6A/9B @ 10 cycles
Weathering Exposure (36 month exposure)	Ratings of 8 or better on all visual inspection	Ratings of 8 or better on all visual inspection	Ratings of 8 or better on all visual inspection	N/R

8 Coating Process Information

The following information is required as a means of documenting the coating process and specific coating used. This information is to be included when documenting the paint performance test results.

Tier 1 Supplier:		**Coater:** (if different from Tier 1 Supplier)	
Contact Name:		Contact Name:	
Address:		Address:	
Phone:		Phone:	
E-mail:		E-mail:	

☐ **Test laboratory has permission to send the test results directly to DTNA Product Validation Engineering.**

Signature: (Requestor's signature) _____ **Date:** _____

Purpose of testing:

☐ Initial Process Verification
☐ Annual Verification (attach Letter of Compliance and Daily Test Results example)
☐ Touchup/Repair Verification
☐ Other, explain:

Is this approved for a PPAP? ☐ **No** ☐ **Yes; PPAP due date:** _____

Paint to be tested (Include manufacturer/brand and product ID for each paint layer)**:**

	Paint MFG	Brand	Product ID	Spray Applied: Single Component	Spray Applied: Two Component	E-Coat	Powder Coat	IMC
1st Layer				☐	☐	☐	☐	☐
2nd Layer				☐	☐	☐	☐	☐
3rd Layer				☐	☐	☐	☐	☐

Paint submitted for testing to the following DTNA standards:

☐ 49-00023, Painting of Metal Parts ☐ -101 ☐ -102 ☐ -103 ☐ -201 ☐ -202 ☐ -203
☐ 49-00087, Paint Performance on Plastic Components ☐ -101 ☐ -102 ☐ -103 ☐ -104
☐ 49-00077, Paint-Prime, Government Vehicle
☐ 49-00078, Paint-Topcoat, Government Vehicle
☐ Other (list): _____

Test sample description:

DTNA part number(s), if applicable (attach list if necessary): _____

Part type (check one): ☐ Cab Exterior ☐ Cab Interior ☐ Chassis

Number of samples submitted: _____

Sample substrate provided by part manufacturer (check Yes or No):

☐ Yes ☐ Production Part; or Samples cut from: ☐ production stock material ☐ production part

☐ No Where were samples obtained? ☐ test coupon ☐ _____

Raw material condition & storage (describe raw material and how it is stored prior to parts manufacturer):
(e.g.: hot rolled, pickled and oiled 1008; stored as unprotected coils outside.)

Substrate cleaning and preparation sequence (Describe all chemicals and equipment used to prepare substrate, including cleaners, abrasives, conversion coatings and so forth. Include the number of stages with product numbers and manufacturer's name.):
(e.g.: Stage 1: Shop blast; Stage 2: Degrease - PPG Chemkleen 611L; Stage 3: City water rinse; Stage 4: Zn phosphate coating - PPG Chemphos 700; Stage 5: city water rinse; Stage 6: seal - PPG Chemseal 100; Stage 7: E-coat - PPG Powercron 6000.)

Curing parameters (Include flash-off, oven temperature, cure time, and so forth):
(e.g.: 30 minute flash; oven temp. 250F; cure time: 30 minutes; cool down time: 15 minutes.)

Part storage prior to shipment to Daimler (Describe typical production part storage duration, where stored, how parts are protected):
E, g, Parts packaged individually and stored for delivery (1-5 days); or Parts paced in returnable racking for delivery to DTNA (1-5 days); or Parts stacked without protective separators ;….)

9 Physical Testing Methods

All tests shall be conducted in accordance with the following procedures, unless noted otherwise on the engineering drawing or purchase order. Minimum passing criteria are listed in Tables 1 – 3.

The number of panels shown for each test indicates the recommended minimum number of panels on which each test is to be performed. The same panel can be used for multiple tests (IE: Dry Film Thickness, Tape Adhesion, and Solvent Wipe) provided the tests do not interfere with each other.

9.1 Gloss – 1 panel

Specular gloss shall be measured in accordance with the procedures cited in ASTM D523. The gloss rating of a finish shall be determined with a Gardener 60° (or equivalent) Gloss Meter.

9.2 Dry Film Thickness – 2 panels

Film thickness shall be measured in accordance with the procedures cited in ASTM D4138 or ASTM D7091.

9.3 Tape Adhesion Test – 2 panels

Adhesion testing shall be performed in accordance with ASTM D3359, Method B.

9.4 Gravelometer Test – 2 panels

Gravelmeter testing shall be performed in accordance with ASTM D3170 at a temperature of -18°C. Testing shall be performed on flat test panels measuring a minimum of 4 inches X 8 inches in size. Provide complete rating of each chip size according to ASTM D3170. No C or D size chips are allowable.

9.5 Solvent Wipe Test – 2 panels

The solvent wipe test shall be performed in accordance with ASTM D5402. Use Toluene as the solvent. Examine the pad after each cycle and count the number of cycles until paint first appears on the pad (a rating of 1 per the table below). Sample shall be rated per the following rating scale. It is not necessary to report film thickness after the test. The relevance of this test is as a quick method of evaluating completeness of cure. Paints failing to meet this requirement may be allowed pending approval based on paint manufacturer's recommendation.

Rating	Paint Surface	Paint Residue on Cloth
0	No Change	None
1	Slight-Barely Observable	Trace Amount
3	Moderate-Readily Observable	Readily Noticeable
5	Severe-Very Observable	Saturated with Color

9.6 Cleaning Agents – 2 panels

Resistance to various cleaning agents shall be evaluated in accordance with ASTM D5402 using the cleaners listed below. Examine the pad after each cycle and count the number of cycles until change in the paint is noticeable or there is paint residue on the cloth. Use the rating scale listed in Section 9.5 Solvent Wipe.

Cleaners
Windex
DuPont 3939-S
Lysol direct
Formula 409

9.7 Pencil Hardness Test – 2 panels

Testing shall be performed in accordance with ASTM D3363. The grade of the hardest pencil that will not scratch or cut the paint film shall be recorded (marring or indenting the paint is not considered a failure). The range shown in Tables 2 and 3 indicate the minimum and maximum hardness allowable for the paint system. Excessive hardness can affect the adhesion of subsequent coatings.

9.8 Brittleness Test – 2 panels (May be performed on the same panels as Pencil Hardness Test.)

Scribe a “furrow” to the base metal with a quarter held in the fingers slightly off perpendicular to the surface, the flat side tilted toward the direction of motion (quick stroke, heavy pressure). If the paint flakes beyond the width of the furrow, the finish is considered brittle.

9.9 Flexibility Impact Test – 2 panels

Testing shall be performed in accordance with ASTM D2794 using a 5/8” diameter indenter. Do not test panels if they do not conform to the standard plaque thicknesses listed in the table of Section 7.2.2. The panels shall be tested painted side up (direct). Paint shall exhibit no cracking at the minimum required values stated in Tables 2 and 3.

9.10 Cylindrical Mandrel Bend – 2 panels

This test only applies to paint processes applied and performed on production applications involving thin gauge material (material thickness <3 mm).

The following procedure will be used according to ASTM D522, Test Method B.

Perform cylindrical mandrel bend (mandrel bend) test at 23°C. The mandrel shall have a diameter equal to four times the thickness of the substrate (before paint).

Test by wrapping the panel 180° around the mandrel in about 1 second. The sample shall be wrapped around the mandrel so that the painted surface is in tension (painted surface up).

The surface of the sample shall be examined with the naked eye for fracture of the substrate or cracking of the paint film in the flexed condition. The painted surface of the sample may show minimal cracking, defined as interrupted short line cracks with a maximum of four (4) uninterrupted line cracks in the flexed condition.

9.11 Abrasion Resistance – 2 panels

Abrasion resistance shall be performed in accordance with the procedures cited in ASTM D4060. The CS-10 abrasive shall be used weighted to 1000 grams.

9.12 Stain Resistance – 2 panels

Stain resistance shall be performed in accordance with the procedures cited in ASTM D1308, Method 3.1.2 for 24 hours. Testing shall include the following standard reagents:

Margarine	Coffee	Chewing Tobacco
Mustard	Pepsi/Coca-Cola	Transmission Fluid
Ketchup	Italian Salad Dressing	

Reagents shall be cleaned from the surface by first wiping with plain water and then using a cloth saturated with DuPont 3939S and a light pressure for 1 minute.

10 Environmental Testing Methods

Test plaques subjected to environmental testing shall be scribed as detailed below and evaluated for corrosion and blistering in accordance with ASTM D1654. Creep from the scribe line will be evaluated per

Procedure A, Method 2; areas beyond the scribe shall be evaluated per Procedure B. If blisters are apparent, their size and density shall be also noted in accordance with ASTM D714.

10.1 Oven Aging – 5 panels

Test panels shall be scribed in accordance with ASTM D1654. Oven age the test panels according the cycle shown below. After aging, one panel shall pass the Tape X-Cut Adhesion per ASTM D3359, Method A; one panel shall pass Gravelometer per Section 9.4. Two additional panels shall pass the Humidity Test per Section 10.3. One panel shall be retained for comparison purposes.

Cycle:	Oven Exposure at 180° F	168 hours
	Recovery	1 hour
	Humidity Exposure	Duration noted in Tables 2 & 3

An air-circulating oven is recommended for oven aging.

10.2 Salt Spray (Fog) Test – 2 panels

ASTM B117 Salt Spray testing shall be performed on scribed samples in accordance with ASTM D1654. At the completion of the exposure, the paint shall be free of appearance changes and pass the Tape X-cut Adhesion Test in accordance with ASTM D3359, Method A.

Galvanized panels shall be evaluated by means of Cycle/Scab NOT by Salt Spray testing.

10.3 Humidity Test – 2 panels

Humidity testing in accordance with ASTM D1735 shall be performed on two panels scribed in accordance with ASTM D1654. At the completion of the exposure, the test panels shall be allowed a ten minute recovery at 24° + 2° C and 50% + 5% Relative Humidity. The paint shall be free of blistering or other appearance changes and shall pass the Tape X-cut Adhesion Test in accordance with ASTM D3359, Method A.

For test durations longer than 500 hours, interim evaluations may be performed at 250 hour intervals. The interim evaluations shall be conducted in the same manner as the final evaluation at the completion of the exposure.

10.4 Water Immersion Test – 2 panels

Immerse two thirds of a painted test panel, scribed in accordance with ASTM D1654, in distilled water in accordance with ASTM D870. Maintain the water bath at 38° + 2° C. At the completion of the exposure, the test panels shall be allowed a ten minute recovery at 24° + 2° C and 50% + 5% Relative Humidity. The paint shall be free of blistering or other appearance changes and shall pass the Tape X-cut Adhesion Test in accordance with ASTM D3359, Method A. Report the final gloss reading per ASTM D523 within 24 hours of completion.

For test durations longer than 500 hours, interim evaluations may be performed at 250 hour intervals. The interim evaluations shall be conducted in the same manner as the final evaluation at the completion of the exposure.

10.5 Filiform Corrosion – 2 panels

Testing outlined in the Section is based on the procedures described in ASTM D2803, Procedure C.

Test panels shall be scribed in accordance with ASTM D1654 prior to the initiation cycle. The initiation cycle shall be 24 hours in a neutral salt fog (per ASTM B117). Following initiation, the panels shall be removed from the salt-fog cabinet and thoroughly rinsed with distilled water. Do not permit the panels to dry before placing them in the humidity cabinet. Panels shall be exposed in a humidity cabinet operating at 104°F ± 3°F and 80% ± 5% Relative Humidity. Panels shall be placed in the chamber so they are no closer than 1.5 inches and not in contact with any metal. The panels shall be

evaluated for filiform corrosion each week (during the weekly inspection the panels shall not be removed from the humid environment). Testing shall be conducted for three weeks.

Filiform corrosion will be noted as thread like filaments initiating at the scribe. The panels shall be evaluated immediately upon removal from the humidity cabinet at the conclusion of three weeks. Care should be taken as filiform will continue to develop after specimens are removed from the humid environment. When failures are observed they shall be documented as to the maximum length of filament observed and approximate count of filaments per inch of scribe length.

10.6 Ethylene Glycol Immersion Test – 2 panels

Immerse two-thirds of the painted panel in a 50-50 mixture by volume of ethylene glycol and water maintained at 23° ± 2°C for 96 hours. Immediately after removal, examine the surface for evidence of blistering. After a two hour recovery in ambient laboratory conditions, examine the surface for color change. The panel shall show no blistering or color change.

10.7 Engine Oil Immersion Test – 2 panels

Immerse two thirds of a painted panel in a bath of current production engine oil, maintained at 71° ± 2°C for 24 hours. After a one hour recovery period, the panel must pass the Pencil Hardness Test according to Section 9.7.

10.8 Diesel Fuel Immersion Test – 2 panels

Immerse two-thirds of the painted panel in diesel fuel maintained at 23° ± 2°C for 96 hours. At the end of the immersion period, the test panel shall show no evidence of peeling, blistering, or any other change of appearance. After a one hour recovery period, the panel must pass the Pencil Hardness Test according to Section 9.7.

Note: Due to the effects of aging, diesel fuel no older than 1 month from time of purchase must be used.

10.9 Cycle/Scab Test – 2 panels

Test panels shall be scribed in accordance with ASTM D1654 and cycled through the exposure detailed below. At the completion of the test, panels shall be evaluated in accordance with ASTM D1654.

Ten cycles consisting of:

1 hour	60°C in air circulating oven
1 hour	-20°C in cold cabinet
22 hours	Salt spray cabinet per Section 10.2
96 hours	4 cycles comprised of: 8 Hours: Humidity per Paragraph 10.3 16 hours: 55% relative humidity @ 23°C
48 hours	55% relative humidity @ 23°C

10.10 Weathering Exposure – up to 16 panels

Accelerated Outdoor Exposure Testing shall be conducted in accordance with ASTM D4141 on six panels. Exterior samples shall be sent to an approved outdoor exposure test facility in either Arizona and/or Florida, and exposed for thirty-six (36) months at 5° to the horizontal facing south (7 panels minimum). Interior panels shall be exposed in the same manner under glass.

Record initial gloss reading as appropriate for the range of the coating. Every six months, wash the bottom half of each test panel with a 1% detergent solution, rinse with clean water, dry with absorbent paper and record gloss. Remove one sample from testing. Do not wax or polish the panel.

Examine the panel with the unaided eye for evidence of peeling, blistering, chalking, cracking, or checking. Record surface condition and month of removal.

Gloss shall not vary by more than 10 points when compared to the initial recorded values. Panels shall be free of peeling or blistering. Chalking, cracking, and checking shall be evaluated and rated in accordance with ASTM D660, D661, and D4214 respectively. A minimum rating of 8 is allowable for chalking, cracking, and checking.

One test panel is removed every six months and returned to DTNA. A total of 8 panels shall be provided, six for exposure, one for comparison purposes by the testing facility and one retained by DTNA.

11 References

ASTM B117	Standard Method of Salt Spray (FOG) Testing
ASTM B209	Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate
ASTM D523	Standard Test Method for Specular Gloss
ASTM D609	Standard Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products
ASTM D660	Standard Test Method for Evaluating Degree of Checking of Exterior Paints
ASTM D661	Standard Test Method for Evaluating Degree of Cracking of Exterior Paints
ASTM D714	Standard Test Method for Evaluating Degree of Blistering of Paints
ASTM D870	Standard Practice for Testing Water Resistance of Coatings Using Water Immersion
ASTM D1308	Standard Test Method for the Effect of Household Chemicals on Clear and Pigmented Organic Finishes
ASTM D1654	Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D1735	Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
ASTM D2794	Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
ASTM D2803	Standard Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal
ASTM D3170	Standard Test Method for Chip Resistance of Coatings
ASTM D3359	Standard Test Methods for Measuring Adhesion by Tape Test
ASTM D3363	Standard Test Method for Film Hardness by Pencil Test
ASTM D4060	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D4138	Standard Practices for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive, Cross-Sectioning Means
ASTM D7091	Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals
ASTM D4141	Standard Practice for Conducting Black Box and Solar Concentrating Exposures of Coatings
ASTM D4214	Standard Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films
ASTM D5402	Standard Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs