



Topcoat, Generic Qualification

1 Scope

This specification details the minimum performance, compatibility and processing requirements for international approval of all exterior topcoats.

1.1 Material Description. Materials qualified to this standard shall meet the performance requirements shown in Appendix A, Table A1 for the specific topcoat type. Appendix A summarizes all requirements for material technology approval. Additional testing or any exceptions to the requirements may be directed by the GM approving engineer. Suppliers must demonstrate that the material technology is production capable via successful trial completion in an agreed upon paint facility prior to use for GM production parts or vehicles. Any material development performance issues or values that fall outside specified ranges must be discussed with the responsible topcoat materials engineer for resolution.

Note: Line trials may begin after 2 years of Florida exposure.

1.2 Symbols. Not applicable.

1.3 Applicability. This specification applies to all exterior topcoats for use on vehicles or parts supplied to GM. Topcoats and their performance levels are defined by classes and types.

1.4 Remarks. The topcoat type defines the requirements for test panel preparation, basic testing, compatibility testing and processability for use in a specific application. Table 1 defines the general topcoat types.

Table 1: Topcoat Type

Type	Usage
A	Rigid Body: Metallic Substrates, i.e., Steel or Rigid Composites with Flex Modulus of > 800 MPa
B	Rigid Parts: Composites with Flex Modulus of > 800 MPa, or Metallic Substrates
C	Flexible Parts: Composites with Flex Modulus of < 800 MPa

1.4.1 Topcoat Class. Table 2 defines the topcoat classes. The topcoat class defines durability, performance and appearance requirements. For this specification, durability is determined by weathering performance (Florida exposure and accelerated weathering tests). Performance is defined by environmental fallout and chemical resistance, scratch resistance and chip resistance. The appearance requirements are defined by GMW15777 appearance standards developed for each vehicle segment. Collectively, these characteristics determine if the material will perform to its intended function under specific conditions through its product lifecycle. Specific requirements are defined in Appendix A. If any of the criteria for a specific class is not met, the classification will be lowered to the appropriate class.

Table 2: Topcoat Class

	DURABILITY	ETCH (Jacksonville)	SCRATCH RESISTANCE	CHIP RESISTANCE	APPEARANCE
CLASS 1	After 5+ years exposure no loss of film integrity	0 - 5	50% Gloss Retention Opel Car Wash	OEM 8 REP 7	Horizontal R _z 9.0 - 8.5 Vertical R _z 8.0 - 7.0
	75% Polished gloss retention after 5 years				
	Color shift of ≤ 8.5 after 5 years				
CLASS 2	After 5 years exposure no loss of film integrity	5 - 7	50% Gloss Retention Opel Car Wash	OEM 8 REP 7	Horizontal R _z 8.5 - 8.0 Vertical R _z 7.0 - 6.5
	65% Polished gloss retention after 5 years				
	Color shift of ≤ 8.5 after 5 years				
CLASS 3	After 4 years exposure no loss of film integrity	7 - 8	50% Gloss Retention Opel Car Wash	OEM 8 REP 7	Horizontal R _z 7.5 - 7.0 Vertical R _z 6.5 - 6.0
	50% Polished gloss retention after 4 years				
	Color shift of ≤ 7 after 4 years				
CLASS 4	After 3 years exposure no loss of film integrity	8 - 10	40% Gloss Retention Opel Car Wash	OEM 7 REP 6	Horizontal R _z 7.5 - 7.0 Vertical R _z 6.5 - 6.0
	70% Polished gloss retention after 2 years				
	Color shift of ≤ 6 after 3 years				
CLASS 5	After 2 years exposure no loss of film integrity	> 10	30% Gloss Retention Opel Car Wash	OEM 6 REP 5	Horizontal R _z 6.0 - 5.5 Vertical R _z 5.0 - 4.5
	70% Polished gloss retention after 1 years				
	Color shift of ≤ 5 after 2 years				

Note: Line trials may begin after 2 years of Florida exposure on specific technology.

1.4.2 Topcoat Appearance. The material must meet or exceed requirements as defined in GMW15777, including specifications for gloss, Distinctness of Image (DOI), orange peel and uniformity. Provide a film build appearance curve that demonstrates the film build required to achieve the optimum appearance.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM D125	ASTM E1356	ISO 2811	ISO/TS 16949
ASTM D1474	EN ISO 2431	ISO 3251	SAE J2527
ASTM D1921	ISO 1148	ISO 6504-3	
ASTM D3960	ISO 2808	ISO 6603	

2.2 GM Standards/Specifications.

9984801	GMW14700	GMW15187	GMW15919
GMW3008	GMW14701	GMW15431	GMW16569
GMW3011	GMW14729	GMW15433	GMW16639
GMW3059	GMW14829	GMW15545	GMW16745
GMW3368	GMW14865	GMW15581	GMW16746
GMW14124	GMW14873	GMW15777	GMW17434
GMW14333	GMW15119	GMW15891	

2.3 Additional References.

ACT Test Panels, Hillsdale, Michigan, USA

3 Requirements

3.1 Submission Letter. Prior to qualification testing, the supplier must submit a letter to the appropriate region (GME, GMNA, GMB, GMK (and GM Holden, if applicable)) with the following information:

- Purpose of the submission

- Description of the topcoat technology chemistry and status
- Comparison to current approved technologies
- Manufacturing site of origin
- History of product evolution
- Key data for evaluating environmental impact, e.g., completed Environmental Assessment Form (EAF)
- Product codes
- Approval center/target plants(s)

3.2 Submission Package. All data and documentation generated during the material development must be included and approved by the responsible engineer. An electronic copy must be prepared and distributed to the responsible engineer of the approving region(s). The documentation is to be in English and the local language of the lead GM region.

3.2.1 Material Identification. All paint layers used in the submission must be identified by product code, batch number and batch date. Color name, WAXXXX and Black and White hiding must be included where appropriate. All related paint materials used for compatibility tests must also be identified in the same manner. All substrates used must be identified by source, product code and part number where appropriate.

3.2.2 Process Identification. A baseline and target range for film build and bake must be established prior to the submission. Actual target and range will be finalized after full evaluation of film build and cure interactions are determined. Application equipment and spray parameters used for the submission must be documented. Target and variance for mix ratio of two-component (2K) materials must be evaluated.

3.2.3 Reprocess System. At the time of the submission, the supplier must provide a recommended reprocess system for the main paint off-line and final line reprocess areas for approval of Type A materials only.

3.2.4 Product Information. The product information in Table 3 must be submitted for all components. Data must be provided as a range for shipped and as-applied in production. Basecoat information is required for the four (4) color families: Black, White, Light Metallic and Medium Red Metallic. Typical film build ranges must be provided (GMW17434). All reducing solvents used in the technology approval must be identified.

Table 3: Product Information Required

Product Information	Test Reference
Formula volume solids	Theoretical calculation per ISO 2811
Formula weight solids	Theoretical calculation per ISO 2811
Formula VOC (without water)	Theoretical calculation
Formula VOC (with water)	Theoretical calculation
Analytical weight solids	ISO 3251
Analytical VOC: 110 °C (230 °F) (without water)	ASTM D3960
Analytical VOC: 110 °C (230 °F) (with water)	ASTM D3960
Viscosity – Cup	Ford 4 or EN ISO 2431 cups
Viscosity – Profile	Document method used
Resistivity	ASTM D125
pH (Waterborne)	ISO 1148
Particle size distribution	ASTM D1921
Black/White hiding ^{Note 1}	Per hiding chip or ISO 6504-3
Glass transition temperature	ASTM E1356
Density	ISO 2811

Note: VOC = Volatile Organic Compound.

Note 1: Black/White hiding must be reported only if a new monocoat/basecoat is being submitted. If so, each color must be submitted.

3.2.5 Formulating Range. The formulating range (design matrix) for all ingredients (i.e., resins, pigments, additives, etc.) must be developed and available as part of the submission package.

3.2.6 Infrared Chemical Fingerprint. The supplier must provide an infrared chemical fingerprint as part of the submission package for four (4) colors (White, Medium Red Metallic, Light Metallic and Black) at target film build and bake. Infrared (IR) spectra established for initial approval is a reference standard. After approval, all materials supplied under the material code must match the initial chemical fingerprint. GM may conduct infrared spectrophotometry analysis of the materials approved to this specification at any time.

3.2.7 Ultraviolet/Visible Transmission through Cured Paint Film (GMW15545). Panels must be prepared as a system per the conditions in Table 4 and processed at target bake on the four (4) core technology colors: White, Medium Red Metallic, Light Metallic and Black. Prepare a set of panels per the conditions in Table 5 processed at target bake with the four (4) core technology colors for information only. Data shall be the following:

- $\leq 0.05\%$ transmission from 290 N•m to 390 N•m
- Straight line from 0.05% transmission at 390 N•m to 0.10% transmission at 430 N•m
- Straight line from 0.10% transmission at 430 N•m to 0.80% transmission at 500 N•m

Table 4: Film Build for Preparation of Ultraviolet (UV) Test Samples

A		B		C	
CONVENTIONAL		INTEGRATED PROCESS		MONOCOAT	
BAKED PS + BC + CC	FILM BUILD	BCP + BC + CC	FILM BUILD	BAKED PS + MC	FILM BUILD
1) PRIMER (PS)	Note 2	1) PRIMER (BCP)	Note 2	1) PRIMER (PS)	Note 2
- Waterbase	0.60	- Waterbase	0.60	- Waterbase	0.60
- Solventbase	0.80	- Solventbase	0.7	- Solventbase	0.80
- Powder	1.80			- Other	Technology specific
2) BASECOAT (BC)		2) BASECOAT (BC)		2) MONOCOAT (MC)	
- Waterbase	Note 1	- Waterbase	Note 1	- Waterbase	Note 1
- Solventbase	Note 1	- Solventbase	Note 1	- Solventbase	Note 2
3) CLEARCOAT (CC)	Note 3	3) CLEARCOAT (CC)	Note 3		
- 1K	1.50	- 1K	1.50		
- 2K	1.50	- 2K	1.50		

Note: 1K = One-component, 2K = Two-component, BC = Basecoat (all – conventional, three (3) wet and monocoat), BCP = Basecoat Primer (three (3) wet), CC = Clearcoat, PS = Primer surfacer (conventional bake), MC = Monocoat.

Note 1: Film build to be a minimum of color and appearance range per color, as specified by the GM color development engineer.

Note 2: If a new primer technology or primer color is used, prepare a primer wedge sample and hold the basecoat and clearcoat to the minimums shown in Table 4.

Note 3: If a new clearcoat technology or clearcoat color is used, prepare a clearcoat wedge sample and hold the primer and basecoat film builds to the minimum shown in Table 4.

Table 5: Sample Preparation for Individual Layers

Film Build
Color Minimum Note 1
38 μm (1.5 mil) Note 1 and 25 μm (1.0 mil)
Color Minimum BC + 38 μm (1.5 mil) CC Note 1
Color Minimum BCP or 20 μm PS (0.8 mil) CC Note 1 + Color Minimum BC Note 1
Color Minimum Note 1

Note 1: Film build as recommended by the appropriate GM engineer.

3.2.8 Odor Characteristics (GMW16639). The material's odor potential must be compared with that of a current production material for White, Medium Red Metallic, Light Metallic and Black at target film build and bake. Any solvent changes for plant-specific implementation must be reviewed to determine if retesting is required.

3.2.9 Bulk Material - Production Part Approval Process (PPAP) Requirements. Product approval is required under established guidelines outlined in ISO/TS 16949. At product approval, the supplier is expected to have reviewed to GM's satisfaction, specific documentation outlined in Advanced Product Quality Planning (APQP), i.e., Product Design Failure Mode and Effects Analysis (DFMEA); Process Failure Mode and Effects Analysis (PFMEA); Key Product Characteristics (KPC); Key Control Characteristic (KCC); Measurement Systems Analysis (MSA); and Manufacturing Control Plans. Specific requirements are to be determined by region.

3.3 Test Requirements. Appendix A outlines the complete test requirements for new technology submissions. For modifications outside the formulation limits of a previously approved technology, testing may be added or deleted by the responsible topcoat engineer.

3.3.1 Test Panel Requirements.

3.3.1.1 Sample Size. The number of samples for each test shall be one (1) per color for all tests except chip, which shall be three (3) per color unless otherwise specified by the responsible engineer. All substrates, pretreatments and coating layers shall be fully identified with source, product code, batch number, bake description and film build.

3.3.1.2 Test Substrates. Test substrates to be used are determined by the topcoat type. Table 6 outlines the typical substrates used. Other substrates may be selected as confirmed by the responsible engineer.

Table 6: Test Substrates ^{Note 1}

Topcoat Type	Substrate Type	Substrate Specification
A	Cold Rolled Steel	U.S.: ACT Test Panels, Hillsdale, Michigan, USA
B	ABS + PC (if target bake ≤ 80 °C) or Cold Rolled Steel (if target bake > 80 °C)	GMW15581 (U.S.: ACT Test Panels, Hillsdale, Michigan, USA)
C	Thermoplastic Olefin (TPO)	GMW15187

Note: ABS = Acrylonitrile Butadiene Styrene, PC = Polycarbonate.

Note 1: Other substrates may be selected per engineering agreement.

3.3.1.3 Composite substrates power washing per 9984801 or appropriate cleaning agent must be used for cleaning all composite substrates.

3.3.1.4 Pretreatment Coating for Metallic Substrates. All metallic substrates must be phosphated per a GMW3011 approved phosphate system and E-coated (electrocoated) with an approved GMW3008 electrodeposition (ELPO) primer. Generic test panels such as ACT panels may be used where appropriate, per agreement with the responsible engineer.

3.3.1.5 Topcoat Paint Application. All test materials must be sprayed at the target application viscosity. Target spray non-volatiles, density (weight per liter or weight per gallon), viscosity and reduction solvent will be established by agreement with the responsible engineer before testing begins. Control samples must be sprayed at production viscosity and with production reducers.

3.3.1.5.1 Topcoat Test Colors Families. New topcoats shall be qualified with four (4) colors:

- White
- Light Metallic
- Medium Red Metallic
- Black

The specific WAXXXX numbers, as defined by the responsible engineer, must be reported. The supplier must demonstrate color match capability to the four (4) test colors as well as any defined premium colors. The color match will be reviewed and approved by the responsible color engineer prior to the start of any testing.

3.3.1.5.2 Film Thickness (ISO 2808). Specific film builds are established by initial screening and agreement with the responsible engineer and are to meet all appearance and performance criteria of this specification. Film build is characterized by the following:

T = Target

L = Low film build

H = High film build

The T, L and H will vary by technology. When preparing test panels, use Appendix A to determine the film build requirements for each test.

3.3.1.5.3 Bake. Bake is defined as the time the substrate is at the target temperature. Document oven type used (for testing performed in North America, gas-fired ovens shall be utilized). Panel temperature must be monitored with thermocouples or thermistors using a Datapaq or agreed upon equivalent to ensure that test panels are processed at specified times and temperatures.

Note: Oven loading and panel position may affect actual cure.

3.3.1.5.4 Target Bake Definition. A target bake must be identified by the supplier such that the topcoat meets all appearance and performance criteria over a minimum range of film build, time and temperature (basic box). The size of the box and the upper/lower limit temperature variance from target will be dictated by the type of technology. The requirements to define the lower limit (LL) and upper limit (UL) temperatures are defined in Table 7. All deviations from this minimum performance window must be discussed with the responsible engineer prior to test initiation.

Table 7: Table Definitions

Symbol	Description	Time (Minutes) ^{Note 1}	Temperature (°C)	Temperature (°F)
T	Target	t	T	T
LL	Lower Limit	T - 5	T - 5	T - 10
UL	Upper Limit	T × 4	T + 15	T + 25

Note 1: Bake time (t) must be compliant per GM Bill of Process as defined by the responsible GM engineer.

3.3.2 In-line Reprocess Panel Preparation. All in line reprocess panels shall be prepared over first coats which have low film and UL bake temperatures unless otherwise specified. Recoats must be applied within 24 h after each topcoat bake. Document the time between bakes. Basic reprocess adhesion should be evaluated without sanding unless otherwise stated. The responsible engineer should be consulted immediately if sanding is required so that long-term weathering tests and process controls can be appropriately established.

3.3.3 Final Line Reprocess Preparation. All final line reprocess panels shall be prepared over first coats which have low film and UL bake temperatures unless otherwise specified. Recoats must be applied within 24 h after each topcoat bake. Document the time between bakes. Panels must be reprocessed and tested in two (2) ways unless specified by the responsible engineer.

3.3.3.1 Spot Reprocess.

- See Appendix A for specific testing requirements where P = Panel reprocess and S = Spot reprocess.
- Use a 10 cm × 30 cm (4 in × 12 in) panel and scuff sand 7.5 cm × 30 cm (3 in × 12 in) down the side of the panel, leaving a 2.5 cm × 30 cm (1 in × 12 in) strip unsanded. Apply a wedge of basecoat/monocoat from 5 µm (0.2 mil) to target film, starting at the bottom of the panel with 5 µm (0.2 mil). Apply a wedge of clearcoat from 5 µm (0.2 mil) to target film, starting at the bottom of the panel with 5 µm (0.2 mil).

3.3.3.2 Panel Reprocess. Divide the panel into two (2) sections horizontally. Sand ½ of the Original Equipment Manufacturer (OEM) panel with 600 grit paper (or equivalent). Recoat with a uniform film of reprocess BC/CC. Minimum basecoat/monocoat film is the minimum for a specific color based upon workability and ultraviolet transmission. The minimum clearcoat film is 38 µm (1.5 mil) unless otherwise specified.

3.3.4 Conditioning. All test samples shall be subject to an aging period of at least 72 h at room temperature 23 °C ± 5 °C (73 °F ± 9 °F) and 50% ± 5% relative humidity following the bake cycle prior to testing unless defined otherwise by the responsible engineer.

3.3.5 Control Materials. Control panels are required for all tests as designated by the responsible engineer. Control materials are to be current, approved production materials. The specific material used as the control will be established by the responsible engineer when the test program is initiated. The supplier is expected to incorporate procedures into all programs to ensure that the right material and processes are used during panel preparation, that testing equipment is properly calibrated and run, and that any unusual defects on outdoor exposure panels can be demonstrated to be an unusual weathering incident.

3.4 Bake Chart Creation. Utilizing an approved statistical software tool, develop a 3 × 3 Design of Experiment (DOE) (nine (9) points) utilizing bake time and bake temperature as variables to provide an estimation of a quadratic response surface model. Checkpoints (2 × 2 DOE, four (4) points) must be used to verify the quadratic model and augment the 3 × 3 design to allow an estimation of a cubic response surface model (see Figure 1 for an example). The bake time has a total of five (5) levels non-linearly distributed to allow for the non-linearity of reaction kinetics. Suggested levels are 10, 20, 30, 70 and 130 minutes. Confirmation points must be used to