Analysis of GM and CAPA Certified Grand AM Hoods & Fenders

Comparison of Fit, Finish, Materials, & Assembly Characteristics

February 18, 2002

Tests conducted by General Motors Senior Quality Engineer and
General Motors Metal Fabrication Division Metallurgist

A. Objective

The purpose of this report is to document our work in analyzing non-OEM hood assemblies and fenders against the standards and specifications General Motors Corporation ("GM") requires for its production and service products. The specimen hood assemblies and fenders analyzed in this report are for the 1999-2001 Pontiac Grand Am.

In particular, we have objectively analyzed measurable features of CAPA certified hoods and fenders. This evaluation compares fit, finish, material, and assembly characteristics on GM and CAPA Certified Parts. This report will compare the differences in quality between CAPA certified parts and the OEM products produced by GM. We will also determine if the products labeled as "CAPA Certified Parts" meet the same specifications as the OEM parts produced by GM.

B. Summary of Findings

In summary, our findings are that the CAPA Certified Parts tested do not meet the same requirements as the OEM products produced by GM. The CAPA Certified Parts tested are of inferior quality and would be deemed unacceptable to provide to our OEM production and service customers.

Dimensional (pages 3 - 8) - The CAPA certified hoods and fenders display unacceptable fit conditions when placed on the checking fixtures used to compare products to the design and specification requirements for the GM hoods and fenders. The CAPA products averaged 33.9% out-of-specification for the probe checks on the certified GM OEM checking fixture.

Assembly – Welds, Adhesives and Components (pages 8 - 11): **Welds:** The CAPA certified hood assemblies have insufficient weld integrity when compared to the GM specification. On average, the percentage of discrepant welds on the CAPA hood assemblies was 23.7%. **Adhesive and Mastics:** The mastic contact on the CAPA Hoods averaged 29.6% below GM specifications.

The CAPA certified hood assemblies were produced without adhesive between the hem. GM specifies and produces its hood assemblies with a two part adhesive that is applied to the full periphery of the hood outer panel before marriage with the inner assembly and hemming. **Components**: CAPA hood #9 exhibited different, smaller weld nuts (vs. GM specified), and hood hinge reinforcements were of different construction compared to the GM hood.

Appearance (pages 11 - 13) - The surface quality on the CAPA products is inferior compared to the surface quality on the GM products. Numerous surface defects were identified including buckles, creases, highs/lows, etc.

Material (pages 13 - 15) - The steel strength of the formed CAPA parts is below GM standards for unformed sheet steel strength. Forming, or stamping, typically increases strength 15-25%. Material strength and hardness testing revealed that the GM OEM hood is ~40% stronger and 80% harder than the CAPA Certified Hood. Chemical analysis of the CAPA hoods shows that they are merchant quality, ultra low carbon, interstitial free (IF) grade steel. The CAPA parts are not bake hardenable steel grades as defined and specified by GM Engineering.

Dent Resistance (page 15 - 16)- The bake hardening alloy combined with thermal processing increases the dent resistance of the product. Static Dent Tests were performed to the SAE standard (J2575) at US Steel on the CAPA #11 hood and the GM OEM hood at the exact same locations on the panel. The CAPA part does not meet the engineering specification, performing at only 13% of the OEM hood in one critical location, and on average it is performing at 42% of the OEM hood. This test dramatically shows the benefit to the customer of the bake hardenable steel used in the GM OEM part.

Coating (pages 16 - 18) – As compared to the GM OEM part, both the #9 and #10 CAPA hoods have _ the thickness of electrocoat primer (ELPO) on the outer surface and _ the thickness on the inner surface. The #10 CAPA hood outer has 24% less zinc galvanized coating on the outside and 32% less zinc galvanized coating on the inside and does not meet the GM Engineering minimum requirement. Out of specification coatings were also noted for both ELPO and galvanized coatings on all the fenders tested. Reduced thickness in electrocoat primer and galvanized coatings can be expected to significantly reduce long term corrosion performance.

C. Description of the Specimen CAPA Certified Hoods and Fenders Used in Analysis

The CAPA certified parts were obtained from an independent GM dealership and Campbell & Co., Dearborn, MI. All parts were handled and stored in the original packaging/box as received until analysis. The products obtained are identified on the following table. Reference to each specific product will be to the "sample #", throughout the remainder of this report.

PRODUCT IDENTIFICATION					
Sample #	**Part Name**	**Application**	**Source Indicated on Box**	**Source Indicated by CAPA**	**CAPA Seal #**
1*	RH Fender	Grand AM '99-'01	Tong Yang Group - Kai Yih	N/A	N/A
2	RH Fender	Grand AM '99-'01	Jui Li Enterprise Co. LTD.	Jui Li Enterprise Co. LTD.	18052864
3	RH Fender	Grand AM '99-'01	Jui Li Enterprise Co. LTD.	Jui Li Enterprise Co. LTD.	18052742
4	RH Fender	Grand AM '99-'01	Jui Li Enterprise Co. LTD.	Jui Li Enterprise Co. LTD.	18052765
5	LH Fender	Grand AM '99-'01	Jui Li Enterprise Co. LTD.	Jui Li Enterprise Co. LTD.	18052623
6	LH Fender	Grand AM '99-'01	API	Jui Li Enterprise Co. LTD.	18052556
7	LH Fender	Grand AM '99-'01	API	Jui Li Enterprise Co. LTD.	18052548
8	LH Fender	Grand AM '99-'01	API	Jui Li Enterprise Co. LTD.	18052505
9	Hood	Grand AM '99-'01	Jui Li Enterprise Co. LTD.	API	17496355
10	Hood	Grand AM '99-'01	API	API	17260612
11	Hood	Grand AM '99-'01	API	API	17260611

* Note: Sample # 1 is a non-OEM product that is not identified/labeled as a CAPA Certified Part.

D. Applicable GM Part Numbers

- The GM part number for the comparable LH Grand Am fender is 22620459.
- The GM part number for the comparable RH Grand Am fender is 22620458.
- The GM part number for the comparable Grand Am hood assembly is 22603354.

E. Test Procedures, Data, and Results

1. Fit on GM Certified Checking Fixture

The CAPA certified hoods and fenders were reviewed on January 8, 2002 at the Lansing MFD plant where the corresponding GM hoods and fenders are produced. The CAPA certified parts were placed on the certified GM OEM checking fixtures used for product monitoring during production. The checking fixtures are used to verify dimensional conformance of Key Product Characteristics (KPC) and Process Monitoring Points (PMP), which measure items such as gaps and contours. The discrepancies observed for the CAPA certified products are as follows.

Summary of Checking Fixture Results for Dimensional Evaluation

PRODUCT IDENTIFICATION		CHECKING FIXTURE FINDING		
Sample #	**Part Name**	**Total Number of Probe Checks (KPC & PMP)**	**Quantity of Probe Checks Out-Of-Spec.**	**Percentage Out-Of-Spec.**
2	CAPA RH Fender	20	7	35.0
3	CAPA RH Fender	20	7	35.0
4	CAPA RH Fender	20	4	20.0
5	CAPA LH Fender	20	4	20.0
6	CAPA LH Fender	20	3	15.0
7	CAPA LH Fender	20	5	25.0
8	CAPA LH Fender	20	4	20.0
9	CAPA Hood	26	14	53.8
10	CAPA Hood	26	12	46.2
11	CAPA Hood	26	14	53.8
	Totals:	**218**	**74**	**33.9**

In addition to the discrepancies indicated by the above data table, the following deficiencies were also identified during the review utilizing the checking fixtures.

- Excessive gap at lower front of CAPA Fender # 5 (Reference Figure 1-A & 1-B)
- Nose not flush (high/outward with respect to mating component) on CAPA Fender # 6 (Reference Figure 1-C)
- Not flush along door-line (inward with respect to mating component), at rear of CAPA Fender # 7 (Reference Figures 1-D, 1-E, & 1-F)
- On the checking fixtures, most of the CAPA fenders required some extra force to clamp the part into car position. For example, the rear bottom section of CAPA Fender # 2 was forced down into position (Reference Figure 1-G)
- Not flush at upper rear section (inward with respect to mating component) on CAPA Fender # 2 (Reference Figure 1-H)
- Not flush at rear (outward with respect to mating component), along door-line on CAPA Fender # 3 (Reference Figure 1-I)
- Not flush at upper rear section (inward with respect to mating component) on CAPA Fender # 8 (Reference Figure 1-J)
- Nose not flush (high/outward with respect to mating component) on CAPA Fender # 8 (Reference Figure 1-K)
- Severely bent front corner (nose) on Fender # 1 (Reference Figure 1-L). This condition prevented part from fitting on the checking fixture, thus no data was collected. Because of severity, with no obvious primer disturbance, damage is suspected to have occurred prior to primer.

- All three CAPA hoods were high across the front, creating an unacceptable gap, on the driver side (Reference Figures 1-M & 1-N for CAPA Hood # 10; Figures 1-O & 1-P for CAPA Hood # 9; Figure 1-Q for CAPA Hood # 9)
- All three CAPA hoods were high at areas along the passenger side edge (Reference 1-R for CAPA Hood # 9)

Note that greater visual gap and contour discrepancies exist between some of the probe checks.

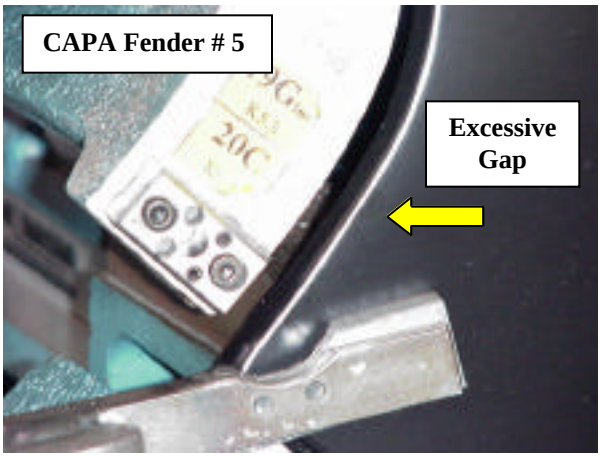


Figure 1-A

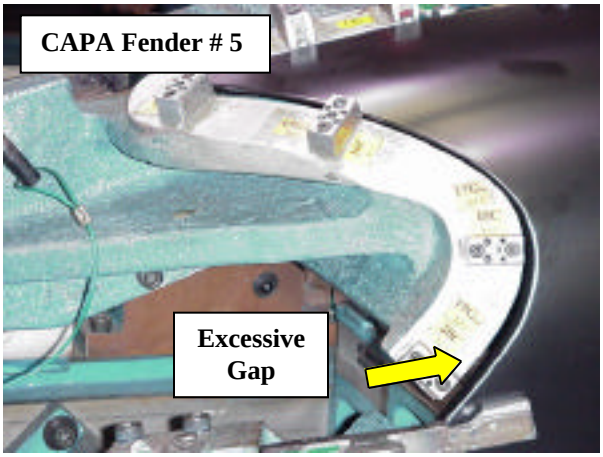


Figure 1-B

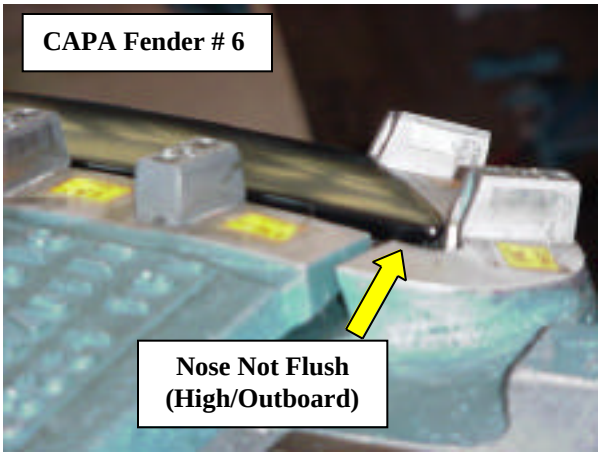


Figure 1-C

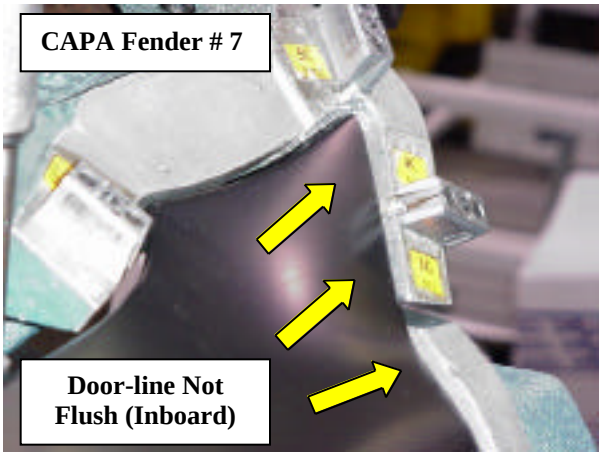


Figure 1-D

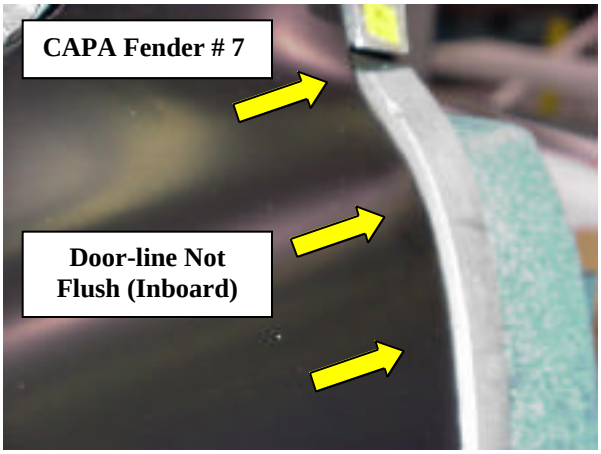


Figure 1-E

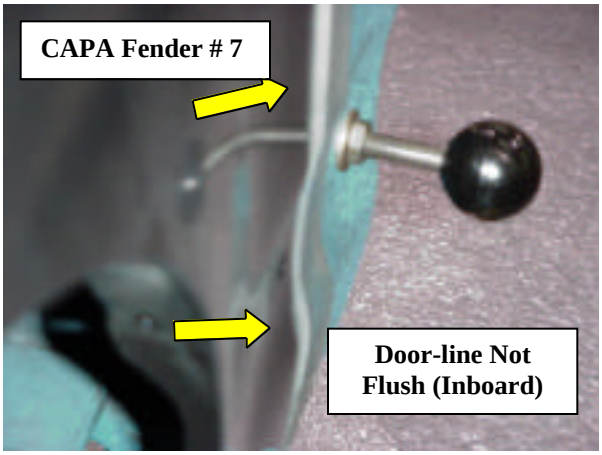


Figure 1-F

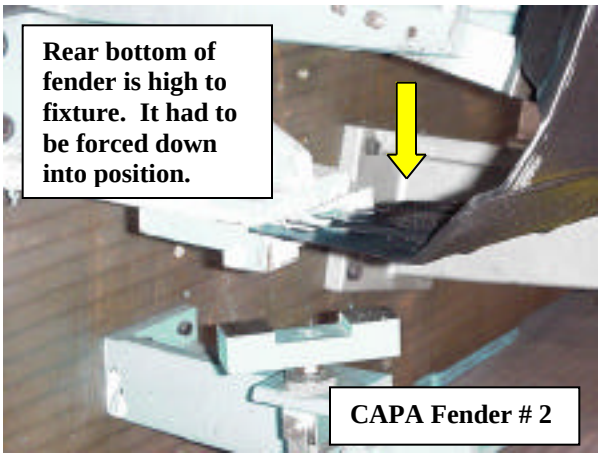


Figure 1-G

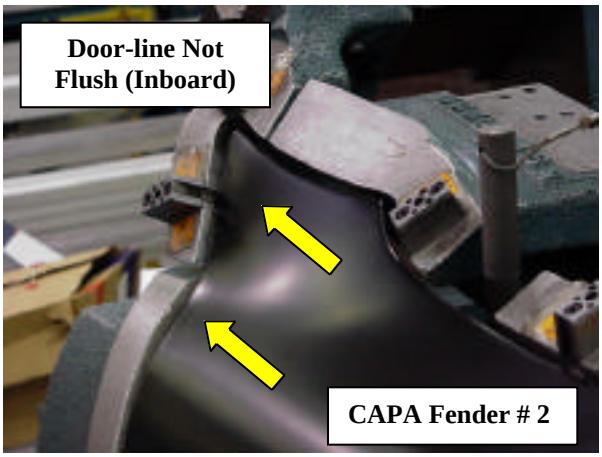


Figure 1-H

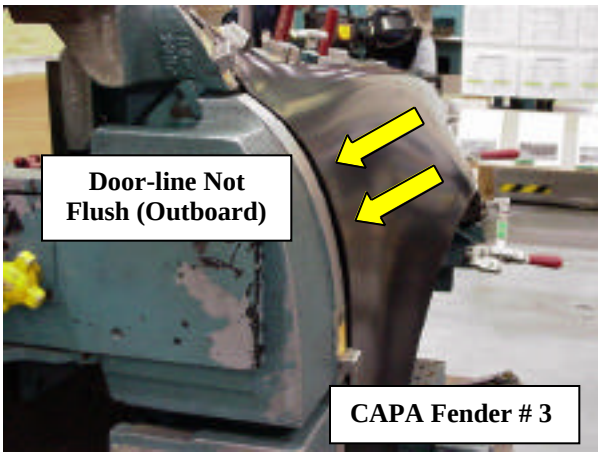


Figure 1-I

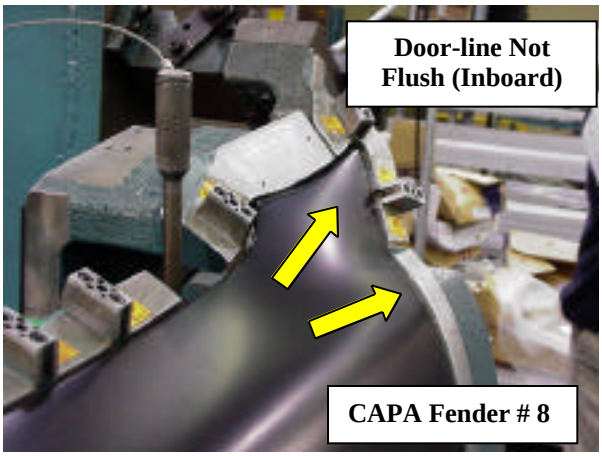


Figure 1-J

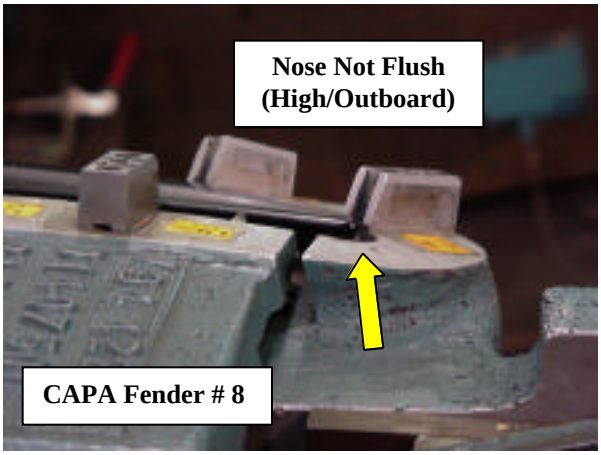


Figure 1-K

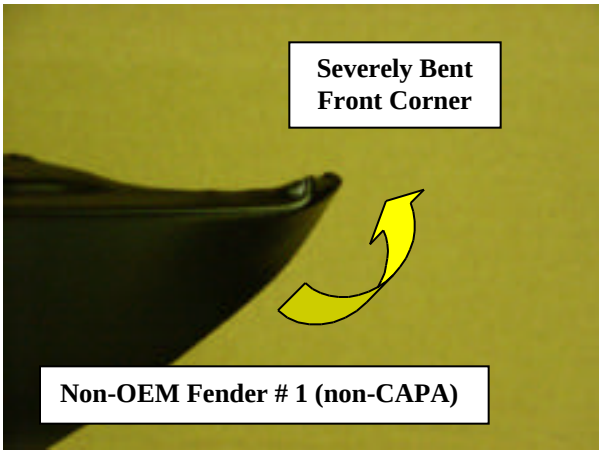


Figure 1-L

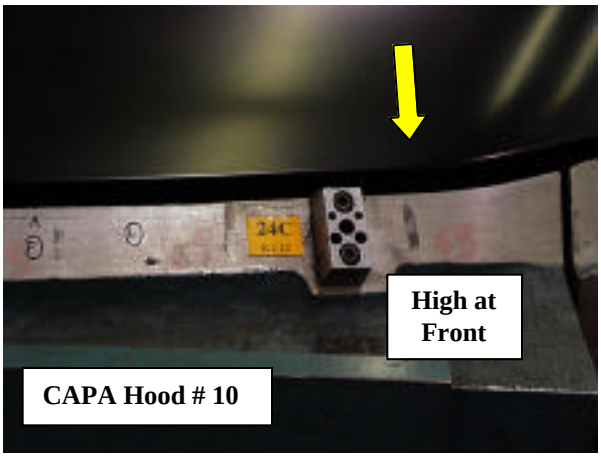
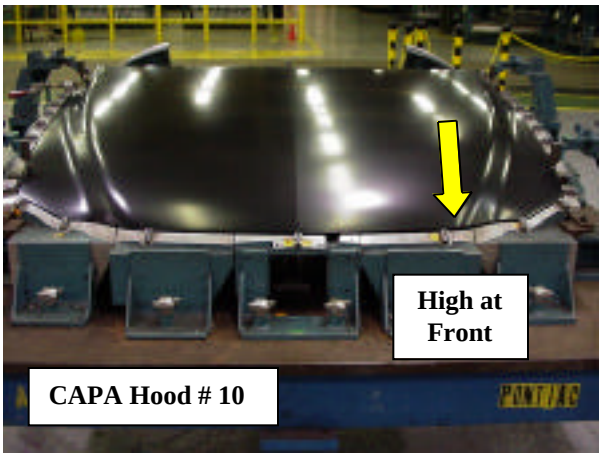


Figure 1-M



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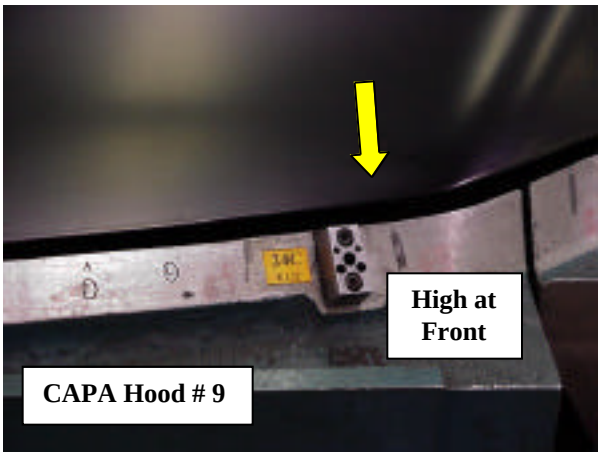


Figure 1-O

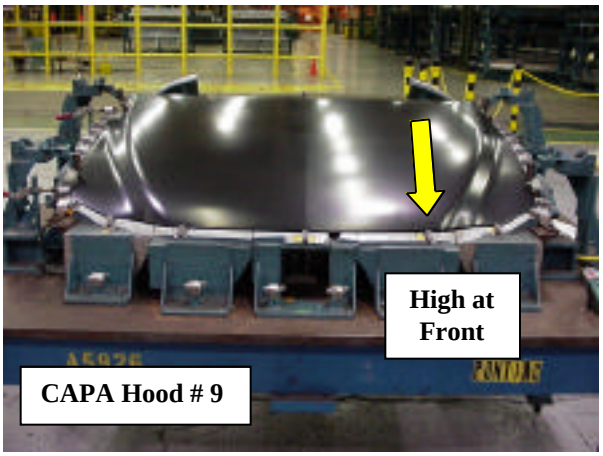


Figure 1-P

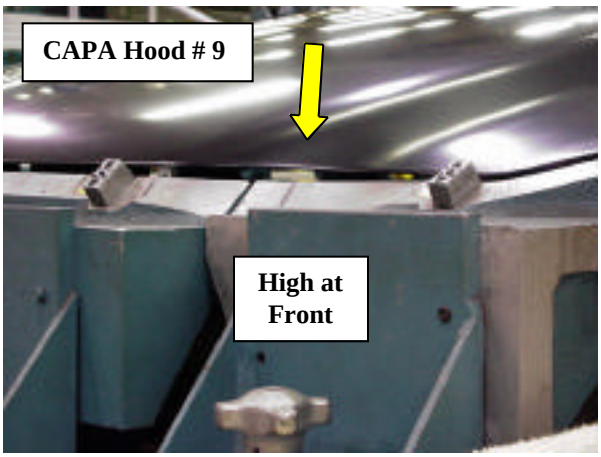


Figure 1-Q

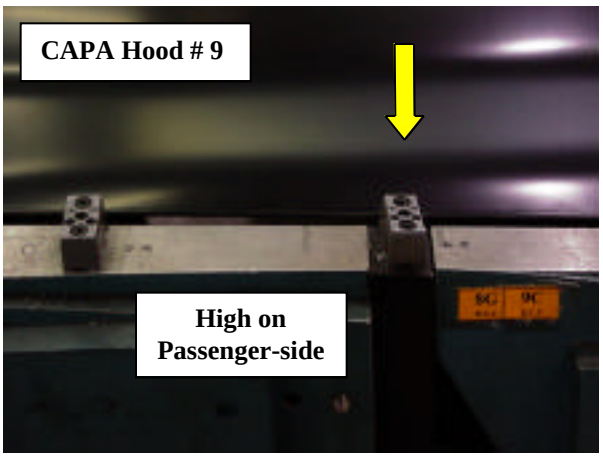


Figure 1-R

2. Hood Assembly Comparison- Adhesive and Welds

Two CAPA hood assemblies were disassembled to compare the assembly and components to those specified and used by GM. This evaluation included a comparison of the mastic and welds. The following differences are noted:

PRODUCT IDENTIFICATION		MASTIC COMPARISON		
Sample #	**Part Name**	**Total Contact Length of all Stitches Required on GM Hood Outer Panel**	**Total Contact Length Present on CAPA Hood Outer Panel**	**% Contact Below Specification on CAPA Hood Outer**
9	CAPA Hood	3120 mm	1939 mm	37.8%
10	CAPA Hood	3120 mm	2452 mm	21.4%
	Totals:	**6240 mm**	**4391 mm**	**29.6%**

PRODUCT IDENTIFICATION		WELD COMPARISON		
Sample #	**Part Name**	**Specified Welds Required on GM Hood Assembly per GM4488M**	**Total Number of Discrepant Welds on CAPA Hood Assembly Compared to GM Spec.**	**Percentage of Discrepant Welds on CAPA Hood Asm., Compared to GM Spec.**
9	CAPA Hood	19	7	36.8%
10	CAPA Hood	19	2	10.5%
	Totals:	**38**	**9**	**23.7%**

In addition to the discrepancies indicated by the mastic and weld data, the following issues were also observed during the assembly comparison review.

- CAPA hood # 9 used different, smaller weld nuts on the Hood Primary Latch Striker Reinforcement, compared to those specified & used on the GM hood (Reference Figure 2-A)
- Hood Hinge Reinforcements were of different construction, having welded inserts at the threaded attachment points on all three CAPA hood assemblies, compared to the extruded reinforcements specified & used on the GM hood (Reference Figure 2-B)
- Hem Periphery Adhesive was absent between the entire hem on the CAPA hood assemblies disassembled (# 9 & # 10) (Reference Figure 2-C which shows a separated inner & outer panel and Figure 2-D which shows an outer panel with the opened hem)
- Anti-Flutter Mastic was not present in the same locations and proportions, as compared to the application placement on GM products. This was discovered on the disassembled CAPA hoods # 9 & # 10. (Reference Figures 2-E, 2-F, & 2-G)
- A caulk-like substance was present over the hem, near the front, on all three CAPA hood assemblies (Reference Figures 2-H, 2-I, & 2-J). Note: This type of substance is not specified, nor present on the current GM hood.
- A Caulk-like substance was present on the top surface, at the rear on CAPA hood # 9. The substance appears to be the same material present on the front hem (Reference Figure 2-K)
- Rough primer was present at the rear corners on the CAPA hoods (Reference Figure 2-L for CAPA hood # 10)

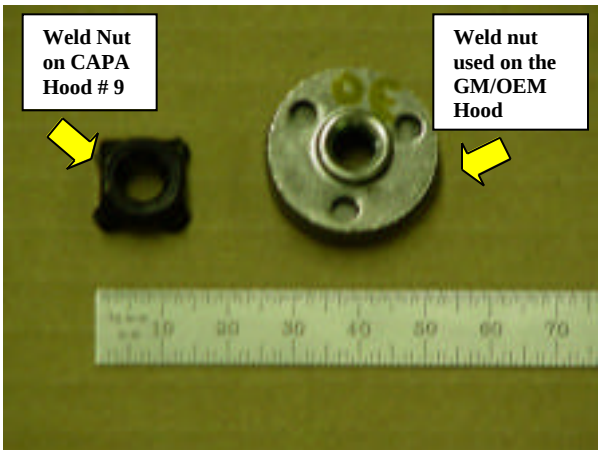


Figure # 2-A

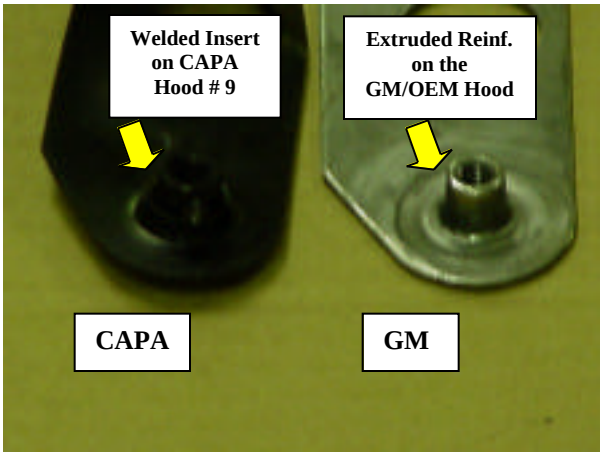


Figure # 2-B

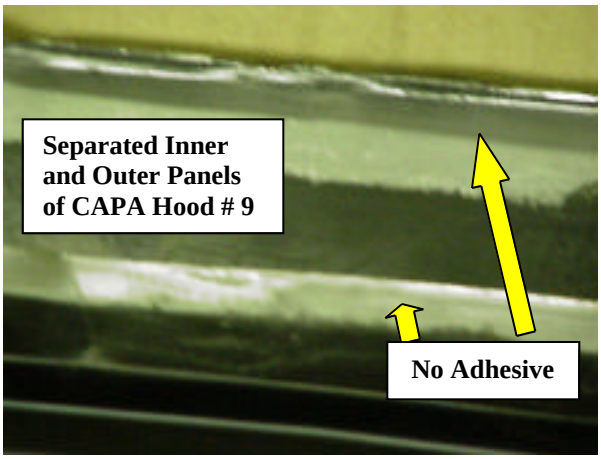


Figure # 2-C

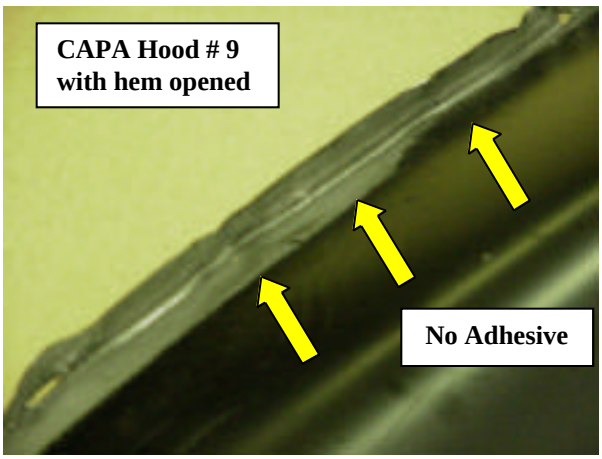


Figure # 2-D

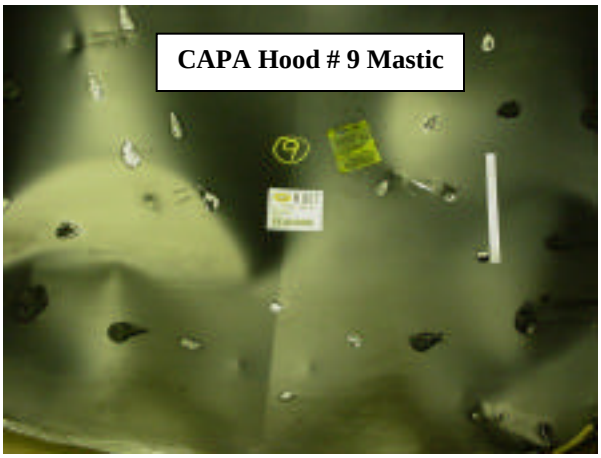


Figure # 2-E

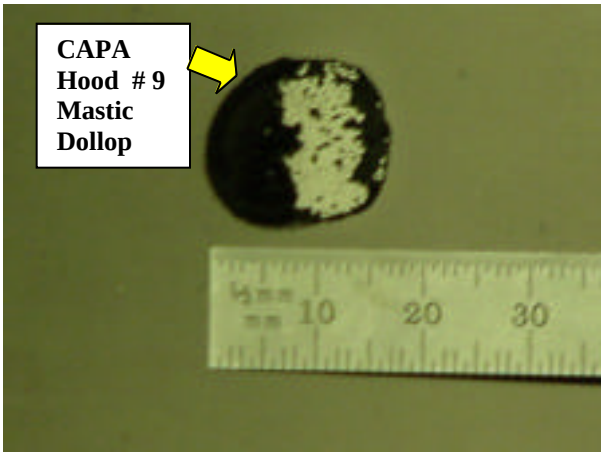


Figure # 2-F

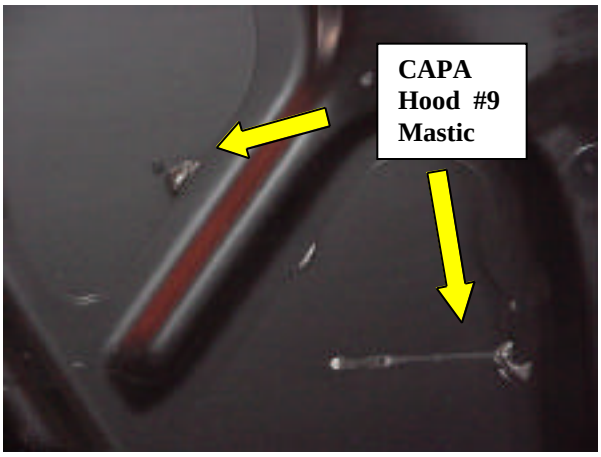


Figure # 2-G

Figure # 2-H

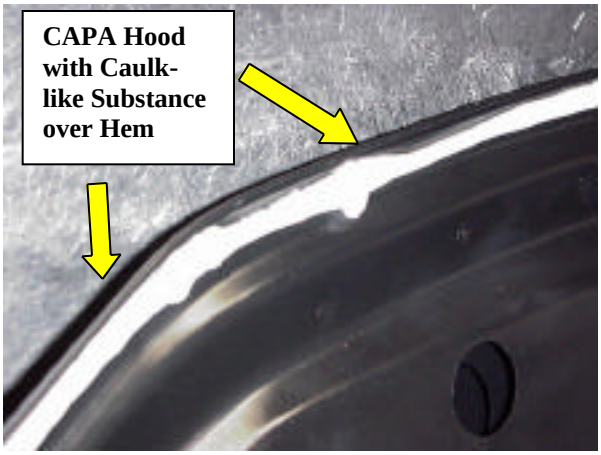


Figure 2-I

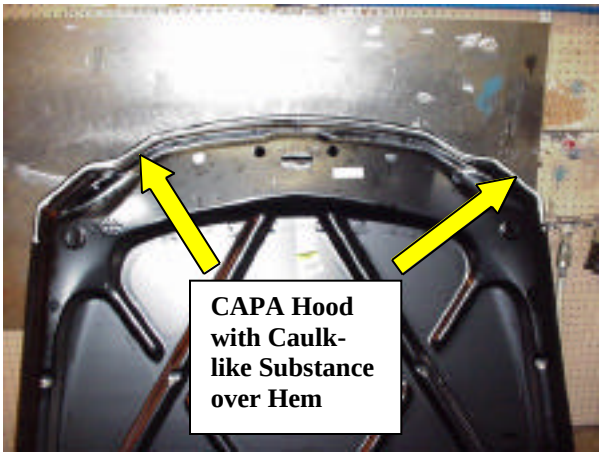


Figure 2-J

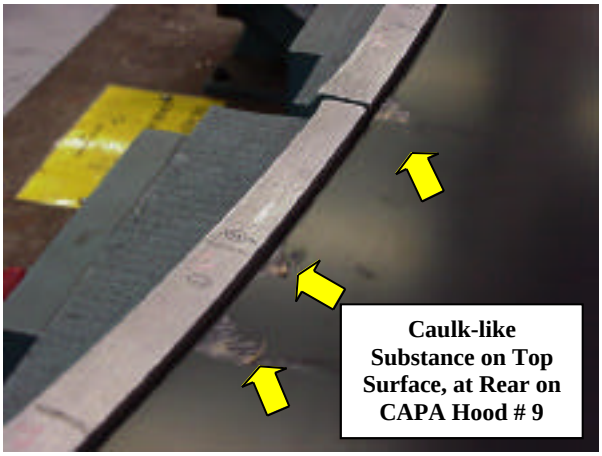


Figure 2-K

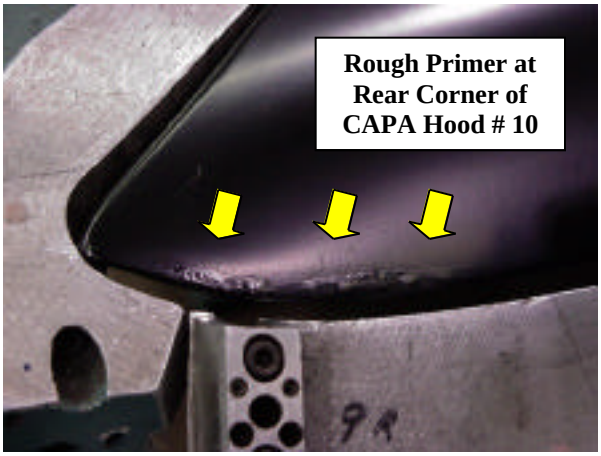


Figure 2-L

3. Surface Quality Check- Hoods And Fenders

Surface quality was reviewed on the CAPA certified products at Lansing MFD on January 8, 2002. The CAPA hood assemblies and fenders were placed in a lighted inspection room to identify surface issues that are not present on the GM products. The inspectors who regularly monitor the GM products were asked to identify surface quality issues that would be unacceptable on the GM products. In this review, many different types of discrepancies were observed. The surface discrepancies consisted of highs, lows, up-dings, down-dings, buckles, creases, ripples, etc. The following photographs display CAPA Certified Parts with the discrepancies indicated:

Figure 3-A

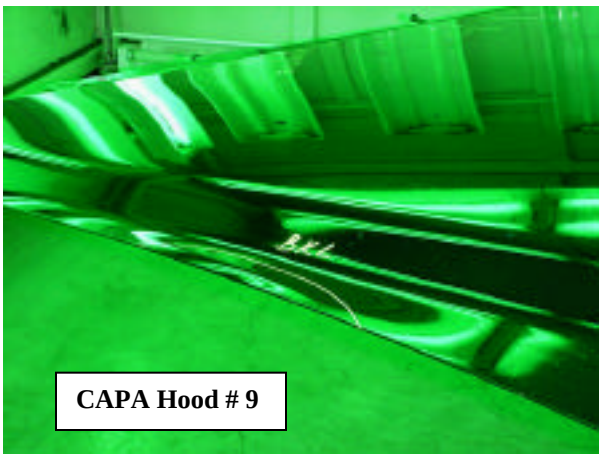


Figure 3-B

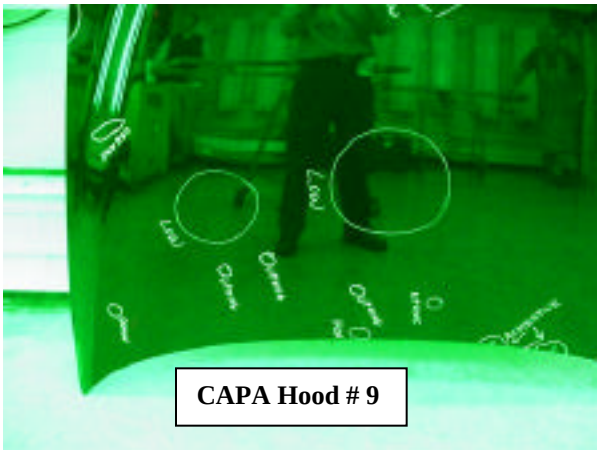


Figure 3-C

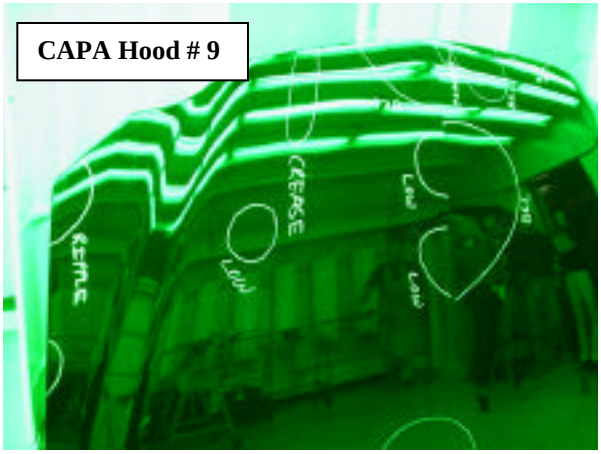


Figure 3-D

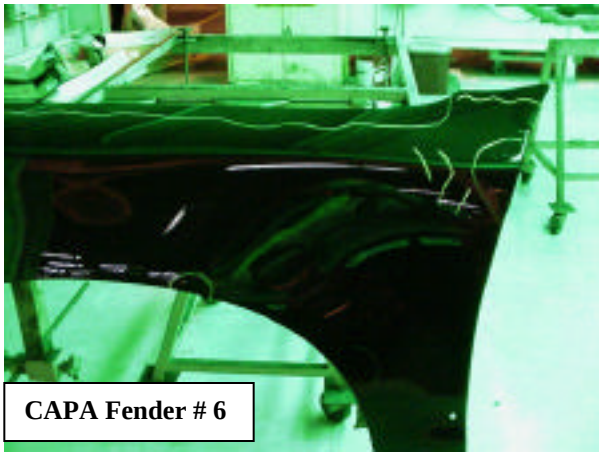


Figure 3-E

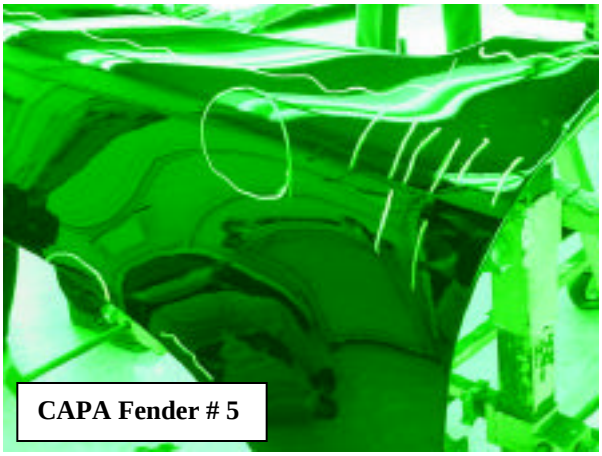


Figure 3-F

Figure 3-G

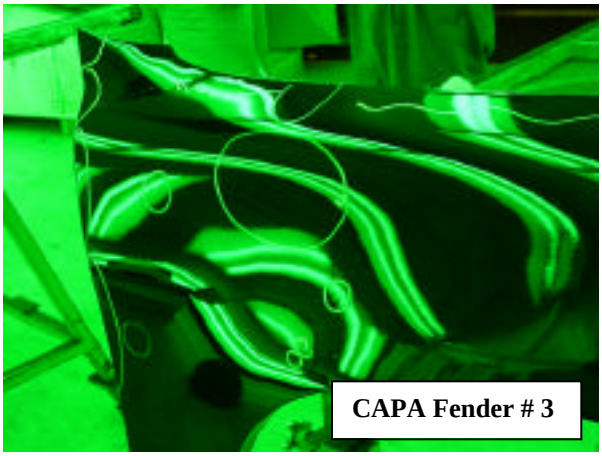


Figure 3-H

4. Material Evaluation

Steel samples from CAPA replacement parts were sent to the A2LA Accredited GMNA Materials Lab where they were compared to the GM specifications for the GM OEM products. Results from this comparison are as follows:

The alloy used in the GM Grand Am OEM hood is a bake hardenable steel. This bake hardenable steel is used to increase the strength and dent resistance of the hood and allows a thinner gage of metal to be used to reduce vehicle weight.

The CAPA hood sample had a yield strength in the formed part that was below the GM OEM engineering requirement of unformed metal. Stamping the part typically increases the yield strength an additional 15-25% (depending on amount of strain) through the metallurgical phenomena of strain hardening. The formed CAPA parts were found to be unacceptable after testing in two different areas to evaluate strength.

4.1 Material Strength

The GM OEM hood is ~40% stronger than the CAPA hoods. Both the #9 and #10 CAPA hoods in the strained condition (after forming) do not meet the GM engineering minimum strength requirement in the unformed sheet.

Sample #9 CAPA Hood-Outer

Sample	Peak Stress MPa	.2% Offset Yield MPa	% Total Elongation
A	294	186	38.3
B	298	185	39.4

Sample #10 CAPA Hood-Outer

Sample	Peak Stress MPa	.2% Offset Yield MPa	% Total Elongation
A	284	193	36.5
B	286	167	40.1

Grand Am Hood

Sample	Peak Stress MPa	.2% Offset Yield MPa	% Total Elongation
A	272	256	20.1
B	277	262	13.0

Metric/English conversion of Yield Strength - 1 MPa = 145psi, therefore 210MPa = 30450psi, 167MPa = 24220psi

4.2 Hardness

The GM OEM Grand AM hood is 80% harder the #9 CAPA version

Test Number	CAPA Hood Outer #9		GM Grand Am Hood Outer	
	HK_{500}	HRB	HK_{500}	HRB
1	98.0	42	152.9	76
2	98.0	42	158.7	78
3	96.7	40	156.9	78
4	98.4	42	152.6	76
5	97.2	41	153.9	77

HK (Knoop Microhardness) converted to HRB(Rockwell B Scale)

4.3 Chemistry

The chemical analysis shows that the CAPA materials are not bake hardenable steel grades as defined and specified by GM Engineering specification. Both are merchant quality, ultra low carbon, interstitial free (IF) grades.

Leco Carbon and Sulfur Analysis

Sample	C	S
CAPA Hood Outer # 9	0.009	0.008
CAPA Hood Outer #10	0.009	0.008
Grand Am Hood Outer	0.033	0.007

Optical Emission Spectroscopy (OES)

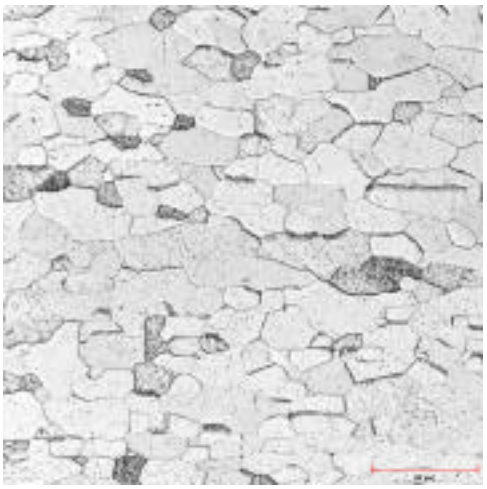
Sample	Mn	P	Cr	Ni	Cu	Al	Si	Ti	Nb
CAPA Hood Outer # 9	0.15	0.015	0.01	0.01	<.01	0.04	<.01	0.032	0.012
CAPA Hood Outer #10	0.05	0.012	0.01	<.01	<.01	0.02	<.01	0.022	0.010
Grand Am Hood Outer	0.20	0.055	0.04	0.01	0.02	0.07	0.01	<.001	<.001

All units are % by wt.

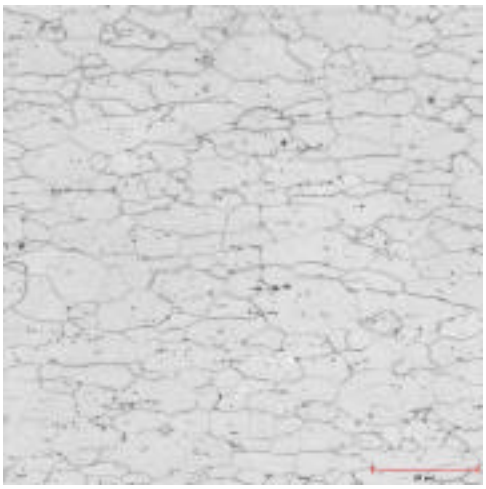
The chemistry of the bake hardenable steel creates a certain grain structure that provides dent resistance to the steel. The CAPA hoods do not have the proper grain structure of a bake hardenable steel.

Material Grain Structure

Sample	Structure	Titanium carbonitride inclusions
#9 CAPA Hood Outer	Slightly elongated ferrite grains size 8.	Trace amounts
#10 CAPA Hood Outer	Slightly elongated ferrite grains size 8.	Few Isolated
GM Grand AM Hood Outer	Slightly elongated ferrite grains size 8 with transgranular fine spheroidized carbide particles and spheroidal carbide particles at ferritic grain boundaries.	None



#9 Hood Outer
Core structure of outer hood 500X
Dark areas are dark etching ferrite grains.



GM Grand Am Hood Outer
Core structure of the outer hood 500X

4.4 Dent Resistance

The bake hardening alloy and thermal processing during ELPO increases the dent resistance of the product. SAE J2575 is the industry procedure for evaluating the dent resistance of a part. This test was used to compare the GM Grand Am hood against the #11 CAPA counterpart. The test results were then compared to GM Engineering requirements.

Static Dent Test results from US Steel performed at the exact same locations on the panel show the CAPA part does not meet the engineering specification. The #11 CAPA hood is performing at only 13% of the GM Grand Am hood in one critical location, and on average it is performing at 42% of the GM Grand Am hood.

SAEJ2575 Standard Dent Test Results

Location	Dent Load (Newtons)	
	CAPA #11	GM Grand Am
S1	20.40	150.50
S2	94.00	126.30
S3	77.20	178.00
S4	66.60	176.00

Note: 20 Newtons is equivalent to a weight of 4.5 pounds

5. Electrocoat (ELPO) and Galvanized Coating Thickness

ELPO and Galvanize coatings are used to provide long term corrosion resistance to the part. Reductions in the thickness of these coatings have been shown to bear a direct relationship to long term corrosion performance.

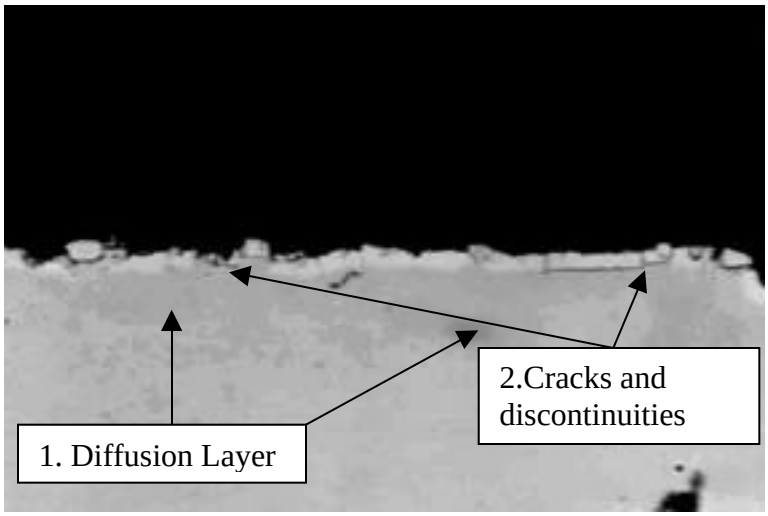
5.1 ELPO

Both CAPA Hoods have 1/2 the thickness of GM Grand Am ELPO on the outer surface, and 1/4 the thickness of the GM Grand Am ELPO on the inner surface. Both CAPA hoods do not meet GM Paint and Polymers Engineering requirements for minimum ELPO thickness.

5.2 Galvanized Coating

The #10 CAPA hood has 24% less zinc galvanized coating on the outside and 32% less zinc galvanized coating on the inside than the GM specification. The #10 CAPA hood does not meet the GM corrosion engineering minimum zinc coating thickness requirement for each side for this vehicle.

The #9 CAPA hood shows an out of specification condition at the interface with the base steel as shown in the picture below. The coating is also cracked, which is unacceptable in the GM specification.



As-polished #9 CAPA Hood Palm Print Sample. Thin coating layer at surface 1000X.
The coating layer appears to have been a diffusion layer (1) into the substrate material.

The #9 and #10 hood outers have a similar zinc coating with intermittent perpendicular crack-like discontinuities and intermittent discontinuities (2) in which there is a lack of coating. The coating appears to have flaked off or chipped away before the ELPO layer was applied.

The #2 and #7 fenders also have low, out of spec, coatings for ELPO and galvanized coating, with the #1 fender showing no galvanized coating at all. You will note that the #1 fender is not a CAPA part. Galvanization does not appear to be universally used by non- OE collision parts manufacturers.

5.3 Metallographic Thickness Measurements – Hoods

CAPA Hood Outer #10

Layer:	**Total**	**ELPO Layer**		**Galvanized Layer**	
Location:	**Material**	**Outside**	**Inside**	**Outside**	**Inside**
Thickness:	T_M, mm	T_E, µm	T_E, µm	T_C, µm	T_C, µm
Minimum:	0.76	13.0	7.0	6.0	6.0
Maximum:	0.77	16.0	9.0	8.0	8.0
Average:	**0.76**	**14.9**	**7.8**	**7.1**	**6.6**
Count, n:	10	10	10	10	10
Std. Dev.:	0.0052	0.9944	0.6325	0.5676	0.6992
95% C.I.:	± 0.00	± 0.6	± 0.4	± 0.4	± 0.4

GM Grand AM Hood Outer

Layer:	**Total**	**ELPO Layer**		**Galvanized Layer**	
Location:	**Material**	**Outside**	**Inside**	**Outside**	**Inside**
Thickness:	T_M, mm	T_E, µm	T_E, µm	T_C, µm	T_C, µm
Minimum:	0.75	26.0	20.0	8.0	8.0
Maximum:	0.75	29.0	23.0	9.0	9.0
Average:	**0.75**	**27.0**	**21.6**	**8.8**	**8.7**
Count, n:	10	10	10	10	10
Std. Dev.:	0.0000	1.1547	0.9661	0.4216	0.4830
95% C.I.:	± 0.00	± 0.7	± 0.6	± 0.3	± 0.3

CAPA Hood Outer #9

Layer:	**Total**	**ELPO Layer**		**Galvanized Layer**	
Location:	**Material**	**Outside**	**Inside**	**Outside**	**Inside**
Thickness:	T_M, mm	T_E, µm	T_E, µm	T_C, µm	T_C, µm
Minimum:	0.73	15.0	8.0	7.0	8.0
Maximum:	0.74	18.0	10.0	10.0	10.0
Average:	**0.73**	**16.6**	**8.8**	**8.3**	**8.9**
Count, n:	10	10	10	10	10
Std. Dev.:	0.0032	1.0750	0.7888	0.9487	0.7379
95% C.I.:	± 0.00	± 0.7	± 0.5	± 0.6	± 0.5

Metric/English conversion of Thickness - 10 µm (microns) = .3937 mils therefore 8.4 µm = .33mils, 27µm = 1.06mils

5.4 Metallographic Thickness Measurements – Fenders

CAPA #7 Outer Fender LH

Layer:		**ELPO Layer**		**Galvanized Layer**	
Location:	**Total Material**	**Outside**	**Inside**	**Outside**	**Inside**
Thickness:	T_M, mm	T_E, µm	T_E, µm	T_C, µm	T_C, µm
Minimum:	0.83	17.0	16.0	7.0	7.0
Maximum:	0.84	20.0	20.0	9.0	9.0
Average:	**0.83**	**18.1**	**17.8**	**7.9**	**7.9**
Count, n:	10	10	10	10	10
Std. Dev.:	0.0042	0.9944	1.1353	0.5676	0.8756
95% C.I.:	± 0.00	± 0.6	± 0.7	± 0.4	± 0.5

#1 Outer Fender RH **CAPA #2 Outer Fender RH**

Layer:	**Total**	**ELPO Layer**		**Total**	**ELPO Layer**		**Galvanized Layer**	
Location:	**Material**	**Outside**	**Inside**	**Material**	**Outside**	**Inside**	**Outside**	**Inside**
Thickness:	T_M, mm	T_E, µm	T_E, µm	T_M, mm	T_E, µm	T_E, µm	T_C, µm	T_C, µm
Minimum:	0.80	11.0	11.0	0.82	16.0	16.0	6.0	5.0
Maximum:	0.81	15.0	13.0	0.84	21.0	20.0	8.0	8.0
Average:	**0.81**	**13.0**	**12.4**	**0.83**	**18.9**	**18.2**	**7.5**	**7.1**
Count, n:	10	10	10	10	10	10	10	10
Std. Dev., s:	0.0053	1.2472	0.6992	0.0070	1.5239	1.5492	0.7071	1.1005
95% C.I.:	± 0.00	± 0.8	± 0.4	± 0.00	± 0.9	± 1.0	± 0.4	± 0.7

Metric/English conversion of Thickness: 10 µm (microns) = .3937 mils therefore 8.4 µm = .33mils, 27µm = 1.06mils