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SMDI Bumper Corrosion Tests

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July 10, 2018

Introduction

There is concern within the automotive industry that steel bumper systems will not be able to meet future OEM 15-year corrosion life requirements. To address those concerns the Steel Market Development Institute (SMDI) Steel Bumper team has undertaken a two-phase simulated testing program to study numerous bumper coating technologies and their corrosion susceptibility to the aggressive operating environment of a bumper. The second phase of the bumper corrosion coating testing program was recently completed. This testing was performed per SAE J2334 for 180 cycles to simulate OEM 15-year life requirements. A total of 24 samples were tested in Phase I and 20 additional samples were tested in Phase II. The samples were representative of different bumper applications, steel grades, manufacturing processes and coating solutions as outlined in Tables 1 and 2.

While the performance varied greatly, there were samples that showed very little corrosion during the 15-year simulated tests. The top performing bumper component samples were coated with a Zn-rich coating from three different coating suppliers. As a result steel bumper systems will remain a competitive solution for future vehicle designs.

Phase I

A total of 24 bumper samples (22 steel and 2 aluminum samples) were tested in Phase I as shown in Table 1. The test samples were obtained from production components supplied by members of the SMDI Automotive Applications Council (AAC) Bumper Team. The steels used in this phase were either hot stamped, roll formed or cold stamped. Bumper component samples were then given to various companies to coat with their recommended coating solutions which could include as many as three individual coatings as detailed in the table.

TABLE 1 – Phase I Bumper Corrosion Results

Bumper	Grade	Coating 1	Coating 2	Coating 3	Min Coating Thickness	Max Coating Thickness	Avg Coating Thickness (mils)	Avg Coating Thickness (mm)	60 Cycle Rating	120 Cycle Rating	180 Cycle Rating
Bumper	MnB1500	AlSi	Supplier B E-coat		2.9	3.8	3.2	0.081	3	3	3
Bumper	MnB1500	GA	E-coat		1.3	1.6	1.47	0.037	2	2	2
Bumper	MnB1900	A-coat			1.8	2	1.9	0.048	1	1	1
Bumper	MnB1500	AlSi	Zn Rich Supplier A	E-coat	1.8	2.4	2.1	0.053	5	5	5
Bumper	MnB1500	AlSi	Zn Rich Supplier A	E-coat	2.2	3.2	2.58	0.066	5	5	5
Bumper	MnB1500	AlSi	Zn Rich Supplier C	E-coat	2.1	3	2.63	0.067	5	5	5
Bumper	MnB1500	AlSi	Zn Rich Supplier D		1.3	1.5	1.44	0.037	4	4	4
Bumper	MnB1500	E-coat	Powder Coat		3.5	4.6	4.1	0.104	2	2	2
Bumper	MnB1500	Supplier B E-coat			1.4	1.5	1.47	0.037	2	2	2
Bumper	MnB1500	Zn Rich Supplier C	E-coat		2.6	2.7	2.62	0.067	5	5	5
Bumper	MnB1500	E-coat			1.1	1.6	1.33	0.034	2	2	2
Aluminum Baseline					0	0	0		5	2	2
Aluminum Baseline	With no steel	Bracket attached			0.7	0.8	0.75 (Brkt)		5	3	3
Bumper beam	MS1300	E-coat			1.4	1.6	1.48	0.038	2	2	2
Bumper beam	MS1300	E-coat	Powder Coat		1.7	4.4	3.04	0.077	3	2	2
Bumper beam	MS1300	E-coat	Zn Rich Supplier A		1.96	3	2.27	0.058	5	2	2
Ped beam	DP980	EG	E-coat		1.9	2.2	2.05	0.052	5	5	5
Ped beam	DP980	EG	Supplier B E-coat		1.8	2.7	2.1	0.053	5	5	5
Ped Beam	DP980	EG	Zn Rich Supplier C	E-coat	2.7	3	2.92	0.074	5	5	5
Ped Beam	DP980	EG	Zn Rich Supplier D		1.5	2.3	1.97	0.050	5	5	5
Chromed Facebar	DQSK	Chrome	Water Based Back Coat		2.2	5.7	3.7	0.094	3.5	3.5	3.5
Facebar	DQSK	Zn Rich Supplier A	E-coat		1.3	1.4	1.4/1.34	0.034	5	5	5
Facebar	DQSK	Zn rich Supplier A	E-coat	Paint	2.6/1.4	3.5/1.7	3.05/1.53	.077/.039	5	5	5
Chromed Facebar	DQSK	Chrome	Chrome Mask Back Coat		2.8	3.5	3.2	0.081	4	4	4

Rating Key
1 – Significant corrosion (present in all areas of part)
2 – High corrosion (present in 3 of 4 surfaces of part)
3 – Moderate corrosion (present in 2 of 4 surfaces of part)
4 – Light corrosion (one area only)
5 – No visible corrosion

The samples were then tested per SAE J2334 for 180 cycles to simulate 15 years of service at Motor City Testing in the test chamber shown in Figure 1.

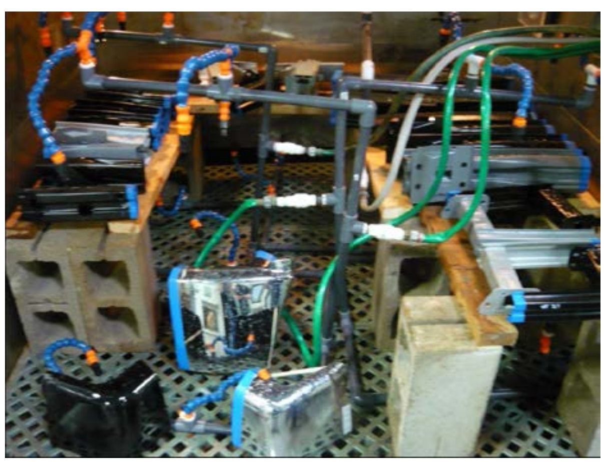

Figure 1: Test chamber used by the SMDI AAC Bumper Team

During the test the samples were removed after every 60 cycles, photographed and rated on a scale of 1 to 5 as detailed in Table 1 (1 = significant corrosion through 5 = no visible corrosion). The pictures after 60, 120 and 180 cycles are shown in Appendix A. Numerous samples (4, 5, 6, 10, 17, 18, 19, 20, 22 and 23) showed little or no corrosion after the entire 180 cycles. The majority of these samples included a Zn-rich coating as one of the layers of coatings. Of note is the aluminum baseline bumpers did show corrosion after the 180 cycles were completed. Detailed observations from Phase I are:

- Hot-formed bumpers have 3 zinc-rich coatings which meet 15-year corrosion life;
- For roll-formed bumpers, EG + E-coat is sufficient to meet 15-year corrosion life;
- For painted facebars, zinc-rich coatings are a solution to meet 15-year corrosion life;
- For chromed facebars, the chrome mask performs slightly better than water-based back coat;
- Powder coating does not appear to improve corrosion resistance; and
- Enhanced E-coat technology performs better than conventional E-coat which is cosmetically better than an A-coat.

The SMDI AAC Bumper Team reviewed the results of Phase I with the members of the team as well as the individual coating suppliers. Note: the coating suppliers were given the results for their coatings only with an idea of relative ranking versus the other coatings. Based on these results and recent technological advancements the team decided to commission a second testing phase.

Phase II

A total of 20 additional steel bumper samples were tested in Phase II as shown in Table 2. The test samples were obtained from production components supplied by members of the SMDI AAC Bumper Team. The steels used in this phase were either hot stamped, roll formed or cold stamped. Bumper component samples were then given to various companies to coat with their recommended coating solutions which could include as many as four individual coatings as detailed in the table.

TABLE 2 – Phase II Bumper Corrosion Results

Sample	Rank	Bumper	Grade	Coating 1	Coating 2	Coating 3	Coating 4	min thickness	max thickness	ave thickness mils	ave thickness mm
1	5	Bumper	22MnB5	Supplier G	Supplier F E-coat			1.2	1.37	1.31	0.033
2	2	Bumper	22MnB5	Zn Rich Supplier C	Supplier F E-coat			2.24	2.91	2.61	0.066
3	15	Bumper	22MnB5	Zn Rich Supplier D				1.14	1.48	1.31	0.033
4	3	Bumper	22MnB5	Zn Rich Supplier A	Supplier A E-coat			1.76	2.03	1.89	0.048
5	10	Bumper	22MnB5	Supplier H	Supplier B E-coat			1.92	2.12	2.04	0.052
6	10	Bumper	22MnB5	Supplier H	Supplier J Powder Coat			4.43	6.59	5.56	0.14
7	13	Bumper	PHS1500	Supplier H	Supplier H	Supplier B E-coat	Supplier J Powder Coat	3.42	4.28	3.81	0.097
8	13	Bumper	PHS1500	Supplier H	Supplier H	Supplier B E-coat		1.64	2.85	2.05	0.052
9	7	Bumper Beam	MS1300	Supplier G	Supplier F E-coat			2.07	2.21	2.13	0.054
10	8	Bumper Beam	MS1300	Zn Rich Supplier C	Supplier F E-coat			2.66	3.88	3.25	0.083
11	14	Bumper Beam	MS1300	Zn Rich Supplier D				0.99	1.54	1.34	0.034
12	4	Bumper Beam	MS1300	Zn Rich Supplier A	Supplier A E-coat			2.55	2.88	2.73	0.069
13	12	Bumper Beam	MS1300	Supplier H	Supplier B E-coat	Supplier J Powder Coat		3.66	4.51	4.1	0.1
14	12	Bumper Beam	MS1300	Supplier H	Supplier J Powder Coat			5.3	6.66	5.92	0.15
15	1	Facebar	HSLA CR	Zn Rich Supplier C	Supplier F E-coat			2.12	2.37	2.26	0.057
16	1	Facebar	HSLA CR	Zn Rich Supplier C	Supplier F E-coat			1.42	1.97	1.75	0.044
17	9	Facebar	HSLA CR	Supplier H	Supplier B E-coat	Supplier J Powder Coat		2.23	3.09	2.78	0.071
18	11	Facebar	HSLA CR	Supplier H	Supplier B E-coat			1.45	1.65	1.52	0.039
19	6	Facebar	HSLA CR	Supplier H	Supplier J Powder Coat			4.71	5.12	4.92	0.12
20	6	Facebar	HSLA CR	Supplier H	Supplier J Powder Coat			2.68	2.83	2.74	0.07

Rank	Sample	Bumper	Grade	Coating 1	Coating 2	Coating 3	Coating 4	min thickness	max thickness	ave thickness mils	ave thickness mm
1	15	Facebar	HSLA CR	Zn Rich Supplier C	Supplier F E-coat			2.12	2.37	2.26	0.057
1	16	Facebar	HSLA CR	Zn Rich Supplier C	Supplier F E-coat			1.42	1.97	1.75	0.044
2	2	Bumper	22MnB5	Zn Rich Supplier C	Supplier F E-coat			2.24	2.91	2.61	0.066
3	4	Bumper	22MnB5	Zn Rich Supplier A	Supplier A E-coat			1.76	2.03	1.89	0.048
4	12	Bumper Beam	MS1300	Zn Rich Supplier A	Supplier A E-coat			2.55	2.88	2.73	0.069
5	1	Bumper	22MnB5	Supplier G	Supplier F E-coat			1.2	1.37	1.31	0.033
6	19	Facebar	HSLA CR	Supplier H	Supplier J Powder Coat			4.71	5.12	4.92	0.12
6	20	Facebar	HSLA CR	Supplier H	Supplier J Powder Coat			2.68	2.83	2.74	0.07
7	9	Bumper Beam	MS1300	Supplier G	Supplier F E-coat			2.07	2.21	2.13	0.054
8	10	Bumper Beam	MS1300	Zn Rich Supplier C	Supplier F E-coat			2.66	3.88	3.25	0.083
9	17	Facebar	HSLA CR	Supplier H	Supplier B E-coat	Supplier J Powder Coat		2.23	3.09	2.78	0.071
10	5	Bumper	22MnB5	Supplier H	Supplier B E-coat			1.92	2.12	2.04	0.052
10	6	Bumper	22MnB5	Supplier H	Supplier J Powder Coat			4.43	6.59	5.56	0.14
11	18	Facebar	HSLA CR	Supplier H	Supplier B E-coat			1.45	1.65	1.52	0.039
12	13	Bumper Beam	MS1300	Supplier H	Supplier B E-coat	Supplier J Powder Coat		3.66	4.51	4.1	0.1
12	14	Bumper Beam	MS1300	Supplier H	Supplier J Powder Coat			5.3	6.66	5.92	0.15
13	7	Bumper	PHS1500	Supplier H	Supplier H	Supplier B E-coat	Akzo Powder Coat	3.42	4.28	3.81	0.097
13	8	Bumper	PHS1500	Supplier H	Supplier H	Supplier B E-coat		1.64	2.85	2.05	0.052
14	11	Bumper Beam	MS1300	Zn Rich Supplier D				0.99	1.54	1.34	0.034
15	3	Bumper	22MnB5	Zn Rich Supplier D				1.14	1.48	1.31	0.033

Again these samples were tested at Motor City Testing using SAE specification J2334 and observed by the SMDI AAC Bumper Team at the end of 180 cycles (15-year simulation test). Pictures of the bumper samples after 180 cycles can be found in Appendix B. The team reviewed each of the 20 bumper samples and rated them from best to worst (see Table 2). Detailed observations from Phase II are:

- E-coats remain a very important barrier technology and can be applied to bumpers produced using common manufacturing methodologies (hot formed, roll formed or cold stamped); and
- Bumpers manufactured from the common methodologies can all meet the upcoming OEM 15-year corrosion requirements using the two layer Zn-rich/E-coat technology.

As in Phase I, these results were shared with the team members and the coating suppliers. At this time no additional corrosion work is required.

Conclusion

The SMDI AAC Bumper Team has worked closely with our customers to provide solutions to the technical issues facing bumper design engineers. The steel bumper corrosion study provides anti-corrosion coating solutions to assure 15-year performance in harsh corrosive operating atmospheres. By providing these solutions the design engineer will have a cost, weight and performance competitive alternative with steel. The SMDI AAC Bumper Team supports the effort to complete one-on-one technology exchanges with key OEM bumper design engineers and share the corrosion project results.