

Automotive Corrosion Symposium 2024

Virtual Tools for Corrosion Engineering



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Abstract

Vehicle corrosion performance has improved over time as customer expectations have grown. Owners expect their cars to last longer, with greater reliability and performance. Advancements have been made in the design phase to meet evolving customer expectations, ensuring corrosion robust designs, E-coat coverage, and proper material selection. This presentation shows how corrosion mitigation strategies, virtual tools, and previous vehicle level testing are all being used to design safe, world-class vehicles while maintaining the lowest possible cost, and boosting manufacturing efficiencies.

Vehicle Development Timeline

Costs tend to increase as you move right on the launch timeline.

Virtual 3D models becomes available. Different vehicle components are released in sequence and are refined in parallel.

Corrosion Engineer assesses body structure

Studio and program team finalizes and approves of design.

Early physical builds begin.

Start of Regular Production (SORP)

Corrosion Engineer assesses chassis structure and components

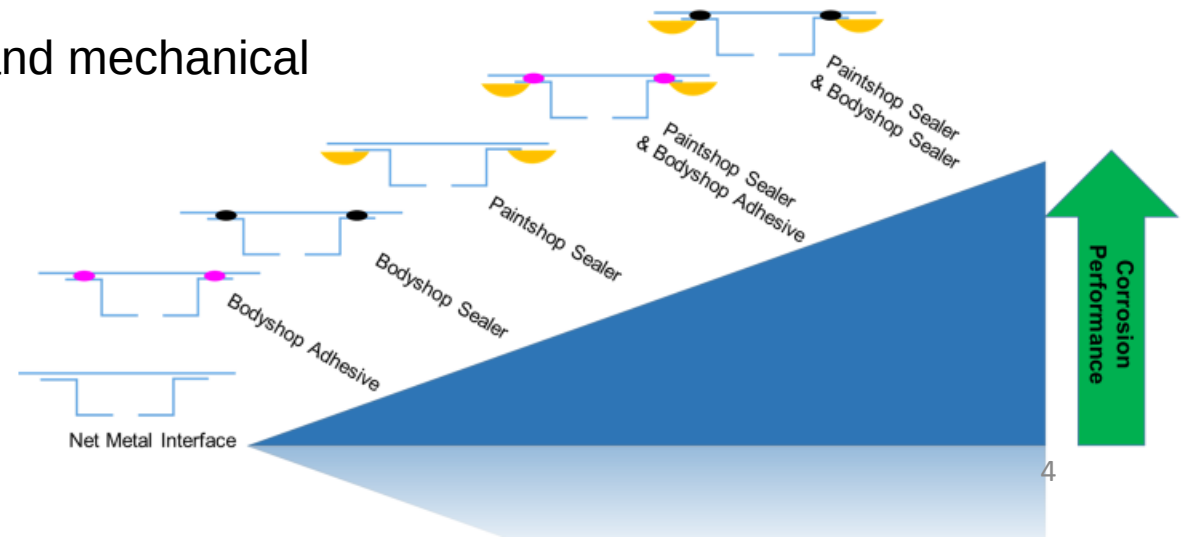
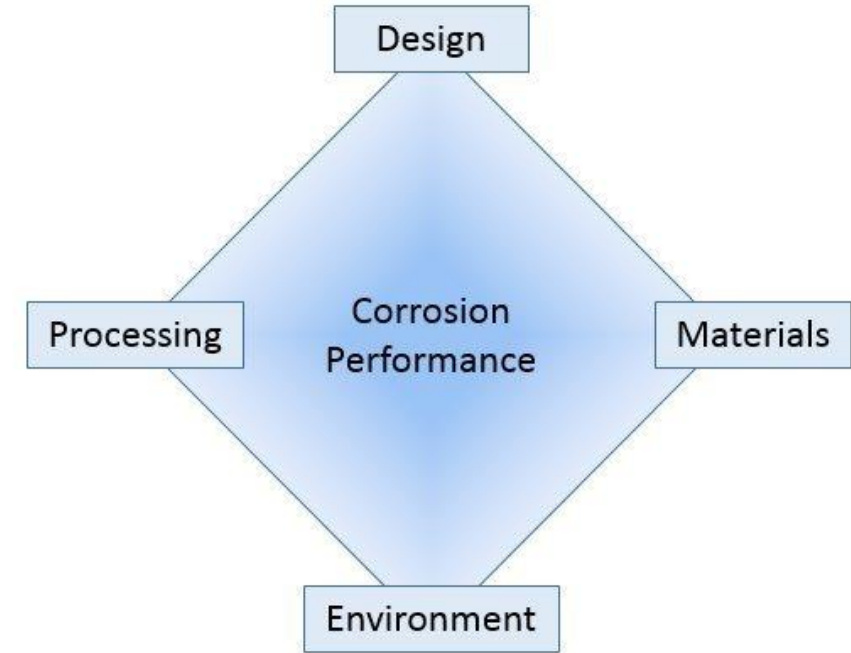
Corrosion Engineer assesses body closures

Corrosion Engineer reassesses structure / closures / components for robust performance

Corrosion testing is conducted on physical properties. Any identified issues are recorded and tracked to resolution.

Corrosion Avoidance

- **Design & CAE**
 - Avoid crevices, water traps, poor drainage and build-up of deposits.
 - Use of ELPO paint simulations to assist in virtual validation.
- **Material Selection**
 - Pick a material that is suited for the environment and consider mating/touching components to avoid galvanic corrosion.
- **Shields & Covers**
 - Hide cosmetic corrosion and protect components from salt water.
- **Barrier Coatings**
 - Anodizing (Aluminum), Paint (Electrocoating, Powder,...), Wax.
- **Sacrificial Coatings**
 - Hot Dip Galvanized, Zinc/Zinc-alloy electroplating and mechanical plating.



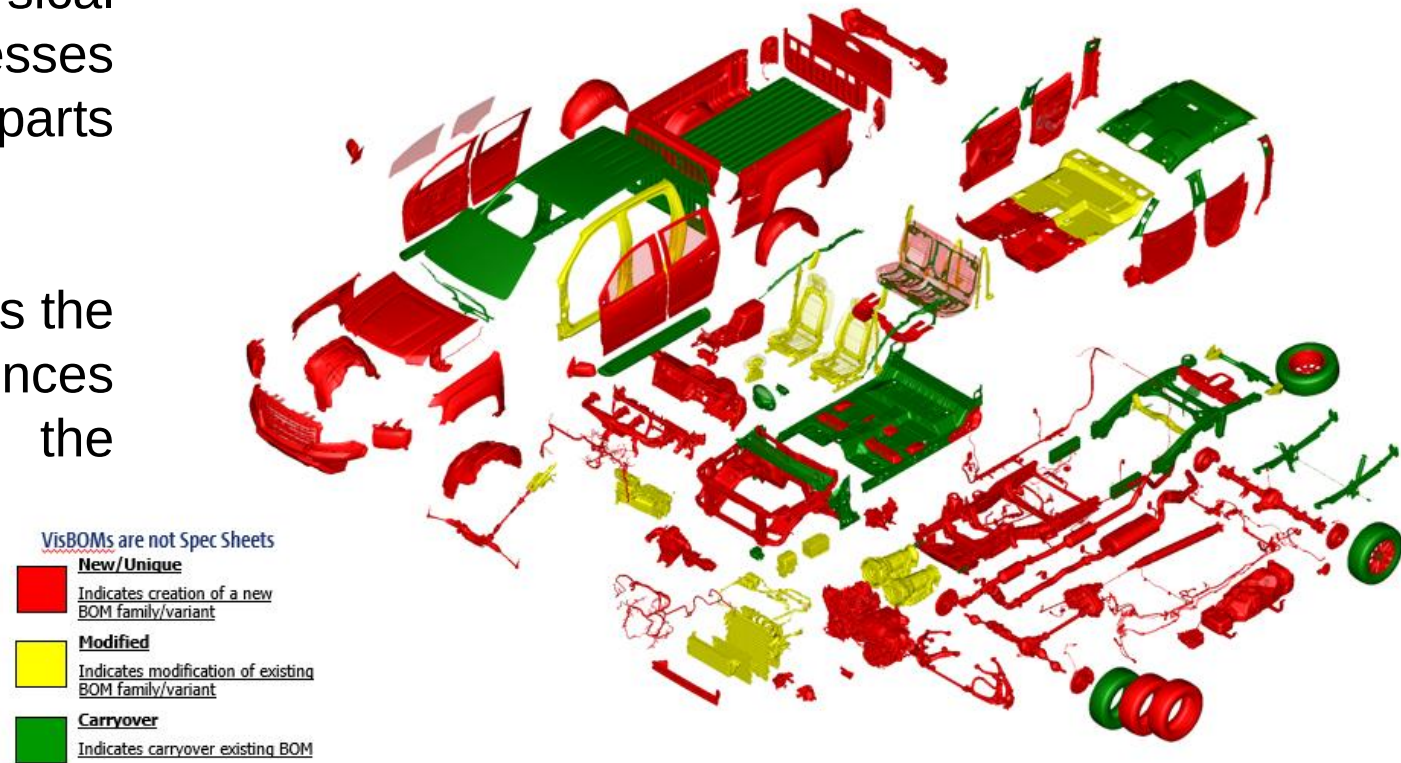
Corrosion Tools for Virtual Validation

GM currently uses...

- Manual VIS Mockup Peer Review – component and body reviews
- Material and Coating Filters – (Identify high risk areas and cost savings \$\$)
- E-Coat Coverage Simulations – (Includes film thickness, puddles, bubbles)
- Splash simulations CAE, full vehicle stone impingement CAE.
- Cordessa galvanic corrosion risk assessment tool. (USCar Project)

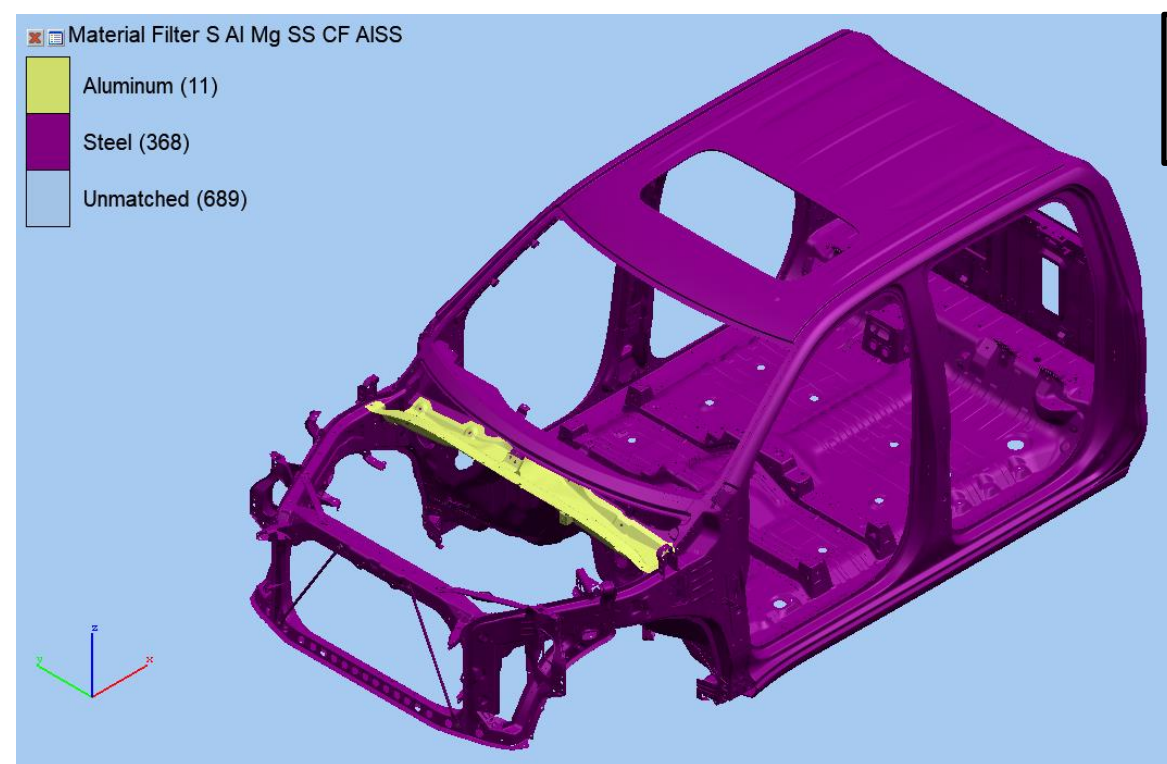
Current Tools – TcVIS Mockup Virtual Reviews

- Corrosion team reviews program VISBOMs (Visual Bill of Materials) to identify areas of the vehicle that require virtual design reviews (targeting new areas of the body / components).
- Corrosion engineer is looking for high risk areas with large amounts of line to line (crevice corrosion risk) or interfaces with dissimilar materials (galvanic corrosion risk).
- Corrosion uses previous physical data when available and assesses risk of the design to ensure parts meet our requirements.
- The VISBOM on the right shows the body and component differences between a new variant and the previous product line.



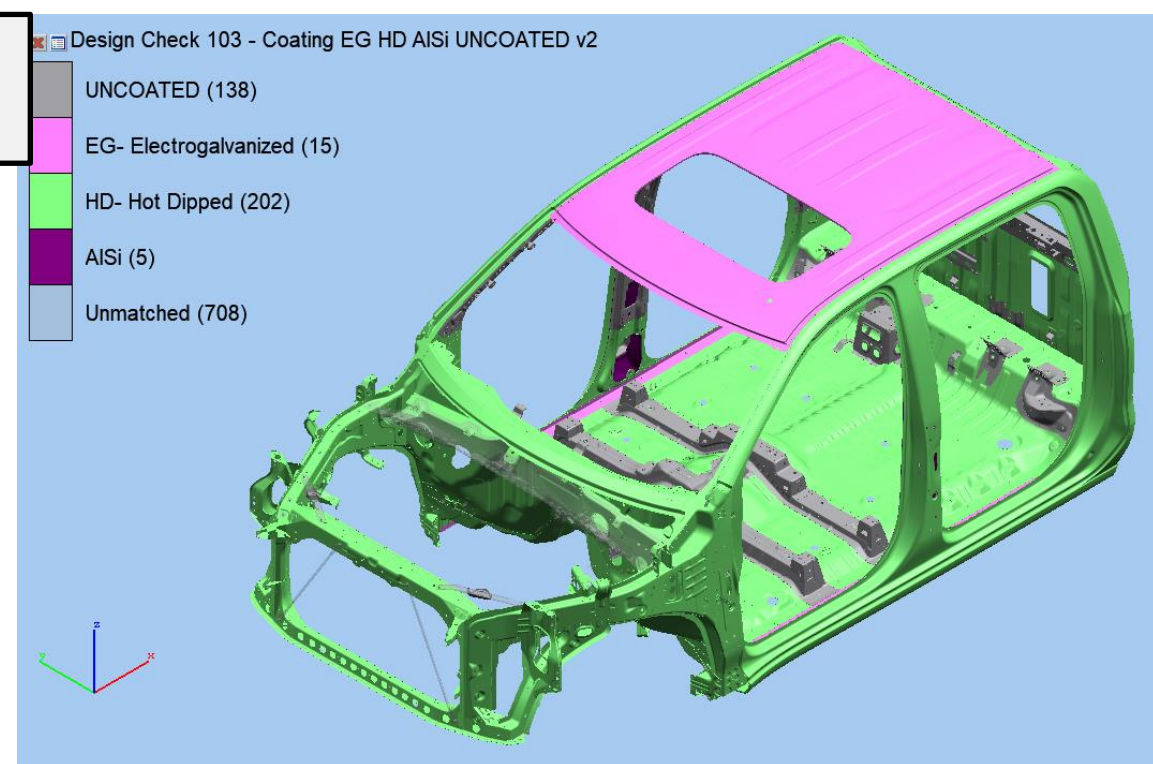
Current Tools – Coating / Material Filters

- Corrosion team uses virtual filter tools in MATH to identify high risk material interfaces and to ensure we meet material templates in release. Cost savings can be in dollars vs cents when checking coatings.



Dissimilar materials can lead to galvanic corrosion. Filter made by corrosion team quickly identifies these areas.

Truck Body

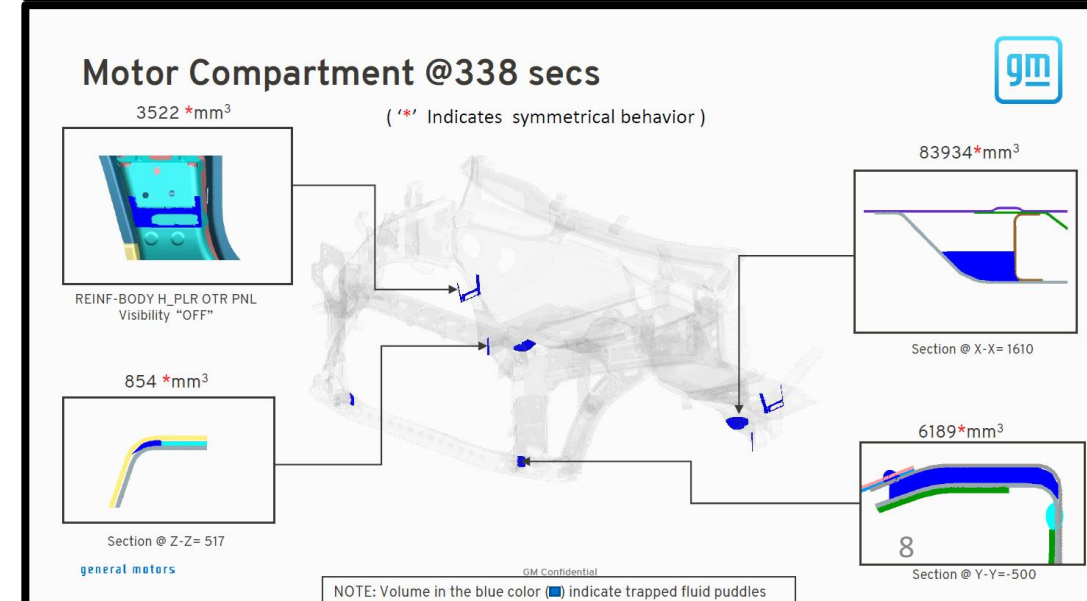
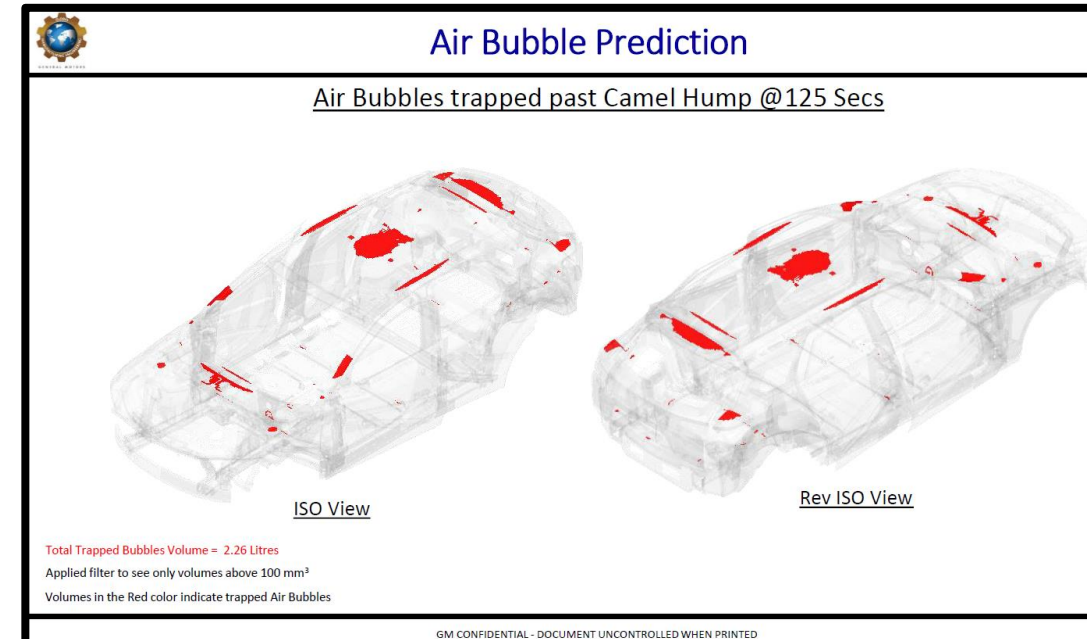
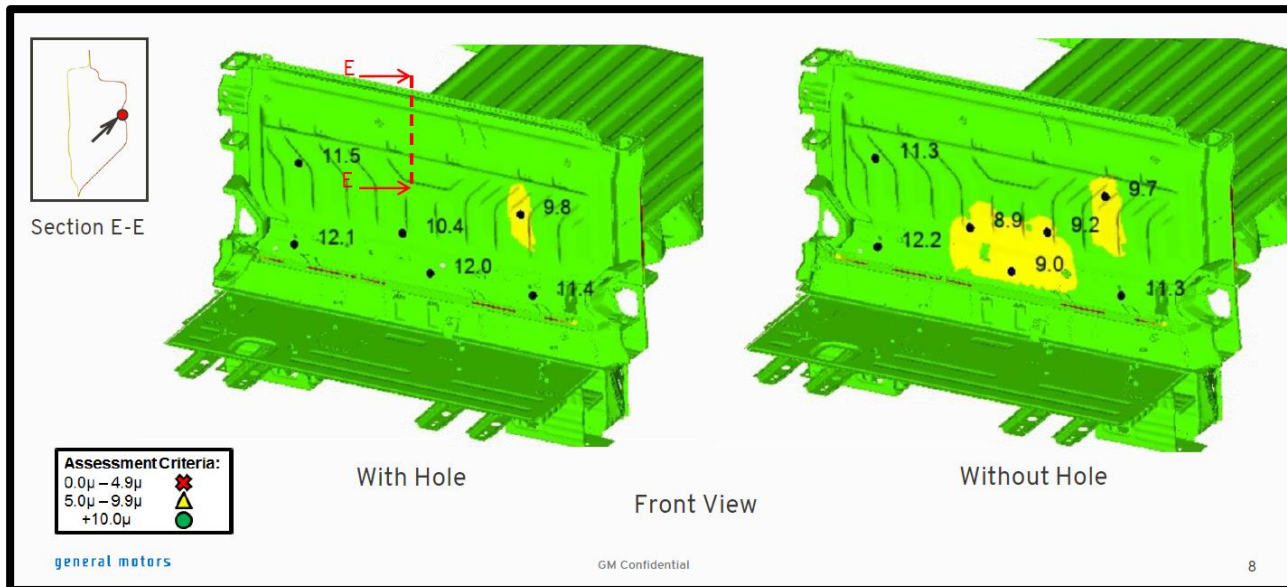


Filter above ensures all body sheet metal parts have proper coating callout for corrosion performance and cost savings.

Current Tools – E-Coat Coverage Simulations

- Corrosion team uses e-coat coverage, ELPO access, and ELPO drainage simulations to get ahead of issues in the design.
- Remedies for bubbles, puddles, and throw are to add drainage, venting, and holes for e-coat throw into the design.

In picture below, e-coat simulation was used to see the effects of how different designs would affect overall e-coat film build performance inside a rear end panel.



Current Tools – Cordessa Galvanic Simulator

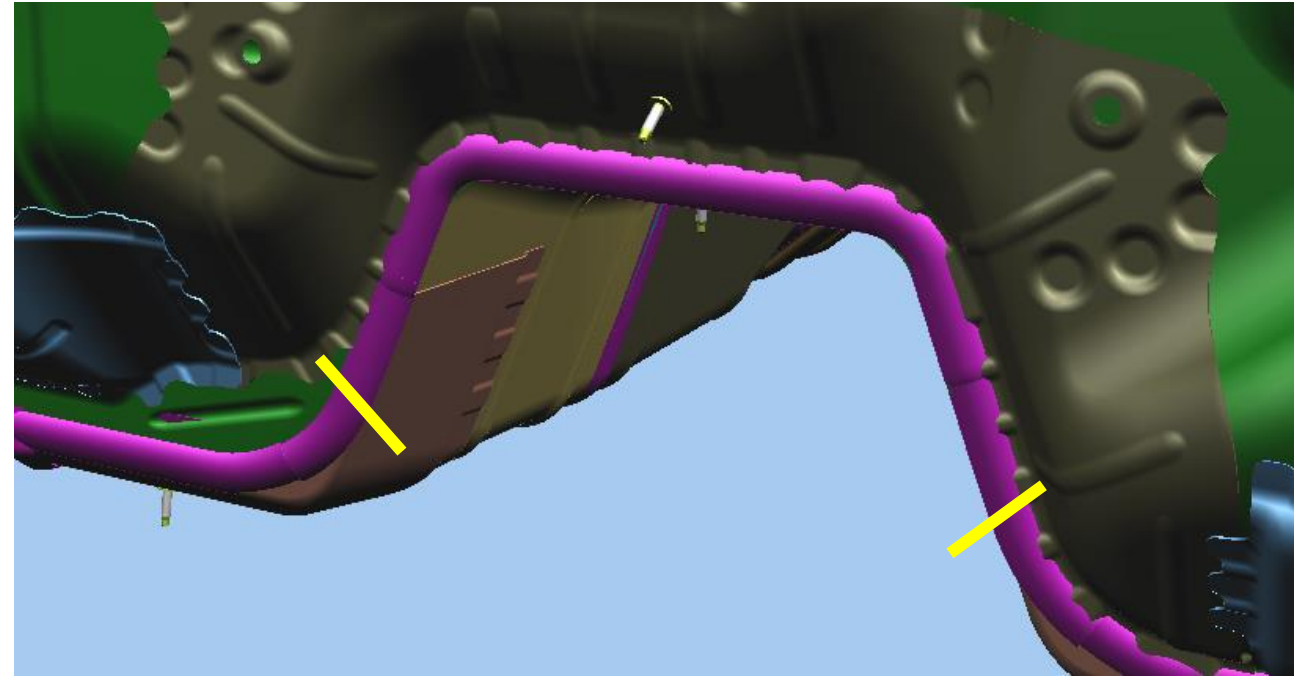
- GM has integrated Cordessa tool into NX software.
- Tool allows a quick lookup of material compatibility in 3.5% NaCl or the MIL-STD-889D electrolyte.

Material Group			
Environment		3.5% NaCl	
Material 1 (Cathode)		Material 2 (Anode)	
Substrate	Steel	Substrate	Aluminum
Designation	1008 Cold Rolled	Designation	6061-T6
Coating	None	Coating	None
Treatment	None	Treatment	None

Potential Difference	9.38E-2 V
Mixed Potential	-7.12E-1 V _{SCE}
Galvanic Corrosion Current Density	2.03E-1 Am ⁻²
Galvanic Corrosion Rate	2.12E+2 microns/year
	8.33E+0 mils/year
MIL-STD-889D Rating	4

Truck Motor Compartment Sealer Optimization

- During launch of a new truck program, the plant was over cycle time on paint shop sealer robots in the engine compartment by 4 seconds.
- Needed to reduce sealer content to meet cycle time.
- Removing paint shop sealer in the tunnel (between yellow lines) allowed for better drainage and saved on cycle time.
- Paint shop sealer deletions here, along with a few other areas in the motor compartment that were low risk for corrosion, allowed manufacturing to reduce cycle time by 6 seconds.

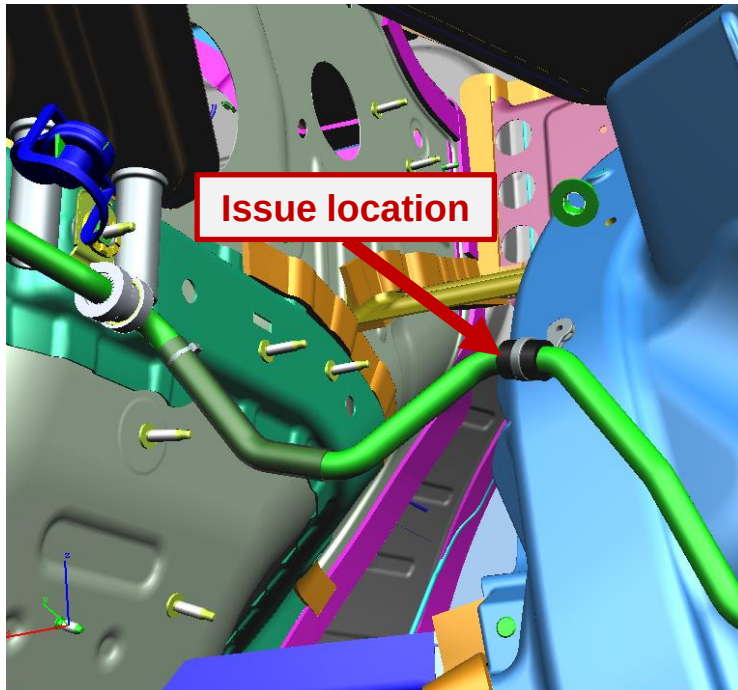


Excellent E-coat and corrosion performance on test vehicles.
Low risk to delete paint shop sealer which could act as a trap for water / mud.

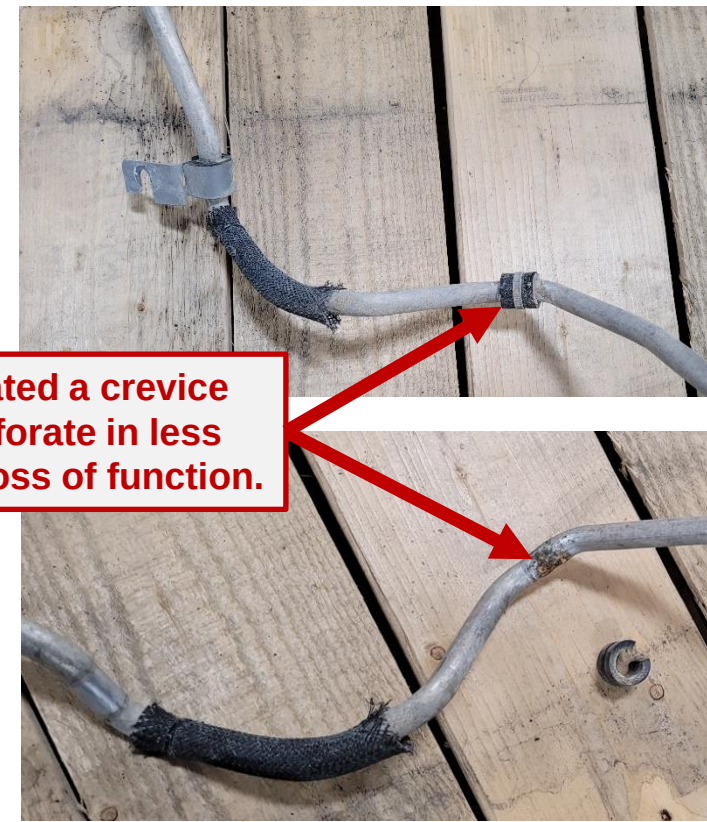


Underhood AC Hose

- Vehicle from a new program ran an accelerated 10-year general corrosion exposure at Milford Proving Grounds
- At the end of test, the vehicle was torn down, and components were inspected for any issues.
- Corrosion was observed on the HVAC hose. The clamp covering it created a crevice corrosion cell.
- Tubing was predicted to perforate in less than 10 years.



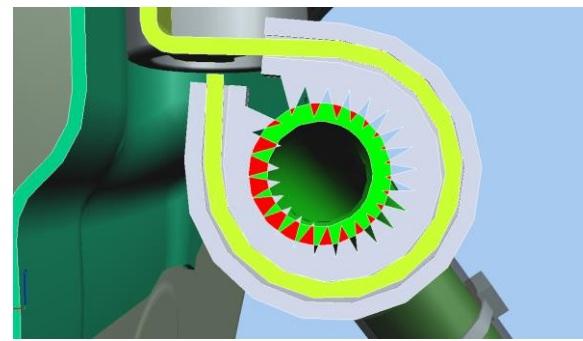
Flat rubber clamp created a crevice joint. Predicted to perforate in less than 10 years, causing loss of function.



Flat rubber clamp created a crevice joint. Predicted to perforate in less than 10 years, causing loss of function.

Underhood AC Hose

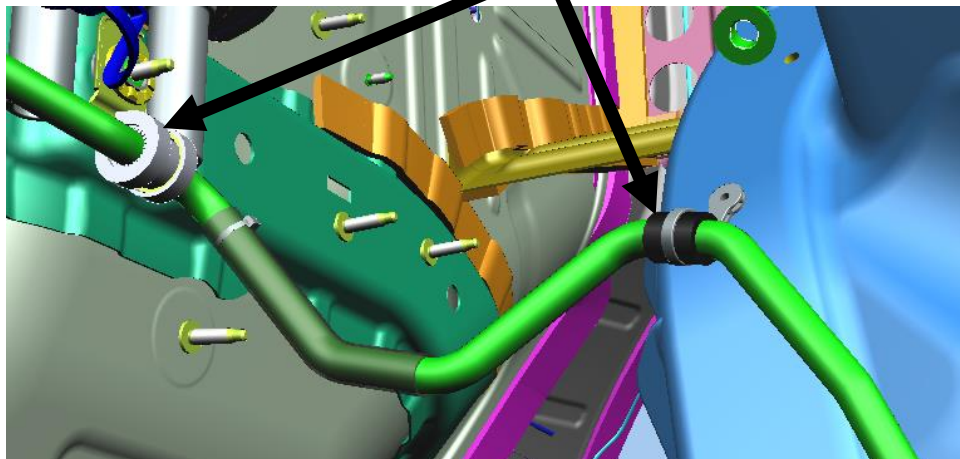
- Directly next to the location with crevice corrosion was a similar clamp but it had a sawtooth design.
- Sawtooth design allowed the area to dry out. No corrosion was present as a result.
- Vehicle release was changed so that both locations utilize the sawtooth style clamp.
- We use physical data like this to update best practices. This information feeds decision making on future programs in the virtual design stages.



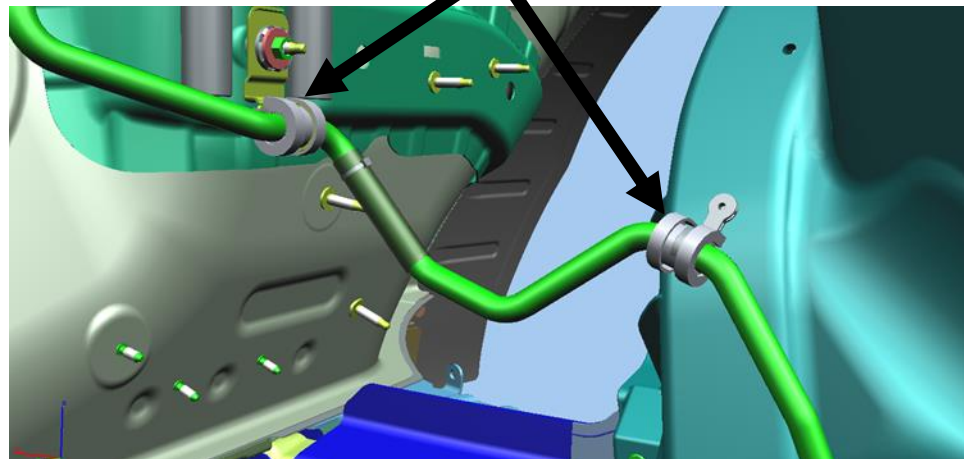
Sawtooth style clamp showed no corrosion issues.



Old release: one sawtooth style clamp, one flat clamp.



Current release: both locations utilize a sawtooth design.



Corrosion Tools for Virtual Validation

GM Corrosion is looking for other tools for virtual validation...

- Material and coating filter tools with greater fidelity/capability.
- Line to line tool, which identifies high risk flanges without sealer, adhesive, and predicts the pooling of water in service.
- Most challenging aspect remains how to develop a model or estimate a corrosion rate without physical data to determine if action is required.

Questions?