Steel Battery Enclosure Design for Electric Vehicles
Webinar Audience Question Follow-Up

#	Audience Question	Tom Wormald's Answers
1	China is the largest producer and seller of EVs, what do the homegrown Chinese EV use for Battery Enclosures? (e.g Wuling, BYD, Geely, etc)	I'm not aware if ArcelorMittal currently has a significant presence in the battery enclosure market in China.
2	When it comes to cladding of the system, which types do we see here regarding fire protection ?	Cladding in the thermal systems of battery enclosures are usually either steel or aluminum designs. Fire protection is usually a function of the upper cover materials.
3	Is the Fortiform in the structural part based on TRIP or Q&P steel recipe?	A big part of ArcelorMittal's strategy for Fortiform (and Gen3 grades in general) has been the Q&P approach. This does not mean that we are not pursuing other strategies as market and technological advancements dictate.
4	What is the lifetime for a battery with a steel enclosure? There is interest in retiring EV batteries to secondary energy storage uses at windfarms and for backup generation at hospitals and other places.	The steel enclosure would not be expected to be the determining factor in the lifetime of the battery assembly.
5	I assume that adhesive bonding is widely used in the final assembly. What type of adhesives are used and what surface treatments are applied to the steel before bonding.	Adhesives have not been widely applied for the current ArcelorMittal battery enclosure solutions. As a steel-intensive structure, we chose to rely much more heavily on spot and MAG welding.
6	Can the steel resist the GTR20 fire protection regulation?	I don't believe that specific standard was evaluated (modeling and evaluation was performed in Europe), but under all our assessments steel outperformed the aluminum benchmark material.
7	Are these CP, DP, martensitic steel galvanized for Battery enclosure application?	For the majority of battery enclosure applications, we certainly see a coated steel grade as recommended - whether that takes the form of galvanized, galvanneal or other (ZnAlMg or additional e-coat) will depend greatly on the OEM strategy and life expectations.
8	Would use consider structural adhesives?	Structural adhesives would certainly be considered in combination with spot welding in certain areas of the designs. Some benefit to stiffness might be achieved if modal targets were found difficult to meet.
9	What is manufacturing technology for these parts - stamping? Are there any other technologies like die casting that are used?	Currently our proposals use both sheet metal stamping and roll forming.
10	To your knowledge have hydroform tubes been used in the side rail structural components?	To my knowledge, no. One challenge will be creating the complex cross-sections we often see in the side rail structures. No reason it could not be a hydroform design if the anti-intrusion performance could be achieved.
11	How important is corrosion protection? Steel might corrode!	For the majority of battery enclosure applications, we certainly see a coated steel grade as recommended - whether that takes the form of galvanized, galvanneal or other (ZnAlMg or additional e-coat) will depend greatly on the OEM strategy and life expectations.
12	You are using steel for the battery cooling plate. Steel has a bad thermal conductivity against Aluminum. Is it already existing in mass production ?	Steel thickness would be scaled to achieve comparable system performance. I'm not certain what steel cooling systems for BEV vehicles are currently in production.

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13	Is there any issue with heat from a crash fire or from a collision repair lowering the strength of the steel battery pack? Or would the entire pack structure need to be replaced after a collision?	Steel is a more stable material at high temperatures than competitive materials. A bigger concern after a collision might be to ensure that the electrical and thermal systems have not been compromised.
14	Hi, are there dedicated manufacturers (specialists) of battery enclosures OR are car makers and tier ones traditionally taking care of it?	I guess we'll have to wait and see. New technology and integration into the BIW could move this towards OEM manufacture, but there are strong indications that Tier 1s will be heavily involved.
15	Controlling springback on the tray must be difficult. Wouldn't ribs help control this?	Lower strength steel grades are proposed in the current design to achieve the formability requirements. As higher strength grades are introduced into modified versions of this design concept then springback control (like ribs) will be necessary, yes.
16	Can you please address why we are seeing so many Aluminum battery box designs?	The generation of BEV vehicles on the road today deal with a strong range anxiety, which leads designers to lower mass at high cost. As battery costs lower and BEV vehicles become more commonplace at a lower price, the advantages of steel battery enclosures (cost, environment, safety) will be even more attractive.
17	As we move towards more advanced steels like press hardened, how much of the cost advantage of steel is negated?	Some increase in cost is expected as strength is increased within a steel design. We believe this increase is largely (if not completely) offset by lower thickness, elimination of reinforcements, and avoiding springback control strategies (for PHS) like restrike dies.
18	Are your customers asking for concepts that integrate batteries into body on frame pick-ups, or are they looking to move to more of a skateboard design for BEV pickups? Integrating it into a BoF helps with the volume, but might lead to a less optimal engineering solution	We expect that a good portion of initial pickup truck battery enclosures will need to adapt to a modified version of a traditional frame design. There are certainly engineering advantages to more integration, but a complicating factor may be platform sharing within a given OEMs product line.
19	Can you please speak to the differences (pros/cons) of a steel tray versus a cast aluminum tray? Cost/Weight/Safety/etc	Cost and as-formed strength would be primary advantages. Cast aluminum could have mass advantages depending on sophistication of design.
20	What about corrosion on a cut side?	Current (GI, GA, EG) and emerging (ZnAlMg) coatings show exceptional protection against corrosion at cut edges.
21	Could steel be recyclable, as aluminum is?	Steel is the most recycled metal in the world. Scrap steel is an integral (and necessary) part of steel production, and segregation by grade is not required.
22	Modal frequency requirement of 35 Hz, is it free or constrained ?	Constrained at bracket connections to the BIW.
23	Are you doing formability studies for the battery tray in Gen 3 steels in presses in your R&D centers or directly with OEM R&D centers?	Current designs of battery trays in our proposals are not considered forming feasible in Gen3 steel grades.
24	Are the shock loads from SAE ?	Abuse shocks yes, proof shocks were provided by international consultant (Ricardo UK)
25	Any study in durability/fatigue weld and rivet failure test and CAE simulation?	No rivets in current ArcelorMittal battery enclosure proposals. No fatigue evaluation was performed on welds in our models (yet) but all combinations were considered feasible.

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26	Have you seen any porosity in spotwelds leading to potential leaks into the battery pack?	None of the weld combinations in the current set of proposals is expected to be especially susceptible to either porosity or LME.
27	Do you have a breakdown of sealing methods used, which is more popular/least popular?	Specifics of the sealing methods and technology were not investigated in the current set of ArcelorMittal proposals.
28	Tube	There are some great advantages to tubular design, but unfortunately it is often stiffness related. We would certainly love to see tubular products integrated into battery enclosures if an appropriate design could be developed. If you have any proposals we would certainly like to discuss.
29	What would you view be on the 2 or 3 pros of and cons of Steel vs Aluminum for battery trays	Amongst the strongest advantages of steel grades in the current generation of battery box designs is impact protection in the minimum package space - maximizing the volume for batteries. The additional cost of corrosion protection and some of the thermal/electrical advantages of competing materials is recognized.
30	Any comment on such comparison with polymer composite based case?	A cost competitive polymer composite for the upper cover would certainly be an option for some designs if all safety requirements could be met.