

GREAT DESIGNS IN **STEEL**

Cleveland-Cliffs Battery Enclosure (CCBE)

Miao Yu

Advanced Applications Engineer

Cleveland-Cliffs Inc.



This project is performed by the Advanced Engineering Team
at Cleveland-Cliffs:

Miao Yu

Feng Zhu

John Makrygiannis

Jimmy Zhang

Sajan George Elengikal

Sobhan Nazari

Yu-Wei Wang



CLIFFS

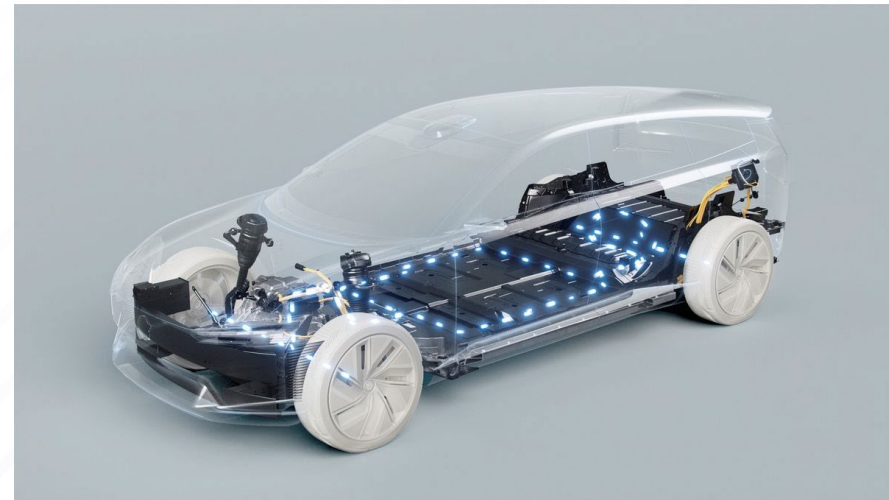
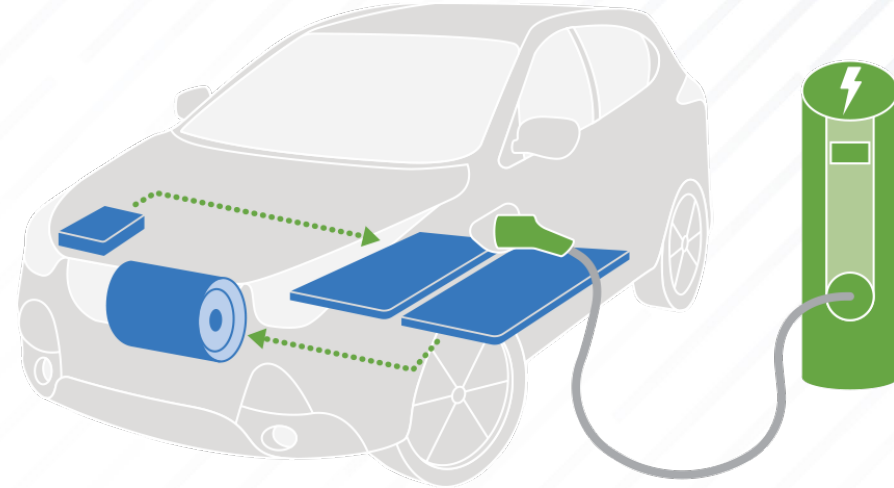
AGENDA

- **Background**
- **Cleveland-Cliffs Battery Enclosure (CCBE) Design Details**
- **CCBE Structure and Stamping of LWB Tray**
- **Tests for Leakage and Thermal Runaway**
- **Summary**

Background

BACKGROUND

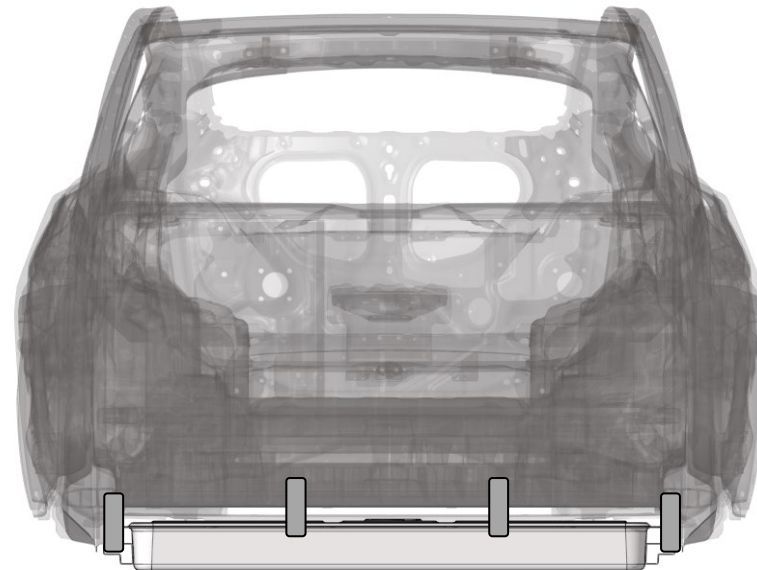
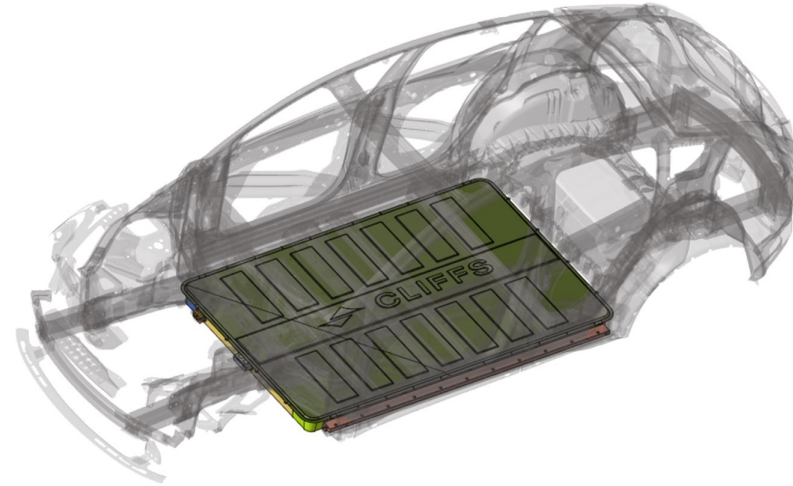
- Electrification is the future of the automotive industry
- Battery enclosure, as a power supply unit, is one of the most important components in battery electric vehicles
- Cleveland-Cliffs offers a sustainable and robust steel battery enclosure solution meeting stringent standards



Pictures from google







BACKGROUND

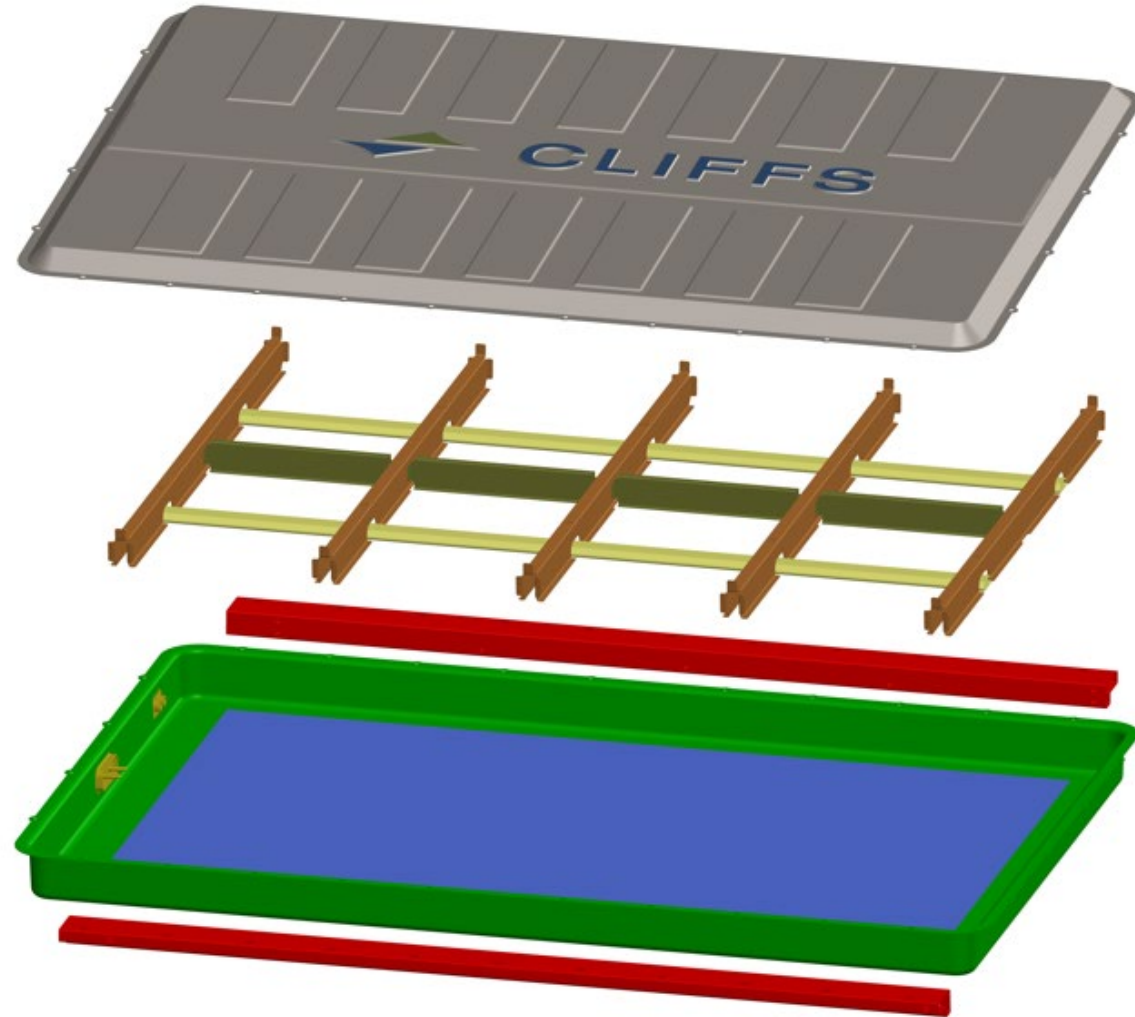
- CCBE is designed for CUV (cross utility vehicle) but can be scaled to fit any other uni-body architectures
- CCBE is connected with BIW through side rails and underfloor



Cleveland-Cliffs Battery Enclosure (CCBE) Design Details

CLEVELAND-CLIFFS BATTERY ENCLOSURE(CCBE) DESIGN DETAILS

-  Top cover
-  Longitudinal members
-  Longitudinal stiffeners
-  Cross members
-  External side crash protection / attachment rails
-  Laser welded bottom tray

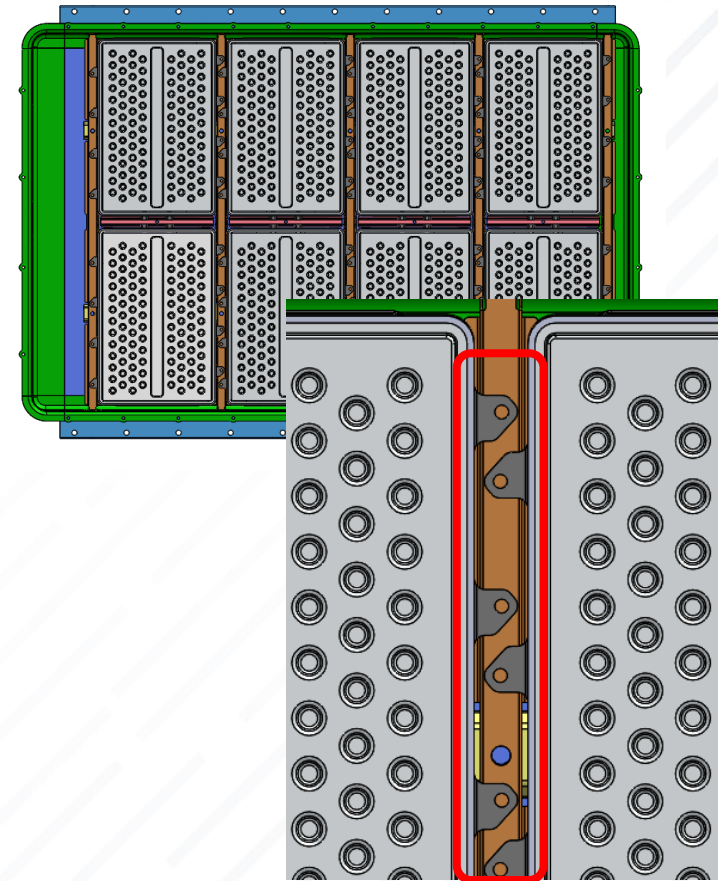
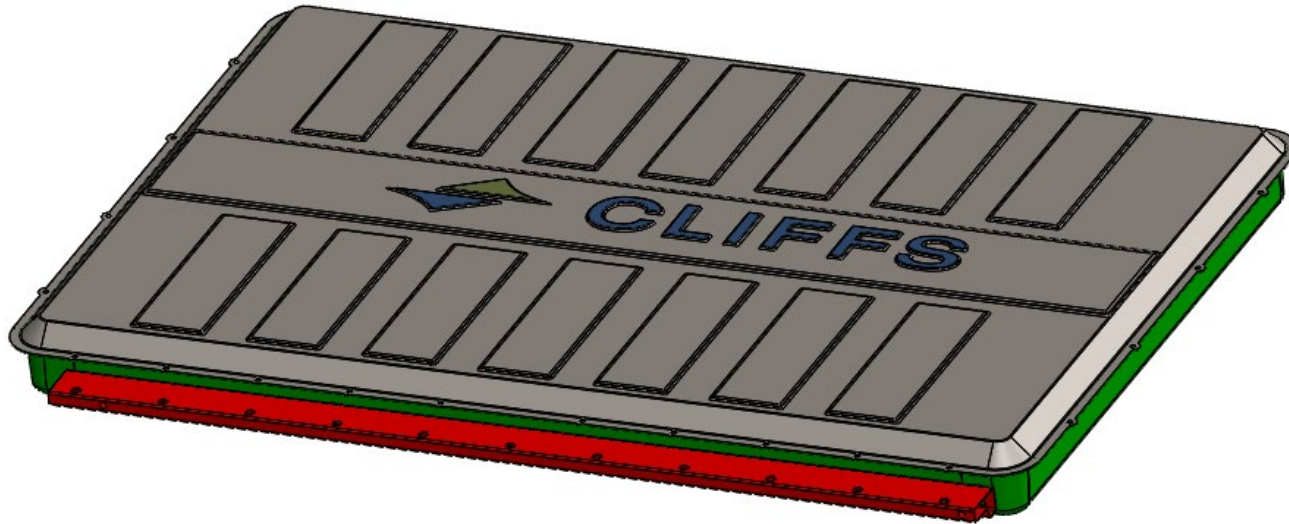


CLEVELAND-CLIFFS BATTERY ENCLOSURE(CCBE) DESIGN DETAILS

Component	Grade	Gauge (mm)
Top cover	Mild Steel	0.8
Cross members	M1500	1.2
Longitudinal members	MP980	1.0
Longitudinal stiffeners	ULTRALUME 2000	1.2
External side crash protection / attachment rails	ULTRALUME [®] 1500	2.0
LWB battery tray	M1700 / Mild Steel	2.0 / 1.4

- Total structural weight is 102kg.


CLEVELAND-CLIFFS BATTERY ENCLOSURE(CCBE) DESIGN DETAILS



- 8 battery modules are bolted on lateral cross members with a staggered pattern
- 80kWh with cylindrical cells
- L x W x H: 2132mm x 1492mm x 157mm

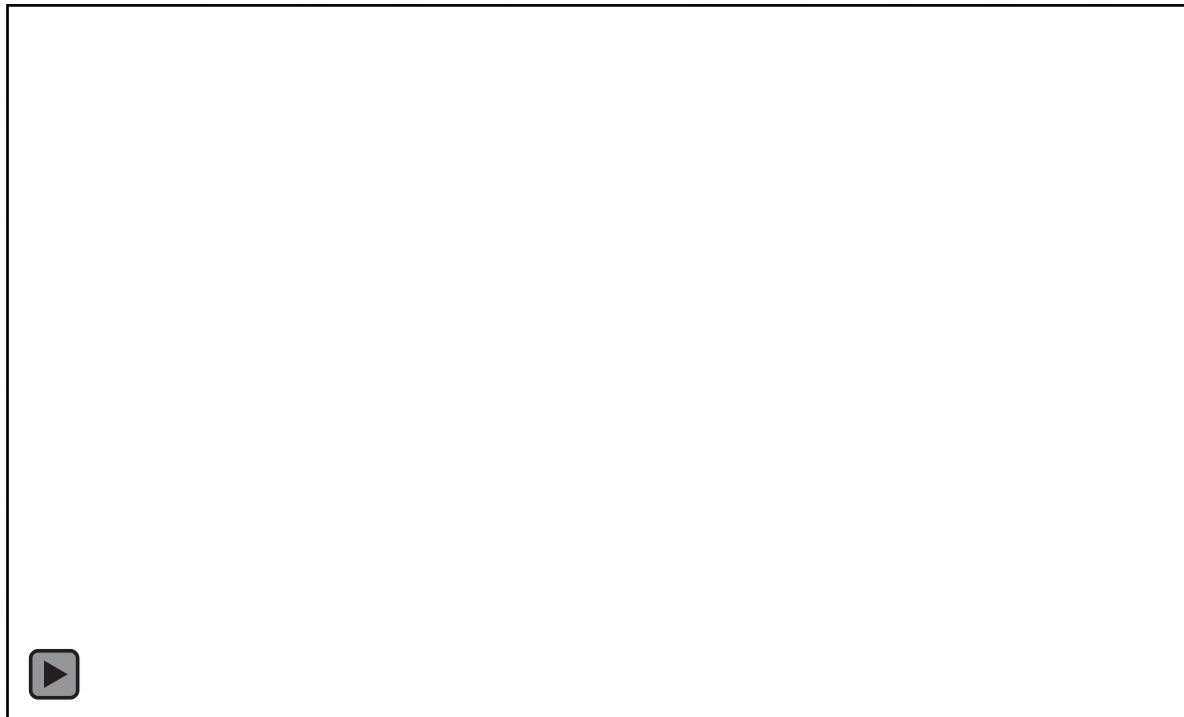
CCBE Structure and Stamping of LWB Tray

CCBE PRIMARY LOAD CASES – SIDE POLE IMPACT

- Analysis object: Battery enclosure component
- Method: Enclosure is impacted by a 150mm pole from side, no contact with battery module before 100kN
- Judgment: OK 



Picture from google

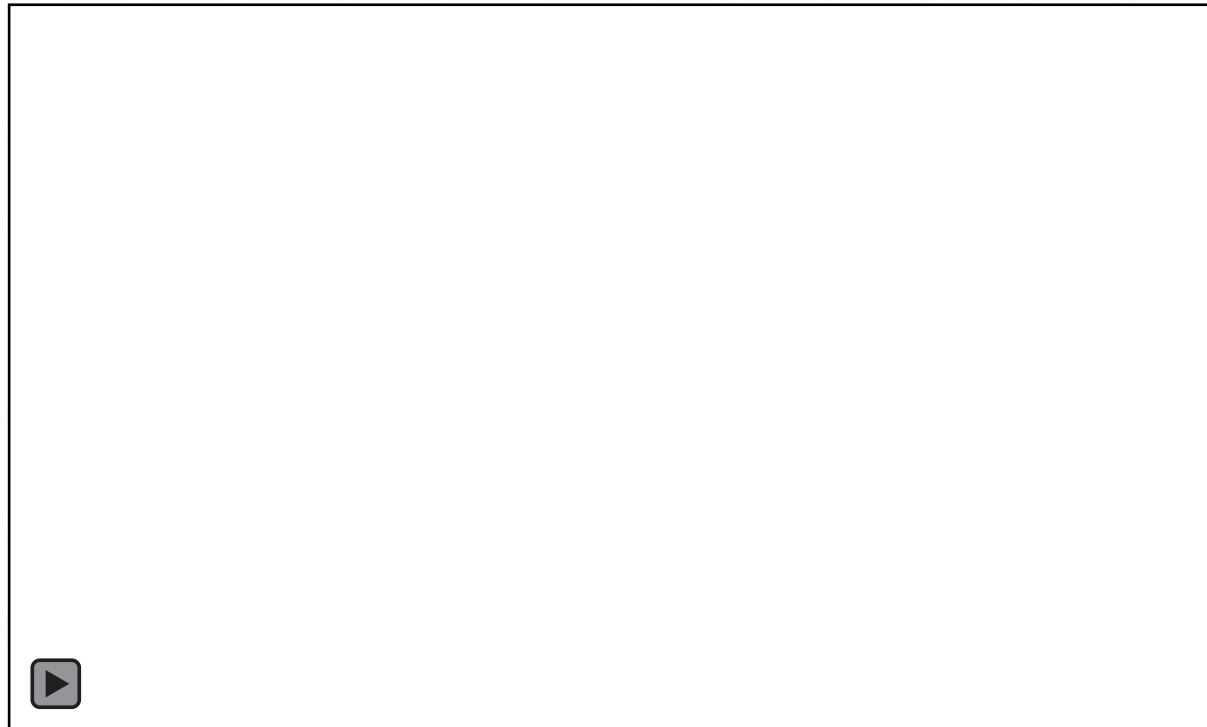


CCBE PRIMARY LOAD CASES – UNDERFLOOR INTRUSION

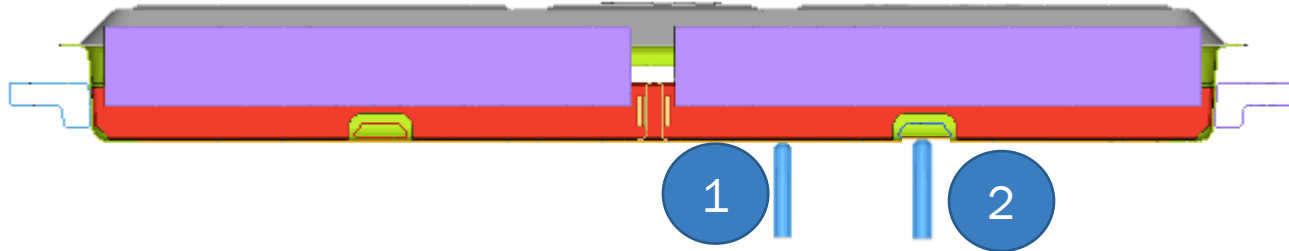
- Analysis object: Battery enclosure component
- Method: Enclosure is impacted by a 20mm diameter pole from bottom, no contact with battery module before 35kN



Picture from google



CCBE PRIMARY LOAD CASES – UNDERFLOOR INTRUSION

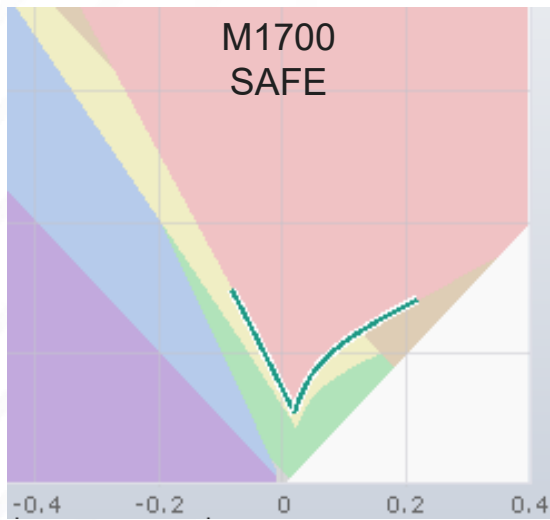
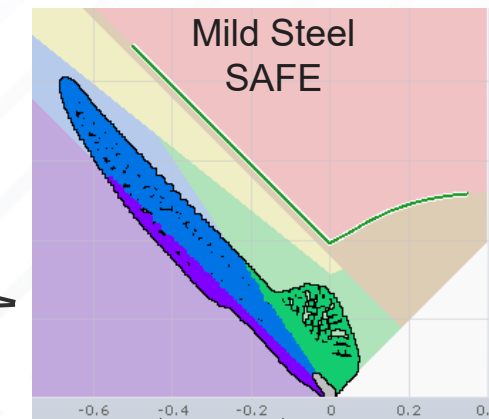
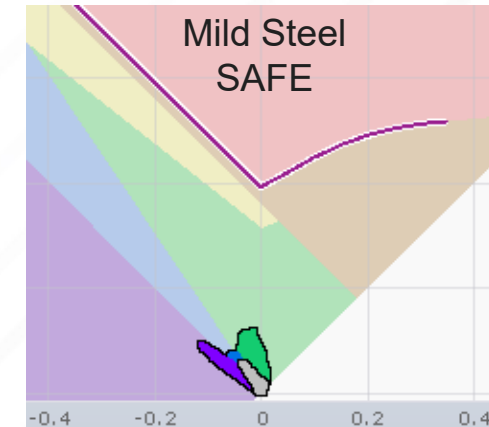
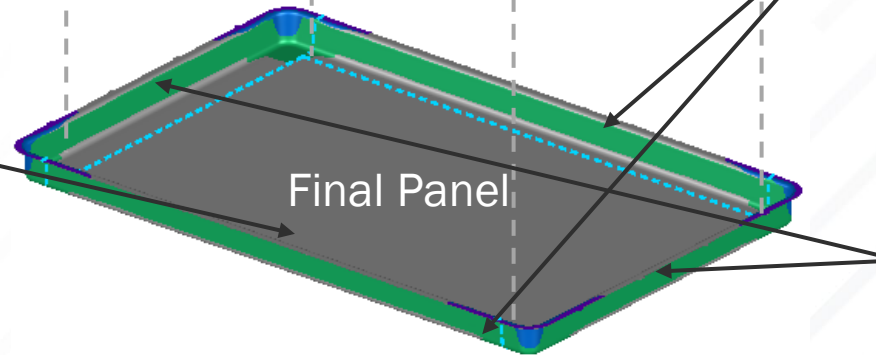
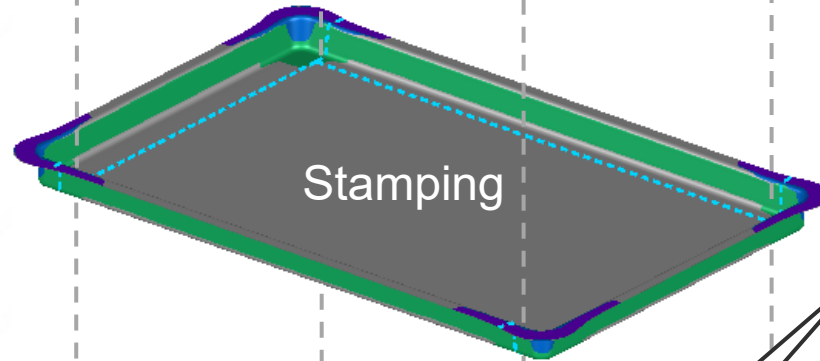
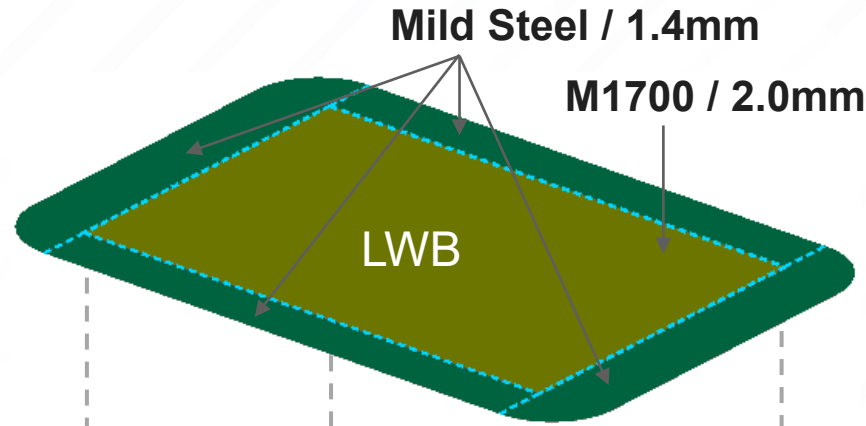
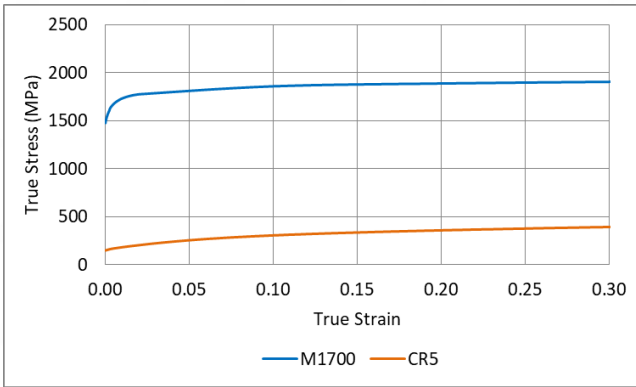


- No contact to battery module while reaching 35kN for both locations

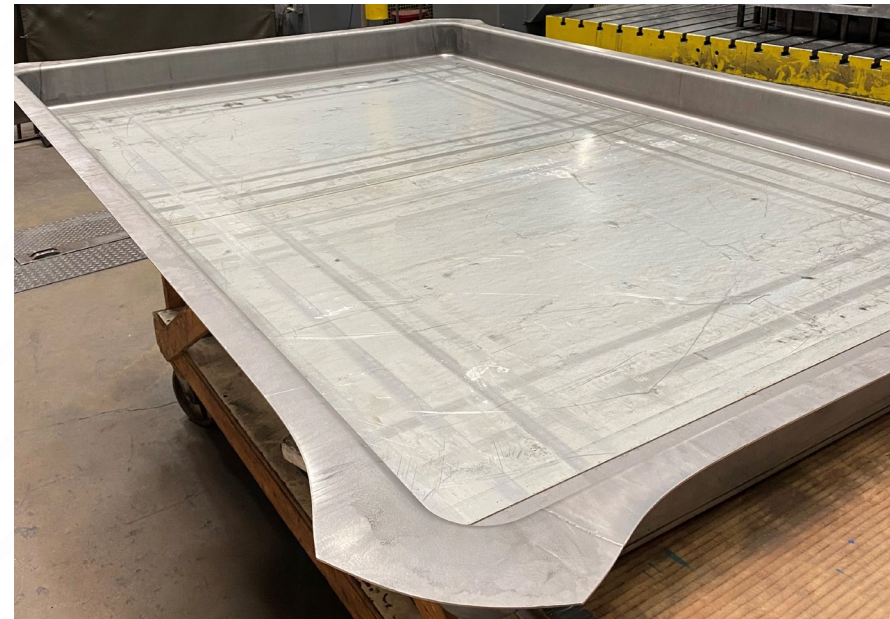
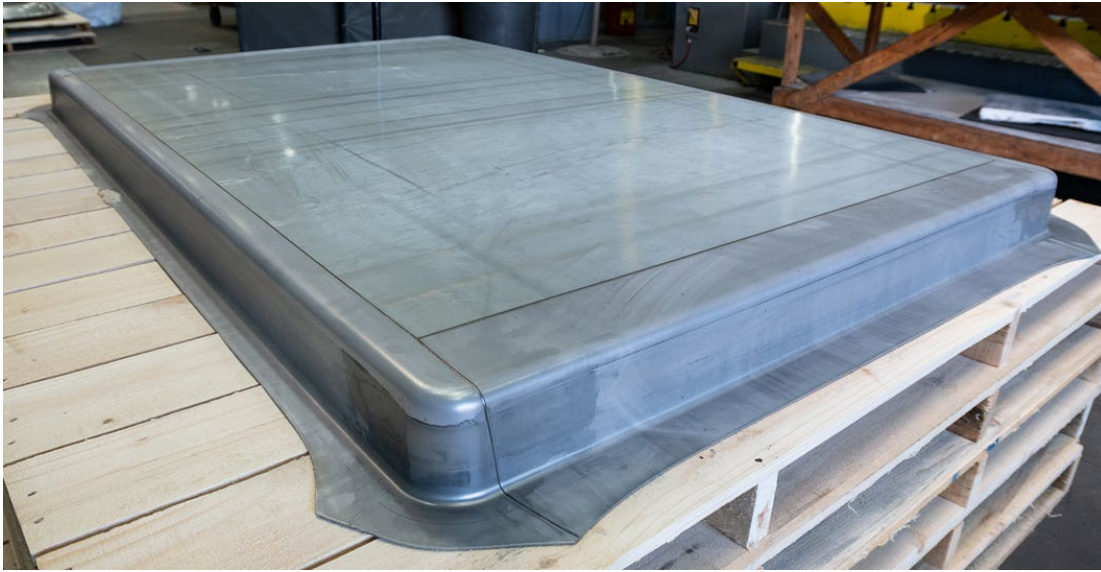
- Judgment: OK



FORMING ANALYSIS: "#" SHAPE LWB TRAY



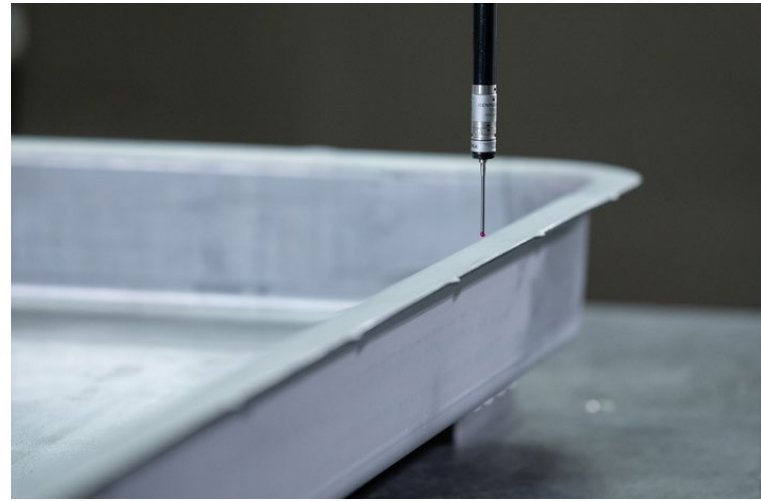
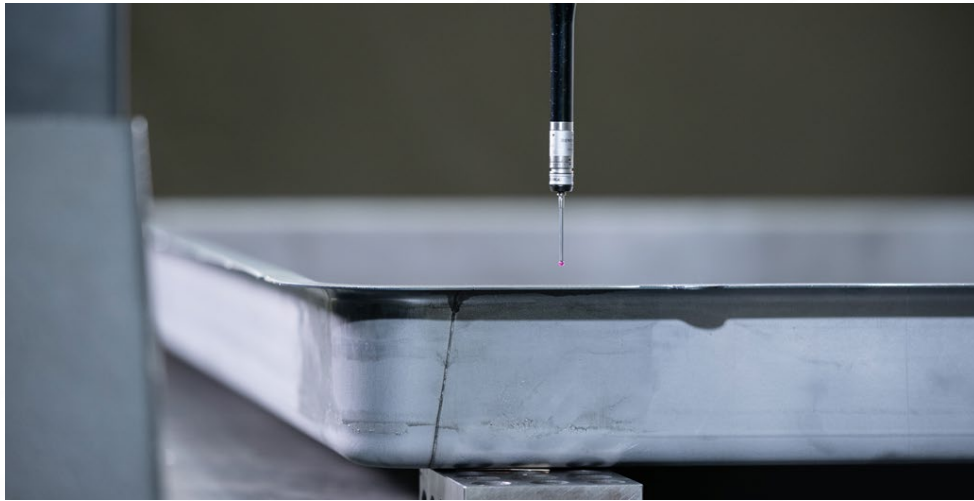
CCBE LASER WELDED BLANK TRAY



- The laser welded tray is successfully stamped



CCBE LASER WELDED BLANK TRAY



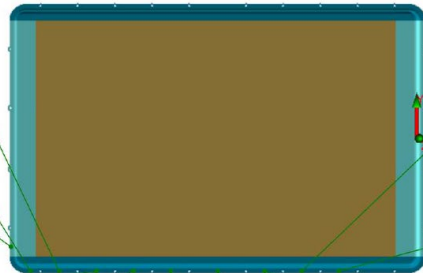
SURF-23				
Normal	All Tol	Mean	Mean Deviation	
X	-1.81.0000	+1.5000	-1.81.0030	0.0030
Y	476.0000	+1.5000	473.9729	0.0271
Z	112.0000	+1.5000	111.3491	0.6509
T	0.0000	+1.5000	-0.6509	0.6509

SURF-22				
Normal	All Tol	Mean	Mean Deviation	
X	-1.988.0000	+1.5000	-1.988.0028	0.0028
Y	476.0000	+1.5000	473.9722	0.0278
Z	112.0000	+1.5000	112.6572	-1.3429
T	0.0000	+1.5000	-1.3429	-1.3429

SURF-21				
Normal	All Tol	Mean	Mean Deviation	
X	2.088.0000	+1.5000	2.087.9833	0.0167
Y	500.0000	+1.5000	499.9702	0.0300
Z	112.0000	+1.5000	110.5354	-1.4646
T	0.0000	+1.5000	-1.4646	-1.4646

SURF-24				
Normal	All Tol	Mean	Mean Deviation	
X	-1.851.0000	+1.5000	-1.851.0014	0.0014
Y	476.0000	+1.5000	475.9716	0.0284
Z	112.0000	+1.5000	111.1398	0.8602
T	0.0000	+1.5000	-0.8602	0.8602

SURF-25				
Normal	All Tol	Mean	Mean Deviation	
X	-1.461.0000	+1.5000	-1.461.0021	0.0021
Y	476.0000	+1.5000	475.9702	0.0298
Z	112.0000	+1.5000	111.1211	0.8789
T	0.0000	+1.5000	-0.8789	0.8789



SURF-29				
Normal	All Tol	Mean	Mean Deviation	
X	2.088.0000	+1.5000	2.088.5044	-0.5044
Y	476.0000	+1.5000	475.9637	0.0363
Z	112.0000	+1.5000	111.4624	0.5376
T	0.0000	+1.5000	-0.5376	0.5376

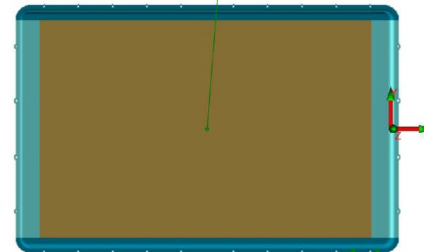
SURF-30				
Normal	All Tol	Mean	Mean Deviation	
X	-403.5000	+1.5000	-403.5049	0.0049
Y	476.0000	+1.5000	475.9676	0.0324
Z	112.0000	+1.5000	111.4270	0.5730
T	0.0000	+1.5000	-0.5730	0.5730

SURF-26				
Normal	All Tol	Mean	Mean Deviation	
X	-1.271.0000	+1.5000	-1.271.0023	0.0023
Y	476.0000	+1.5000	475.9716	0.0284
Z	112.0000	+1.5000	112.2962	-0.2962
T	0.0000	+1.5000	0.2962	-0.2962

SURF-27				
Normal	All Tol	Mean	Mean Deviation	
X	-1.029.0000	+1.5000	-1.029.0015	0.0015
Y	476.0000	+1.5000	475.9703	0.0297
Z	112.0000	+1.5000	111.4729	0.5271
T	0.0000	+1.5000	-0.5271	0.5271

SURF-28				
Normal	All Tol	Mean	Mean Deviation	
X	2.788.5000	+1.5000	2.788.5022	0.0022
Y	476.0000	+1.5000	475.9714	0.0286
Z	112.0000	+1.5000	111.4758	0.5242
T	0.0000	+1.5000	-0.5242	0.5242

SURF-31				
Normal	All Tol	Mean	Mean Deviation	
X	2.788.5000	+1.5000	2.788.5031	-0.0031
Y	476.0000	+1.5000	475.9688	0.0312
Z	112.0000	+1.5000	111.4673	0.5327
T	0.0000	+1.5000	-0.5327	0.5327



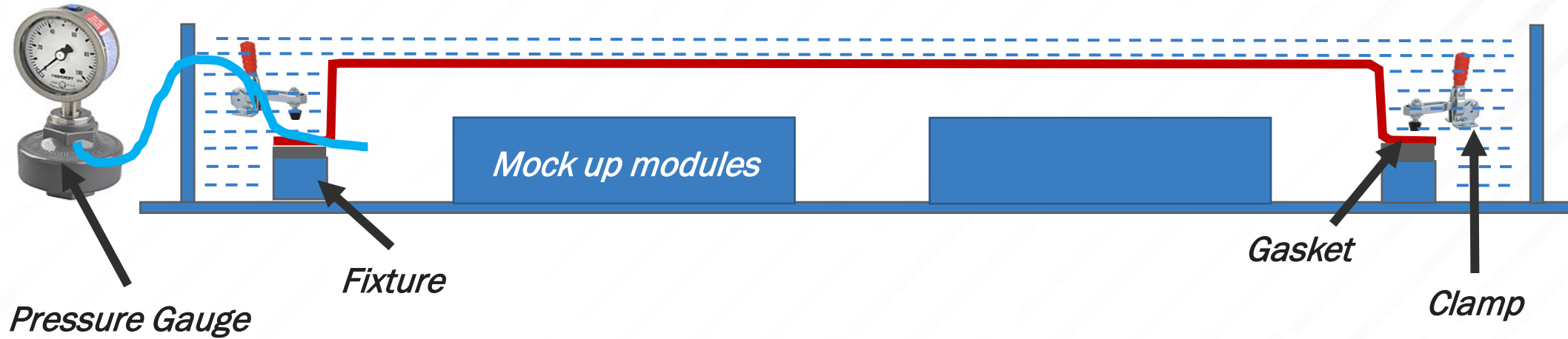
DUAL				
Normal	All Tol	Mean	Mean Deviation	
X	0.0000	+1.0000	0.0000	0.0000

SURF-32				
Normal	All Tol	Mean	Mean Deviation	
X	6.45.0000	+1.5000	6.45.0023	-0.0023
Y	676.0000	+1.5000	675.9713	0.0287
Z	112.0000	+1.5000	110.2744	1.7256
T	0.0000	+1.5000	-1.7256	1.7256

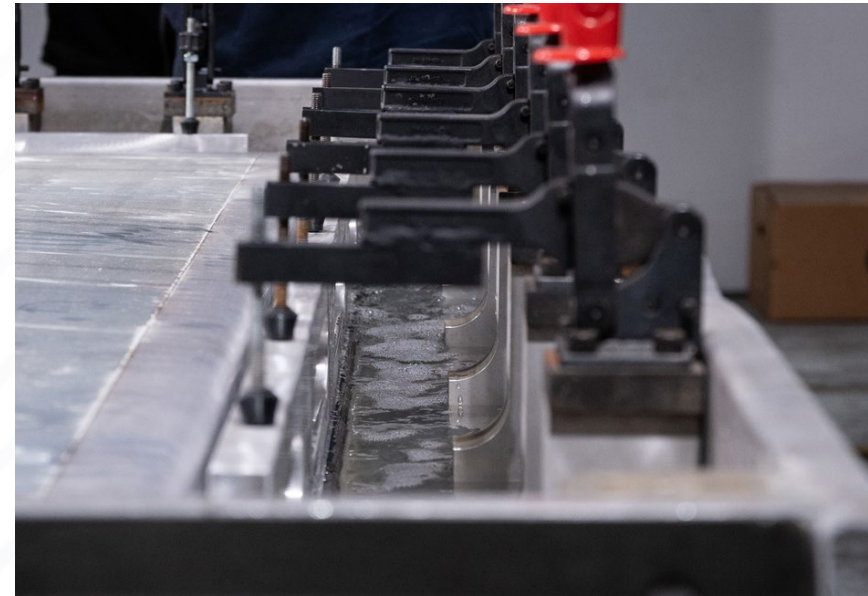
- The flange achieves +/- 1.5mm flatness tolerance

Tests for Leakage and Thermal Runaway

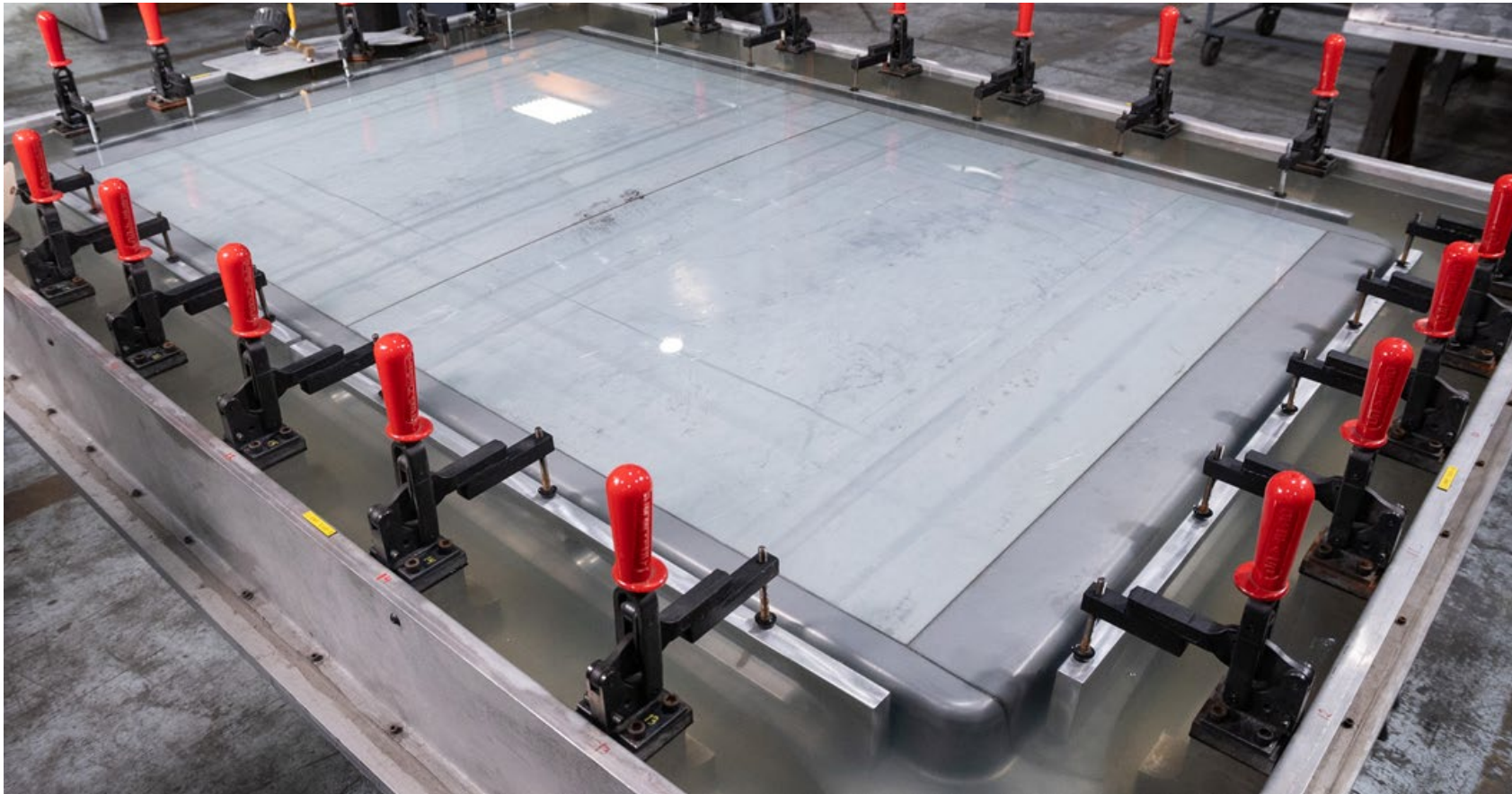
LEAK TEST FOR CCBE LASER WELDED BLANK TRAY



- The tray is placed upside down and clamped on the fixture
- Requirement: Leaking rate less than 15 Standard Cubic Centimeters per Minute (SCCM) in 15 minutes

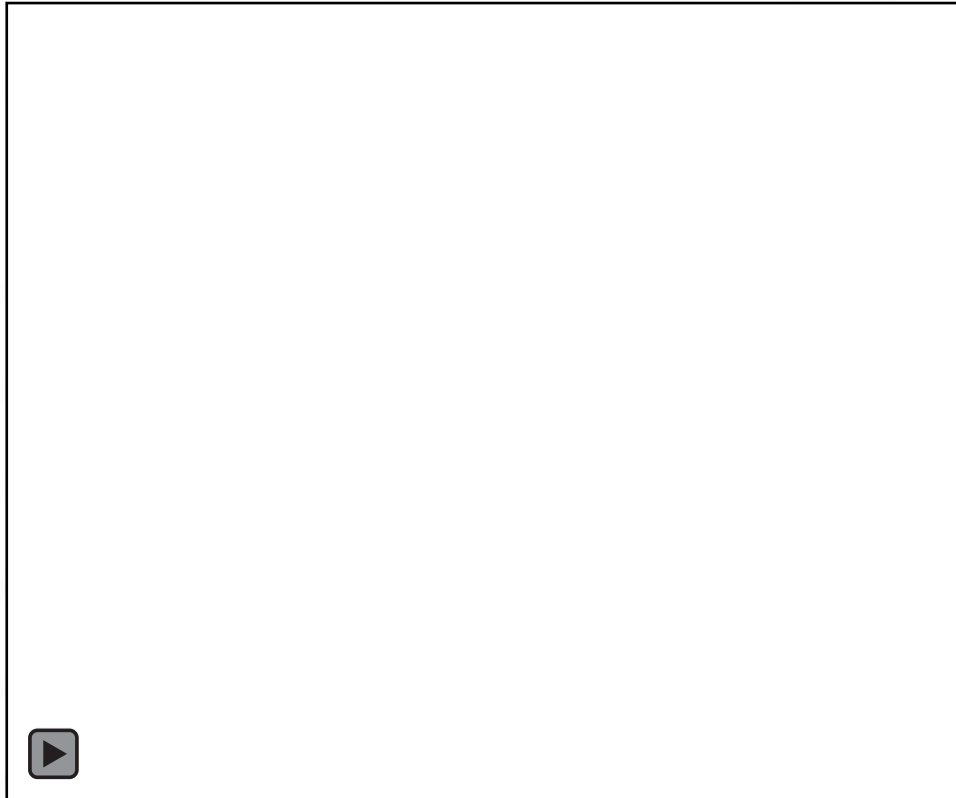


LEAK TEST FOR CCBE LASER WELDED BLANK TRAY

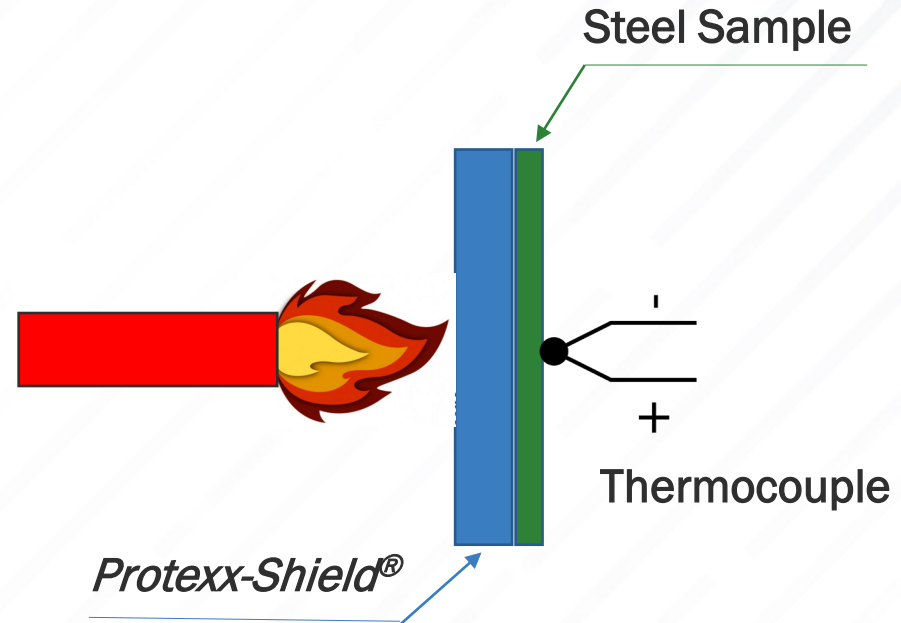


- No leakage under 0.5psi for 15 minutes (0 SCCM for 15 minutes). The tray passes the requirement

CCBE THERMAL RUNAWAY SOLUTION



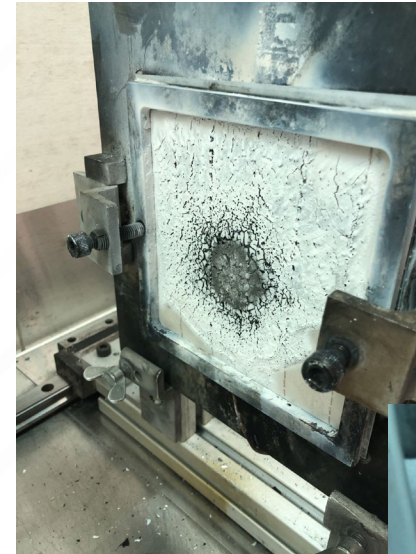
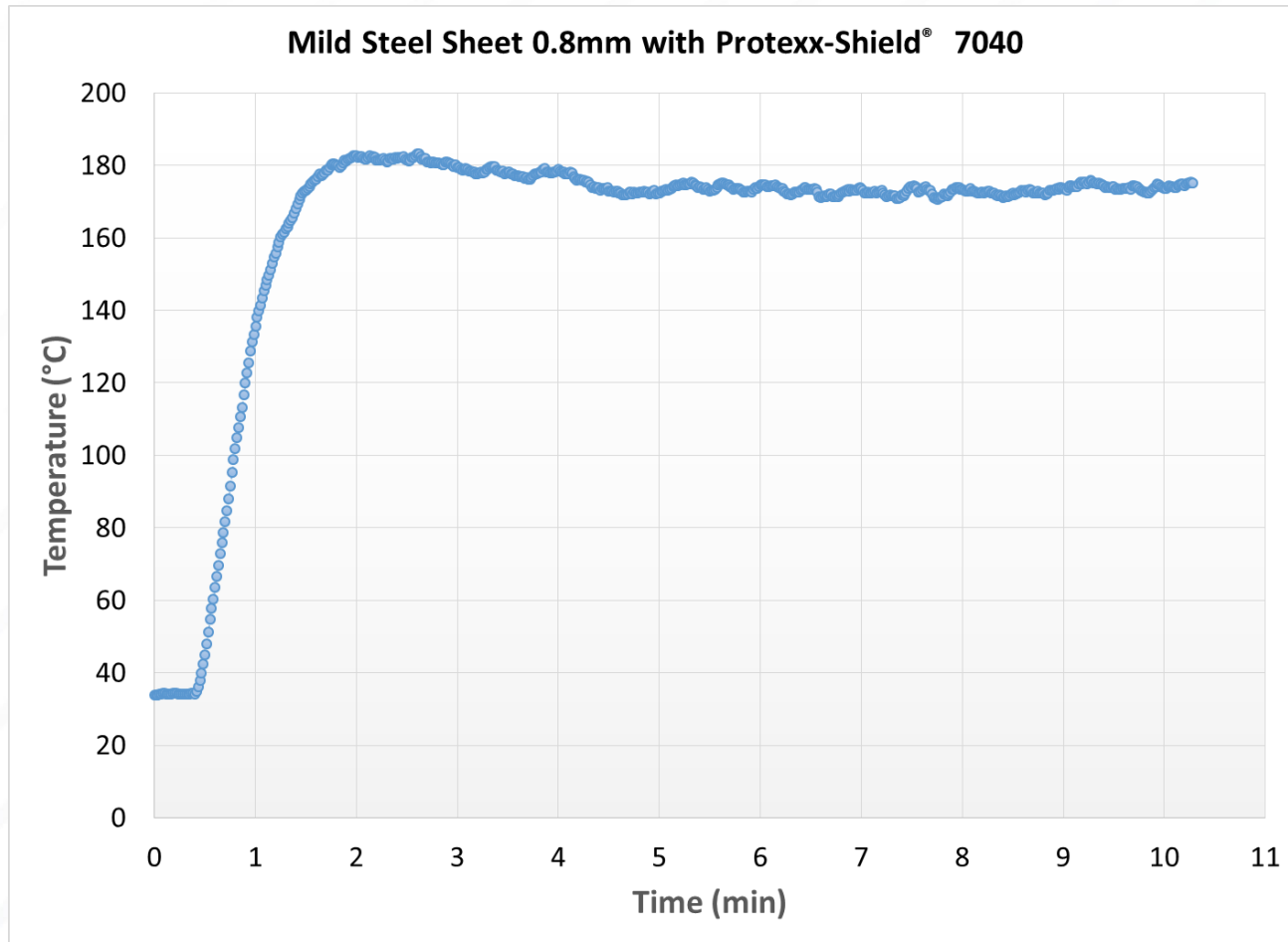
Video from Tenneco



1000 °C torch heating for 10 minutes on front side. Back side temperature should be below 200 °C



CCBE THERMAL RUNAWAY SOLUTION



Front side



Back side

Data and Pictures from Tenneco

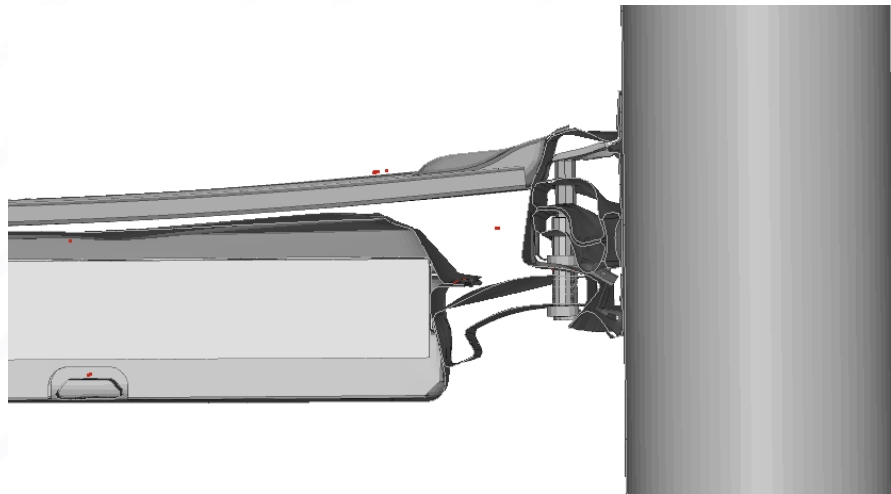
- The solution (0.8mm mild steel with Protexx-Shield® 7040) controls the temperature around 180°C for at least 10min

Summary

SUMMARY

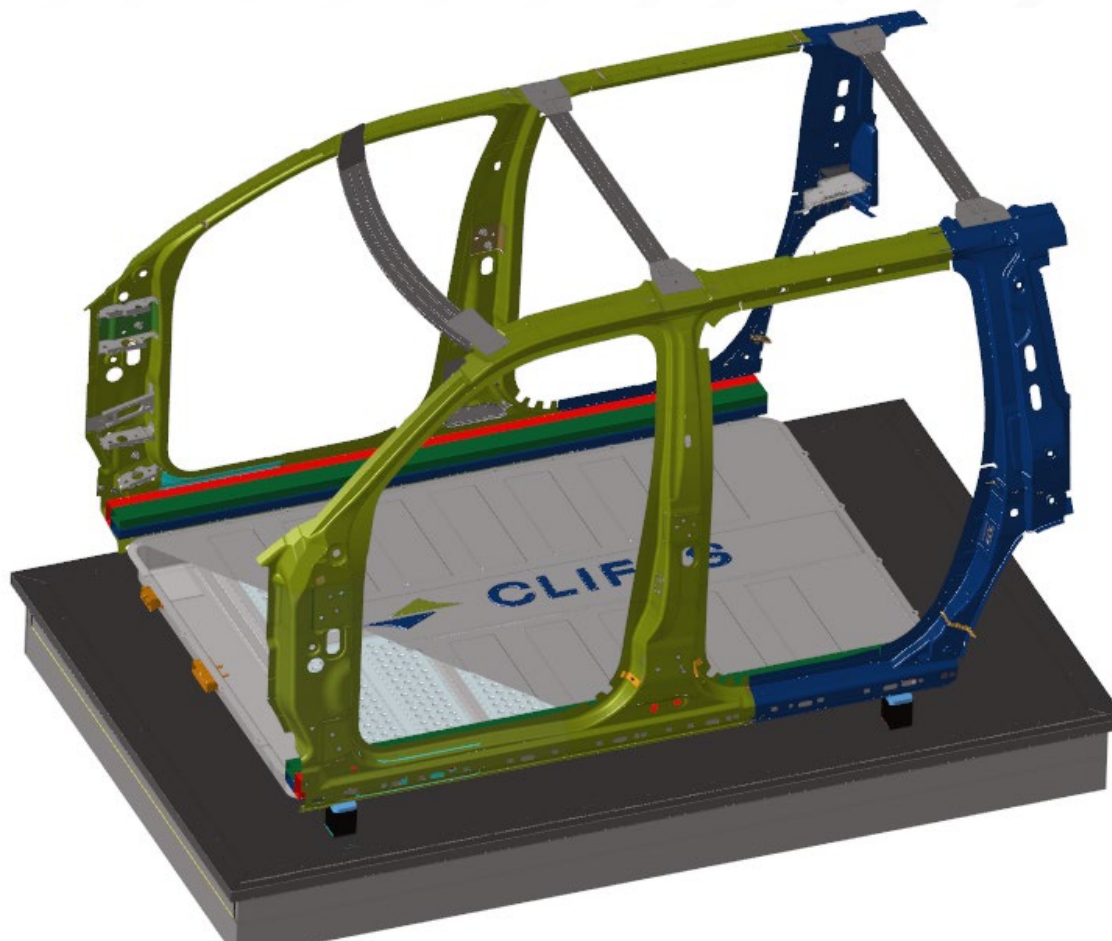
- CCBE is a sustainable and robust steel solution meeting structure standards and safety requirements
- Optimizations on further weight reduction and benchmark studies
- Investigations about sub-system level model including rocker assembly and seat cross member

	Judgment
Side Pole	✓
Underfloor Intrusion	✓
Stamping	✓
Flange Flatness	✓
Leak Test	✓
Thermal Runaway	✓



CLEVELAND-CLIFFS 2024 GDIS DISPLAY

GDIS



ACKNOWLEDGEMENT

We greatly appreciate the support of:

TWB Company
System Protection of Tenneco



FOR MORE INFORMATION

MIAO YU

CLEVELAND-CLIFFS INC.

MIAO.YU@CLEVELANDCLIFFS.COM

YU-WEI WANG

CLEVELAND-CLIFFS INC.

YU-WEI.WANG@CLEVELANDCLIFFS.COM