SES(等価構造計算書) EV編

Accumulator Side Protection,
Tractive and HV side Protection (EV only)
Rear Impact Protection (EV only)

Accumulator Side Protection

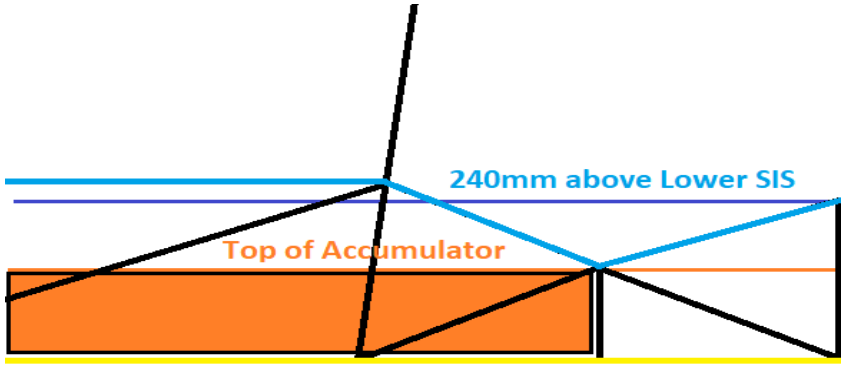
記入した数値が正しいことを確認できる図面を添付すること

F.11.2.1 Side Impact Protection

a. All Accumulator Containers must be protected from side impact by structure Equivalent to SIS(F.6.4, F.7.5)
   The Accumulator Container must not be part of the Equivalent structure.
b. Accumulator Container side impact protection must go to a minimum height that is the lower of the two:
   - The height of the Upper Side Impact Structure
   - The top of the Accumulator Container at that point

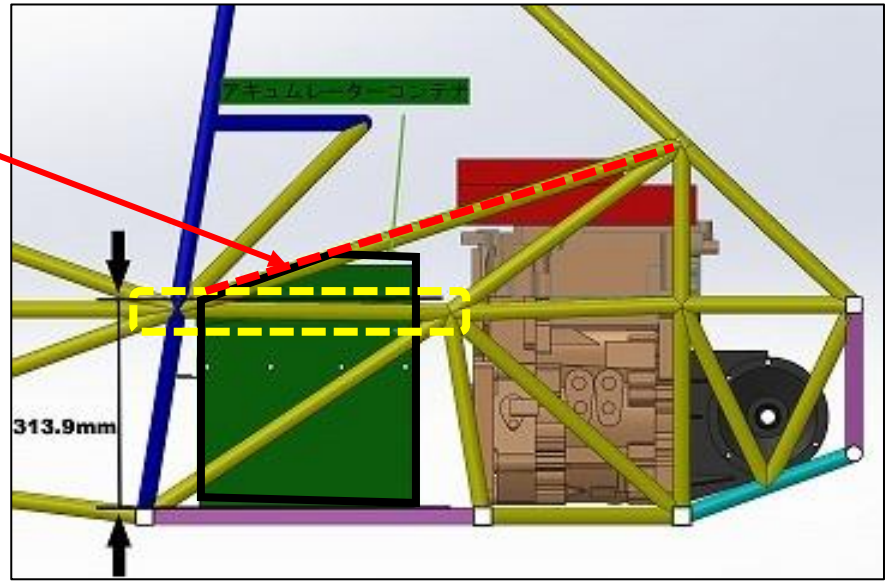
SIS とRear Impact の間の三角構造による HV 保護は、Lower SISの上方 240 mm または アキュムレータの上部のいずれか低い方まで低くすることができます。 最大高さはありません。

黄色破線のパイプが、Lower SISの上方 240 mm（Upper SISのこと）と同じ高さなら、ACCが上に飛び出していても良い。つまり、赤色破線のパイプは無くても良い。



**The triangulated HV protection between the SIS and Rear Impact may be as low as 240mm above the Lower SIS or the top of the accumulator, whichever is lower.
There is no maximum height.**

BLANK				
F.11.2.1.a Accumulator Side Protection	**Minimum**	**Tube Used**		EQ
F.3.2.1.m Example: 25.4mm x 1.6mm round	Size B	Round		EQ
F.3.4.1.b Wall thickness:	1.2		mm	BLANK
Outer Diameter (OD):	25		mm	BLANK
Wall thickness:	1.2		mm	BLANK
Outer Diameter (OD):	25.0		mm	BLANK
Tube cross sectional area (A):	114		mm^2	BLANK
Tube second moment of inertia (I):	8509		mm^4	BLANK



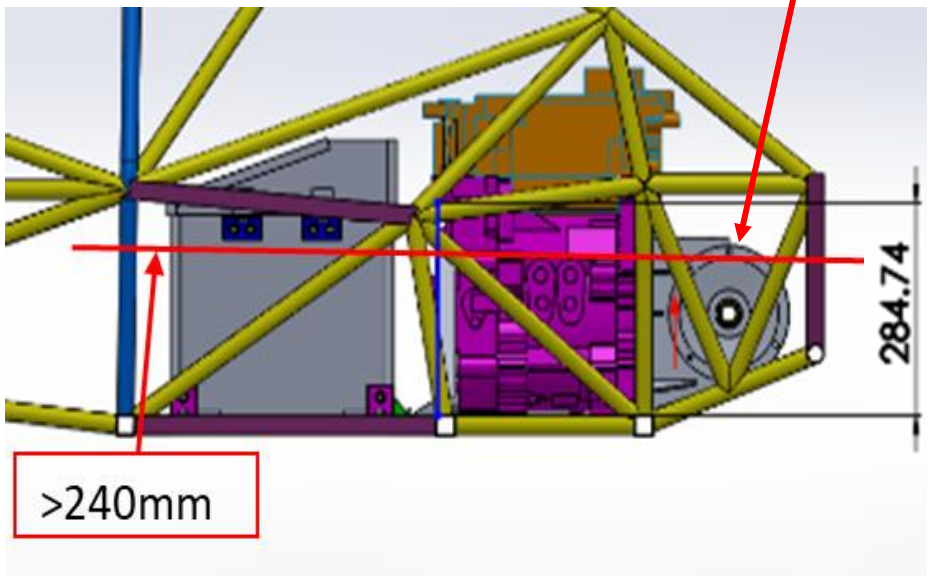
Air Gap to Driver's Seat

記入した数値が正しいことを確認できる図面を添付すること

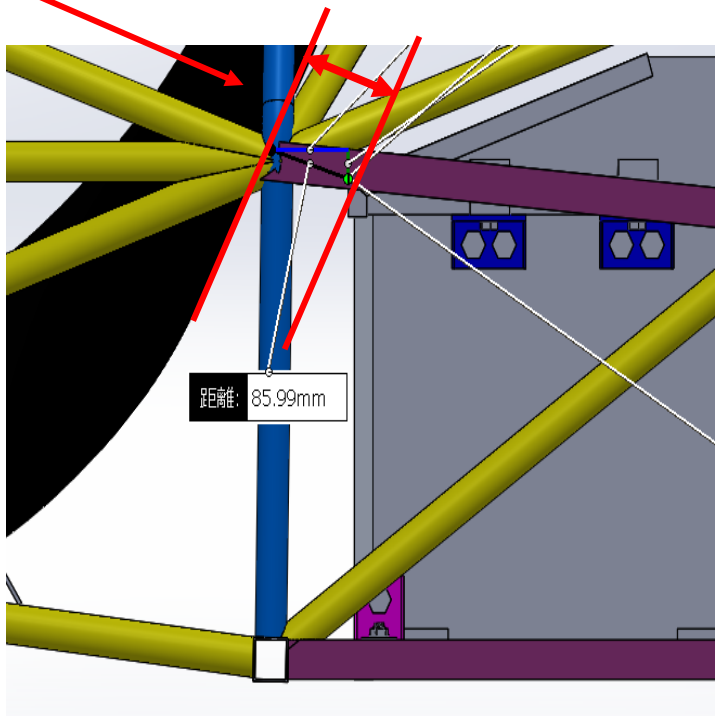
T.1.6 Heat insulation requirements apply at operating and failure temperatures.
T.1.6.3.b An air gap no less than 25mm is required between the accumulator and the driver's seat.

BLANK			
T.1.6.3.b	Air gap to driver's seat >=25mm:	mm	BLANK
	Top surface of HV Protection:		BLANK

左図のように240mm以上であること示すこと



右図のようにACCとシートとの最小距離を入力すること



Tractive and HV Side Protection

記入した数値が正しいことを確認できる図面を添付すること

Tractive and HV Side Protection (EV Only)

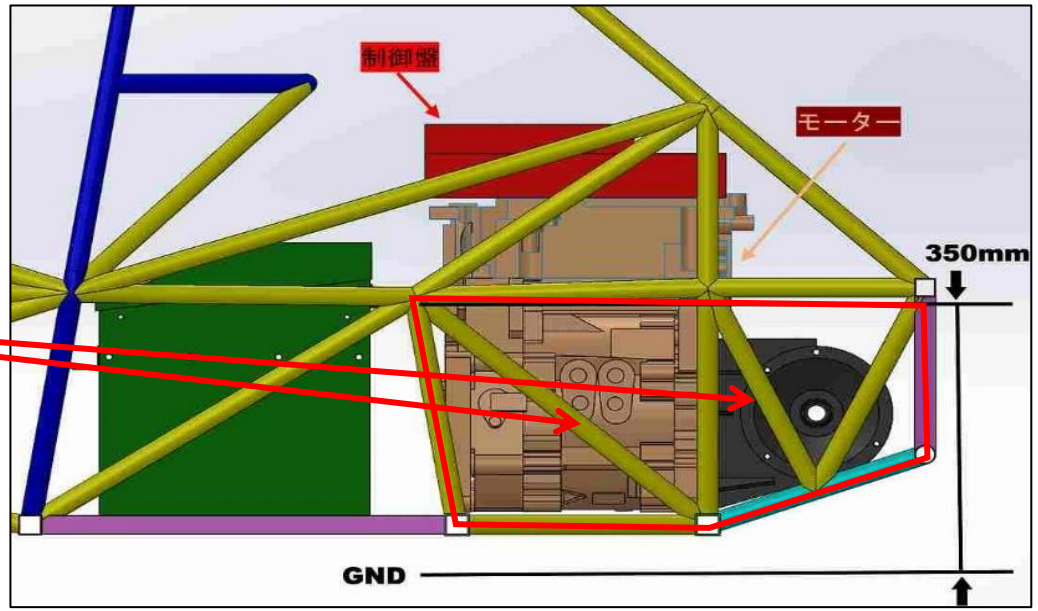
このSide Protectionは 350mm以下で必要である

F.11.2.1.a From the side, below 350mm, all HV components must be protected with an upper tube, a lower tube, and a diagonal tube or tubes completely triangulating the upper and lower tubes.

BLANK

F.11.2.1.c Tractive Side Protection	Minimum	Tube Used		EQ
F.3.2.1.n Example: 25.4mm x 1.2mm round	Size C			BLANK
F.3.4.1.c Wall thickness:	1.2		mm	BLANK
Square side:	25		mm	BLANK
Wall thickness:	1.2		mm	BLANK
Square side:	25.0		mm	BLANK
Tube cross sectional area (A):	91		mm^2	BLANK
Tube second moment of inertia (I):	6695		mm^4	BLANK

右図で赤枠に囲まれたゾーンで必要。MHBSやFBHSと同様、Φ25.4mm、t=1.2mm以上のパイプが求められる



矢印で示したパイプ以外、Side Protectionを構成するパイプの全てに該当する。

F.11.2.1.b The entire top edge of the upper tube must be at least 240mm above the lowest point of the top surface of the Lower SIS tube.

BLANK

EV motor location:	Select Drop Down	BLANK
Top surface of HV Protection:		BLANK

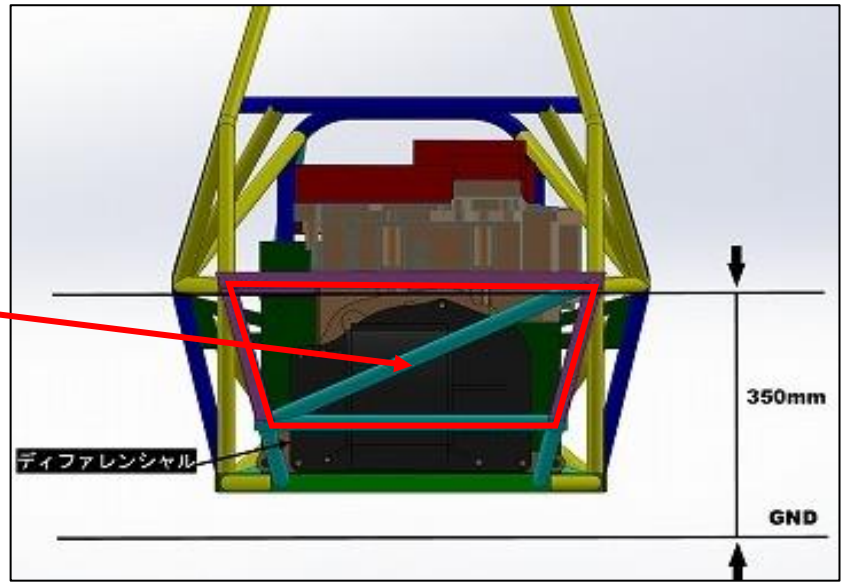
記入した数値が正しいことを確認できる図面を添付すること

Rear Impact Protection

記入した数値が正しいことを確認できる図面を添付すること

F.11.2.2 From the rear, below 350mm, all HV components must be protected with an upper tube, a lower tube, and a diagonal tube or tubes completely triangulating the upper and lower tubes. Triangulation may be asymmetric.
If a billet plate replaces all three tubes, it must fully overlap the tractive side protection tubes.
F.11.2.2.a Increase from Size C to Size B if the accumulator is < 100mm (3.937in) from the rear impact .

図で赤枠に囲まれたゾーンで必要。
Φ25.4mm、t=1.6mmまたは、
□25mm、t=1.2mm 以上のパイプが求められる



このRear Impact Protectionは 350mm以下で必要であり、通常は三角構造が求められる。

BLANK				
F.11.2.2.a	Min distance from Accumulator to Rear Impact?		mm	BLANK
	Accumulator Rear Impact Protection	**Minimum**		BLANK
F.3.2.1.m	Example: 25.4mm x 1.6mm round	Size B		BLANK
F.3.2.1.b	Wall thickness:	1.2	mm	BLANK
	Square side:	25	mm	BLANK
	Wall thickness:	1.2	mm	BLANK
	Square side:	25.0	mm	BLANK
	Tube cross sectional area (A):	114	mm^2	BLANK
	Tube second moment of inertia (I):	8509	mm^4	BLANK

F.11.2.2.b The entire top edge of the upper tube or plate must be at least 240mm above the lowest point of the top surface of the Lower SIS tube.

BLANK			
Top surface of Lower SIS to top Rear Impact >=240mm:		mm	BLANK

記入した数値が正しいことを確認できる図面を添付すること

Rear Impact Protection

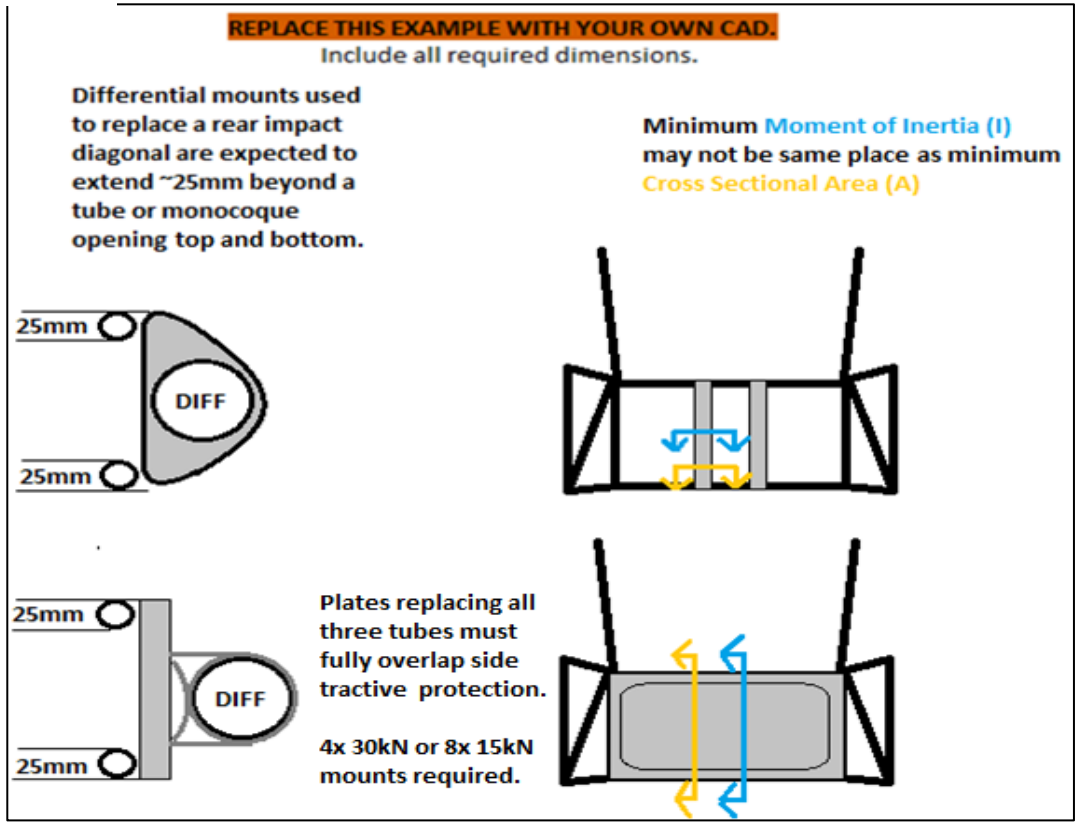
記入した数値が正しいことを確認できる図面を添付すること

通常の三角構造で構成されるRear Impact Protectionを　Replaceするという考え方。

F.11.2.2.b The Rear Protection must be fully triangulated to the rest of the frame with structural tubing.
If a plate replaces all three tubes, 4x 30kN or 8x 15kN mounts are required.
Bolted joints must be documented if a removable panel or tube is used.

BLANK				
F.11.2.2.a	**Rear Impact Tubes Replaced:**	**0**		BLANK
F.3.3-5	Material:	Steel		BLANK
F.3.4.2	Young's Modulus (E):	2.00E+11	Pa	BLANK
	Yield Strength (Sy):	3.05E+08	Pa	BLANK
	Ultimate Strength (Su):	3.65E+08	Pa	BLANK
			Pa	BLANK
		0.00E+00	mm^2	BLANK
		0.00E+00	mm^4	BLANK
	Mount longitudinal Edge to Moment of Inertia Centroid (R):	12.500	mm	BLANK
Buckling Modulus	E_1*I_1 <= E_2*I_2:	0.00E+00		BLANK
Critical Strength	S_1*A_1 <= S_2*A_2:			BLANK
Bending	4*S_1*I_1/r <= 4*S_2*I_2/r:			BLANK
Deflection	Bending_1/(48*EI):			BLANK
Energy	0.5*Bending^2/(48*EI):			BLANK

右図で示すように、
Diff Mount もしくは Rear Bulkheadが計算上、同等以上の強度をも持っていれば、三角構造のパイプが無くても良い。



E：縦弾性係数
Sy: 降伏強さ
Su: 最大引張強さ

SES(等価構造計算書) EV編

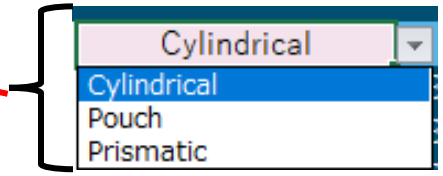
F.10-11 EV Accumulator

Accumulator Segments

「Voltage」、「Capacity」等は事前提出のEV関連書類と対比します。
入力ミスをしないこと。

	BLANK			
	Cell type:			BLANK
	Maximum Voltage:		V	BLANK
	Cell mass:		g	BLANK
	Nominal Capacity:		mAh	BLANK
	Maximum segment cells in series:			BLANK
	Maximum segment cells in parallel:			BLANK
EV.5.1.2	Maximum segment voltage:	0.0	V	EQ
EV.5.1.2	Maximum segment capacity:	0.00	MJ	EQ
	Number of segments in series:			BLANK
	Number of segments in parallel:			BLANK
EV.3.3.2	Maximum accumulator voltage:	0.0	V	EQ
	Maximum accumulator capacity:	0.00	kWh	EQ

	BLANK			
	Accumulator, number of segments high:			BLANK
	Accumulator, number of segments wide:			BLANK
	Accumulator, number of segments long:			BLANK
	S x P = 0	**L x W x H =** 0		EQ
F.10.3.2.b	Maximum segment mass <=12kg (26.4lbs):		kg	BLANK
F.10.3.2.d	Min fastener count in fastened connections between vertical walls:			2



3択から選ぶ事

Cylindrical

Pouch

Prismatic

Accumulator Segments 入力例

赤枠部分が2023年と特に違う。要注意。

EQ

Accumulator Segments

	EQ			
	Cell type:	Pouch		EQ
	Maximum Voltage:	4.2	V	EQ
	Cell mass:	255	g	EQ
	Nominal Capacity:	10000	mAh	EQ
	Maximum segment cells in series:	12		EQ
	Maximum segment cells in parallel:	1		EQ
EV.5.1.2	Maximum segment voltage:	50.4	V	EQ
EV.5.1.2	Maximum segment capacity:	1.81	MJ	EQ
	Number of segments in series:	8		EQ
	Number of segments in parallel:	1		EQ
EV.3.3.2	Maximum accumulator voltage:	403.2	V	EQ
	Maximum accumulator capacity:	4.03	kWh	EQ

合計のセルは96枚

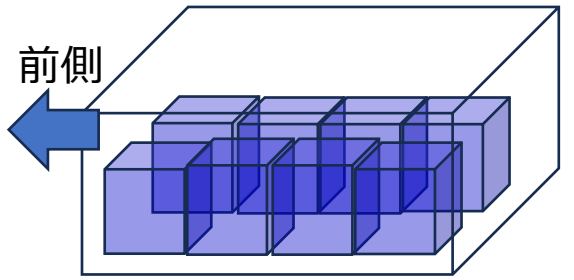
1セグメント内のセル数

1＝セグメント内部は1直

セグメント数！

1＝全てのセグメントは1直

もしセグメントが8個
図のように搭載されていたら



高さ方向 ＝1段
横方向 ＝2列
前後方向＝4個

	EQ			
	Accumulator, number of segments high:	1		EQ
	Accumulator, number of segments wide:	2		EQ
	Accumulator, number of segments long:	4		EQ
	S x P = 8	**L x W x H =**	8	EQ
F.10.3.2.b	Maximum segment mass <=12kg (26.4lbs):	6	kg	EQ
F.10.3.2.d	Min fastener count in fastened connections between vertical walls:			2

=G73*G74

=G79*G80*G81

Segment数は自動計算される

=IF(D82=G82,"EQ",IF(OR(D82=0,G82=0),"BLANK","CHECK"))

判定基準：
D82＝G82となれば「EQ」となる
左の例では 8＝8

Accumulator Segments 入力例

2023年との違い･･･耐20G, 耐40Gは自動計算される

Material	E (Pa)	S_Ultimate (Pa)	Shear (Pa)
Steel Unwelded	2.00E+11	3.65E+08	2.11E+08
Steel Welded	2.00E+11	3.00E+08	1.73E+08
6061-T6 Unwelded	6.90E+10	2.90E+08	1.67E+08
6061-T6 Welded	6.90E+10	1.75E+08	1.01E+08

材料特性を入力

EQ

Accumulator Segments

EQ

F.10.3.4.a Restraint Method:	Friction		EQ
Segment structure material:	Aluminum		EQ
F.10.3.4 Cell mounting and bracing material:	E:	6.90E+10 Pa	EQ
	UTS:	2.90E+06 Pa	EQ
	Shear:	1.67E+08 Pa	EQ

Segment structure top view cross section between walls:		mm^2	BLANK
F.10.3.4.b Vertical acceleration 20*mass*segments_high:	0.00E+00	N	BLANK
Segment compression strength UTS*top_view_area:	0.00E+00	0.00%	BLANK
Segment structure front view cross section between walls:		mm^2	BLANK
F.10.3.4.b Lateral acceleration 40*mass*segments_wide:	0.00E+00	N	BLANK
Segment compression strength UTS*top_view_area:	0.00E+00	0.00%	BLANK
Segment structure side view cross section between walls:		mm^2	BLANK

Segment の各断面積を入力

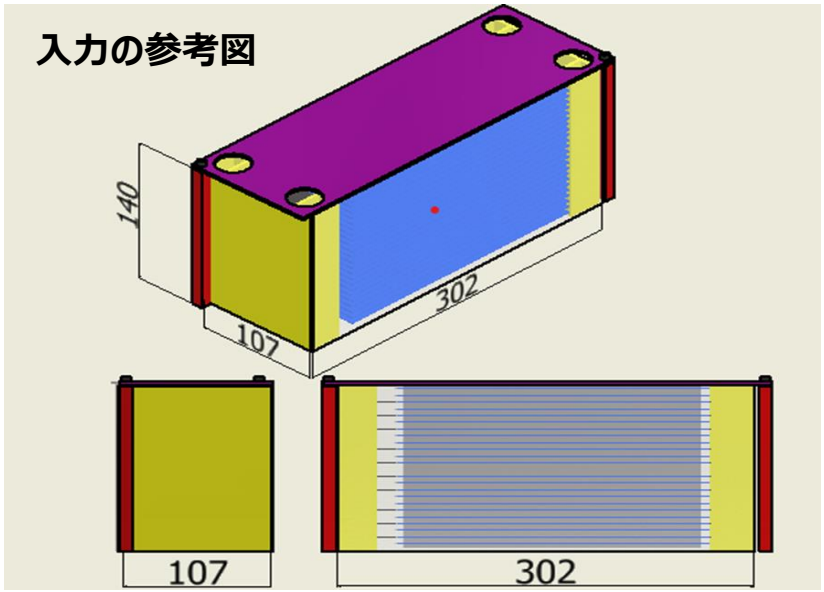
EQ

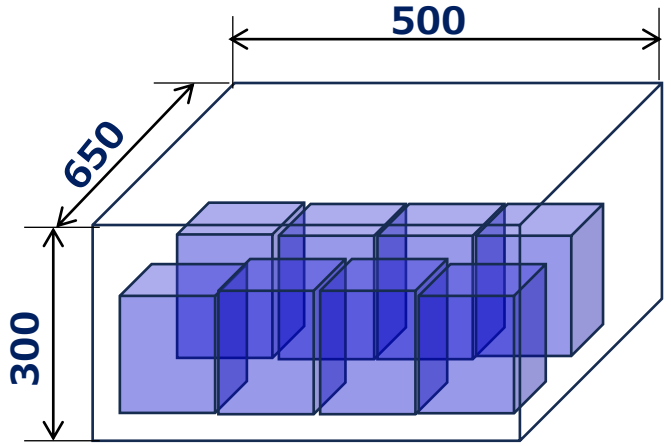
Accumulator total front to rear length:	500	mm	EQ
Accumulator total left to right width:	650	mm	EQ
Accumulator total bottom to top height:	300	mm	EQ

ACCサイズを入力

Non-segment volumes must be included in mount offset, rows 61-63.
Do not mount to non-segment volumes.

入力の参考図





Segmentの内壁の高さ

要求される　上面図、正面図、側面図をサイズ入りで記載すること

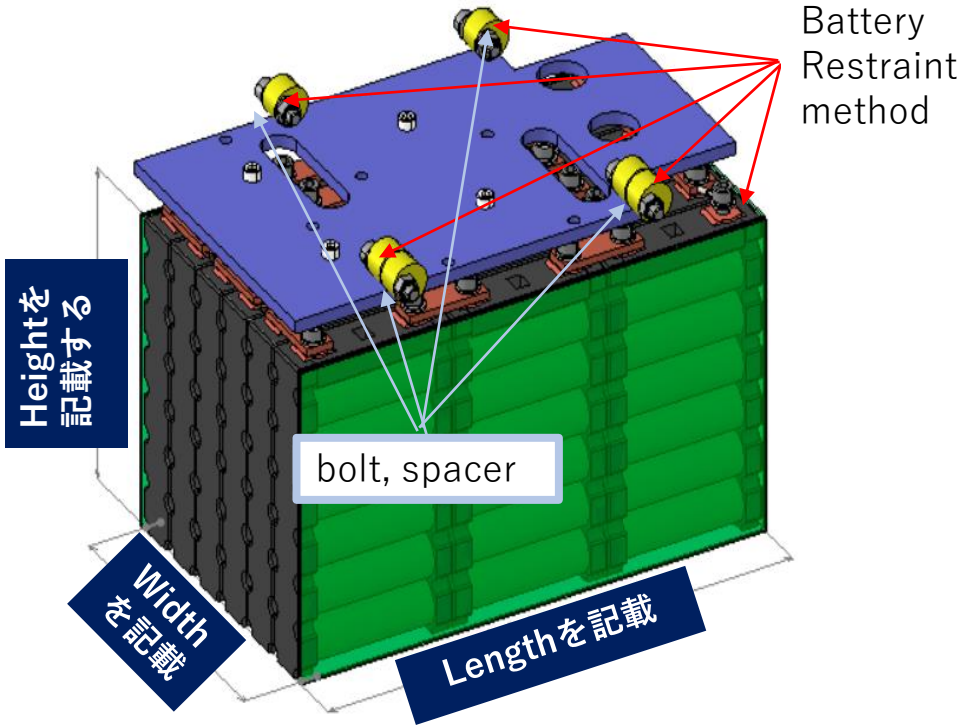
ここに注目！

Segment top view structural cross section.
Segment front view structural cross section.
Segment side view structural cross section.
Include all dimensions entered below.

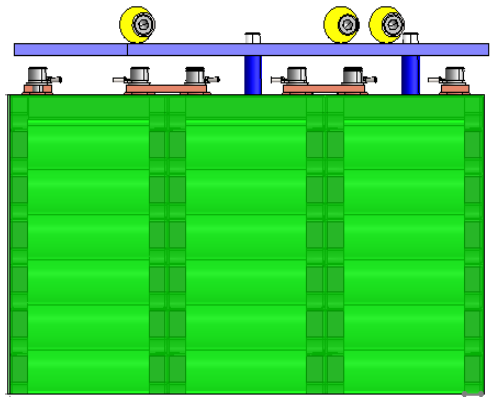
内壁の高さについて：F.10.3.1.b
内壁はセグメント全体以上の高さが必須（Must）
内壁はセグメントの上の蓋まで伸びていることが望ましい（Should）

Segmentについて：
Cell全体を覆えていること（Must）
セグメントの上の部品まで覆う方が望ましい（Should）

Segment Isometric view

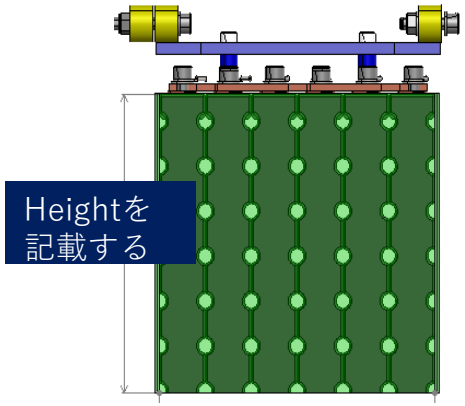


Lateral Cross Section



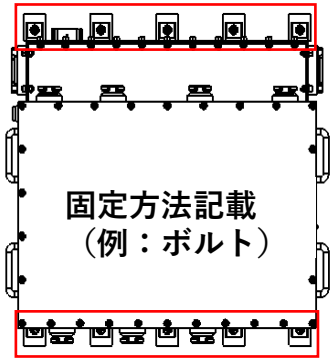
Lengthを記載する

Longitudinal Cross Section



Widthを記載する

ACC Restraint Method



Accumulator Container

2024年で新規追加された項目。

EV.4.3.5 Any Accumulators that may vent an explosive gas must have a ventilation system or pressure relief valve to release the vented gas
EV.4.3.6 Completely sealed Accumulator Containers must have a pressure relief valve
EV.4.3.7 Pressure relief valves must not have line of sight to the driver, with the Firewall installed or removed

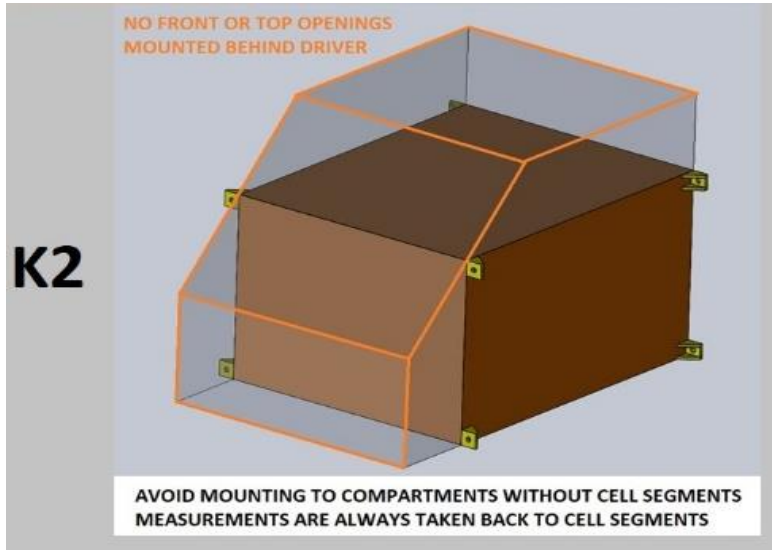
EV.4.3.5 爆発性ガスを放出する可能性のあるアキュムレータには、放出されたガスを逃がすための換気システムまたは圧力リリーフ弁が必要です。
EV.4.3.6 完全に密閉されたアキュムレータコンテナには圧力リリーフ弁が必要です
EV.4.3.7 ファイアウォールが取り付けられているか取り外されている場合、圧力リリーフ弁はドライバーの視界に入ってはいけません

下記項目は2択となっており、どちらの場合も右のようなイメージ（CAD図）を添付すること。

BLANK
EV.4.3.5-7 BLANK
Any opening, including pressure relief valves, must face away from the driver.

EQ
EV.4.3.5-7 Image shows accumulator segments are not completely sealed EQ
Any opening, including pressure relief valves, must face away from the driver.

EQ
EV.4.3.5-7 Image shows pressure relief valve is not pointed at the driver EQ
Any opening, including pressure relief valves, must face away from the driver.



Accumulator Container

2024年で荷重の計算方法が変更されたが、内容は同じ。
Corner Attachment と Mass Based の Load値の計算基準になる。

2023年

Composite teams: Enter tab names for materials used.

BLANK

Low Est	0	Total mass of all segments:		kg	BLANK
High Est	0	Total accumulator mass:		kg	BLANK
F.10.5.6		Corner attachment test load:	0	N	each
F.10.5.7		Mass based min attachment number:	4x at 15000	N	each

2024年

Composite teams: Enter tab names for materials used.

BLANK

Low Est	High Est	Cell Mass				
0	0	0	Total mass of all segments:		kg	BLANK
			Total accumulator mass:		kg	BLANK
F.10.5.6			Corner attachment test load:	0	N	each
F.10.5.7			Mass based min attachment number:	4x at 15000	N	each

前述(右)の数値を入力すると・・・
結果は同じ

2023年

Composite teams: Enter tab names for materials used.

EQ

Low Est	48	Total mass of all segments:	48	kg	EQ
High Est	48	Total accumulator mass:	62	kg	EQ
F.10.5.6		Corner attachment test load:	6082.2	N	each
F.10.5.7		Mass based min attachment number:	10x at 15000	N	each

2024年

Composite teams: Enter tab names for materials used.

EQ

Low Est	High Est	Cell Mass				
2	26	2.04	Total mass of all segments:	48	kg	EQ
			Total accumulator mass:	62	kg	EQ
F.10.5.6			Corner attachment test load:	6082.2	N	each
F.10.5.7			Mass based min attachment number:	10x at 15000	N	each

Attachment の計算基準

EQ

	Cell type:	Pouch		EQ
	Maximum Voltage:	4.2	V	EQ
	Cell mass:	255	g	EQ
	Nominal Capacity:	10000	mAh	EQ
	Cells in series:	12		EQ
	Maximum segment cells in parallel:	1		EQ
EV.5.1.2	Maximum segment voltage:	50.4	V	EQ
EV.5.1.2	Maximum segment capacity:	1.81	MJ	EQ
	Number of segments in series:	8		EQ
	Number of segments in parallel:	1		EQ
EV.3.3.2	Maximum accumulator voltage:	403.2	V	EQ
	Maximum accumulator capacity:	4.03	kWh	EQ

8個のSegmentが全て6kg＝48kg

EQ

	Accumulator, number of segments high:	1		EQ
	Accumulator, number of segments wide:	2		EQ
	Accumulator, number of segments long:	4		EQ
	S x P = 8	L x W x H =	8	EQ
F.10.3.2.b	Maximum segment mass <=12kg (26.4lbs):	6	kg	EQ
F.10.3.2.d	Min fastener count in fastened connections between vertical walls:		2	

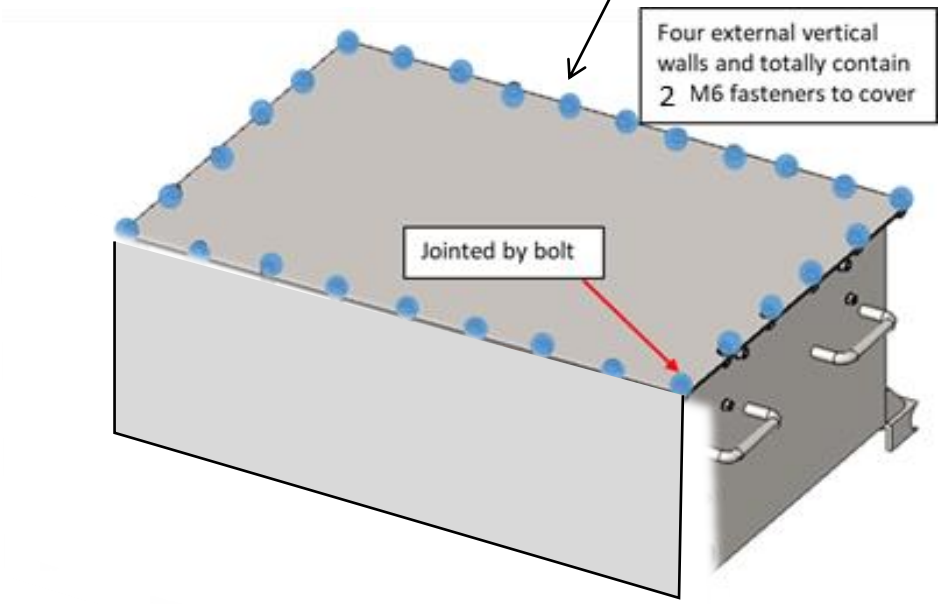
ACC Container 外壁

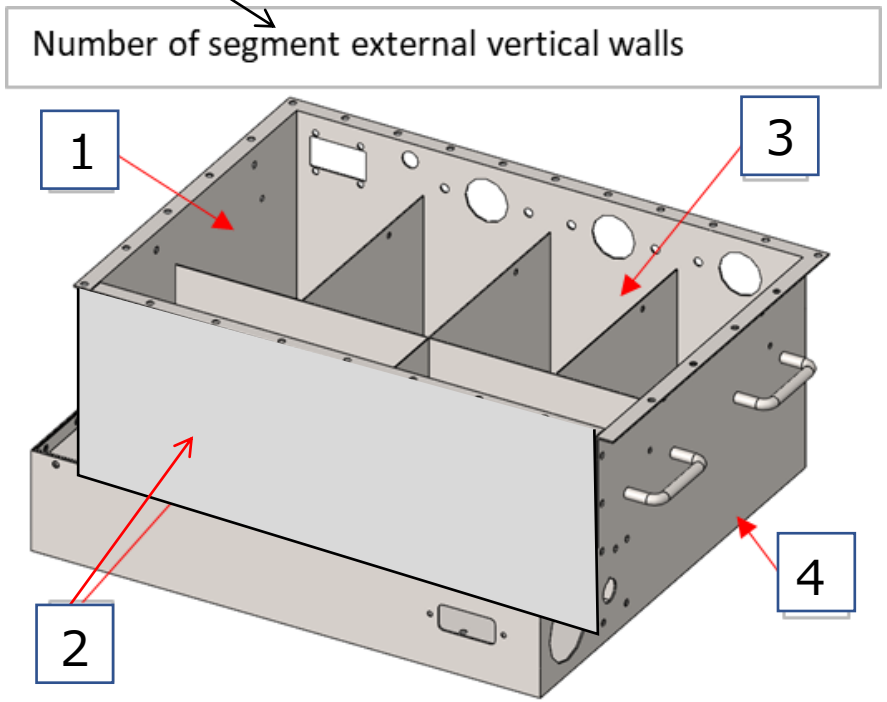
記入した数値やJoining方法が分かるエビデンス（CAD図）を添付すること

BLANK		
F.10.2.4	Number of segment external vertical wall divisions:	BLANK
	Number of cover fasteners:	BLANK

F.10.3.1.c Min 2 per wall division when using fasteners between external walls and floor.
F.10.3.1.d Min 1 per wall division when using fasteners between internal walls and floor.

特にFastener数は分かりやすく表示すること
三面図よりもアイソメ図の方が理解しやすい





ACC Container 壁の接合方法

記入した数値やJoining方法が分かるエビデンス（CAD図）を添付すること

	BLANK			
F.10.2.3	Vertical wall joining method:	**4択です**		BLANK
	Average unit strength of 50% weld, 0.9mm wall:	135	N/mm	N/A
			N	N/A
			mm	N/A
			N/mm^2	N/A
			mm	N/A
F.10.2.3.b				EQ

Vertical Wall の接合方法を選択し、各々「BLANK」で要求されている項目を入力すること。

	BLANK			
F.10.2.3	Vertical wall joining method:	**Fastened**		EQ
	Average unit strength of 50% weld, 0.9mm wall:	135	N/mm	N/A
F.10.2.3.b	Fastener shear capability:		N	BLANK
	Maximum fastener spacing:		mm	BLANK
			N/mm^2	N/A
			mm	N/A
F.10.2.3.b	Fastener shear / spacing >= Unit baseline:			EQ

Indicate weld paths in image.

	BLANK			
F.10.2.3	Vertical wall joining method:	**Welded**		EQ
	Average unit strength of 50% weld, 0.9mm wall:	135	N/mm	N/A
10.2.3.a	At least half the perimeter must be welded:		%	BLANK
	Shortest weld >= 25mm (1in):		mm	BLANK
			N/mm^2	N/A
			mm	N/A
F.10.2.3.b				N/A

	BLANK			
F.10.2.3	Vertical wall joining method:	**Bonded**		EQ
	Average unit strength of 50% weld, 0.9mm wall:	135	N/mm	EQ
			N	N/A
			mm	N/A
	Shear strength of adhesive (Use 'Fastened' for rivets):		N/mm^2	BLANK
	Minimum bond overlap (Leave space to rivet):		mm	BLANK
F.5.5.3	0.5*adhesive x overlap >= Unit baseline:			EQ

	EQ			
F.10.2.3	Vertical wall joining metho	**Continuous Layup**		EQ
	Average unit strength of 50% weld, 0.9mm wall:	135	N/mm	N/A
F.10.2.3.b			N	N/A
			mm	N/A
			N/mm^2	N/A
			mm	N/A
F.10.2.3.b				EQ

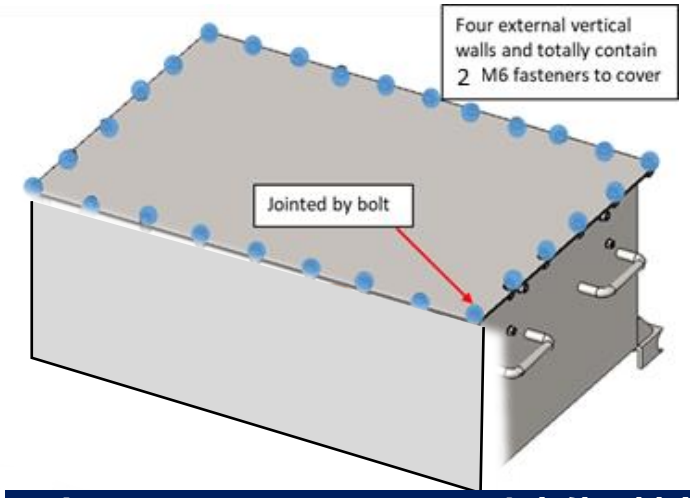
Continuous Layup のみ入力不要

最低75%が覆われている

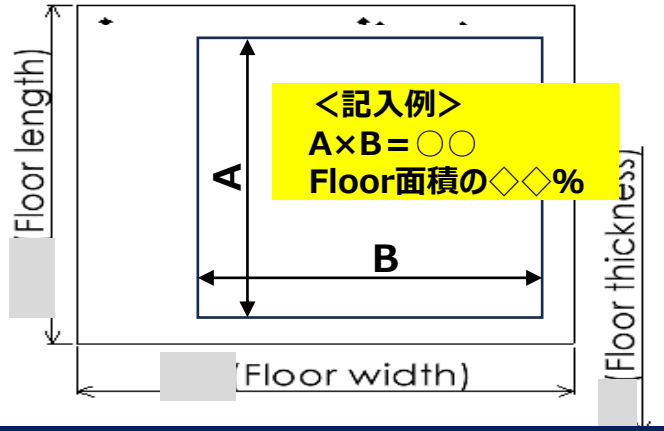
記入した数値が分かるエビデンス（CAD図）を添付すること

以下の75%ルールについて、例年エビデンスの不備が多い。
エビデンス不備の場合、SESは即「Not OK」と判定する。

F.10.2.1	**MINIMUM ACCUMULATOR FLOOR**			
	BLANK			
F.10.4.3	All segment floor sections >= 75% area:			BLANK
F.10.2.1	**Accumulator Floor Construction:**			EQ
	Steel: 1.25mm (0.049in), Aluminum: 3.2mm (.125in):		mm	BLANK
	Material Used:			BLANK
F.10.2.2	**MINIMUM ACCUMULATOR WALLS**			
	BLANK			
F.10.4.3	All segment wall sections >= 75% area:			BLANK
F.10.2.2	**Minimum Wall Construction:**			EQ
	Steel: 0.90mm (0.035in), Aluminum: 2.3mm (0.090in):		mm	BLANK
	Material Used:			BLANK
F.10.2.2	**MINIMUM ACCUMULATOR COVER/LID**			
	BLANK			
No accumulator holes with line of sight to driver:				BLANK
F.10.4.3	All segment cover sections >= 75% area:			BLANK
F.10.2.2	**Accumulator Lid:**			EQ
	Steel: 0.90mm (0.035in), Aluminum: 2.3mm (0.090in):		mm	BLANK



上記のAccumulatorコンテナ本体に対するFloor部を図示し、必要サイズを入力する事



Walls部、Cover/Lid部についても同様に図示し必要サイズを入力する事