
ALSTOM STANDARD FOR RAILWAY APPLICATIONS FITTING AND SEMI-STRUCTURAL COMPOSITE PARTS

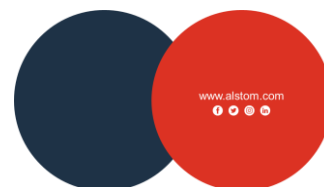
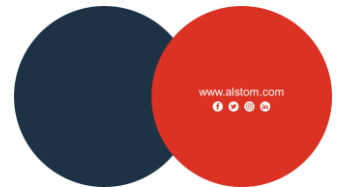


TABLE OF MODIFICATIONS

Revision	Publication	Summary of Changes
C	22/11/2022	Update after ex-BT integration (convergence)
B1		General update prior to publication
B	21/03/2018	RoE update for brackets and NF F 01-281 applicability
A	20/07/2015	First issue
/	29/08/2014	Original issue



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1. PURPOSE

This ALSTOM Standard defines the technical conditions to be fulfilled for supplying parts in composites materials for interior (i.e. internal lining) and semi-structural applications (i.e. front end, external fairing, etc.).

It doesn't cover the highly loaded parts used in car structure (car body shell, bolster, bogie, etc.) nor electronic boards.

This ALSTOM Standard is not a purchase specification but lists the main definitions and describes the different processes and requirements related to composite parts development.

The ALSTOM Standard can be used as a "clause by clause" support where the supplier answers can be registered in last two columns.

CbC	Supplier Answers: C=Compliant / NC = Non-Compliant / NA = Not Applicable
Comments	Supplier Remarks / Explanations on the answer of C/C

Even if International Standards exist in different languages, English version is considered as official reference.



2. NORMATIVE REFERENCES

2.1. STANDARD REFERENCES

Reference	Title	ASTM Alternative
ISO 75-2	Heat deflection Temperature measurement	ASTM D648
ISO 286	Geometrical product specifications (GPS)	N/A
ISO 527-4	Plastics – Determination of tensile properties	ASTM D-638
ISO 1172	Textile-glass-reinforced plastics – Prepregs, moulding compounds and laminates – Determination of the textile-glass and mineral-filler content – Calcination methods	ASTM D3171
ISO 1183	Plastics – Methods for determining the density of non-cellular plastics	ASTM D792
ISO 2113	Reinforcements fibers – Woven fabrics	N/A
ISO 2559	Textile glass – Mats (made from chopped or continuous strands)	N/A
ISO 2768	Tolerances for linear and angular dimensions without individual tolerance indications	N/A
ISO 2813	Paint & varnish Gloss level determination	ASTM D523
ISO 4628-2	Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance	None
ISO 4892-2	Specifies methods for exposing specimens to xenon-arc light in the presence of moisture	ASTM D2244
ISO 7784-1	Paints and varnishes – Determination of resistance to abrasion – Part 1: Rotating abrasive-paper-covered wheel method.	ASTM D 4060
ISO 11357	Differential scanning Calorimetry	ASTM D3418 ASTM E2602
ISO 13003	Fibre-reinforced Plastics	
ISO 14125	Fiber-reinforced plastic composites – Determination of flexural properties	ASTM D790
ISO 14126	Fiber-reinforced plastic composites – Determination of compressive properties in the in-plane direction	ASTM D695
ISO 14129	Fiber-reinforced plastic composites – Determination of the in-plane shear stress/shear strain response, including the in-plane shear modulus and strength, by the plus or minus 45 degree tension test method	ASTM D4225
ISO 14130	Fiber-reinforced plastic composites – Determination of apparent interlaminar shear strength by short-beam method	ASTM C1425
ISO 16000-3	Indoor air Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air -- Active sampling method	ASTM D2194

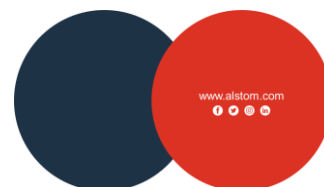


ISO 16000-9	Indoor air Part 9: Determination of the emission of volatile organic compound from building products and furnishing – Emission test chamber method	ASTM D5116
ISO 16143-1	Stainless steel for general purposes – Part 1: Corrosion-resistant flat products.	None
ISO 16143-2	Stainless steel for general purposes – Part 2: Corrosion-resistant semi-finished products, bars, rods and sections.	None
ISO 17025	General requirements for the competence of testing and calibration laboratories	None
ISO 13003	Fibre-reinforced plastics – Determination of fatigue properties under cyclic loading conditions	ASTM D3479
ISO 22628	Road vehicles - Recyclability and recoverability - Calculation method	None
ISO 9227	Corrosion tests in artificial atmospheres – Salt spray tests	ASTM B117
EN 59	Glass reinforced plastics - Determination of indentation hardness by means of a Barcol hardness tester	ASTM D2583
EN 438-2	High-pressure decorative laminates (HPL) - Sheets based on thermosetting resins (usually called laminates) - Part 2: Determination of properties	None
EN 1245	ADHESIVE- Determination of PH	ASTM D1583
EN 50153	Railway applications - Rolling stock – Protective provisions relating to electrical hazards	None
EN 12663-2010	Railway applications – Structural requirements of railway vehicle bodies.	None
EN 45545-2	Railway applications - Fire protection on railway vehicles - Part 2: requirements for fire behavior of materials and components	NFPA 130
ASTM D2562	Standard Practice for Classifying Visual Defects in Parts Molded from Reinforced Thermosetting Plastics	N/A
ASTM D-256	IZOD impact Test	N/A
EN 1245	Adhesives - Determination of pH	ASTM D1583

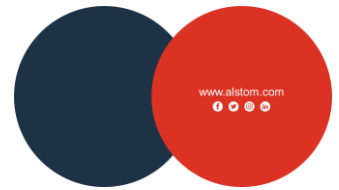
None: no equivalent identified but supplier can make proposition.

2.2. ALSTOM STANDARD REFERENCES

Reference	Title
ENG-STD-003	Instructions to Suppliers concerning commercialization and use of dangerous substances
ENG-FRM-001	Supplier Form: Commitment & Declaration on Dangerous Substances
DTRF 150214	Fastened Assemblies Mounting Requirements
DTRF 150223	Adhesive Bonded Assemblies Design



DTRF 150620	Industrialization for glued assemblies
DTRF 150608	Standard Painting Process
DTRF 150217	Metalic parts corrosion resistance requirements



3. TERMS AND DEFINITION

TERM	DEFINITION
Laminate	Usual name for monolithic composite material
Sampling	Definition of the different layers of reinforcement elements constituting the laminate
Sandwich composite	Material constituted by a core (foam, honeycomb...) between two laminate skins
Specimen	Test specimen material (normalized) laminate or sandwich representative of the part
Annexed test specimen	Test specimen realized in an adjacent way and collectively in the part
Manufacturing batch	Parts from the same category having the same manufacturing process and the same materials batch (matrix, reinforcement, gel coat) and the same range of thickness
Series part	Part from a stabilized process compliant with the technical and dimensional prescriptions of the designer and previously validated by investigations requested on the reference part (type part)
Type part	Reference part validating the supplier capability to produce in series at expected quality level
Gel coat	Surface layer rich in resin, loaded and/or pigmented, deposited on negative shape (mold) before stratification in order to protect the laminate
Topcoat	Extra gelled coating: resin layer loaded and /or not pigmented, applied on surface and or cut edge after stratification for surface tightening
Critical area	Part area subject to significant mechanical stress and/or with complex shape which could lead to damages or aesthetic defects
Common area	Part area outside the designated area
Designated area	On drawing part, area with specific controls. A part can be 100% in designated area
Dangerous substance	Each substance considered as dangerous regarding the directive CEE 67/548 / CEE and regulation CLP



Some recommendations are given in chart form and each function is characterized by the limits to be reached. Each function is associated to one or several acceptance criteria (requirement requested or necessary for the implementation of the assembly), as well as the levels (quantification of the criterion on an adapted scale) with a flexibility (tolerance).

TERM	DEFINITION
F0	The specified conditions cannot be challenged in any circumstances. The requirement must be met.
F1	The requirement is not mandatory but must be followed, unless an alternative solution can be demonstrated to be at least equivalent.



4. ABBREVIATIONS LIST

ABBREVIATION	DEFINITION
BA	Business Award
CbC	Clause by Clause
CF	Cohesive failure
CDS	Component Development Site
DFQ	Design For Quality
DADI	Design Annotation & Dimension Instruction (DTRF150250)
DFMEA	Design Failure Mode and Effects Analysis
EMC	Electro Magnetic Compatibility
FAI	First Article Inspection
FEA	Finite Element Analysis
FEFO	First Expired First Out
FMR	First Mounting Review
FRP	Fiber Reinforced Plastics
HLU	Hand Lay-Up
PDR	Preliminary Design Review
Phases	Steps defining the project follow-up milestones
RoE	Return of Experience
RTM	Resin Transfer Molding
SCF	Superficial Cohesive Failure
SDR	Specification Design Review
STEP	Standard for the Exchange of Product model data
TDS	Technical Data Sheet
TPP	Test Program Plan
TPS	Technical Purchase Specification
VIP	Vacuum Infusion Process



5. TECHNICAL REQUIREMENTS

5.1. PARTS CLASSIFICATION

The parts in composite materials covered by this ALSTOM Standard are classified depending on their location and the mechanical stress they can withstand, after mounting on the railway rolling stock, according to Table 1.

Category	Location and mechanical load	Examples
A	Exterior parts	Front end, fairings, covers, trap doors, doors, etc.
B	Interior parts subject to significant mechanical stress	Floor, stairs, desks, seats, lining supporting grab handles, toilet module etc.
C	Interior parts not subject to significant mechanical stress, but with « direct contact » with people	Window surrounds, window pier shields, vertical linings, etc.
D	Interior parts not subject to significant mechanical stress, and without any « direct contact » with people	Roof arch areas and covers mounted on the ceiling, etc.

Table 1 : Parts classification

5.2. TYPE / SUPPLY CHAIN

There are three main schemes for composite-material parts procurement in ALSTOM. Supply type 1 and 3 must be preferred.

Supply type 1 “Built to Print” - Parts covered by a detailed ALSTOM definition drawing or annotated 3D. These parts are essentially carried over from former projects or/and parts for which the definition document is sufficiently detailed, so that the supplier does not need to carry out any design study. It essentially corresponds to parts designed by CDS Interiors but can also be parts re-used from old projects.

Supply type 2 “Co-development” - Parts covered by an ALSTOM preliminary definition, for which the supplier is expected to carry out detailed design and industrialization studies prior to manufacturing. The ALSTOM definition includes the general geometry of part, its dimensions and the functional interface surface areas, the specific mechanical strength, appearance... requirements. A provisional 3D Lean model (STEP format) is also related to the definition. The supplier is expected to carry out a detailed design study for such parts, before manufacturing (i.e. definition of drafts, definition of thickness by calculation or RoE, detailed definition of inserts, etc.).



Supply type 3 - “Built to Spec” - Parts covered by the supplier’s definition, within the scope of overtaking a global function defined in a TPS. Within this scope, the supplier is expected to carry out the complete design study. In this type 3, the input data from ALSTOM are TPS and allocated 3D volume and interfaces.

The target of this ALSTOM Standard is to specify the generic technical, organizational, and documentary requirements, expected for the work to be performed depending on the Supply type described above.



6. DEVELOPMENT PROCESS

6.1. DFQ CYCLE

The basic deliverables include the following elements:

- Contractual documentation: see § 8
- Manufacturing tooling and equipment: see § 9.3.

Supplier development process for Supply types 2 & 3 must follow below instructions.

The composite supplier shall participate in product development through 3 design reviews:

- SDR 33%
 - 3D Concepts validated by supplier
 - Gap & Flush + layout validated by supplier
 - TPS and /or Clause by clause agreed & signed
- SDR 66%
 - Supplier assembly tooling concept validated
 - Packaging concept validated
 - Validation plan validated
 - Go 3D 80% modelling
 - DFMEA action plan
- PDR 10%
 - Tooling's drawings check
 - Go tooling

Any request for validation by ALSTOM marks a milestone.

Within the framework of co-design together with ALSTOM, the supplier:

- Shall examine the 3D models forwarded by ALSTOM, analyze the part's feasibility and make any suggestions that it deems to be necessary to guarantee the correct behaviour of the part. If the constructive arrangements planned by ALSTOM seem to bother the mechanical strength of part over time, the supplier shall advise ALSTOM and make suggestions to achieve the requested quality (material, additional attachments, inserts, support bases, reinforcement, geometrical & dimensional specification, thickness, radius, etc.).
- Shall participate to the review of critical design topics: a list shall be drawn up in order to study the impacts on manufacturing and mounting in ALSTOM.
- Shall participate in the confirmation of specified functional interfaces.
- Shall propose improvements in geometry, if necessary, and shall verify or validate by Engineering the drafts applied associated to molding process selected (radius, draft angle, cutting line or undercuts...).
- Shall model the radii (digital machining).



6.2. INDUSTRIALIZATION

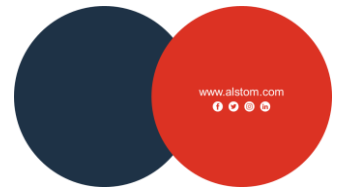
The supplier:

- Shall manufacture the models (mother parts).
- Shall communicate the process implemented, the materials that are part of the lay-up, with generic / reinforcement / insert sampling and assembly procedures.
- Shall submit the calculations notes, the test programs and reports (these documents shall be validated by ALSTOM; please refer to § 8).
- Shall give 3D or 2D definition of the inserts; the values of mechanical strength of inserts for parts that are subject to heavy exterior stress shall be given in the notes on the drawings (please refer to Appendix 2). It will be necessary to check, in case of optimization of metal/metal contact, that the stainless-steel brace is over the composite surfaces (0/+0.5 mm).
- Except with ALSTOM advice (see TPS), realizes the detailed drawings for all levels of equipment of each part under CAD mock-up (2D) or annotated 3D. The drawings will be reviewed with ALSTOM Design Office.
- Shall produce the moulds, after validation of the models design (please refer to § 7.1), and provide evidence of the constituting materials (structure, sturdiness); it shall also provide a guarantee of capacity of moulded parts as well as the detailed list of all tools and equipment that participated in the part's manufacturing (please refer to § 9.3).
- Shall manufacture the first parts for validation (First Article Inspection); an assessment of the way the critical points have been considered shall be made (presentation of manufacturing sheets).
- Shall participate to First Mounting Review, as per ALSTOM requirement.
- Shall manufacture the serial parts, considering improvements made further to FMR.
- Shall update the drawings according to improvements made further to FMR.

At « Tender » stage, the supplier shall submit a development program that integrates the deadlines imposed by ALSTOM, a validation plan describing the items to be validated, the resources implemented for validation and the acceptance criteria that must be met.

A planning shall be issued by the supplier including the different development phases and in particular:

- Design, industrialization, validation of model and mold, manufacturing launch, date of 1st delivery
- Development tests
- Type tests
- Serial tests kick-off
- Approval and certification



7. VALIDATION PROCESS

The constitutive materials of parts corresponding to this ALSTOM Standard shall comply with the relevant international regulations (see requirements in § 7.3.1).

4 Milestones are confirmed by ALSTOM validation:

- Milestone 1: Master model control or mould control if directly from machining / TPP
- Milestone 2: Structural calculations / Critical points review / Assembly validation
- Milestone 3: FAI (First Article Inspection, Results of TPP)
- Milestone 4: FMR (First Mounting Review)

7.1. MILESTONE 1 - MASTER MODEL CONTROL

The Master model shall receive ALSTOM agreement which keep the possibility to ask for modifications such as aesthetic improvement.

The supplier will indicate the tooling forecasted to perform dimensional and geometrical specifications expressed with necessary tolerances on the drawing.

A detailed assembling sequence & measurement process will be delivered by the supplier to secure the understanding of geometrical & dimensional tolerancing.

A 3D control will be required for a complex shape and/or large size with 16 point /dm² minimum and electronic report to compare to 3D model.

The TPP shall be established by the supplier and checked by ALSTOM including standard, definition and quantity of samples and requirement.

7.2. MILESTONE 2 - CALCULATIONS/REVIEW/VALIDATION

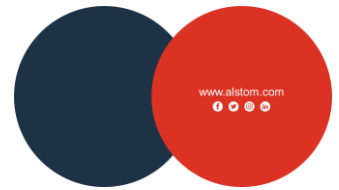
At least one review shall be planned to:

- Validate the structural calculations, including mechanical test report
- Point out the critical points and follow their resolutions
- Validate the assemblies by fixing inserts drawing review

7.3. MILESTONE 3 - FAI

The tests and controls to be made are those described and presented in the following table depending on the category (A, B, C or D defined in §5.1) selected for the part (non-exhaustive list which can be completed if necessary for special processes and specific load cases.

Example of minimum qualification plan in §7.3.5



Even if some tests or means of proofs are not required by ALSTOM for some categories, it does not exempt the part to comply with the requirements. For that purpose, ALSTOM reserves the right to perform, at the expense of the supplier, tests associated with requirements if ALSTOM has a doubt.

7.3.1 DIMENSIONAL & GEOMETRICAL TOLERANCES RELATIVE TO FUNCTIONS

All functional dimensions and tolerances should be indicated into the definition (2D / 3D). If there is no indication on the drawings, generic tolerances below must be applied.

Description	Requirement	A, B, C, D	Supplier answer	Comments
Dimensional specification				
Thickness (nominally constant)	For closed mold process (RTM (light), infusion, vacuum bagging, SMC, BMC): T +/- 10 % For open mold process (HLU) : +/- 15 %	F1		
Tolerances linear	ISO 2768-c	F1		
Geometrical specification				
Straightness on cuts	ISO 286 Grade IT13	F1		
Flatness	ISO 286 Grade IT13	F1		
Aspect of edge, chamfer and radius				
All sharpened edge (or define chamfer) of apparent inserts	To be rounded	F0		
All radius nominally below R6	Listed and added in the control plan Lower Specification Limit is mandatory	F0		

7.3.2 FIXATION POINTS REQUIREMENTS

Description	Requirement	A	B	C	D	CbC	Comments
Materials							
Fixing parts	All fixing parts or brackets must be in stainless steel. In case of use of other type of steel, the fixing element must be subject to saline mist test ISO 9227.	F0	F0	F0	F0		
Stainless steel	compliant with ISO 16143-01 and ISO 16143-2						
Exterior	Stainless steel 304 L minimum Passivated after any process of transformation.	F0					



Interior humid environment	Stainless steel 304 minimum passivated after any process of transformation if exposed to humidity (condensation, cleaning agent...)		F1	F1	F1		
Interior dry environment	Stainless steel 304		F1	F1	F1		
Other type of steel	Saline mist test ISO 9227 acceptance criteria according to DTRF 150217						
Exterior	Duration 960 hours	F0					
Interior humid environment	Duration 600 hours		F0	F0	F0		
Interior dry environment	Duration 480hours		F0	F0	F0		
PH resin + water in contact with resin and adhesive	EN 1245 or ASTM D1583 : PH>4	F0	F0	F0	F0		
Common area							
Part thickness	→ Compliant with weight allocation and mechanical strength, it shall be submitted to ALSTOM → According to drawing in case of ALSTOM detailed design.	F0	F0	F0	F0		
Tolerances (except if otherwise stated on the drawing)	±1 mm for each value < 1 000 mm ±1 mm/m, for each value > 1 000 mm	F0	F0	F0	F0		
Flatness	±1 mm / 1 m	F0	F0	F0	F0		
Designated area	To be indicated on drawing						
In interface areas or areas that may generate interferences	Nominal thickness +1 / -0 mm		F0	F0			
In calibrated area (except if otherwise stated on the drawing)	Nominal thickness +0,5 / -0 mm		F0	F0			
Straightness of edges	±1 mm / 1 m	F0	F0	F0	F0		
Critical area							
Connecting and joints of assemblies	§ 10.3	F0	F0	F0	F0		
Maximal weight of the part (except specific requirement)	Must not exceed 510% of the specified weight.	F0	F0	F0	F0		

7.3.3 TECHNICAL REQUIREMENTS

Requirement	Value	A	B	C	D	CbC	Comments
Reinforcements	Must respect: EN 13417 EN 13473 EN 14118 EN 14020 ISO 13002 EN 13003 EN 14598	F0	F0	F0	F0		
Barcol hardness	EN59: > 45 (Organic resin thermoset)	F0	F0	F0	F0		
Thickness of over lamination for brackets	≥ 0,6 x thickness of part	F0	F0				



Use of glue	Bonding assembly acc. to DTRF 150223	Fo	Fo	Fo	Fo		
On composite substrate	Compatibility with part material	Fo	Fo	Fo	Fo		
On other substrate (steel, stainless steel, ...)	Audit process/ Qualification drawing:			Fo	Fo		
	Bonding without over-lamination forbidden for insert fixing exterior fairings or structural parts	Fo	Fo				
Windscreen and lateral windows	For bonding of windscreen lateral window, the adhesive bonding area must be free of paint and gelcoat	Fo	Fo				
Geometry							
Minimum radius of composite parts (except if otherwise stated)	All radius < R6 nominally should be listed and add in the control plan	Fo	Fo	Fo	Fo		
Machined edges	Covered by gel coat or finishing paint for exterior parts in contact with environment effects	Fo	Fo	Fo	Fo		
No area allowing liquid retention	Supplier must manage a real draining strategy to avoid liquid retention	Fo	Fo	Fo	Fo		
Interior of part (raw surfaces of the parts)	Top-coat finishing according to specific requirements	Fo					
Electrical protection (as per requirements)	EMC and earthing	Fo	Fo	Fo	Fo		
Release agent	Use of silicone and Siloxane oil or wax is strictly prohibited	Fo	Fo	Fo	Fo		
Wax marks	No marks	Fo	Fo	Fo	Fo		
Dangerous substances	Respect of standard requirements ENG-STD-and furniture in ENG-FRM-001	Fo	Fo	Fo	Fo		
Recycling	File " Recyclability & Recoverability Calculation Template "	Fo	Fo	Fo	Fo		
VOC (Volatile Organic Coumpounds)	Provide VOC and aldehydes tests reports according to ISO 16000-3 and 16000-9		F1	F1	F1		According to Project TPS



7.3.4 MECHANICAL PERFORMANCES

Requirement	Value	A	B	C	D	CbC	Comments
Identification of level of stress on each fixing point	Tensile, shear and Torque load value	F0	F0				
1 minimum resistance R of each attachment insert (perpendicular traction)	R > 20 daN				F0		
	R > 50 daN	F0	F0	F0			
Assembly by inserts of fixation	According to DTRF 150210 For categories A and B, we will keep the assemblies with interfaces type Metal/Metal (the composite ensures the insert fixing, the insert ensuring the mechanical fixing of the composite part).	F0	F0	F1	F1		If we accept composite/metal fixation minimum and maximum torque must be defined on the drawing considering creep effect.
Dimensioning calculation	Mechanical calculation or FEA, according to agreement with ALSTOM	F0	F0				
Nota:	The following calculation approach is validated for: Glass fiber and polyester, vinylester or acrylate resin. Environment : -25 / +45°C 65% < relative humidity Max 30 day at 85%	F0	F0				
Multilayer anisotropic approach: For long fibers fabrics (multiaxial composed by roving layers)	FEA software needs mechanical data layer per layer in order to calculate Tsai Wu criteria for composites: Each layer of composite must be characterized. See Material Data for Calculation.	F1	F1				
« Breaking » criteria	Margin: 2.5 (1/2.5=0,4) under proof load and margin 3.5 (1/(3.5)=0,28) in fatigue load for 10 million cycle (for FEA calculation on composite material / TSAI WU criteria with control of shearing). Note: Some weakest margin can be accepted if a justification based on RoE and material database is presented to ALSTOM for approbation (with fatigue test ISO 13003 10 million cycles).	F1	F1				
Materials data for calculation	1) Young modulus 0° & 90° 2) Poisson ratio 3) Tensile strength 0° & 90° 4) Compression strength 0° & 90° 5) In plane shear Modulus 6) In plane shear strength 7) Interlaminar shear stress	F1	F1				



Single-layer quasi isotropic approach: if no long fiber fabrics (MAT)	Each construction of the part must be characterized. One equivalent material is included into FEA model. See Material data for Calculation.	F0	F0				
« Breaking » criteria	Margin 2.5 under proof load and margin of 3,5 in fatigue load (10 million cycle) for Quasi-isotropic approach. Note: Some weakest margin can be accepted if a justification based on RoE and material database is presented to ALSTOM for approbation (with fatigue test ISO 13003 10 million cycles).	F0	F0				
Materials data for calculation	1) Young modulus 0° 2) Poisson ratio 3) Tensile strength 0° 4) Compression strength 0° 5) In plane shear Modulus 6) In plane shear strength 7) Interlaminar shear stress	F0	F0				
Multilayer anisotropic approach		F1	F1				
« Breaking » criteria	Margin: 2.5 (0,4) under proof load and margin 3.5(0,14) in fatigue load (for FEA calculation on composite material / TSAI WU criteria with control of shearing). Note: Some weakest margin can be accepted if a justification based on RoE and material database is presented to ALSTOM for approbation	F1	F1				
Single layer Quasi isotropic approach		F0	F0				
	In case of quasi-isotropic approach mechanical test campaign must be performed to determine acceptance criteria. This campaign must consider environmental ageing and fatigue. Acceptance must be based on loss of linearity value						
Inserts mechanical strength	Calculation and validation by tests of fixation forces compare to Load evaluated during calculation phase with safety margins equal to: 2 for the exceptional accelerations load cases defined in EN12663, 5 in other load cases (example: aerodynamic effects on fairing).	F0	F0				



	Validation by type tests in tensile and shearing on set of 3 samples with boundary conditions representatives of reality. (Curve Forces / deformation to provide in the report. Report must contain maxim stress at break and Failure pattern with pictures)						
Implementation procedure	To be specified by supplier	Fo	Fo	Fo	Fo		
Drape-forming drawing of various parts	Sampling defined by the supplier: generic/reinforcements: calculations document inserts: type tests document	Fo	Fo	Fo	Fo		
Stiffeners or ribs	Use of stiffeners (core) or ribs is possible to increase rigidity. No marking must appear on the visual side.	Fo	Fo	Fo	Fo		
Declaration and management of critical points (Appendix 2)	Considered in series manufacturing	Fo	Fo	Fo	Fo		

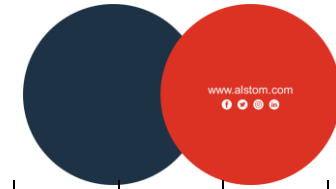
7.3.5 CONTROL IMPLEMENTATION

Requirement	Value	A	B	C	D	CbC	Comments
Preservation of follow-up documents	Conservation of follow-up files during 7 years after delivery. Delivery of follow-up documents at each delivery.	Fo	Fo				
Records of curing cycle	In case of specific procedures, also for pre-impregnated and phenolic matrix (conservation of follow-up files during 7 years after delivery).	Fo	Fo				

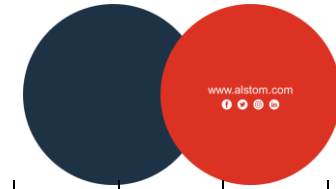
7.3.6 DESTRUCTIVE CONTROL ON TEST SPECIMENS

This table is a minimum qualification plan; the final qualification plan should be validated by Engineering teams.

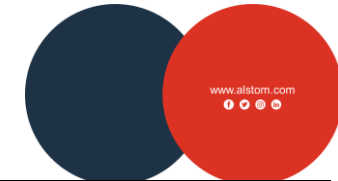
FRP parts					Class of parts			
Characteristic	Description	Requirement	Test type	Standard	A	B	C	D
HDT Heat deflection temperature	Test to be done if the TDS of the resin don't give the value	>65°C	Type test Method e A	ISO75-2 or ASTM D648	F0	F0	F0	F0
TG gelcoat	Test to be done if the TDS of the gelcoat don't give the value	>80°C		ISO 11357 or ASTM D3418	F0	F0	F0	F0
Aspect and Material integrity	Visual inspection Each product	According to ASTM D2562 table 1: level 1 for category: A, B, C level 2 for category D	Routine test	ASTM D2562	F0	F0	F0	F0
IZOD impact Test		>6 feet*lbs/inch	Type test	ASTM D-256 Method A	F0 (NAM) F1 (other)	F0 (NAM) F1 (other)	F0 (NAM) F1 (other)	F0 (NAM) F1 (other)
Color (Gelcoat parts)	Visual inspection each product ΔE measurement can be each painting batch	No visible difference compared to master sample Measure by colorimeter ΔE CIE lab < 1,5 for each batch of gelcoat	Routine test		F0	F0	F0	F0
Gloss (Gelcoat parts) date sample reference	Measure at 60° Each batch	According to design book Proposition: +-UB10	Routine test	ISO 2813 or ASTM D 523	F0	F0	F0	F0



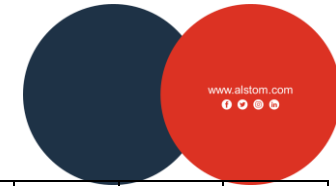
Gel coat thickness	Measure the wet film Each product	According to recommendation in the gelcoat datasheet	Routine test	NA	F0	F0	F0	F0
Gelcoat Color fastener (Non painted, non-filmed parts)	Exposure to Xenon-arc lamps Procedure according to ISO 4892-2, Method A, cycle N° 1, 1500 hours	Gloss >= 50% of initial value $\Delta E < 2$, if $C^* \leq 7$ $\Delta E < 4$, if $7 < C^* \leq 30$ $\Delta E < 8$, if $30 < C^*$	Type test	ISO 4892-2 or ASTM D2244	F0			
Gelcoat Color fastener (Non painted, non-filmed parts)	Exposure to Xenon-arc lamps Procedure according to ISO 4892-2, Method B, cycle N° 2, 150 hours	Gloss > = 80% of original requirement $\Delta E < 1.5$	Type test	ISO 4892-2 or ASTM D523		F1	F1	F1
Gelcoat Cataplastm resistance for not painted parts	Materials: strips of padding or cotton for automotive polishing, deionized water Samples preparation: padding is entirely saturated with water and laid down on the whole surface Test duration: 7 days Blistering quotation according to ISO 4628-2 after samples cooling and drying	Test temperature: 60°C $\pm 3^\circ\text{C}$ (158. ° F) Except for internal composite and plastic parts at 40°C $\pm 3^\circ\text{C}$ (104 °F) Cross cut test: inferior or equal to 2 Blistering: Max degree 3, max size 2 ($\leq 3(S2)$) Max degree 2, max size 3 ($\leq 2(S3)$)	Type test	ISO 4628-2	F0	F0	F0	F1
Gelcoat Scratch resistance (Non painted, non-filmed parts)	3 samples of 100 x 100 mm Procedure according to EN 438-2, article 25	Scratch < 50 μm under 0.5 N load	Type test	EN 438-2article 25	F1	F1	F1	F1



Gelcoat Impact resistance (Non painted parts)	1 sample of 230 x 230 mm, steel ball of 324 ± 5 g, Ø 42.8 ± 0.2 mm, 175 cm fall down	No flaking or cracks	Type test	EN 438-2 §21	F1	F1	F1	F1
Impact resistance (Painted parts)				see DTRF 150608	F1	F1	F1	F1
Gelcoat Abrasion resistance (Non painted, non-filmed parts)	3 samples of 100 x 100 mm, with a central hole of Ø6.35 mm Procedure according to ISO 7784-1 Cycle : 100 Load : to be defined by machine calibration with zinc plate,(40 -0/+5 mg) Abrasive paper : P180	Calculated lost weight < 50 mg or < 25 mg for floor application	Type test	ISO 7784-1 or ASTM D 4060	F0	F0	F0	F0
Paint qualification	In case of Paint application supplier must respect DTRF 150608 especially for qualification process	Qualification according DTRF 150608 chapter 7	routine test	DTRF 150608	F0	F0	F0	F0
Bending test	5 samples for each test for 2 directions	See parts class	Type & Routine test .test result validity for 5 years	ISO 14125 Method A ASTM D790	Average >110 Mpa with minimum of 80 Mpa	Average >110 Mpa with minimum of 80 Mpa	Average > 80Mpa with minimum of 60 Mpa	Average > 80Mpa with minimum of 60 Mpa



Bending test (Sandwich structures)	5 samples for each test for 2 directions Applicable for sandwich structure skin	See parts class	Routine test	ISO 14125 Method A ASTM D-790	Average >110 Mpa with minimum of 80 Mpa	Average >110 Mpa with minimum of 80 Mpa	Average > 80Mpa with minimum of 60 Mpa	Average > 80 Mpa with minimum of 60 Mpa
Mechanical resistance for inserts	Test the most critical insert of the part in loading direction Insert and load direction defined by engineering based on FEA calculation	See parts class	Type test		see project requirement (FEA)	see project requirement (FEA)	> 1500 N	> 1500 N
Torque resistance for embedded inserts	According to insert diameter, torque value according DTRF 150214 CP C20 + 20%	Insert do not move	Type test	DTRF 150214	F0	F0	F0	F0
Polymerization degree	Procedure according to ISO 11357-5	>95%	Type test	ISO 11357-5 or ASTM E2602	F0	F0	F0	F0
Barcol hardness	Each product	>35	Routine test	EN 59-1001 ASTM D2583 Method A.	F0	F0	F0	F0
Tensile Properties	Test to be done just after BA for FEA calculation According to way of calculation	Test for characterization for calculation data, no requirement	Type test	ISO 527-4 ASTM D-638	F0	F0	F1	F1



	Measurements of Modulus E1/ E2, Poisson ratio ν_{12} and Strengths at break σ_1/σ_2 lost of linearity value elongation at break. (Tensile test curves s=f to provide)							
Compressive Properties	Test to be done just after BA for FEA calculation According to way of calculation Measurements of strengths at break σ_1 and σ_2 lost of linearity value elongation at break. (Tensile test curves s=f to provide)	Test for characterization for calculation data, no requirement 4mm thickness specimen	Type test	ISO 14 126 or ASTM D695	F0	F0	F1	F1
Interlaminar Shear Properties	Test to be done just after BA for FEA calculation According to way of calculation Measurement of ILSS	Test for characterization for calculation data, no requirement. 4mm thickness specimen	Type test	ISO 14 130 or ASTM C1425	F1	F1	F1	F1
In Plane Shear Properties	Test to be done just after BA for FEA calculation Measurement of In plane Shear Modulus G12	Test for characterization for calculation data, no requirement. 4mm thickness specimen	Type test	ISO 14 129 or ASTM D4255	F1	F1		
Density of composite	Test to be done just after BA	Test for characterization for calculation data, no requirement	Type test	ISO 1183 or ASTM D792	F0	F0	F0	F0
Fiber Ratio in volume		Test for Characterization: HLU>20% LRTM>15% VIP >45%		ISO 1172 method B ASTM D3171 procedures G&E	F0	F0	F0	F0

7.3.7 NON-DESTRUCTIVE CONTROL ON FINISHED PRODUCT

The following controls must be performed:

- Weight
- Barcol hardness
- Visual inspection: According to ASTM D2562 level 1 or Level 2 depending on parts category

7.4. MILESTONE 4 - FMR

If necessary the supplier is responsible for updating the documentation (3D, drawings or annotated 3D) with modifications identified during First Mounting Review. The update of means of proof is also under supplier responsibility.

In correspondence with serial launch, as part of special processes and in coordination with ALSTOM, the supplier presents a serial tests program which results are delivered to ALSTOM.

Example:

- Process: bonding/under pressure /under high temperature...
- Material control (FEFO) control implementation (pressure record/temperature...)
- Mechanical behavior control (follow-up samples...)



8. SERVICE SCOPE

Documentation to be provided in the development phase

The documentation to be provided for each project is defined in the list of contractual documents. This list is actualized for each project according to specified needs and requirements.

For parts covered by a detailed ALSTOM definition drawing, only the table 2 is applicable. For other cases, the tables 2 & 3 are applicable.

Requirement	Value	Flexibility	Supplier answer	Comments
Weight of the part and sub-assemblies		FO		
Type Tests program and serial test program (minimum requirement in Erreur ! Source du renvoi introuvable.		FO		
Type tests report		FO		
Serial tests reports		FO		
Control plan with list of geometrical & dimensional specification		FO		
Work instruction to repair composite parts		FO		
Respect of standard requirements ENG-STD-003 and furniture ENG-FRM-001	See 9.1	FO		

Table 2

Requirement	Value	Flexibility	Supplier answer	Comments
Technical / functional / material specifications	As per specific requirements expressed in the Technical Purchase Specification	FO		
Prior to calculations, are required: <ul style="list-style-type: none"> • Reference to calculations software • Type of modelling • Justification of materials characteristics selected • Boundary conditions • Results views in displacements, stresses (for isotropic materials) and Tsai Wu criterion (for composite materials) • Results analysis with conclusion. 		FO		



After calculations: <ul style="list-style-type: none"> Detailed calculations report Finite elements models in universal format (HyperWorks, Optistruct). 				
Part and sub-assembly drawings	See Nota → Erreur ! Source du renvoi introuvable.	F0		
Detailed drawings set including sampling of the different layers of fabrics in the part		F0		
Bill of Materials		F0		
Bill of geometrical & dimensional characteristics		F0		
The 3D models produced within the scope of supplier's design studies: <ul style="list-style-type: none"> → Are mandatory in case of a polyester part covered by a Technical Purchase Specification to validate the interfaces of the part on the digital mock-up, → Are appreciated within the scope of a part covered by an ALSTOM preliminary definition. 				
3D model format	CATIA V5 or STEP file	F0		
Formalism of drawings (title block, tolerancing language...)	As per presentation criteria chosen for the project	F0		
Calculation's report		F1		
Evidence for definition, dimensioning and technical performance with review of critical points.		F0		
Description of quality of production tools (please refer to § 5.2)		F0		

Table 2



9. OTHER REQUIREMENTS

9.1. ECO-DESIGN

As part of our eco-design approach, the study of the environmental impacts of materials and manufacturing processes is included into the process of validation of any new product solution.

Therefore, materials are chosen and combined by considering:

- Dangerous nature of constituting chemical substances, respecting rules established in ENG-STD-003
- Their characteristic of emission in volatile organic compounds, for the parts in categories B, C and D,
- Their end of life treatment (unmounting / recycling / elimination).

Requirement	Furniture	Flexibility	Supplier answer	Comments
Commitment of compliance and declaration of dangerous substances	ENG-FRM-001 v.3	FO		
Evaluation of recyclability and recoverability performance	File « Recyclability & Recoverability Calculation Template »	FO		According to TPS
Analysis of COV emissions and Aldehydes according to ISO 16000-3 AND ISO 16000-9	Test's report	FO		According to TPS

The requirements corresponding to two last points of the previous table will be defined in the Technical Purchase Specification (TPS).

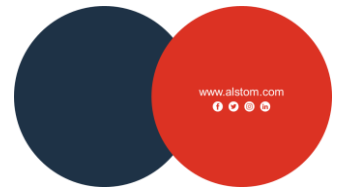
9.2. FIRE – SMOKE

The deliverables associated to Fire-Smoke requirements, defined in Technical Purchase Specification (TPS). Test laboratory must be ISO 17025 accredited.

9.3. MOULDS AND TOOLING MARKING

The moulds and tooling shall be identified with identification plates including the following information (FO):

- Name of builder
- Reference of builder
- ALSTOM identification code for product
- Customer's number if required
- Drawing revision
- Month and year of manufacturing



- Serial number
- The sentence « *PROPRIETE INSAISSABLE ALSTOM SA. Etablissement d’Aytré – La Rochelle* » (for example).

The identification plates shall remain legible throughout the equipment’s lifecycle.

The supplier shall fabricate enough molds and jigs to withstand manufacturing of the entire scope of supply. One mold can guarantee a minimum of parts depending on the process (see table below).

Characteristic	Process type				
	Hand Layup	RTM	Prepreg / Vaccum Infusion	SMC	RIM
Minimum number of demoldings	250	250	250	2000	500

Below an extract of order text:

Specific rules in the tooling orders:

The deadline pointed out is purely theoretical, nevertheless it serves as payment date which will only be made after agreement of our departments.

After the tooling payment, they will become our exclusive property and have to be marked INTANGIBLE ALSTOM PROPERTY. Establishment of XXX.

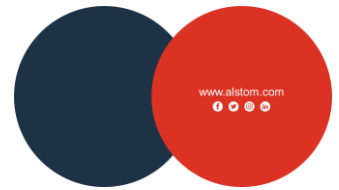
You will be in charge of:

- *Maintenance*
- *Possible repair*
- *Insurance*

You shall ensure the whole manufacturing of the quoted business. It will not be able to be used by third parties or destroyed without the authorization written and signed by ALSTOM SA. The tooling payment purpose of our order will be made after acceptance of the first articles reception by Quality Department ALSTOM SA.

A table listing the tooling set of intangible property ALSTOM SA. Establishment of XXX shall be updated and sent us once a year at the time of your accounting closing.

It shall contain: the material description, quantities, ALSTOM SA order number. Establishment of XXX, telephone number, price, holding date, and finally, holding location.



9.4. PARTS MARKING

The equipment shall support identification plates with the following information (FO):

- Name of builder
- Reference of builder / manufacturing site
- ALSTOM identification code for product
- Customer's reference if required
- Drawing revision
- Month and year of manufacturing
- Serial number
- Batch number resin / gelcoat
- Mold number

The identification plates or label shall remain legible throughout the equipment's lifecycle, but shall not be visible to passengers (location to be validated by ALSTOM). QR code could be also use in accordance with ALSTOM.

9.5. PRODUCTION TOOLS REQUIREMENTS

Requirement	Value	Flexibility	Supplier answers	Comment
Manufacturing mould inspection				
Identification (mould and equipment)	Designation (encoding with parts list / materials / process definition)	FO		
Geometry	Conformity with model	FO		
Geometry	Dimensional stability considering shrinkage	FO		
Surface condition	Barcol > 45	FO		
Number of times the mould can be used	To be specified by supplier but validated by ALSTOM see Table § 9.3	FO		
Load capacity of mould (Parts / day)	To be specified by supplier but validated by ALSTOM	FO		
Maintenance and storage precautions	Please refer to § 9.6	FO		



9.6. STORAGE CONDITIONS

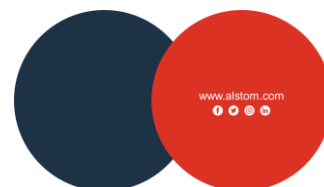
If specific precautions are needed, the supplier shall write a document describing the procedures and precautions to be taken for storage of:

- Raw materials according to TDS (T°C, humidity...)
- Parts
- Moulds and equipment during and at the end of the project.

9.7. LIFTING – MOUNTING

Requirement	Value	CbC	Flexibility	Comment
Lifting - mounting	As per possible recommendations on drawing or in Technical Purchase Specification		F1	
Equipment weight objective < 12 kg			F1	
Equipment weight between 12 kg & 24kg	Must be handled by 2 people		F1	
Equipment of weight > 24 kg				
Lifting points	Depending on context		F0	
Position of lifting points	Equipment assembly drawing depending on context		F0	
Handling method / Position of lifting points	To be provided in equipment assembly drawing		F0	
Definition of specific tools / Handling method	To be provided		F0	
Definition of specific tools	To be provided		F0	
If weight > 100 kg, special FEA load cases must be provided in calculation note			F0	

When specific precautions of lifting or mounting must be applied, the supplier must prepare a document describing these precautions.



9.8. PACKAGING

- No part distortion
- Parts fixed together in the packaging
- No fixation screw between cover and packaging
- Visible side covered with a protective film



10. APPENDICES

10.1. NOTA

The following information must appear on drawings

NOTA on drawing:

Part according to Technical Specification DTRF 150232

Type of part: category A / B / C / D according to DTRF 150232 (see pictogram in DADI)

Value of requirements for mechanical strength of each type of insert for parts subject to mechanical stress (for categories A and B only):

Tensile strength:

Xx Mpa

Shearing strength:

Xx Mpa

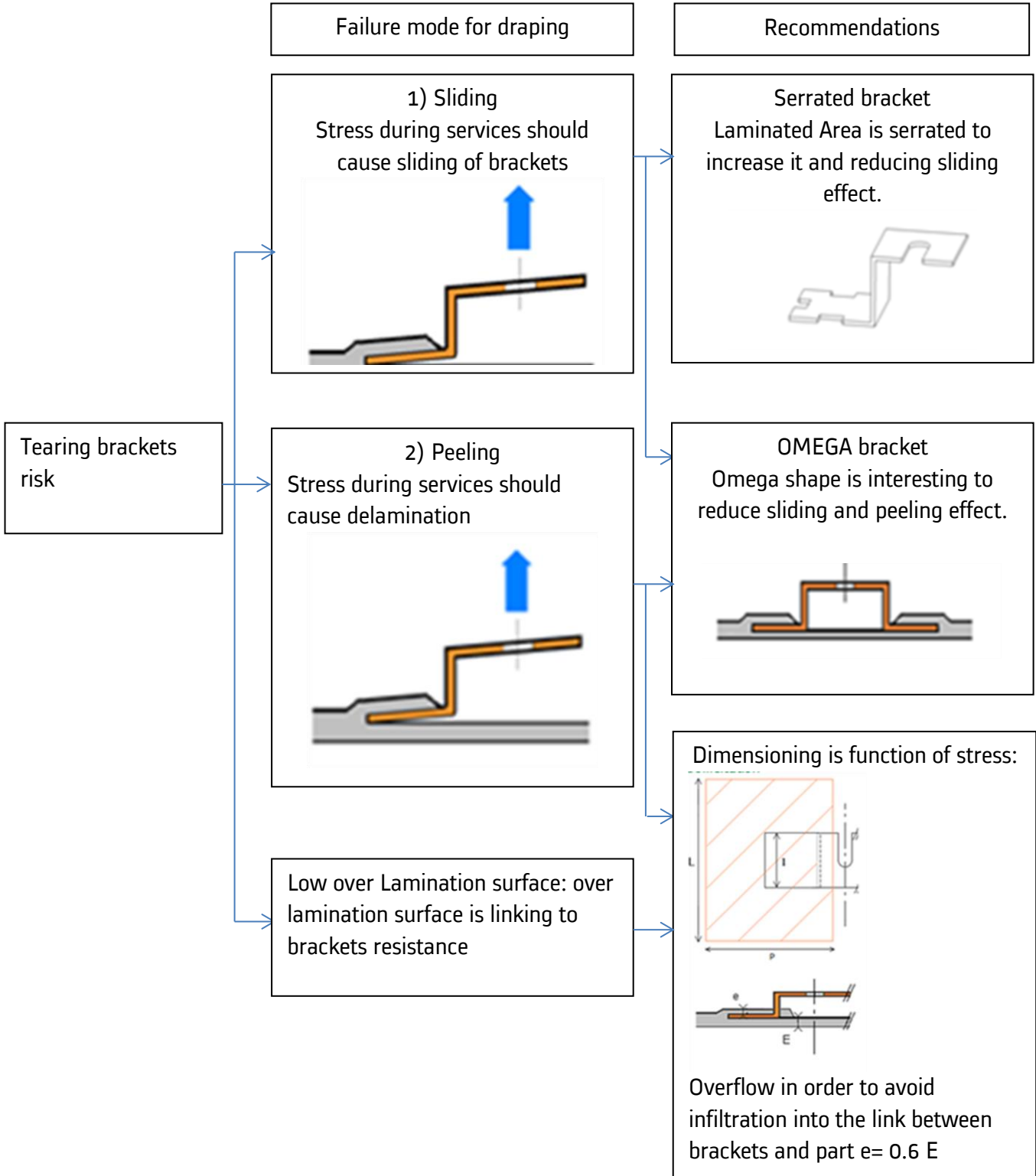
Painting according to specification ... under area ...

Weight of part:

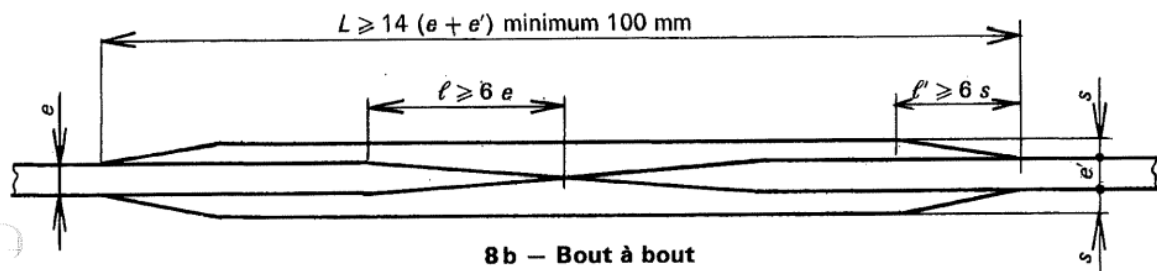
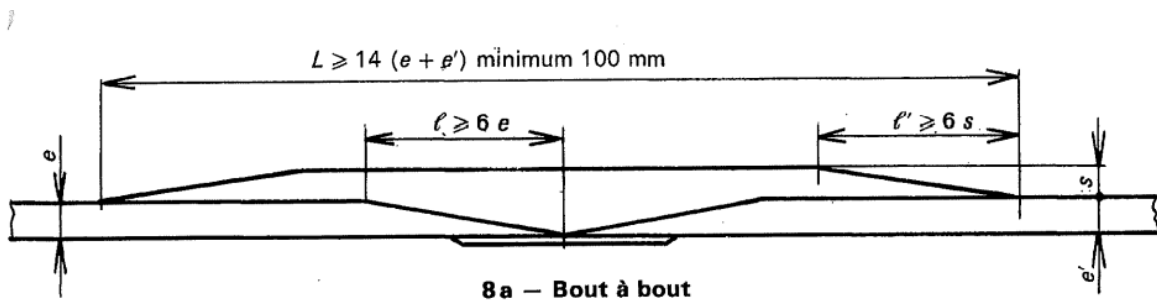
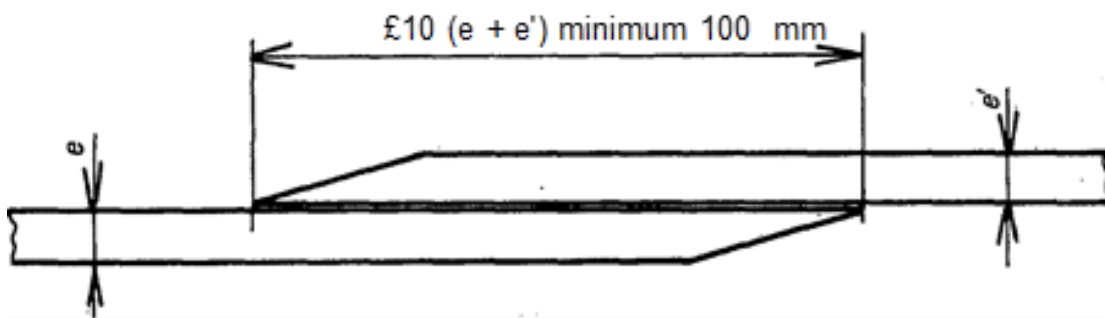
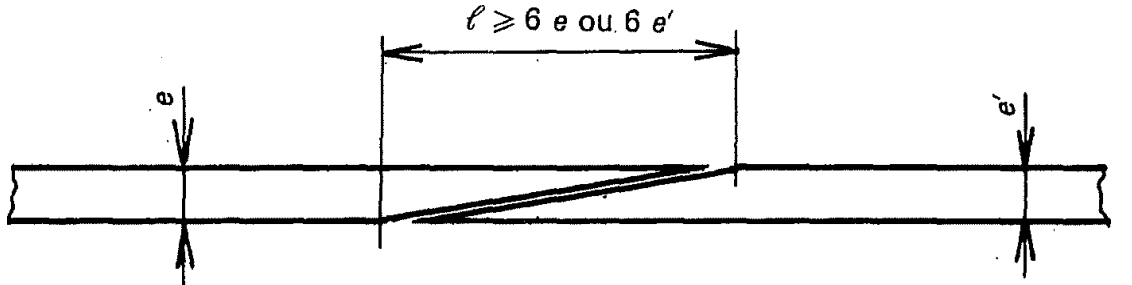
10.2. CRITICAL POINTS

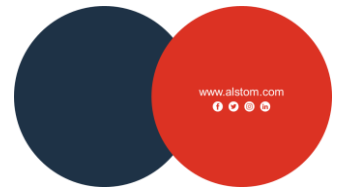
	Critical points	Risks	Action
Shape	Shape variation (thickness, surface ...) 	Crack, break or Shrinkage 	. Add reinforcement locally .Add monting condition on the draw
	Radius / fillet < 6mm 	bubble / tear /bursting 	. Add reinforcement locally -> Add woven roving or multi-axial
Weight		Failure to comply with the specifications	. specification analyse -> layout optimisation
Rigidity	Flexibility 	Vibrations/ deformations (aerodynamic) Bad	.shape optimisation: -> Thickness / Fallen edge/ stiffener .increase fixation point -> Shapers / indication on drawing
Waterthighness	water retention Area 	Water retetion and hydrolyse 	suppression
	joint face from conter form 	lay out discontinuity - crack -water infiltration 	.Linking of different parts of mold with layout continuity
	Brackets position in sandwich construction 	Compression / shear of core and water infiltration in the core 	. Selection of core material .put brackets in monolithic skin
	non open brackets 	water infiltration 	
Brackets	Shape and lamination	tearing/ sliding / bending	Dimensionnning with calculation mechanical test
Visible area	Aspect for vissble parts	defects on visible area	drawing remarks
calibrated Area	Thickness variation	Mounting interference	Quotation and tolerances on the draw

Brackets over lamination:



10.3. CONNECTING AND JOINTS OF ASSEMBLIE





10.4. VALIDATION OF ADHESIVE BONDED ASSEMBLY

In the absence of European standard governing railway bonded joints, two cases exist:

- For a Region (like Germany) or a project where the DIN 6701 is part of the contract, it is mandatory to follow the DIN 6701. In this case the DTRF 150223 defines additional requirements from ALSTOM.
- All other cases: follow the design cycle described in DTRF 150223. This ALSTOM Standard contains main definitions used for a glued assembly, the notion of family used in ALSTOM, as well as the fundamental rules for dimensioning including safety level.

Over laminated bracket is not considered bonded

The ALSTOM Standard DTRF 150223 applies to all products (component parts and/or parts in direct interface with the body shell) and designed by ALSTOM and contracted or manufactured by ALSTOM and its suppliers. It is directly linked to the DTRF 150620 which standardizes, for ALSTOM, the industrial rules for adhesive bonds Reference documents, standards and norms.