



The Composite Technology

Total EN 45545 Solutions for Flame Retardant Composites Gelcoats & Topcoats, Resins & Coatings from one Company




EN 45545 HL 3
ALSO WITH CARBON FIBRE

Alstom ETR 675

REQUIREMENTS OVERVIEW

The requirements for composites in the railway industry are increasing more and more. To provide the best protection for passengers in case of a fire, composite materials must be flame-retardant and have smoke-reducing characteristics.

Mäder is the only supplier who is able to offer a [global system of Resins/Gelcoats/Coatings](#), ensuring excellent fire-smoke resistance.

FOCUS ON EN 45545

Hazard Level Classification

HL1, HL2, HL3

Level pass / fail requirement stringency [Material compliant to HL3 fulfills HL1 & HL2 requirements].

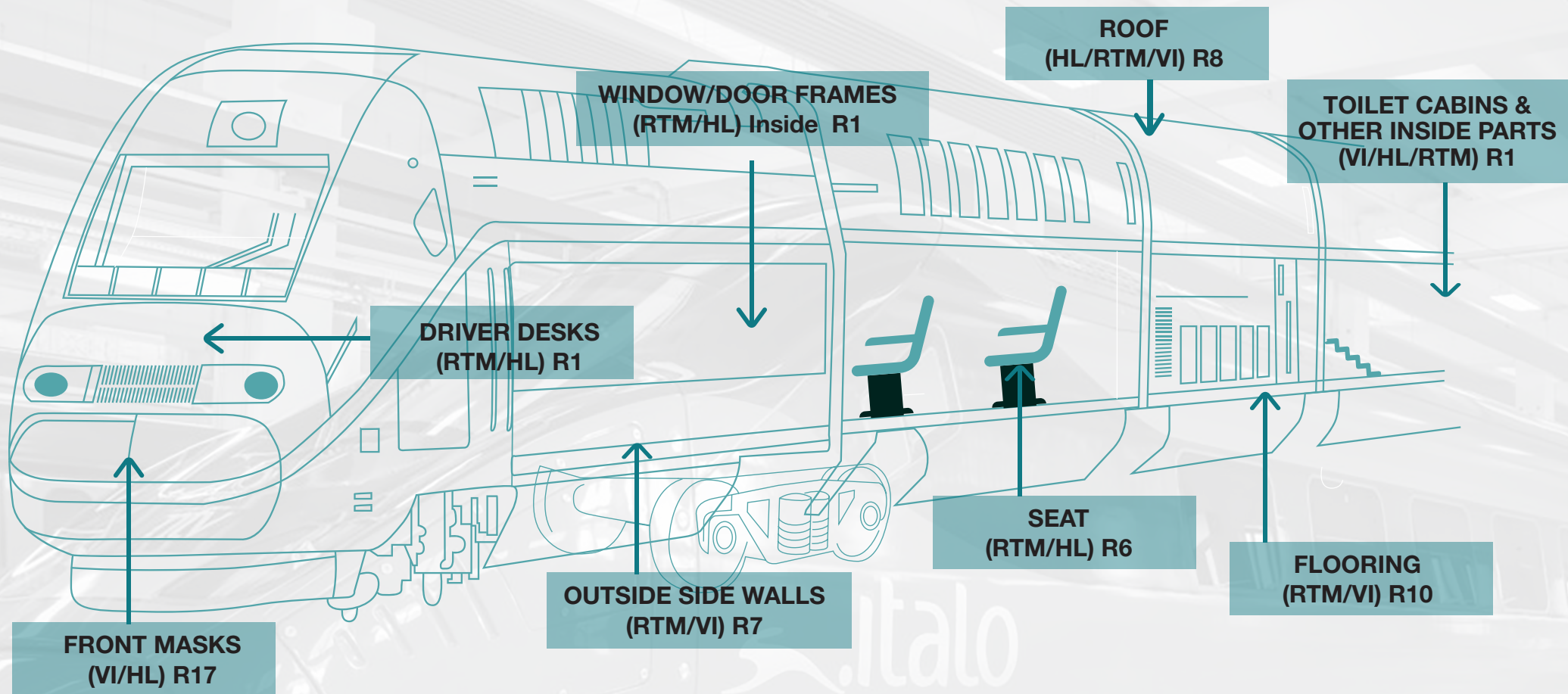
HL classification dependent on operation and design category.

Requirement Set

R1, R2, R3...

The material requirement set (R1, R2, R3..) defines the specific tests and pass/fail criteria of the associated products (IN1A, 1EX2, F1...) for each Hazard. Level classification (HL1, HL2, HL3).

| REQUIREMENT SET | | | R1 | | | R6 | | |
|------------------------------------|-----------------------------------|--------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Test method | Parameter & unit | Maximum or Minimum | HL 1 | HL 2 | HL 3 | HL 1 | HL 2 | HL 3 |
| T 02 ISO 5658-2 | CFE kWm ⁻² | Minimum | 20 | 20 | 20 | | | |
| T 04 EN ISO 9239-1 | CHF kWm ⁻² | Minimum | | | | | | |
| Irradiance of the following tests: | | | 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² |
| T 03.01 ISO 5660-1 | MARHE kWm ⁻² | Maximum | - | 90 | 60 | 90 | 90 | 60 |
| T 10.01 EN ISO 5659-2 | D _g (4) dimensionless | Maximum | 600 | 300 | 150 | 600 | 300 | 150 |
| T 10.01 EN ISO 5659-2 | D _g max. dimensionless | Maximum | - | - | - | - | - | - |
| T 10.01 EN ISO 5659-2 | VOF ₄ min | Maximum | 1200 | 600 | 300 | 1200 | 600 | 300 |
| T 10.01 EN ISO 5659-2 | CIT _g dimensionless | Maximum | 1,2 | 0,9 | 0,75 | 1,2 | 0,9 | 0,75 |

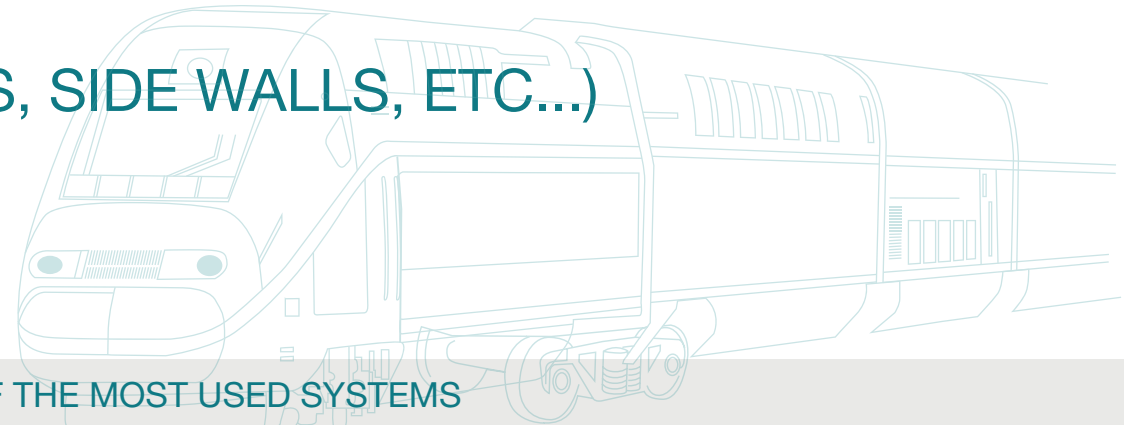


| R7 | | | R8 | | | R10 | | | R17 | | |
|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| HL 1 | HL 2 | HL 3 | HL 1 | HL 2 | HL 3 | HL 1 | HL 2 | HL 3 | HL 1 | HL 2 | HL 3 |
| 20 | 20 | 20 | | | | | | | 13 | 13 | 13 |
| | | | 4,5 | 6 | 8 | 4,5 | 6 | 8 | | | |
| 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² |
| - | 90 | 60 | - | 50 | 50 | - | - | - | - | 90 | 60 |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | 600 | 300 | - | 600 | 300 | 600 | 300 | 150 | - | 600 | 300 |
| - | - | - | - | - | - | - | - | - | - | - | - |
| - | 1,8 | 1,5 | - | 1,8 | 1,5 | 1,2 | 0,9 | 0,75 | - | 1,8 | 1,5 |

R1: INSIDE PARTS (TOILET CABINS, SIDE WALLS, ETC...)



Stadler EC-250



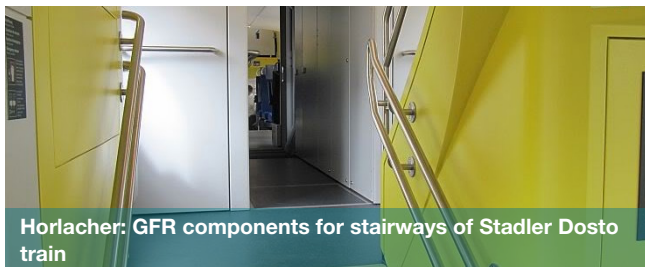
EXAMPLE OF THE MOST USED SYSTEMS

| | |
|--------------------|---|
| PAINT | 1 or 2 layers system |
| GELCOAT | Nuvopol GC 37-03 TGP / Nuvopol GC 37-05 TGP |
| HLU RESIN | Giralithe Ditra 2109-10 XP |
| RTM-L RESIN | Giralithe Ditra 2109-10 XP White 3010 |

More details about all our systems in page 14



Horlacher: GFR components for toilet cabins for Stadler EC-250 train



Horlacher: GFR components for stairways of Stadler Dosto train

| REQUIREMENT SET | | R1 | | |
|------------------------------------|--------------------|----------------------|----------------------|----------------------|
| Parameter & unit | Maximum or Minimum | HL 1 | HL 2 | HL 3 |
| CFE kWm ⁻² | Minimum | 20 | 20 | 20 |
| Irradiance of the following tests: | | 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² |
| MARHE kWm ⁻² | Maximum | - | 90 | 60 |
| D _s (4) dimensionless | Maximum | 600 | 300 | 150 |
| VOF ₄ min | Maximum | 1200 | 600 | 300 |
| CIT ₀ dimensionless | Maximum | 1,2 | 0.9 | 0.75 |



We recommend to paint the inside parts with minimum one layer of paint to avoid scratches and protect the surface against humidity and cleaning agents. The paints are available in different colours and gloss-grades.

R6: TRAIN SEAT PANS & BACK RESTS

EXAMPLE OF THE MOST USED SYSTEMS

| | |
|--------------------|---|
| PAINT | 1 or 2 layers system |
| GELCOAT | Nuvopol GC 37-03 TGP / Nuvopol GC 37-05 TGP |
| HLU RESIN | Giralithe Ditra 2109-10 XP |
| RTM-L RESIN | Giralithe Ditra 2109-10 XP White 3010 |



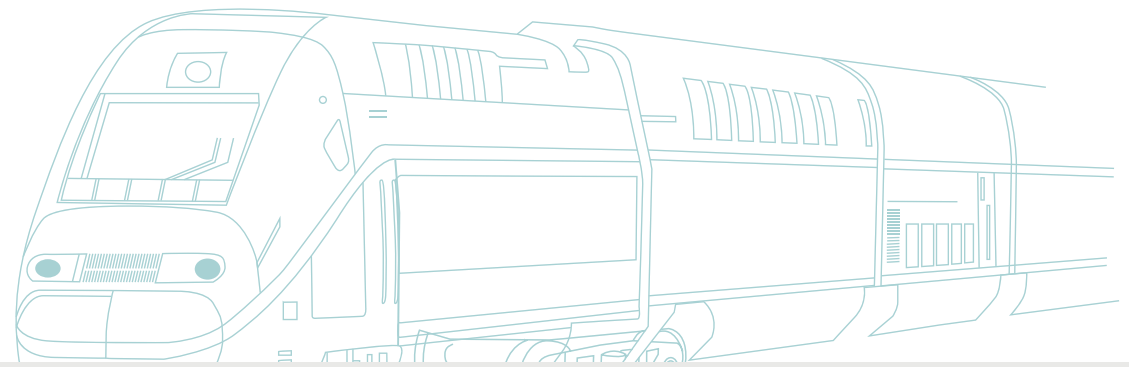
More details about all our systems in page 14

| REQUIREMENT SET | | R6 | | |
|------------------------------------|--------------------|----------------------|----------------------|----------------------|
| Parameter & unit | Maximum or Minimum | HL 1 | HL 2 | HL 3 |
| Irradiance of the following tests: | | 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² |
| MARHE kWm ⁻² | Maximum | 90 | 90 | 60 |
| D _s (4) dimensionless | Maximum | 600 | 300 | 150 |
| VOF ₄ min | Maximum | 1200 | 600 | 300 |
| CIT _G dimensionless | Maximum | 1,2 | 0,9 | 0,75 |



We recommend to paint the seat pan (if it isn't upholstered) with minimum one layer of paint to avoid scratches and protect the surface against humidity and cleaning agents. The paints are available in different colours and gloss-grades.

R7: TRAIN SIDES OUTSIDE



Bombardier FLEXITY II Gold Coast



Alstom Citadis X05 Skirt protection



Alstom Citadis X05

EXAMPLE OF THE MOST USED SYSTEMS

| | |
|----------------|--|
| PAINT | 3 layers system |
| GELCOAT | Nuvopol GC 37-05 TGP / Nuvopol GC 37-11 TG |
| HLU RESIN | Giralithe Ditra 2109-10 XP |
| RTM-L RESIN | Giralithe Ditra 2109-10 XP White 3010 |
| INFUSION RESIN | Nuvocryl FR 60-90 G |

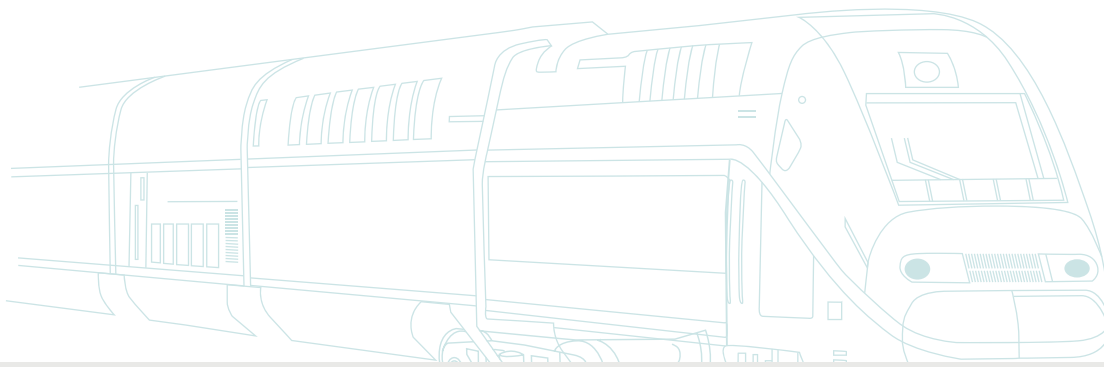
More details about all our systems in page 14

| REQUIREMENT SET | | R7 | | |
|------------------------------------|--------------------|----------------------|----------------------|----------------------|
| Parameter & unit | Maximum or Minimum | HL 1 | HL 2 | HL 3 |
| CFE kWm ⁻² | Minimum | 20 | 20 | 20 |
| Irradiance of the following tests: | | 50 kWm ⁻² | 50 kWm ⁻² | 50 kWm ⁻² |
| MARHE kWm ⁻² | Maximum | - | 90 | 60 |
| D _g max. dimensionless | Maximum | - | 600 | 300 |
| CIT _g dimensionless | Maximum | - | 1,8 | 1,5 |



We recommend to paint the outside parts with a three layer-system of paint to avoid scratches and protect the surface against humidity and cleaning agents. The paints are available in different colours and gloss-grades.

R8: TRAIN ROOF OUTSIDE



EXAMPLE OF THE MOST USED SYSTEMS

| | |
|-----------------------|--|
| PAINT | 3 layers system |
| GELCOAT | Nuvopol GC 37-05 TGP / Nuvopol GC 37-11 TG |
| HLU RESIN | Giralithe Ditra 2109-10 XP |
| INFUSION RESIN | Nuvocryl FR 60-90 G |



Example of a roof application

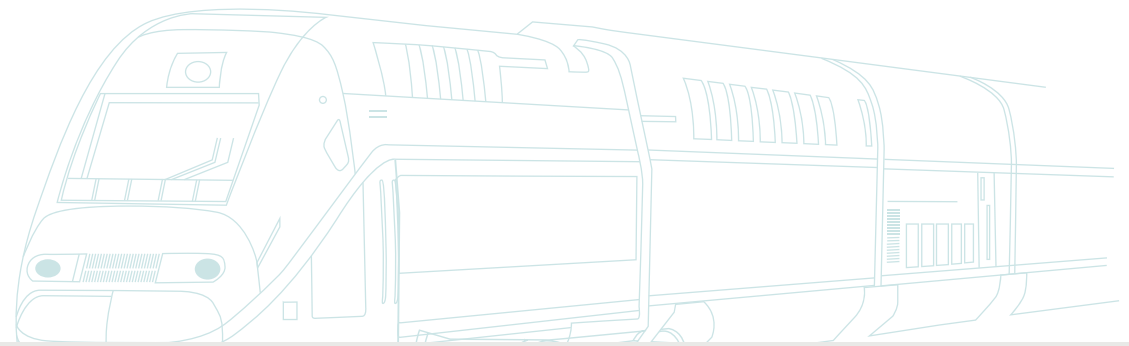
More details about all our systems in page 14

| REQUIREMENT SET | | R8 | | |
|------------------------------------|--------------------|-----------------------|-----------------------|-----------------------|
| Parameter & unit | Maximum or Minimum | HL 1 | HL 2 | HL 3 |
| CHF kWhm ⁻² | Minimum | 4,5 | 6 | 8 |
| Irradiance of the following tests: | | 25 kWhm ⁻² | 25 kWhm ⁻² | 25 kWhm ⁻² |
| MARHE kWhm ⁻² | Maximum | - | 50 | 50 |
| D _g max. dimensionless | Maximum | - | 600 | 300 |
| CIT _g dimensionless | Maximum | - | 1,8 | 1,5 |



We recommend to paint the outside parts with a three layer-system of paint to avoid scratches and protect the surface against humidity and cleaning agents. The paints are available in different colours and gloss-grades.

R10: TRAIN FLOORS



EXAMPLE OF THE MOST USED SYSTEMS

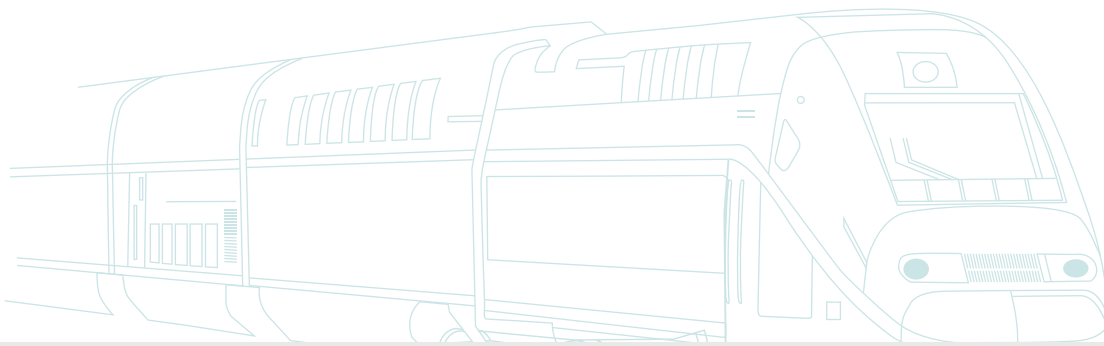
| | |
|-----------------------|----------------------------|
| FLOOR COVERING | Carpet or Linoleum |
| GELCOAT | Nuvopol GC 37-03 TGP |
| HLU RESIN | Giralithe Ditra 2109-10 XP |

More details about all our systems in page 14

| REQUIREMENT SET | | R10 | | |
|-----------------------------------|--------------------|----------------------|----------------------|----------------------|
| Parameter & unit | Maximum or Minimum | HL 1 | HL 2 | HL 3 |
| CHF kWm ⁻² | Minimum | 4,5 | 6 | 8 |
| radiance of the following tests: | | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² |
| D _g max. dimensionless | Maximum | 600 | 300 | 150 |
| CIT _G dimensionless | Maximum | 1,2 | 0.9 | 0.75 |



We recommend to cover the parts with a floor covering like textile, carpets or linoleum.



R17: FRONT MASK OUTSIDE

EXAMPLE OF THE MOST USED SYSTEMS

| | |
|-----------------------|--|
| PAINT | 3 layers system |
| GELCOAT | Nuvopol GC 37-05 TGP / Nuvopol GC 37-11 TG |
| HLU RESIN | Giralithe Ditra 2109-10 XP |
| INFUSION RESIN | Nuvocryl FR 60-90 G |

More details about all our systems in page 14

| REQUIREMENT SET | | R17 | | |
|------------------------------------|--------------------|----------------------|----------------------|----------------------|
| Parameter & unit | Maximum or Minimum | HL 1 | HL 2 | HL 3 |
| CFE kWm ⁻² | Minimum | 13 | 13 | 13 |
| Irradiance of the following tests: | | 25 kWm ⁻² | 25 kWm ⁻² | 25 kWm ⁻² |
| MARHE kWm ⁻² | Maximum | - | 90 | 60 |
| D _g max. dimensionless | Maximum | - | 600 | 300 |
| CIT _o dimensionless | Maximum | - | 1,8 | 1,5 |



Front End Alstom ETR 675: High Strength Vacuum Infusion



Front End Locomotiv Kasachstan: Normal Vacuum Infusion

NB Specific possibility for carbon fiber with our Nuvocryl FR 60-100



We recommend to paint the outside parts with a three layer-system of paint to avoid scratches and protect the surface against humidity and cleaning agents. The paints are available in different colours and gloss-grades.

VACUUM INFUSION FOR EN 45545 COMPOSITES



Astom ETR 675



Alstom Bombardier M7



Alstom Corrodia Smart



Hitachi Caravaggio



Alstom Lyon



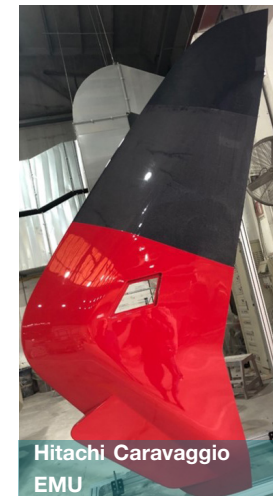
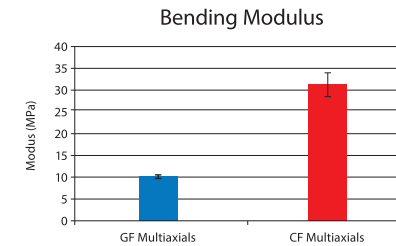
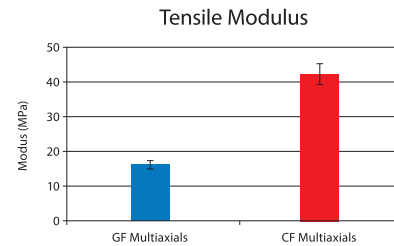
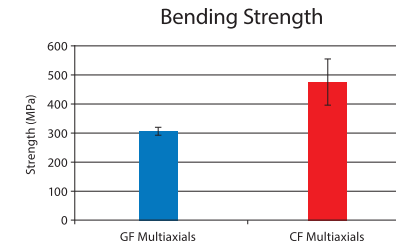
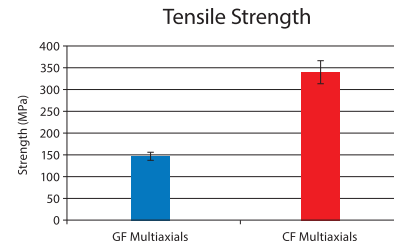
Hitachi Soloniki



Alstom RER Paris

HIGHER WEIGHT REDUCTION & IMPROVEMENT OF MECH. PROPERTIES WITH THE USE OF CARBON FIBER

| Process | GLASS FIBER | | CARBON FIBER |
|------------------------|---|--|--|
| | Class HL2 R17 | | Class HL3 R17 |
| | HAND LAY UP Weight kg / m ² | INFUSION Weight kg / m ² | INFUSION Weight kg / m ² |
| Fiber content | 30% | 63% | 55% |
| Gelcoat weight | 1,2 | 1,2 | 1,2 |
| Glass fiber weight | 5,4 | 5,4 | - |
| Carbon fiber weight | - | - | 2,8 |
| Resin weight | 12,6 | 3,2 | 2,3 |
| Total / m2 | 19,2 | 9,8 | 6,3 |
| Total Front weight | 192,0 | 98,0 | 63,0 |
| Weight reduction | - | 94,0 | 129,0 |
| Weight loss percentage | - | 49% | 67% |



Hitachi Caravaggio EMU

VACUUM INFUSION IS ALSO POSSIBLE FOR LOWER STRENGTH REQUIREMENTS

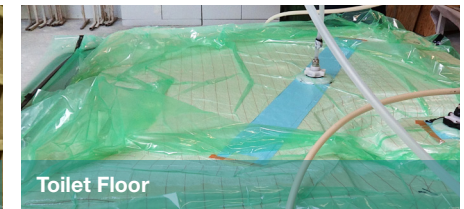
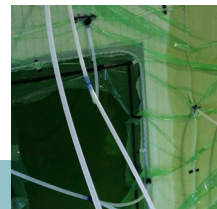


Locomotive Front Mask

Preparation with glass and peel-ply



Infusion start and after 4 minutes



Toilet Floor

Low cost approach for lower strength requirements with Giralithe Ditra 2109-10XP white 3010

Also for inside applications for lower weight, better, constant quality and strength Vacuum infusion systems for various applications depending on the mechanical strength

RTM LIGHT SYSTEM FOR EN 45545 INTERIORS AND EXTERIORS

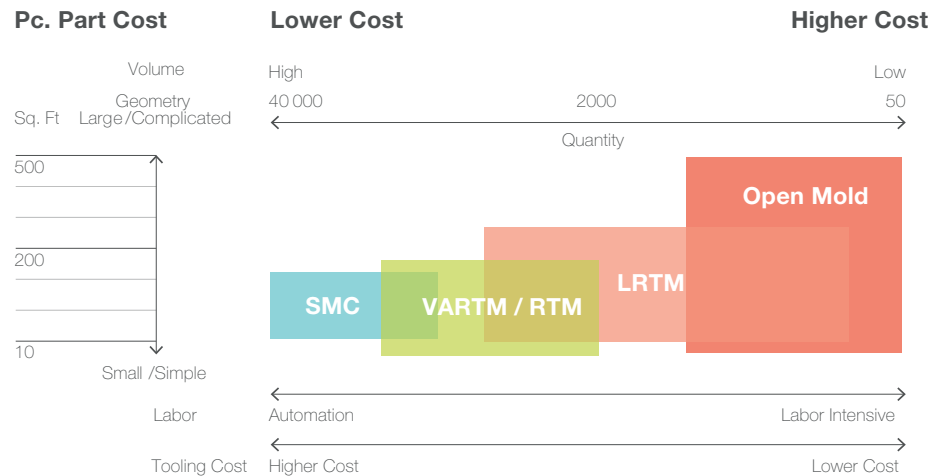
MANUFACTURING EFFICIENCY WITH RTM LIGHT

EXAMPLE OF THE MOST USED SYSTEMS

| | |
|--------------------|--|
| PAINT | 2 layers system (inside) / 3 layers system (outside) |
| GELCOAT | Nuvopol GC 37-03 TGP / Nuvopol GC 37-05 TGP |
| RTM-L RESIN | Giralithe Ditra 2109-10 XP White 3010 Giralithe Ditra 2109-10 Grey 3100 |

More details about all our systems in page 14

SOME RTM LIGHT REFERENCES



Advanced RTM Light

- High quality composites with constant weight and properties
- Industrial process
- Lower costs per part than hand lamination from about 100 pieces

RTM Light versus SMC

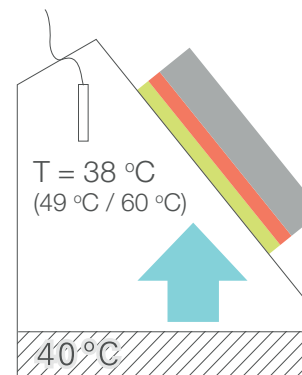
- Shorter lead time
- Low in front costs
- No limitation in dimensions (up to Front Cups)
- No dependences from press availability: wider supplier range

For many interior composites the RTM / RTM light method is more cost efficient and has shorter lead times.

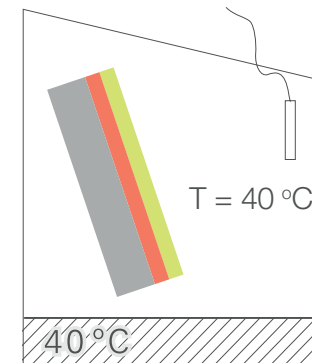
BEST IN CLASS WATER-/ HUMIDITY RESISTANCE OF INTUMESCENT GELCOATS



MÄDER IS LEADING THE WAY WITH INNOVATIVE HIGH PERFORMANCE INTUMESCENT GELCOATS



Part 1:
Continuous condensation



Part 2:
Method for using samples in
condensation water climates

© Fraunhofer IPA

Condensed water test DIN EN ISO 6270

Coating materials – Determination of resistance to moisture

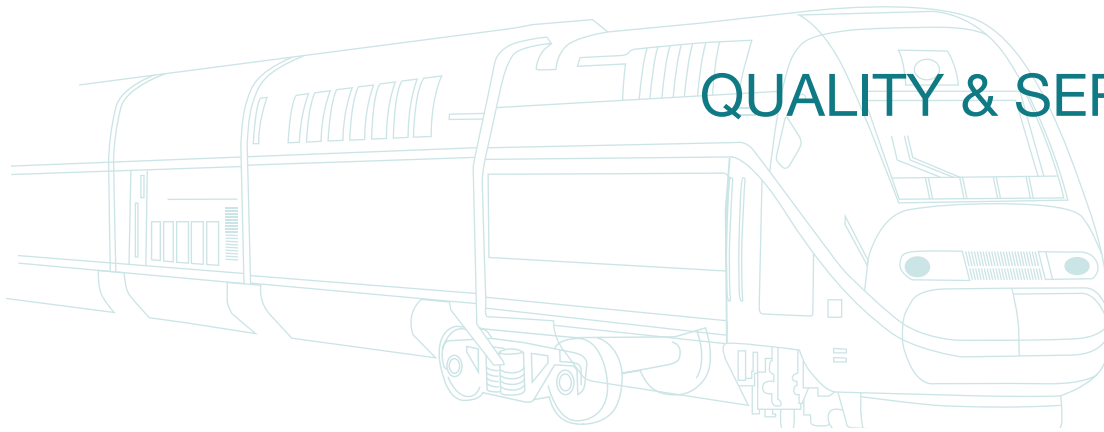
Humidity Resistance

All Mäder Gelcoats / painted composites are tested according DIN EN ISO 6270-2 for 10 days inside and 20 days outside “no bubbles”

Water Resistance: Best in Class!

Nuvopol GC 37-03 TGP, not coated passes over 20 days, coated over 40 days

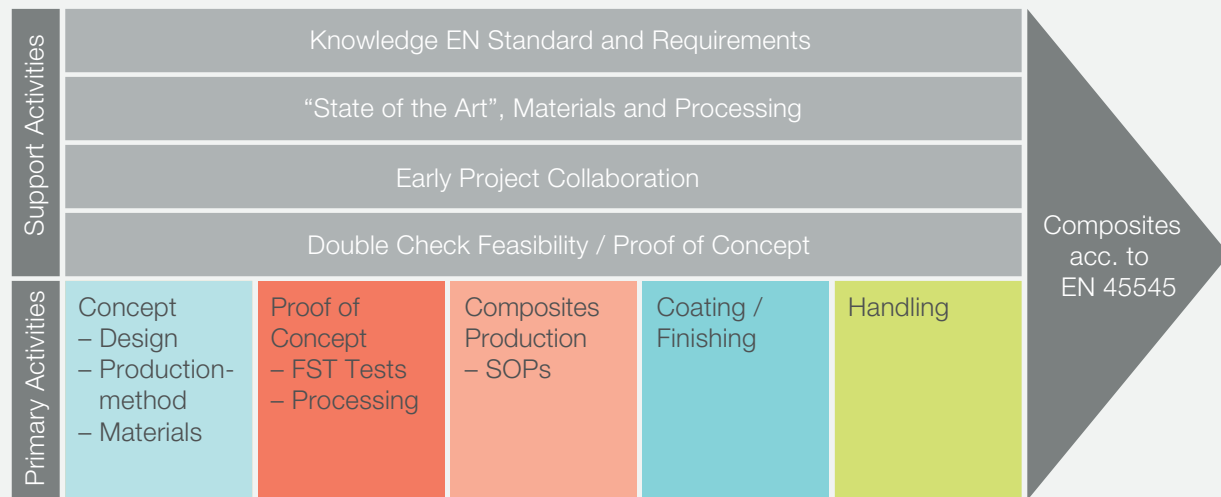
QUALITY & SERVICE FOR EN 45545 COMPOSITES



MÄDER GIVES WITH A DEDICATED TEAM FULL TRAINING & SERVICE TO OEMs AND COMPOSITE MAKERS

THEORETICAL PART

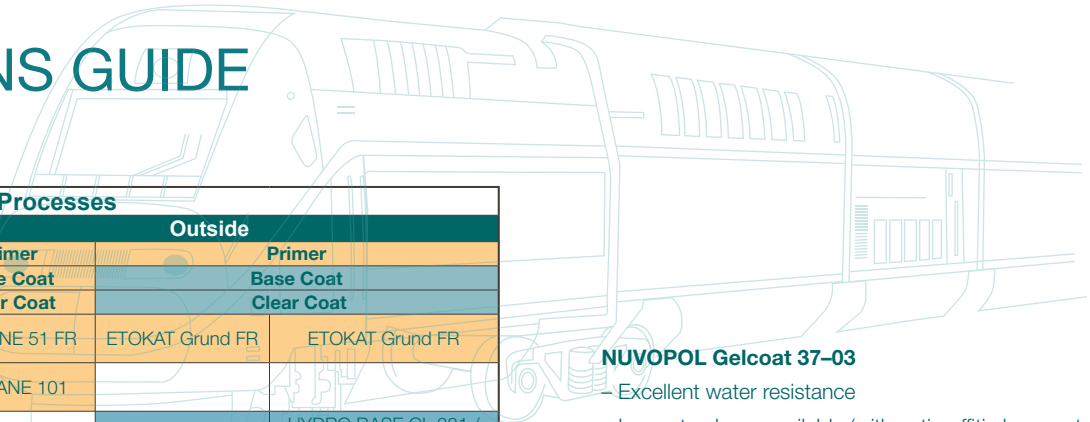
EN 45545 Conclusion / Elements for Success



PRACTICAL PART / PROCESSING SOP



MÄDER TOTAL EN 45545 SOLUTIONS GUIDE



| ...for Hand Lamination, RTM light and Vacuum Infusion Processes | | | | | | | |
|---|-------------|-----------------|------------------|------------------|-------------------|------------------|---|
| Coating Options | Inside | | | | Outside | | |
| | Single Coat | Primer Top Coat | | Primer | Primer Base Coat | Primer Base Coat | |
| | | | | Top Coat | Clear Coat | Clear Coat | |
| | Primer (SB) | | ARTHANE 51 FR | ETOKAT Grund FR | ETOKAT Grund FR | ARTHANE 51 FR | ETOKAT Grund FR |
| Base Coat (SB) | | | | | ARTHANE 101 | | |
| Base Coat (WB) | | | | | | NUVOVERN AQUA | HYDRO BASE CL 381 / NUVOVERN AQUA RAPID |
| Clear or Top Coat (SB) | ARTHANE 251 | ARTHANE 251 | NUVOVERN DS 10:1 | | BARNIZ ARTHANE AG | | |
| Clear or Top Coat (WB) | | | | NUVOVERN AQUA DS | | NUVOVERN AQUA | NUVOVERN AQUA |

NUVOPOL Gelcoat 37-03

- Excellent water resistance
- In most colours available (with antigraffiti clear coat recommended)
- Faster tack-free
- Lower costs
- Experience since 2012 for various parts

| | |
|-----------------|--|
| Gel Coat | NUVOPOL GC 37-03 TGP / NUVOPOL GC 37-03 TGP (A) / NUVOPOL GC 37-05 TGP / NUVOPOL GC 37-11 TG (new) |
|-----------------|--|

| Processing Options | Hand Lamination | |
|--------------------|--|---|
| | Resins | GIRALITHE DITRA 2109-10 XP / GIRALITHE DITRA 2109-11 XP |
| | Fiber Content | 25 - 35 % by weight |
| | RTM light / RTM | |
| | Resins | GIRALITHE DITRA 2109-10 XP White 3010 / GIRALITHE DITRA 2109-10 Grey 3100 |
| | Fiber Content | 20 - 40 % by weight |
| | Vacuum Infusion | |
| | Resins | NUVOCRYL FR 60-60 G / NUVOCRYL FR 60-90 G / NUVOCRYL FR 60-100 (new) |
| Fiber Content | 40 % up to 65 % by weight for high strength application / 50 % weight saving | |

NUVOPOL Gelcoat 37-05

- No auto-demoulding on large parts: Vacuum Infusion or HL the next day possible
- Very low smoke values: compensates smoke from coatings
- HL3 R1 in coloured gelcoat
- Flexible
- Experience since 2014

NEW: NUVOPOL Gelcoat 37-11

- Excellent CFE values
- Low smoke
- Styrene free
- Adjustable gel time
- Best in class water/humidity resistance

| Tests | Performance | | | | | | |
|---------------|---------------------------------------|--------|-----|-----|-----------------------------|-----|--|
| | Humidity Resistance DIN EN ISO 6270-1 | passed | | | | | |
| | EN 45545-2 | HL 2 | | | R 17 HL 3 with Carbon Fibre | HL2 | |
| Anti Graffiti | yes | | yes | yes | yes | yes | |

Gelcoat

The choice of the gelcoat depends on various factors: Please ask for specific recommendation
Gelcoat thickness: 0.8-1.0 mm

EN 45545 (R1, R17, R7, R8...)

Depending thickness, sandwich, coating and manufacturing methodes

(SB) Solvent based

(WB) Water based

WITH ALL TYPES OF COATINGS

OVER 35 EN 45545 REFERENCES



HITACHI Caravaggio



ALSTOM Metro Sydney



BOMBARDIER UC490
S-Bahn Hamburg



SIEMENS RRX



ALSTOM Riyadh Metro



BOMBARDIER REGIO 2N



BOMBARDIER FLEXITY II
Australia



STADLER GIRUNO EC250

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