LEONARDO

Electronics

Helicopters

Aircraft

Cyber & Security

Space

Unmanned Systems

Aerostructures

HPRD – High Pressure Repair Dome

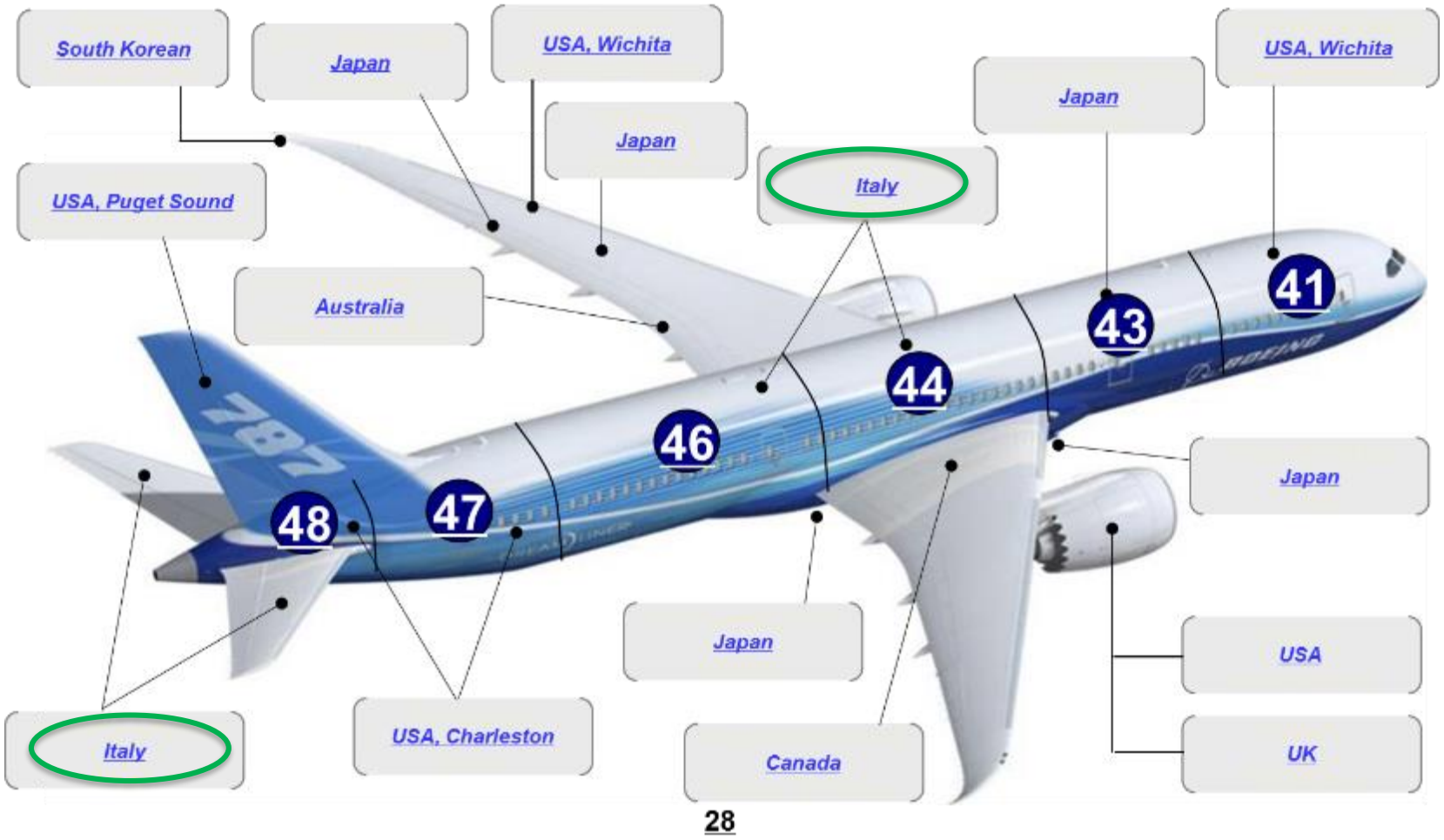
Maggio 2023

Leonardo Aerostructures

Manufacturing of big structural aircraft component (composite or metal) for biggest European and American programs:

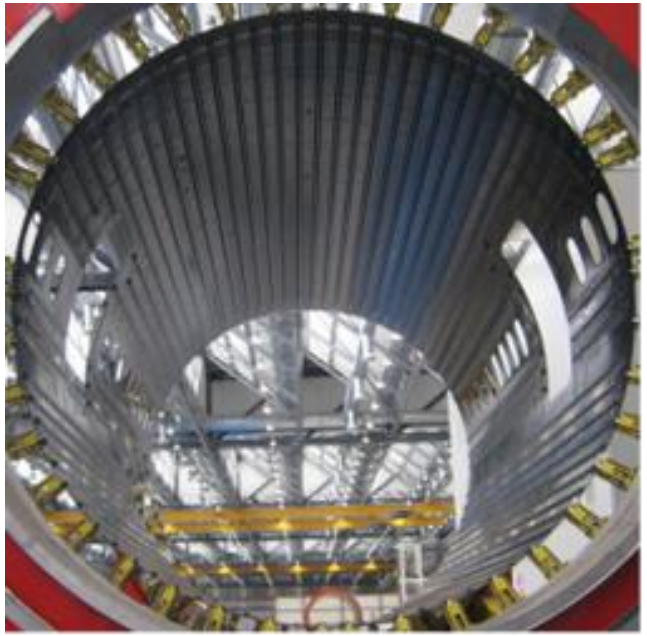
- **Boeing**, 787 Dreamliner, 767 e 777.
- **Airbus**, A380, A320 e A321.
- **ATR** (with ATR consortium), fuselage and impennage.
- **Bombardier** C-Series
- **Lockeed-Martin**
- **EFA**

Leonardo Package on 787 Dreamliner



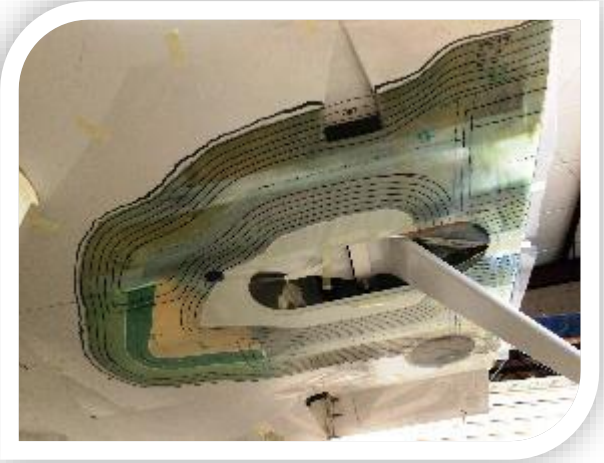
One Piece Barrel

- Leonardo produce 2 section of fuselage of 787 with the «One Piece Barrel» Technology.
- This means that an entire section of fuselage (more than 10 meters long) with stringers becomes after cure a unique composite piece.
- Damages can occur during production process and during service and advanced repair tecnique need to be developed
- Horizontal Stabilizer too, is manufactured in one piece technology



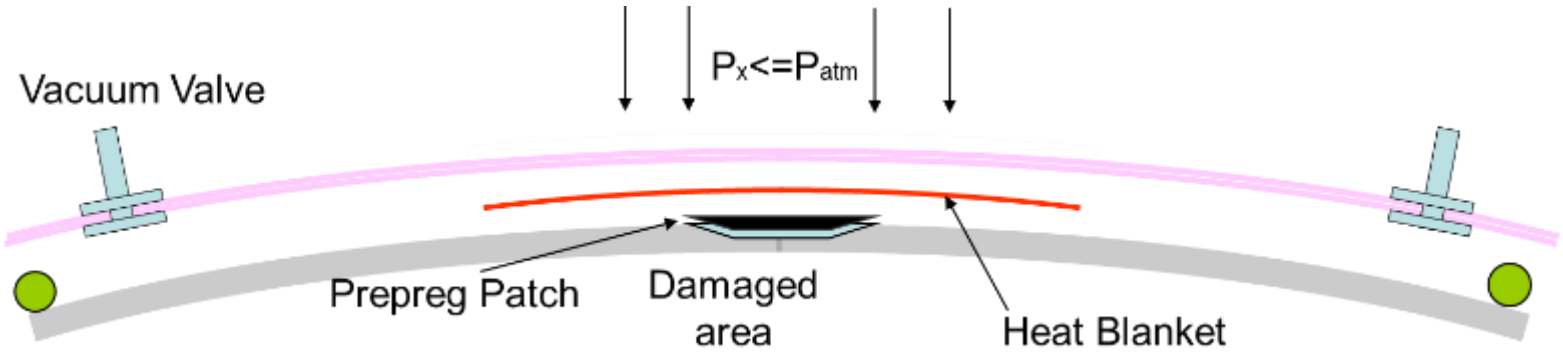
Introduction

- Aircraft structures require regular inspections, with established not-destructive procedures, in order to ensure the structural integrity, efficiency and safety
- If a defect is detected, the repair is often the most economic suitable choice, especially for large, complex and thus expensive structures. (with 3 days of rework is possible to save a part with a cost of more than a million of dollars)
- The objective of structural composite repair techniques is to restore as much as possible the original strength and stiffness of a damaged component.
- Bonded or co-cured composite scarf repairs are generally preferred respect to bolted ones due to the higher possibility of applicability and to a better efficiency of this technique



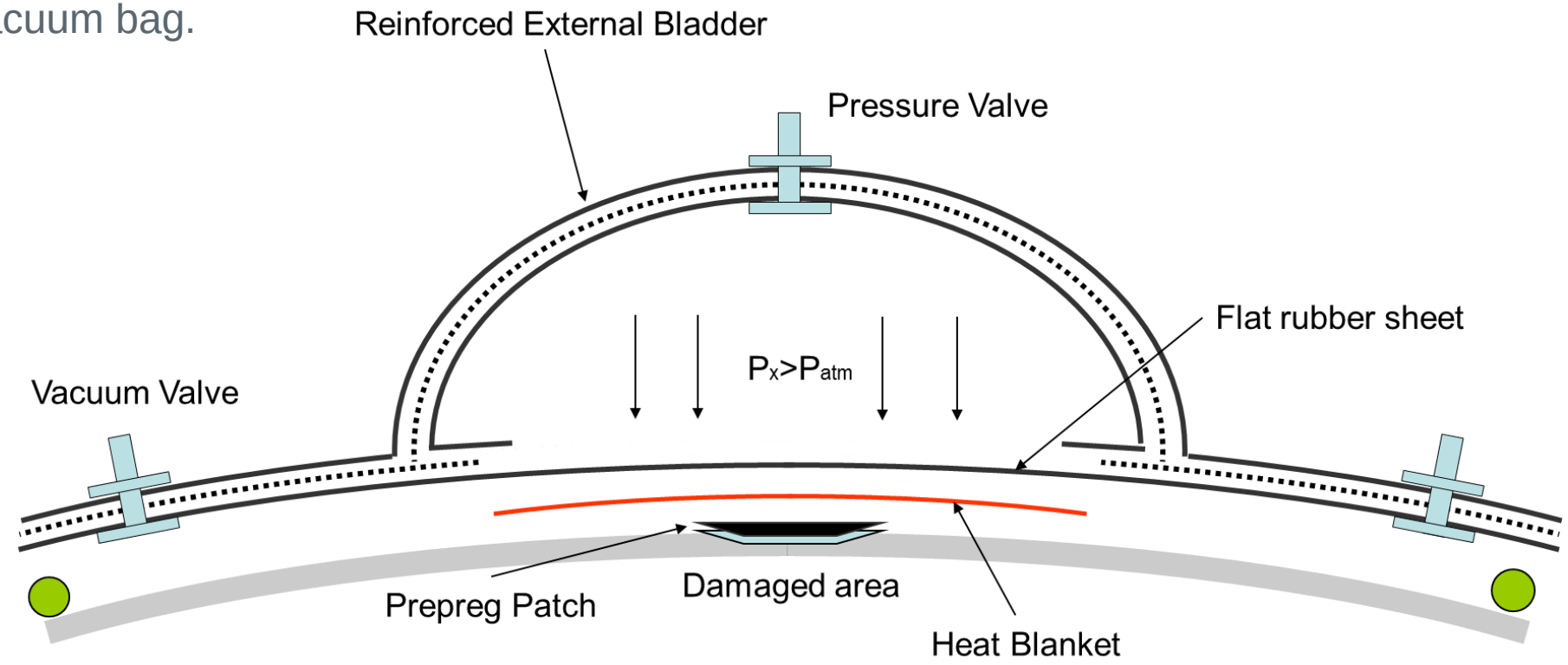
Actual Repair Process

- Actual Repair process use a vacuum bag to apply pressure to co-cure or cobond a prepreg patch to a scarfed damaged area
- Maximum applied pressure could be Atmospheric Pressure Px<=Patm
- The patch will be heated and consolidated using a heat blanket or a heat source like an IR lamp
- Due to low pressure, actual Repair process generate some failure (porosity, delamination, bond line porosity, bond line delamination) that can lead to a repetition of the repair



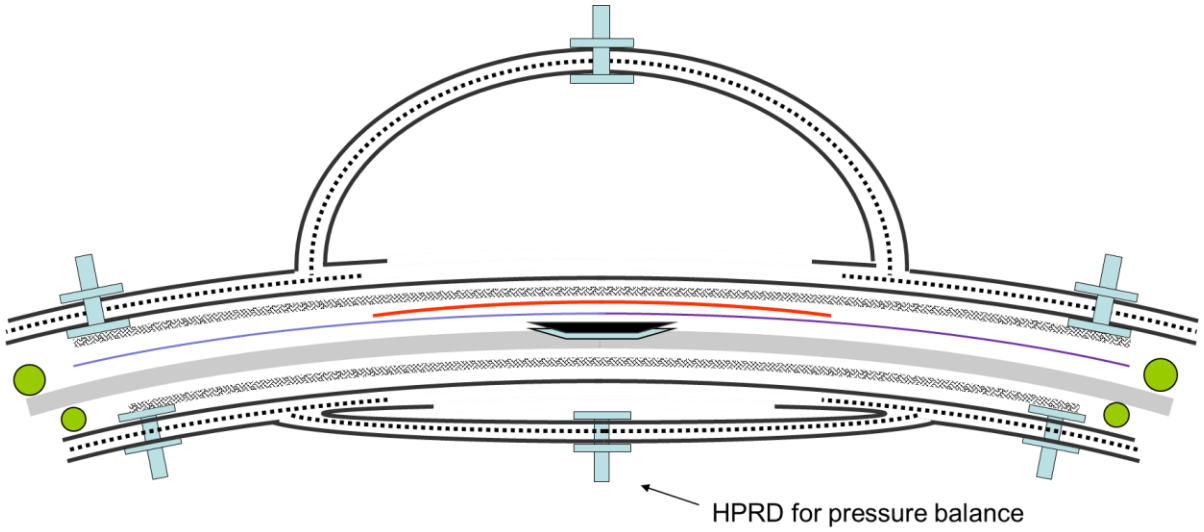
Description of HPRD

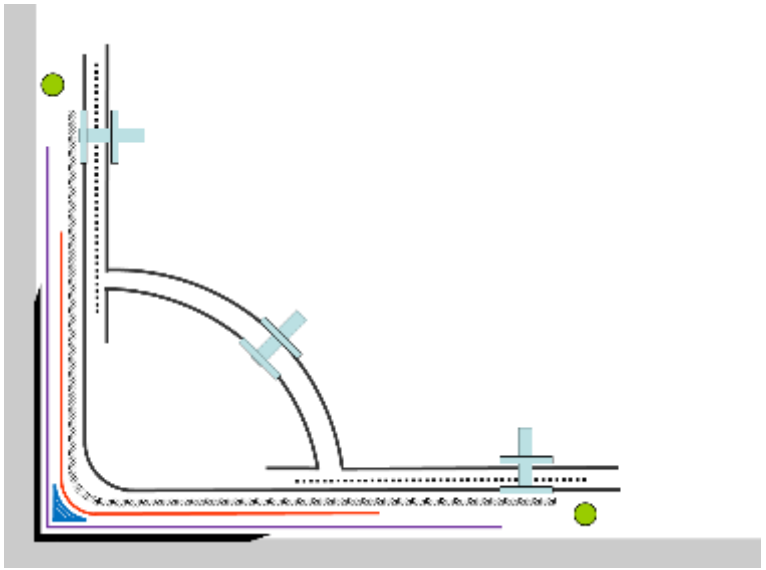
- HPRD consists of a flat rubber sheet integrated with a reinforced external bladder.
- The flat sheet is hold in place by the vacuum, applied trough Vacuum Valves connected as reported in Figure below. An higher pressure Px (up to 3 bar) can be achieved insufflating air inside the bladder trough the pressure valve. The flat rubber sheet is wider than the dome to balance the pressure inside and avoid the swell of the vacuum bag.



Description of HPRD

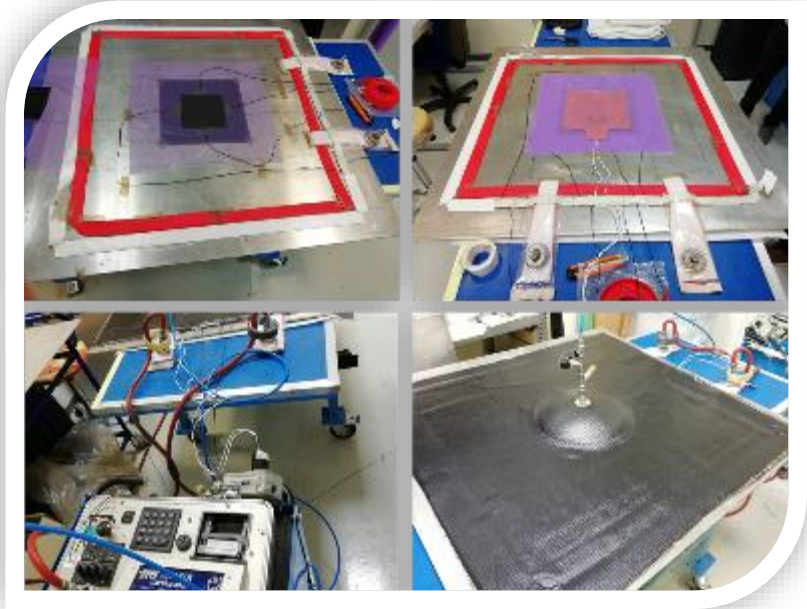
- When required, in order to minimize the deformation of the structure (for example for repair of thin skins or large structures), a similar system for pressure compensation can be applied on the other side of the structure.
- HPRD could be also applied on contured Shape



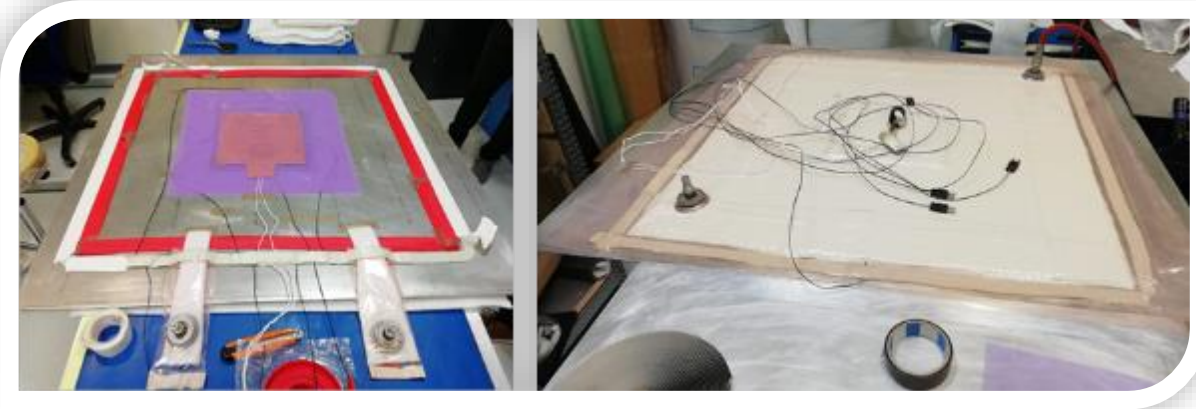


Validation Tests

- In order to validate the described technology composite laminates were consolidated using:
  - HPRD
  - autoclave (reference process)
  - vacuum bag (state of the art for repair, maximum pressure applied atmospheric pressure).



View of the HPRD process used to produce test laminates



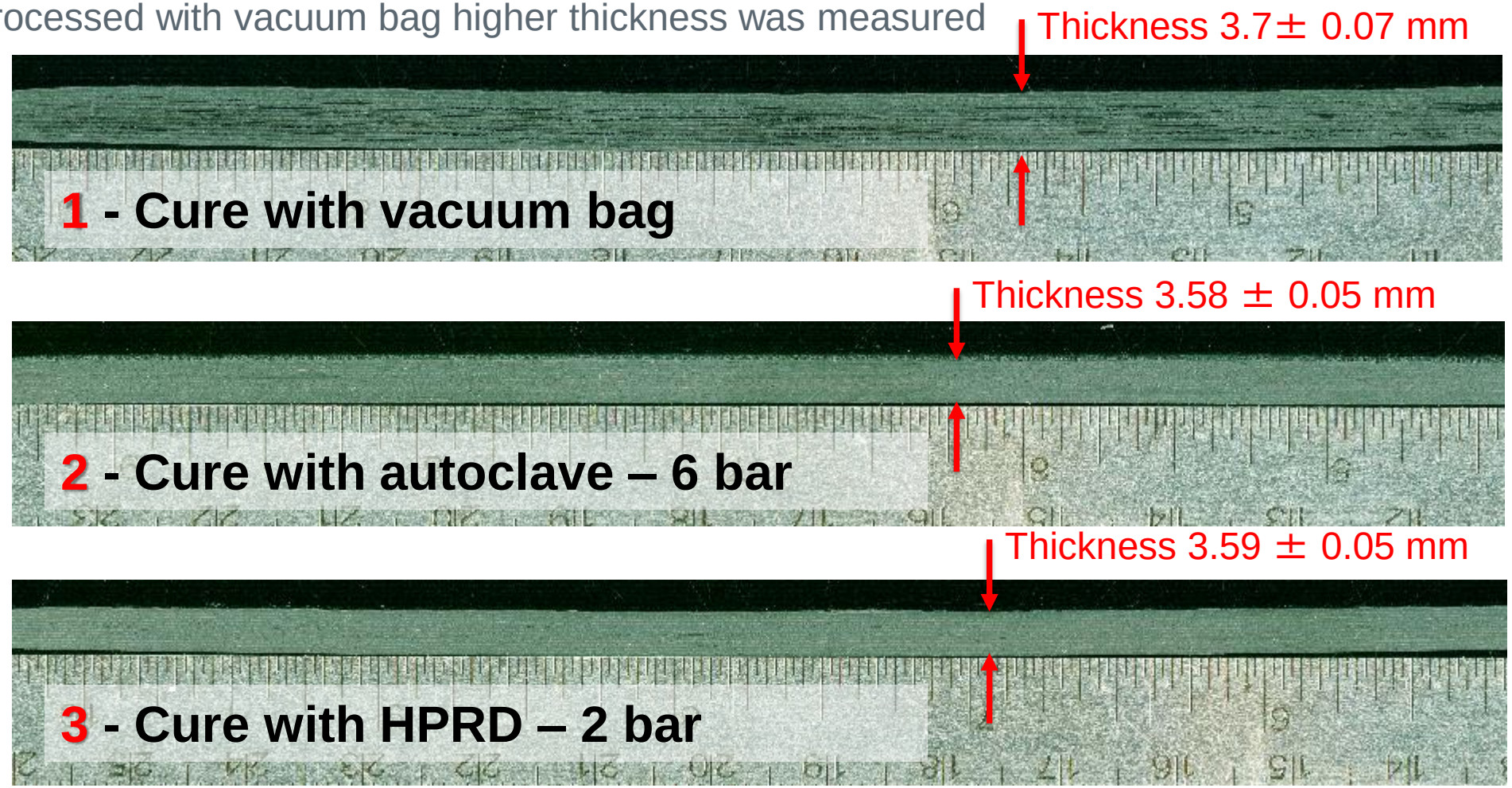
View of the vacuum process used to produce test laminates for comparison

Results

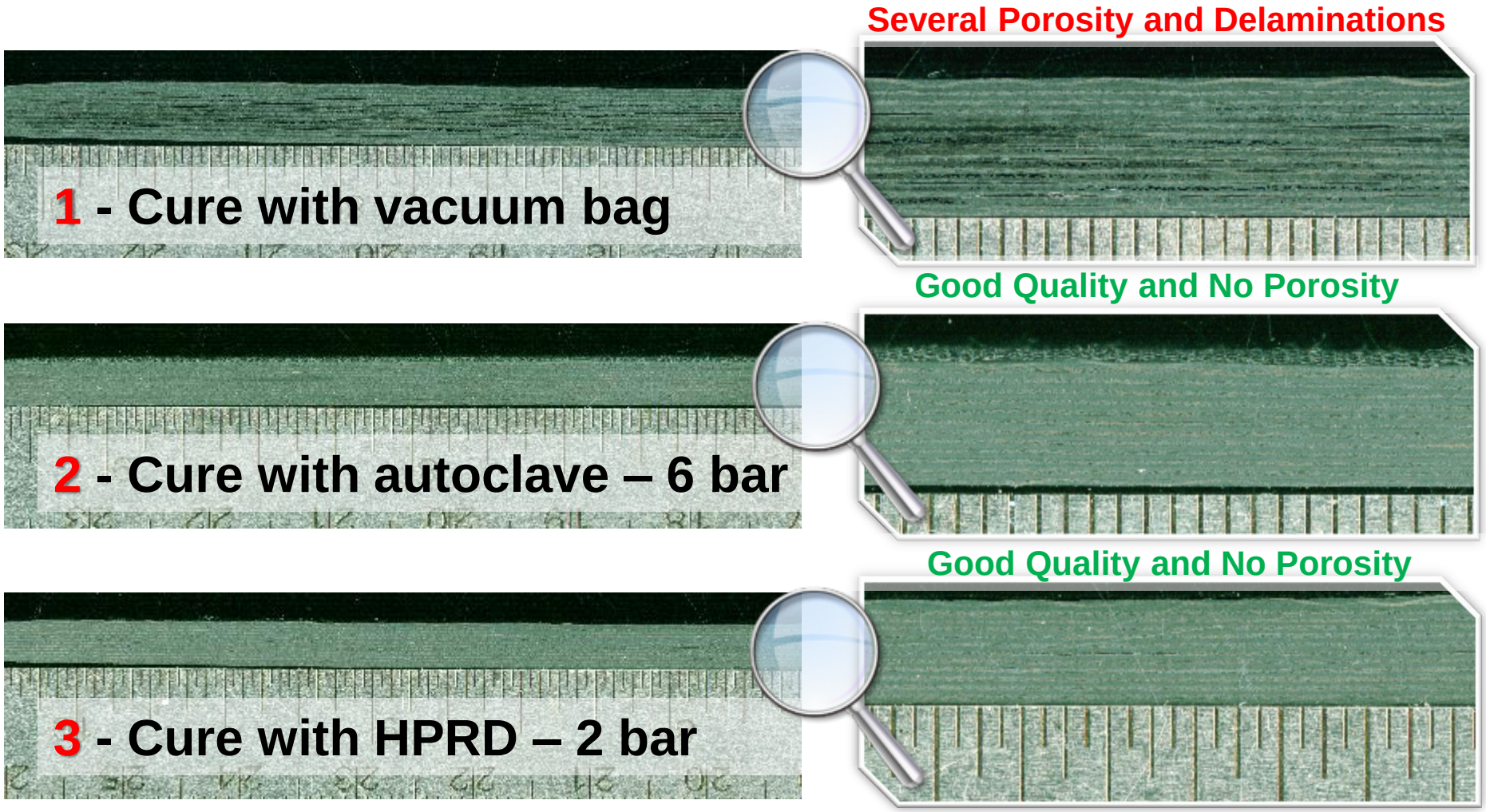
- In order to compare the laminates produced with different processes were carried out on the panels:
- thickness measurements
- optical microscopy
- Ultrasonic inspections
- Mechanical tests (short beam test ILSS)

Results - Thickness

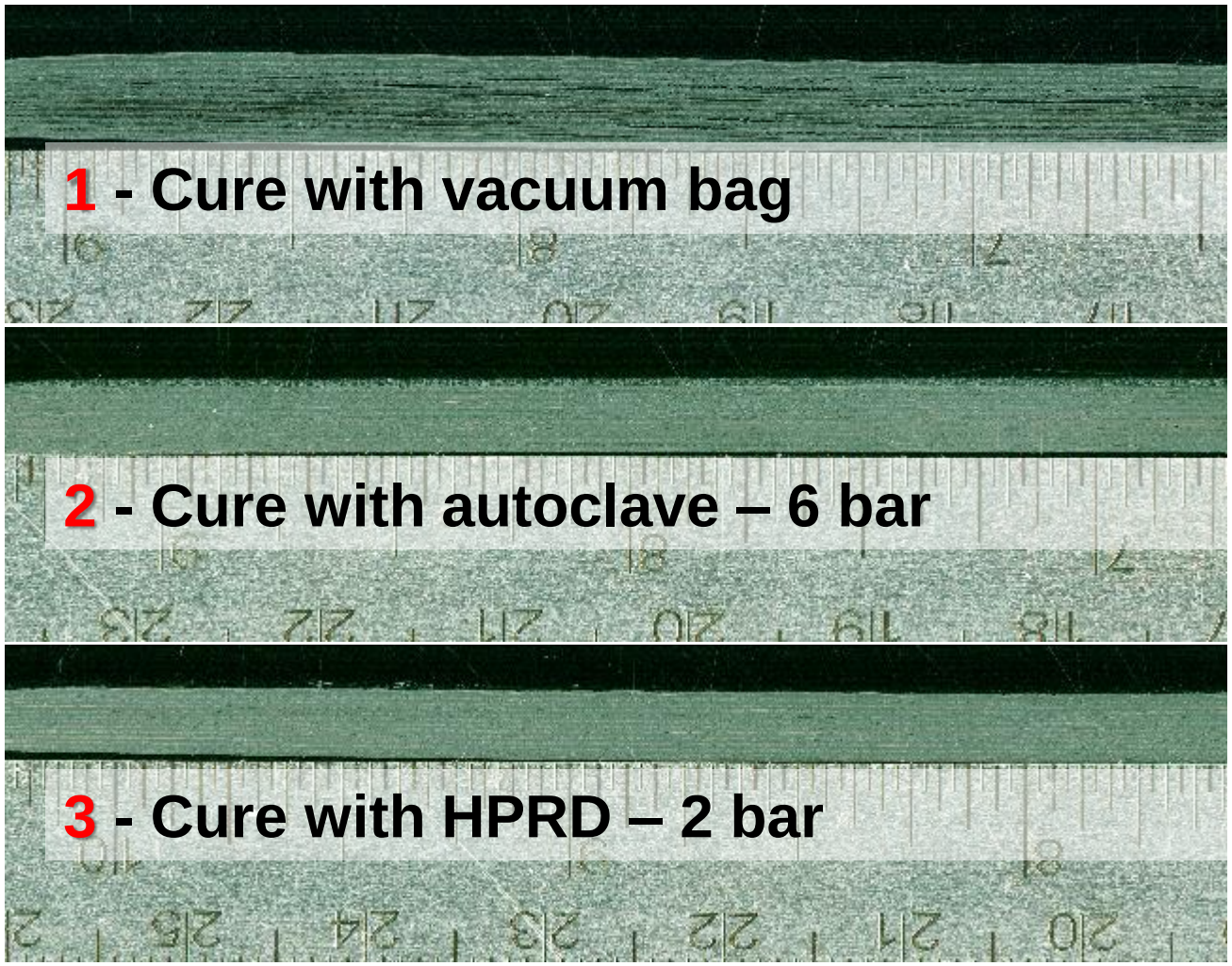
- The thickness measured for HPRD panels is comparable with the thickness of autoclave panels. Instead for the panel processed with vacuum bag higher thickness was measured

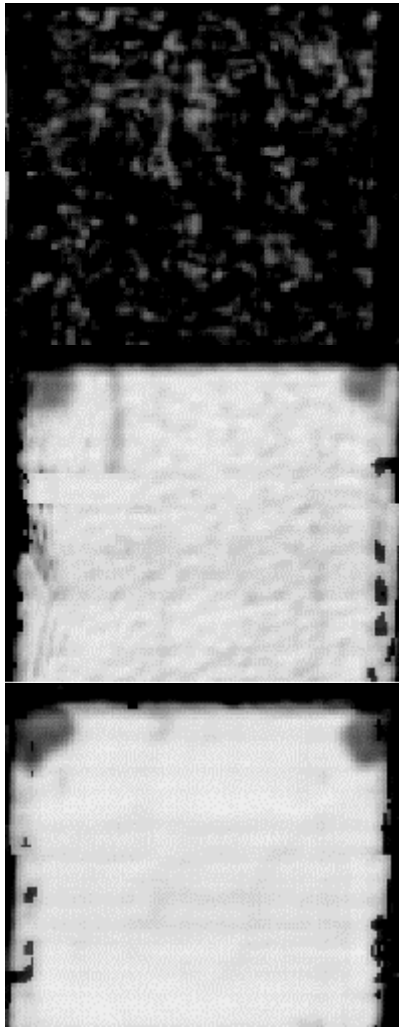


Results - Micrography



Results – Ultrasonic Inspection





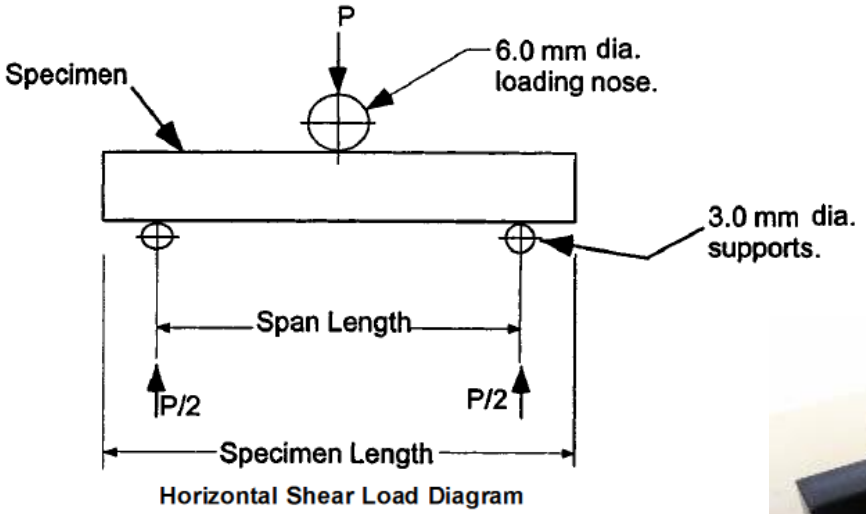
Diffuse porosity
> than 6%

No porosity.
Noise is due to surface breather mark-off

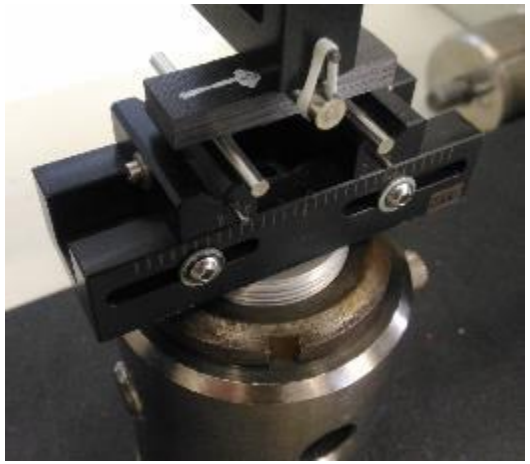
No porosity.

Results – Short Beam Test

- Short Beam Test was used to evaluate interlaminar shear strenght. The data can be used for research and development purposes concerned with interply strength and in this case was very useful to compare composite materials cured with different processes.

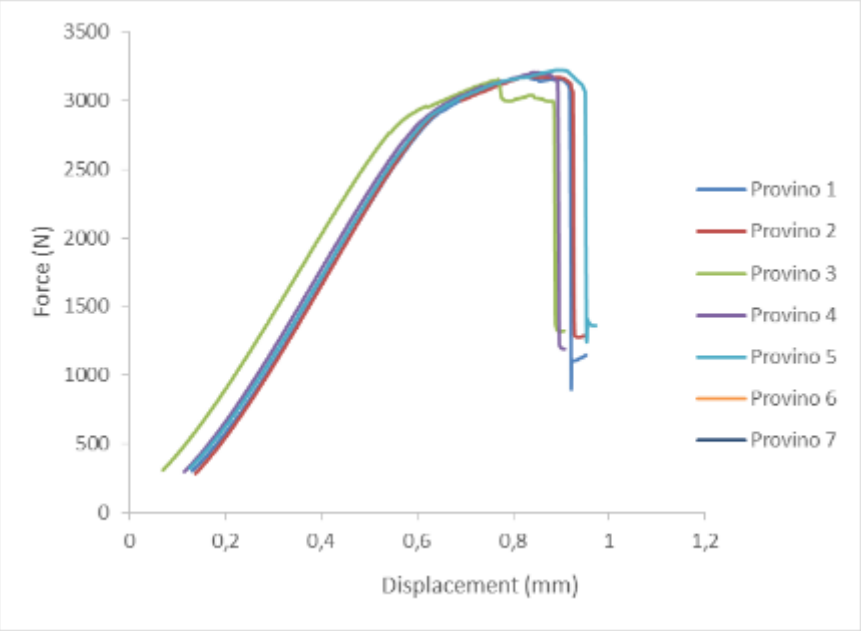


Horizontal Shear Load Diagram



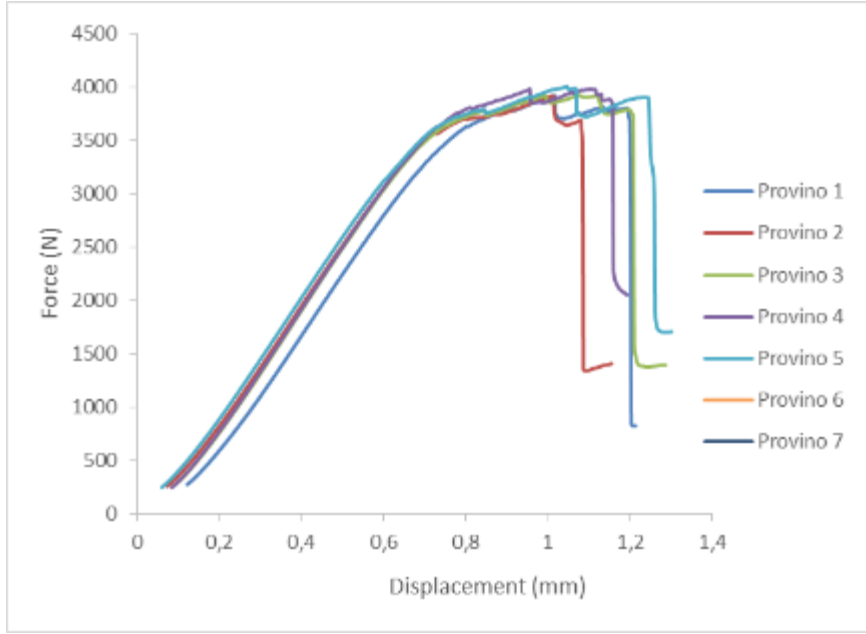
Results – Short Beam Shear Test

Cure with autoclave – 6 bar



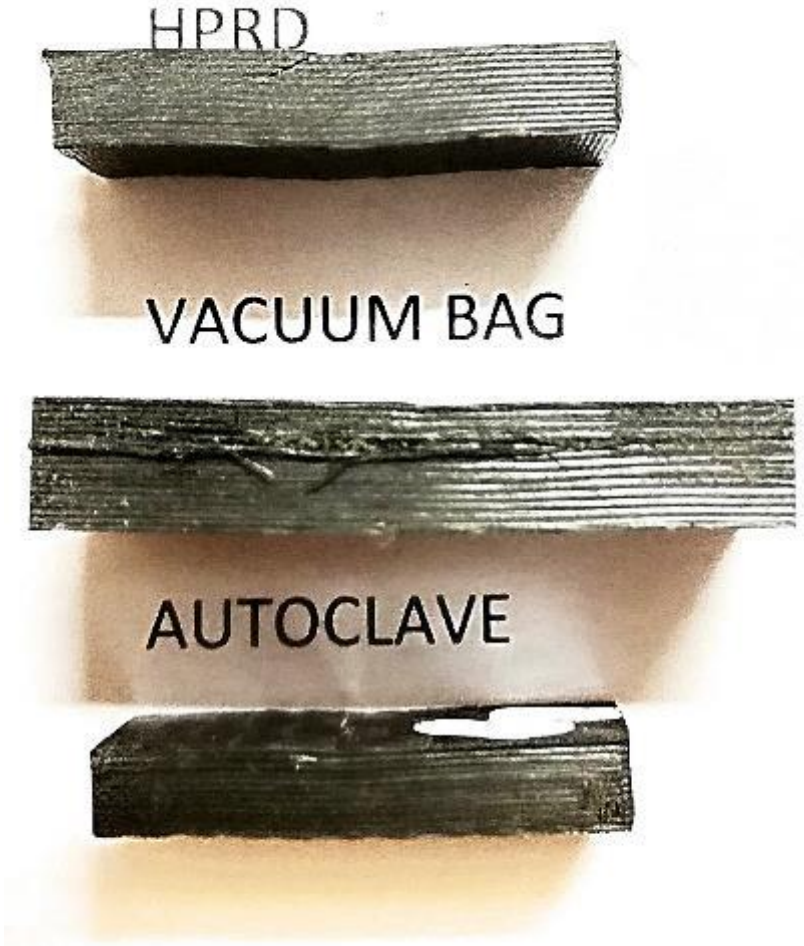
AUTOCLAVE	Average	dev.st	$CV_{\%}$
ILSS (MPa)	67,40	0,52	0,77%

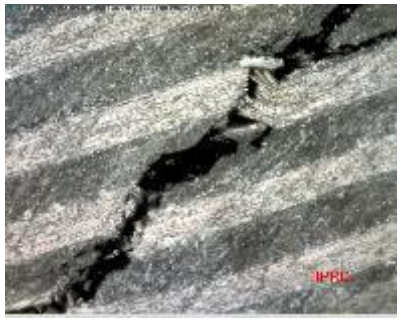
Cure with HPRD – 2 bar



HPRD	Average	dev.st	$CV_{\%}$
ILSS (MPa)	73,71	1,07	1,46%

Results – Short Beam Shear Test





Conclusions

- The results previously shown demonstrate the good performance of the composite panel processed with HPRD technology, comparable with the properties of autoclave cured composite.
- Low void level was detected with macrography and NDI inspections for HPRD panel, comparable with autoclave panel.
- Instead, the panel processed with simple vacuum bag, and so with a maximum consolidation pressure of 1bar, shows properties significantly lower (high void and delamination content).
- Short beam tests demonstrate that mechanical properties too are comparable between HPRD and autoclave cure.
- **An industrialized prototype with stable and repetitive result need to be developed to support process qualification**

Richieste

Leonardo garantisce:

- il supporto tecnico per l'industrializzazione del prototipo
- Il testing dei prototipi

Leonardo chiede:

- la realizzazione di almeno un prototipo in gomma rinforzata per alta temperatura
- Definizione di un processo produttivo

CONTACTS

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THANK **YOU**
FOR YOUR ATTENTION

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