

Joining of Thermoplastic Composite Materials

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Key design drivers for the introduction of new technology on the A340-500/600

Reduce structural weight of aircraft

- Improve durability of composite components
- Reduce manufacturing lead-times
- Achieve all of above without incurring cost penalty

Requirements which have to be met:

- All materials and processes used on aircraft must be qualified to the appropriate standards
- Design allowables must be generated to support stress calculations
- Components must be subjected to certification tests to demonstrate their ability to meet Airworthiness Authorities' requirements

Some of the challenges of using thermoplastic composites

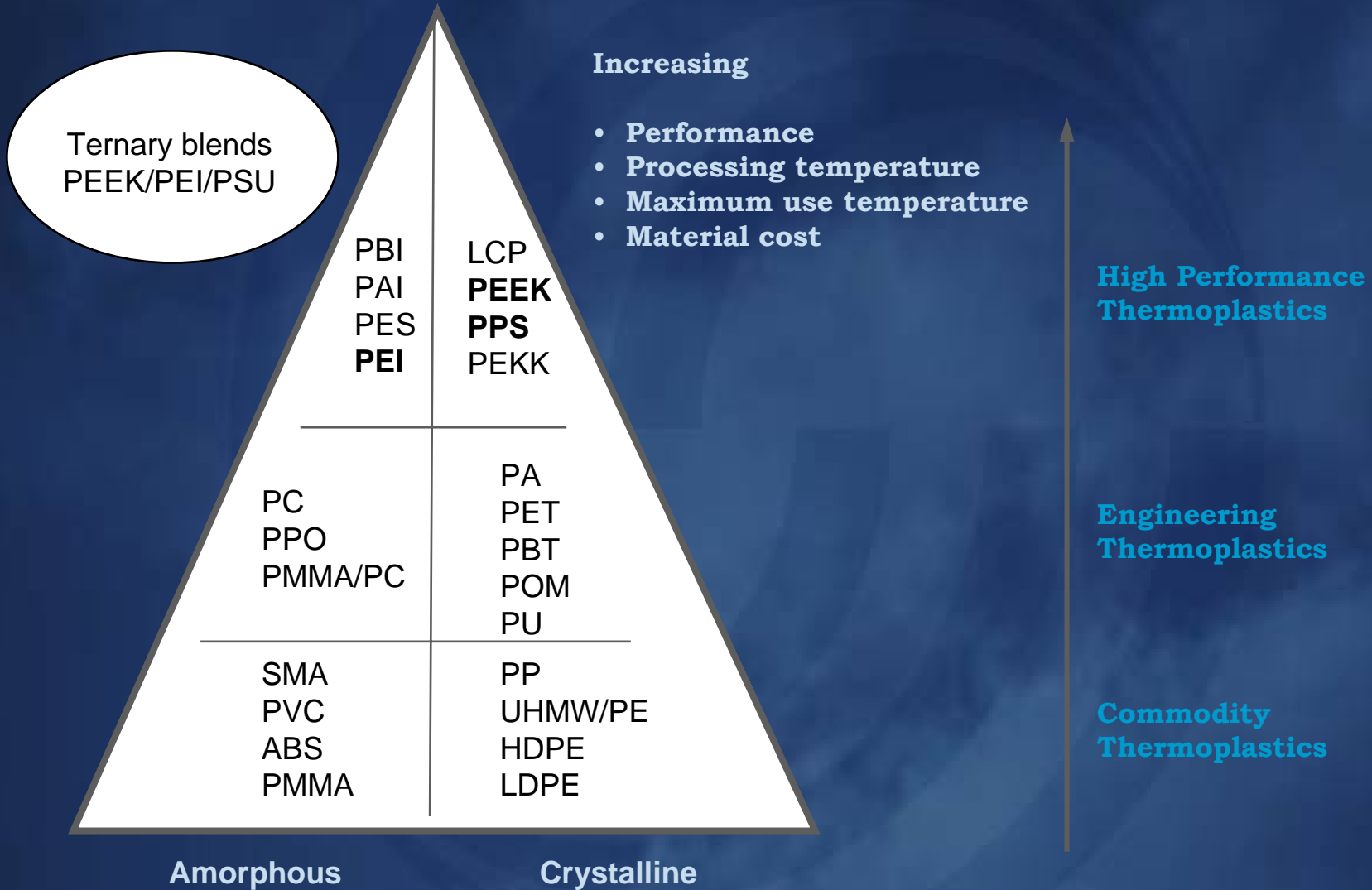
- High processing temperatures require special foils and consumable materials. These in themselves tend to be less flexible than those used traditionally
- For PPS inert atmospheres are required during autoclave consolidation cycles
- Tooling must be dimensionally stable and be capable of repeated thermal cycling at temperatures up to 350°C
- Thermal effects such as spring forward are exaggerated and must be considered in the design and tooling phases of the project
- High performance semi-crystalline thermoplastic matrix systems tend to be very stable chemically and may need special surface treatments to promote paint and bonding adhesion.

Thermoplastic Materials

Thermoplastics have all the advantages of thermosets (strength, stiffness, low weight, corrosion resistance, part count reduction, design flexibility etc), with the additional benefits of:

- **unlimited storage life, with no need for refrigeration**
- **faster cycle times**
- **superior toughness**
- **improved FST performances**
- **weldability**
- **recyclable**

Classification of Thermoplastic Materials



Classification of Thermoplastic Materials

The engineering thermoplastic materials employed by Airbus are :-

Amorphous

- PEI (polyetherimide)

Excellent mechanical properties but limited chemical resistance.

Used extensively in cabin due to excellent FST properties

Semi-crystalline

- PPS (polyphenylene sulphide)
- PEEK (polyetherether ketone)

Excellent mechanical properties and excellent resistance to solvents, Skydrol etc.

Used extensively on A340-600 and A380

NOTE: Semi-crystalline materials such as PPS and PEEK are very difficult to adhesively bond due to the inert nature of the material and low surface energy

Welding

There are many methods used to weld thermoplastics,

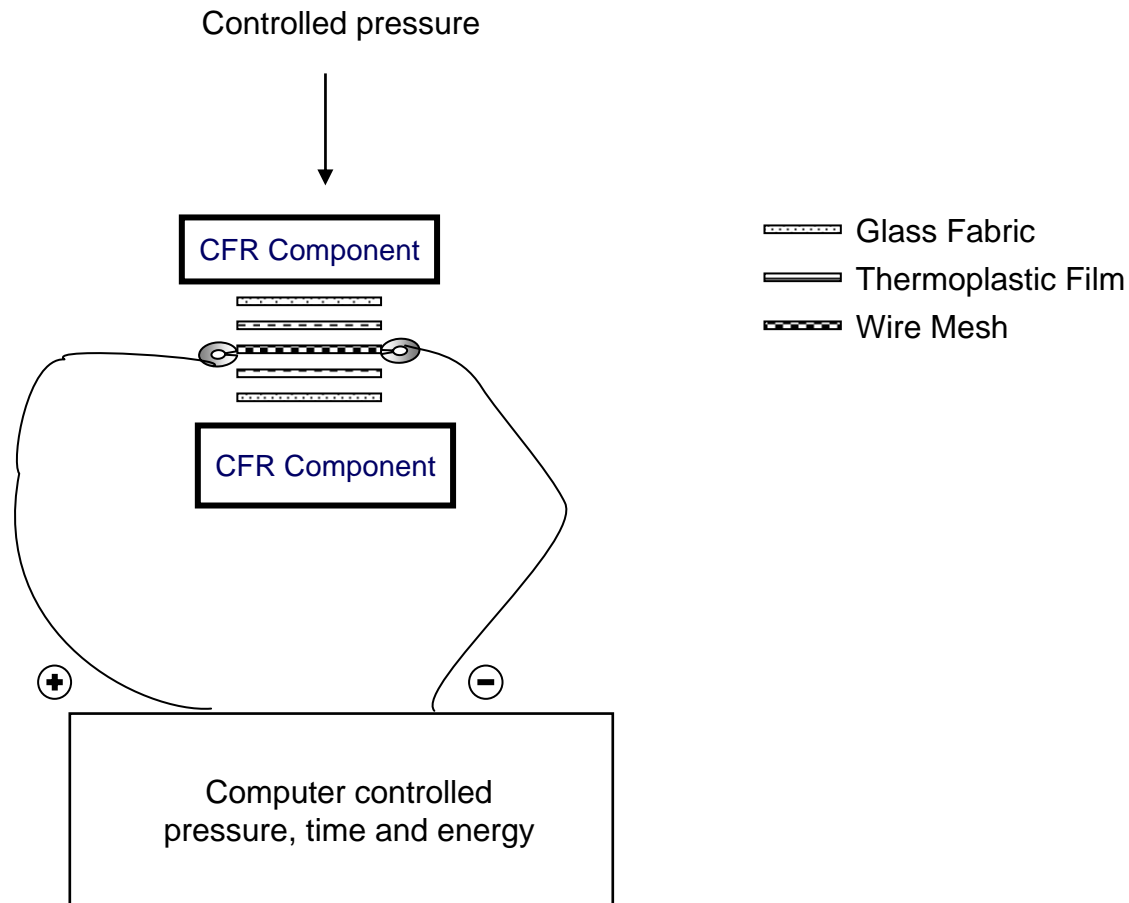
- External heat sources, such as hot plate, flame and lasers
- Friction, such as spin welding, ultrasonic
- Induction welding
- Resistive, such as metallic implant wire or tape or carbon tape

AIRBUS EXPERIENCE

Resistive welding of glass reinforced PPS for the A340-600 J Nose

Carbon implant (resistive and inductive) welding development is being conducted.

Schematic of resistance welding



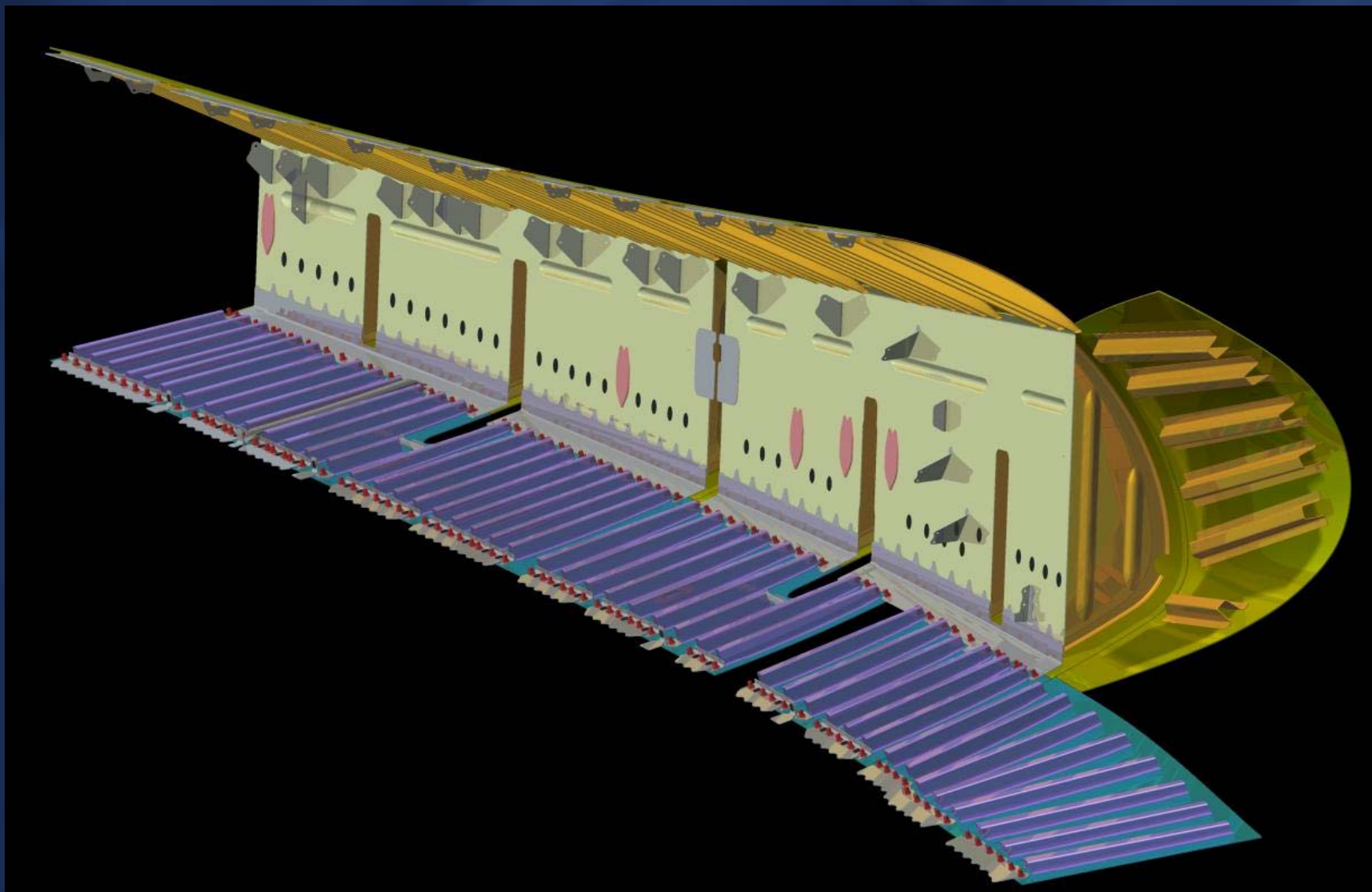
Resistance welding of A340-600 J Nose riblets



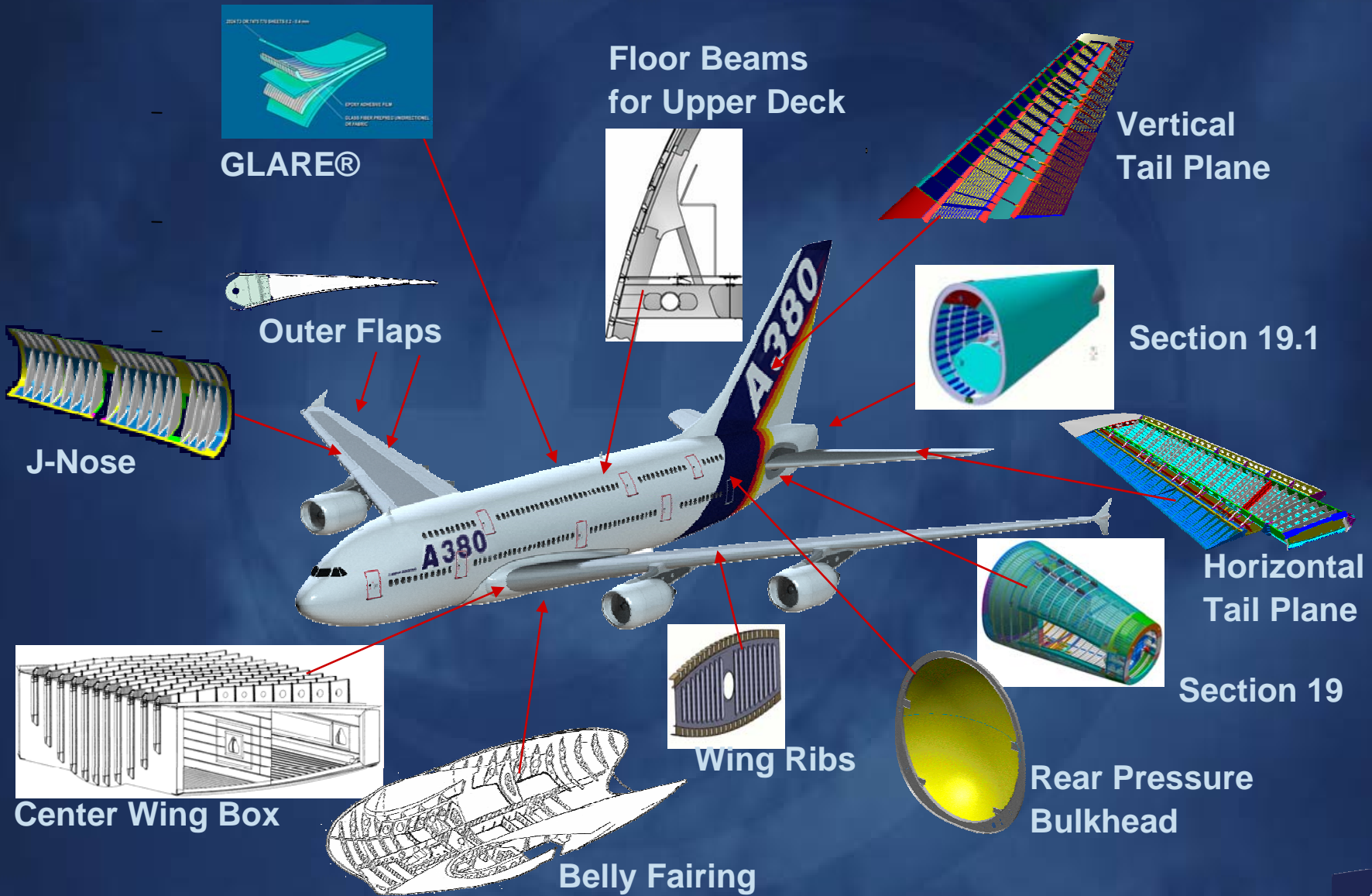
Installation of thermoplastic J Nose leading edge on to wing



Details of the welded J-nose assemblies



Potential applications for A380



Adhesive Bonding – Semi-crystalline Thermoplastics

- Work carried out at Airbus on PPS

Surface preparation

- Alumina blasting
- Corona discharge
- Flame treatment
- Adhesion promoters

Adhesives

- Two part epoxy EA 9394
- Two part polyurethane SW 7838
- Epoxy film adhesive AF 163

None of the adhesives/surface treatments produced results which met the minimum hot/wet lap shear design requirements of 1000psi

Today no adhesive bonding techniques are approved for manufacture and repair of semi-crystalline thermoplastics

Bonding – Amorphous Thermoplastics

Amorphous thermoplastics such as PEI can be satisfactorily adhesively bonded using conventional adhesive systems

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