Methods and Materials for Improving Cosmetic Finishes

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Methods and Materials for Improving Cosmetic Finishes

- Shrinkage of FRP Resins
  - Mechanisms for shrinkage
  - Stress-free temperature
  - Effect of shrinkage on cosmetics
  - Methods to isolate shrinkage
- Methods and Materials for Improving Cosmetics
  - Vinyl ester barrier coats
  - Other methods

Cosmetic Quality of FRP

- The Consumer's Expectations
- Automotive/Marine Type Finishes Have Become the Goal in FRP Manufacturing

The Cost of Print and Distortion

- Rework, air-filing, block sanding, fairing, post-finishing, repairs, QC work, rejects, buffing, patching, re-sprays, P.I.

Cosmetic Standards Are Largely Subjective

- Beauty is in the eye of the beholder
- Variance in customer expectations

Defining Cosmetic Quality

- Cosmetic surface flaws go by many different names: *Print-though, distortion, heat lines, orange peel, dimples, waviness, glass print, wrinkles, pock marks, puckered, poor profile, glass pattern, balsa print, woven roving checks, rough surface, heat distortion*
- All of these terms describe a visible flaw in the smoothness of the surface of a finished fiberglass part.
- These flaws are usually only cosmetic in nature and rarely disrupt the underlying structure integrity.

Defining Cosmetic Quality

- There are various types of surface distortions that are caused by different mechanisms. While not all types can be neatly classified, all print and distortion can be group grossly into two sets:

- Small-term distortion (< 0.5 mm)
- Long-term distortion (> 0.5 mm)

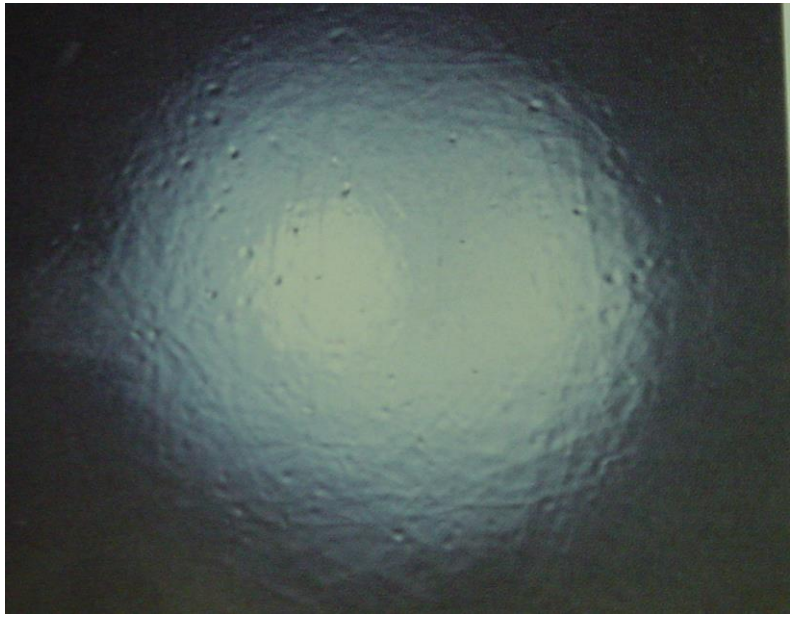
Defining Cosmetic Quality

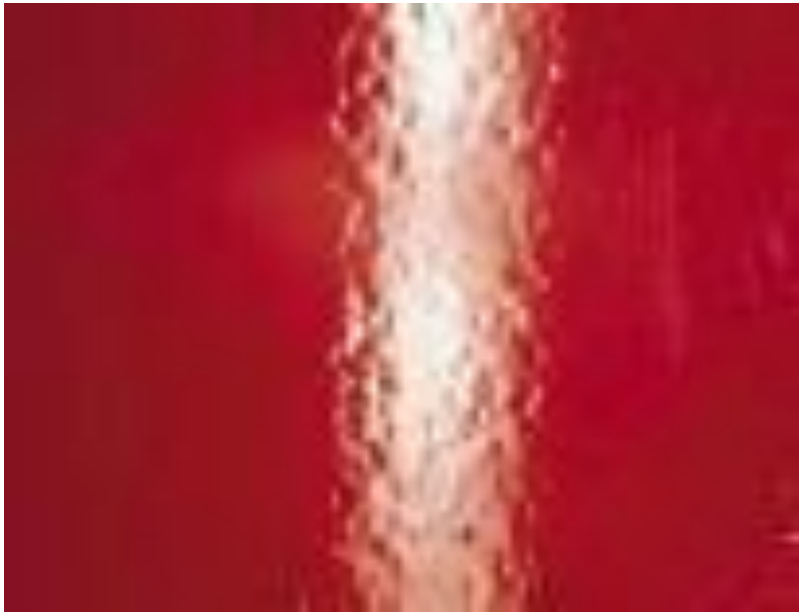
- **Small-term distortions** are on the size order with flaws (orange peel, fish eyes, etc.) in the coating film thickness (paint or gel coat)

- **Small-term distortions** show the individual fibers of the layer of reinforcement directly behind the film.

Types of Cosmetic Flaws

Examples of Small-Term Distortion





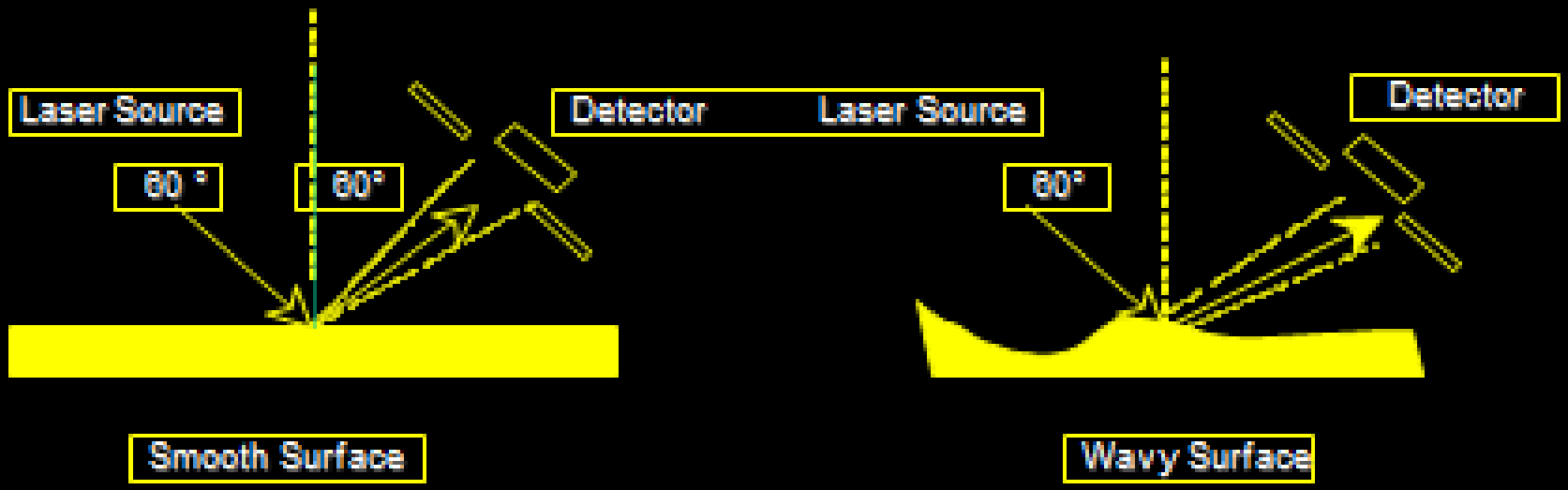
Defining Cosmetic Quality

- **Long-term distortions** are flaws that are larger in size and may even disrupt the surface enough to be felt.
- Larger flaws in application of the coating film, such as sag lines or curtaining are long-term distortions.
- Other common examples are the transfer of patterns of the reinforcing fabrics and cores to the surface.

Measuring Surface Profile

- Cosmetic surface quantified using
  - ❑Byk Gardner Wavescan Plus

Byk Gardner Wavescan Operation



Overall Rating Scale

- Range 0 to 10.5
- 0 wavy surface
- 10.5 smooth surface

Sources of Cosmetic Flaws

- Primary source for print is the **tooling**.
- Every flawed copy costs more than the tooling to fix.

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  - Methods to isolate shrinkage

- Methods and Materials for Improving Cosmetics
  - Vinyl ester barrier coats
  - Other methods

Shrinkage

- Unsaturated polyester resin shrinks when it cures
  - A part is slightly smaller than a mold due to:
    - ✓Cure shrinkage – in the mold
      - Amount depends on the resin, affects dimensions.
      - Some shrinkage is necessary for demolding.
    - ✓Cooling shrinkage – after exotherm
      - Amount depends on the stress-free temperature.
    - ✓Post-cure shrinkage – after de-mold
      - Amount depends on the unfinished cure.
      - Usually affects cosmetics, not dimensions.
    - ✓Glass and filler content effect the shrinkage

Stress-Free Temperature

- All items expand and contract with changes in temperature.
- Temperature changes cause stresses.
- The temperature at which the resin solidifies has no thermal stress, or the ***stress-free temperature.***

Laminate Thermal Stresses

- High exotherm causes high stress-free temperatures.
- High stress-free temperatures cause high thermal stresses when it cools to ambient temperature.
- Worst thermal case is outdoor winter storage.
- Low exotherm minimizes thermal stress.

Shrinkage

- All typical thermoset polymers shrink:
  - Gel coat always shrinks
  - Barrier coat always shrinks
  - Skin laminate always shrinks
  - Bulk laminate always shrinks
- Reinforced layers shrink less than un-reinforced layers.
- Differential shrinkage rates can result in warpage.

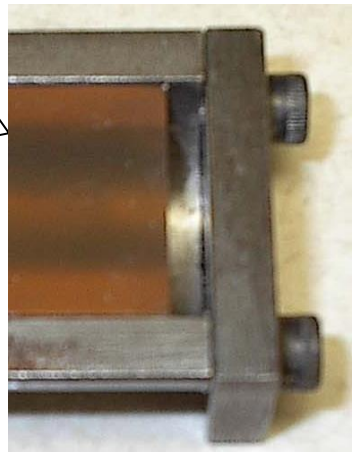
Conventional UPR

❑Linear Shrinkage

Linear Shrink Mold

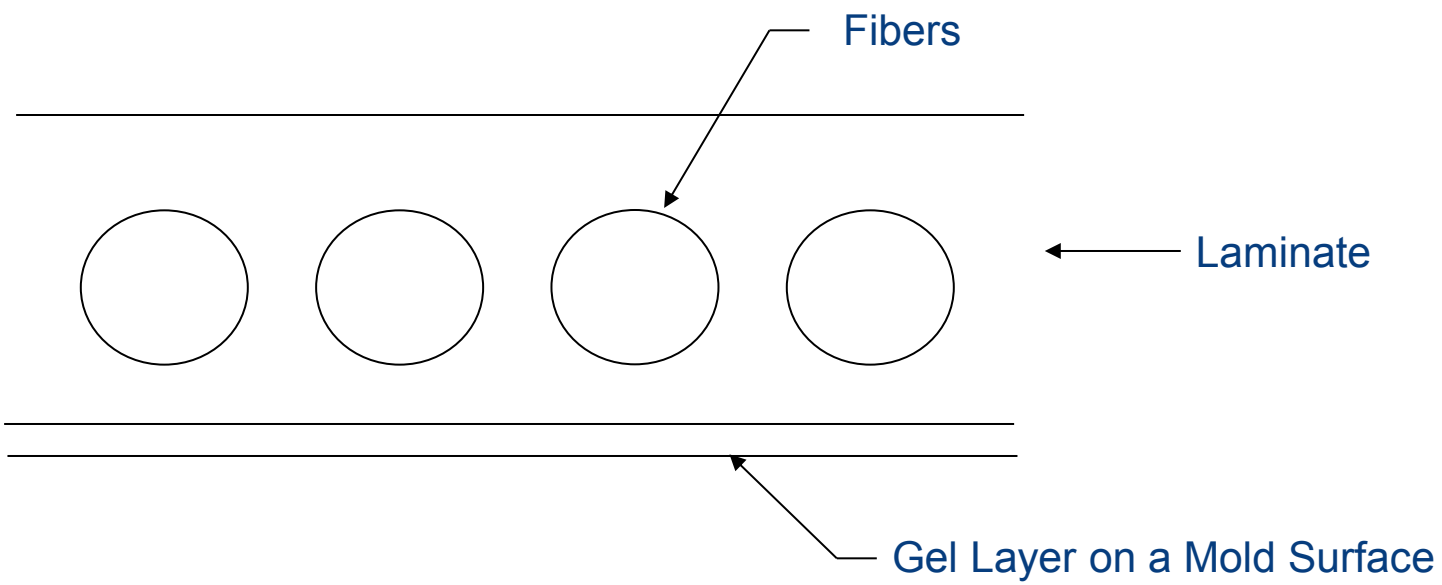
Linear Shrink Mold with Uncured Conventional UPR

Linear Shrink Mold with Cured Conventional UPR

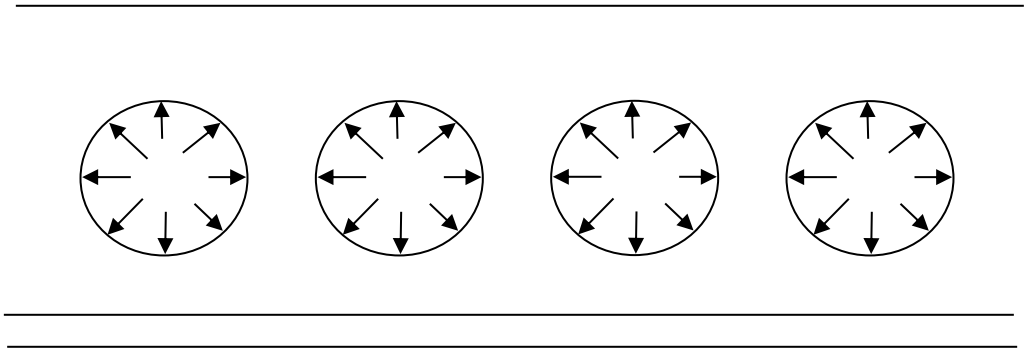


Conventional UPR has significant linear shrinkage.

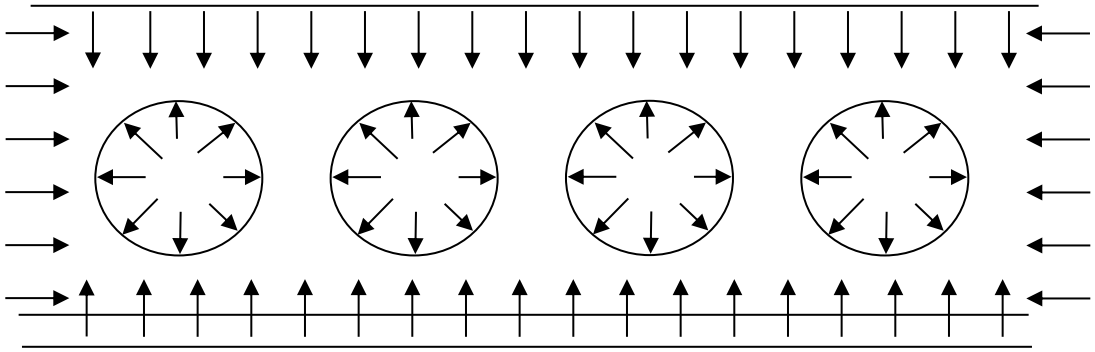
Idealized Laminate Description



Stiff Fibers Resist Being Compressed

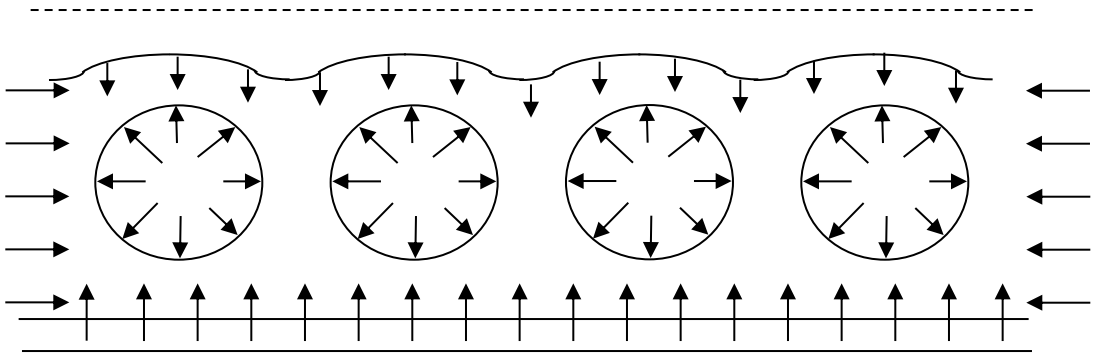


Laminate Shrinkage Begins



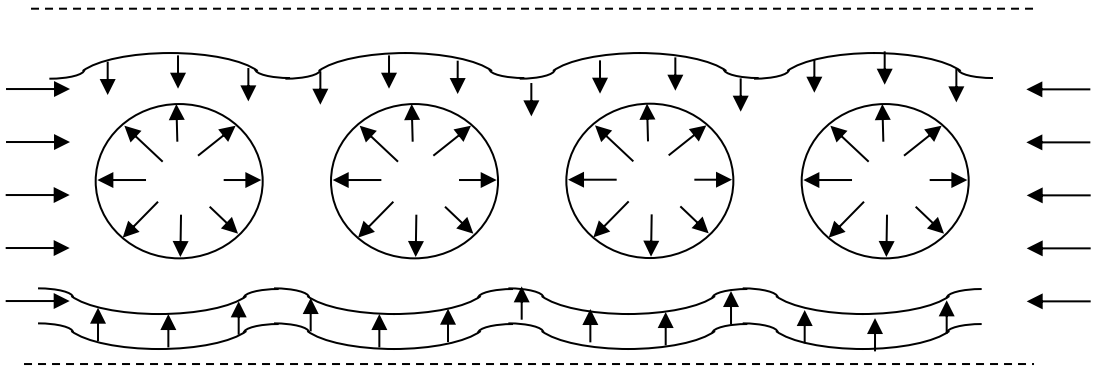
If the Gel Coat Stays in Contact with the Mold…

The shrinkage is driven to the back side.



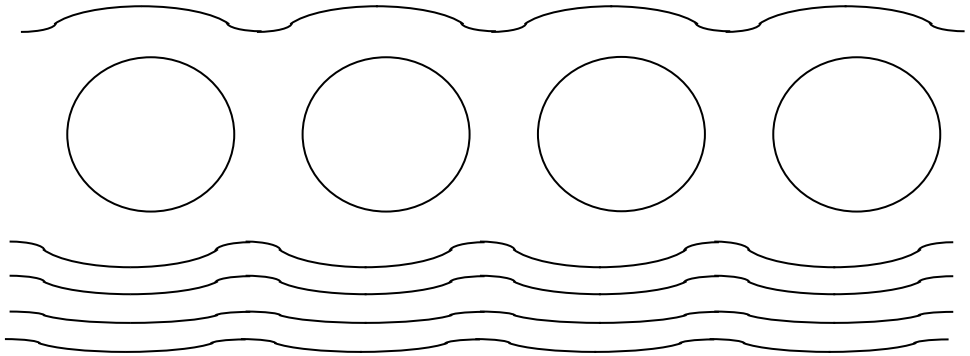
If Post Cure Shrinkage Occurs…
Or if the Gel Coat Softens…..

The shrinkage occurs on the front side, too



Thick Gel Coat or Barrier Coat Helps Smooth out the Surface…..

Barrier coats isolate the shrinkage from the surface



The Degree of Shrinkage Affects the Type Distortion

- Small amounts of shrinkage can give “distortion”.
- More shrinkage gives an apple sauce/orange peel texture.
- Even more and fiber bundles become visible.
- Up to and including the “*look*” of the weave.

Shrinkage Occurs:

- Because of Cure
  - In the mold
- Because of Post-cure after De-molding
  - When it wasn't finished curing
    - ✓Not enough heat
    - ✓Not enough catalyst and/or promoter
    - ✓Not enough time
- Because of Cooling from the Stress-Free Temperature
  - High exotherm is bad
- Because of Cure-Shrinkage Stress Relaxation
  - When you get close to the glass transition temperature
  - Happens even when fully cured

Minimizing Shrinkage

- Conventional UPR resin requires a long, slow cure.
  - Complete cure to avoid post-cure.
  - Low exotherm to minimize thermal stresses.
  - Thinner is better.

Isolate Gel Coat from Resin Shrinkage

- Barrier Coat - Applied like Gel Coat
  - Improves surface profile.
  - Decreases cycle time.
  - Adds material cost & HAP emissions.
  - Proper selection and application improves blister resistance.
  - Allows less expensive bulk resins to be used behind.

Isolate Gel Coat from Resin Shrinkage

- Skin Coat - Applied via spray-up or hand-lay up
  - Improves surface profile.
  - Resin determines blister resistance.
  - Proper selection and application improves blister resistance and structural integrity.
  - Allows less expensive bulk resins to be used behind.

Isolate Gel Coat from Resin Shrinkage

- CoreMat, Trivera, Veils
  - Improves surface profile.
  - Extra labor.
  - Not easily conformable.

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Isolate Gel Coat from Resin Shrinkage

❑ *For Long-Term Distortion:*

- Skin coats resins - Applied via spray-up or hand-lay up
- Sheet goods - Veils, CoreMat, Trivera, etc.

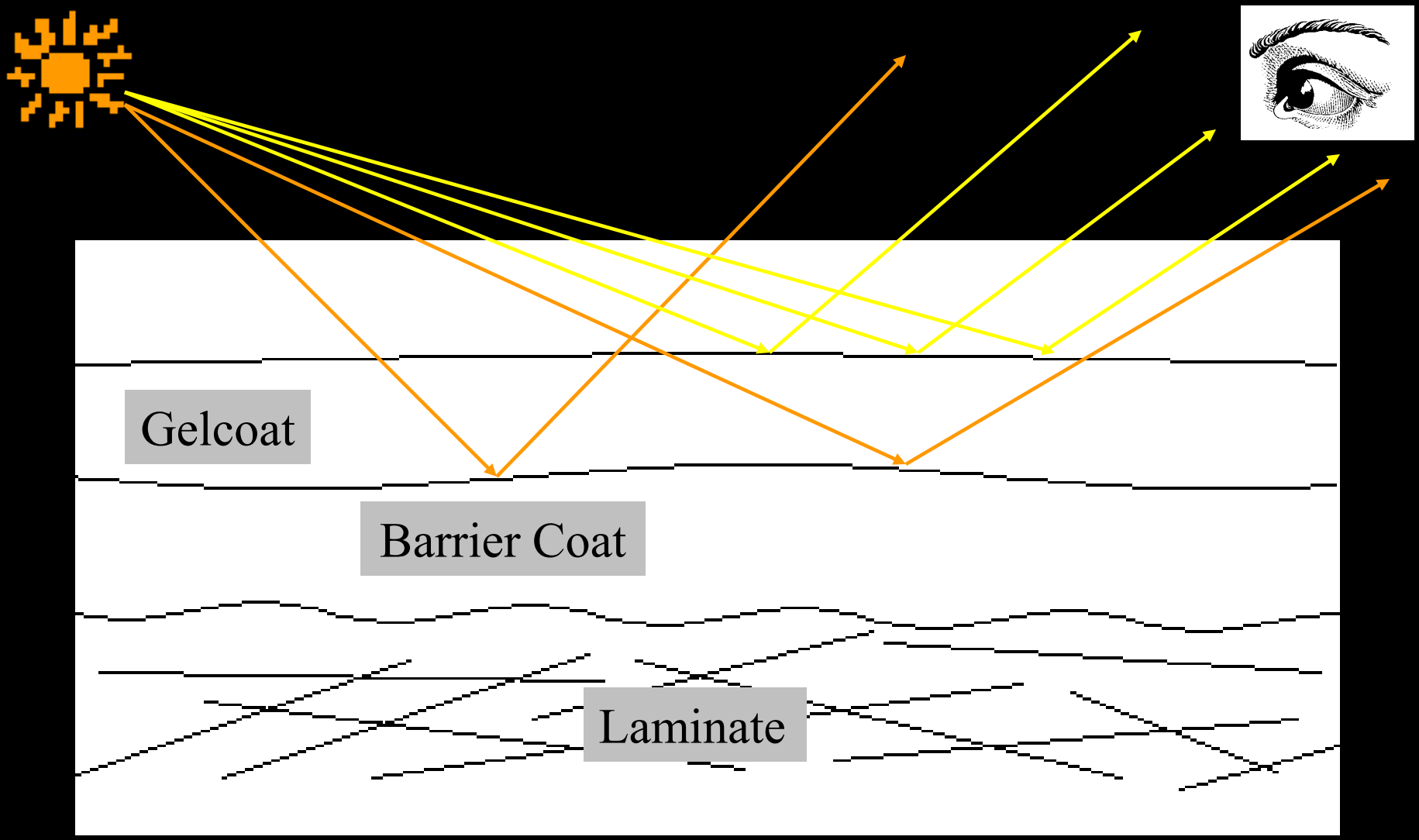
❑ *For Short-Term Distortion*:

- VE barrier coats

Reasons to Use Vinyl Ester Barrier Gel Coats

- Eliminates fiber print-through and distortion for smooth parts.
- Reduces osmotic blistering.
- Increased production rates…More parts per day.

How Barriers Improve Cosmetics



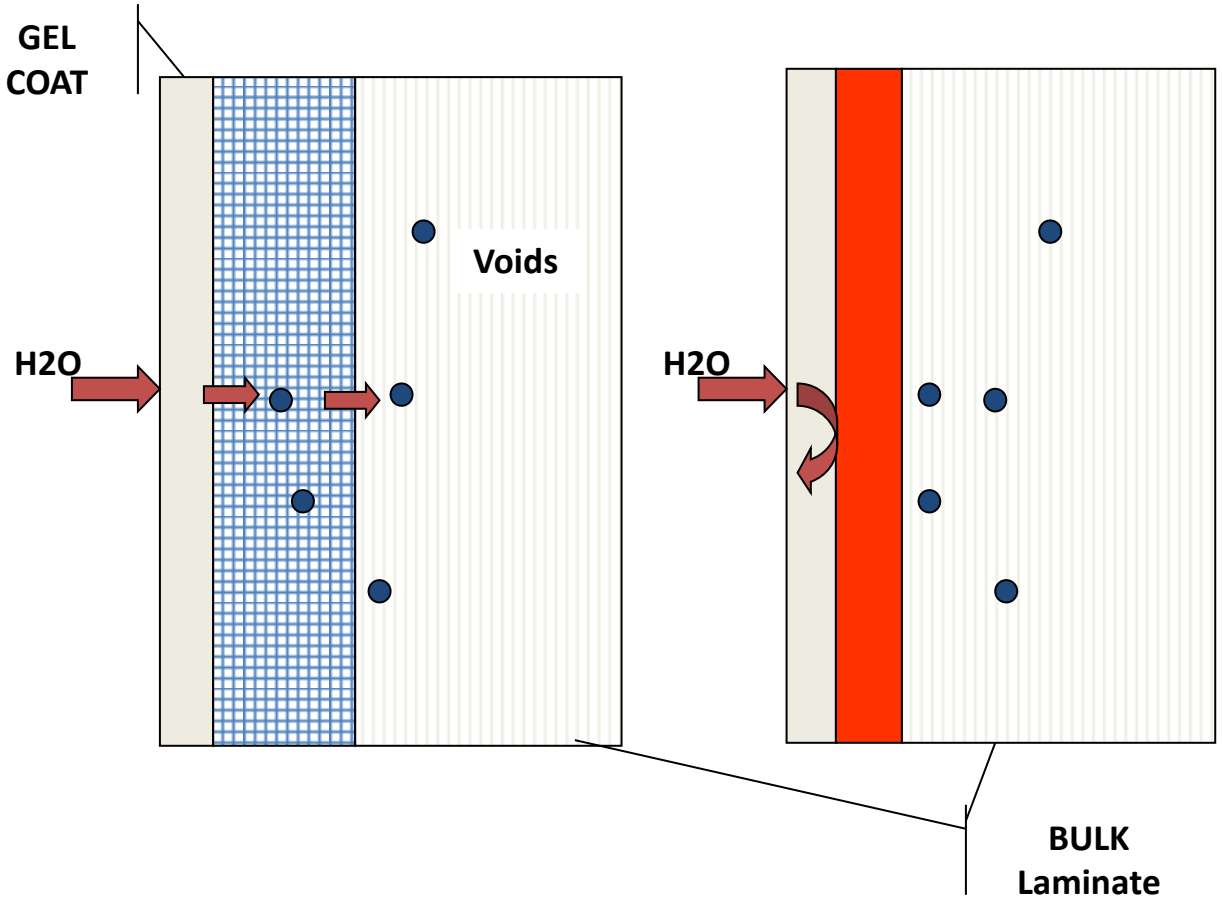
Surface Profile of Composite With and Without VE Barrier Coat

	Composite No Barrier	Composite with Barrier
Surface rating before post-cure	8.8	9.2
Surface rating after post-cure	3.8	6.0

- Panel was post-cured at 65°C for 72 hours.
- The laminate is 32mm in thickness and 30% in glass content of 2,54 cm chopped glass.
- The surface rating has the scale of 0 to 10.5. The higher the rating, the better the surface profile.Surface rating is based on the BYK-Gardner Wave-Scan ACT™ orange peel standards.

❑Used Below the Waterline ….

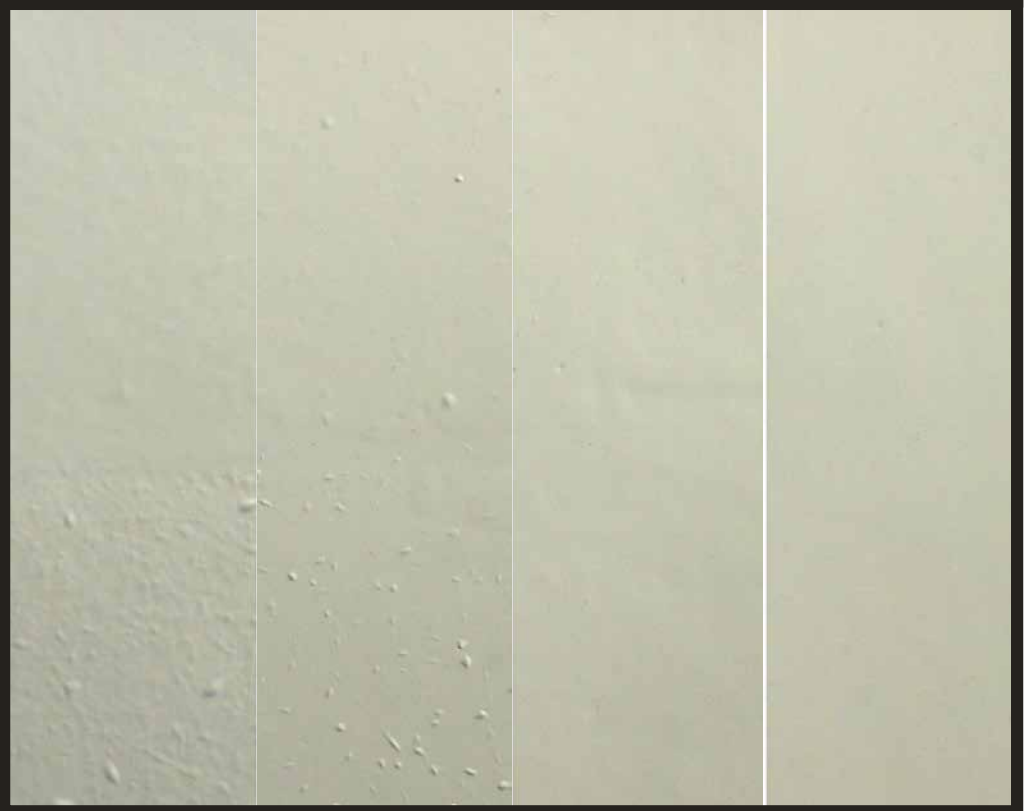
- 100 hours exposure to boiling water-superior performance
- 3 years at ambient-zero blisters



STANDARD GEL COAT

THICK SECTION

THIN SECTION



	NO BARRIER	VE SKIN with FIBER	VE BARRIER	BARRIER + SKIN
Hours @ 100 C	46	52	92	92
Blister Rating (Thick)	0.5	0.5	0.1	0.2
Blister Rating (Thin)	2.0	1.2	0.0	0.0

VE Barrier Coats Add Toughness

- VE resins have a higher toughness than most gel coats (no pigments and fillers).
- Laminates using VE barrier coats crack less than double thickness gel coat.

Improve FRP Cosmetics

- Isolate the gel coat from:
  - Heat
  - Shrinkage
- Use VE Barrier Coats:
  - To block short-term distortion
  - Protect from blister formation/print from laminate voids
- Use Sprayable Syntactic Foams:
  - To block long-term distortion
  - Hide print from woven roving, core, or putty lines

SELECTED PRODUCTS

❑GEL-COAT

- **POLYCOR HWR SERIES** : Advanced technology polyester developed for superior weathering resistance to surface yellowing and chalking. POLYCOR HWR SERIES offer excellent gloss retention, reduced yellowing, high colour stability, reduced chalking, reduced stress cracking, more resilient surface, low water absorption and high blister resistance.
- **ARMOFLEX 99 F** : Advanced technology polyesters that have been formulated for polyester industry. ARMOFLEX 99 F gel coats have lower volatile organic compounds (VOC's) than standard gel coats. ARMOFLEX 99F offers good UV resistance for reduced chalking and yellowing in outdoor application, good resistance to water and osmotic blistering, greater transfer efficiency, less overspray and enhanced crack resistance.

❑BARRIER-COAT

- **EPOVIA OPTIMUM BC 4200 PA** : Based on selected vinyl ester resins, BC 4200 PA offers an improving gel coat cosmetics (reduction of fiber pattern and low shrinkage), good mechanical properties, high distortion temperature, improving hydrolytic performance over the gel-coat products alone.

SELECTED PRODUCTS: Resins

LAMINATING RESINS

- **DISTITRON® VE 100ST** (series available in different viscosity and reactivity) is a thixotropic pre-accelerated vinylester - resins with excellent mechanical and thermal characteristics providing both low both excellent chemical resistance to prevent blistering formation and low shrinkage to guarantee excellent final cosmetics. In order to comply with ever stricter environmental legislation for VOC emissions a low styrene content version is also available
- **DISTITRON® VEef220 STZ**: the resin contains less than 35% of styrene without including any other monomer in its formulation**.**
- **EPOVIA Optimum KRF 4031TA:** modified vinylester resin, thixo preaccelerated,, fast curing time, high hardness, low shrinkage to improve aesthetic surface.

INFUSION RESINS

- **DISTITRON® VE 100 SC** is a vinylester resin with high thermic-mechanical characteristics, excellent chemical and hydrolysis resistance, excellent fibreglass wettability and flowing. Due to its special polymer designed for infusion
- **DISTITRON® VE 370 SC** combines low viscosity with lower styrene content without sacrificing mechanical and thermal properties. Both are non-preaccelerated giving maximum flexibility of pot life needed for the infusion depending on amount of Cobalt salts added.
- **EPOVIA Optimum KRF 4436 AL** infusion vinylester resin, preaccelerated, low viscosity, reduced print through
- **ISO-NPG** series were also developed as they can garanteee high mechanical characteristics and very good hydrolysis resistance in application where VE resins can not be used.
- Several versions of **DISTITRON® 152** are available with different reactivity depending on season and infusion time needed.
- The portfolio includes also Orto-DCPD resin like **DISTITRON® I100 SV1,5** that can guarantee fast flowing and excellent impregnation of the dry materials.

Cosmetic Quality of FRP

Using the right methods and materials, FRP can meet the consumers expectations at a lower overall cost!