Fiberglass pipes and tanks engineering training

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LinkedIn

What we will cover today

- Why GRP behaves differently (block 1)
- Why systems fail (block 2)
- Building blocks (block 3)
- Behaviour and design (block 4)
- Standards (ISO 14692 / EN 13121) (block 5**)**
- **Inspection and failure detection (block 6)**

From design to operation

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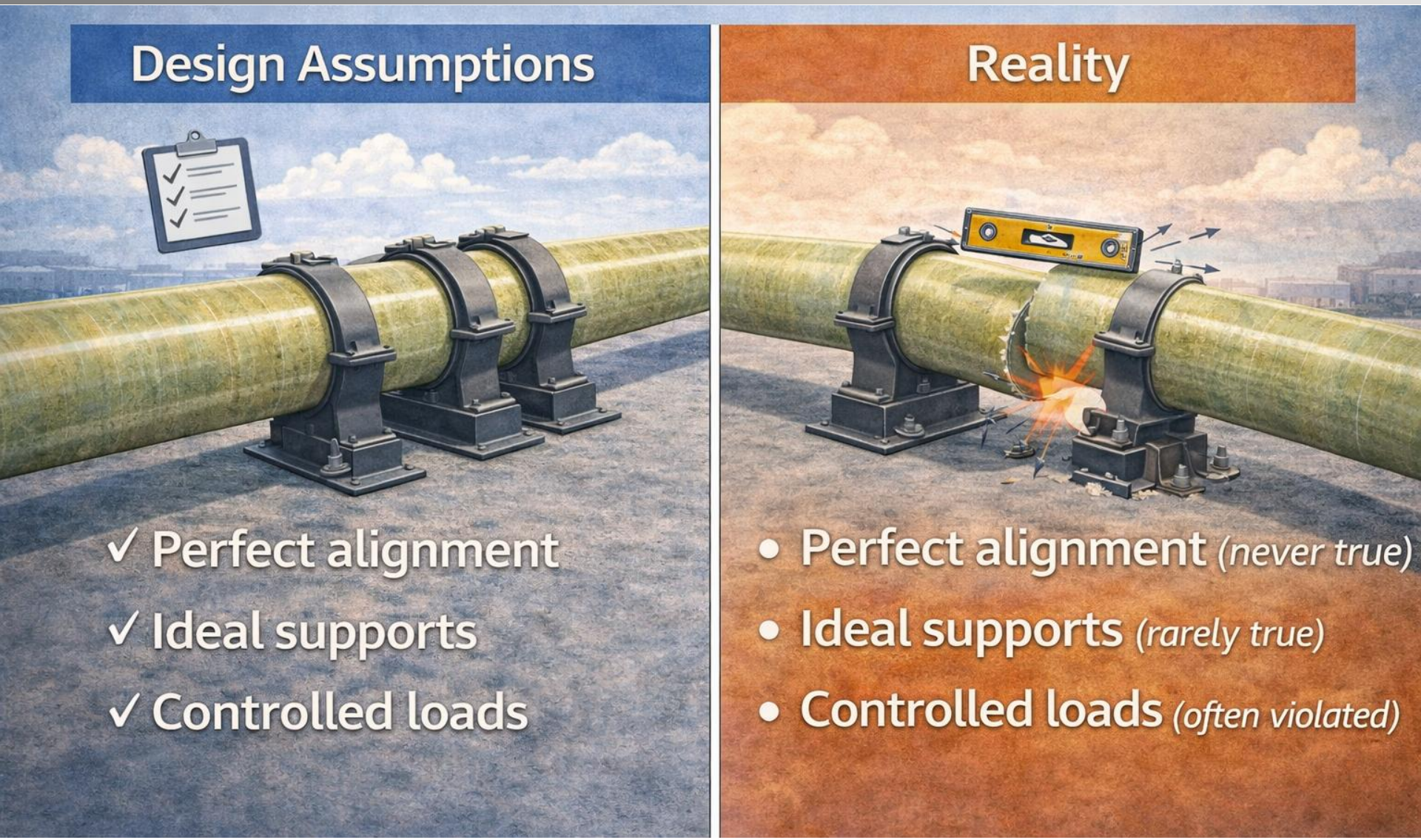

Where Things Go Wrong in Practice

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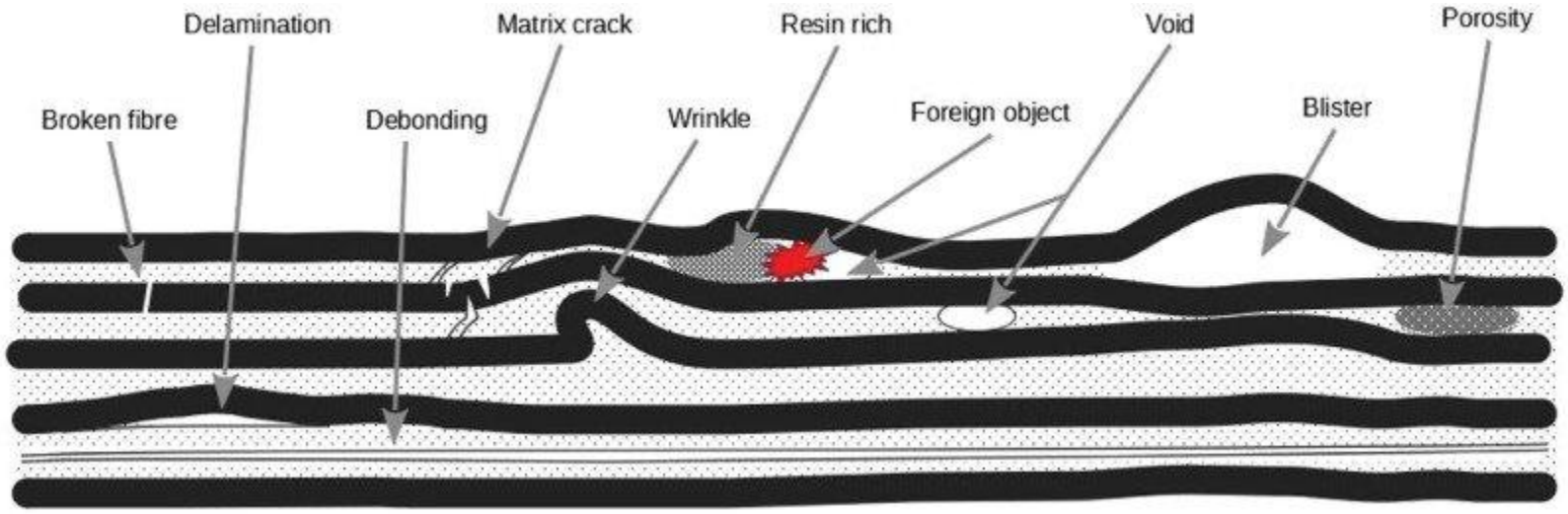
- Installation errors
- Material variability
- Operational deviations
- Aging / degradation

Typical defects



- Cracks
- Voids / porosity
- Delamination
- Dry spots
- Fibre misalignment
- Poor curing

“Most defects come from the process — not the material itself.”

Inspection of GRP systems – what can we see?

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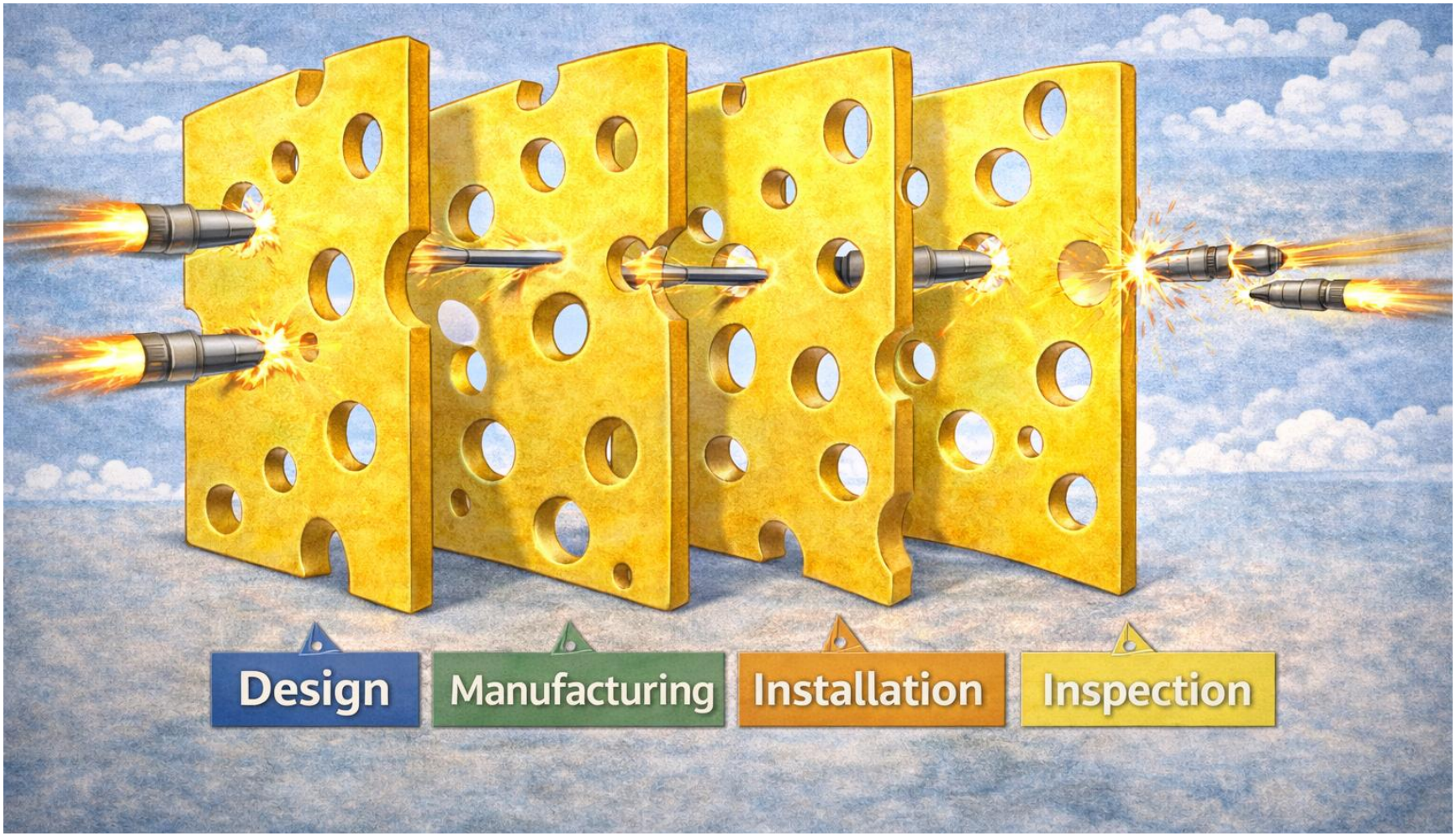
- **Some damage visible**
- **Some is invisible**

- **Not all damage is easily detectable**

“After everything we’ve learned — how do we actually verify a GRP system in reality?”

Prevention vs detection



- Best inspection = good design + installation
- Inspection = last line of defence

“You cannot inspect quality into a system”

Supports & Installation Errors

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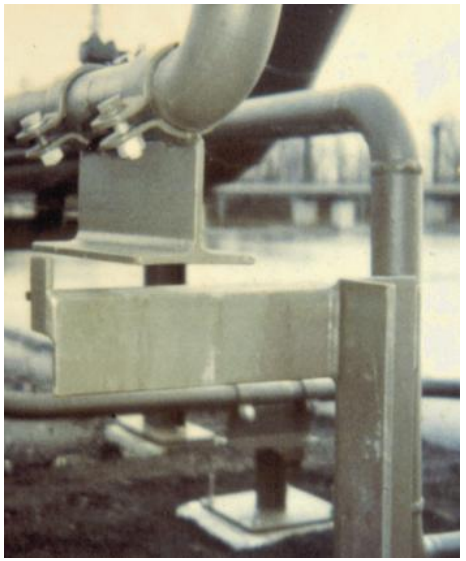

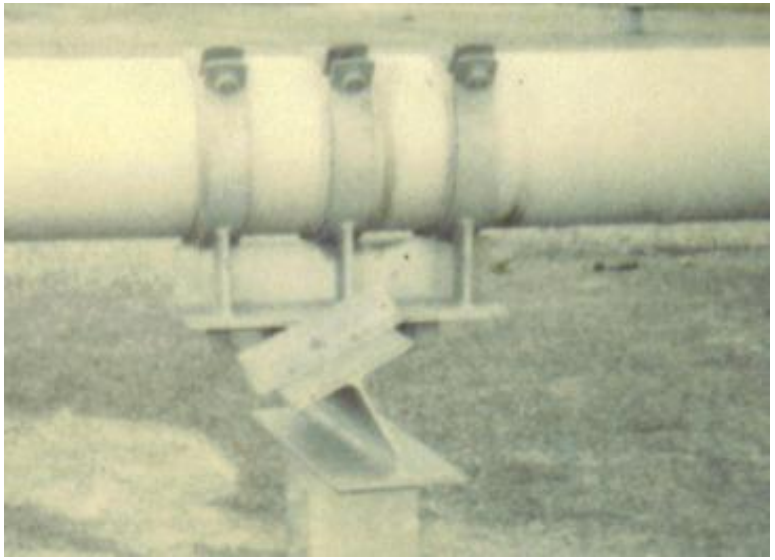

- Wrong support spacing
- Wrong support design
- Missing guides
- Locked expansion
- Point loads

Joint failures

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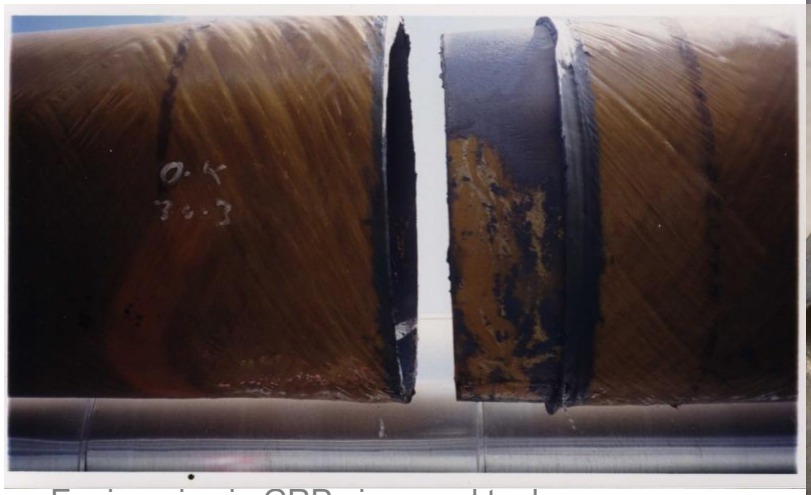
Joint failure:

- Adhesive joints:
  - Poor surface prep
  - Misalignment
- Laminated joints:
  - Poor curing
  - Air inclusions

Not detectible afterwards



Joints require workmanship

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Principle:

- Joint performance is equal or more than the connecting pipe
- Preparation in the trench or on site

Requires extra safety:

	STEEL	GRP
Project responsible	contractor	contractor
Responsible for joint method	Welding coordinator	supplier
Supervision	inspection	supplier
Training/certification jointer	EN287/nobo	supplier

Goal for the future

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To ensure the safety of the installed pipe system:

- Field installation by
  - Actual trained and skilled GRP field specialists
  - Independent training and examination

What do we need

- Accepted competence profiles, for example based on ISO 14692-4
- Certified by an independent organization like Kiwa, Dekra, DNV
- Certification based on actual competences
- Sanctions by not fulfilling certification/QA rules

What happens during operation?

- Cracks
- Blisters
- Delamination
- Chemical degradation
- Moisture ingress

Damage evolves over time — often starting small and invisible. But a lot of GRP issues are visible before catastrophic failure

In service defects

- Cause
  - Overheating
  - Static overload,
  - Impact
  - Fatigue
  - Lightning strike
  - Creep
- Result
  - Delaminations,
  - Bond failures
  - Cracks
  - Ingress of moisture
  - Fracture/buckling of fibers
  - Failure of the interface between fibre and matrix

Inspection of plastics

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- Non-destructive inspection
  - Visual inspection
  - Hydrotest - commissioning
  - Acoustic emission
  - Ultrasonic
  - X-ray
  - etc. (Tetrahertz, thermograpy, (laser) shearography, membrane resonance..)
- Destructive inspection
  - Mechanical
  - Thermoanalytical
  - Microscopical
  - chemical

GRE NDT is harder than steel

Inspection of GRP systems – what can we see?

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- **Some damage visible**
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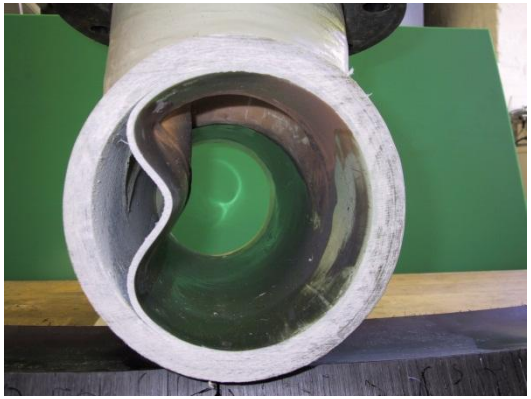
- **Not all damage is easily detectable**

“After everything we’ve learned — how do we actually verify a GRP system in reality?”

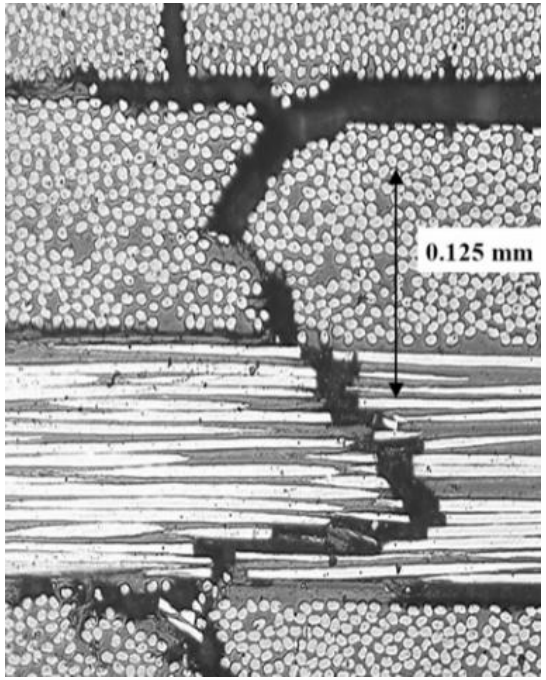
Inspection method: VISUAL

- Surface Damages (liner, topcoat, structural wall)
- Impact (hit), can cause a crack
- Decolouration
- Mechanical damage



USE BACKLIGHTING

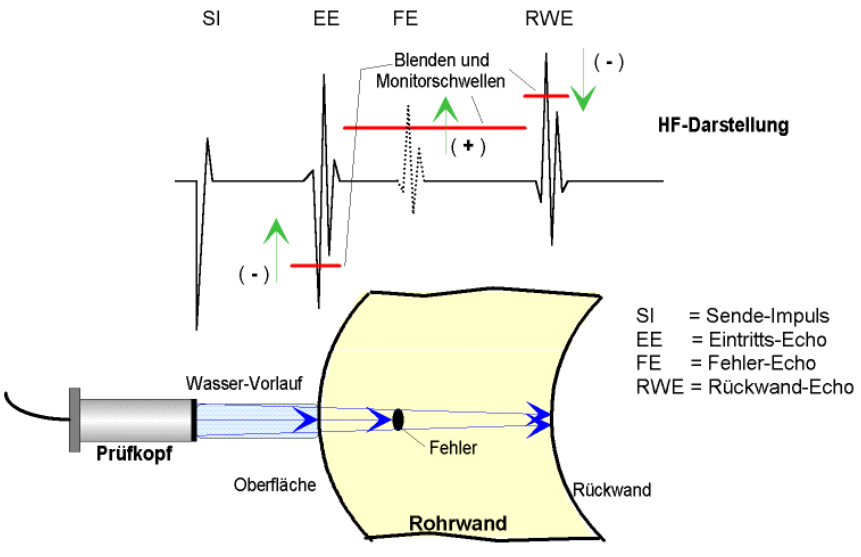
TAP (acoustic impact)



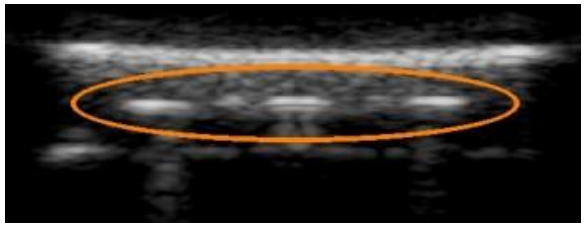
Moisture meter

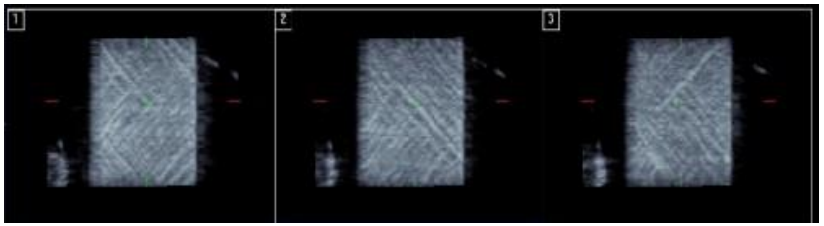
- Increased conductivity due to moisture absorption
- Measures changes in density

Ultrasonic



- 50 yrs old
- Weld inspections
- Wall thickness measurements
- Well suitable for material faults
- Difficult to interpret
- Different displays: A-B-C-S-scan, pseudo 3D





UTComp

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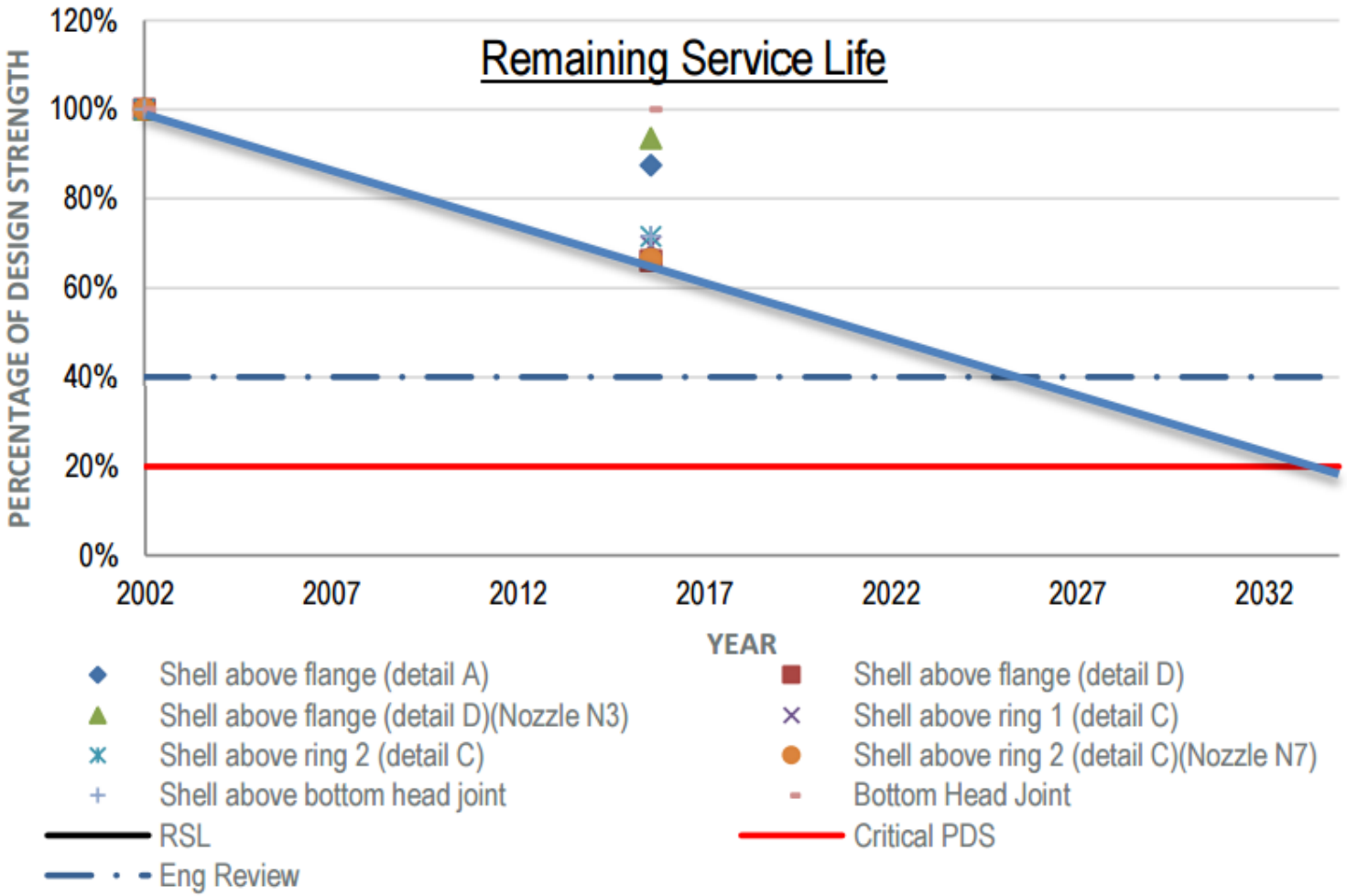
Claim:

- Full life cycle information about GRP
- Non-destructive, non interruptive during operation
- Material faults, strenght, degradation, rest of life prediction
- On new and in-service equipment
- Preventing failure

UTComp


Remaining Service Life
PERCENTAGE OF DESIGN STRENGTH
120%
100%
80%
60%
40%
20%
0%
2002
2007
2012
2017
2022
2027
2032
YEAR
Shell above flange (detail A)
Shell above flange (detail D)(Nozzle N3)
Shell above ring 2 (detail C)
Shell above bottom head joint
RSL
Eng Review
Shell above flange (detail D)
Shell above ring 1 (detail C)
Shell above ring 2 (detail C)(Nozzle N7)
Bottom Head Joint
Critical PDS

UTComp – real case

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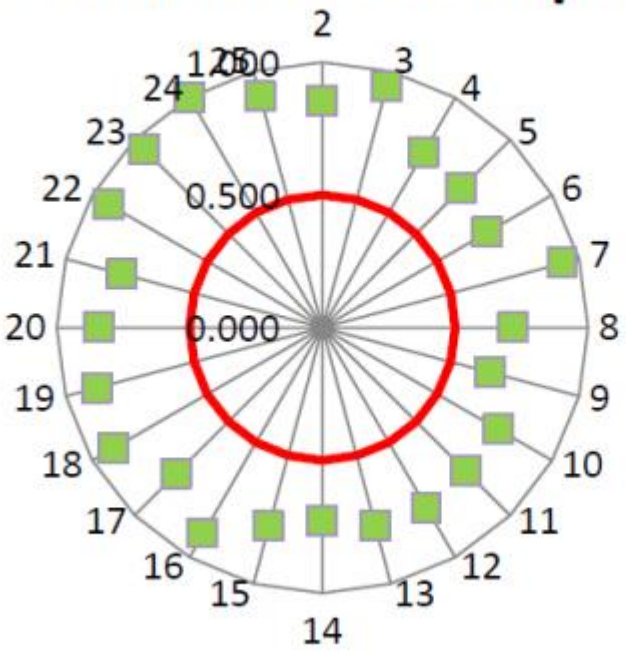
Course A Small Nozzle Repad Bonding



Acoustic emission

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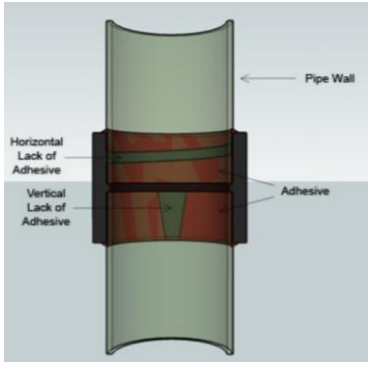
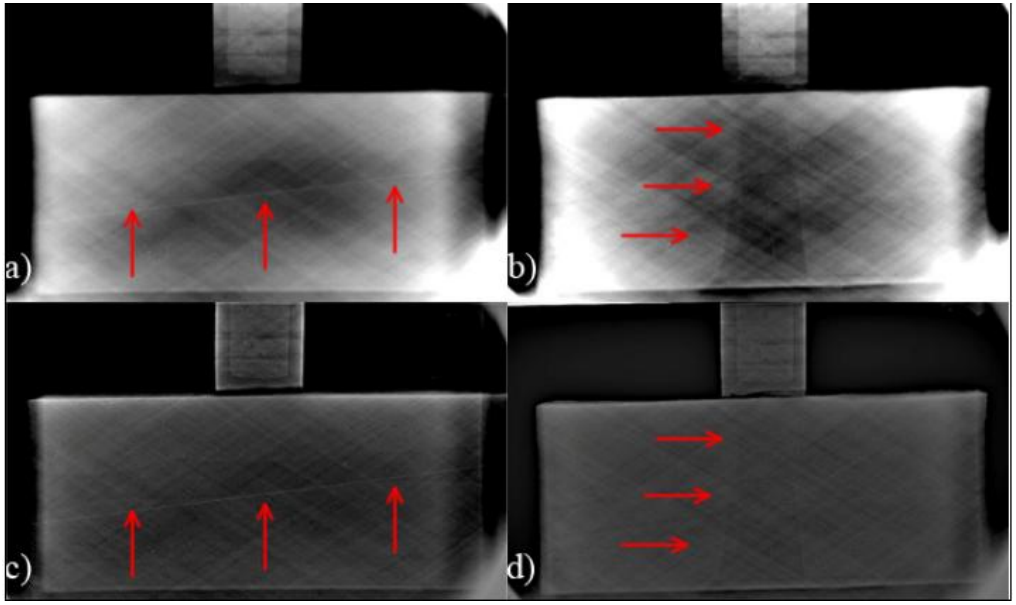
- certain types of defects –actively growing- generate sudden energy release/stress waves
- To detect fractures, debonding, relaxation, interlaminar defects
- ‘listening’ to bursts of acoustic waves emitted with a component
- Can locate defects using triangulation
- Difficult to interpret, complex analysis
- only ‘active’ defects
- Mostly results lack general validity (don’t know what you hear…)

X-radiography

- Composites are very transparent to x-rays
- Well suited for volumetric defects and complex components
- Growing due to practical/compact (digital, low intensity) recording setup
- Limited to thinner walled laminates (thicker gets blurry)
- Adhesive bonded joints show good contrast
- Mainly for cracking: Also small cracks(crazing) visible
- No delaminations or disbonding visible (without penetrant/contrast agent)
- Requires 2 sided access

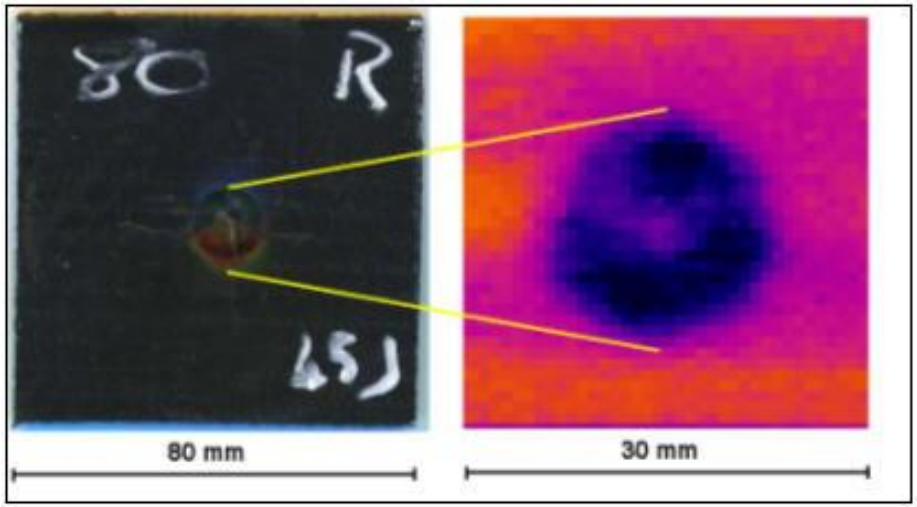


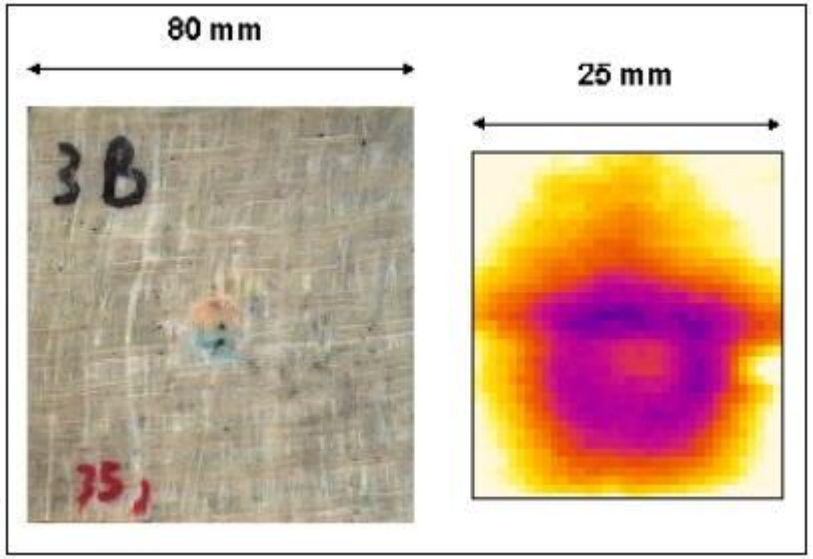


Thermography

- Measures variation in heat emitted by the object
- Growing technology due to improved equipment

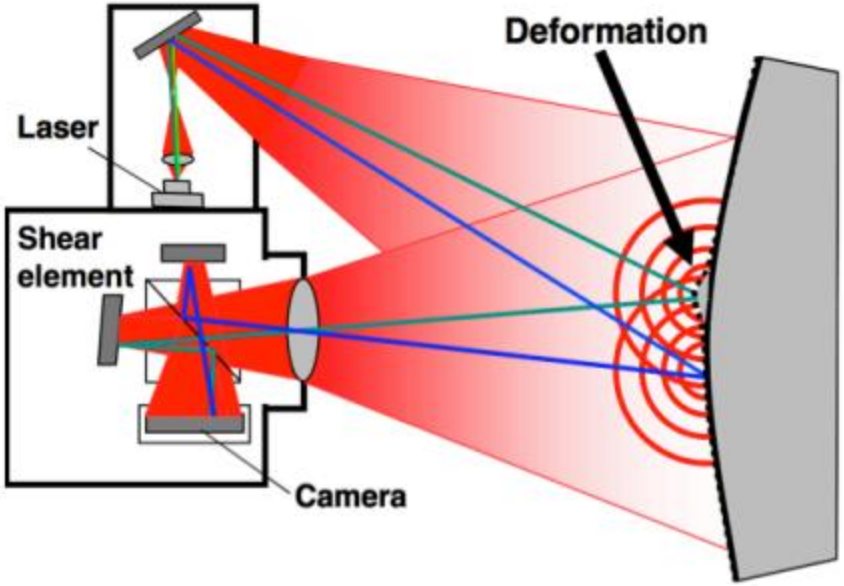
- Discontinuities (delaminations, debonds, voids) will show lower thermal conductivity





Laser Shearography

- Suitable for delaminations, debonding, poor adhesion, etc
- It can even indicate areas of reduced or incr. adhesion
- Uses reflection of a scanning laser to determine strain fields
- Detects very small surface changes
- Expensive
- Different stress methods
- Mainly in aircraft, spacecraft etc.



Pressure testing and commissioning

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Hydrotest purpose:

- Leak detection
- System integrity

Limitations of inspection

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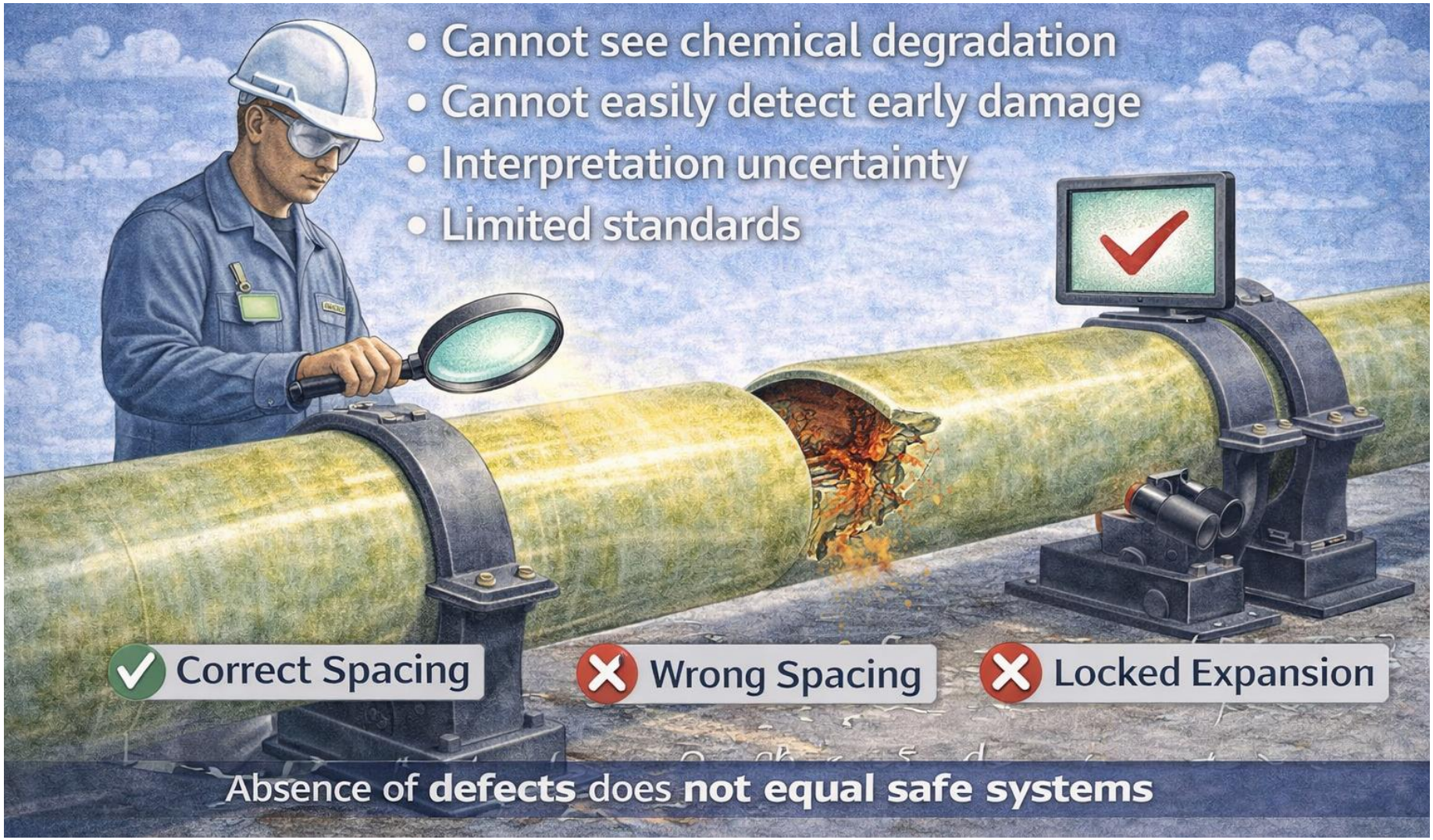

“Just because you don’t see anything — doesn’t mean it’s safe.”

Inspection methods STRUCTURAL

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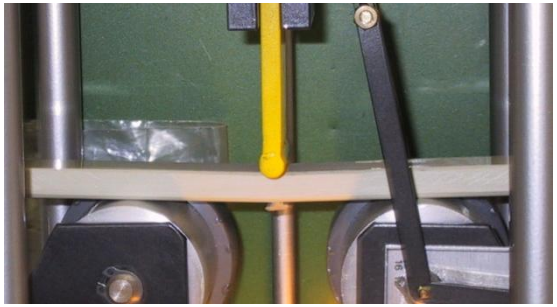
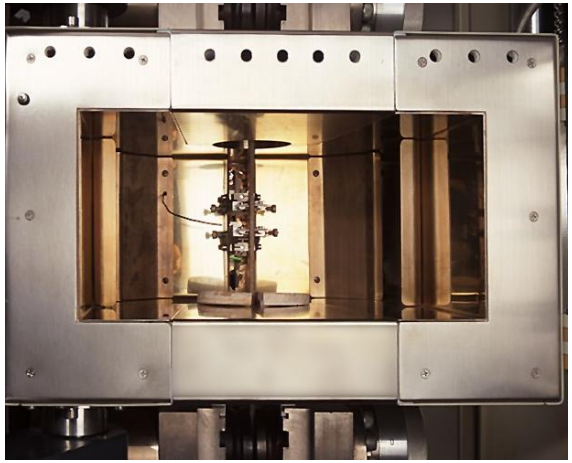


- Destructive: a sample needs to be taken
- Layer thickness /
  number of reinforcing layers
- Mechanical properties
- Also: material buildup
- UEWS
  - Glass resin compatibility



- Consider: include sample when new
  - No damage, no repair, 0hr sample

Axial tensile strength

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Spools testen:

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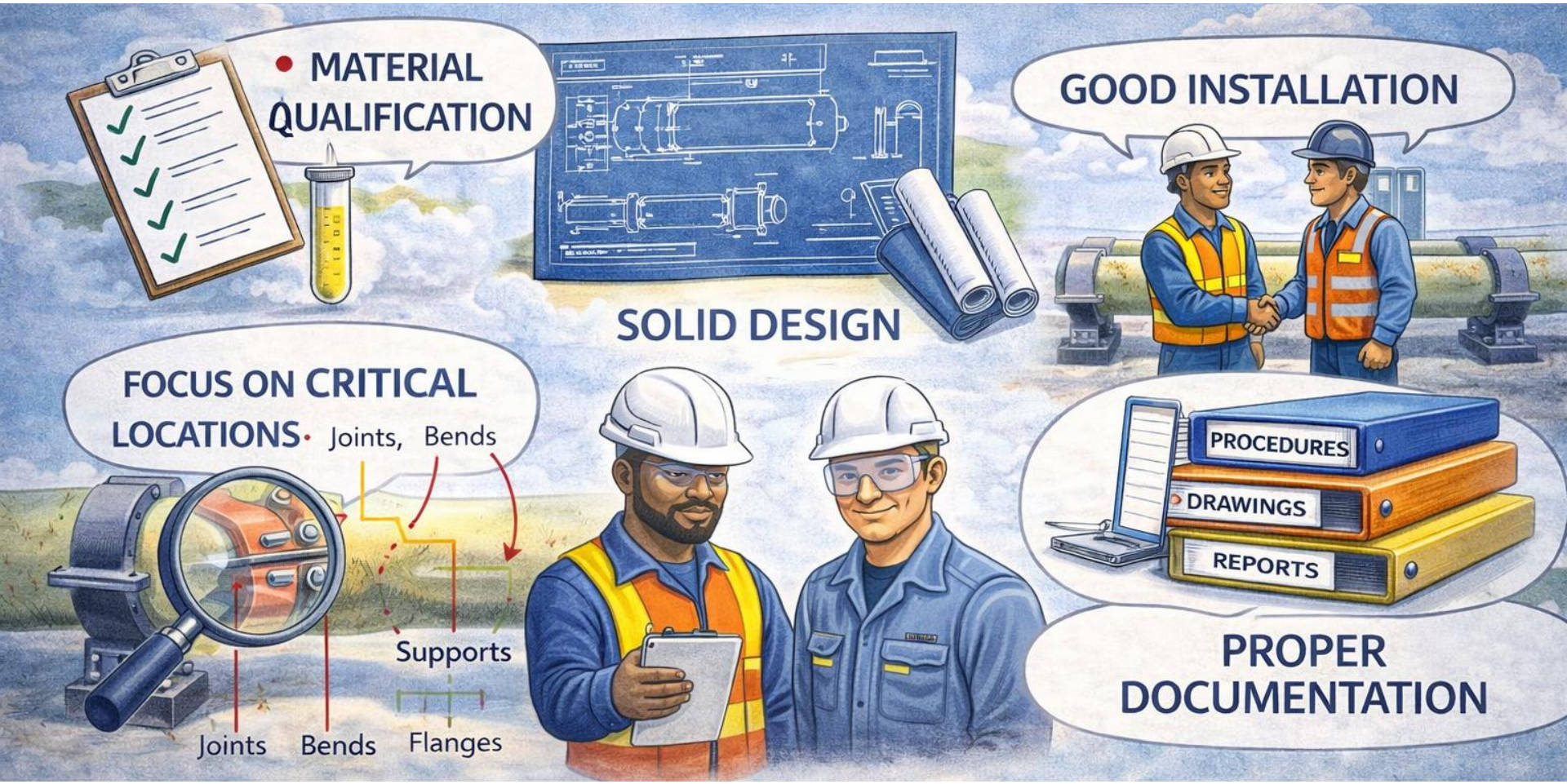
UEWS setup

What should we focus on?



Closing the loop

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Design, standards, and inspection are one system — not separate steps

Block 1 → behavior
Block 2 → failure
Block 4 → design
Block 5 → rules
Block 6 → reality check

- Inspection is limited
- Prevention is critical
- Understanding behaviour is essential

“Inspection supports engineering — it does not replace it”

We thank you for your attention

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Material, pictures and information courtecy of:

-Det Norske Veritas NL
-Dynaflow Research Group NL
-Future pipe industries NL
-Kimab – SE
-NOV Fiberglass Systems USA
-Shell Global Solutions NL
-Alvitiq AB – Edsvalla
-AOC formulations - NL