

# Blast Testing of PFP Systems – Small Scale Understanding of a Large Scale Problem

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PFPNet Conference  
2024

# “Explosions” - deflagrations in congested geometries



Courtesy of   
DNV

# Cyclic response of structural elements (overpressure)



Courtesy of   
DNV

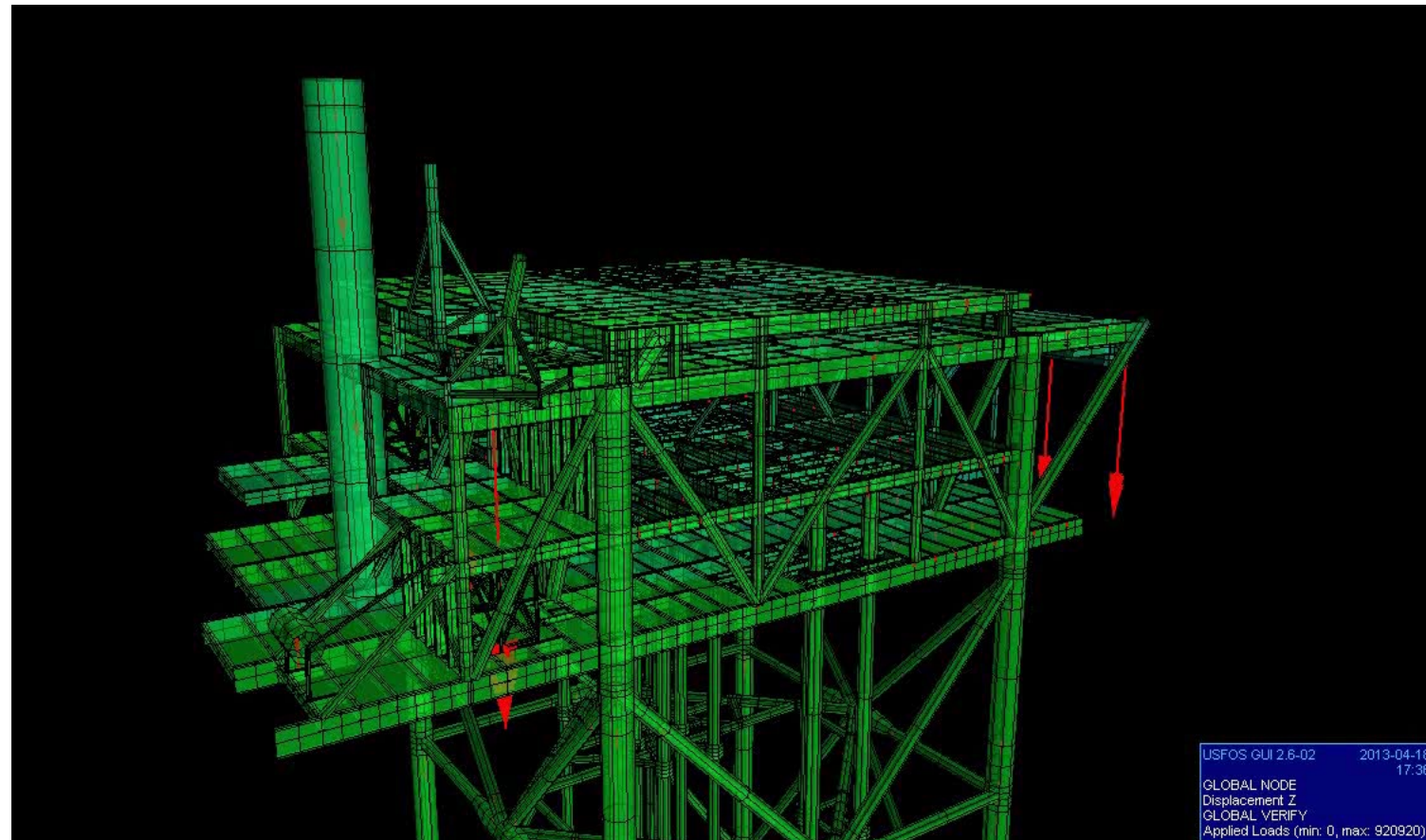
# Cyclic response of structural elements (drag loading)



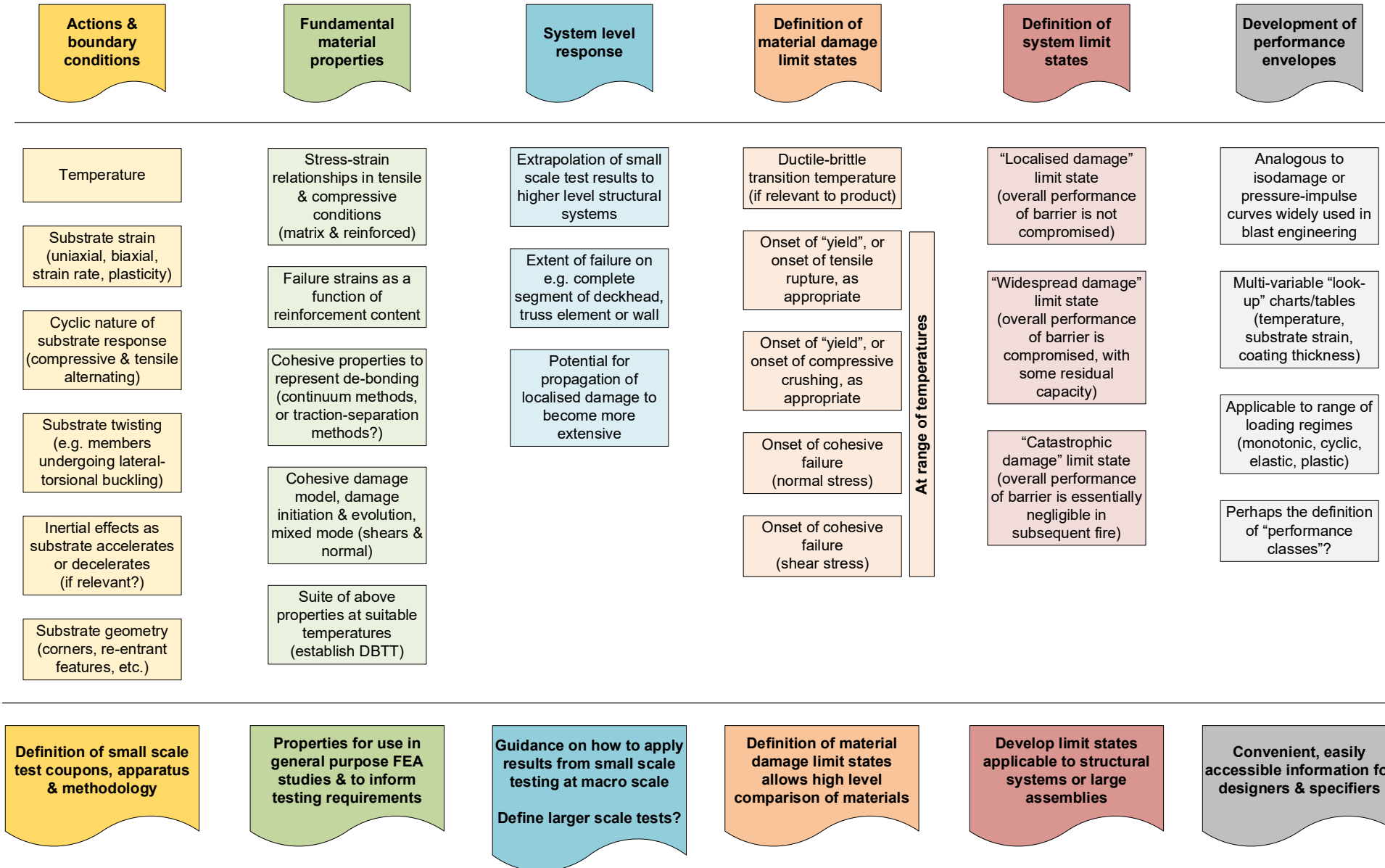
Courtesy of  **Rhino** <https://rhino-hysafe.com/>  
HySafe

***“Explosions don’t load PFP coatings – structures do.”***

***“The PFP coating system is mostly a passenger aboard the moving structure.”***

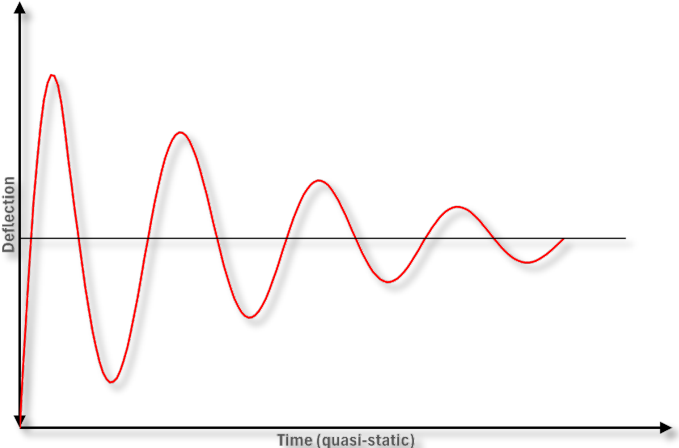
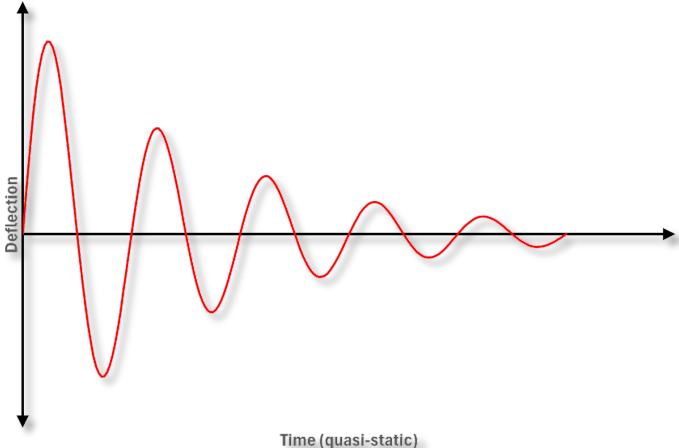
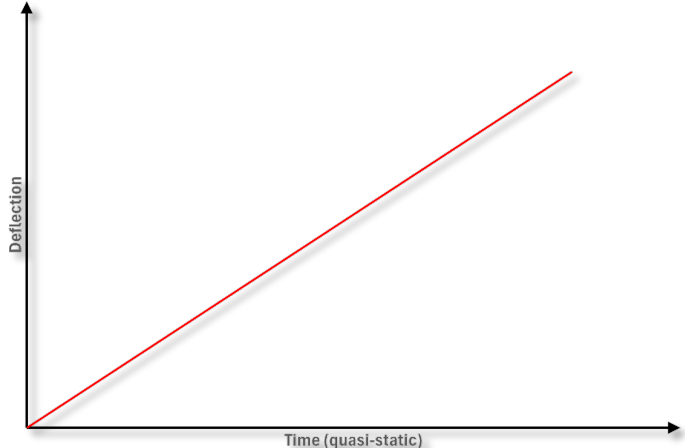


**Themes & concepts raised during group meeting on 04 Sept 2024**



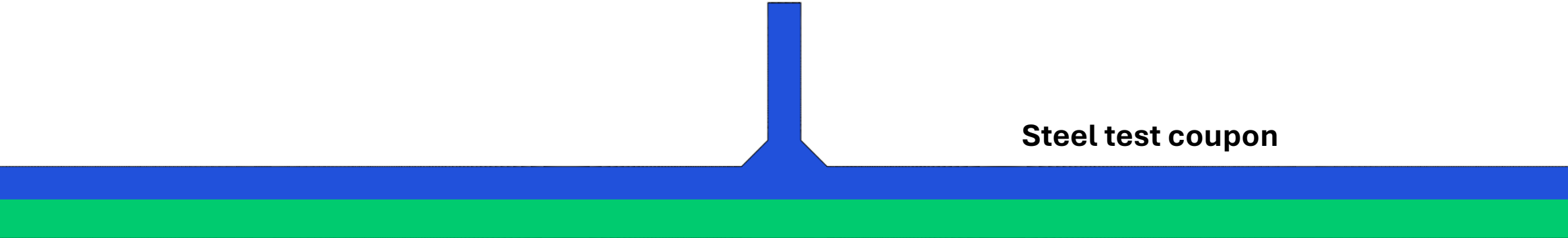
At range of temperatures

# Conceptual outline of testing



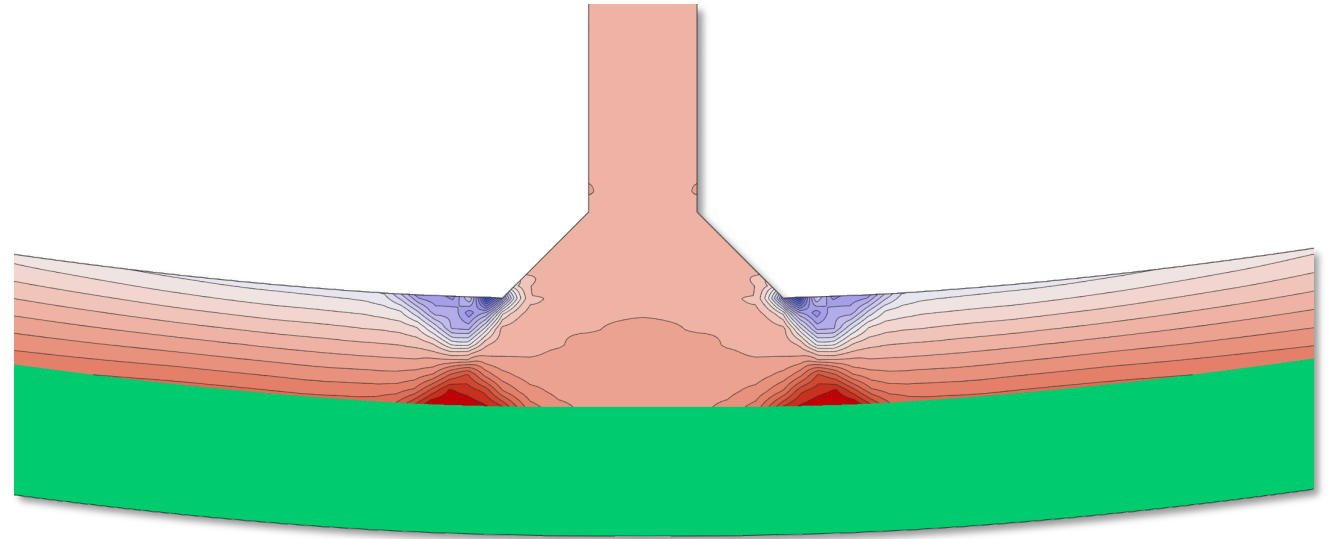
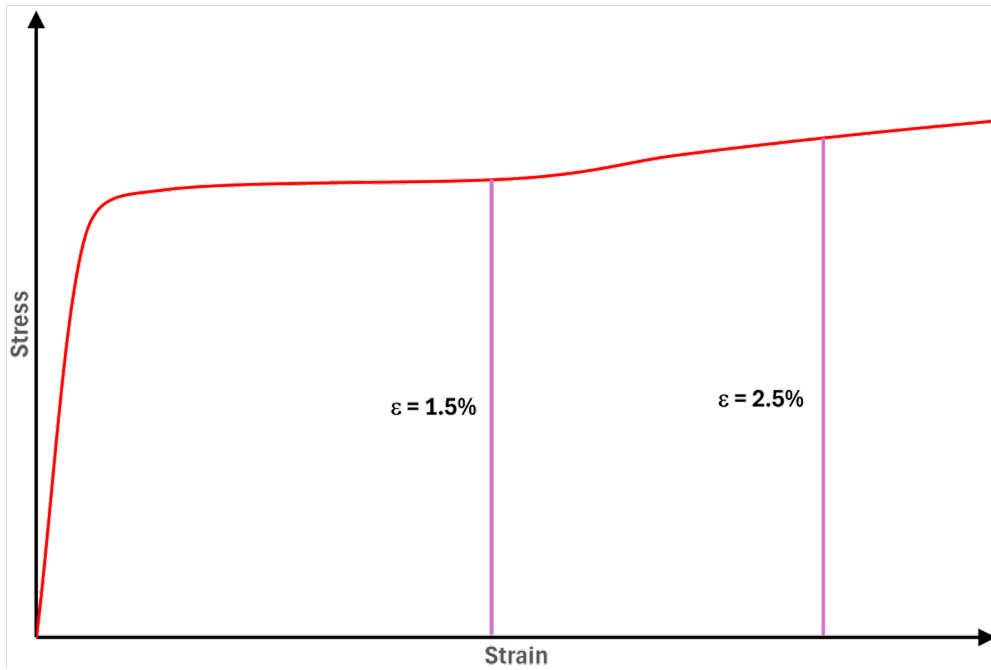
### Forcing function

- Displacement controlled
- Coupon suitable for loading in both directions
- Separate tests at each specified temperature



PFP coating

# Stress ( $\sigma$ ), strain ( $\varepsilon$ ) & coupon configuration



## Appropriate strain limits?

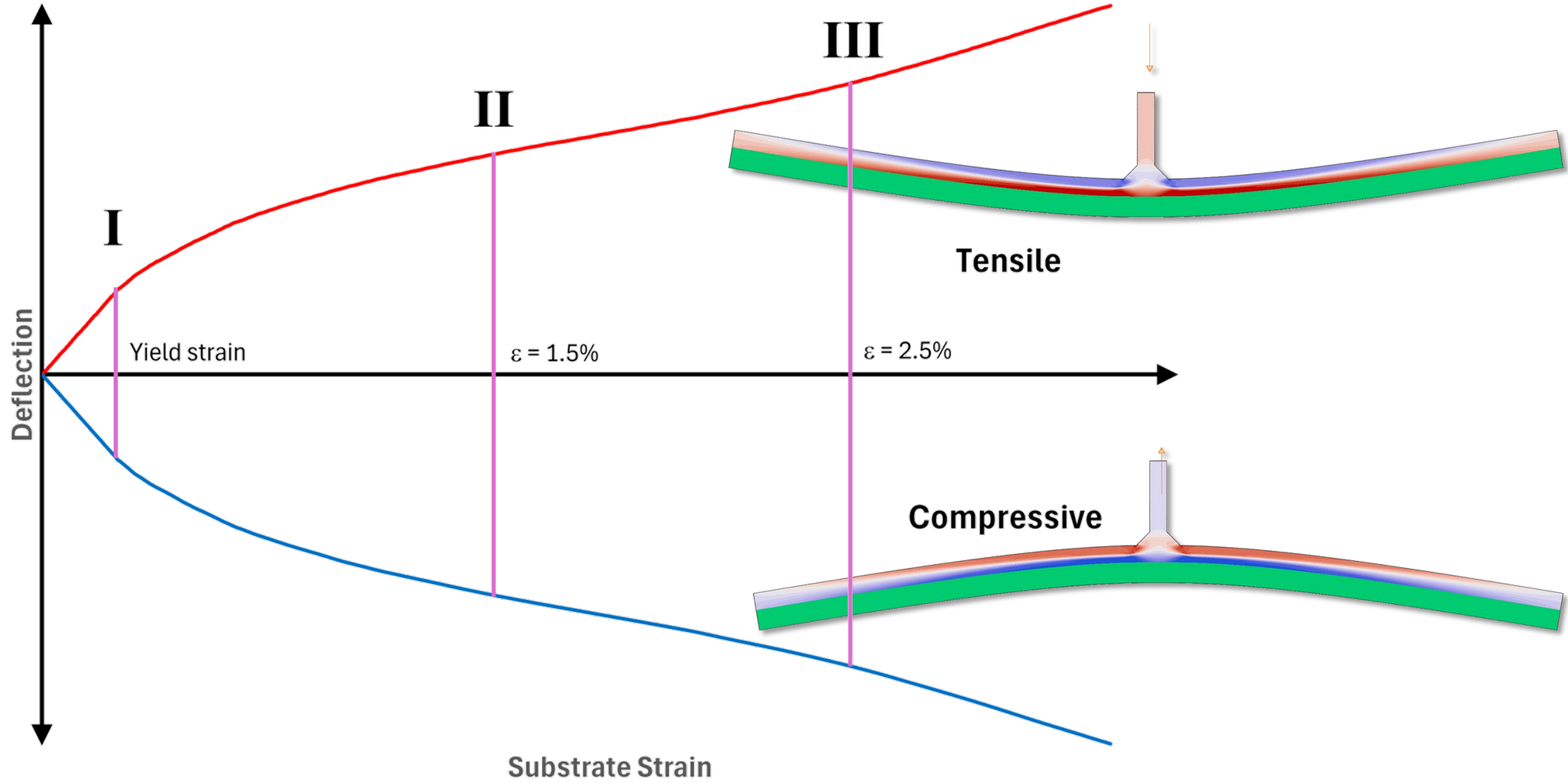
- Design codes (Euro, AISC, NORSOK)
- Strains often limited to 5% (i.e. significant plasticity)
- However, it seems improbable that test strains need exceed 1.5% to 2.5% - especially at lower temperatures

## Coupon configuration

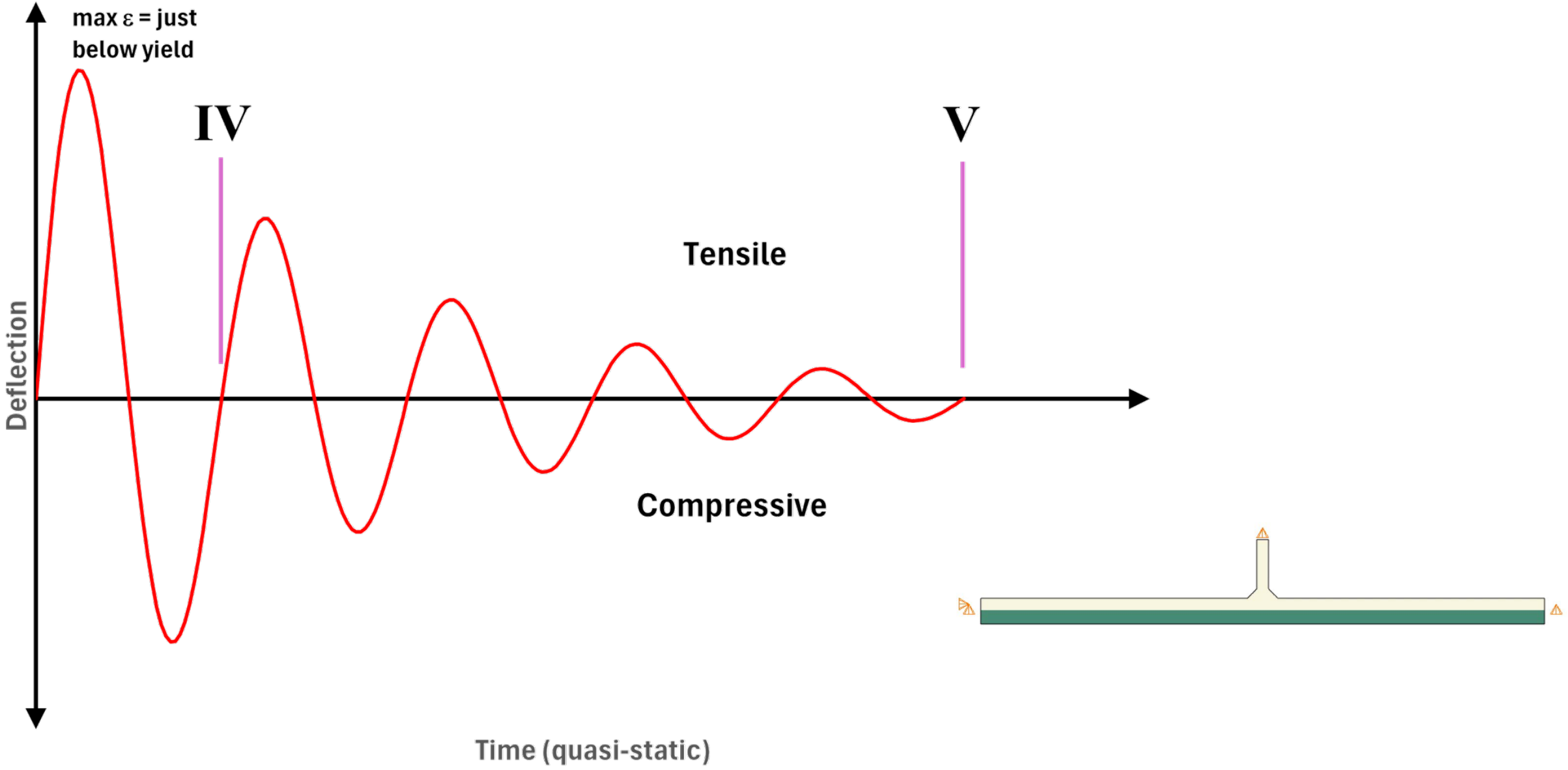
- Full penetration butt welded “driving plate”
- Mimic beam web/flange junction
- Produces some variation in substrate strains
- Many options can be envisaged to provide such variation



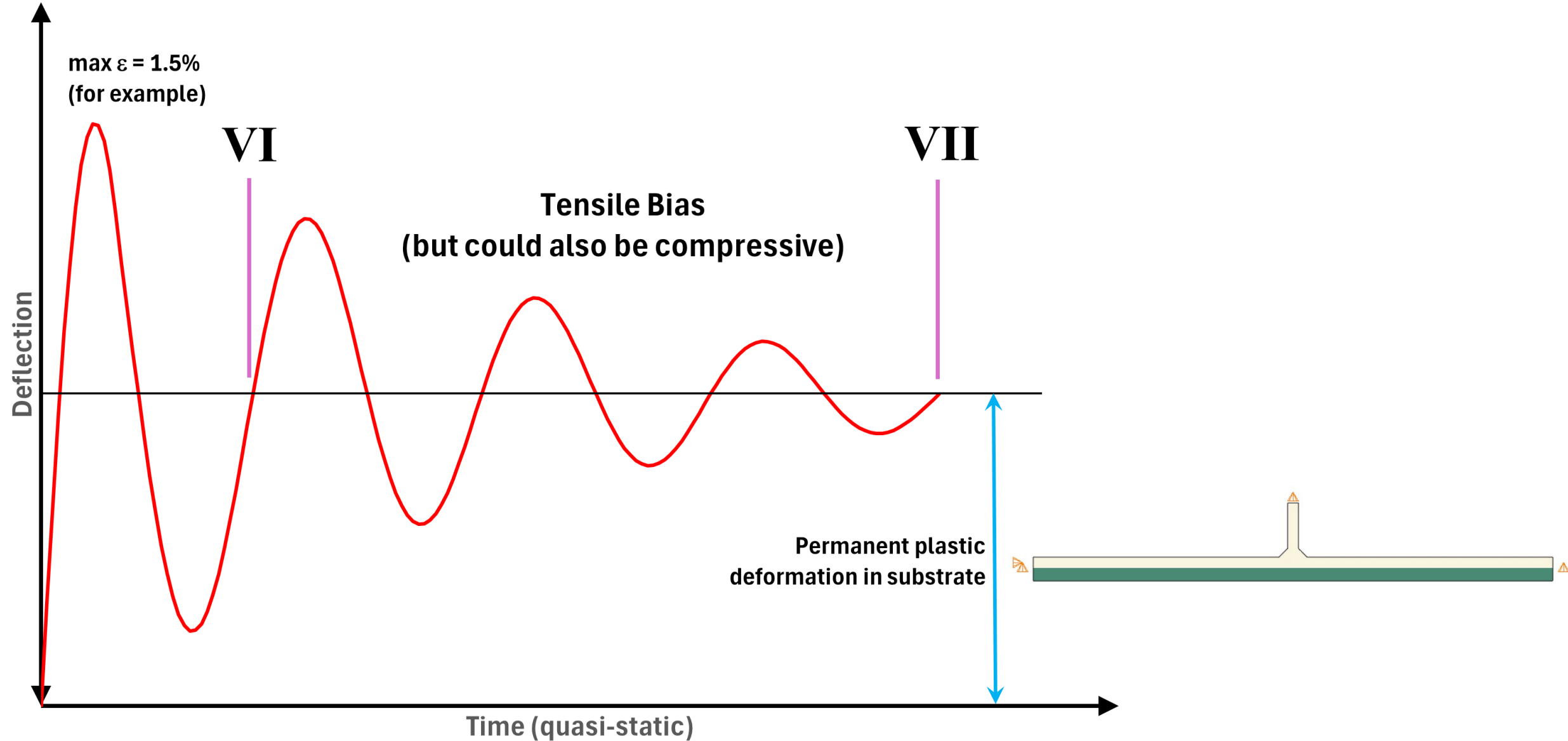
# Monotonic testing



# Cyclic elastic testing



# Cyclic plastic testing



# Coating performance “map” concept

CLASS/ TEMP.	I	II	III	IV	V	VI	VII
+30	Green	Green	Green	Green	Green	Green	Green
+20	Green	Green	Green	Green	Green	Green	Green
+10	Green	Green	Green	Green	Green	Green	Green
0	Green	Green	Green	Green	Green	Green	Green
-10	Green	Green	Green	Yellow	Yellow	Red	Red
-20	Green	Green	Green	Yellow	Yellow	Red	Red
-30	Green	Green	Yellow	Yellow	Yellow	Red	Red
-40	Yellow	Yellow	Yellow	Red	Red	Red	Red

## Performance Classes

- I** Intact at onset of yield in substrate (monotonic)
- II** Intact at 1.5% strain in substrate (monotonic)
- III** Intact at 2.5% strain in substrate (monotonic)
- IV** Intact after one cycle up to yield
- V** Intact after multiple cycles in elastic range
- VI** Intact after one cycle up 1.5% strain
- VII** Intact after multiple cycles with residual plasticity

- Convenient format for specifiers & purchasers
- Provides for comparison between products and/or manufacturers
- Other variables can be brought to bear (e.g. coating thickness, degree of reinforcement, substrate enhancements, etc)

# Concluding remarks

- Reliable retention of PFP coatings as structures respond to explosion loading is essential for subsequent fire performance
- Explosions expose coated structures to cyclic displacements, up to and beyond yield in the substrate
- Substantial insight into the tenacity of the coating can be gained by relatively simple testing:
  - Adherence & robustness under steadily increasing strain & curvature
  - Adherence & robustness under damped, cyclic loading (inc. in plastic range)
  - Sensitivity to temperature
  - Validation of analytical and FEA material models
- NOTE: If quasi-static performance is inadequate, the prospects under dynamic loading are not good
- Simple testing should be amenable to definition in Codes & Standards
- Limitations of simple testing may help define scope of larger scale/complex testing