PFPNet
PASSIVE FIRE PROTECTION NETWORK

PFPNet Houston 2025

Assessment and Repair of Damaged PFP

Simon Thurlbeck, PhD CEng
Director, PFPNet

May 1st, 2025

PFPNet
PASSIVE FIRE PROTECTION NETWORK

What do we know about performance of old fireproofing/PFP systems

Testing Old Fireproofing Materials

30 Years in the North Sea

PFPNet
PASSIVE FIRE PROTECTION NETWORK

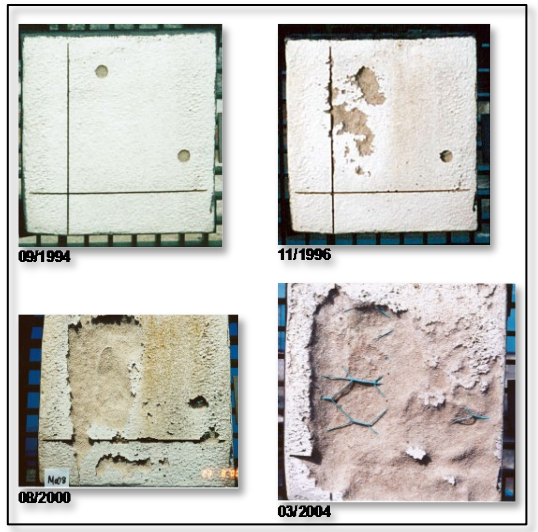
- Mandolite M40 and Chartek 59
- Originally for A60 bulkheads
- Subject to hydrocarbon pool and jet fire testing for 2 hours
- Looking for time to 140°C on panels and 400°C on webs

- Both materials good on panels
- Both underperformed on webs but gave some performance
- Cause: thinner material and mesh location

Shell/HSE Long Term Weathering Tests

PFP	Weathering	Thickness (mm)	Reinforcement
Chartek III	10.7 years	22	Wire mesh at 5 mm
Chartek IV	8.5 years	15	Wire mesh round perimeter Carbon / glass mesh at 8 mm
Firetex M90	7.5 years	19	H120 scrim mesh at 9 mm
Mandolite 550	12.4 years	45	Wire mesh at 30 mm
Pitt-Char XP	10.7 years	29	No mesh – only 5 x 30 mm diameter washers at 14 mm
System E (Mandolite 990)	8.5 years	19	Wire mesh at 10 mm
Thermolag 400	10.7 years	20	Wire mesh at 10 mm

All coatings
Initiated in 1990 – 35 years ago
Coated to H120 specification
CUF occurred at edges due to poor preparation
PittChar XP suffered from this preparation issue



PFPNet
PASSIVE FIRE PROTECTION NETWORK

PFP	Thick-ness (mm)	Furnace test mean time for 140 °C rise (minutes)		Fire resistance after weathering ± 12 min.	Jet fire test mean time for 140 °C rise (minutes)	Fire resistance after weathering ± 15 min.
		Initial	Final			
Chartek III	22	72	67	SAME	97 top	BETTER
Chartek IV	15	54	56	SAME	77 top	SAME
Firetex M90	19	66	68	SAME	56 bottom	SAME
Mandolite 550	45	87	> 120	BETTER	117 bottom	BETTER
Pitt-Char XP	29	68	87	SAME	35 bottom	WORSE
System E	19	68	62	SAME	44 bottom	SAME
Thermolag 440	20	51	99	BETTER	113 bottom	BETTER

Non-Coating Systems
Enclosures, jackets, penetrations, etc

PFPNet
PASSIVE FIRE PROTECTION NETWORK

- No weathering/ageing testing reported
- Performance affected by combinations of:
  - Removal and correct reinstatement
  - Repeated removal
  - Seals
  - Weather shielding
  - Corrosion protection systems

Conclusions on “Ageing” of PFP Systems

PFPNet
PASSIVE FIRE PROTECTION NETWORK

- Limited published data – some is confidential
- We know legacy Fireproofing/PFP systems perform in fires
- Some fire test standards allow for a reduction in fire resistance performance of coatings after durability test exposure (10%-25%).
- Age can be managed – **IF MAINTAINED**

- For long term performance, Fireproofing/PFP systems must be correctly:
  - designed and detailed,
  - manufactured,
  - specified,
  - installed and,
  - maintained and repaired through life to manufacturers recommendations

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Damage

Severity Levels and Advisories

Severity – a measure of how bad damage is in terms of fire resistance performance and/or integrity damage

Damaged PFP

PFP Severity Level Guidelines

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Fireproofing/PFP Systems

- Lightweight Cementitious Coatings
- Epoxy Intumescent Coatings
- PFP Jacket Systems
- PFP Enclosure Systems

- ** Concrete Fireproofing**

Protected Items

- Structural Steelwork
- Equipment Supports
- Barriers
- Critical Process Control Equipment (CPCEs)
- Process vessels and pipework

Will be used in PFPNet Training Courses

What are Severity Levels?
Assessment Guidelines

PFPNet
PASSIVE FIRE PROTECTION NETWORK

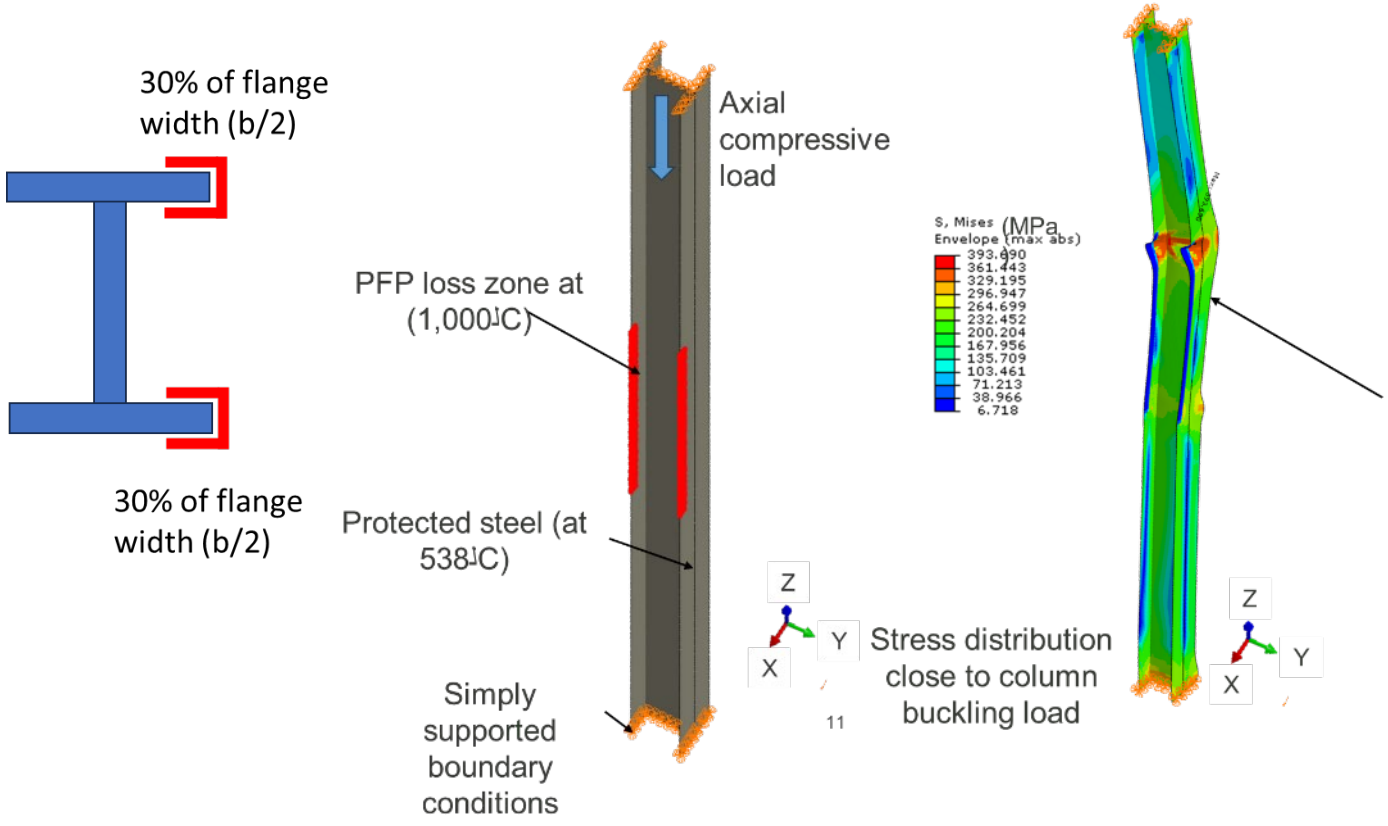
- A best estimate of how bad damage is
- Based on limited published test data, analysis results, and **a lot** of opinion and experience
- PFPNet has collected what is available, and asked industry
- **Not** a risk assessment method
- An input to **any** assessment methodology
- Aimed at inspector/integrity manager
- Considers fire protection and substrate integrity

Damaged PFP JIP

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Analysis Results

Example: W10 x 49



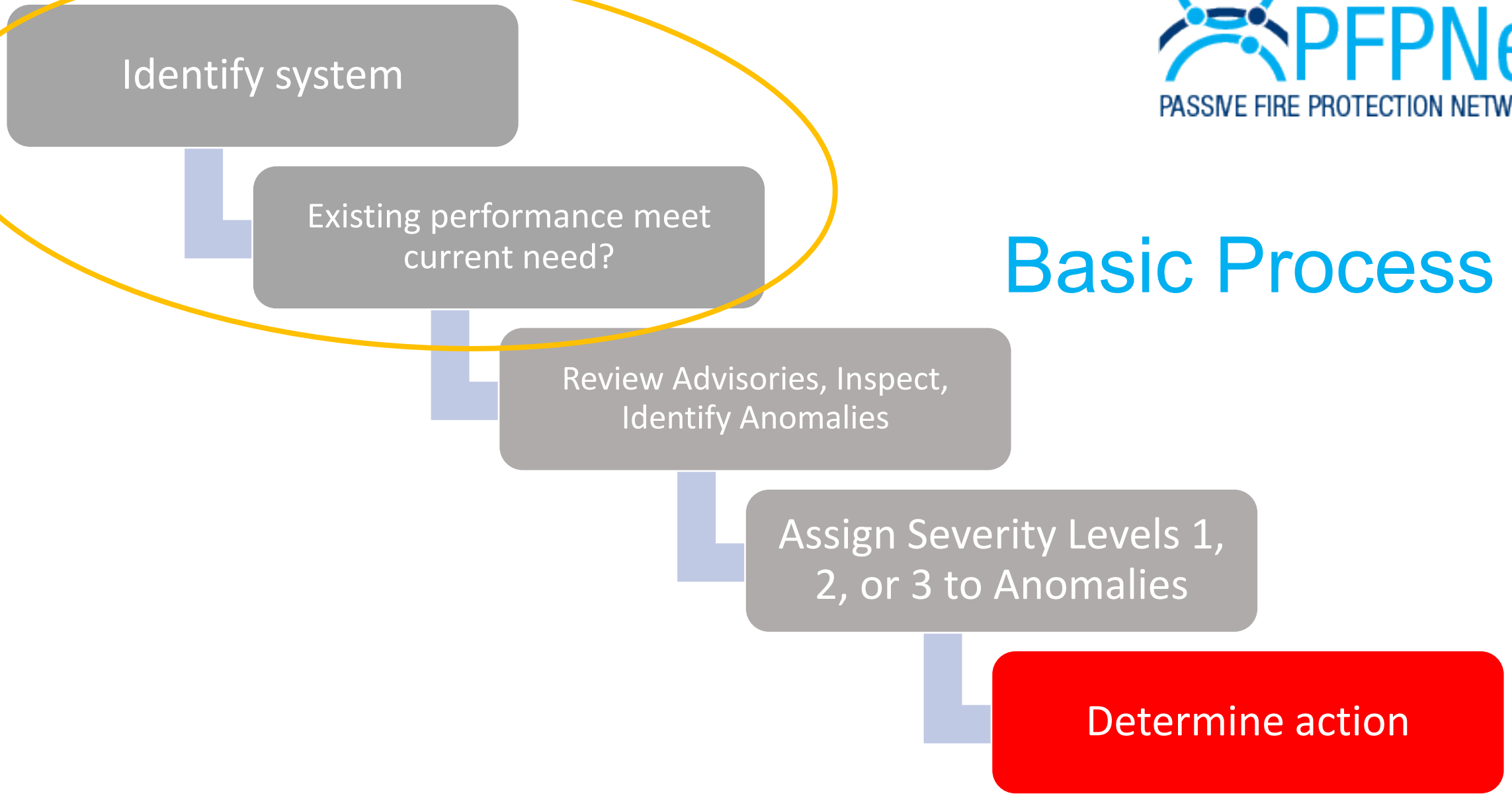
Location and size of damage
Dimensions of member
Restraint, load level

Exposed Steel Temp (°C)	PFP Loss Length	Capacity / Failure Load (kN)	Failure Mode
26°C	--	2,000	Capacity governed by yielding
1,000°C	0.5 m	1,098 (55%)	Flange local buckling and subsequent global buckling
1,000°C	1.25 m	976 (49%)	Flange local buckling and subsequent global buckling

Severity Level	Description of Anomalies	Action
Level 3:	Anomalies present but will not affect the ***immediate*** fire and integrity performance.	Anomalies have the potential to become Severity Level 2 or 1 anomalies if not dealt with in a timely manner.
Level 2:	Anomalies will result in a level of fire protection that is below that of original state, ***but some fire protection will still be provided***. Anomalies will lead to a significant and rapid deterioration of the PFP system, or the substrate, before next routine scheduled inspection.	Remedial action required if reduced performance or loss of integrity is unacceptable, or to prevent degradation to a Level 1 anomaly.
Level 1:	Presents immediate dropped object hazard to personnel. Anomalies cause gross failure of PFP during fire scenario Anomalies directly invalidate the certified rating of a PFP system that is critical for emergency response or prevention of escalation Anomalies located on a region of the protected item which is critical to the fire resistance performance of the item in a fire CUI caused by PFP is severe and loss of substrate integrity is judged imminent.	Immediate** remedial action required to remove immediate hazard, restore require fire protection resistance or remediate substrate loss of integrity.

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Basic Process



Specification Check

Why is it important?

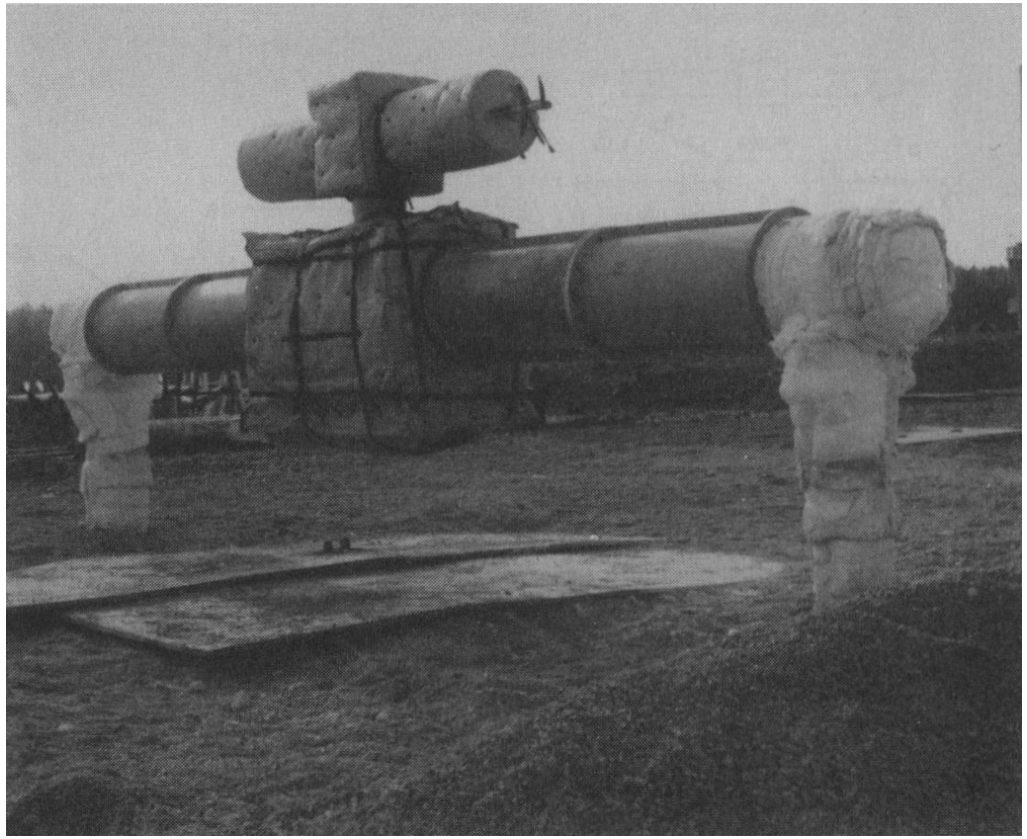
PFPNet
PASSIVE FIRE PROTECTION NETWORK

- Differences between design, specification and testing of old and new PFP/FP Systems
- Evolution: A – H – J
- Not “new” fires, but better understanding
- Now: HHF Jet Fires, H_2 Jet Fires, Battery Fires
- Materials, details and thicknesses have evolved

- Q1: Will our legacy PFP/FP systems provide the protection we currently need?
- Q2: Why are we repairing them if they don’t?

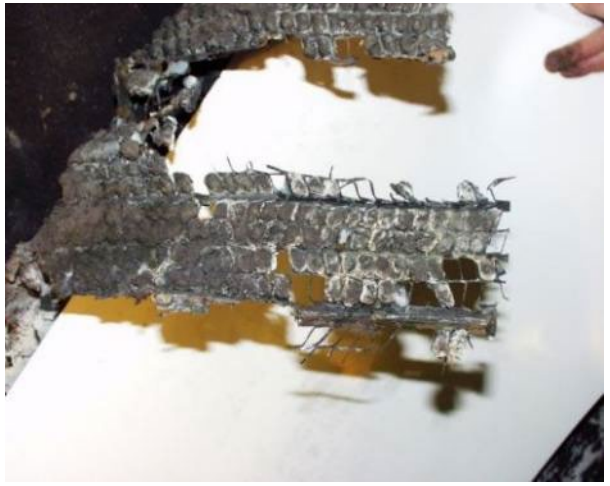
Old Systems in a New Environment

PFPNet
PASSIVE FIRE PROTECTION NETWORK



Old Systems in a New Environment

PFPNet
PASSIVE FIRE PROTECTION NETWORK



Old Systems in a New Environment

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Checking the Specification

The dangers of assuming an old system is OK

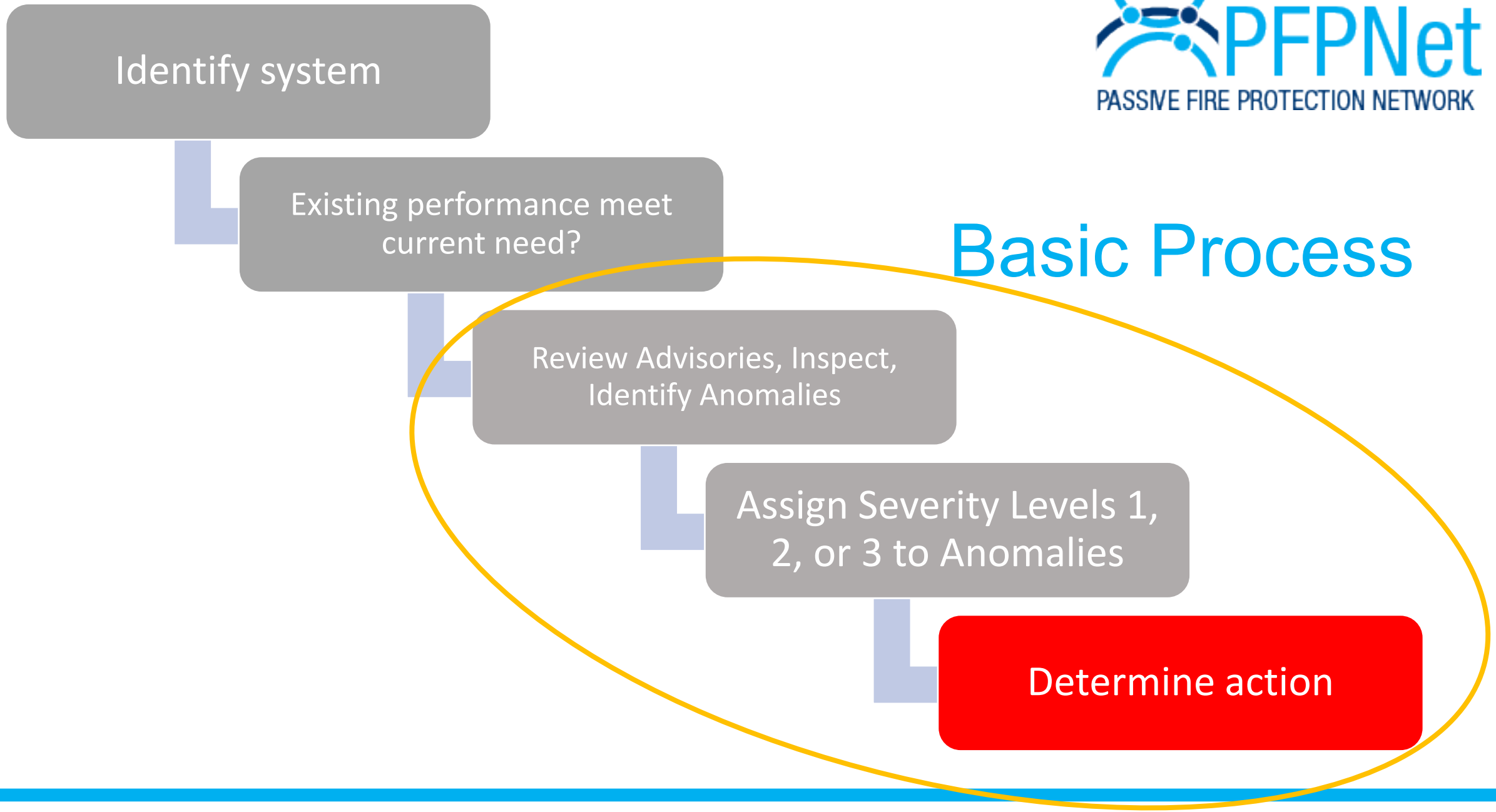
PFPNet
PASSIVE FIRE PROTECTION NETWORK

- “Don’t do it”

- Ignore ad hoc rules (eg A60 = H30 = J15)
- The devil is in the detail
- Half as thick doesn’t mean it has half the performance
- Seek advice: original manufacturer/experienced 3rd Party

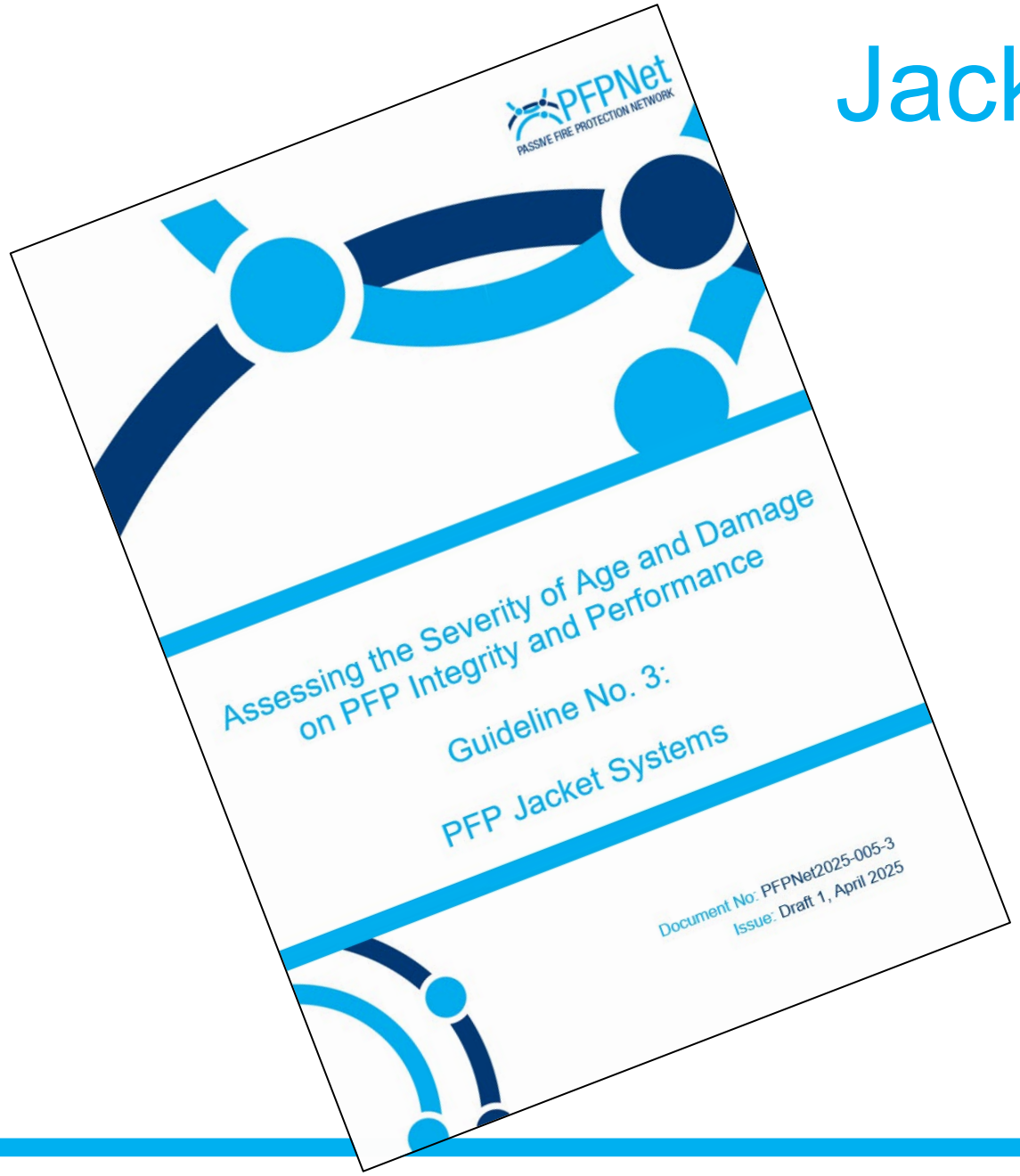
PFPNet
PASSIVE FIRE PROTECTION NETWORK

Basic Process



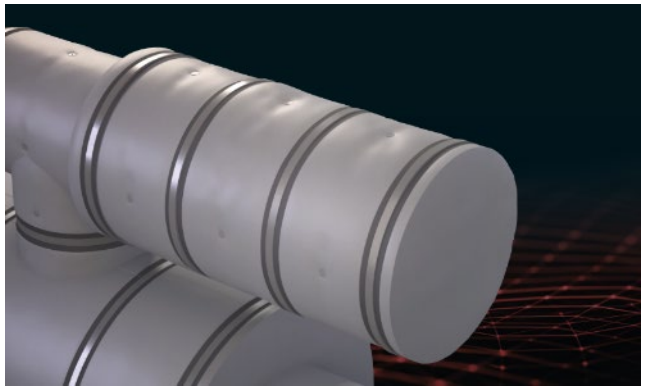
Jacket Systems

PFPNet
PASSIVE FIRE PROTECTION NETWORK



PFP Jacket System – Damage Assessment Checklist		
Damage	**Description**	**Severity**
Pack Thickness	Are any Panels reduced in Pack Thickness	1
Missing Items	Are any Panels Missing:	1
	Are any Joint Covers Missing:	1
	Are any Rain Covers Missing:	3
Joints	Are insulated joint covers fitted:	1
	Are Corner Joints a Good Fit-up:	1
	Overlap Joints to Correct Dimension:	1
	Are butt joints fully tightened:	2
	Are corner joints fully tightened:	2
	Are overlapping joints fully tightened:	2

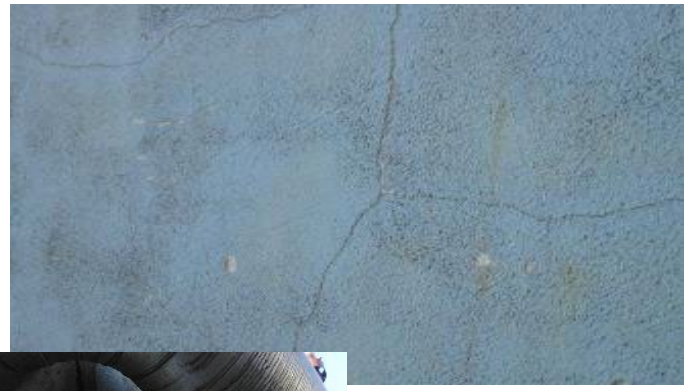
PFP Jacket System – Damage Assessment Checklist		
Damage	**Description**	**Severity**
Mechanical Fastening	Is there Mechanical Fastening:	1
	Is system retained by installation aids only:	1
	Is Banding Fitted at Terminations:	1
	Are some belts & buckles missing:	2
	Are some lacing anchors missing:	2
	Are some lacing loops missing:	2
	Are belts & buckles loose / unfastened:	2
	Is some Single Lacing Wire Missing:	2
	Single Lacing in Place Rather Than Double:	3
*If a Fastener is Loose, Tighten Immediately.		3



LWC PFP

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Damage	Protected Item	Description	Severity
Dropped Object	Any	Significant area detached and only lightly retained that poses a risk to life safety or plant integrity	1
Cracks hairline, shrinkage, wide, part or through thickness	Process Vessel	>3mm wide – any length – bonded/disbonded	1
		Any crack width - disbonded	1
		<3mm wide - bonded	2
	Barrier	>3mm wide – bonded – any length	1
		Any crack width - disbonded	1
		<3mm wide - bonded	2
	Structural Steel	>3mm wide – any bond - any length	1
		<3mm wide - any length – on edge feature	1
		<3mm wide - disbonded	1
		<3mm wide – bonded	3
	General	>3mm wide – any bond – any length	1
		Any width or length - disbonded	1
		<3mm wide – bonded – any length	3
Disbonded (no cracks visible)	Any	Unbonded area >1.25m^2	1
		Unbonded area < 1.25m^2	3



Damage	Protected Item	Description	Severity
Individual area of mechanical damage (gouge, scrape, chip, removal, etc) 3,000mm² = 50 x 60mm = 2" x 2.5" 10,000mm² = 100x100mm = 4" x 4"	Process Vessels and Barriers	Any area with remaining depth < 50% of thickness	1
		Area > 10,000mm² with remaining depth > 50% of thickness	1
		Area between 3,000mm² and 10,000mm² with remaining depth > 50% of thickness	2
		Area <3,000mm² with remaining depth > 50% of thickness	3
	Structural Steel And General	Any area with remaining depth <50% of thickness and located on an edge feature	1
		Area > 10,000mm² with remaining depth < 50% of thickness – any location	1
		Area between 3,000mm² and 10,000mm² with remaining depth > 50% of thickness – any location	2
		Area <3,000mm² · any depth – any location	3
Multiple areas of mechanical damage 500mm = 20"	Any	Two or more individual Severity Level 1 anomalies within 500mm of each other	1
		Two or more individual Severity Level 2 anomalies within 500mm of each other	1
		Two or more individual Severity Level 3 anomalies within 500mm of each other	2

Damage	Protected Item	Description	Severity
General Material Loss	Any	Any area eroded down to/through retention system	1
		Surface spalling over a wide area of item	2
		Localised light surface spalling or surface erosion	3
Waterlogged Material	Any	Soft and corrosion product visible	1
		Soft and algae visible	2
		Soft on immediate surface only	3
Topcoat	Any	Large area over entire item is damaged	1
		Medium area or multiple small areas	2
		Small local areas	3
Terminations and Details	Any	Mastic seal missing or brittle	1
		Open/disbonded termination	1
		Corrosion product at termination	1
		Material split and open at corner beads	1
Signs of Substrate Integrity Damage	Any	Wide open crack in LWC material	1
		Bulging, disbonded and cracked LWC material	1
		Leaching of corrosion products through LWC material	1

What lies beneath - CUF

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Advisories

Identifying problems and errors that keep on happening

PFPNet
PASSIVE FIRE PROTECTION NETWORK

What are they?

- Captured knowledge for future users
- Observations/opinions/experience on root causes of observed damage
- Provide:
  - Source of good and bad practice
  - Improve detailing/design to improve integrity
  - Education tool for training
  - Help to guide inspections

What do they cover?

- Understanding the Test Certificate or Test Report
- Detailing Practice – box construction
- Components – edge beads, seals
- Connections and fastenings
- Other Hazards – explosions
- Application and Installation
- Inspection and Maintenance
- Differences in Designs for different hazards

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Repairs

Short, Medium and Long Term
Same materials
Dissimilar materials
Overclad systems

Temporary Repairs

PFPNet
PASSIVE FIRE PROTECTION NETWORK

No Certification, no testing
No fire resistance
Stopping material from falling

“Short/Medium” Term Repairs

PFPNet
PASSIVE FIRE PROTECTION NETWORK

Often ad hoc and untested
Time limited
Evaluate impact on risk

FR Repair Mortars and Putties

For Jet and Pool Fire Repairs

PFPNet
PASSIVE FIRE PROTECTION NETWORK

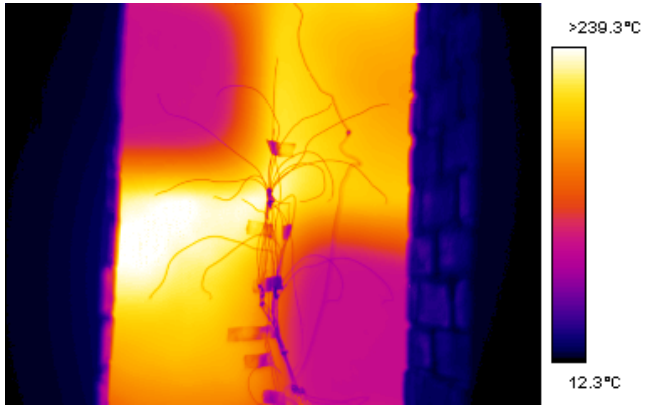
- Tested
- Time limited
- Size limited

Long Term Repairs

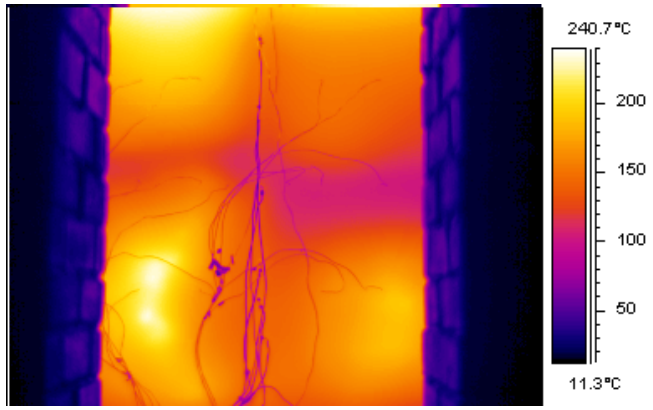
PFPNet
PASSIVE FIRE PROTECTION NETWORK

Tested
Not Certified
Manufacturer recommended

Dissimilar Material Repairs



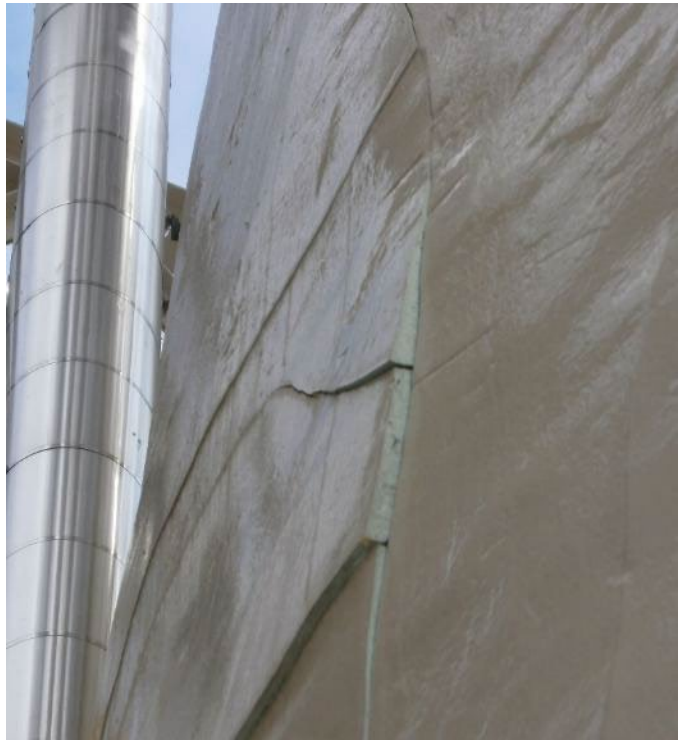
Simple butt joint



Stepped/chamfered (Chartek)

Long Term – Overclad Repairs

PFPNet
PASSIVE FIRE PROTECTION NETWORK



Adaptations from other certifications (eg vessels)
Require “confidence” in what is happening beneath

Component-Based System Repairs

If a component or fixing is missing – replace it

PFPNet
PASSIVE FIRE PROTECTION NETWORK

No Short Cuts

Panels and components are easily replaced

Conclusions

PFPNet
PASSIVE FIRE PROTECTION NETWORK

- This is a large, wide-ranging subject that can’t be covered in 25 minutes.
- Including questions.
- Any Questions?