



Investigation of size of PFP defect and rate of heat up study
 How Big? How hot? How Long?

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Background


- Industry guidance such as NORSOK, FABIG, PFPNet reference an area of attachment or size of defect where there is not a requirement to install PFP
- These have been adopted and grand-fathered into project specifications, certifications and design assessments
 - NORSOK = 1000mm²
 - FABIG, PFPNet, etc = 3000 mm²
- There is no publicly available fire test evidence to support these values
- PFPNet intend to investigate this phenomenon in more detail and provide guidance
- PPG proposed running a quick and simple test on insulated plate as first step to understand the issue.

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PFP Anomaly Testing
 Test Configuration



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Test Set 1

500 x 500 mm plate
No void

1,000 mm²
Ø 35 mm

10,000 mm²
Ø 113 mm

5,000 mm²
Ø 80 mm

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Test Set 2

500 x 500 mm plate
No void

1,500 mm²
Ø 44 mm

2,000 mm²
Ø 51 mm

3,000 mm²
Ø 62 mm

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Thermocouple positions

- TC's spaced 50mm apart
- Back face of plate insulated with 25 mm Firemaster[®] blanket after thermocouples have been place
- Thermocouples show temperature rise distribution away from centre of plate against time

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Thermocouple positions

- Larger void size effects more than the thermocouple at centre point
- Thermal imaging could be beneficial but back face was covered in insulation

The diagram illustrates a cross-section of a furnace door with various thermocouple (TC) positions and void sizes. Position A is at the center point, B is at the top edge, C is at the bottom edge, D is at the left edge, and E is at the right edge. Void sizes are indicated by concentric circles: 200mm, 400mm, 800mm, and 1600mm. A legend indicates that A is 1000 mm², B is 2000 mm², C is 4000 mm², and D is 16000 mm². The PPG logo is in the bottom right corner.

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Test Specimens

The first photo shows a grey surface with two circular holes. The second photo shows two rectangular samples mounted in a furnace door. The third photo shows a white Firemaster blanket covering the back face of the samples. Captions below each photo describe the process. The PPG logo is in the bottom right corner.

Samples spray applied with masking to create hole

Samples mounted in the furnace door, facing into furnace, ready for test

Firemaster® blanket on back face of samples when mounted in furnace door

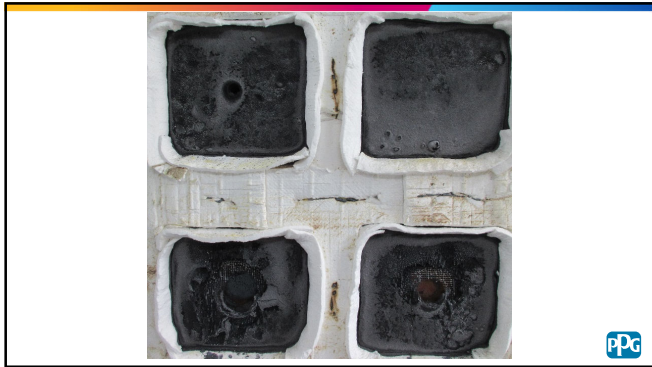
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PFP Anomaly Testing

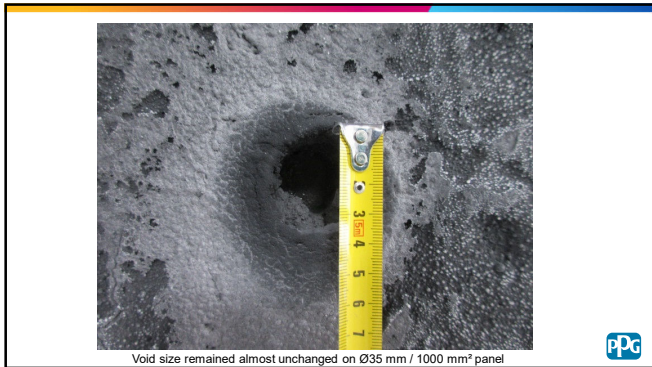
Post Test Pictures

The slide features a blue background with a large, colorful geometric shape on the right side, composed of overlapping triangles in shades of pink, orange, and yellow. The PPG logo is in the bottom right corner.

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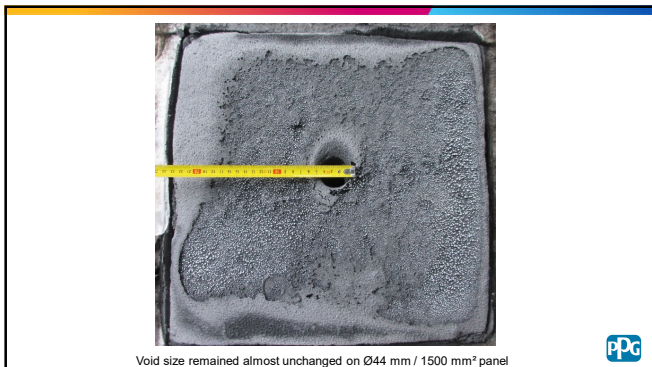


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Void size remained almost unchanged on Ø35 mm / 1000 mm² panel

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Void size remained almost unchanged on Ø44 mm / 1500 mm² panel

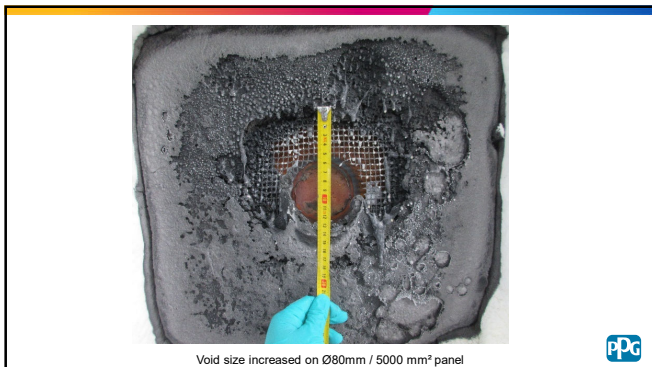
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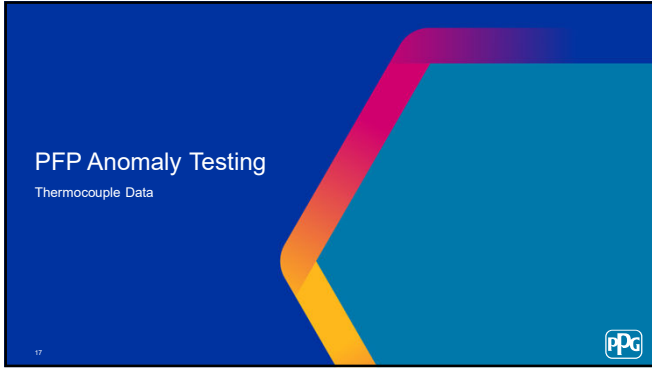
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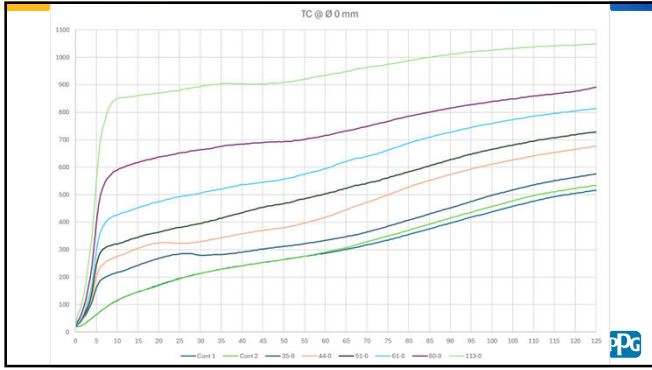
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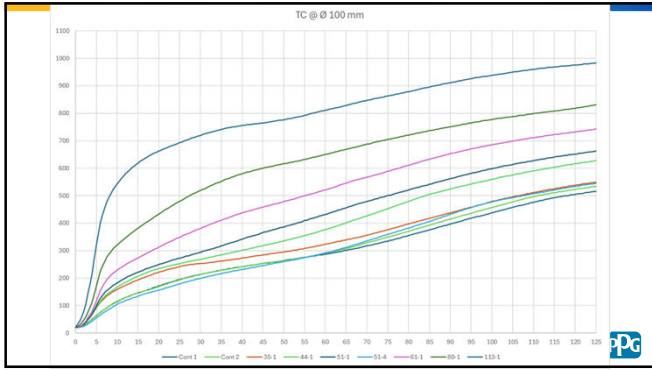
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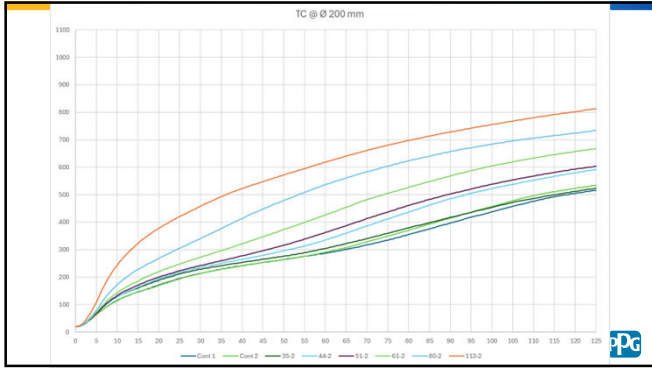
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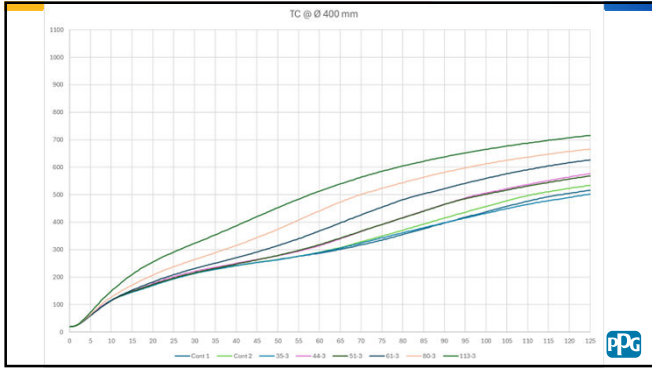
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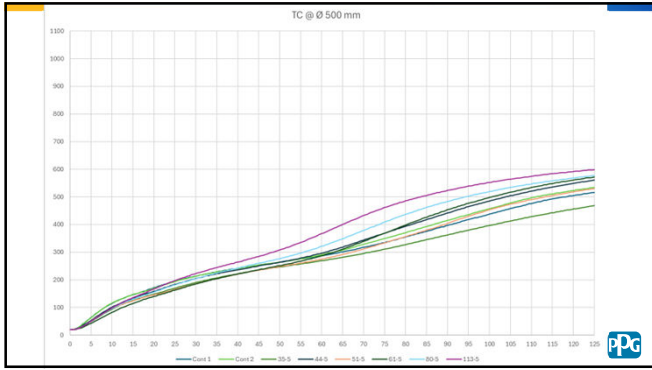
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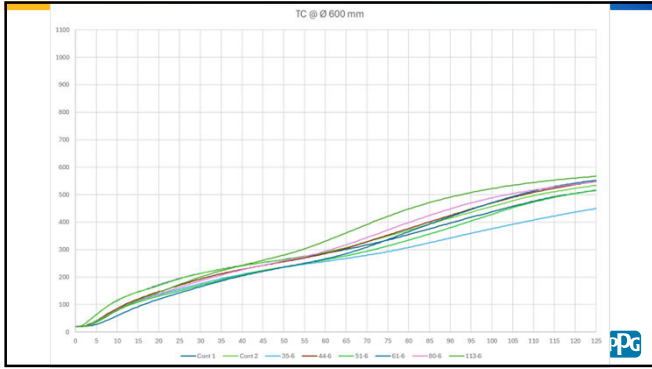
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PFP Anomaly Testing
Assessment of Performance

PPG

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Assessment Criteria
How hot is too hot!

- Industry does have some guidance that can be considered.
- Significant difference between structural steel, process equipment & divisions
 - Local hot spot could result in BLEVE
 - ΔT_{max} for insulated divisions only 180°C (~30% above average)
- UL 1709 – 20% increase in local temperature used in fire testing structures
 - Average of Thermocouple = 1000°F (538°C)
 - Individual Thermocouple – 1200°F (649°C)
- UL2431 – 15% reduction in fire duration
- In combination or mutually exclusive?

13 Performance Criteria


13.1 The determination of heat through the protection material during the period of the exposure for which classification is desired shall not raise the average temperature at any of the four levels of the steel column above 1000 °F (538 °C) and no thermocouple shall indicate a temperature greater than 1200 °F (649 °C)

13.9 Protective coating system

13.9.1 Protective performance of the protective coating system for the target thickness of multiple joints shall be as follows:

Average FT = 0.95 CRT

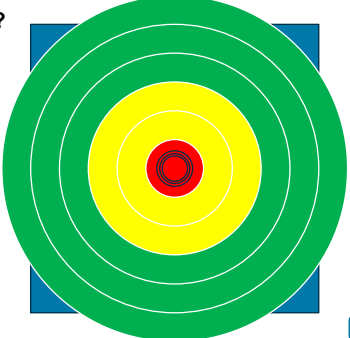
Individual FT = 1.05 CRT



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What should we target?
How do we prioritise?

- Using these industry precedents, we can help looks at categorising based on:
 - Size
 - Duration deviation
 - Temperature deviation



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Data at 120 minutes

Thermocouple	Control 1	Control 2	Ø35 mm	Ø44 mm	Ø51mm	Ø62 mm	Ø80 mm	Ø113 mm						
			962 mm ²	1,512 mm ²	2,043 mm ²	3,019 mm ²	5,027 mm ²	10,029 mm ²						
TC-0	505	523	563	117%	665	127%	718	137%	805	154%	876	173%	1044	207%
TC-1	505	523	538	110%	651	124%	732	140%	818	162%	976	193%		
TC-2	505	523	512	101%	579	113%	657	128%	724	143%	802	159%		
TC-3	505	523	490	97%	564	108%	657	128%	724	143%	802	159%		
TC-4	505	523	476	94%	555	106%	634	122%	718	140%	802	159%	640	127%
TC-5	505	523	456	90%	549	105%	619	117%	689	136%	761	151%		
TC-6	505	523	437	86%	537	103%	604	116%	674	135%	746	149%		
Average all TC	505	523	496	98%	581	111%	642	123%	718	140%	802	159%	776	151%

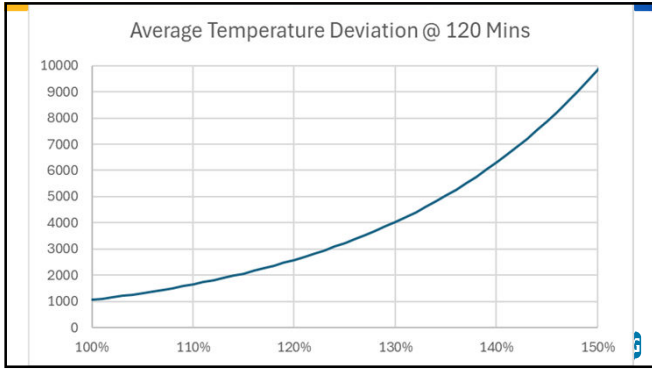
Data at 102 minutes (85% of time)

Thermocouple	Control 1	Control 2	Ø35 mm	Ø44 mm	Ø51mm	Ø62 mm	Ø80 mm	Ø113 mm						
			962 mm ²	1,512 mm ²	2,043 mm ²	3,019 mm ²	5,027 mm ²	10,029 mm ²						
TC-0	505	523	506	100%	618	118%	672	129%	766	146%	843	167%	1028	204%
TC-1	505	523	487	97%	579	113%	657	128%	724	143%	802	159%	942	186%
TC-2	505	523	462	91%	549	105%	619	117%	689	136%	761	151%		
TC-3	505	523	439	87%	533	102%	604	116%	674	135%	746	149%	670	133%
TC-4	505	523	424	84%	500	96%	584	112%	657	128%	724	143%	604	120%
TC-5	505	523	403	80%	493	94%	462	88%	505	96%	549	105%	542	110%
TC-6	505	523	382	76%	478	91%	439	84%	480	92%	496	101%	443	104%
Average all TC	505	523	443	88%	528	101%	531	101%	593	113%	645	128%	722	144%

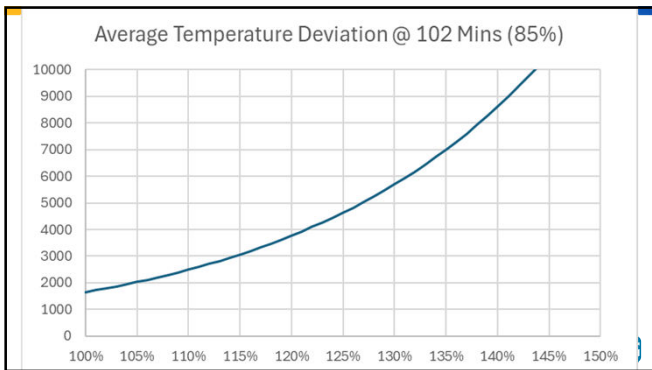
2 hours



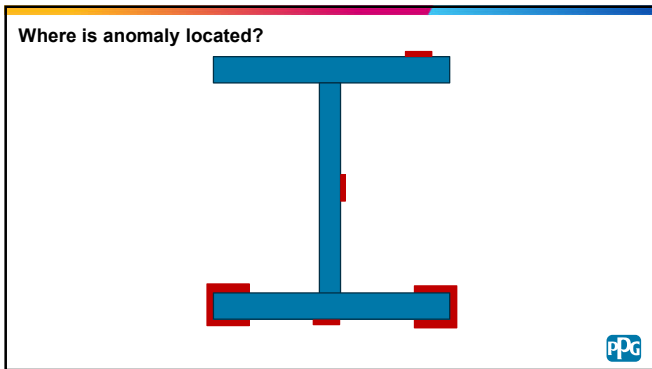
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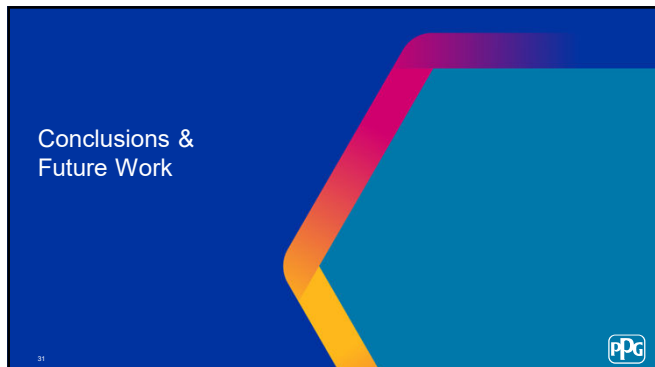
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<p>Conclusions</p> <ul style="list-style-type: none"> • No PFP = No Protection • Even small defects will cause localised heating. • A relationship can be established against anomaly size to temperature and/or time deviation. • No defect can be considered safe for process/pressure equipment. • Do we need to design in safety factors? 	<p>Future Work</p> <ul style="list-style-type: none"> • Effect of PFP thickness • Effect of jet fires • Different shapes of anomalies • Effect of multiple anomalies • Different technologies – cementitious, phenolic, AES fibres, etc <p>Acknowledgement</p> <p>Ting Wang S&T Product Development Chemist, Expert Kunshan R&D Global Technology Centre</p>
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Thank You

Questions?

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