Hydrogen Bakeout Monitoring

Superheat FGH, 13 November 2012

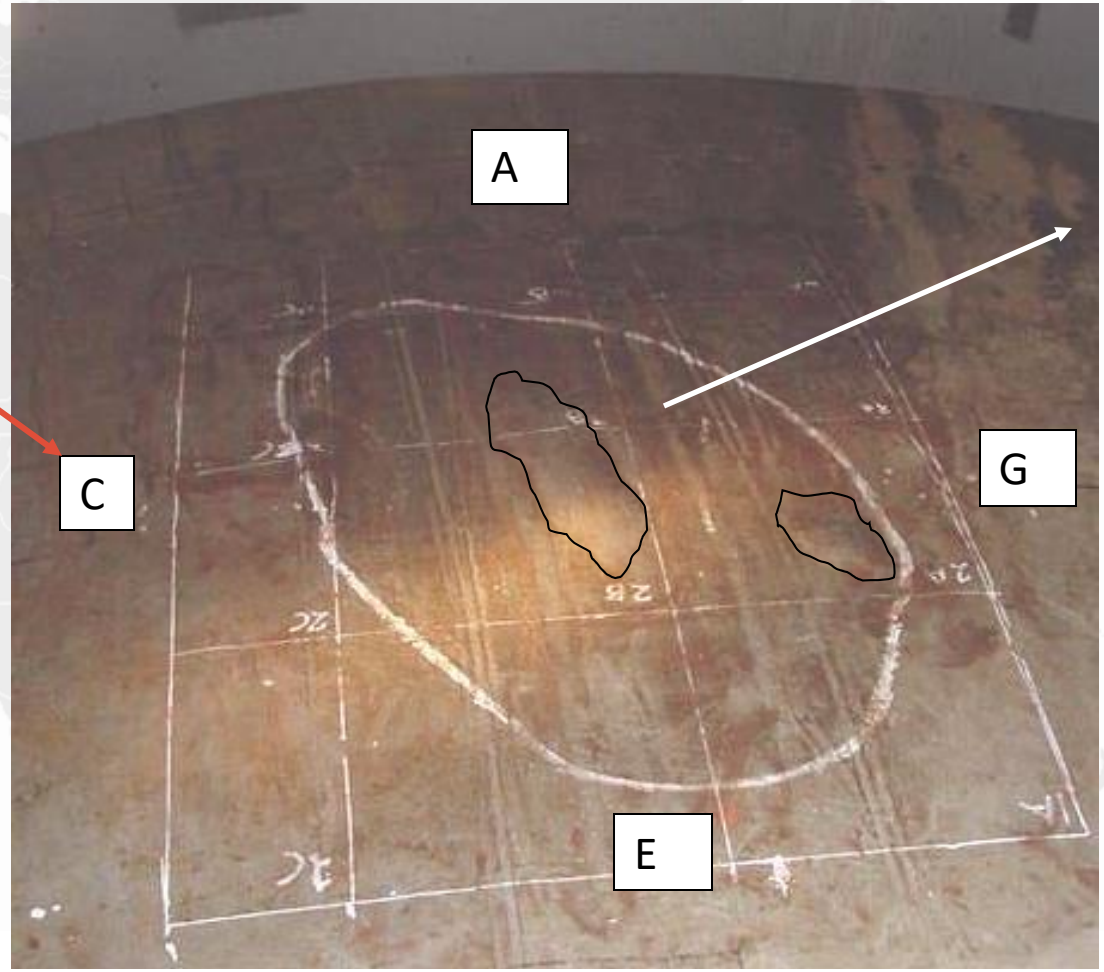
Frank Dean

Cases of Monitored Bakeout Preventing Unscheduled Downtime

Case A

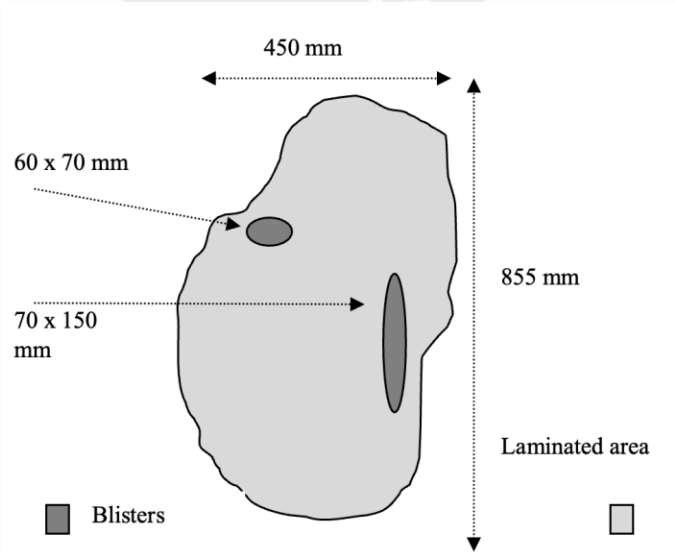
Vessel dome in HF service had sustained hydrogen damage. Areas of blistering are indicated

Arrow shows direction of recent lamination growth

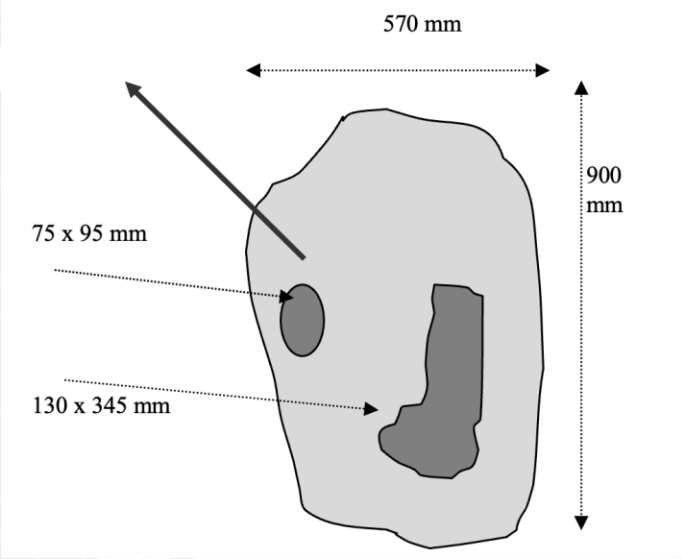


…as determined by TOFD and USTM.

Sept. 1999

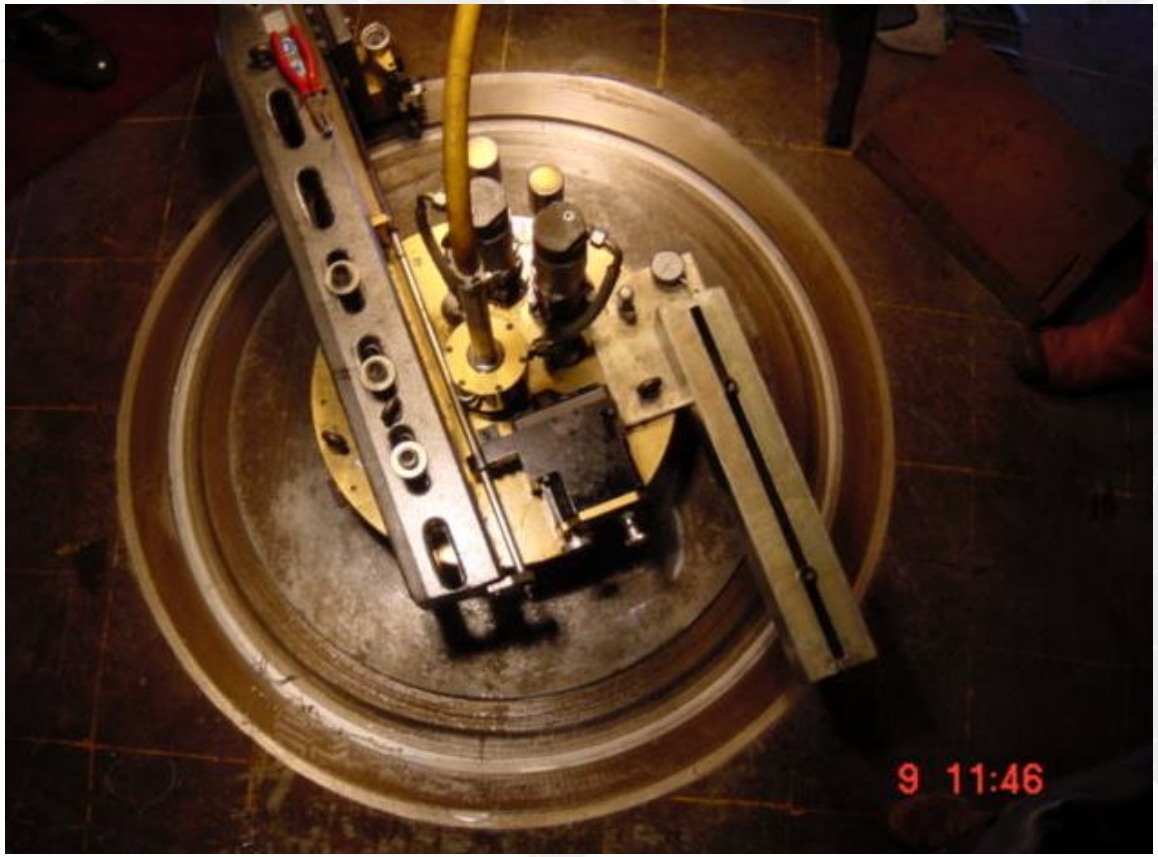


Dec. 2000

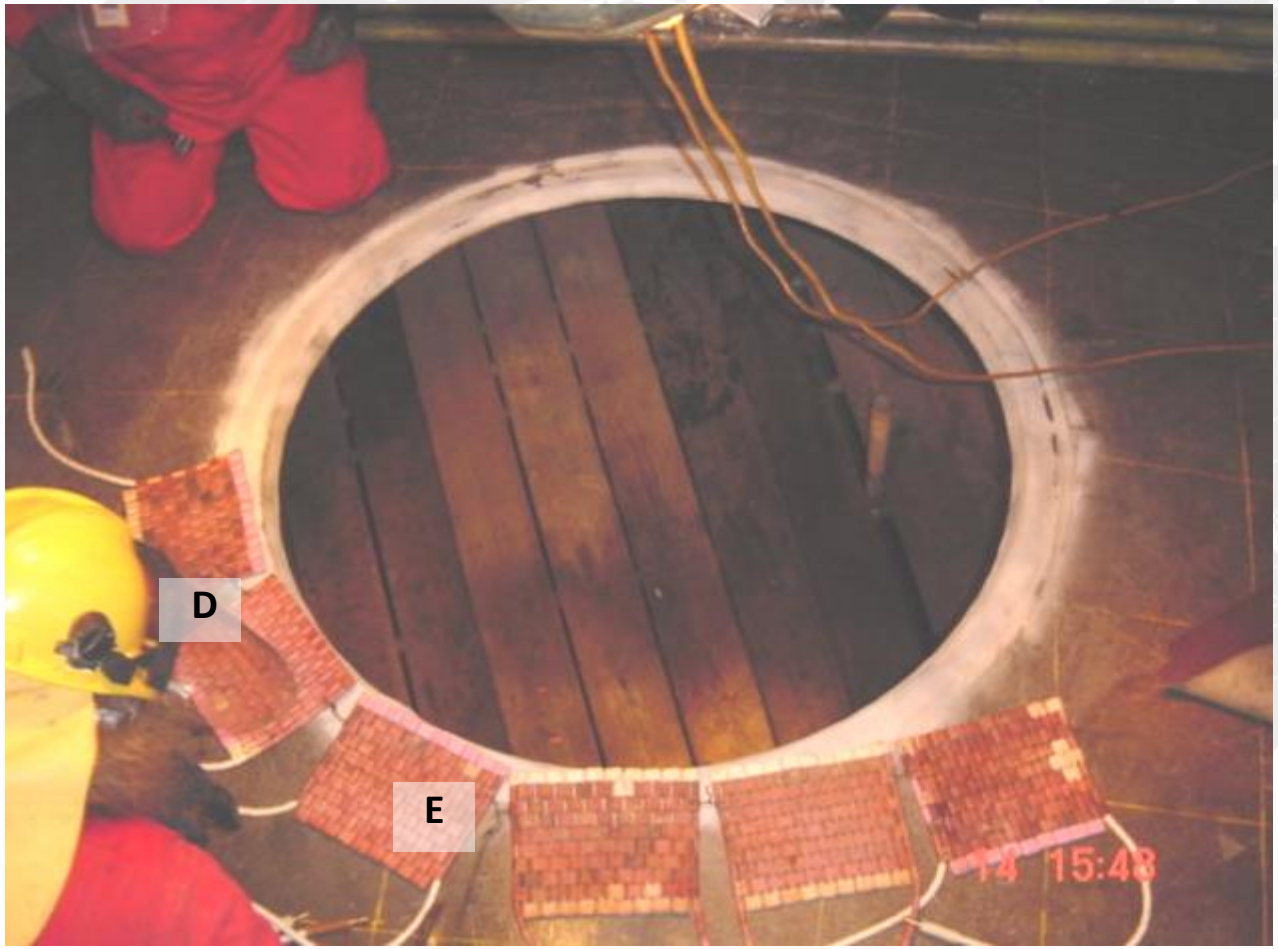


Steel 4cm thick, Damage was 7 – 15 mm from *external* face.

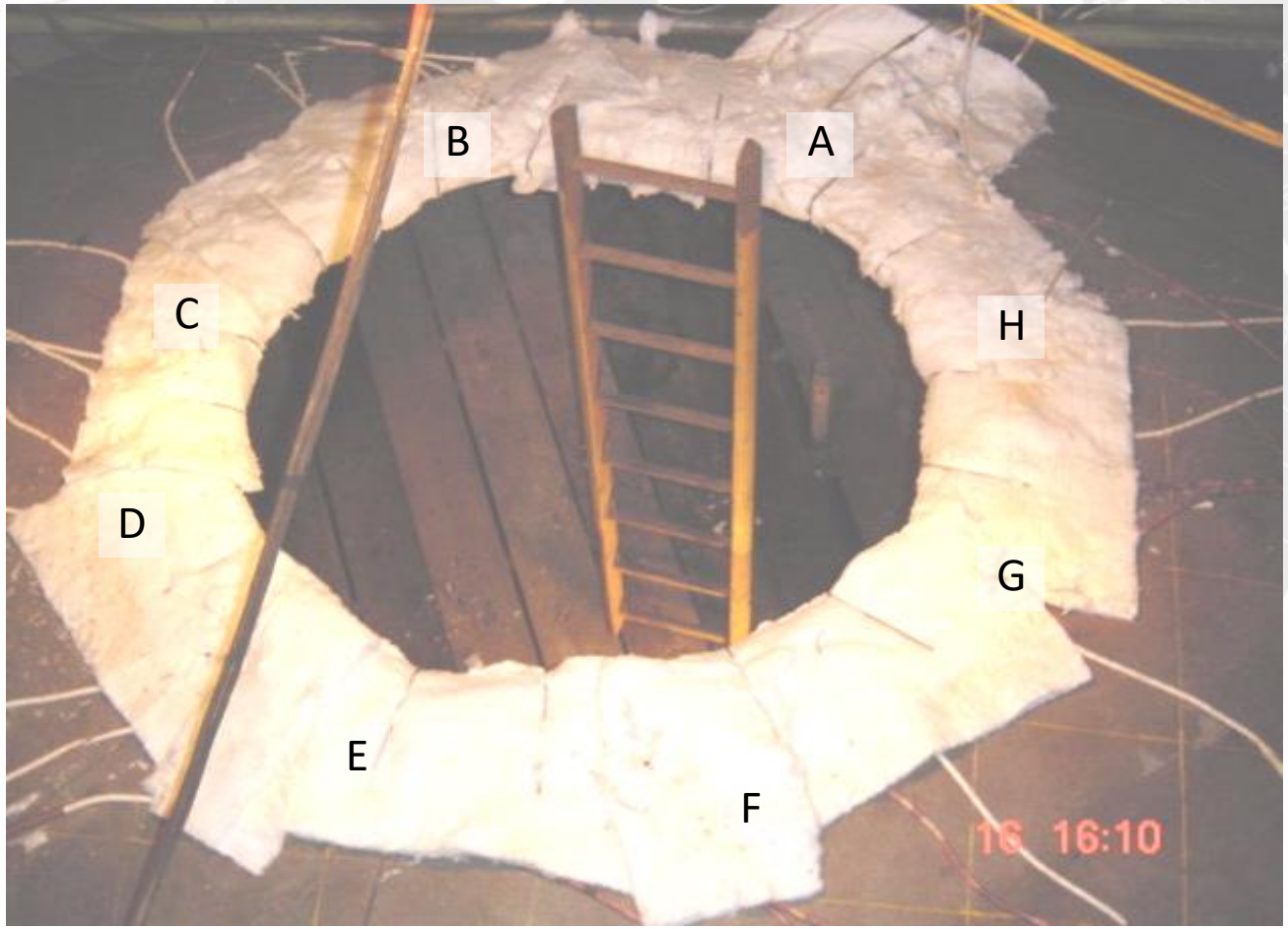
It was decided to remove the affected steel:



…set up heat treatment circuitry…



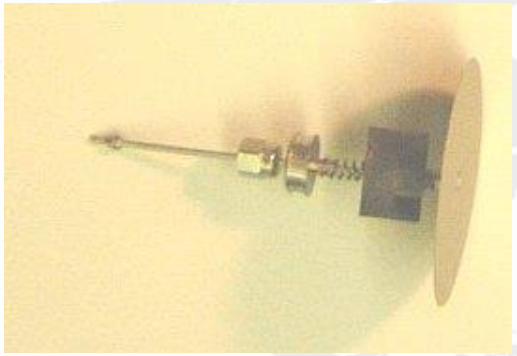
…bake out at 300 degrees Centigrade whilst monitoring hydrogen at circumferential sites, note 3 is normally sufficient …



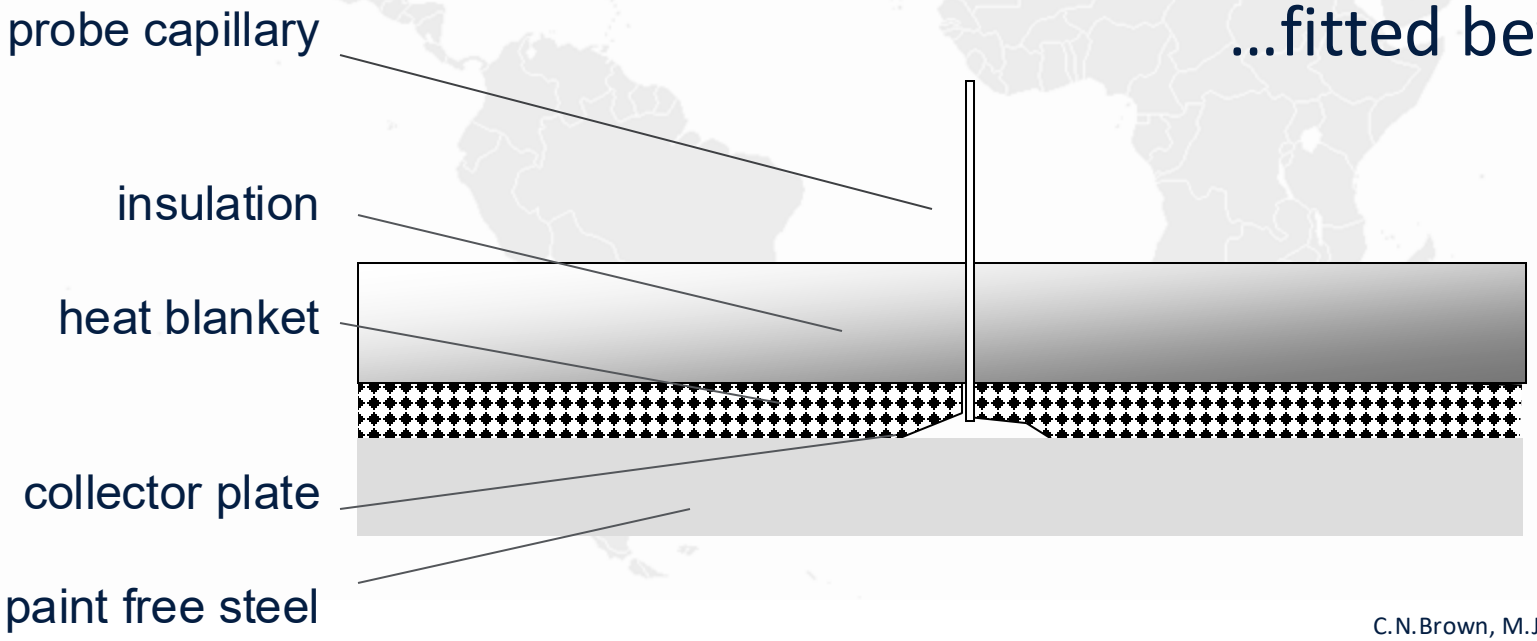
…and fit a new plate.

Hydrogen Monitoring

Hydrogen monitoring engaged the Hydrosteel® HT-R probe…

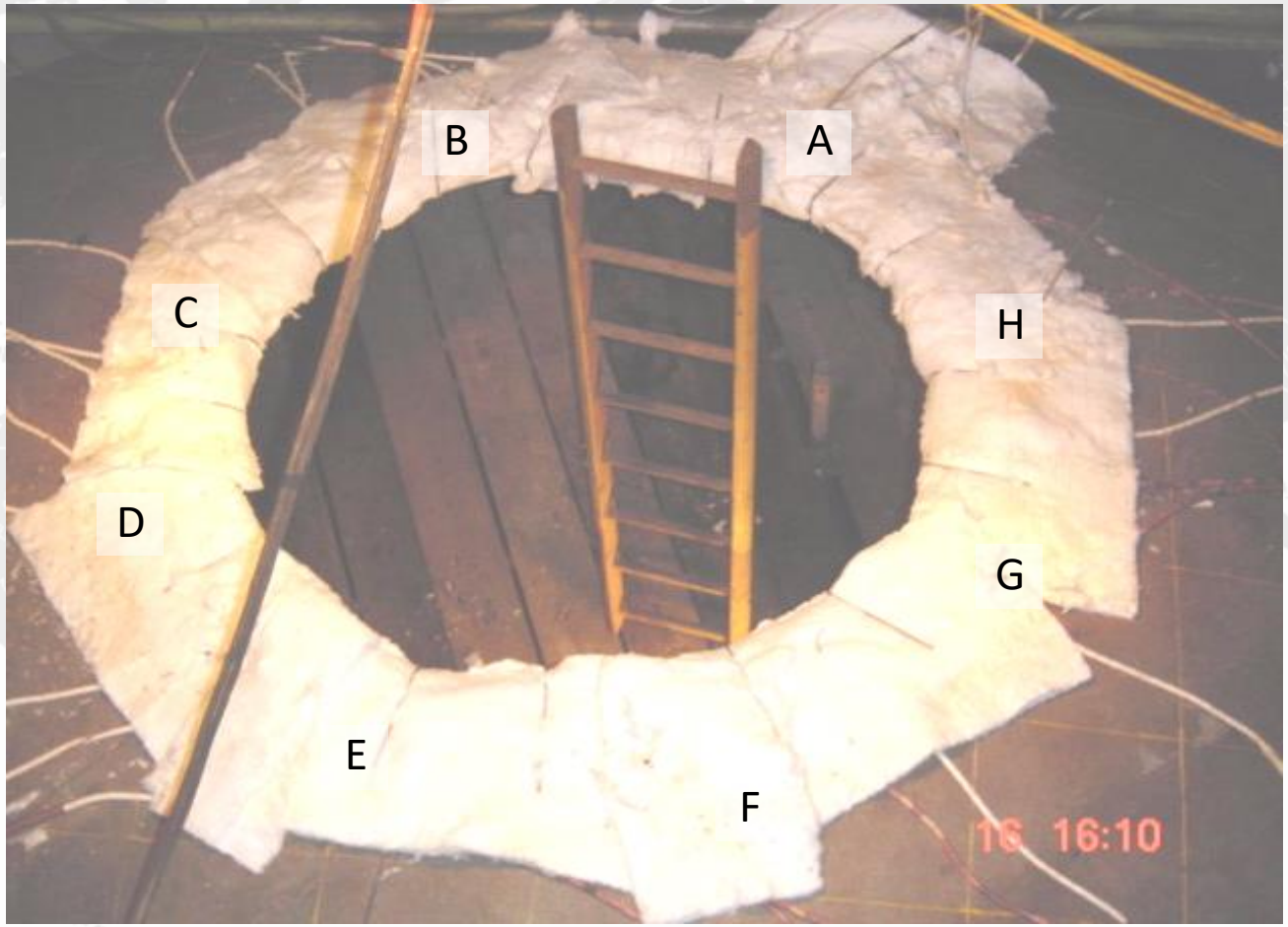


…fitted between adjoining heat pads…



C.N.Brown, M.J.Carroll, F.W.H.Dean, J.H.Harrison, A.Kettle, Corrosion 2004, NACE, Paper 04478.

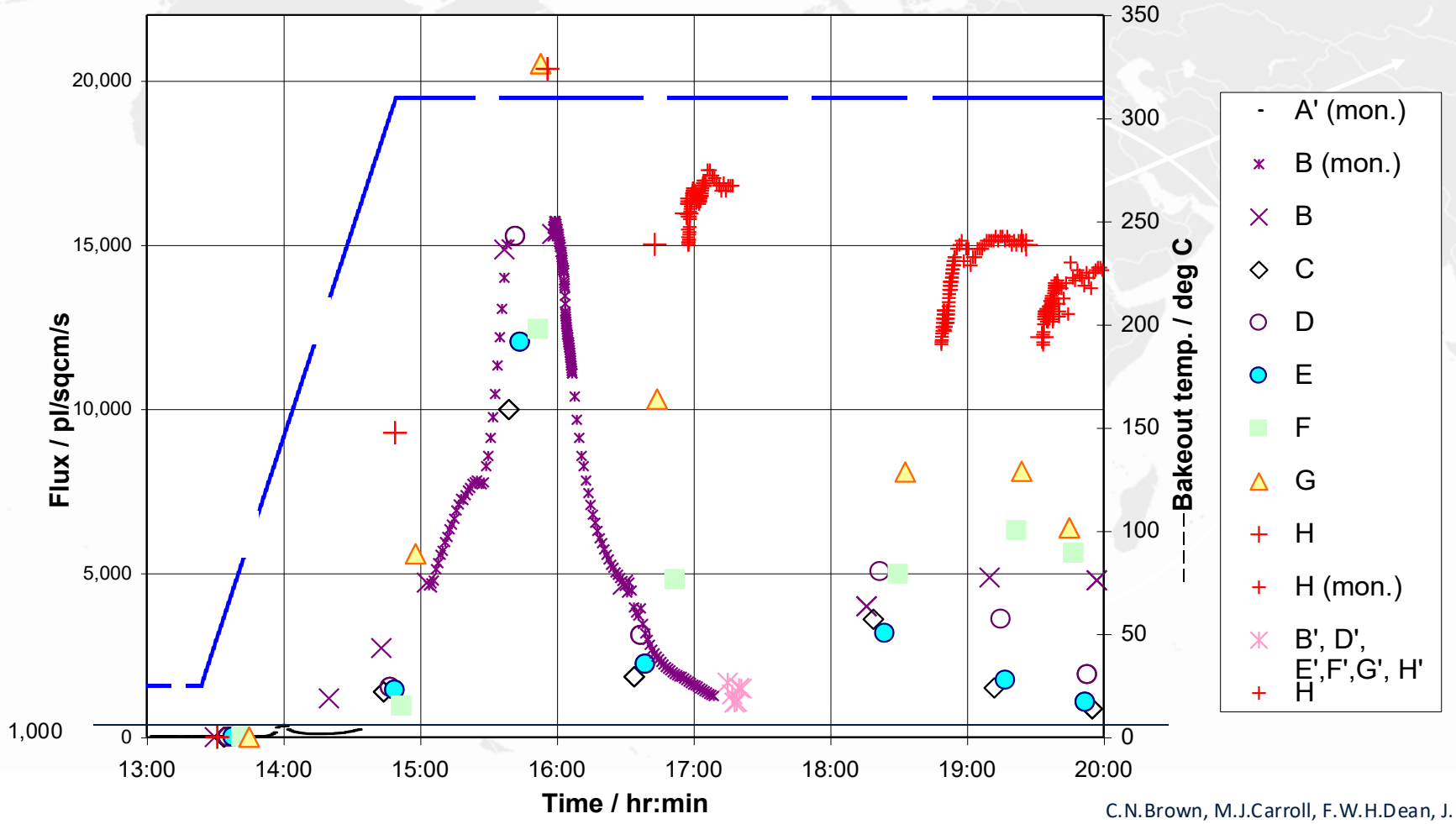
Monitoring Sites



C.N.Brown, M.J.Carroll, F.W.H.Dean, J.H.Harrison, A.Kettle, Corrosion 2004, NACE, Paper 04478.

Top of vessel in HF service: 8 circumferential locations

Note:
- co-trending of all sites
- flux peaks at 16:00 hr
- low flux from entry face sites
- flux magnitude

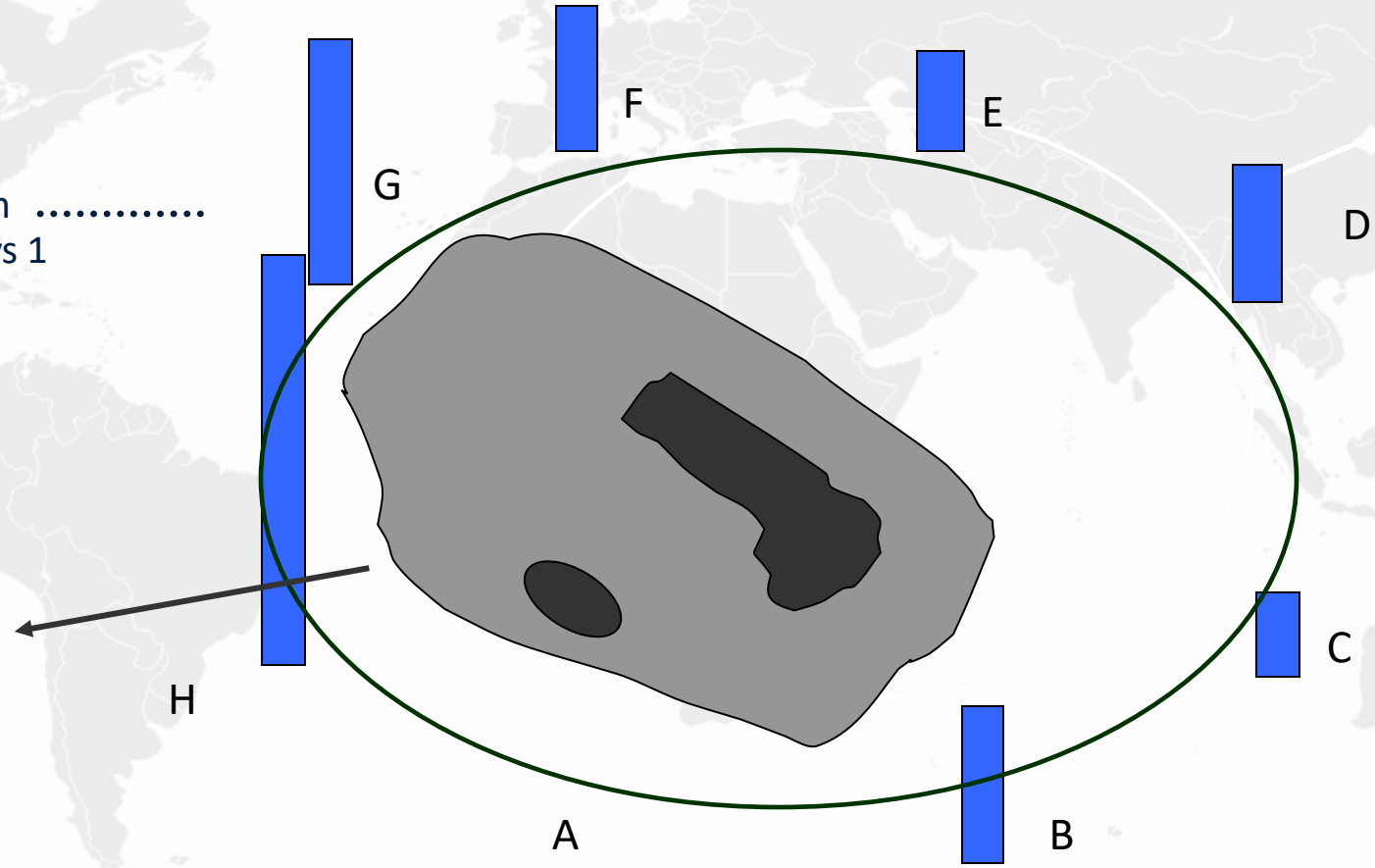


C.N.Brown, M.J.Carroll, F.W.H.Dean, J.H.Harrison, A.Kettle, Corrosion 2004, NACE, Paper 04478.

Correlation of bakeout monitoring data with historic damage

Outgassed concentrations obtained by summing area under each site flux profile: e*g* 10,000 pl/ cm^2 /s for ~3 hr = 1 ppm.cm hydrogen in steel

3.00 ppm.cm:
= 1.2 ppm from .....
2.5 cm depth vs 1 ppm weld threshold!



Direction of lamination growth

C.N.Brown, M.J.Carroll, F.W.H.Dean, J.H.Harrison, A.Kettle, Corrosion 2004, NACE, Paper 04478.

Due to high flux, monitoring was continued for an additional 8 hours whereupon it fell below 1000 pL/cm^2/s.

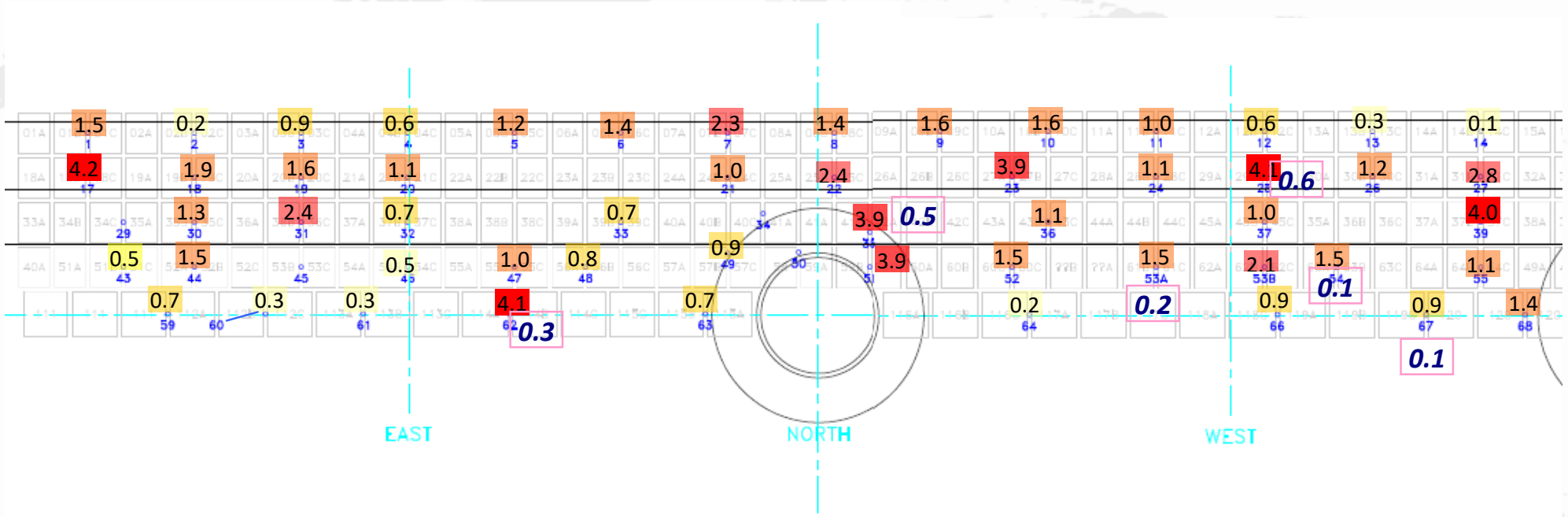
Case A Conclusion

This eliminated a small but significant risk of weld failure that could have cost $2-3m in lost production alone.

Refiner wrote into procedure discontinuance of bake out permissible after reaching peak temperature, on decreasing flux of <1000 pL/cm^2/s.

Major Installation Engaging 66 Probes

Major Installation Engaging 66 Probes



Total outgassed hydrogen in PPM colour coded. Numbers in italics indicate estimated remaining diffusible hydrogen in excess of 0.1 ppm at a few sites

Case B Conclusion

Due to high flux, bakeout was correctly extended to 16 hours.

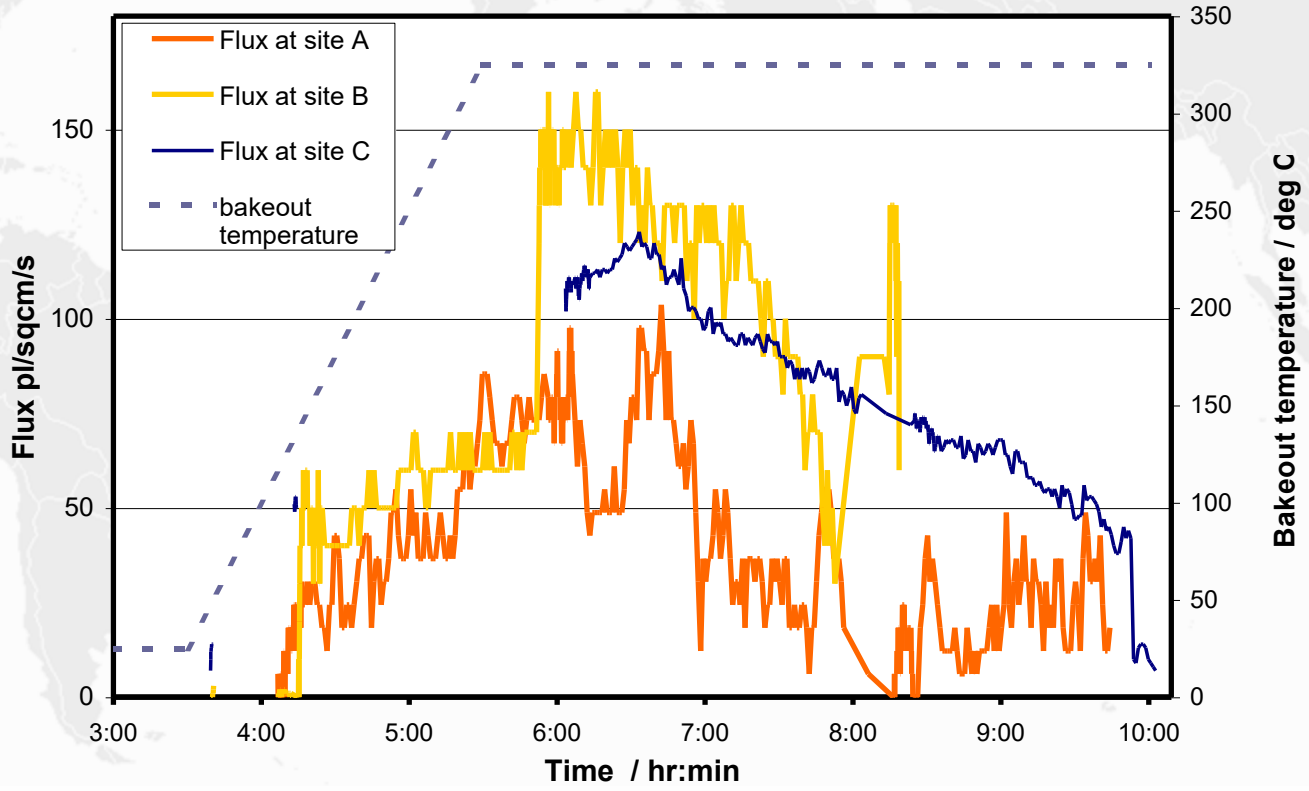
This eliminated a small but significant risk of weld failure which would have cost an estimated $5-10M in lost production alone.

The exercise enabled more confident profiling of hydrogen escape.

Case Studies Enabling Foreshortened Downtime

Case A

Pre-weld hydrogen bakeout monitoring on three equidistal, circumferential sites on a high-pressure hydrogen column section, 5cm thick. Service ~80ºC



C.N.Brown, M.J.Carroll, F.W.H.Dean, J.H.Harrison, A.Kettle, Corrosion 2004, NACE, Paper 04478.

Case A Conclusion

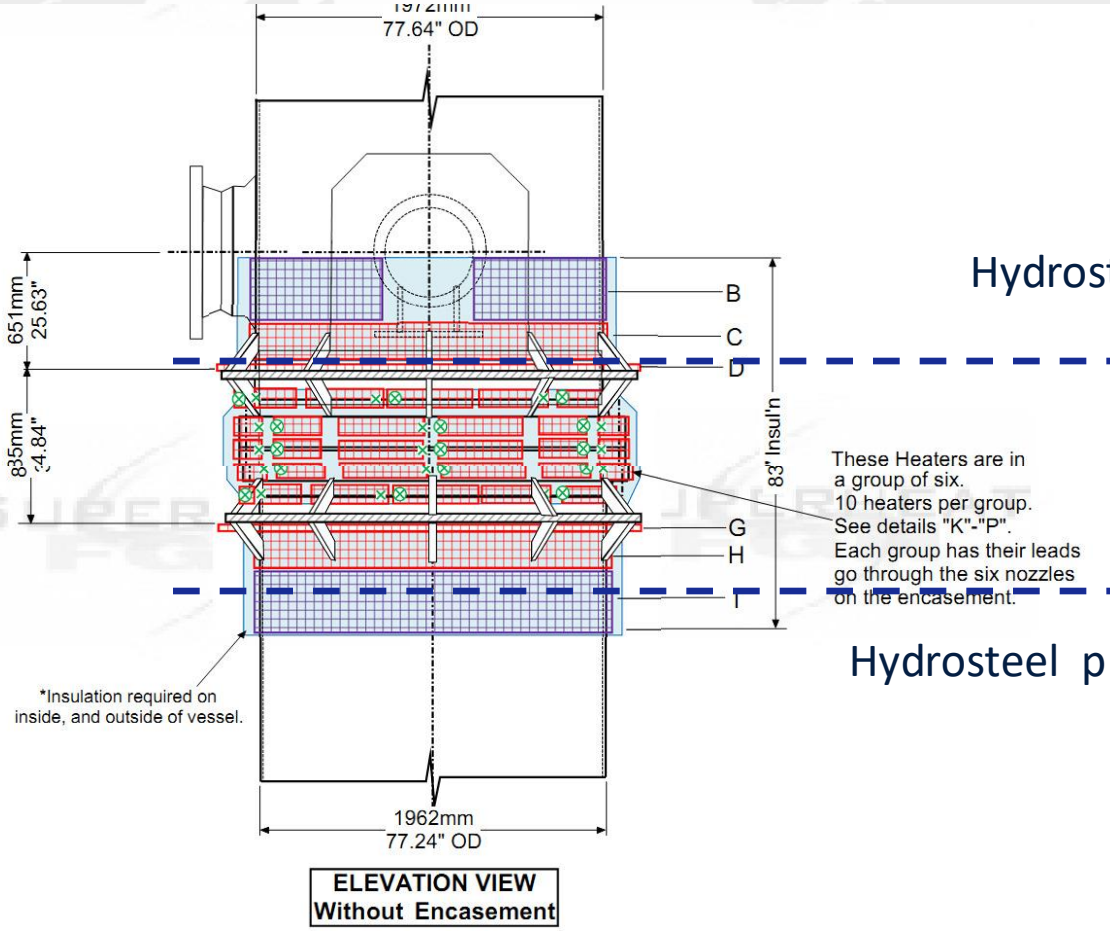
Turnaround on column potentially foreshortened by 4 hours.

Cost of monitoring: $5k

Estimated average saving: $35k

Case B

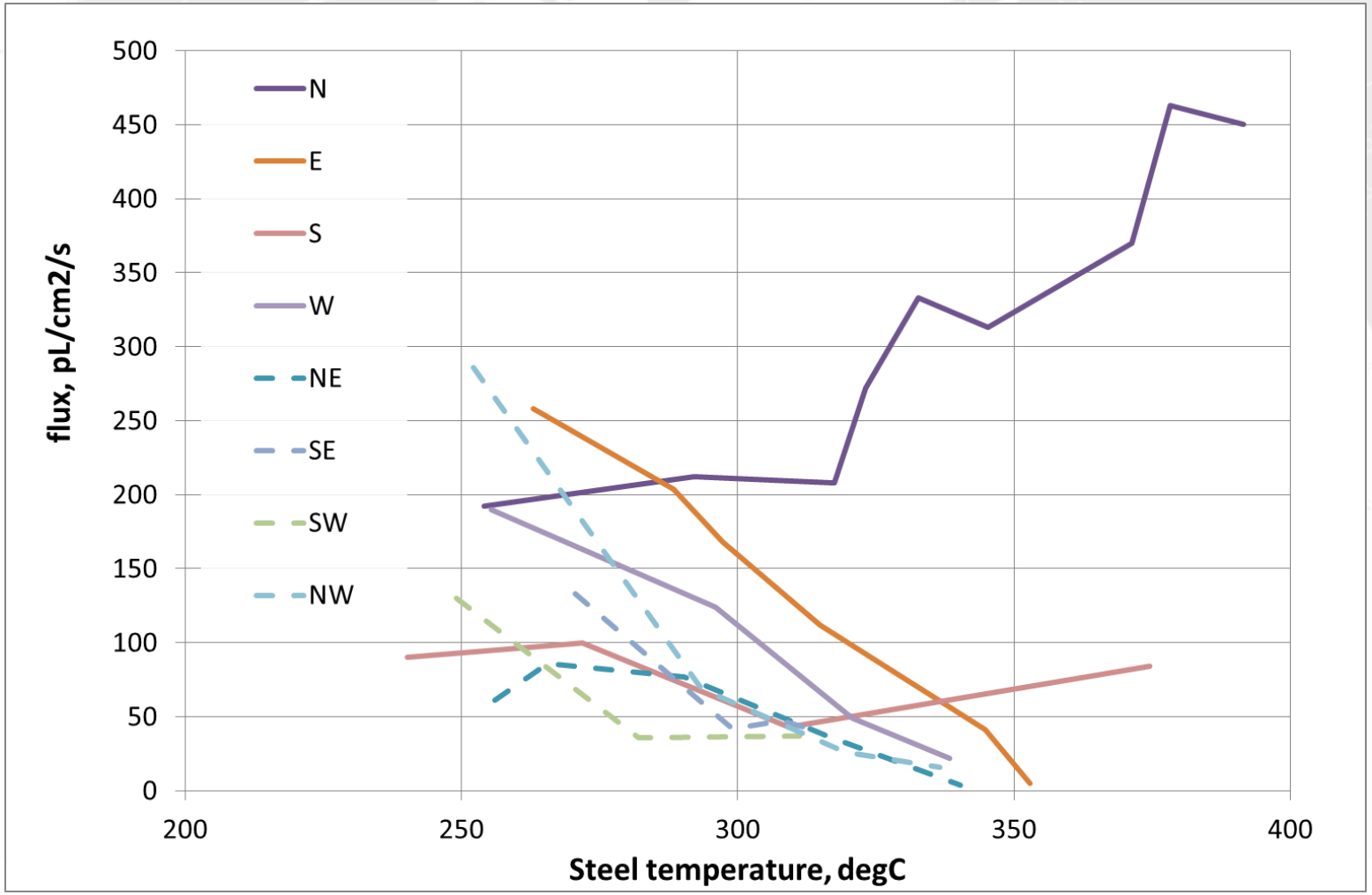
Texas tower encasement repairs - PWHT



Hydrosteel probes placed N,E,S,W

Hydrosteel probes placed NE,SE,SW,NW

Flux versus temperature



Case B Conclusion

Turnaround on tower, behind schedule, foreshortened by 6 hours.

Cost of monitoring: $7k

Estimated Average Saving $70k

Hydrogen bakeout monitoring foreshortens equipment turnaround by hours, eliminates risk of weld failure and always reassures.

Plant integrity staff realise the advantages of a monitored hydrogen bakeout over blind procedure.

The missing link is real-time bakeout monitoring offered on a worldwide basis.

Superheat FGH.