

An end-user perspective on Australian pressure equipment industry developments

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Introduction:-

- My mandate (Guideline!):
 - Account of Australian pressure vessel code development
 - User perspective on pressure vessel performance
- ‘Stories’
- Trevor Kletz (1985) ‘What went wrong’¹
- Trevor Kletz (2003) ‘It’s still going wrong’¹
- Why?
- Andrew Hopkins: “Organisational Inattention²”
- My thesis: OI causes Safety, Technical and Commercial mishap
- And to all industries and businesses – and Standards & Regs
- And to this address? You be the judge!

Setting the scene:

- “Why is ‘*Welding*’ important?” (What is its ‘Place’, it’s Context?)
- Sits at Node between:-
 - ‘Process’ design
 - Mechanical design
 - Actual operation
 - Inspection/NDT
 - Corrosion
 - Materials
 - Maintenance
 - etc etc
- Who ***really*** understands this?
- Who else ***should*** really understand it?
- What other aspects of industry should they understand?
- And ***HOW*** are they to understand it?

Stories: Why are 'Stories' important?

- Andrew Hopkins, 'Disastrous Decisions'³, encourages story telling:
- “Many accidents are disturbingly similar to previous occurrences, -- the lessons of those - events have not been assimilated. It is not enough to send out bulletins --. Companies must ensure that their staff have really learnt the - lessons. One way -- is to tell ***and retell*** the stories -- so that people are sensitised to (past) mistakes – and recognise - precursor events. Because catastrophic events are beyond the direct experience of most people, learning from one's own experience is generally not an option; one must learn from the experience of others. Storytelling was -- important -- in pre-literate societies. In an era where information is transmitted at ever-increasing rates, taking time to tell (*and listen to**) the stories is still a vital means of ensuring that lessons are learnt.”
- Stories *should* be entertaining – and instructive!
- *I added '*and listen*'. And it's not just 'Staff' who need to learn – managers too.

Overview:

- The decline of the Australian refining & PV Fabrication industries.
- Overseas PV manufacturers.
- An account of the refining industry and its safety considerations.
- Stories of failures and the reasons behind them, including some not related to pressure vessels, to show the same factors apply.
- Stories of commercial and other incidents – again, the same factors apply.
- Discussion of ‘Organisational Inattention’ or ‘lack of engagement’ which is behind almost all failures, and the decline of many successful manufacturing and other businesses, and how this relates to issues with Australian Standards.
- If Organisations really ‘understood’, many (most?) incidents would be averted.

Australian Oil Refining - An industry in decline.

- Pre 2012: 7 refineries, Total 760,000 bbl/day (120 million litres).
- Three refineries closed 2012 to 2015 - four remain as follows:-
- Mobil Altona: - profitable, crude from Exxon Bass Strait, then -??
- BP Kwinana – feedstock (condensate) from NWS then - ??
- Shell Geelong sold to Viva - ??
- Caltex Lytton (Brisbane) - ??
- WHY the decline?
- All built in a commercially easy or protected environment
- Protection removed in late 1980's
- **BUT international obligations (Tanks 109/110)**
- Global competition increasing: Reliance refinery (India) 1,200,000 bbl/day.
- But half US refineries <100,000 bbl/day - ??? (Pipelines??)

Bulwer Island Refinery

Crude Column 1.8m dia



Reliance Refinery
Crude column – 10 to 12m dia?



Australian Pressure vessel manufacturing - An industry in decline?

- Many major manufacturers closed – or hanging on
- Not assisted by fabrication errors
- Many smaller manufacturers apparently thriving – diversified?
- Much of the o/s opposition is a lot bigger.
- Is the size of a fabricator important to its success?
- Efficiencies?
- Customer base?
- Customer expectations?
- Is the o/s opposition ‘better’?
- Or is it just unit cost?

Fabrication failure – HP reactor (to the left in the photo)

- 18MPa @ 450°C
- 2 ¼ Cr 1 Mo ¼ V
- 3m ID x 32m tall
- 430 tons
- (cf 1500+ tons)
- 170mm thick shell
- Italy 1999
- Biggest fabricator I had ever seen



5" Nozzles

Single forging
Set-through
Integral flange



Nozzle cracked during fabrication

Through-wall at nozzle boss

Y shaped crack

Total length determined by UT - 2.5m



Internal view

Through-wall at boss
Cracked under
stainless steel lining



Cause #1:-

Litany of what not to do:

- Local preheat
- Local DHT (350°C) instead of full-girth ISR (630°C)
- Intent: Save Time and Cost

Result:

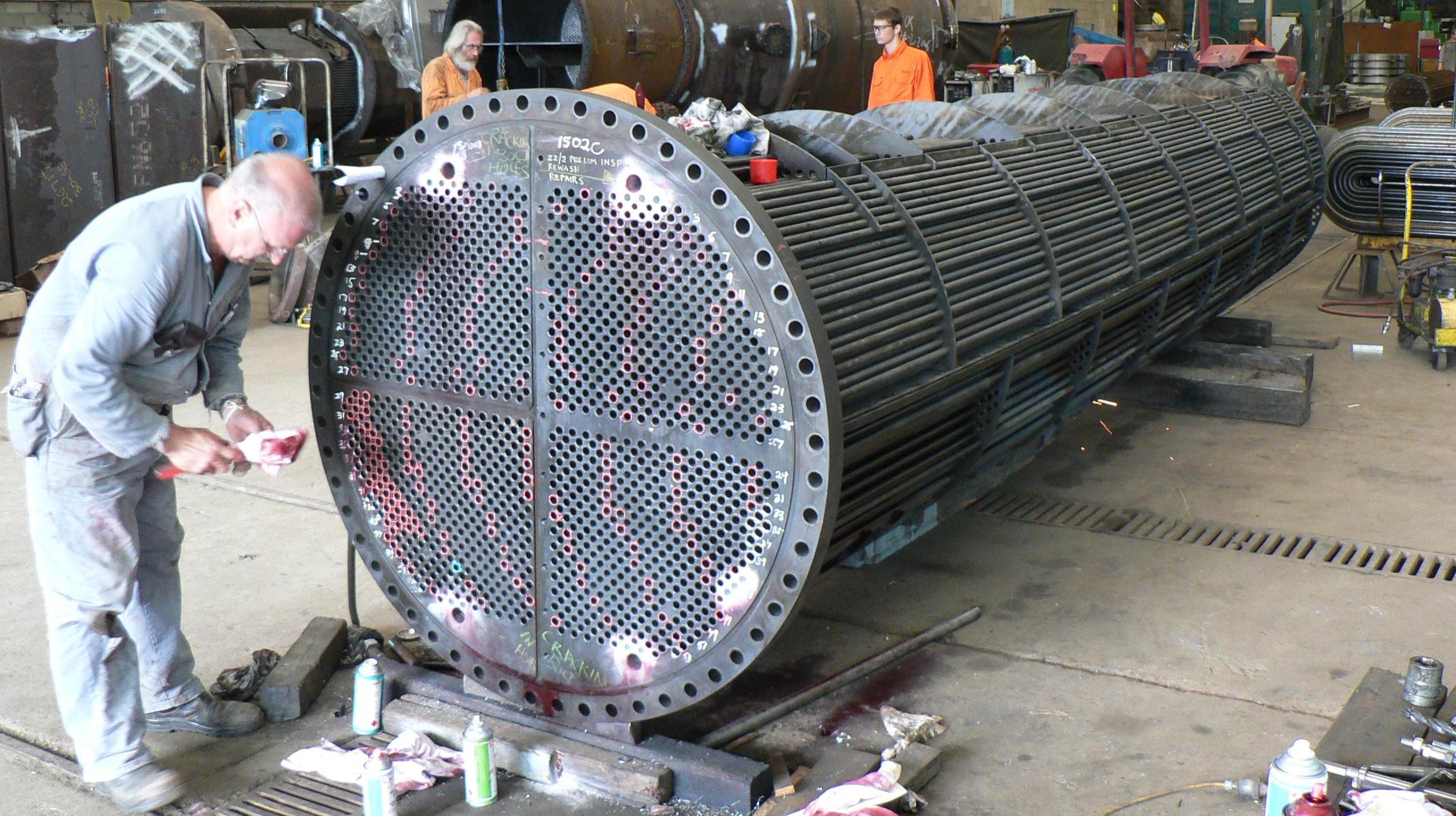
- More Time and Cost
- Our (BP's) project under threat.
- Fabricator under threat (and went out of business).

Underlying cause:

- Organisational Inattention
- 'Misdirected leadership'

Cause #2:-

- Local Consumable supplier – matched composition
- As-welded weld metal Charpy: 7J
- Years later:
- Martin Prager, MPC - developed the material
- Major issue: Ductility of as-welded consumable
- ?? Missed by licensor, engineering contractor, etc.
- ‘Organisational Inattention’ in fabrication design/specification?
- (Consumable supplier had known -- ??)



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22/2 PRELIM INSP
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High pressure heat exchanger

CISCC

Chlorides from hydrotest water??

Design/drafting oversight:-

Eye-bolt location only shown with centre-point and Dia.

(OD not drawn)

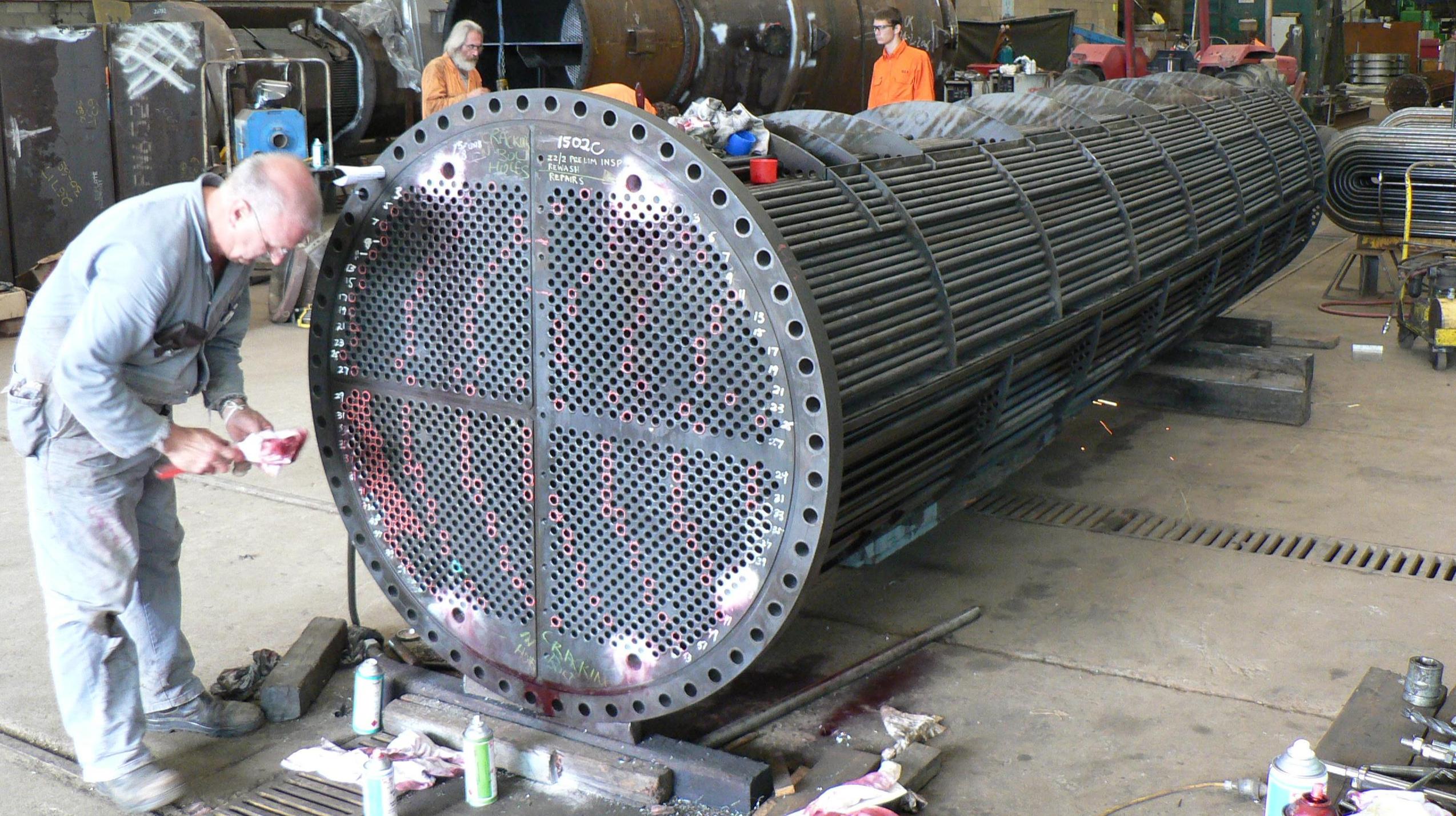
'Design inattention'

Non-empowered (or sleeping!)
workshop supervisor?



Outcome:

- To fabricator:
 - None.
 - The crack was found at first TAR after 6 years in service.
 - Fabricator long out of business (an incident with an 8 foot long crack in a heavy walled reactor built around the same time as this exchanger).
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- To us:
 - 10 years production with minor leak affecting product quality and \$ (never quantified).
 - \$250,000 for a new bundle (possibly not worth the cost!).



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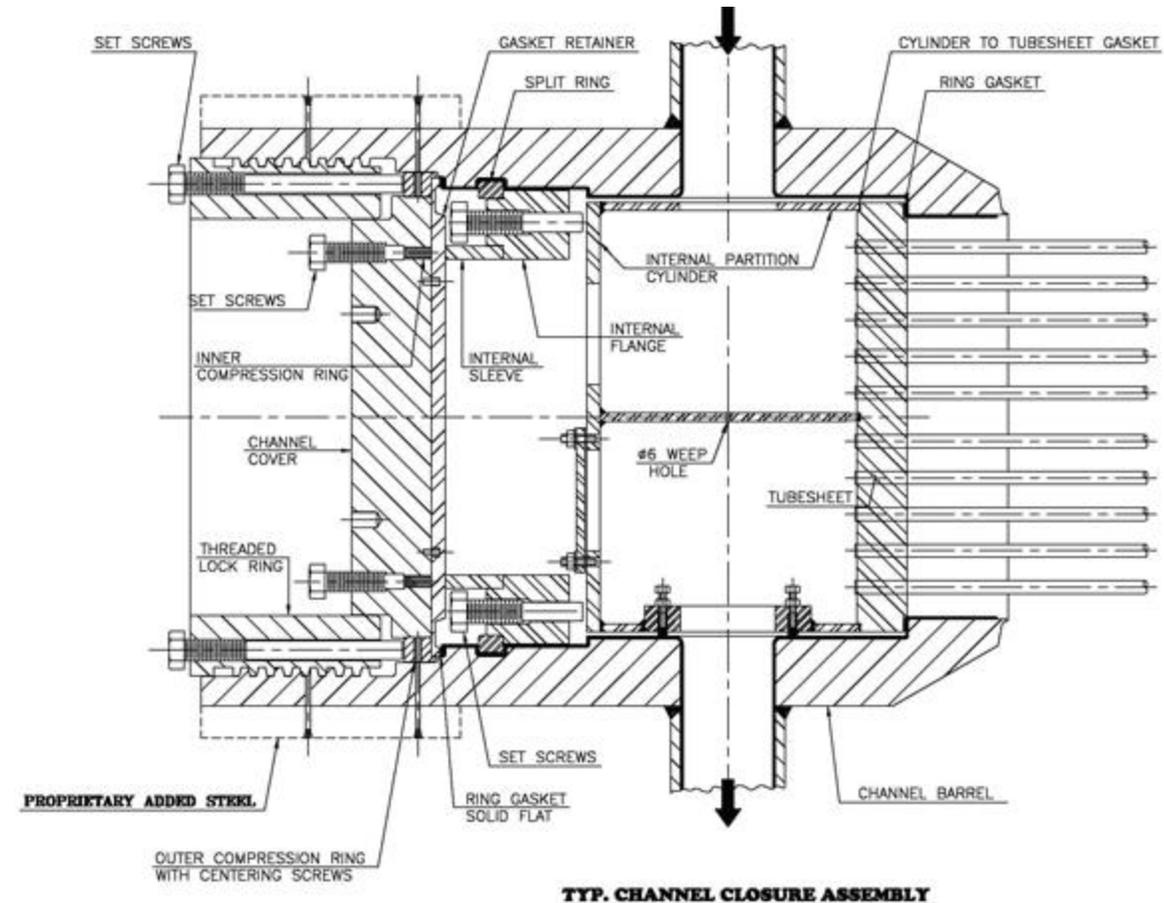
Issues with o/s fabricators:

- Pressure Swing Absorbers (9 off – Korea) – CS, 65mm wt, 2m ID
 - Girth welds RT with Cobalt in panoramic shot
 - Repairs performed – ‘adjoining defects’ ignored (360°!)
 - Fatigue duty (17 min cycle) – intense and costly inspection over life of vessels.
- Heat exchangers - Thailand – virtually re-welded at first TAR
- Critical heat exchanger made in China (Anhydrous HF/Cooling water)
 - Every tube tacked to **back** of tubesheet (I had spec'd no tacks– though I was thinking of the front!)
 - 1400 little, unproven welds! In AHF service!!
 - Very long bundle – vertical in service, huge stresses during maintenance
- Chinese cryogenic flange – non-isotropic properties
- Comment from Chinese conference attendee: Did we realise that Chinese engineers do not interpret codes? (Government job.)
- Chinese workshop with posters all around – in English!

- Examples of ‘Organisational Inattention’?

Issues with o/s fabricators (2):

- Dutch fabricator: Monel channel.
- Breach lock exchanger (Singapore: JSW)



Refining – an overview

- Convert crude oil into useful products (mostly fuels).
- Processes include: Fractionation, Thermal Cracking, Hydro-processing, hydrogen production, Reforming, Coking, Alkylation and other 'chemical' processes, Desulphurisation, Sulphur production.
- Utilities (Steam, Air, Nitrogen, Water, Cooling water etc.), Tankage
- Processes range from low pressure and temperature to severe conditions
- Process Design critical: eg Relief cases – HAZOP, HAZAN
- Operational safety critical: HAZOP, procedures, training
 - Steam-out of relief line in acid section of HF Alkylation unit (HFA).
 - Repeated corrosion failures of a drain line, also in HFA, explained when we found an operator was in the habit of flushing it out with a water hose.
- Plant integrity critical: Many damage mechanisms, high consequence of failure.

Organisational Inattention

- “ – the attention of the organisation was simply not focussed on the control of catastrophic risk” (Andrew Hopkins, ‘Managing major hazards’.)
- Applies to (almost) all catastrophic failures
- Applies to Titanic, the Comet disasters, Flixborough, ---

Replace the word ‘catastrophe’ and it also applies to:

- the fabrication incidents
- many commercial failures
- corporations who fail to respond to a changing environment

- (Attention to slips & trips instead?)

Flixborough and other preventable disasters --

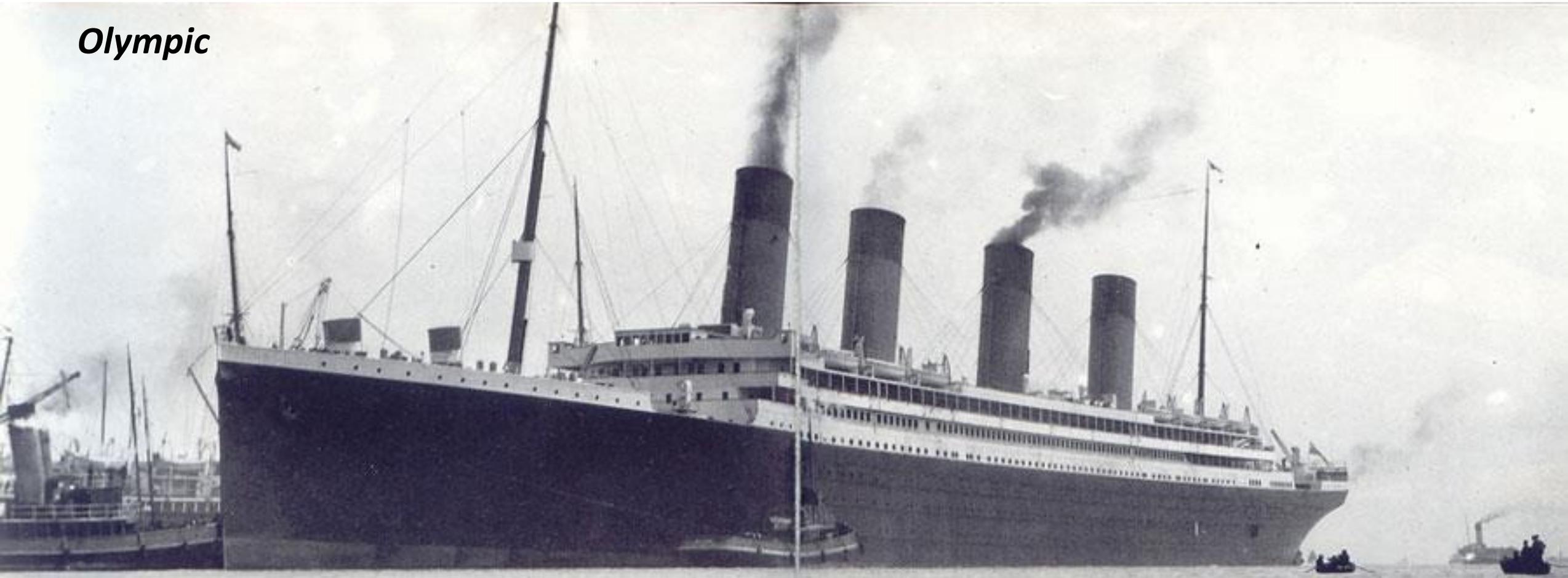
- 1974 – Chemical plant destroyed by massive explosion - **only** 28 killed
 - Temporary pipe ‘designed’ and installed by Chemical engineers
 - Industry Response:- HAZOP (?) – irrelevant
- Comet: First commercial jet airliner – several broke up in flight
 - Fuselage pressure tested *then* fatigue tested – unrealistic life prediction
- Asbestos: Health concerns known 1920’s – little concern for 70 (?) years
- Bhopal: Release of Methyl Isocyanate (MIC) (AS4343: VHL)
 - 3000? 8000? dead, 40,000 permanently injured, 550,000 affected
 - Storage of MIC not necessary
 - *Production* of MIC not necessary (but higher production cost)
- Union Oil, Chicago, 1984: MEA absorber column repair weld – 18 dead
- ‘Unchanging level reading’ – Bulwer Crude tank, Texas City, Bunccefield.
- Signal Hill fire 1958, Amoco Bulwer Island Tank bund design 1963/4

-- and commercial incidents:

- US and British vehicle (& motorcycle) industries:
 - Blind to Japanese Performance, Quality and Customer focus
 - Joseph Juran, W. Edwards Deming: TQM
 - Has to be driven **at** (my word) the TOP of the organisation
 - BL: Preserve the Line at all costs (eg non-heat treated engine components)
 - Labour relations – ‘British Disease’
 - Harley Davidson – saved by committed management
 - - what (had) separated Harley-Davidson from its Japanese competitors: “It wasn’t robotics or culture or morning calisthenics and company songs; it was professional managers who understood their business and paid attention to detail”⁴
- ie it’s all the same thing – Organisational Inattention

Recognise this ship?

Olympic



White Star Line (abridged history)

- Founded 1845; 1868: Take-over by Thomas Ismay, (1837 – 1899)
- “– Commanders must use their intelligence to - navigate - whilst securing their passengers with a comfortable - crossing. Safety and security are a top priority. Steer your ship for -- safety, not for a gain in speed or obbsinety.”
- Ships foundered with great loss of life, typical for the times?
- Bruce Ismay retained policy for comfort (even in steerage!) over speed
- (Partly economic – horsepower quadruples 22 knots to 25)
- Nevertheless, Ismay:
 - Retained Commodore Edward Smith despite his ‘well grounded career’
 - 3 groundings 89-09; Olympic in 2 collisions + lost propeller 1911; reckless speed; failed to train officers
 - Chose Smith for Titanic’s maiden voyage – and Smith’s valedictory (!!)
 - Contrary to policy he encouraged a fast crossing – and escaped in a lifeboat. (A broken man.)
- ‘Organisational inattention’ (Fanatic?)
- ‘Safety outweighing every other consideration’ – Framed Notice in every WSL chart room in 1912.

Outcome

- Lives Saved: 70
- Lives Lost: 1,500
- Total passengers 2,200
- Max Lifeboat Capacity 1,600

- “Had all lifeboats been filled and launched an additional 895 people may have been saved.”
- *(Could this lifeboat really have held 73 people? I count 14 to 15 on board.)*



What on earth has all that to do with HERA?

- My thesis: 'Organisational Inattention' is at the heart of all (preventable) failures.
- Flixborough, Texas City, Macondo, 2.5m long cracks in heavy wall pressure vessels during construction, Tay Bridge, Union Oil, Comet, the John Thompson reactor (exploded during hydrotest 1965), Buncefield, the South Sea Bubble, Lehman Brothers, Ireland,
- All are doomed to being repeated ad infinitum until that is learned!
- But the Titanic never repeated, did it?
 - *MS Mikhail Lermontov* 1986 (?? Possibly not--)
 - Costa Concordia 2012 ?
 - Air Asia Flight 8501 ?
 - Others -- ?

Australian Standards

The following is as I understand it (and simplified version):

- SA 'released' to the 'Free market' – Government support withdrawn.
- 2003: Sold (leased?) publishing rights to SAI Global (listed company).
- Invested sale proceeds just in time for GFC.
- Affect on Industry: “Why volunteer to write standards for SA that then have to be purchased from SAIG to benefit their shareholders?”
- Privatisation and splitting up of power gen companies has severely impacted support for such activities.
- Andrew Hopkins might say:
 - “ – the attention of the government was simply not focussed on:- the role of standards in the community, the way Industry supports their development, the nature of the business, etc.”

Australian Standards (Continued)

- A personal opinion - from correspondence, paraphrased:
- “Standards Australia are nobbled by agreements they have with the Federal Government that limits anything that can be construed as a restriction on trade unique to Standards Australia and not (imposed) on other global standards. We cannot specify competencies such as AICIP or inspections by accredited organizations. This will be a big problem for AS-NZS 3788, competency of inspectors is critical.”
- “SA released from gov’t support but still shackled to the fence”
- Concern expressed by State government bodies also.

Australian Pressure Vessel Standards strategy:

- AS1210 Pressure Vessels:
 - Amendments will continue but these will be nothing serious – merely error fixes, clarifications that arise, and bringing published rulings in to main standard
- AS1548 -- steel plates for pressure equipment:
 - ME-001 has endorsed to do some work on AS1548 but there's no movement at present. There's a need to address the Boron issue and casting methods. We'll try to tackle this once ASNZS 3788 has got underway.
- AS2593 Boilers - Safety management and supervision systems:
 - ME-001 has endorsed to do some work. No plan yet.
- AS4041 Pressure Piping
 - ME-001 has recognized the need to do some technical revisions to this standard. No plan yet.
- AS4458 Pressure equipment - Manufacture
 - ME-001 has recognized the need to do some technical revisions to this standard. No plan yet.

AS-NZS 3788:-

Pressure equipment – In-service inspection

- Last revised 2006
- Several submissions for revision rejected
- New proposal 2016:
 - Review standard and produce an unrestricted document published by WTIA
 - Extract reference to repair and create separate WTIA repair code
 - To be funded by WTIA and AICIP
 - Retain IP, both documents to be licensed to SA at no charge
- Revision to be chaired by myself
- SA have agreed – ?
- But I'm not sure exactly where we are in the process.

Conclusion:

The major threats to the industry stem from:

- ‘Organisational Inattention’
 - Not identifying, or denying, ‘what’s important’
 - Focussing on the low hanging fruit (slips & trips)
- Applies to all types of ‘threat’ from ‘interesting’ to costly to catastrophe

Or, as Andrew Hopkins might put it:

- “ – the attention of the organisation was simply not focussed on what was important”
- And not helped by the current political mood!
- Organisational Attention must *pervade* the organisation.
- Management – at all levels – must understand the place and context of all functions
- Focus on the ‘coal face’ – Not on the shareholders!
- and NOT on the Board!
- Most importantly: Tell – and listen to – stories!

Challenge:- Get the message across:

- Recent Process Safety publication
- Golden opportunity to focus on the Do-ers:
 - The panel operator
 - The fitter with the spanner
 - The plant operator with the wheel-dog
 - The designer
 - The drafter
 - The plant engineer
 - etc etc

So, what did they come up with?



Systems & procedures

Engineering & design

Assurance

Knowledge & competence

Human factors

Culture

Leadership

References and Further Reading

- 1: Trevor Kletz 'What went wrong' (Butterworth-Heinemann/IChem E 1985) and 'Still going wrong!' (Elsevier 2003)
- 2: 'Managing major hazards' Andrew Hopkins, Allen and Unwin, 1999 (Quotation is from the Conclusion)
- 3: 'Disastrous Decisions' Andrew Hopkins - CCH Australia 2012 (Quotation is from the Conclusion).
- 4: The Turnaround at Harley-Davidson (Forbes Greatest Business Stories of All Time by Daniel Gross, et al.)

Titanic: I have been reading about Titanic for over 40 years, but now it's mostly on the net.

An aspect overlooked by many is the way a novel, 'Futility', pre-empted much of the real disaster, proving the disaster was easily foreseeable. The fictional ship was called 'Titan'.

Also well worth reading:

Appendix F: Personal observations on the reliability of the Shuttle
RP Feynman. Available on the net.

(Richard Feynman, Nobel prize-winning physicist and one of my heroes (along with Isambard Kingdom Brunel), dissenting from the commission findings on the Challenger shuttle disaster.)

Or see Wikipedia 'Rogers commission report' which includes a summary of the above.