PIPELINES AND PUBLIC SAFETY: HOW RELIABLE ARE WE?

E. (Ted) Metcalfe

Independent Consultant

0419 047 449

tedmetcalfe@bigpond.com

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1. Introduction

This paper presents an overview of many aspects of safety in the Australian petroleum pipeline industry, and considers the wide range of factors and influences that play a role in preventing harm to the public, the environment, our operators and our construction workers.

Note that this paper comprises observations and opinions based on 45 years of practice as a professional engineer, nearly 40 of those years in the Australian pipeline industry. Some of the opinions expressed may differ from current APGA policy and industry practices.

Good engineering outcomes are critical to protecting the public from failure of any major infrastructure installation, and one of the objectives of this paper is to carefully examine the role played by professional engineers in safeguarding the public from pipeline failures.

Topics addressed include:

1) The status of professional engineering in Australia; the impacts of changes in our industry on engineering, and the transition of pipeline engineering from in-house expertise to out-sourced commodity.
2) Why "complex engineered systems" sometimes fail, primary contributing factors to such failures; and how High Reliability Organisations strive to avoid failure.
3) A review of various influences on the performance of pipeline engineers; highlighting the roles played by management, lawyers, technical regulators and engineers themselves for assurance of excellent engineering outcomes.
4) Perspectives and experienced opinions on the current performance of the Australian pipeline industry in occupational and process safety, workplace accidents; and some focus areas for potential improvement.
5) Observations on success to date in "bridging the knowledge gap" in our industry. Progress made, further opportunities, and challenges to be overcome.
6) Identification and mitigation of potential major threats to public safety posed by Australian pipeline networks.
7) Summary, and the importance of this knowledge for the utilisation of existing pipeline networks in development of the Future Fuels industry.

All of the above topics are relevant for continuous improvement of the reliability of the Australian petroleum pipeline industry.

Opportunities to further enhance the safety reputation of our industry are proposed, and recommendations for consideration by those leading our industry are made.

To put pipeline safety matters in proper context, first we must consider two closely related aspects of engineering;

1) Engineering as a profession in Australia, and
2) Complex Engineered Systems.

2. The Status of Professional Engineering in Australia

It is informative to compare the status of professional engineering in Australia with that in Canada, where I spent my first few years as an engineer.

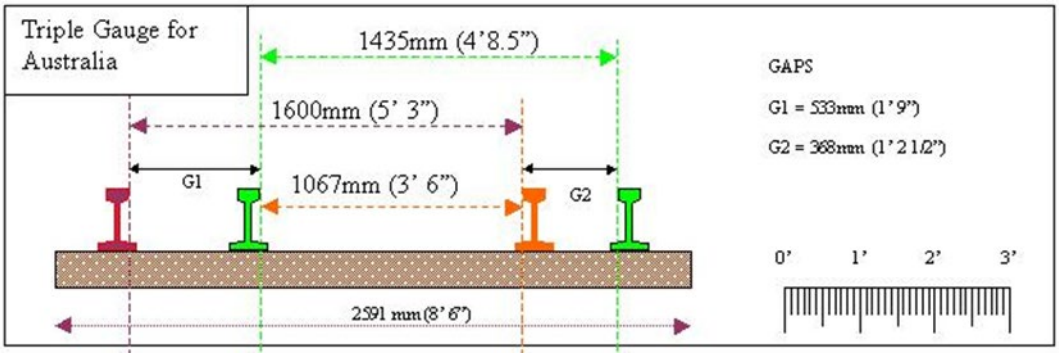
When I arrived in Australia about 40 years ago, I was surprised to find that there was no single organisation to which all professional engineers belonged, and that the standing of the profession in the eyes of the public was quite different. In Canada it was Doctors, Lawyers and Engineers who were held in high regard as professionals by the public, and Accountants were on the next rung down on the ladder. In Australia, it seems that it is Doctors, Lawyers and Accountants on the top rung, and Engineers are somewhere well down on the ladder of public respect.

One reason for the difference is that in 1936 the Canadian government put in place national legislation to regulate the profession and restrict the very use of the term "engineer" to those with proven qualifications and competence to practice the profession of engineering.

In contrast, engineering is not formalised as a profession in Australia, where there has never been similar national legislation to regulate the practice of engineering. The Australian public generally sees engineering as just another trade or occupation, much like plumbers, electricians and mechanics.

At Federation in Australia, the States were allowed to keep their existing legislation, which meant that laws governing the building industry at the time (and perhaps engineering by default) became State responsibilities, not Federal.

Ironically, the origin of the word "engineer" is with trains and railways. This diagram illustrates how well individual States of Australia initially collaborated on the engineering design of railways…



……not very well at all.

Australia does have Professional Standards Councils in each State, with legislation governing professional standards and including arrangements for Limited Liability Schemes to provide indemnity protection for members of professional associations. Engineers Australia was once associated with those Schemes, but that relationship ended many years ago.

The situation for engineers in Australia is best summed up by these quotes from the President of the Institution of Engineers Australia, as taken from a book written in 2008 by Brian Lloyd, himself a former president of the Institution of Engineers Australia. (Ref 1.)

> "*His …presidential address …. identified the issues of the day as ethics, the status of engineers, statutory registration, education of engineers, and restriction of the term 'engineer' to the profession*".
>
> A later address stressed the need for "*restricting the use of the word 'engineer', registration of engineers with IEAust as a qualifying body, a code of ethics and the engineer's duty to his profession*".

The speaker in both cases was Prof. Henry Warren, the first president of the Institute of Engineers Australia, speaking in 1920-21.

In my opinion, all of these issues remain largely unresolved, so management of the profession in this country has not improved much in 100 years.

The De-Engineering Story

Engineering has changed in other ways in the past couple of decades, but not for the better.

When I came to Australia some 40 years ago, nearly all public infrastructure including major pipelines was owned and operated by governments. Each organisation had large internal centres of engineering excellence to provide the necessary technical expertise and policy advice for governments, and they hired new graduates and trained them in their cadet programs. In the pipeline industry, organisations such as TPA, PASA, SECWA and Gas and Fuel were examples.

After the financial crisis of 1987, on the advice of government lawyers and accountants, the infrastructure was progressively sold off to private interests, neatly creating a windfall revenue for the government while transferring the risks associated with responsibility for integrity and maintenance to the new owners. Unfortunately, this also created a commercial incentive to cut corners in the management and maintenance of the infrastructure.

Engineering services were devalued to the point of becoming merely an out-sourced commodity to be tendered and awarded to the lowest bidder. This competitive approach has negatively influenced the standard of engineering services being provided in the pipeline industry.

The established centres of engineering excellence disappeared, and in-house engineering capability declined when the more experienced (and expensive) engineers were made redundant. Several of the redundant engineers in our industry elected to set up practice as experienced independent consultants offering services on short-term assignments to clients in the industry.

Registration of Professional Engineers

A closely related and directly relevant issue is the new legislation now in place in the State of Victoria for mandatory registration of professional engineers.

Although I am strongly in favour of mandatory registration for professional engineers, I believe it must be implemented at a national level, and be administered in a consistent manner across all States in order to be effective and to improve the status of professional engineering.

When the Professional Engineers Registration Bill was introduced in 2018, proponents of the Bill (including Engineers Australia) published material claiming that mandatory registration would make the public safer by preventing the “engineering failures” which had occurred in Australia’s history. (Ref 2.)

Because of a reading hobby of mine, I was already familiar with the details of many failures of engineered systems in Australia. I knew very well that incompetent engineering was not a primary contributing factor in several of the events listed by proponents of the legislation as examples of failures that would have been prevented by registration of engineers!

I also noted that some other significant public fatality events unrelated to engineering incompetence were curiously omitted from the justifications put forward by the proponents of the legislation, so I undertook to study the matter further with some surprising findings.

It is no wonder that the profession of engineering is too often held in poor regard in Australia:

a) The ACIL Tasman report listing the "engineering failures" (commissioned by Engineers Australia and others) purported to be a cost-benefit analysis, however the assumptions provided to ACIL Tasman for their financial calculations were flawed and exaggerated so as to inflate the apparent financial benefit of mandatory registration of engineers.

b) I believe that the Engineers Registration Bill was introduced to address the result of decades of poor regulatory oversight of the occupied building industry in Victoria. Labor governments have progressively modified building industry regulations to favour the developers, and the consequence is Faulty Towers (many new apartment buildings with structural defects), a growing problem with black mould in many buildings, and the worst of all, a proliferation of occupied buildings with flammable cladding. In my opinion, the Victorian government has introduced legislation which would allow them make scapegoats of engineers in the event of a "Grenfell Tower" event in Victoria.

c) Engineers Australia claims to be the voice of the profession, which implies that they actually represent professional engineers. I was most disappointed to discover that such is not the case at all. Engineers Australia is registered as a tax-exempt charity and has denied under oath that it represents its members. (Ref 3.)

d) There is a National Engineering Register, but it is not mandatory to be listed there to practice engineering in Australia. In order to become listed, fees must be paid for both competency assessment and professional indemnity insurance premiums.

So Victoria now has even more flawed legislation, drafted by bureaucrats with limited knowledge of professional engineering practice.

Will State-based legislation for engineers make the public safer? Probably not.

After decades of similar legislation in the State of Queensland (the RPEQ scheme) there is simply no documented evidence that Queenslanders are safer than people in other States. Indeed, the new Montague Road offices of Queensland's building regulatory agency were covered with flammable cladding!

The RPEQ scheme seems more focused on prosecution and punishment than improving the profession of engineering; and the scheme failed to prevent the Dreamworld tragedy. In addition, I've examined some rather dodgy pipeline engineering documents with an RPEQ stamp on them in Queensland.

Governments once had experienced engineering advice available to them from within government-owned infrastructure organisations. Now that those centres of engineering are gone, and very few elected politicians are engineers, it is not surprising that government policy fails to better acknowledge the engineering profession.

Responsibility for maintenance of public infrastructure extends far beyond the engineering profession; and infrastructure failures cannot be linked to presence or absence of an engineering registration scheme.

How does this legislation affect pipelines and public safety?

I have included this discussion of mandatory registration of professional engineers in Victoria specifically to illustrate an important directly relevant point for pipelines and public safety.

The upshot is that governments, when faced with a threat (or even a perceived threat) to public safety which could kill people, will draft and enact legislation and regulation in order to be seen to be doing something to prevent such deaths.

That's what has already happened in Victoria in response to public frustration with the failures of the occupied building industry, and governments will do the same if a similar threat to the public from the pipeline industry is demonstrated or even perceived.

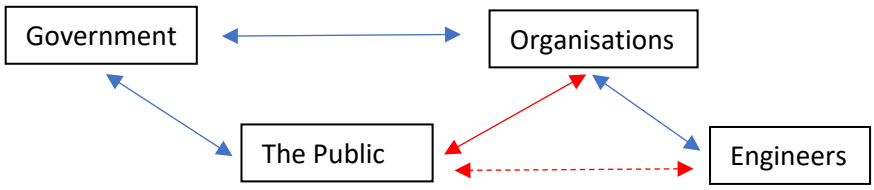
2. Some Key Concepts Relevant to Public Safety

The Role of Engineers

If a pipeline ruptures, it must have been the pipeline engineers who failed in some way…right?

Again, probably not.

There are several parties involved in keeping the public safe: engineers, the organisations who employ them, and governments as well as the public themselves.



There are direct interface relationships between the governments, the public and the organisations; and authority relationships between the engineers and the organisations employing them, but only an indirect link between engineers and the public.

Organisations that employ engineers must bear responsibility for engineering outcomes and for protection of the public.

Complex Engineered Systems

For purposes of this discussion, *complex engineered systems* include anything designed by engineers to be used, owned, operated and maintained by other people, most of whom are <u>not</u> engineers. This includes airplanes, ships, vehicles, systems for power generation and distribution, processing facilities, railways, buildings, spaceships, and of course, pipeline systems.

Such systems are normally a complicated assembly of structures, engines, control systems, actuation devices and emergency response components all meant to operate reliably and safely. Even a bridge is a complex arrangement of critical support members meant to withstand a variety of loading conditions, and bridges require inspection and maintenance for continued safe operation.

Integrity threats may arise during initial fabrication/construction; or later during the operating life of the asset. Early recognition and management of all integrity threats is critical for assurance of continued safe operation without endangering the public.

Some common features of complex engineered systems:

a) They are often created and operated by a combination of private and government initiative.

b) They are subject to government policy, regulatory oversight or management.

c) Normally they are strongly influenced by commercial interests.

d) System failure impacts directly on public safety, with potential fatalities.

e) To understand why they fail, it is critical to acknowledge complexity and tight coupling.

f) When different engineered systems fail, there is no common cause, but there are many similarities in the factors contributing to failure.

Of course, engineers design and help to build these systems; but engineers are often not involved in later key decisions which impact the integrity and reliability of the systems; the control, operation and maintenance of the systems; or whether or not owners respond effectively to warnings of potential failure of the systems.

I have studied more than 20 major Australian failure events and another 30 events which happened overseas. After reading many investigation reports, coronial inquiries and Royal Commissions I have identified ten common themes of failure, none of which can be directly attributed to engineers alone:

1) Management focus on commercial interests and profit motives, giving priority to short-cuts and cost savings such as restricted budget and schedule for design, reduced maintenance, deferral of expenditures and redundancies for experienced personnel. Rust-bucket cargo ships are just another example of run-down engineered systems.

2) Giving priority to maintaining schedule instead of pausing to better understand potential failure modes, then proceed with caution. ("*Launch that rocket today!*"; "*Get that drilling rig off the hole!*"; "*Get your ship into port on time!*")

3) Organisational factors which either fail to identify emerging threats, or conspire to dismiss identified threats by manipulating risk assessment processes in order to justify a desired commercial outcome.

4) Internal communication failures within organisations, including poor articulation of concerns, not fully informing all the right people, and loss of corporate memory.

5) Human error in operation associated with unforced errors; with complacency due to mundane operational routine and familiarity; or various other quirks of human nature and unconscious bias.

6) Contracting strategies such as Engineer Procure and Construct (EPC) and Public Private Partnerships (PPP) in which professional engineering objectives can be thwarted by other parties who are driven by a profit motive.

7) In the procurement of materials and services, tender evaluation criteria which give greater priority to low price than to quality, experience and track record.

8) Employment of inexperienced engineers because they are less expensive than experienced engineers.

9) Purposely seeking and leveraging lax regulatory environments, as is the case with the flagging of cargo ships in countries where inspections are rare and penalties are minimal.

10) Human tendency to gamble by engaging in risky behaviour:

- Examples include substance abuse, careless operation of motor vehicles and boats, and participation in extreme sports.
- We already knew that it is not possible to cure stupid, but we have recently learned that it can be very difficult to quarantine it too!

The key point of the above list of themes is that in my informed opinion, engineering incompetence is not a common theme in failure of complex engineered systems.

For all failure events studied both in Australia and globally, not just those with fatalities, I estimated that engineers were at fault to some extent less than 20% of the time.

I recently had access to an insurance industry database documenting over 40 years of history in the global pipeline industry, listing more than 1,200 insurance claims paid out for pipeline failure events. That database attributes only 14% of reported pipeline failures to faulty design, which supports my findings.

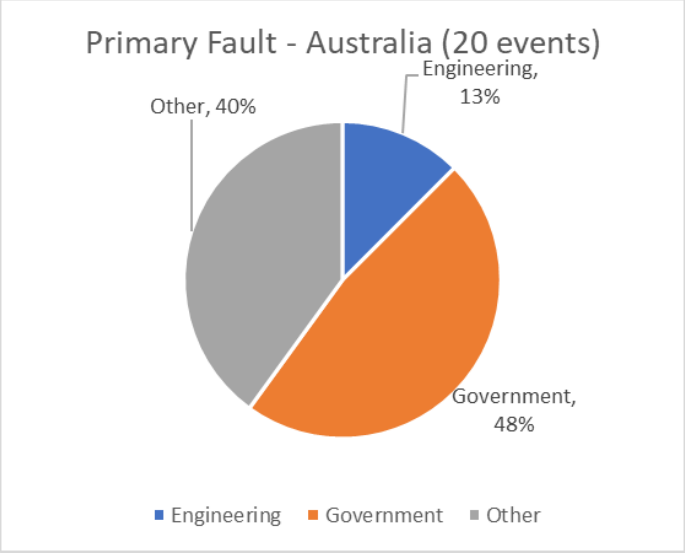
I have discovered something however which should worry you. My analysis demonstrates that it's actually failures by government entities which are most often the primary contributing factor to public fatalities in Australia.

I refer here to failure events for which a government entity:

a) Owned the infrastructure that failed, or

b) Was responsible for care and maintenance of the infrastructure, or

c) Had regulatory oversight of the systems.



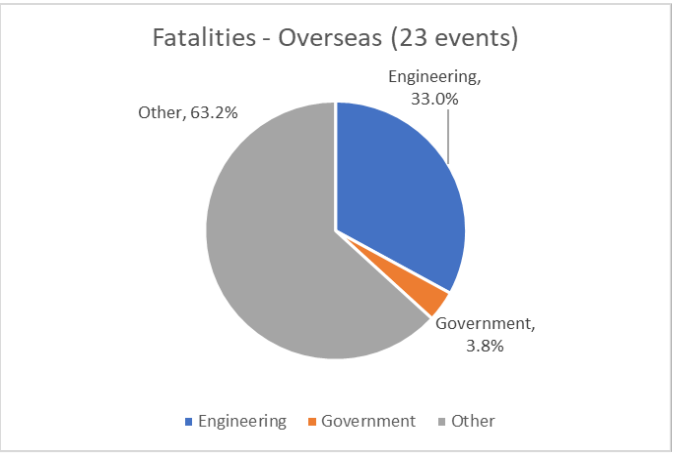
Four well-known events in this category include the Granville Train Disaster of 1977; two events which happened in 1997, the failed implosion of the Canberra Hospital and the Thredbo Landslide; and the Longford Gas Plant Explosion of 1998.

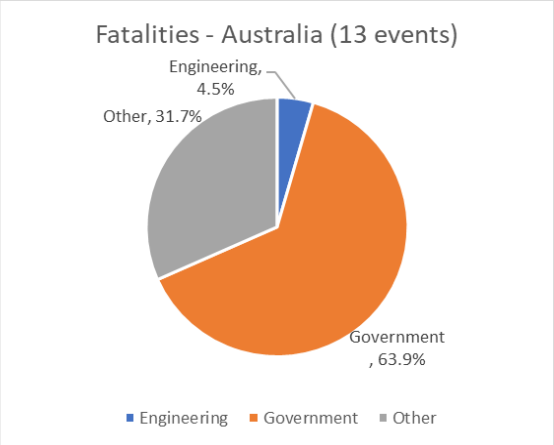
The collapse of the West Gate Bridge during construction in 1970 is another interesting study. Yes, there were design errors, but it must be acknowledged that the box girder design was an innovative step-out from proven designs, and failures when "pushing the envelope" in engineering design are not unusual.

Although commonly referred to as an engineering failure, the West Gate Royal Commission report also exposes government failures in both regulatory oversight and project management, strong industrial relations influences, and political pressure to hasten the completion of the bridge. (References 4. through 8.)

Bushfires are not unusual in Australia, often sparked by failures of electricity distribution systems; and people being burned alive in a bushfire is all too common in Australia. The coroners' findings in relation to the Black Saturday bushfires in Victoria made a total of 67 recommendations, all aimed squarely at government agencies; yet bushfire continues to kill Australians. (Ref 9.)

However, what really surprised me was comparing my findings for Australian failure events resulting in fatalities with those which happened overseas.





The role of actions (or failure to act) by governments in Australia stands out in stark contrast to the role of governments in global failure events, especially for those events which resulted in fatalities. In Australia, clearly engineers are not a threat to the public, but it is obvious which party is a serious threat…… our governments.

Engineers work within organisations, and it is the organisations that manage the design, construction, operation and maintenance of the systems and infrastructure which sometimes fails and kills people.

It is actually governments and organisations that must be reliable for protection of the public from harm.

High Reliability Organisations

Accidents do happen with complex engineered systems. In industries where the risks are high with serious consequences of failure, one might expect that the frequency of accidents would also be high. Examples in the high risk and high consequence category include commercial airliners, nuclear power plants, spaceships, aircraft carriers and hospitals.

When an organisation operates in such industries but has successfully and consistently prevented major accidents and failures from occurring, it is often referred to as a *High Reliability Organisation (HRO)*.

It is my opinion that the Australian pipeline industry should strive to become a high reliability industry.

In their book *Managing the Unexpected*, Weick and Sutcliffe listed five traits of HRO's (Ref 10.):

a) A preoccupation with failure.

b) A reluctance to simplify interpretations.

c) Sensitivity to operations.

d) A commitment to resilience.

e) A deference to expertise.

The importance of the last point is best underscored by the Space Shuttle Challenger explosion in 1986, which happened after the decision by NASA management to dismiss technical expertise warning them about potential O-Ring failure.

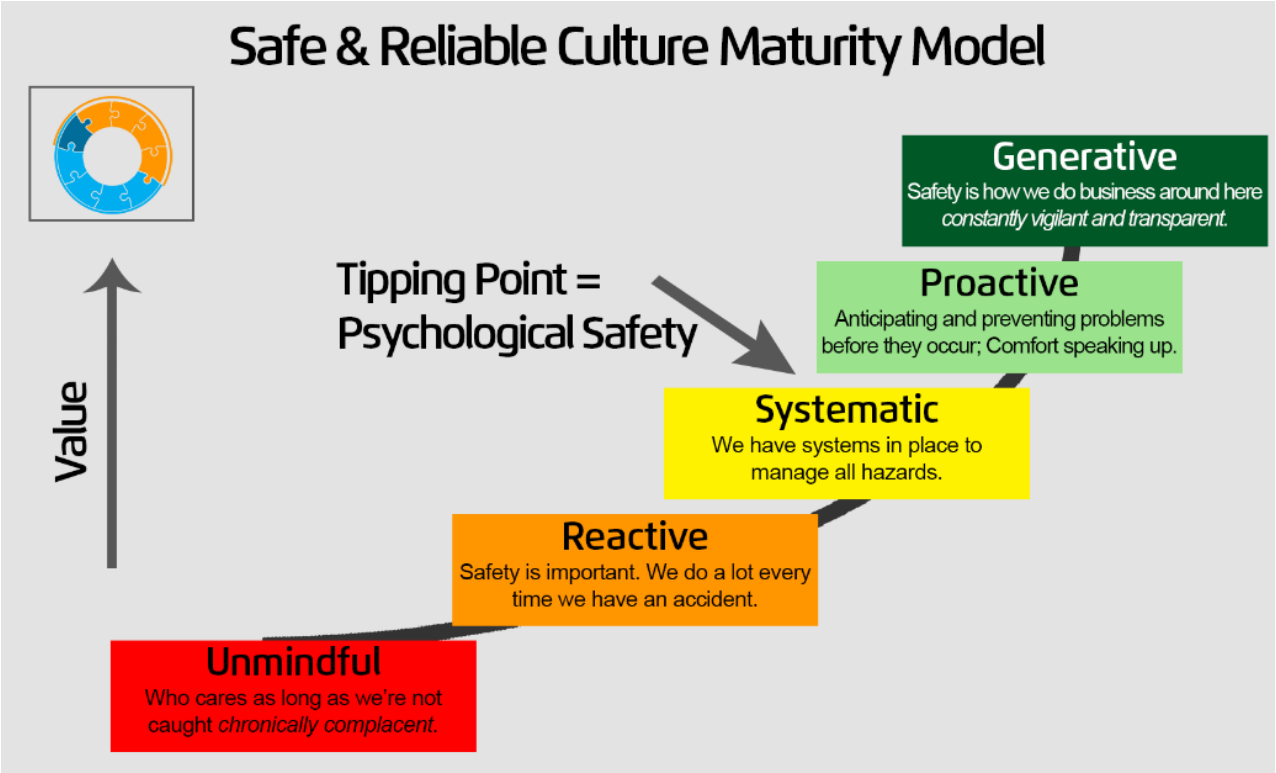
Focus on deference to expertise raises an important question relevant to this review of pipelines and public safety…….

Which expertise is most important in assuring public safety?

In reaching decisions, managers of organisations must seek advice from many sources including legal, financial, commercial, environmental, operations, and public relations; as well as engineering.

Of all such sources, only engineering advice directly pertains to assurance of public safety, whereas advice from each of the other sources could in fact lead to a reduction in public safety.

Organisations employing engineers can and do have rather different attitudes to public safety, depending on the maturity of the collective safety culture within the organisation, as described in the following diagram:



(From *A Framework for High-Reliability Organizations in Healthcare* - Health Catalysts – Ref 11.)

If we were to undertake an honest examination of the collective Australian pipeline industry, at which level on the above model would our entire industry be placed?

3. Collaboration or Conflict? - Influences on Engineering Outcomes

In the petroleum pipeline industry as in any industry, we rely upon good engineering outcomes to ensure protection of the public and the environment from harm.

However, two key observations are relevant here:

a) Engineers do not perform their tasks in isolation and are not solely to blame for poor engineering outcomes as some would have us believe.

b) Buying engineering services is just like dining out in restaurants; you can have service that is fast, cheap, and high quality.

The catch is that you can't have all three at once.

So, who else is involved in assurance of good engineering outcomes?

Project Management

Engineering outcomes can be degraded by cost and time restrictions, such as not completing technical definition of the project before cost and schedule are fixed. You know you are dealing with inexperienced project managers when you hear things like:

> *We're not wasting money on engineering until we know for sure that the project will go ahead.*
>
> *Even though we are behind schedule, we cannot defer the Investment Decision or Project Completion dates we have already announced. We will just have to catch up by fast-tracking the engineering and construction.*

Commercial imperatives can take priority over good engineering practice, and I have witnessed many examples of this in my career, including:

- Engineers being chastised for "gold plating" the design when they incorporate design features to make maintenance easier and safer, or the system more reliable.
- Management pressure to accept the lowest bid price and hope for the best.

Operations and Maintenance Management

Maintenance budget restrictions and deferrals are another example. Safety in maintenance depends on whether the corporate objective is to maintain the pipeline or to maintain a profit.

Many years ago, I was part of a team recommending that an old oil production facility should be upgraded to make it safer and more reliable. To get funding approval we made a presentation to the Project Review Committee. They listened and then asked us "*What happens if we do nothing?"* We could not prove that doing nothing would actually result in lost oil production revenue, so funding approval was denied.

Dealing with clients who have inexperienced engineers in-house on staff can be frustrating for experienced suppliers of services and products. Although engineering services are often out-sourced, the in-house supervision and management of those services must still be competent and experienced for good engineering outcomes. Simply holding the external services providers responsible for engineering outcomes contractually is neither adequate nor effective.

Operating organisations are often restructured when companies are bought and sold and merged. The resulting organisation is "streamlined" or "downsized" to cut costs, and experienced engineers can be deemed either too expensive or not aligned with the new corporate values, and made redundant. Another downside of such restructuring is that too often the original corporate engineering specifications and standards are not kept up to date by the new organisation.

Lawyers

Lawyers are indeed genuine professionals, but their motives are different from engineers. The primary obligation for lawyers is to serve their clients, and they will do so unless compelled otherwise by law.

In the pipeline industry lawyers often influence the management of risk by selecting project contracting strategies which transfer execution risk to others instead of sharing risks with the client.

I am a strong proponent of relationship contracting, particularly Early Contractor Involvement (ECI) in which the project is undertaken in two stages. The client, the engineers, and the

construction contractor all work closely together during an initial planning phase to better understand all the risks and requirements before the construction price is fixed. It is well established that such projects are much less likely to end up in major dispute or litigation.

Many lawyers prefer to transfer all execution risk onto the contractor, creating a higher probability of dispute arising with additional demand for legal services.

Confidentiality restrictions and/or involvement of client legal counsel can be intimidating for service providers, particularly for independent consultants with engineering but not legal expertise.

In my experience, lawyers have a way with words in contracts for engineering services:

> Once while working with a lawyer to draft a scope of work for engineering services, I asked him "*What does "good oilfield practice" actually mean to you?"*
>
> He replied *"It means whatever I want it to mean if we get into a dispute with these guys."*
>
> Another time I was trying to help a lawyer understand the AS2885 Standard. In frustration he said "*You guys write this stuff so that you can earn more money interpreting it.*"
>
> I replied "*You're right, we learned from watching lawyers drafting legislation for politicians!*" He just grumbled "*You'll keep*".

Technical Regulators

Technical Regulators are also important for assurance of good engineering outcomes and public safety in our industry. I think they have a difficult job, because in their work they are required to serve two masters at once, political policy and engineering professionalism.

In my experience, the co-operation between technical regulators in most States and the regulated parties of our industry is quite good. Our regulators strongly encourage compliance, which is certainly in the interests of public safety.

The regulators can and will be a lot harsher with us if a major failure event with public fatalities happens.

In the pipeline industry we are far better off than the occupied building industry with its' acknowledged failures of regulatory oversight over many years. Worst is the revised legislation which allowed builders and developers to directly employ both engineers and inspectors, who were then told "*Do what we want or we will get someone else who will!"* We all know how that has turned out in the Faulty Towers.

Engineers themselves

Of course, the behaviour of individual engineers themselves is critical to public safety. Professional engineers are obligated to serve and protect both the community and the environment.

"*Hold Paramount*" is a term which appears in almost every engineering code of ethics in the world, except that of Engineers Australia. It means that professional engineers will always give first priority to protecting the community and the environment, unless prevented by others from doing so.

Being a good professional engineer requires more than just technical skills and competence, it's also important that the engineer demonstrates professionalism.

Professionalism is a function of the behaviour of the individual and how the individual interfaces with others in the workplace. It requires working only within one's area of competence, honesty in all communications, and demonstration of good judgement in decision making.

It is my observation that professionalism is no longer emphasised enough in Australian engineering education, if it ever was. A few years ago, I asked a senior manager at Engineers Australia how he valued professionalism in competency assessment. I was stunned when he replied that they no longer consider professionalism as a core competency because it makes achieving Chartered status too hard!

Here's two important mantras for all professional engineers:

> *Do the right thing!*
>
> *Speak up for safety!*

Some of my experiences while speaking up in the interests of safety have been quite disappointing. I was once involved in recommissioning a pipeline that had been out of service for a long time with potential internal corrosion, and I made a presentation to management recommending that it should have an intelligent pig inspection before starting up again.

During a coffee break, the Managing Director bailed me up in the hallway and said bluntly that he would not support my recommendation because his company was about to announce publicly that the pipeline was back in service. To him, recovery of his share price was more important than the integrity of his pipeline.

Risk Assessments

Engineers play a key role in conducting risk assessments. In my experience, manipulation of risk assessments represents the most disturbing example of management influence on engineering outcomes.

Here's an important message for decision-makers in management:

> *The purpose of holding a risk assessment is not to get the answer you want, but to get the advice you need!*

Risk assessments allow decision-makers to seek advice based on careful consideration of all possibly relevant matters by a group of appropriately experienced individuals. A quote used by Peter Tuft is directly applicable here;

> "*Failure comes from failure to imagine failure*."

That's exactly what a proper risk assessment is supposed to do……. imagine all possible and credible modes of failure and implement controls to ensure that they do not occur.

Several times in my career I have experienced management pressure on the risk assessment process through attempts to drive the outcome to a conclusion favoured by management for commercial reasons.

Examples include:

- Before the risk assessment even starts, telling the risk assessment attendees what answer they are supposed to come up with, and
- At the conclusion of the risk assessment, telling the attendees that they have to vote either for or against the outcome preferred by management, and who votes which way will be noted for the record.

4. Safety in the Australian Pipeline Industry: How reliable are we?

Here's some of my perspectives on our current performance in both occupational and process safety, construction workplace accidents, and some focus areas for improvement.

In my opinion, we're generally reliable, but we can and should strive to be even better at ensuring employee and public safety.

Is our reputation for safety just a declaration or is the reputation earned?

In other words, is our industry safe because we regularly say that it is safe; or because we can actually prove that we proactively act on any emerging issues to ensure that our safety performance is the best possible?

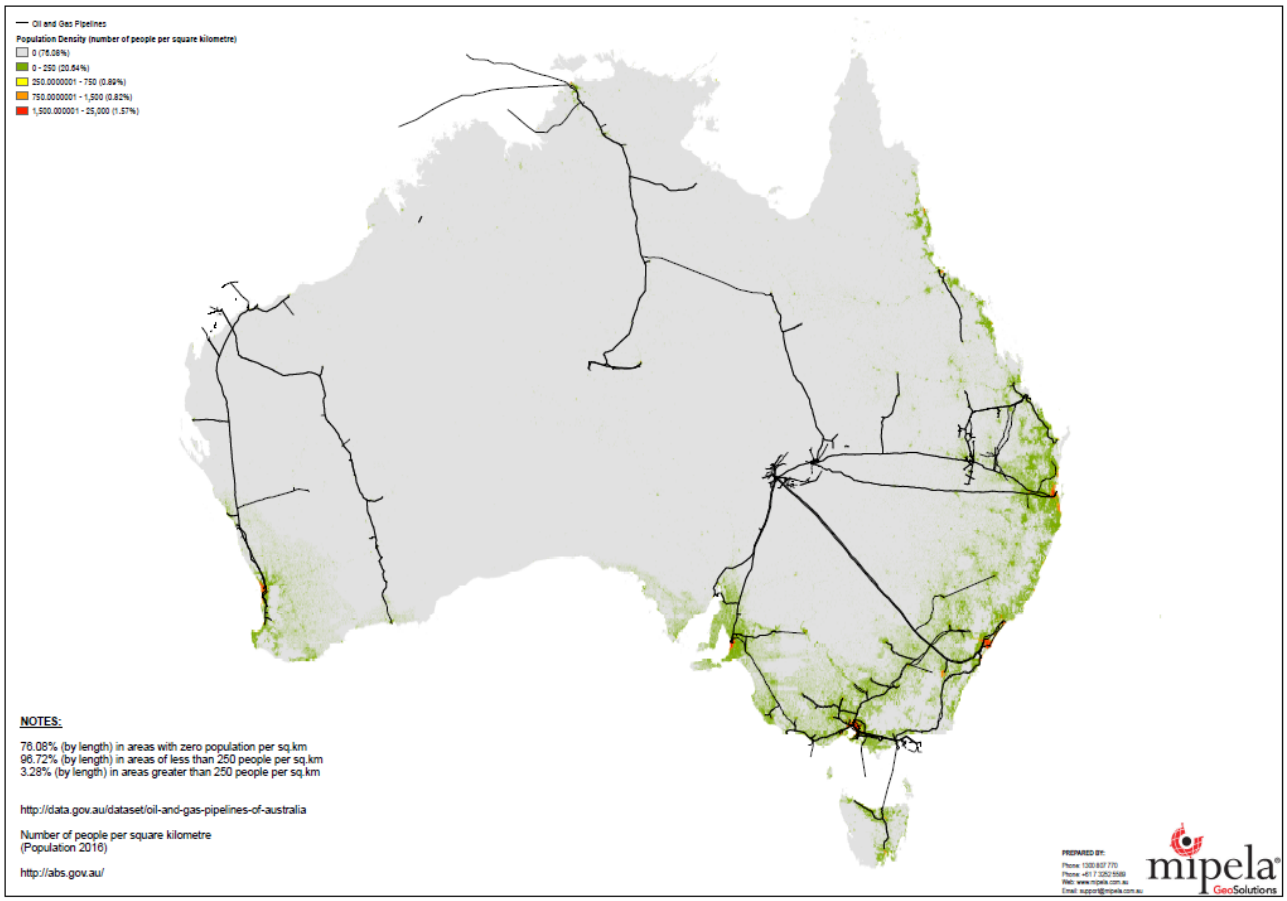
Are we good or are we just lucky?

We must also consider the question of reliability from this perspective:

How much of our reputation is good management and how much is just good luck?

In my opinion, we are actually rather lucky in several ways:

a) Compared with Europe and North America, Australia is not densely populated at all. The majority of our pipelines are located where people are not. Here's a map of our major pipelines versus population density shaded in green. (Thanks to the good folks at Mipela Geosolutions)



After the Moomba Sydney Pipeline ruptured in 1982, we did a lot of research on Stress Corrosion Cracking and learned a lot. We were lucky that the rupture happened in a very remote area and not in the more densely populated Sydney area.

b) Our regulatory oversight in Australia is far better than that of the USA, and we work co-operatively with our technical regulators. We are lucky that we have so far escaped the wrath of any government action determined to be seen to be doing something in response to public fatalities or other pressures.

c) Our AS2885 Pipeline Standard is arguably the best in the world, but we have achieved that and we continually update it thanks to a small army of volunteers, some of whom are independent consultants willing to work tirelessly for no pay. We once had a lot more of those independent consultants on our committees, and we really are lucky that we still have at least a few such individual volunteers.

d) It was unpaid independent consultants like Max Kimber, Ken Bilston, Phil Venton, Peter Tuft, Leigh Fletcher, Brian Martin and others who got Australia onto the world stage of pipeline research by negotiating the Tripartite Agreements. They were also instrumental in forming the first Energy Pipelines CRC. That team has retired …… will we be lucky enough to replace them? Or will experienced independent engineers in future simply focus on paid work instead of volunteering on committees?

e) Finally, we are lucky that our industry is small enough that membership of APGA is not restricted to only one segment of our industry. We are all members of a single Association which delivers very good industry-wide networking opportunities and effective communications, something not practical in other larger countries.

How do we define and measure our Safety Performance?

There's at least three different ways in which we do this, and all are important:

1) One is *Occupational Health and Safety;* prevention of slips, trips and falls. In my opinion, in terms of occupational safety we are very good and getting better.

2) Another measure is *Process Safety* which avoids failure events of very low frequency but very high consequence. I am not satisfied that we are doing well in terms of Process Safety. The concept of High Consequence Recognition (HCR) was in my opinion an excellent initiative, but due to strenuous objections by some in our industry, HCR exists in the AS2885 Standard as guidance only, and is not mandatory.

3) The measurement of safety in terms of protecting the public from harm is whether or not a failure of pipelines has resulted in fatalities of members of the public. Here in Australia to date we have not experienced such a pipeline failure incident, a reputation which is much better than that of many other countries overseas. In my opinion, this is due to a combination of good management and good luck.

Here's something to think about….

Is Zero Public Deaths an accurate statement?

If, strictly speaking, "zero public deaths" means that no one who was not involved with pipelines has died as a result of a pipeline infrastructure failure incident, then yes, to my knowledge the statement is accurate.

However, I wish to challenge this notion by highlighting how we acknowledge fatal accidents involving construction workers during pipeline construction projects.

Fatalities during Construction

I have read with interest both the Brady Review of fatalities in the Queensland mining industry (Ref 12.) and the coroner's report of the Dreamworld tragedy; Queensland again. (Ref 13.) I was quite disturbed by some of the findings documented in those reports, and I wondered:

"*How would our pipeline industry look under the glare of the coroner's spotlight?*"

Given my knowledge of the industry and my experiences over many years, the more I pondered that question, the more concerned I became.

The Brady Review was about workers in the mining industry, which shares many characteristics with pipeline construction including operation of heavy equipment, harsh environments, remote sites, specialised work crews, rostered work cycles, etc.

Any construction industry suffers fatalities of workers. I have visited the area where the Snowy Hydro Scheme was completed many years ago; and I have read much about the collapse of the West Gate Bridge. Both of those projects honoured workers who died during construction with memorial plaques.

Our pipelines network has been constructed as multiple projects over many years, and many construction workers helping to build our pipelines have died while employed on a project, but we have not erected any plaques to honour them.

So, I undertook to find out for myself how pipeline construction in Australia might compare with the mining industry, but soon discovered that it is not easy to make valid comparisons, as illustrated here:

	Brady Review - Mining	**Pipeline Construction**
Nature of workplace	Contained on fenced site not involving public areas.	Not normally fenced; must use public roads.
State and Regulator	Queensland only.	All States and Territories.
Records	In the files of the Regulator.	No central database.

Different organisations executing pipeline projects often apply different criteria to define a "project fatality"; and several pipeline construction fatalities have occurred on public roads.

Regardless, I pressed on with my informal review, and decided to consider the 40 years from 1980 to 2020, which is approximately the time I have worked in this industry.

Criteria and Terminology

The terms "workplace" and "jurisdiction" can have different meanings on different pipeline projects. For mining the workplace is a well-defined site, whereas pipeline project workplaces by their very nature include carefully controlled sites but also require travel on public roads.

Jurisdiction considers the extent to which the location where the fatality occurred could feasibly have been controlled by the project or monitored by the project, and again pipeline projects are quite different from mining in terms of jurisdiction.

For purposes of my initial listing, I considered a pipeline construction fatality to be <u>anyone who was employed on a pipeline project and died during the term of that employment</u>, regardless of cause of death or workplace legislation applicable.

I was already aware of at least a dozen such fatalities during my time in the industry.

Records of Fatalities

All of the mining fatalities analysed by Dr. Sean Brady took place in one State, and he had all the files of investigation documents handed to him by the Department of Natural Resources Mines and Energy (DNRME) for his examination. After asking many people in our industry who ought to know, I had to conclude that we do not have a similar industry-wide database of construction fatality records. Companies keep their own internal records, APGA began recording safety statistics only about 2006, and member companies only report acknowledged project statistics to APGA.

I briefly reviewed the websites of Safe Work Australia and workplace statistics websites in each State, and found to my disappointment that "pipeline construction" is not a category that is distinctly identified in their records for statistical purposes. Statistics for fatal accidents in our industry might be found in the records of different States under various headings including *Construction*, *Oil and Gas*, *Resources*, *Electricity Gas and Waste*, or *Transportation Infrastructure*.

So instead, I just asked several other old pipeliners what they remembered about fatality events during construction, and I was surprised to learn about many additional fatalities that I was not previously aware of, so my list got longer. In some such conversations I was cautioned for simply being willing to ask. To quote one colleague, "*Tread carefully mate. There's a dark side to our industry, and you might be asking too many questions*."

Initial Findings

After setting aside several of the fatality events on the list as arguably not related to construction or otherwise debatable, I examined the remainder for any apparent trends or insights that might be gleaned from this informal review.

Comparing the two 20-year periods, we are not getting better, we are trending in the wrong direction. Before you say that my trend analysis is too coarse at 20 years then 20 years, most of the deaths <u>not</u> included because of debatable circumstances happened in the last <u>ten</u> years.

For further trend analysis I allocated each fatality to one of only four categories; *Driving*, *Unplanned Movement, Medical Episode* and *Other:*

- Fatalities while *Driving* have significantly reduced, which indicates that the widespread use of In Vehicle Monitoring Systems (IVMS) has been a good safety initiative for pipeline construction.
- What that also means however is that *Unplanned Movements* and *Medical Episodes* are emerging as larger issues for our industry. Job Safety Analyses (JSA) and risk assessments have focused strongly on prevention of *Unplanned Movements*, but *Medical Episodes* are still happening despite all efforts such as pre-employment medical screening and health care provisions in the workplace.

Finally, I wondered how many of the pipeline construction fatalities on my list would have been formally reported as project statistics, and I estimate that only about half of the fatalities which occurred over the past 20 years were considered workplace statistics. Many fatalities would have been reported instead as a death on public roads, or as caused by health issues deemed unrelated to the workplace.

So, here's the conundrum …… we have legally and properly reported many fatalities of our pipeline construction workers as deaths of members of the public, but as an industry we still claim that we have not killed any members of the public.

That just does not seem right to me.

Opportunities for Improvement

"Beyond compliance" is an objective pursued by High Reliability Organisations. In my opinion, we should go beyond compliance in documenting and analysis of all pipeline construction fatalities.

If we had a single central database of fatality records and investigation reports available for analysis by experts in this area, we may be able to better understand the influences of alcohol and other drugs; work-related health stresses, and even consider mental health issues such as suicide among pipeline construction workers.

The government of West Australia has undertaken an Inquiry into mental health issues associated with the Fly-in Fly-out (FIFO) workers in the Pilbara region, and they found that those workers are far more likely to commit suicide than to die in a workplace accident. (Ref 14.)

5. Success in Bridging the Knowledge Gap

Our efforts to date in "bridging the knowledge gap" in our industry serve as evidence that we are indeed striving to become even more reliable in some areas.

We've made progress in the past several years, but the current status is not what was anticipated when we started these efforts, and there are still remaining challenges to be overcome.

On a more positive note, Susan Jaques is an outstanding leader in this area, actively involved as a volunteer in various initiatives to promote transfer of knowledge to younger pipeliners, and she is to be commended for her dedication to this important task.

Pipeline Engineering Training

We've done very well in defining the competencies for Pipeline Engineering, but achieving widespread assessment using those competencies is a slow evolution. A couple of years ago when I checked there were only nine "*Oil and Gas Pipeline Engineers*" on the National Engineering Register after ten years of effort! I know of about fifty pipeline engineers whose names perhaps should be on that list.

Engineering competency is critical to public safety, but the concept of being assessed for competency is not catching on for Australian pipeline engineers.

Competency demonstration is not even mandatory in our industry……..Why not?

AS2885.INFO Website

Engineers using the AS2885 suite of Standards sometimes have questions about interpretation and intent. The AS2885.INFO website was developed to help answer those questions and is being managed by a small team of experienced pipeline engineers. The site has a strictly limited scope, meant only to assist those using the AS2885 suite of Standards. It is not a general pipeline industry knowledge resource.

It's a relatively new initiative, and current indications are that the site is seen as useful by pipeline engineers who use the Standard, so hopefully the concept will continue to prove helpful for our pipeline industry. We now also have a blog for informal correspondence to go with it.

(Ref 15.)

Telling Stories

Research and studies of learning and knowledge transfer have clearly identified the benefits of telling stories as an effective means of passing knowledge to others, however this is something our industry is not doing well at all. For various reasons there has always been much reluctance to share openly any lessons learned the hard way, despite such knowledge being very important in teaching younger engineers.

Some things young pipeline engineers ought to be aware of will simply not be found by a Google search. Unless we get better at telling stories about mistakes that our industry has made in the past, we risk making the same mistakes over and over again.

Here's just three examples of stories heard during my career, and the lessons I learned from hearing the stories:

a) Smithfield Lateral HDD - Don't screw the subcontractor who still holds as-built survey data that you might need in future.

b) McArthur River Pipeline Construction - Don't attempt two technology innovations at once, as they may not go well together.

c) Varanus Island Pipeline Explosion - Don't gamble in conducting risk assessments.

I haven't put details of the first two events in this paper due to potential negative reactions from others, however a formal investigation was published for the Varanus Island explosion (Ref 16.) On reading the investigation report of that failure I felt angry that this could happen in our industry. In terms of our public safety reputation, that was a close call.

A few years ago, I was one of the speakers at a YPF event in Melbourne, and I took the opportunity to do an informal survey of the audience by naming all three of the above events and asking the audience to put their hand up if they were already aware of what had happened. No hands went up. So, I said, "*If you are interested in learning about these events in our industry, come see me in the bar afterward*". No one did.

> *Are young pipeline engineers of today not interested in learning what went wrong in order to avoid repeating the past mistakes of our industry?*

A gap can only be bridged if parties on both sides agree that a gap even exists.

6. What could possibly go wrong?

Here's my opinions on potential major threats to public safety posed by our pipelines industry and how we can mitigate them.

Ageing Infrastructure

The Thunder River Rapids Ride which killed four at Dreamworld was 30 years old at the time. On an inch-kilometre basis, about half of Australia's pipelines are already older than 30 years.

> *Have we done all of the required maintenance throughout the lifetime of these pipelines?*

We must heed the lessons of major pipeline failures overseas such as what happened in San Bruno and in Boston, caused by overdue and incompetent upgrading of old pipeline systems.

The UK provides a very good example of a better way to deal with ageing infrastructure. After the Grenfell Tower fire in London and the failure of the Ponte Morandi bridge in Italy, the Institution of Civil Engineers UK set up a task force to better understand ageing public infrastructure.

After investigating thoroughly, they produced a most informative report called "*In Plain Sight*". It was given that title because they discovered that much of the evidence of potential failure of ageing public infrastructure was actually easy to see. It's well worth reading if you are serious about keeping the public safe from infrastructure failures. (Ref 17.)

Society will tolerate potholes, water main bursts and power blackouts as just inconvenient.

Society will not tolerate a major petroleum pipeline failure that kills members of the public or creates significant environmental harm.

Complacency

That we have not experienced a major failure of an Australian pipeline with public fatalities does not mean that it is unlikely to ever happen.

Another well-known Peter Tuft quote is directly applicable here:

> "*It's perfectly safe, as long as you never forget that it is extremely dangerous."*

Although there have been some close calls, no commercial Qantas airliners have crashed, and it is easy for some people to believe that it won't happen. We are often lulled by some form of what I call the "Qantas" mindset, in which we allow past history to predict the future.

The management team running Dreamworld for Ardent Leisure once had the Qantas mindset too.

Qantas is a High Reliability Organisation; Ardent Leisure was not.

Inadequate Competence, Professionalism and Experience

Observations I have made over the past several years indicate that some engineers in Australia do not demonstrate adequate competence and professionalism, and too often do not have enough experience to take on the roles they have been given.

APGA is actively addressing the competency issue, but the uptake so far among pipeline engineers is disappointing.

We must get better at promoting engineering professionalism and ethics for young pipeline engineers in Australia! At least some undergraduate engineers in Canada now study a textbook for a university course on professionalism and ethics. (Ref 18.)

Many years ago, I had the opportunity to work alongside and learn from Ken Bilston, and his guidance has definitely been a positive influence on my career in this industry. He often said that

> "*Engineered systems obey the laws of nature, not the laws of man*".

Here's my addition to Ken's guidance:

> *The design of high integrity engineered systems requires high integrity design engineers; and that's what professionalism in the practice of engineering is all about.*

Here's another important message for young pipeline engineers about gaining experience:

- There's no app for experience! You've got to lace up the boots and go to the field.
- Take every opportunity to gain experience while wearing boots yourself. In the field you will get a better understanding of what is being built, and you will have the opportunity to work alongside others who are not engineers and wear their boots every day to make a living.
- There's much you can learn from them. Some of the best teachers wear boots.

Public Image Management

In my opinion, probably the greatest threat to public safety is the priority placed on public image management.

> *Image management is the art of creating an impression for others that either you or your organisation always adhere to standards and principles which, in reality, are sometimes not attained in practice.*

The art of public image management is very well illustrated inside the Canberra Bubble.

Our politicians are highly skilled at ducking and weaving and passing the buck. They keep telling us how good they are at managing aged care, keeping banks and insurance companies honest, caring for those with disabilities, addressing climate change and protecting the environment; but the evidence of their failures is stark.

Public Image management can take many forms:

- Shifting blame; exaggeration
- Plagiarism and quoting out of context
- Filtering or cherry-picking the data (*It's not a Lost Time Incident, he's on "light duties"*)
- Deliberate misinformation (misrepresentations, baseless claims, plausible deniability, etc.)

Censorship is another form of image management. I have experienced various forms of this in my career, including clients insisting that their communications with me be verbal only, leaving no evidence trail in writing, allowing them to later deny what they said.

Why is public image management a potential threat to the public?

Firstly, it does nothing to keep the public safer, and instead it encourages our managers to focus outward and be deliberately positive, pretending to be what we sometimes are not. To better protect the safety of the public, we must give greater priority to a management focus which is <u>inward</u>, critically examining the inner workings of the organisation for any and all warning signs, and seizing every opportunity to implement change and become even safer.

Secondly, it is critical that we maintain the trust of the public. That trust will be eroded if we over-play the public image management card. Given the failings of our government responses to the pandemic, most Australians do not trust politicians any more.

The public would indeed be safer if both politicians and pipeline companies put as much effort into effectively managing public safety as they do into managing their own public image.

> *Which takes greater priority in <u>your</u> organisation, Public Safety or Public Image?*

7. Why strive to become even more reliable?

The recent APGA strategic focus on social responsibility is critically important to our survival as an industry, and quite simply, striving to become even more reliable is socially responsible.

Climate change and public perceptions of anything involving fossil fuels, including natural gas, have become game-changing issues which we must address. Championing natural gas as the "transition fuel of choice" will not be enough to save us from the dustbin of "white elephant" infrastructure in the longer term. We must reinvent the pipeline industry to maintain the support of the very same public that we are striving to protect.

The production, storage and transport of hydrogen currently being studied by our Future Fuels CRC research is a potentially huge opportunity for us, but it can only be seized once. A genuine focus on becoming a high reliability industry can only improve our chances of a successful transition to a new economy based on safely managing hydrogen and other future fuels in pipelines.

Any slip-ups with process integrity and public safety of pipelines will quickly ruin the opportunity for our industry, consigning the pipeline industry to an uncertain future.

General Recommendations

For our industry to become even more reliable in protecting the public there's two things that we must always be willing to do:

1) Avoid the negative consequences of commercial pressures on engineering outcomes, and
2) Give greater priority to genuine safety culture than to public image management.

Yes, engineers are involved, but they are not in control of these actions.

Regardless, I believe there are some things we can do to make engineering better.

Focus on Engineering Training

1) Competency Assessment Exams

   In my opinion, competency assessment procedures should include the requirement to achieve a pass mark on a formal written competency examination. Think about it, in Australia you must pass a written test to get a degree, become an Australian citizen or to get a driver's licence, but not to practice professional engineering.

   To be licensed as a professional engineer in Canada today requires successful completion of a written Professional Practice Examination based on a nominated textbook. (Ref 18.)

   To become licenced as a practicing mechanical engineer in many States of the USA requires candidates to undertake some 14 hours of written examination answering questions set by the American Society of Mechanical Engineers.

   James Trevelyan, author of *The Making of an Expert Engineer*, and Phil Hopkins, a well-known consultant and educator in the global pipeline industry, are both of a similar view. (Ref 19 and 20.)

2) Access to Experience

I have been critical of the experience levels of the in-house engineering staff at some organisations in our industry. In-house engineering capability is important, and I recommend that companies should seriously consider regular short-term engagement of experienced independent consulting engineers to augment internal expertise and also to provide mentoring opportunities for younger pipeline engineers. This also fits well with the recommendation that we must get better at telling stories.

3) The "Technical Authority" concept

In the recently released FFCRC project output report *Pipelines and Public Safety: An Engineering Practice Guide* we recommended that organisational structures in our industry should incorporate a role called the Technical Authority, which is much like a role that I once knew as the Chief Engineer. (Ref 21.)

The individual filling the role must have good interpersonal skills and significant industry experience, be respected by the Board, remain independent of the usual senior management commercial pressures, and be readily accessible as an advisor to junior engineers. As a member of the corporate staff, the Technical Authority would be protected from liability issues by the company's own corporate legal counsel and Professional Indemnity insurance cover.

"Learning from Dreamworld" Survey

Here's a suggestion that I believe would help the Australian pipeline industry to achieve even greater levels of reliability in terms of public safety.

As discussed already, my reading of the Brady Review of mining fatalities in Queensland and the Coroners' report of the Dreamworld tragedy both prompted me to wonder:

"*How well would the pipeline industry measure up if similarly examined?"*

We are justly proud of our reputation in relation to public safety in the pipeline industry. But to paraphrase a sentiment expressed by several witnesses at the Dreamworld coronial inquest:

"It had not happened in thirty years so we just didn't think it ever would happen."

We should take this as a warning not to rely too much on our reputation. We can only learn from the mistakes of others if we genuinely are willing to learn, and that may require a good hard look in the mirror.

The Dreamworld coroner identified at least ten focus areas in his criticism of the amusement ride industry. Based on those focus areas I propose that we should undertake a *"Learning from Dreamworld"* survey of our own pipeline industry.

"*But wait,*" you say, "*pipelines are very different from amusement rides!*"

Sorry folks, the focus areas identified by the coroner also apply directly to the pipeline industry, because all of them represent <u>systemic issues</u> potentially found in any organisation or industry.

We should undertake an honest assessment of the performance of Australian engineering and operating companies in the pipeline industry across all of the following areas which were discussed in the coroner's report on the Dreamworld Tragedy:

1. Genuine and effective application of risk assessment processes.
2. Assessment of competency and effectiveness of training for engineers (Design).

3. Utilisation of competency outcomes, and compliance with engineering registration obligations.
4. Assessment of competency and effectiveness of training for operators (Operation and Maintenance).
5. Proactive management of ageing infrastructure in terms of process safety and system integrity monitoring with adequate funding for maintenance and upgrades.
6. Assurance of conformance with Australian Standards. (How to go about demonstrating this was recently an interesting topic of discussion in a webinar run by the AS2885.INFO team.) (Ref 22. - APGA *Demonstration of Conformance* webinar held August 4)
7. Maintaining and updating Licences and Approvals to Operate. We are probably in good shape here, but it's worth confirming for every pipeline in every operating organisation.
8. Determine existing levels of organisational safety culture maturity in our industry.
9. Examine how effectively management responds to infrastructure failures in service.
10. Willingness to implement expensive changes if recommended by investigations and risk assessments.

To be informative yet anonymous, this survey would have to be done first on a company-by-company basis, then outcomes summarised to present an overview of our entire industry, with identification of any areas in which we are not yet as good as we could be.

Yes, such a survey would represent a good deal of effort and expense, but we already work closely with some very good researchers who know how to do this and could easily handle the legwork.

Is enhancing the safety reputation of our industry worth the effort?

Or should we just wait and let some coroner do the research for us instead?

If we don't strive for continuous improvement…..

We've all heard about "the bad apple in the barrel". Various organisational behaviour studies have clearly established the potentially negative impacts of one bad apple in the workplace.

In the Australian pipeline industry, there are hundreds of individuals who must work co-operatively together to maintain the good integrity reputation of our industry. In nearly 40 years as an engineer, I have met and worked with many such individuals.

The Australian pipeline industry is like a barrel, and in my experienced opinion our industry does contain some bad apples.

If things go horribly wrong and people die because of a pipeline failure here in Australia; the coroner will have no sympathy for us.

Politicians, regulators, the media and the Australian public will not see individual apples, they will only see the entire barrel, and the consequences will affect every one of us.

That's why our entire industry must continue to strive to become even more reliable.

E. (Ted) Metcalfe

Final for Upload to APGA

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REFERENCES

1. Lloyd, B. E. *Engineering in Australia: A Professional Ethos*, Histec Publications, Melbourne 2008
2. *The Economic Basis of the Case for National Registration of Engineers in Australia* - ACIL Tasman – January 2012
3. WA Standing Committee on Legislation - *Taxation Legislation Amendment Bill 2014 - Transcript of Evidence taken at Perth Thursday, 30 October 2014*
4. *Formal Investigation of an Accident on or about the Up Main Western Railway Line at Granville on 18th January, 1977* – J. H. Staunton
5. Canberra Hospital Implosion - *Inquest into the death of Katie Bender on 13th July 1997* – Shane G. Madden
6. *Report of the inquest into the deaths arising from the Thredbo landslide* – Derrick Hand, 29 June 2000
7. The Esso Longford Gas Plant Accident - *Report of the Longford Royal Commission* – Dawson and Brooks, June 1999
8. *Royal Commission into the Failure of West Gate Bridge* – 14 July, 1971
9. Black Saturday – *The 2009 Victorian Bushfires Royal Commission Final Report* – July, 2010
10. *Managing the Unexpected – Sustained Performance in a Complex World* (Third Edition) - Weick and Sutcliffe – 2015
11. *A Framework for High Reliability Organisations in Health Care* - Health Catalysts – November 2018
12. "*Review of all Fatal Accidents in Queensland Mines and Quarries from 2000 to 2019*" – Dr. Sean Brady – For the QLD DNMRE – December 2019
13. *Inquest into the deaths of Kate Goodchild, Luke Dorsett, Cindy Low & Roozbeh Araghi at Dreamworld, October 2016* – James McDougall – February 2020
14. *Inquiry into Mental Illness in Fly In, Fly Out Workers* - Submission from the City of Karratha – September 2014
15. Visit the AS2885.INFO website at https://as2885.info/index.php?title=Main_Page
16. *Findings of the Investigations into the Pipe Rupture and Fire Incident on 3 June 2008 at the facilities operated by Apache Energy Ltd on Varanus Island* – WA Department of Industry and Resources / National Offshore Petroleum Safety Authority – 7 October, 2008
17. *In Plain Sight – assuring the whole-life safety of infrastructure* – Institution of Civil Engineers UK – October 2018
18. *Canadian Professional Engineering and Geoscience: Practice and Ethics* (Sixth Edition) – Andrews, Shaw and McPhee
19. *The Making of an Expert Engineer* – Prof. James Trevelyan, University of Western Australia - 2014
20. Various journal articles and papers by Phil Hopkins - See website *Phil Hopkins Ltd – Pipeline Training and Consultancy* at http://philhopkinsltd.com/

21. *Pipelines and Public Safety: An Engineering Practice Guide* – FFCRC Project Report. (Currently available only to FFCRC members, but soon to be available from APGA)
22. APGA webinar on Demonstration of Conformance held 4 August. (To be available from APGA and AS2885.INFO)

About the Author

Ted Metcalfe graduated with an Honours degree in Mechanical Engineering in Canada, commenced working in the oil and gas industry in Calgary in the late 1970's, and after several years with Amoco Canada moved to Australia in 1982, where he has since worked almost entirely in the pipeline design, construction and operation industry.

He has been employed by operating companies, engineering consultancies, and construction companies; and for the past 30 years has traded as an independent consultant providing services to clients in the industry.

He has been directly involved in the study, design, construction and operation of many high-pressure cross-country transmission pipeline and associated facilities projects in Australia.

For many years he has been active in the Australian Pipeline and Gas Association, is a member of the Research and Standards Committee of that organisation, and is actively involved with the Future Fuels Cooperative Research Council, assisting with research projects involving the influence of organisational factors on engineering practice and public safety.

He is a member of the Forensic Engineering Society of Australia, and seeks to better understand the reasons for failure of complex engineered systems. He reads extensively about such matters in books, formal investigation reports and journal articles.