AUSTRALIAN PIPELINE RESEARCH

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Introduction

In 2001 Max Kimber delivered a paper[1] on Australian pipeline research to the EPRG PRCI 13th Joint Technical Meeting in New Orleans. Since that time the Australian Pipeline Industry Association has accepted the invitation of EPRG and PRCI to join the international pipeline research community. We are pleased to join this Joint Technical Meeting in Berlin as a full participant in international pipeline research. We hope that our modest research program is able to complement the much more comprehensive programs of PRCI and EPRG. Of course, we have not been entirely isolated from the work of either PRCI or EPRG, since a number of pipeline companies have held membership of the former from 1984 through to 1998.

As was indicated in Mr Kimber's paper at the last JTM, Australia's gas and liquid petroleum pipeline industry is quite small, with only about 12,000 km of onshore gas transmission pipeline and 3,000 km of onshore liquid petroleum pipeline. The Australian pipeline research program is modest, as befits our small industry and has been in operation since 1996.

Research Program	Cash Cost ($A)	Total Cost Including In-Kind and subsidies* ($A)
1996 –1998	600	2.0 million
1998 – 2000	617	2.4 million
2000 – 2002	610	2.0 million
2003	350	1.2 million

* Most of the research is carried out through Cooperative Research Centres that are supported by both industry and government

Research has focussed on particular issues facing the Australian industry and its reliance on long distance small diameter pipelines often traversing very remote areas for most of their length. Most new pipelines in Australia are designed to operate at pressures of 15Mpa and most other pipelines built since the mid-1980s operate at 10MPa. The Australian Standard for petroleum pipelines is being rewritten with a view to increasing operating stress levels of up to 80%, and new pipelines often include design provisions to allow re-rating to 17 MPa. A significant part of our current research program is directed to providing sound reasons for higher operating stresses. We are also investigating the use of higher strength steels to further reduce construction costs.

We have not ignored the operation of pipelines and the remainder of the program has been devoted to improving safety and reducing operating costs

The High Pressure Pipeline Industry in Australia recognises the need for applied research to enable it to become more efficient in all aspects of the industry. As such it has over the last 3 years embarked on a diverse program covering construction welding methods and problems confronting Operator in the daily management of the completed pipelines.

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1 Kimber, M.J., *Research In The Australian Pipeline Industry*, EPRG – PRCI Joint Technical Meeting, New Orleans, May 2001, Paper #6

APIA has found it convenient and cost effective to use, as its main contract researcher, the Cooperative Research Centre for Welded structures (CRC-WS), which is based at the University of Wollongong in New south Wales and incorporates the engineering schools from the Universities of Adelaide, Sydney and Western Australia and researchers from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Australian Nuclear Science and Technology Organisation (ANSTO). Research work is often undertaken as part of post graduate studies and permits supplementation by the universities to such an extent that the value of the research through in-kind contribution more than doubles the value of the industry cash contribution.

The results of the Research are held confidentially by the APIA, sponsors of the Research and the CRC-WS. Some of the work has resulted in the development of software tools that is of use to the industry in its normal operation and can be purchased by the broader industry from the CRC-WS. There are other speakers at this conference that will refer to this, particularly the work that has been undertaken in the area of hydro-testing of newly constructed pipelines.

Where research work is directly related to the development of Australian Standards for pipelines, it is our policy to release the results of that work to provide justification for the content of the Standard and education for pipeline designers and operators..

The Australian Standard, AS 2885 *Pipelines Gas and Liquid Petroleum,* is largely non prescriptive, in contrast to other national and international standards for pipelines. The paper[2] to be presented by Mr Fletcher to this JTM compares the Australian Standard with others and comments on the absence of empiricism in AS2885 and its reliance on the “laws of nature” rather than the ‘laws of man”. All natural gas pipelines in Australia are licensed by the appropriate state based government regulator, which requires compliance with AS2885. The industry has been successful in ensuring that AS2885 is the *only* set of safety and operating rules with which a gas pipeline has to comply but is more extensive than ISO13623, 2000 Petroleum and Natural Gas Industries-Pipeline Transportation Systems. It builds on the principal of engineering accountability by providing policies, principles and practices through the provision of guidelines to the owner and operator of the pipeline.

While the Australian Standard is non-prescriptive, it requires the owner and operator to take responsibility for their actions this means that we regard research as essential to provide the necessary support to ensure that engineering decisions in the context of AS2885 can be made with confidence. Regulators require independent compliance audits to be undertaken and where a pipeline does not meet the requirements of AS2885, financial penalties can be levied.

The Pipeline Research Program from 2000

The most recent two-year research program, that began in late 2000, includes projects in the following areas:

- Pipeline resistance to external interference – Phase II
- Pipeline awareness – further development of improved methods of protecting pipelines from third party damage
- Mechanised in-service welding
- Development of a knowledge base for mechanised girth welding
- Development of on-line monitoring for welding
- Hot cracking of weld metal in girth welds
- Defect acceptance levels and fracture risk in pipeline girth welds
- Adhesion of field joint coatings to extruded polyethylene
- Pipeline hydrostatic test behaviour to accommodate 80% SMYS operating stress levels

[2] Fletcher L., Venton P., Kimber M., Haddow I., A*ustralian Standard AS2885: A Modern Standard For Design, Construction, Welding, Operation And Maintenance Of High Integrity Petroleum Pipelines*, 14th Joint Technical Meeting, Berlin, Germany, May 2003

- Investigation into the causes of the precipitation of elemental sulphur in transmission pipelines

This program is managed by a committee constituted by the APIA that meets quarterly to review progress on the research. This committee consists of Sponsors and a representative of the CRC for Welded Structures. Each year there are 3 Research Forums held at which the researchers present the results of the work to a broader representation of the Sponsors.

A new program has just been approved and the following projects are to be undertaken:

- Effect of Transient Loss of Cathodic Potential
- Effect of Factors Related to Hydrogen Cracking for In-service Welds (Project with PRCI)
- Pipeline Resistance to External Interference – Phase III
- Field applied coatings to cold, damp valves/pipework
- Fracture Propagation Control
- Hydro-test software development

We are also continuing with the finalisation of:

- Adhesion of field joint coatings to extruded polyethylene; and
- Adhesion of field joint coatings to extruded polyethylene

Results of the 2000 – 2002 Program

There are separate papers at this meeting which cover the results of the research in the following projects:

- Mechanised in-service welding
- Development of a knowledge base for mechanised girth welding
- Development of on-line monitoring for welding
- Hot cracking of weld metal in girth welds
- Defect acceptance levels and fracture risk in pipeline girth welds
- Pipeline hydrostatic test behaviour to accommodate 80% SMYS operating stress levels
- Investigation into the causes of the precipitation of elemental sulphur in transmission pipelines
- Links between Australian research and the development of Australia's pipeline standards

As a consequence this paper will concentrate on the results of the remainder of the projects.

Pipeline Resistance to External Interference

This project has concluded but a third stage is to commence this year. The report for stage 2 is available on application to members of the EPRG and PRCI.

The work[3] was conducted by Daniel Brooker at the Centre for Oil and Gas Engineering at the University of Western Australia under the supervision of Professor Beverly Ronalds and the industry adviser was Phil Venton Chairman of ME38 and ME38 /1 the committees that manage AS2885.

The project had its origins in the need for the industry to have better information available to it in the management of risks that high pressure pipelines are exposed to. It is important for a pipeline owner to have some knowledge of the possible sources of third party interference and the likelihood of this actually causing a breach in the pipeline. Consequently a project was commenced that examined initially through

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[3] Brooker, D.C., *Resistance of Pipelines External Interference Phase II - Final Report*, APIA/CRC-WS Research Project 98-66, Draft completed March 2002

computer based finite element analysis the affect of various distortions of a high pressure pipeline and follow this work up with some field tests. The results showed good correlation between the finite element analysis and the field work and was able to confirm some of the work previously completed.

The following is an abridged summary of the findings in the final report:
This project was initiated in response to the release of the Australian Standard - *Pipelines—Gas and liquid petroleum* AS2885(1997) Part 1 Design and Construction, in which pipeline designers are allowed to use penetration resistance as a physical measure for protection against puncture. The Standard does not provide any guidance as to how this is to be quantified for input into the design and, since the Standard requires the designer to take engineering responsibility for protection measures, it was essential that the designer was provided with the appropriate guidance on this matter. Having completed a world wide literature survey on this topic which also collated a database of damage sources and pipeline damage sources for Australian pipelines the second phase concentrated on experimental and modelling work.

Experimental Work
Experimental work was conducted on an abandoned segment of pipeline of 300mm nominal diameter, 6.35mm wall thickness and API15L-X46 grade steel. Six different types of equipment were used in the test work- two different types of excavator, two types of vertical drilling equipment, a horizontal directional drill and a bulldozer fitted with a ripper.
All of these different equipment types, with the exception of the smaller excavator, caused sufficient damage to be considered credible external interference threats. The observed damage included denting, gouging, and puncture of the pipeline.

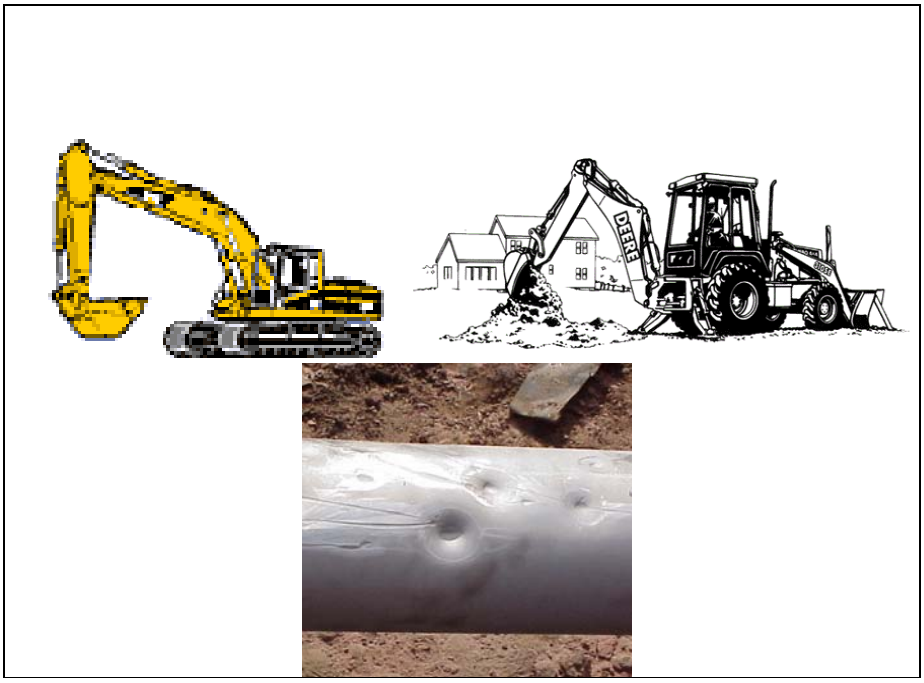

Figure 1: Excavator Damage

The main objectives of this work were twofold:

- To provide qualitative evidence of the type and level of damage that horizontal and vertical drilling machines inflict on pipelines, recognising that little work has been done on these types of drilling machines.
- To provide some data on excavator denting/puncture for verification of the numerical work.

The tests showed that drilling equipment of all types is capable of puncturing pipelines if the drill head provides a cutting action. Because operators may continue drilling operations well after initial contact, even thick walled pipelines are vulnerable to drills. For this reason, procedural measures rather than physical measures are recommended for these threats.

The tests using the D6H bulldozer showed that pipelines are also vulnerable to ripping operations, with pipeline resistance to penetration alone viewed as insufficient protection. Maintenance of adequate separation by burial (as determined by risk assessment), together with procedural measures, is a more appropriate measure of protection against threats of this nature.

Figure 2: D6H Bulldozer with Ripper

Figure 3: Puncture from D6H Bulldozer Ripper

Finite Element Analysis

A new technique for simulating material failure in finite element analysis was formulated, suitable for puncture analysis of piping. The method models ductile failure through a material softening approach, and can be applied using easily obtainable material properties.

These are:

- Yield stress
- Ultimate stress
- Percent elongation at rupture

The effects of multi-axial stresses are taken into account.

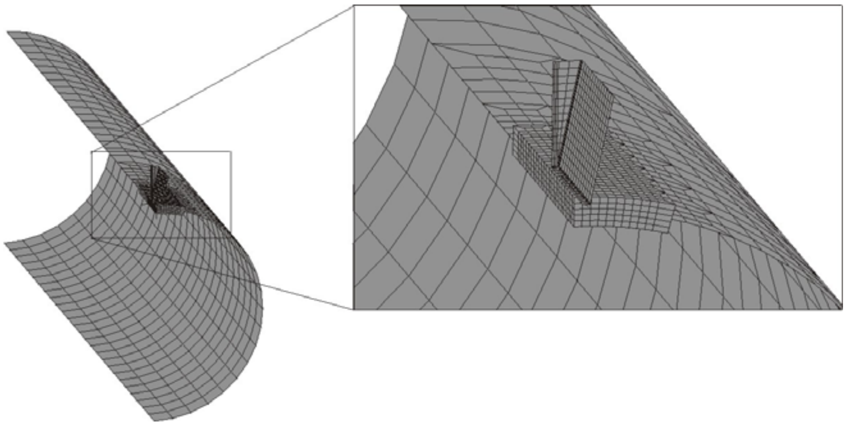

Figure 4: Finite Element Model

This work has resulted in the establishment of a predictive equation that has been compared to the three tests completed by the EPRG.

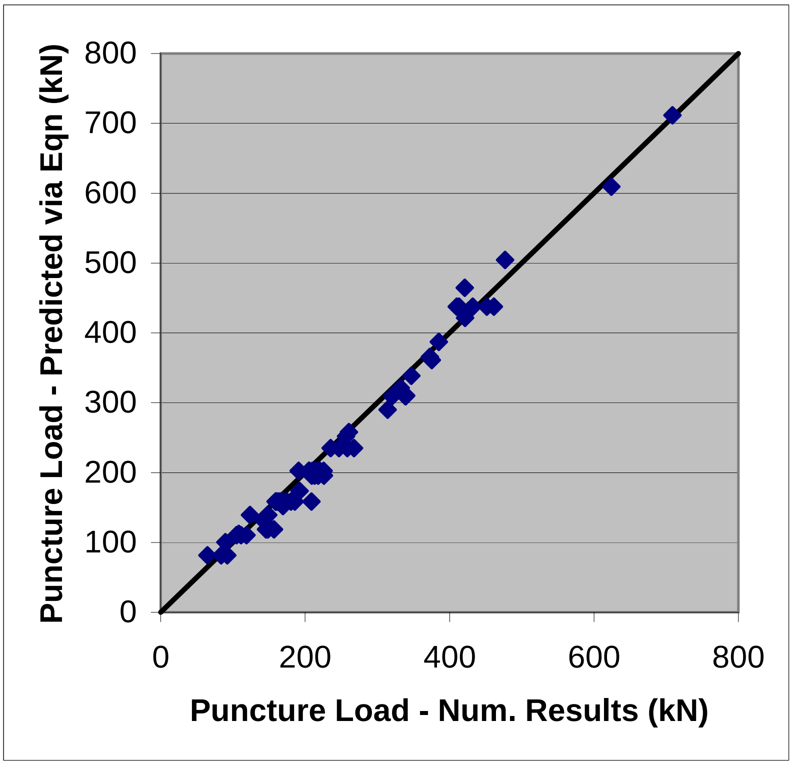

Figure 5: Results of Predictive Equation

The same results were compared with the equation developed by Driver and Zimmerman 1998[4] and the field results show good correlation as shown in figure 6 below. Note scale difference

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[4] *R Driver,T Zimmerman A Limit States Approach to the Design of Pipelines for Mechanical Damage, in 17th Int Conf on Offshore Mech and Artic Eng 1998*

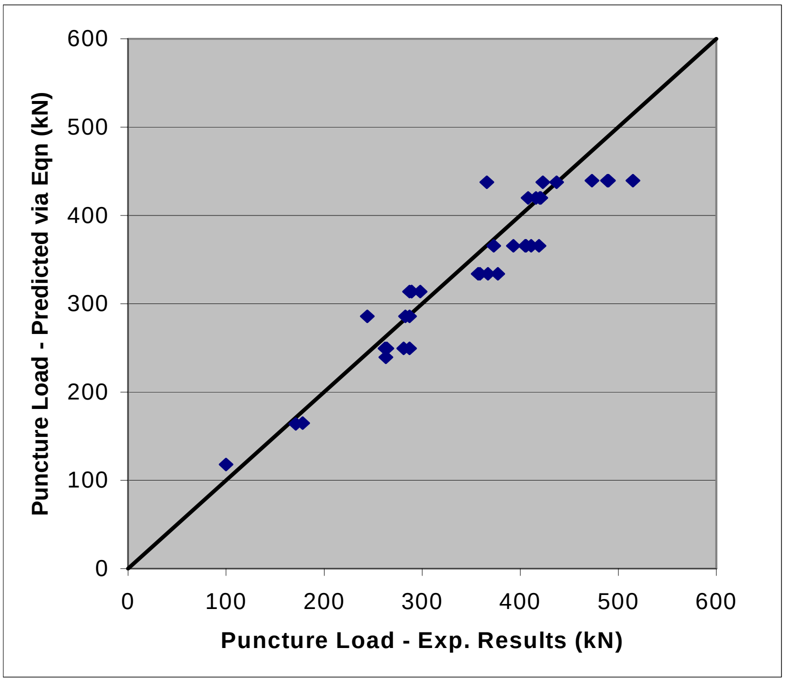

Figure 6: Driver Zimmerman Comparison

From this work a table of design criteria has been determined.

Pipe Wall Thickness (mm)	Material Grade	P Teeth (8x7mm)		GP Teeth (50x3mm)	
		% Likelihood of Puncture	**Puncture Risk**	**% Likelihood of Puncture**	**Puncture Risk**
3.2	X42	96%	HIGH	18%	LOW
	X52	77%	HIGH	7%	VERY LOW
	X65	51%	HIGH	0%	NIL
4.8	X42	29%	MODERATE	0%	NIL
	X52	16%	LOW	0%	NIL
	X65	0%	NIL	0%	NIL
6.4	X42	0%	NIL	0%	NIL
	X52	0%	NIL	0%	NIL
	X65	0%	NIL	0%	NIL

5T Excavator **Max. Load Capacity=35.9kN**

P Penetration Teeth
GP General Purpose Teeth

Figure 7: Design Table Puncture Resistance

This has shown that:

- Pipelines of 6.4mm wall thickness and higher are generally resistant to penetration by General Purpose (GP) type teeth by equipment up to 45T.
- Most typical pipelines, regardless of wall thickness, are vulnerable to puncture from Penetration (P) type teeth.

It has been shown that the Finite Element modelling has replicated the experimental results reasonably accurately both in terms of puncture loads and the deformation of the pipeline under load. Also comparisons of the numerical results to measured deformations has shown that the maximum force data provided by the excavator manufacturers is a reasonable estimate for the load experienced by a pipeline.

Study on Puncture
Using the material failure model that was developed, a parametric study was conducted on the puncture of pipelines under excavator tooth loading. This showed that:

- The puncture load is not sensitive to pipe diameter, internal pressure or the angle of the tooth with respect to the axis of the pipe.
- The puncture load is strongly dependent on tooth size, pipe wall thickness, material grade and position of contact.
- Simple analyses based on punching shear or membrane stresses tend to over predict puncture loads for small sharp teeth.

An equation for predicting puncture load has been developed and this has been shown to be consistent with experimental data. It has a wide range of design criteria both in tooth size and pipeline size. The angle of contact is an important conclusion for this.

Conclusions are:

- Pipelines with wall thicknesses of 6.4mm and above typically have good protection against penetration from excavators of operating weights of up to 20tonne when they are fitted with unworn, general purpose(blunt) teeth.
- Pipelines of wall thicknesses of 4.8mm provide similar protection against general purpose teeth for excavators up to 15tonne.
- Pipelines of all sizes are vulnerable to penetration from even light excavators when highly worn or penetration type teeth (i.e, small sharp teeth) are used.

Study on Denting
This was done under excavator loading and Finite Element model analysis.

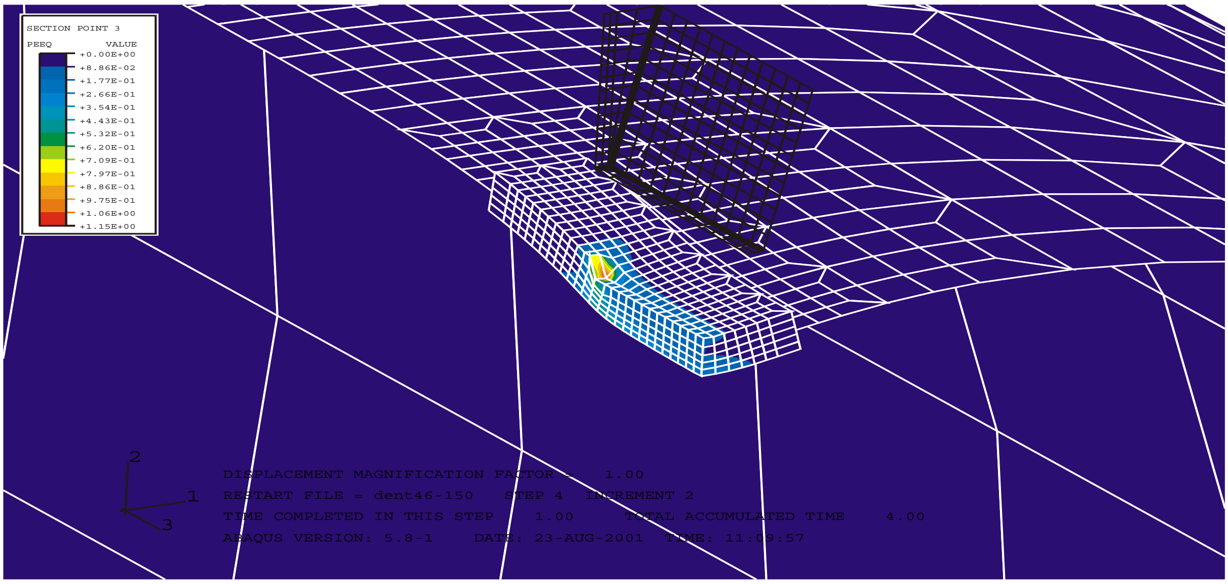

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Figure 8: Finite Element Model for Denting

From this a load deflection curve for elastic and plastic deformation obtained and the following conclusions reached:

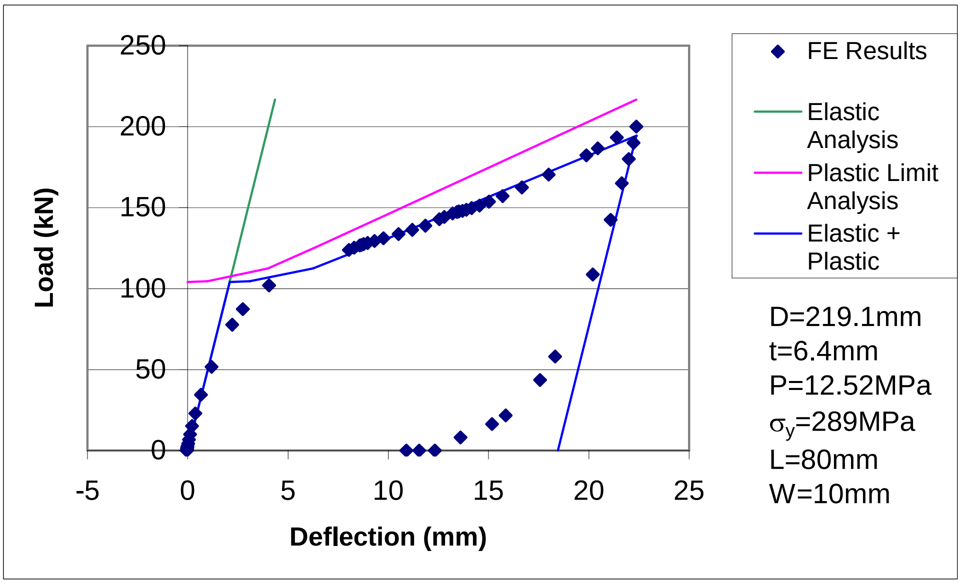
Elastic Response

- Deflection in the elastic region can be predicted using shell theory by approximating the loading as diametrically opposed pressure loads on a finite length end-fixed cylinder.

Plastic Response

- The load-deflection behaviour in the plastic range can be approximated via plastic limit analysis. Membrane extension occurs in the longitudinal direction only.

From this a further set of theoretical predications can be made.



This chart shows the deformation commencing at the left hand side and the change in the load for the various types of deformation up to the point of puncture when the deformation load reduces as shown on the right hand side of the chart.
It is then concluded that:

- Application of these methods for typical pipelines show that, in general, pipelines are very resistant to the formation of large dents (e.g. those exceeding 6% Diameter) provided internal pressure is maintained. Pipelines with higher material grades and diameters are more effective in resisting dents.

Outcomes of the Research Work
This research has assisted the Industry in its quest to understand the affect of third party interference on pipelines from excavators, dozers, and drilling machines. It has provided the following:

- A more accurate design equation for pipeline puncture
- A corresponding equation for pipeline denting
- Benefits to Industry
  - providing a method for quantifying puncture and denting resistance of pipelines to external interference

The equations and detailed substantiation of this is available to PRCI and ERPRG members.

Pipeline Awareness[5]
The current revision of the Australian Standard, AS2885.1 -1997, adopts a risk based approach to the protection of pipelines from damage. The Standard requires that “each threat to the pipeline and each risk from loss of integrity of a pipeline is systematically identified and evaluated”, and that “action to reduce threats, and risks from loss of integrity, is implemented so that risks are reduced to As Low As Reasonably Practical (ALARP)”. As threats to the pipeline, and the consequences of loss of pipeline integrity, change over time, this process is not limited to the design stage, but is required to continue over the life of the pipeline. Since the publication of this Standard there was been a complete revision to AS2885 Part3 Operations and Maintenance in 2001. This provided additional guidance on the management of pipeline integrity and mandated the risk assessment process for the daily operation and

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[5] Roach I., *The Prevention of Damage to Buried Pipelines Caused by Unsupervised Excavation [Pipeline Awareness]*, APIA/CRC Research Project 1999-69, August 2002

maintenance tasks. Whereas this guidance has been identified by the researcher as quite general in nature this was a deliberate action in the Standard as it was not intended to produce a mandated set of requirements but guidance and a process that the Operator could use to ensure that adequate protection was in place. As mentioned earlier the principal of the Standard is about accountability and robust engineering decisions. The methods adopted by the Operator need to stand a professional test.

This project was conceived as more of a sociological, rather than an engineering research project because an understanding of the behaviour of the pipeline operator's staff and that of those who make threats to the pipeline is critical, if a pipeline operator is to protect the integrity of a pipeline from third (or first party) party damage. This is so, since pipeline patrols, awareness program, advertisements in local newspapers and contact with landowners are all ephemeral and must make sufficient impact on those who operate excavation equipment to ensure a long-lasting awareness of the presence of a pipeline. The short-hand title of this project was "Pipeline Awareness" The project drew on interviews with pipeline operators, excavation personnel and landowners and also from work done by the US Office of Pipeline Safety.

In order to assist the operator in deciding which methods to use in maintaining the integrity of the pipeline research was undertaken by Ian Roach as part of a post graduate course at the University of Wollongong with management by the CRC for Welded Structures.

The research has concluded and the principal conclusions recommendations and findings are included from the final report. This report is available to PRCI and EPRG members.

The study confirmed the widely held belief that excavation, and similar activities, are the leading cause of pipeline incidents and accidents and that incidents involving third parties constitute the largest subset of this group. The incident of damage by third parties to Australian Pipelines was less than that for European or North American Pipelines. This may be due to the remote location of many of the pipelines in Australia.

All pipeline owners and operators in Australia have formed an industry group to discuss technical matters and this group has been gathering statistics on pipeline interference incidents over a period of approximately 15 years.

A summary of this data base for all incident occurrences from the database is as follows.

Cause of Incident	**Number**	**Percent %**
Materials of construction such as weld or steel failure	8	7
Corrosion including leaks and stress corrosion cracking failure	17	14
External Force from third parties and pipeline company staff	93	78
Other	1	1
Total	**119**	**100**

A more detailed breakdown of the External force category is as follows-

Cause	**Number**	**Percent %**
Storm	2	2
Erosion	2	2
Ground Movement	3	3
Impact Own Equipment	20	22
Impact Third Party Equipment	62	67
Unknown	4	4
Total	**93**	**100**

In summary, Australian high pressure pipelines have suffered only 93 external force incidents in 15 years over about 12,000 km of pipeline. Only [3?] of which breached the pipeline. .

The researcher made a number of conclusions observations and recommendations regarding the management of the various procedural measures undertaken by Operators in managing the integrity of high pressure pipelines.

A summary of these conclusions, guidance and recommendations for procedural measures for the management of pipeline integrity has been prepared.

The principal aim of procedural measures is to ensure that all activity that occurs in close proximity and over the pipeline is always able to be detected prior to any damage occurring to the buried structure. There has been a large variety of measures used, from field procedures and emergency response to actual physical barriers.

In some cases these are mandated by regulation and others by assessing the results of a detailed risk study.

Despite all of the best intentions of the transmission pipeline company, interference does occur. This has been found to be as the result of one or more of the following:

- failures of attention;
- failures of memory;
- failures of knowledge; and
- deliberate violations of safety rules.

Some procedural measures are more susceptible to a particular type of human failure than others. For example, signposting may be useful against the threat from an excavator operator who has forgotten to check for the presence of buried pipes and cables, but may not be very effective against the threat from an excavator operator who believes he has the knowledge and skill to carry out his work without help from the operators of buried facilities.

It has been shown however that that the effectiveness of the procedural measures such as pipeline markers, buried marker tape, and one-call systems, is greatly enhanced if effective liaison is maintained with the owners and occupiers of land through which a pipeline runs, and with those organisations and individuals who are involved, in any capacity, with activities that could threaten the pipeline. Consequently an effective land owner and third party liaison program has been found to be essential.

Land may be occupied by the actual owner or a tenant and consequently it is essential that an up to date alignment sheet must be maintained. It must show property boundaries, the names of the owner and/or occupier and contain topographic and other local information to allow accurate and easy reference to known points to permit location of the pipeline. The alignment sheet must be made available to all pipeline operating staff to allow them to contact the owner/occupier and to describe the precautions that must be taken to protect the pipeline..

An effective landowner liaison program should include comprehensive records of contacts made. The records should be reviewed at regular intervals to assess the effectiveness of the program in reaching the target audience.

The number of third party organisations, that could potentially be involved in activity that damages a pipeline, is very large, and the first problem of third party liaison is to discover who they are. As well as those parties that could be involved in the activities that threaten the pipeline, liaison should be maintained with the planning authorities that must approve development work in the area. Other organisations that should be contacted are other utilities large earth moving contractors and road constructing authorities.

Liaison may, and should, take many forms. These include formal processes such as toolbox meetings, distribution of safety literature, and processes for advising of new development plans, and informal processes such an occasional telephone call to ask if anything interesting is happening. Regardless of the method of communication it is necessary that the target groups are made aware that damaging a pipeline can be both dangerous and expensive, and that they must contact the pipeline operator, either directly or via a one-call service, prior to commencing work at a new site.

In some jurisdictions working near a pipeline without notifying the pipeline operator is an offence, and substantial penalties, such as fines, can be imposed. These penalties can be effective in deterring unsafe behaviour. However, a person detected performing un-notified work near a pipeline, and members of his organisation, are prime candidates for education, and this approach may be more effective in many cases.

An effective third party liaison program includes comprehensive records of contacts made. The records are analysed regularly to evaluate the effectiveness of the program.

Pipeline Markers: Pipeline markers are considered to be effective against a particular threat if at least one marker can be seen by the person undertaking the threatening activity.

In practice it is usually found that there are few locations where dangerous activity could never occur. Consequently it is considered by many pipeline operators to be sound practice to locate markers:

1. At every property boundary.
2. Both sides of every crossing of a road, railway, water course, buried service, etc.
3. At every abrupt change of direction.
4. So that from any position on the pipeline route a person can see at least one sign in each direction.
5. Where possible, directly above the pipeline, within a reasonable tolerance of say one metre.

Where structures that might require maintenance or replacement, for example power poles, are located close to a pipeline, attaching a suitable sign to the structure will enhance the effectiveness of the marking system.

Effective pipeline marking applies these rules regardless of land use in the area, and including in remote areas.

Commonly used marker styles, listed in descending order of effectiveness, are:

1. Large cylindrical signs mounted at eye level.
2. Large double sided flat signs mounted at eye level.
3. Large single sided signs mounted at eye level.
4. Small flat signs at low level, or short tubular signs.
5. Stencilled kerb signs.
6. Adhesively attached kerb signs.
7. Flush mounted pavement signs.

The difference in effectiveness between the first three styles listed above is not very great.

In some locations, for example residential areas, pipeline markers may be considered unsightly, and there have been cases where markers have been removed or relocated by people who found them offensive. A highly visible marker is not effective after it has been removed, and one of the less conspicuous designs may be a better choice in these locations.

Experience has shown that it is impossible to guarantee that every marker will be installed, and will remain for the life of the pipeline, in precisely the correct location. Therefore it is unwise to indicate, on a marker, the precise location of the pipeline relative to the marker. It is much better simply to state that there is a pipeline in the vicinity, or words to that effect. Accurate location of a pipeline must be carried out, before commencement of excavation or similar activity, by the pipeline operator using appropriate equipment and procedures. Attempting to locate pipelines by measurement from markers is unsafe.

Special markers are often provided for the assistance of land or aerial patrols. These include kilometre posts that can be read from the air, and brightly coloured fences where pipelines cross property boundaries. These markers can be very useful, but are not considered to be effective against external interference threats.

Buried Marker Tape: Buried marker tape is considered to be effective against a particular threat if it is not possible to damage the pipeline without first exposing the tape.

However in the case of horizontal directional drilling or deep ripping, buried marker tape is clearly not effective.

To be effective the tape needs to be installed so that it will not break when it is stuck by the excavation equipment. This can be achieved by laying the tape in a zigzag or looped pattern so that there is plenty of slack. Greatest benefit is derived from buried marker tape when it is used in developed areas, or in particularly vulnerable areas such as crossings.

Patrolling: Patrolling is considered to be effective against a particular threat when Patrolling has many functions. The only function considered here is the detection of un-notified activity before the pipeline is damaged.

Patrols contribute to protection from third party damage in three ways.

1. Regular patrolling keeps the patrol personnel up to date with activity in their patrol area such as land development and seasonal agricultural activity. They get to know the people and organisations that live and work in the area and with whom it is necessary to maintain liaison. In this way they may become aware of future excavation activity long before it poses any threat to the pipeline.
2. Patrolling identifies missing, damaged, or defaced pipeline markers and allows repair or replacement to be carried out in a timely fashion, thus ensuring the marking system remains as effective as possible.
3. Patrolling may discover activity, with potential to damage the pipeline, that has not been notified to the pipeline operator in advance.

While the value of items one and two above is very real, there are circumstances where a threat to a pipeline may only be detectable for a short period before the danger becomes immediate. To be effective against such threats the patrol frequency needs to be such that the activity will be detected before any damage is done.

Daily patrols will be effective against most threats, but each case should be considered on its merits.

In rural and remote areas the resources required to mount daily patrols would, in most cases, be more effectively used for landowner and third party liaison.

One-Call Services: Participation in a one-call a one-call service has been shown to be very effective in ensuring that pipeline operators are notified, One-call services are effective for pipelines located on both public and private land, but are most effective for public land in populated areas.

The effectiveness of a one-call system is highly dependent on the pipeline operator’s internal systems being able to respond accurately and rapidly to all inquiries, and to follow up, when necessary, with competent and timely assistance and advice.

It was found that it is poor practice to issue drawings showing the location of a pipeline to a person who is about to commence excavation close by as the likelihood of notification to the one-call system reduces.

Where the response to a one-call inquiry indicates that there is a pipeline near the proposed work, it is more effective to give the name and direct contact number of the person who will be responsible for providing assistance to the inquirer, than to only provide the telephone number of the operating company’s office.

It is better to contact an inquirer in person, soon after the response to the inquiry has been forwarded via the one-call system, than to wait for a contact from him.

Remote Intrusion Monitoring: Remote intrusion monitoring is a recent development and there is little experience in applying it to the protection of pipelines. However it is clear that the ability to detect a potentially dangerous activity, and raise an alarm at an appropriate remote location, is not sufficient to constitute an effective measure. The pipeline operator must also have the ability to mobilise a patrol, and reach the location of the threat, before any damage occurs.

Adhesion of field joint coatings to extruded polyethylene

Most pipeline operators have been troubled by the failure of tape and shrink sleeve joint coating on pipeline coated with high density polyethylene. Australia has its share of pipelines where failure of the joint coating has resulted in active corrosion. This prompted research into the means by which cross-linked polyethylene shrink sleeves could be made to bond to the surface of the high density polyethylene parent coating to form a water-tight joint. The project recognises that it is nearly impossible to get material to bond to the surface of polyethylene, unless the surface is pre-treated to develop a form of surface activation. This research project is a carry-over from our 2002 program and is already producing useful results..

This project was initiated following field investigation of pipelines that had been coated with shrink sleeves that although appeared to be in good condition were on further investigation not adhering well. In Australia there is a training course for field technicians covering the application of these sleeves but despite this, poor results are achieved by fully trained applicators.

Research initially failed to find a method that would be of practical use but over the last few months attention has turned to the adhesion of joint coatings to three layer coating and there has been a significant breakthrough that may result in a relatively easy and inexpensive method to achieve such bonding. Experimental work is continuing and we are awaiting the results of the current tests before releasing any of the information. It is expected that this project will now move quite quickly to the engineering and environmental phase and a recent review meeting has prepared a program to test the adhered joints in a number of conditions and to assess the viability of application of this material in a factory environment.

Research Program 2003

The Research and Standards Committee of the APIA had approved by its Executive Committee a research program for 2003. This included for the first time research that is being undertaken as a joint project with PRCI on Hydrogen Assisted Cold Cracking of pipeline welds during in service welding.

Projects currently underway include:

Effect of Transient Loss of Cathodic Potential: Pipeline cathodic protection levels can be reduced below those normally required for corrosion protection by transient effects due to stray traction currents and telluric influences. Limited studies were undertaken some years ago and the results have been incorporated into criteria in the present pipeline cathodic protection standards. However, it is likely that these criteria are in some instances excessively restrictive and in other circumstances may be inadequate. This project will examine the protection criteria and extend the data already available. Experimental work will include simulating the effect of transient under-potential excursions and developing criteria for adequate protection. Laboratory studies will be accompanied by field installations and testing to verify applicability. The results will be used as a basis for revision of the pipeline cathodic protection codes.

There is expected to be both economic and safety benefits resulting from this work.

The economic benefits would be:

- the extension of asset life and reduced costs for repairing corrosion damage
- reduced expenditure on pigging or other forms of inspection.
- possible reduction of capital costs of pipeline construction.

The safety benefit would be the reduced risk of gas escape due to corrosion.

This work is to commence in February 2003.

Field applied coatings to cold, damp valves/pipework: Situations are often encountered, particularly on gas pipelines immediately downstream of regulator stations, where pipe surface temperatures are low and below the atmospheric dew point. These cold, damp conditions make it difficult to apply a high performance long life coating that will deliver its normal level of performance. In addition, curing times of epoxies and similar materials as presently used are extended to unacceptably long timeframes, and full cure hardness may not be obtained.

In many situations it is impractical to reduce gas flow sufficiently to enable coating application at higher temperatures. A high performance field applied coating is required, suited for underground service and compatible with commonly used barrel coatings, that can be applied and will cure on cold damp pipe.

In order to address this issue a research project is to be undertaken that will consider this issue.

It will review coating requirements and systems that are commercially available. Then on the basis of factors such as claimed performance and consideration of the chemistry of the materials, determine those that might provide the characteristics required. From this three products will be selected for further evaluation. Laboratory and field trials on the selected products will be performed to determine application and any performance limits.

Conclusions

This paper has provided a summary of the key findings from two of the projects that have recently concluded as well as a brief synopsis of the work planned for 2003.

The conduct of research through the CRC for Welded Structures and the linkage to academic institutions has ensured a high level of research capability and maximum value for the funds spent. The APIA is grateful for this association and the close linkage between Industry and academia has been invaluable.

Research continues into areas that will ensure that the High Pressure Pipeline Industry continues to improve both construction and operation and maintenance of pipelines and assists in the preparation of Standards.

With the requirement for engineering accountability paramount in the Australian Industry this research is an important basis for the progression of knowledge to enable such accountability to be supported by sound information.