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SURVIVING CHANGE IN THE PIPELINE BUSINESS

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ABSTRACT

The oil and gas pipeline business started in 1861 with the transportation of oil in cast iron pipes in Pennsylvania, USA. Nearly 150 years later we are seeing significant change in the business, but this change is not so much centred on the engineering but more on legislation, staff and the world economy.

This paper presents some of the major changes we are experiencing in the pipeline business and suggests some ways of surviving this change.

KEYWORDS

Change, staff, globalisation, politics, ethics, litigation, integrity, liability, pipelines, poverty.

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1. INTRODUCTION

The oil and gas pipeline business has been with us for many years. As early as 400BC, the Chinese used bamboo pipe to transmit natural gas to light their capital, Peking. In 1821 wood pipe was used to transport natural gas in New York state, but we had to wait until 1861 for our first metal transmission pipeline. The labour disputes and weather problems associated with transporting oil in barrels on rivers by horse-drawn barges in Pennsylvania lead to short cast iron oil lines driven by pumps being constructed in 1861.

We have experienced major changes since those early years: welding; high strength steels; long distance, high pressure transmission; offshore lines, etc.. But what changes are we experiencing now and what changes can we expect?

It is surprising, but many of the major technology changes we anticipated ten or twenty years ago, have not occurred. For example, we have expected new materials such as non-metals or high strength steels to revolutionise our new pipeline constructions, but this is not happening. Figure 1 shows that the amount of new high strength steel strength (greater than allowed by the pipeline specification, API 5L) in use in today's pipelines is less than 0.0001% of the total length of operational pipelines.

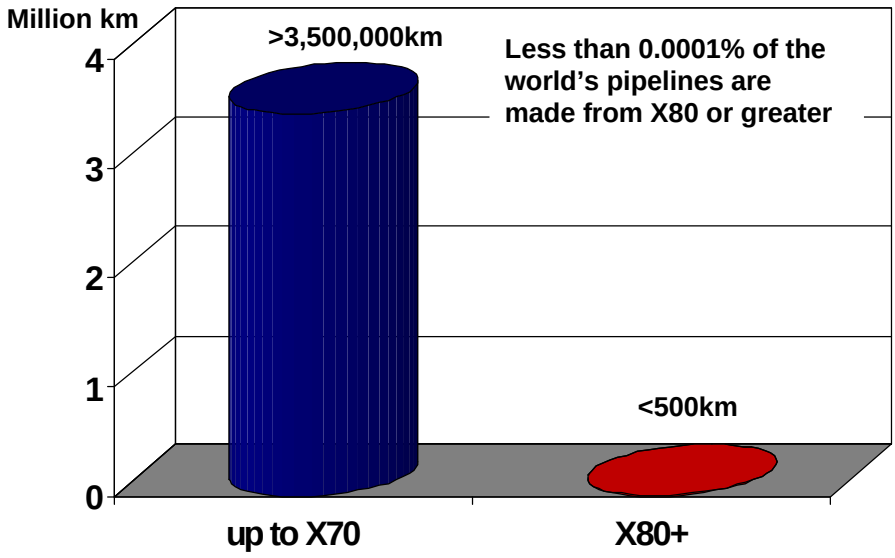


Figure 1. Total length of high strength (X80+) line pipe steel in use today.

Similarly, we expected 'environmentally friendly' renewable energy to start replacing our oil and gas, but again this is not happening, Figure 2. Renewables (ignoring large scale hydro-electric projects) account for only 2% of the world's primary energy needs.

Where we are seeing great change in our industry is in:

- globalisation
- politics
- litigation
- poverty and ethics
- corporate change
- people changes

Therefore, this paper looks at change in our pipeline business from the above perspectives and gives some advice on how to survive all these changes. This paper is a continuation of earlier papers [1,2] on the subject of 'change'.

First of all we will consider the changes that we experience in our everyday lives, then we will look at some changes that are occurring in our business and see how we can survive these changes.

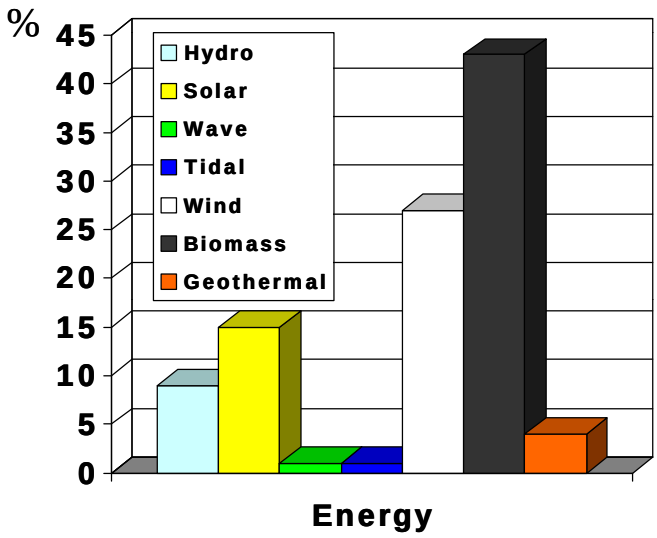


Figure 2. Renewable Energy: market share[2] [3].

2. CHANGE IN OUR PERSONAL LIFE

We live in an ever-changing world, and as individuals we must live with change. In our home life we see change and transformations, for example [4]:

- REVERSAL - 100 years ago the 'front' of our house was where we lived and played. It was safe. The 'back' of the house was for servants, tradesmen, rubbish and toilets. Now, road traffic at the front of our house, means the 'back' is where we play, entertain, landscape gardens, build conservatories, etc.. Think about where you put the rubbish for collection now?
- CLEANLINESS - We have less people living in our houses, but are obsessed with cleanliness; modern houses are small because of the irrational demand for multiple toilets and sinks.
- COMPARTMENTALISATION - 100 years ago we had many rooms, but demand for space in the 1960s created 'open plan'. Now, working styles mean that people need rooms at home to work, hence we now need many rooms. The future will see more work from home, but differing work times. Therefore, the next change for our homes is being used 24 hours per day….

And the Western World needs to be prepared for a change in the homes we live in: by 2016 there will be 25% more homes than there were in 1991. Most will be occupied by single people, with many single, professional women who choose to live alone. This is why we see so many apartments being built. Modern, single people do not want houses and gardens, with their associated high maintenance in terms of labour.

We usually accept and welcome change in our domestic environment, but can be very reactionary when we face change in our workplace. This is reasonable, as much of the change is unpleasant: downsizing, re-engineering, etc., fluctuating price of oil (with its effect on job security), etc..

[2] 'Biomass' is mainly wood, animal wastes, etc. 'Hydro' means small scale projects.

We will now discuss some issues that affect our industry today.

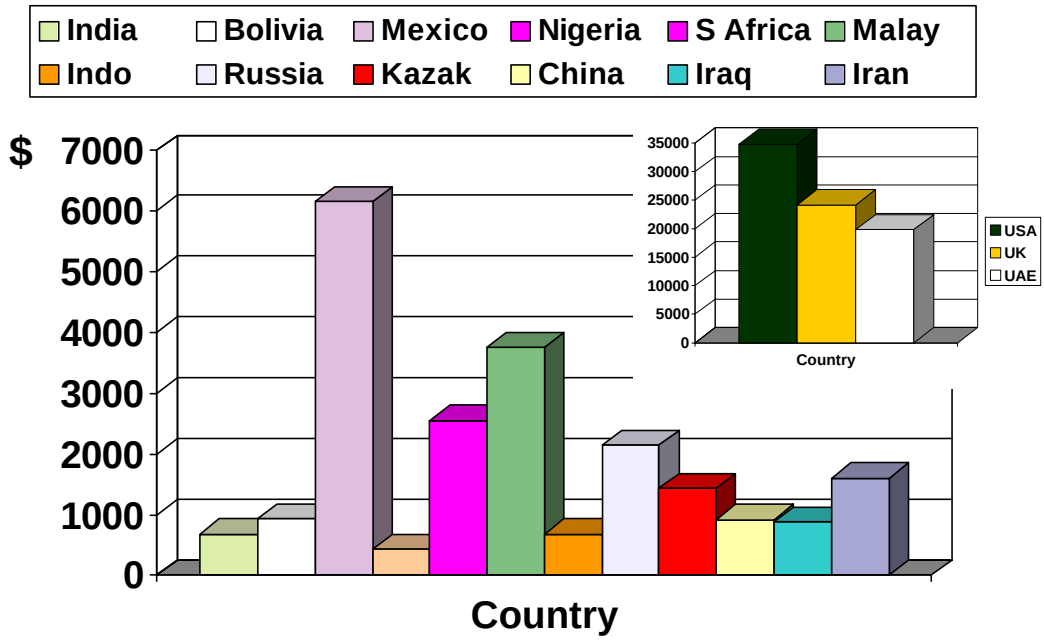
3. GLOBALISATION

3.1 General

Want a new pipeline? Well, it can be designed in India, use line pipe from Brazil, be constructed by an Australian outfit, using Indonesian welders. Oh, and it can be owned by a company in Houston.

The 'old' world was national or near-international, but in the 'new' world we have a global economy and communications [5]. Globalisation allows the economic integration of all world trading regions, and it is being called the Second Industrial Revolution. Currently the old and new world are side by side. This can lead to confusion: staff expect the 'old' rights and securities, but there is no new world order on the horizon.

Globalisation allows us to work 'as a unit in real time on a planetary scale', and it is being dominated by the Multi-National Companies (MNCs). The MNCs dictate trade flow, not vice-versa – this is how powerful the MNCs are.



Source: United Nations

Figure 3. Gross domestic product[3] ($USA) in various countries compared to Western countries.

A major effect of globalisation is job transfer: usually low skilled work from the developed world to the undeveloped world. The West cannot possibly undercut the cost of work in many countries: Figure 3 shows the gross domestic product for various counties. It can be seen that many GDPs are below $1000, compared with GDPs of >$20,000 in the developed world.

The transfer of jobs is being driven by advances in telecommunications technologies that permit the global integration of markets. The capacity for international communications continues to grow

[3] GDP is output of economic goods and services produced by a country. It is a measure of how much is spent by consumers on new goods in a country

rapidly, such that managers anywhere in the world can oversee globally dispersed production and service activities. For example, Nike Inc. and Mattel Inc. do no manufacturing in the USA now.

A global free market creates a two-tier compensation system:

- one tier provides high-paying career tracks for technologically adept workers,
- while the other offers relatively low-paying jobs for low-skilled workers.

But note that it is not only unskilled jobs migrating abroad because of wage rates. Skilled workers are also facing increased competition from abroad. The jobs most at risk are white-collar, high-tech positions in computer programming, design, and financial services. These jobs are going to China, India, Singapore, and Taiwan as well as to low-wage countries in eastern Europe at a fraction of U.S. wages. For example, the salary of a computer programmer in India or Bulgaria is ~10% of that in the United States.

The flow of jobs is not one-way. There is a counter flow as foreign-based corporations employ workers at all levels from production to design and research in their North American and West European plants. For example, foreign automobile companies now employ tens of thousands of USA workers, and 10% of all industrial research and development in the United States today is conducted by subsidiaries of foreign corporations

3.2 Effect on new pipelines

What effect will this globalisation have on the pipeline business? Well, certainly all major construction contracts will be under international scrutiny. Typically, we construct 20,000 miles of new pipeline/annum: this is a $24billion business, and 50% of these new builds are expected in North and South America. Additionally we are currently building about 5,000 miles of offshore pipelines/annum: this is a $5billion business with 60% in NW Europe, Asia Pacific and the Gulf of Mexico.

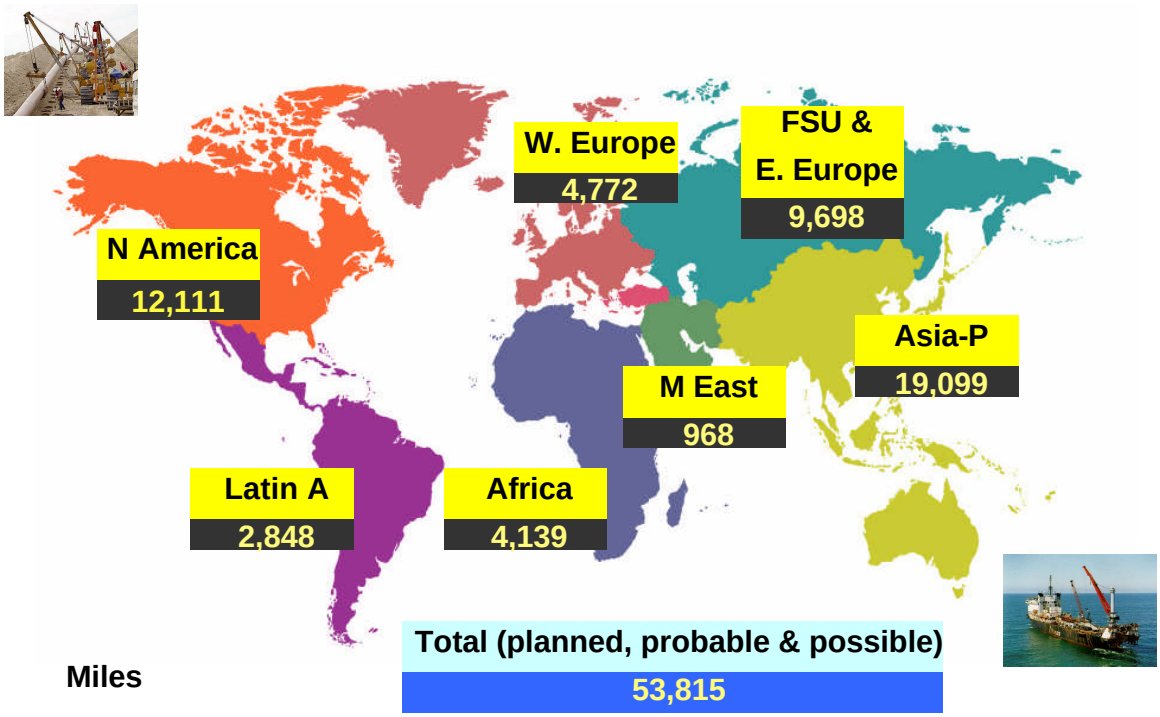


Figure 4. Pipeline Builds 2003-4 [6].

Figure 4 gives the projected onshore and offshore pipeline builds [6]: the split is 88% onshore: 12% offshore. Over the next decade we will see new constructors emerge and new material suppliers emerge from the undeveloped world. We are already seeing much lower design costs offered by

engineers in parts of the undeveloped world. These engineers are skilled, hardworking, and their low cost is likely to drive pipeline design work into their parts of the world.

These new entrants have lower operating costs, are more mobile, and also better positioned in many of the regions in Figure 4 (cf Figures 3 and 4). They will be driven by the demands to support a world population that will increase to 9 billion in the next few decades.

3.3 Effect on existing pipelines

The USA pipeline market is vast, with nearly 1,000,000 km of transmission pipelines. New standards and regulations require formal inspection strategies, and it has been estimated that operators will need to spend over the next 5 years [7]:

- Pigging = $2.74billion
- CP/Corrosion = $2.5billion
- 'Direct Assessment' = $6.37billion

Already, new inspection companies from outside the USA are pressing for some of this business, but the major effect on pipeline companies will be the increased scrutiny by regulators and the general public. As new safety regulations appear in many countries around the world, the onus will be very much on pipeline engineers to ensure they have a demonstrably safe pipeline: this will cost pipeline companies, and the industry should recognise this.

3.4 Overview

Globalisation will affect workers who expect steadily growing incomes, job security, and recognition of their self-worth; unfortunately, workers can no longer count on a lifetime of work from a single corporation. For example, following 40,000 redundancies, the AT&T vice president for human resources said, 'People need to look at themselves as self-employed, as vendors who come to this company to sell their skills.…'. The measure of success in the global market is not the number of employees retained, but the improved bottom line achieved by pursuing new opportunities.

Globalisation affects all areas of engineering: under 3,500,000 people are employed in manufacturing in the UK now, compared to 10,000,000 fifty years ago. In the UK, 10,000 jobs are being lost per month [12], as manufacturers compete on the global market, and compete with low cost imports.

This global economy will effect all pipeline companies. For example, a big change in the USA pipeline market has been caused by the downturn in both the global economy and the USA economy. This has caused the decline in new pipeline builds from 21,040 miles to 12,111 miles over the past year [6]. Additionally, a decline in the financial stability of energy companies has lead to many pipeline sales; for example, Williams sold its 5,800 mile Texas Gas Transmission Line for $1,045,000,000. Declining profits, change of ownership, bottom line, etc., will put even greater pressure on the operational pipeline engineer to reduce costs.

Finally, it is surprising, but USA pipeline companies spent less (-18%) on maintenance in 2002 than previous years due to uncertainty over proposed new safety regulations and stock market price devaluations [7]. This conflict of tighter margins and increased safety requirements needs to be addressed.

4. POLITICAL DIMENSIONS

4.1 Politics…

Oil and wars have been linked many times: the Trojans used catapults to hurl flaming pitch, gathered from oil seeps, at Greek ships, and in 1911 Winston Churchill controversially decided that the British Navy should change from (British coal) steam power to (Persian) oil power to assure

the country's mastery of the seas. In more recent years we've seen the conflicts in Kuwait and Iraq, and its effect on oil prices and oil markets.

Pipeline engineers cannot change politics, but we need to be aware of their effects on our business, and one of these effects is covered next.

4.2 Sabotage and terrorism

It is interesting to note that there is a significant increase in reported attacks on pipelines. In some countries, sabotage is common. Sabotage to an oil pipeline in Colombia in 2001 cost Occidental Petroleum $US445 million in lost production: Colombia's Caño limón oil pipeline has been attacked 654 times by the National Liberation Army, or 'ELN', since 1986.

In Iraq in 2003, the main oil pipeline from the Kirkuk oilfields in northern Iraq to Turkey's Mediterranean port of Ceyhun was attacked, causing Iraq to lose $7milllion/day. Additionally suspected sabotage to a water pipeline in the same year in Iraq left 300,000 Iraqis without water.

The largest supplies and reserves of oil and gas are in the Middle East, but many of the big oil and gas regions have either some terrorist elements, or are targets of terrorism.

Terrorism is a real threat to the oil and gas business, and as we expand our pipelines in insecure regions, we will find our security costs rising. Additionally, we need to reduce sabotage risks to our pipelines. This will involve [14]:

- Identifying processes for assessing pipeline system and facility vulnerabilities
- Developing uniform definitions of security conditions
- Developing graduated sets of countermeasures for each security condition level

Some USA pipeline companies are already acting: controlling access; using intrusion detection; reviewing electronic systems against terrorism; preplanning with FBI/military; hiring armed guards. We will need a government/industry partnership to address security needs (this is already started in the USA), but some quick measures we can apply are:

- Limited access to pipeline maps/information,
- Identify key facilities and secure,
- Background checks for selected state and pipeline personnel,
- Security exercise program,
- Plan rapid restoration of pipeline service following an attack/sabotage.

5. LITIGATION

5.1 Engineers are liable.

Engineers are human, so they will make mistakes, but now any major incident involving a pipeline will be the subject of close law enforcement scrutiny. How will the pipeline engineer's conduct be appraised? An incident would be considered a crime if any 'harm' was linked to 'culpable conduct' [9].

The following evidence would show 'culpable conduct':

- History of repeat violations

- Deliberate behaviour
- Efforts to conceal
- Tampering with monitoring devices
- Activities such as false statements, obstruction, etc.

Companies would face charges after the prosecutors have considered:

- Was the offence serious (e.g. great harm)?
- Were wrong-doings common in the company and corporate?
- Was management aware of this?
- Is there a history of offences?
- Did the company quickly identify and report the incident and respond to it effectively?
- Has the company a 'compliance program' in place, and is it being applied diligently (e.g. were wrong-doers quickly disciplined)?
- Would innocent shareholders or employees suffer disproportionately?

5.2 Accidents (sometimes don't) happen.

Engineers cannot claim 'accidents will happen'. Accidents happen, but many 'accidents' should not be described as 'accidents'. If an 'accident' has preventable causes, it may become a criminal case.

And the fact that the engineers involved in the 'accident' did not intend an accident to occur, is not a defense. [9]. Was it an 'accident waiting to happen'? It is a question of 'reasonable care' – did the engineers exercise 'reasonable care'?

The potential for errors in the pipeline business is increased due to the simple fact that our business is a 24 hour day business, and this can introduce many human errors. Many studies have shown that the times of day when most humans make mistakes are around 14.00-16.00pm and 03.00-04.00am: night workers are twice as likely to make mistakes. Exxon Valdez, Chernobyl, Bhopal and Three Mile Island all happened during the night shift, so we must be very aware of the potential errors of our control room staff in the early hours of the morning.

5.3 Recent lessons for engineers

What is the lesson here? Well, it is a hard lesson. In 2003, a Federal judge in the USA sentenced two pipeline engineers to jail following a liquid pipeline explosion in 1999 [8]. This is the first time that pipeline employees have received jail time, and pipeline accidents are in the public minds now. For example, in Virginia and Connecticut, property owners are opposing new pipeline constructions, and in Canada residents are doing similar, claiming emotional anguish caused by safety fears [8].

How can we survive the change in litigation? The first responsibility of any engineer is safety [2]. Whether we design, operate or maintain, it is safety that is our goal. Consequently, we need to constantly review the risk associated with our pipeline, and manage all the data we are provided with to ensure we track our pipeline's condition. Additionally, we need to constantly train and update all engineering levels [10].

This is going to be difficult. As stated in Section 3.4, pipeline companies in the USA are not increasing maintenance budgets, and high integrity liabilities and the costs to meet new USA regulations has caused several pipeline companies to liquidate assets (sale or transfer).

Decreasing maintenance budgets, increased liabilities, lower profits… and the threat of legal action against pipeline engineers who make mistakes is not the environment we need to improve safety.

6. GLOBAL ENERGY AND POVERTY: DEALING WITH ETHICS

We work in a vastly wealthy business: oil and gas majors have been recording huge profits for many years [2]. Unfortunately, most of the world does not enjoy the benefits of this wealth, as we do. Now, many pipeline engineers are faced with a moral crisis: they are working in poor countries and extracting oil and gas from these countries, but the local population are not benefiting. Consider the following facts [11]:

- In sub-Saharan Africa, women can carry 20 kg of fuel wood an average of 5km every day. The effort uses up a large share of the calories from their daily meal, which is cooked over an open fire with the collected wood. Stoves using dung and charcoal emit large amounts of CO, etc. This exposes poor people to particulate and carbon monoxide concentrations.
- Women and children are exposed for the longest periods of time. The World Health Organisation estimates 2.5 million women and young die prematurely each year from breathing the fumes from biomass stoves.
- The World population is currently ~ 6 billion, and by 2050 it will reach ~ 9 billion. Some 2.8 billion of the world's people currently live on less than $2 a day – this is defined as "poor", and 2.4 billion people rely on 'biomass' (wood, dung, etc.) for cooking & heating.
- 1.6 billion people use no electricity at all: most of these people live in South Asia and sub-Saharan Africa. 1.4 billion will still be without electricity in 2030.

We should not underestimate the impact of pipelines in poor regions, and how the local people see pipelines as a rich source of revenue, but never see the revenue. They can be driven to desperate measures to share the wealth. For example, in the Niger-Delta region of West Africa, there was about 5000 deaths from oil pipeline vandalisation and explosions in 2000 [13].

Speaking at a news conference in 2000, the president of the National Association of Niger-Delta Professionals said the deaths resulted from 781 cases of vandalisation and 82 cases of explosions of oil pipelines in the region [13].

How can we deal with this moral issue of poverty in regions where we build pipelines and extract the oil and gas from beneath the bare feet of the people? There are two ways:

- ensure the company you work for has an ethics policy, and it is applied, and
- constantly consider your own position in any project in a poor country.

In all projects we must balance business issues with social responsibilities. Hence, staff on a project must carefully consider all aspects:

- political,
- environment,
- social, as well as
- technological.

This means we have to consider interests beyond those of the investors or equipment suppliers, and consider all socio-economic and human rights issues.

7. CHANGE IN THE INDUSTRY

Most companies have undergone major organisational changes in the past decade. It is a fact that this change is going to continue, and we will need to accept and survive these changes.

What have we learnt from the changes, and how can we survive further changes? There have been many books and reports written on surviving change, but another way to survive change is to review some themes in change management and assess their credibility. In this way, we can

ensure that the changes that are proposed are good and robust. So, we can now kill some myths about ‘change’.

1. People hate change:

- Wrong. They may be wary of the pace of change, and weary from previous changes, but the truth is that people are happy to change. People change their clothes, hairstyle, jobs, offices, marriage partners. They re-arrange their furniture, they travel to new places and they re-arrange their lives on a regular basis [15]. The fact is that often when staff resist change it is for a reason – the change is either badly thought out or not needed.
- It is well known that the top obstacle to successful change is employee resistance at all levels: front-line, middle managers, and senior managers [16]. But the top reasons for employee resistance are a lack of awareness about the change, comfort with the ways things are and fear of the unknown. Middle managers resist change because of fear of losing control and overload of current tasks and responsibilities. So, good communication and clear planning will reduce these concerns.

2. Change is a good way to eliminate bad people and dead wood:

- Wrong. One of the early signs of real transformation is that people whom the organization has valued begin to leave. Smart people who have choices about where they work often see that the company is changing in a way that will make their skills less valuable. A good number of them move to other companies that still value their skills. Who does not leave the company? A lot of others who have no choice, and those who cannot find a decent job elsewhere [17].

3. The people we need during change are strong, adaptable risk-takers who can cope with today's insecurity for tomorrow's gain:

- Wrong: whoever says this has never been through change. Why does a job have to be insecure? If you tell staff that ‘things are insecure’, you will lose credibility, and lose staff.
- Those who make the transformation a success are ordinary employees, not those who were stars in the old system. People who make major changes work are typically more worried than courageous, more cautious than daring [17].

4. In the engineering industries, you need to rely on experience:

- Yes, experience is very important but it is also overrated. Take care with what you mean with ‘experience’. An engineer can have 25 years experience, but this could be doing the same job every year, i.e. he/she has 25x1 years experience. This ‘experienced’ engineer has as much experience as a graduate with one year’s experience in the same job.

5. Engineering is a commodity - price driven - so don’t worry about the engineers or the engineering : cut salaries and cost:

- If society continues to value and pay other professions (lawyers, accountants, city analysts) more than engineers and scientists, then they must accept a decrease in both quality and safety in our engineering structures. A young person will consider engineering (tough degree syllabus, slow promotion, low pay, shrinking industry, threat of jail if you get things wrong…), reject it, and choose an easier, better paid option.
- Similarly, society must review its double standards; it accepts high fees from some professions (e.g. from lawyers), under-performance by others (financial advisers), and incompetence elsewhere (pension fund management), but aims to imprison lowly paid engineers if they make errors in control room signals or maintenance scheduling.
- The prime role of engineers is safety. However, engineering in now seen as a commodity; price-driven. This means that engineering and engineers are viewed as the ‘lowest of three prices’. Quality is becoming secondary.

6. Always go for the lowest price in engineering:

- Wrong. This is an approach favoured by financial officers – it has never been the culture amongst engineers. And this is for a (bitter) reason. Quality costs. The lowest of three prices is the lowest for a reason. You can do the maths….
- Any CEO or Contracts Department who honestly believes that engineering is a commodity, and that quality is not a key differential should ask themselves the simple question: 'when you buy a car/TV/dishwasher, do you always choose the cheapest? Or, alternatively, the next time the CEO buys his/her top of the range Mercedes, point out that a car is a commodity and quality is not a differential, and then suggest a 1000cc Fiat is more appropriate….

7. A key area we need to change is 'sharing knowledge':

- Yes, sharing knowledge through new databases, etc., is essential, but beware… if your staff are ignorant, they will share their ignorance; if your staff are unhappy, they will share their unhappiness; if your staff are disorganised, they will share chaos. Decide on what knowledge you want to share, and share it effectively.

8. We need to change to 'goal setting' or 'performance factors' to motivate our staff:

- Yes, but only if the goals are agreed with staff and achievable. Remember, it is the achievement of goals that is motivating, not the setting [18].

9. Money doesn't motivate people:

- Really? Try giving all your staff a pay cut, and watch motivation.
- If money were enough to get people to do their jobs, there would be no problems. But there are problems. Perhaps managers should not have to use rewards to motivate people to work hard or do a good job. However, observations of work performance show that although money alone is not enough to get all people to do what they are supposedly getting paid to do, rewards do work to motivate behaviour [19].

10. We're in a hostile 'real world' – get 'real':

- Patronising and wrong. Managers can tell staff about the 'real world', but most staff would question whether their manager is in the real world, and most subordinates have had more life-experience than their bosses.
- Staff know that under-performance can lead to unemployment, so why point out this negative fact? This style of 'threat management' has several problems [20]: first, the threats may not work; second, even if the threats get the desired performance, the employee is likely to perform only at the minimal level required and may also become disgruntled; third, if the threats lead to the employee leaving the company, there is a turnover cost that may be significant.

11. Work stress is inevitable:

- Why? We are lead to believe that our lives and work are now very complex, but is this true? Yes, we are bombarded by useless emails, by silly meetings, etc., and if we attempt to attend to these distractions we may become stressed, but that is our choice! Once you correctly understand what stress is and what really causes it to occur, you can prevent or eliminate much of the stress you ordinarily experience [21].

8. PEOPLE IN THE INDUSTRY – RECENT LESSONS

Currently, we have an ageing workforce and there is a major shortage of good quality engineers in our business: this has been the case for many years. To attract young talent we must offer an attractive career, including financial reward. References 1 and 2 covered the changing priorities of today's workers, and how to make careers more attractive, so it is not covered here. However, we must remind ourselves of the situation we are now in and the importance of retaining our skilled staff.

8.1 Ageing workforce

The 'developed' western world populations are ageing as birth rates fall. Massive skills shortages are looming which are already very evident in the marine industries. The issue is not new, but becoming more important by the year. For example, in the UK across all industries 25,000 engineers retire annually and only 12,000 graduates replace them, and the number of engineering graduates in the UK is decreasing[4]. In one major contractor, for the past decade the average age of senior engineers and project managers has been moving upwards - it is now 49 years and increasing by about one year in every two. Estimates suggest that the offshore oil and gas industry could lose over 50% of its most experienced workers by 2007.

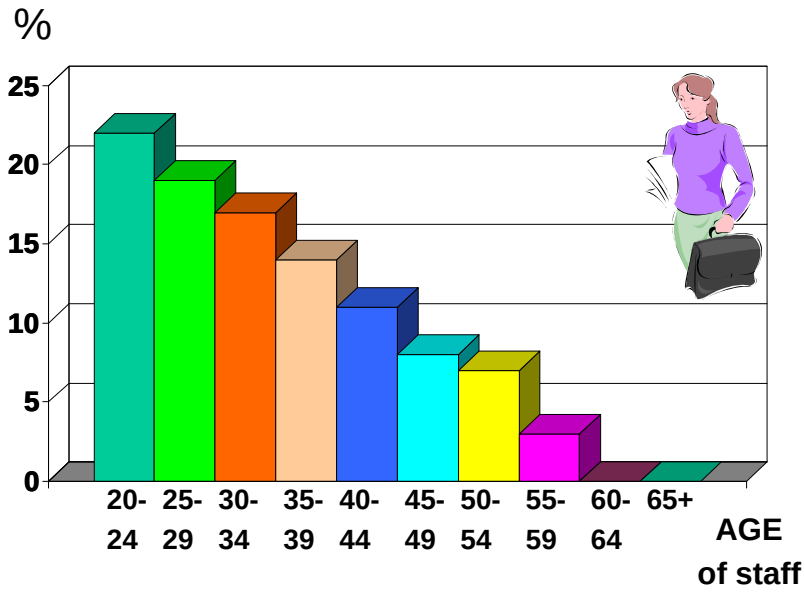


Figure 5a. Typical age profile in high technology companies, conglomerates and consultancies.

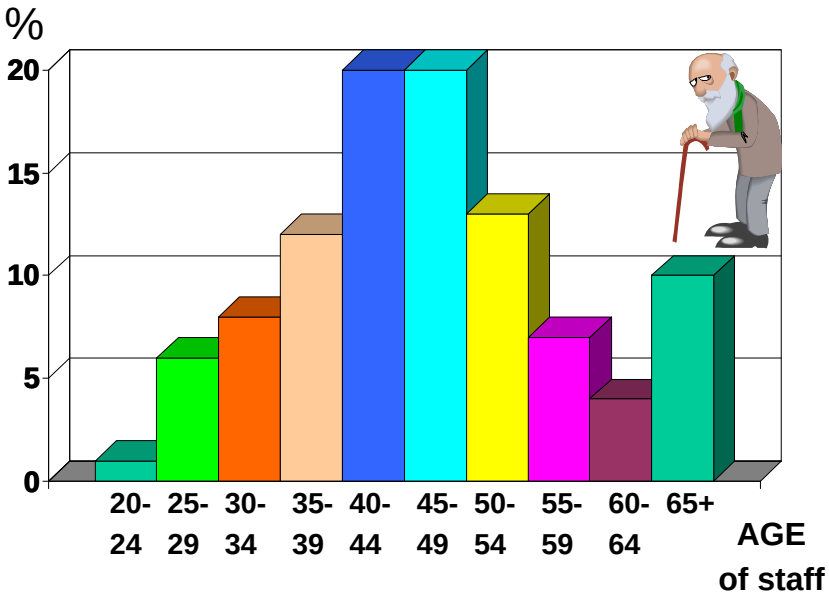


Figure 5b. Age profile in the oil and gas business (from Society of Petroleum Engineers).

[4] In the academic year 2002-3, the number of engineering graduates decreased from 32,400 to 31,100. The number of graduates in all other subjects increased [23].

Figure 5 compares the age range in the oil and gas industry with the age range in ‘conglomerates’, high technology companies and consultancies [22]. We can clearly see the ‘bubble’ in the oil and gas industry, centred around employees approaching or passing 50 years of age.

8.2 Attracting Young Talent

Engineers rightly value experience, and reward experience. But we must take care not to become obsessional about experience, and we must not always value experience above other attributes such as a willingness to learn, a willingness to change, and new knowledge. These latter three attributes are often offered by younger staff, and missing in experienced staff.

The age profile in the oil and gas business (Figure 5), and the emphasis on experience, compared to other industries, will certainly deter the entry of young professionals into the business. How do you convince a young person to enter the business if [22]:

- The majority of the workforce is twice your age; they're also almost all white males.
- You will not be allowed to work on any really exciting technical challenges early in your career—those go to the "experienced" hands.
- You will need at least 10 years of experience to be considered for any midlevel technical or managerial position.
- No one is going to go out of their way to share his/her knowledge with you. You're expected to learn by "putting in your time."
- You will be laid off—probably more than once.

Young oil and gas professionals expect significant technical challenges early in their careers, just as their peers in other industries will expect and receive. Furthermore, they expect their careers to progress every rapidly, allowing them early access to management or senior technical positions. Young people expect to manage projects in their 20s, people in their 30s, and companies in their 40s. Yes, a project manager at 25, an engineering manager at 35, and a CEO at 45. Oh, and they will want to retire between 50 and 55. And why not?

How can we bridge this gap between an ageing workforce, bulging with experience and expertise, and young workers eager to rapidly acquire this knowledge. The solution is knowledge transfer and management (see next section).

8.3 Loss of intellectual capital [24,25]

We are now seeing a switch from ‘physical capital’ to ‘intellectual capital’ in companies. This is because knowledge is now a major source of competitive advantage in all industries. World-class companies must operate in a continuous improvement environment - in such an environment, knowledge and brainpower are the company’s greatest assets:

i. INTELLECTUAL CAPITAL - TANGIBLES - includes legally recognised intellectual property such as copyrights, patents, brand names, trademarks, etc.. They can be accounted for using historical data.

ii. INTELLECTUAL CAPITAL - INTANGIBLES - includes employee know-how, capability and the knowledge carried in heads (including corporate memory).

iii. ORGANISATIONAL CAPITAL - includes intellectual capital but also management and organisational culture.

iv. VALUE? The market value of a person is mainly determined by a combination of the knowledge the person creates and owns. A company’s worth is an accumulation of its employees’ knowledge. The market value of a company is determined - in large part - by the

intellectual capital, as perceived by the investing public. Exxon's intellectual capital has been valued at 72% of its market value. Dupont was valued at 84%. Coca Cola was valued at 96%.

Unfortunately, it is a fact that the intellectual capital of the oil and gas business continues to 'leak into other industries at an alarming rate' [25].

How can we protect our intellectual capital? First, we need a management programme and commitment to retain this capital. This will involve identifying our key staff: these staff will either possess the corporate memory (how and what we did in the past) and intellectual capital (what we need in the future). We transfer corporate memory to younger staff by mentoring and team briefs, and knowledge management where we retain extensive libraries of past practices, data and reports. We can preserve and grow our intellectual capital, by refining our business processes, exploiting technology, and cultivating an environment that promotes creation, collection and sharing of knowledge.

This can be difficult: 'knowledge is power'. Many engineers are proud and protective towards their knowledge, but this protection must change. The veterans of the industry must be encouraged to share and record their knowledge and be rewarded accordingly. Hence, we must capture, record and transfer our engineering knowledge.

i. KNOWLEDGE CAPTURE: Companies need to actively encourage staff to share their knowledge. This will not happen by accident: it must be planned.
ii. KNOWLEDGE RECORDING: Record knowledge, in some sort of knowledge management system (reports, written lectures, databases, etc.), and allow time for this to be prepared and transferred.
iii. KNOWLEDGE TRANSFER: The knowledge management system, the knowledge transfer lectures, etc., must be accessible to all staff. Staff mentoring, and staff secondments will help, as will retaining retirees on part time contracts, purely to mentor.

9. CONCLUDING COMMENTS

This paper has addressed some of the wider issues and changes occurring in our business. They present major challenges to all of us, but the key is to value our engineers, manage our staff and data, and always to put safety first.

A final comment – more of a plea – concerns training and mentoring pipeline engineers. We work in the pipeline industry, but we are not organised as engineers. What is a 'pipeline engineer'? We know what a civil engineer is, and institutions ensure standards are met and support is provided. But this is not the case with pipeline engineers.

There are changes occurring: ASME now has a Pipeline Division, and university courses in, Rio, Brazil, Newcastle upon Tyne, UK, and Calgary, Canada are, or will, offer students Master programmes in pipeline engineering.

But as the industry changes we will need to rapidly introduce new talent into an environment that is more profit-driven, requires multiple skills, produces huge amounts of data, and has increasing pressures from regulations and the law.

We need to be better organized.

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