BUILDING AN INTERDEPENDENT SAFETY CULTURE IN HEAVY INDUSTRY

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Queensland Alumina Limited (QAL) has a demonstrated history of continuous improvement in safety performance. However, since 2005, safety performance has essentially plateaued with no consistent year-on-year improvement. As a result, it was proposed that a cultural shift was required to facilitate the next "step change" in site safety performance. As such, a Safety Culture Team was appointed, consisting of representatives from management staff, training department, and operations and maintenance employees.

For one month, this group of 10 employees were taken out of their normal operating roles and dedicated their time to identifying the current site safety culture and recommending avenues to modify the culture to improve safety performance. This included benchmarking local heavy industries, undertaking a site-wide "culture" survey (with over 98% participation) to determine what behaviours and factors "make a safe crew" as well as what not to do in "a less safe crew", developing communication strategies to engage the entire workforce (including contract workforce) of over 1200 employees, providing concise graphical summaries of the results, and providing a quantitative interpretation of the statistically significant factors.

In the present paper, the importance of the composition of the team, techniques employed to "categorise" site safety culture, the data generation and statistical interpretation will be presented; along with the conclusions and implemented items that contributed to halving the serious injury rate at QAL.

This paper gives invaluable insights into how a heavy industry can *"Build an interdependent safety culture, where we foster each other's health, safety and well-being: every where, every day."*

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1. Introduction

It has been recognised that organisational culture is a significant contributor to an organisation's safety performance. Recently, Du Pont (Hewitt 2011) identified that the safety culture of an organisation has a direct link to their safety performance (Figure 1). Based on this work, Du Pont recognised that **companies who actively help their employees conform to safety initiatives do, in a sense become "other's keepers". They contribute to a safety network and have a strong sense of organisational pride in their safety endeavours. This** *interdependent safety culture*, is an obvious driver to improved safety performance.

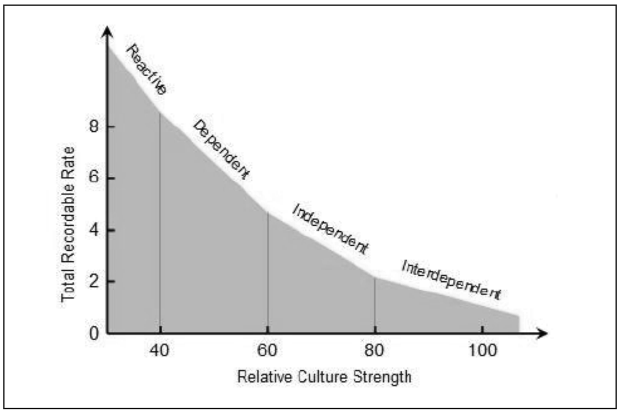

Figure 1 : Dupont Bradley Curve (Hewitt 2011, p.6)

This is an important concept for Queensland Alumina Limited (QAL), because despite continual safety improvement for many years, the rate of improvement has declined since 2005 (Figure 2) and indeed began to trend adversely by 2009.

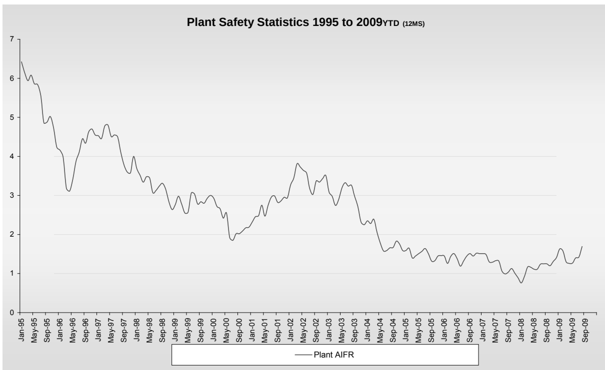

Figure 2 : QAL Historical All Injury Frequency Rate[1] (AIFR) to 2009

Therefore, in an effort to improve safety performance to deliver an incident, illness and injury-free workplace, it was recognised that an understanding of the current site safety culture was required, along with specific recommendations to move to an "interdependent safety culture".

Therefore, in late 2009, a Safety Culture Team (SCT) was established with employees taken out of their normal operating roles for one month for three specific tasks:

- review the existing safety culture
- identify what makes a safe team
- make recommendations for improvement.

2. Selection of the Safety Culture Team (SCT)

As the project was to essentially change the culture of the workforce, and attempt to move towards interdependence, it was important to **engage** the workforce during the entire process. Therefore, selection of the Safety Culture Team members was critical to the overall success of the programme. Consequently, a

1 AIFR = number of serious injuries per 200,000 work hours (lost time + restricted work + medical treatment)

team of 10 employees was selected from a cross-section of the site, including Superintendents, Operations Supervisors, Acting Supervisors, Fitters and Field Trainers. Not only were the roles selected important, but the individuals chosen had a proven track record of a "passion for improvement". Finally, an important addition was a team member with a statistics background, which aided correct development of questionnaires, thereby aiding interpretation of results.

3. Scope of Safety Culture Team

Prior to embarking on such a resource-intensive project (10 people for 4 weeks full-time), it was essential to get a clear statement for the purpose of the team. As such, we met several times with the company Managing Director for guidance. As an outcome, we developed a "mission statement" to ensure that we could maintain our direction and traction in the coming weeks:

(To) Build an interdependent safety culture, where we foster each other's health, safety and well-being: every where, every day.

The next step in the process was to set a plan and timeline for achieving this plan. Tasks were then assigned appropriately.

4. Measuring Site Safety Culture

Assessing the culture of an organisation is arguably a combination of subjective and objective measures, both of which need to be combined into a single dataset for analysis. Further, the dataset and analysis must be performed such that the output can be assessed and converted into recommendations and actions. Throughout all of this, due to the 'human' nature of the work, communication and engagement of the workforce was essential.

4.1 Communication and Engagement

The communication plan and engagement strategy was critical to the success of this project. This strategy included:

- Plant Bulletins published via email with weekly updates.
- Site Intranet web page
- Dedicated email address for the team
- Phone number

A prerequisite for success was the engagement of a broad cross section of personnel for QAL and contract groups, including staff and wages. To assist with the adoption of recommendations, the decision was made to complete face-to-face discussions and surveys with every available person on site.

4.2 Measuring Lag Safety Indicators

To commence the data analysis, the SCT utilised the statistics already available from the site Safety Department. These "lag" indicators were provided by the Health, Safety, Environment and Community (HSEC) Manager as raw data on 58 crews across the refinery. These crews were essentially the QAL crews consisting of either operations or maintenance operators. They did not include contractor crews or QAL staff teams.

The supplied data also included potential lead indicators:

- Crew QSafe Participation (QSafe = site behavioural safety observation programme)
- Compliance to minimum scheduled training requirements
- Team Day Attendance
- Crew Absences

4.3 Measuring Current-State Safety Culture

To measure the current site safety culture, a survey of the workforce was required. For this survey, it was critical to engage the workforce and therefore receive the most representative response. As such, the SCT had learnt from the lessons of the past from other surveys, and were adamant that "dumping" surveys on the cribroom table, or emailing them did not result in a very high response rate. Further, the demographics of the respondents arguably skew the results. Therefore, pre-warning of the process via the above communication methods was used pre-emptively. Approximately a week later, the SCT team members were dispersed en masse across site. All interviews were conducted face-to-face and questionnaires distributed and collected during the interview process. They were packaged and mailed back into unlabelled internal mail packaged – to ensure the respondents of the anonymity of the process.

To ensure positive engagement, the interviews were conducted peer-to-peer. Further, due to the face-to-face strategy and the 24/7 shift work nature of the site, many interviewers conducted these surveys on night-shifts and weekends, both to ensure that all crews were covered, and also as a sign of the commitment we had to the process.

Finally, the wording, semantics and non-verbals used during these presentations were essential to ensure the workforce of our integrity. As such, each interviewer role-played the presentation to ensure that it was presented appropriately to the audience, and that the "message" was consistent across site.

As a result of the above attention to detail, the SCT achieved over 98% response rate.

4.4 Benchmarking Safety Performance

Gladstone is relatively unique due to the concentration of industrial sites. Further, a number of these sites are either owned or operated by Rio Tinto Ltd. Therefore, these sites have common safety measurement systems and reasonably open ability for other sites within the Rio group to access the information.

Therefore, the SCT benchmarked QAL against three other local heavy industrial sites. We shared our experiences and findings with these sites, and took away positive programmes and ideas from our visits.

4.5 Identification of Lead Safety Indicators

This component of the process was intended to identify why one team could operate for many years without injury and another team, operating in similar conditions, could not. The components of this review included: supervisor behaviours, team member behaviours and safety statistics, including both lead and lag indicators.

Due to the intensive and invasive nature, it was critical that discrete crews were "targeted" and that interviewers were selected and trained. As a result, to develop the appropriate "questionnaire", brainstorming sessions were held with the 10 SCT members.

The resulting questionnaire was designed to identify safe, interdependent leader and team behaviours. The questionnaire was reviewed by the team statistician to ensure that the responses could be statistically interpreted into a meaningful result. Specific crews were then selected as a sub-sample of the 58-crew population, and selected based on "good", "poor" or "indifferent" historical safety performance. Eleven work teams in total were surveyed, nine from QAL and two from the larger contract groups onsite. Interviewers from the SCT were selected to ensure peer-to-peer "interviews".

The style of the interview was also important to ensure an honest response. Hence, the questions were memorised and all asked verbally. There were no forms or any indication during the "interview" to suggest their answers were being recorded. The results were documented immediately following each interview.

Finally, to avoid any subjectivity on the part of the interviewers, the crews were selected based on their performance by the SCT leader & statistician. The 11 crews were then "distributed" to the interviewers without any knowledge of their historical safety performance. Hence, this was a ***deliberate blind trial.***

4.6 Summary of Results

4.6.1 Analysis of Historical Indicators

The supplied data for injury frequency rate and potential lead indicators was reviewed to determine if there may be any statistical correlation between lead and lag indicators.

From this data, main effects plots were generated for each of the lead variables. From these main effects, it was observed that some crews had a very low injury frequency rate, whilst others were quite high. Similarly, some crews had better minimum compliance, absenteeism, QSafe participation and Team Day attendance records. However, based on the main effects plots, there didn't appear to be any significant single item that correlated with an improved safety performance (other than specific crews).

To double-check this (excluding crew impact), a fit to the data was attempted using minimum least squares technique in MiniTab©. As the data is continuous, the least-squared errors technique was used to attempt to fit a multi-linear regression via backwards elimination. From this analysis, no elements were statistically significant (at the 95% confidence level).

Therefore, from the data from the 58 crews, there were essentially no statistically significant lead indicators that would assist in developing a crew with a reduced injury frequency rate. Therefore, it was important to consider more closely the attributes of the crews that have a low injury rate against those with a higher injury rate.

4.6.2 Analysis of Safety Culture Questionnaire Results

The developed safety culture questionnaire consisted of 24 true/false questions, along with 3 open-ended questions. Ironically, unbeknown to the SCT at the time, this survey format was almost identical to that used by DuPont (Hewitt, 2011).

The benefit of a binary (true/false) response questionnaire is that the data can be summarised quite easily. In this case, we needed a methodology to summarise ~1000 results into (preferably) a single measure of current state. This was achieved by using the radar plot functionality in MS Excel©.

Further, because of the ~1000 responses times 24 questions, this required ~24,000 data entries. To facilitate this process, an MS Excel© VBA code was developed to with a data entry form to populate MS Excel©.

The 24 questions essentially consisted of 12 questions relating to generic safety behaviours, with the remaining 12 questions revolving around the role of leadership in safety. Consequently, the dataset was split into two, and two radar plots developed. As each radar plot consisted of 12 points, we presented them to the workforce as "Safety Clocks", with one being the "Safety Culture Clock" and the second being the "Safety Leadership Clock". These clocks are presented below in Figure 3 and Figure 4.

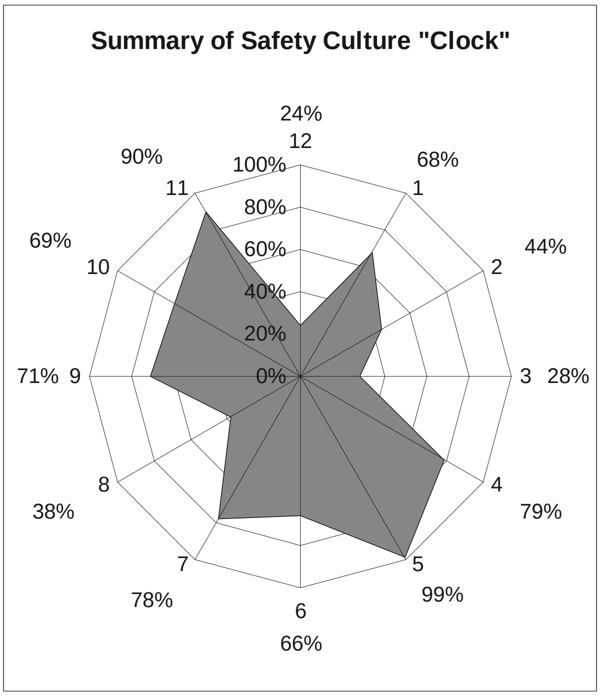

Figure 3 : QAL Safety Culture Clock

To interpret the "clocks", a positive response (True) to each of the 24 questions would be represented by 100% on the "hour" of the clock. Therefore, due to the discrete wording employed in the original questionnaire, it was possible to graphically display the 'desired' safety culture for the organisation, being one with each "clock" fully coloured-in. Further, due to the generic nature of the questions, it is possible to re-survey the employee population again in the future and generate an updated set of "clocks" and therefore determine if the organisation has moved closer to safety interdependence.

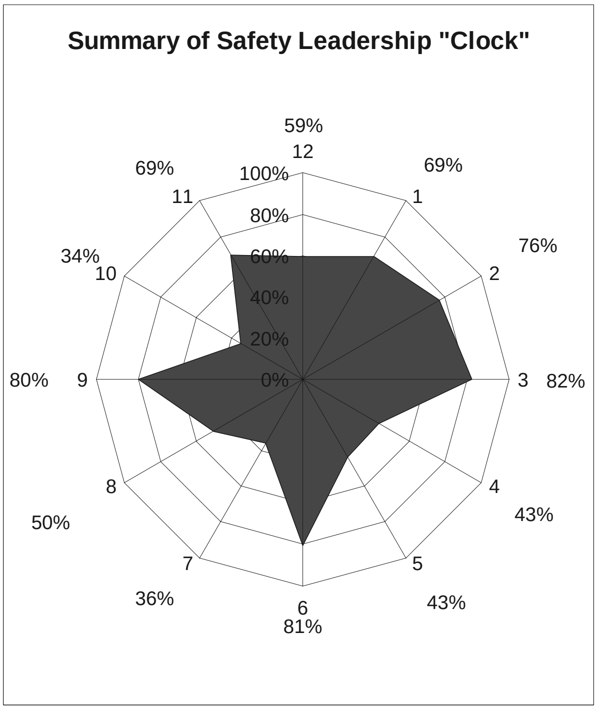

Figure 4 : QAL Safety Leadership Clock

Of note is the overwhelming response to general culture questions (Figure 3) related to several interdependent characteristics, viz:

q.5 – I care about my workmates' wellbeing (99%)

q.11 – I want to be actively involved in improving safety at QAL (90%)

Therefore, the QAL culture was ready and accepting of safety improvements of an interdependent nature.

For the three open-ended survey questions, there were 1038 responses. These were entered into MS Excel© and grouped into twelve categories. The results were then summarised via a pivot table and presented in a stacked-bar, Pareto plot (Figure 5).

The three most significant deficiencies were in the categories:

- Training-Leadership
- Systems-General
- Systems-Safety

These results assisted the SCT in the direction for recommendations: notably that safety leadership was identified as the single-most important factor.

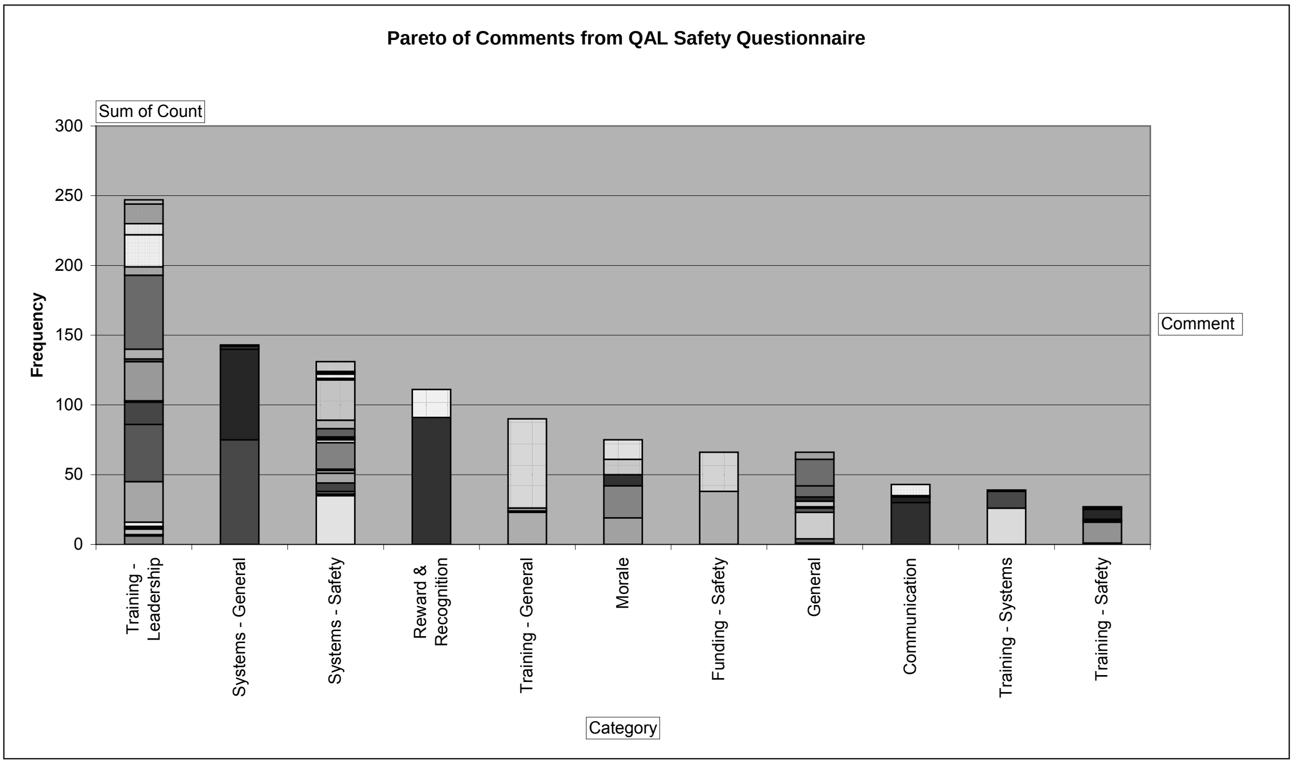

Figure 5 : Pareto of Comments from QAL Safety Questionnaire

4.7 Analysis of Contributing Factors ("Lead" Indicators)

To assist in identifying the lead indicators of a "good safety crew" vs "poor safety crew", selected crews with varying levels of safety performance were targeted with key questions to determine any links between leading indicators and injury frequency rate. These crews were:

Table 1 : Summary of Crews Selected for Safety Interactions

Crew ID	Crew (coded)	Injury Rate	Injury Rate (ranked)
15	A	0.89	H
18	B	0.00	L
50	C	0.75	M
25	D	0.50	M
30	E	0.11	L
9	F	0.93	H
37	G	0.41	M
44	H	0.04	L
54	J	0.00	L

To assist in determining the statistically significant lead indicators, "safety interactions" were held with a total of 43 crew members across the above 9 crews. A set of 13 key questions were verbally presented to each member and the responses recorded on a scale 1-5 (1 being the lowest response).

The 559 responses (13 questions to 43 individuals) to these questions were entered into MiniTab© and an attempt was made to correlate the responses against the crew's injury frequency rate. Should a statistically significant fit be obtained to any of the posed questions, then it was reasonable to assume that individuals displaying those attributes tend to display behaviours that are characteristic of "safe" crews. Thus, a list of lead indicator variables can be established, whereby a set of "Lead Safety KPIs" may be drawn.

To undertake a statistical analysis of the data, it was not possible to utilise Gaussian statistics, as not all the data is continuous. Further, as the injury frequency rate was essentially continuous, yet the covariate data (ie. responses to questions) was discrete, a generalised linear model (GLM) would be appropriate. This is an issue, as QAL does not possess the software to enable effective GLM modelling and interpretation. Therefore, the injury frequency rate was ranked into "Low", "Medium" and "High" (per Table 1). This enables analysis via Ordinal Logistic Regression in MiniTab®.

For the Ordinal Logistic Regression, a Logit function was utilised (with "Crew" established as the sole factor), and factors and covariates assessed for statistical validity via backward elimination to reduce the model to a statistical fit. From this technique, only four (4) of the questions were deemed to yield a statistical significant fit to the ranked injury frequency rate. These were:

Table 2 - Questions Yielding Statistically Significant Correlation with Injury Rate

Question (coded)	Question	Odds Ratio
A	Do you actively participate in Qsafe?	3.89
C	Are you involved in developing the daily work plan?	1.88
F	Do you participate in tool box safety discussions?	7.63
H	Does your team have safety discussions before start of work?	0.41

From this analysis, it can be established that the injury frequency rate is actually NOT crew-dependent. Indeed, the statistical fit with "Crew" was very poor. More correctly, it is important HOW the crew undertakes their safety discussions etc.

4.7.1 Goodness of Fit

"Goodness of fit" tests were also conducted between injury frequency rate and the above four lead indicators utilising MiniTab®. Both the Pearson and Deviance tests had p-values significantly greater than 0.05, indicating that the model fit is very good. Further, the p-value for the coefficient for each of the above 4 questions is less than 3%; again indicating extremely high confidence (97%) that each term is statistically significant.

4.7.2 Model Output Interpretation

The odds ratio outlined in Table 2 provides a guide for the impact of every "point" increase (on the posed 1-5 scale) in the degree of response to each question. For instance, the more that the crew member felt they participated in their toolbox meeting, then they were 7.63 times MORE likely to be in a safe crew. Similarly, active QSafe participants were 3.89 times more likely to be in a safe crew (for every point increase in participation). Involvement in the daily work plan was 1.88 times. Of significant interest is the statistically significant result that being involved in a safety discussion at the start of work was only 0.41times more likely. Therefore, you were indeed LESS likely to be in a safe crew if you had a generic safety discussion rather than a formal toolbox. This was explored further.

After discussion with the Safety Culture team members concerning this phenomenon, the response was fairly clear. Some crew members from the "less safe" crews reported that they don't have a toolbox meeting. Instead they have a generic safety discussion. This was believed to be non-specific and prolonged. By the end of it, the crew members were simply impatient to actually get to work. Consequently, the data suggests that there is a statistical correlation between this type of generic safety discussion and POORER safety performance.

Hence, in summary, a good, defined, concise toolbox meeting is CRITICAL to good safety performance. However, if done incorrectly, it is actually detrimental!!

5. Conclusions

From the work of the Safety Culture Team, a list of specific conclusions was developed and presented to senior management. Amongst these items, was the clear identification that the role of leadership in safety and the consistency thereof, was critical to improving safety performance. Further, well-executed pre-task hazard assessments and concise, high-quality pre-start, safety-focussed "toolboxes" were also essential to "*building and interdependent safety culture".*

As a result, the above items were addressed with specific programmes and training undertaken. As a consequence of this and other key initiatives, the site AIFR improved (Figure 6).

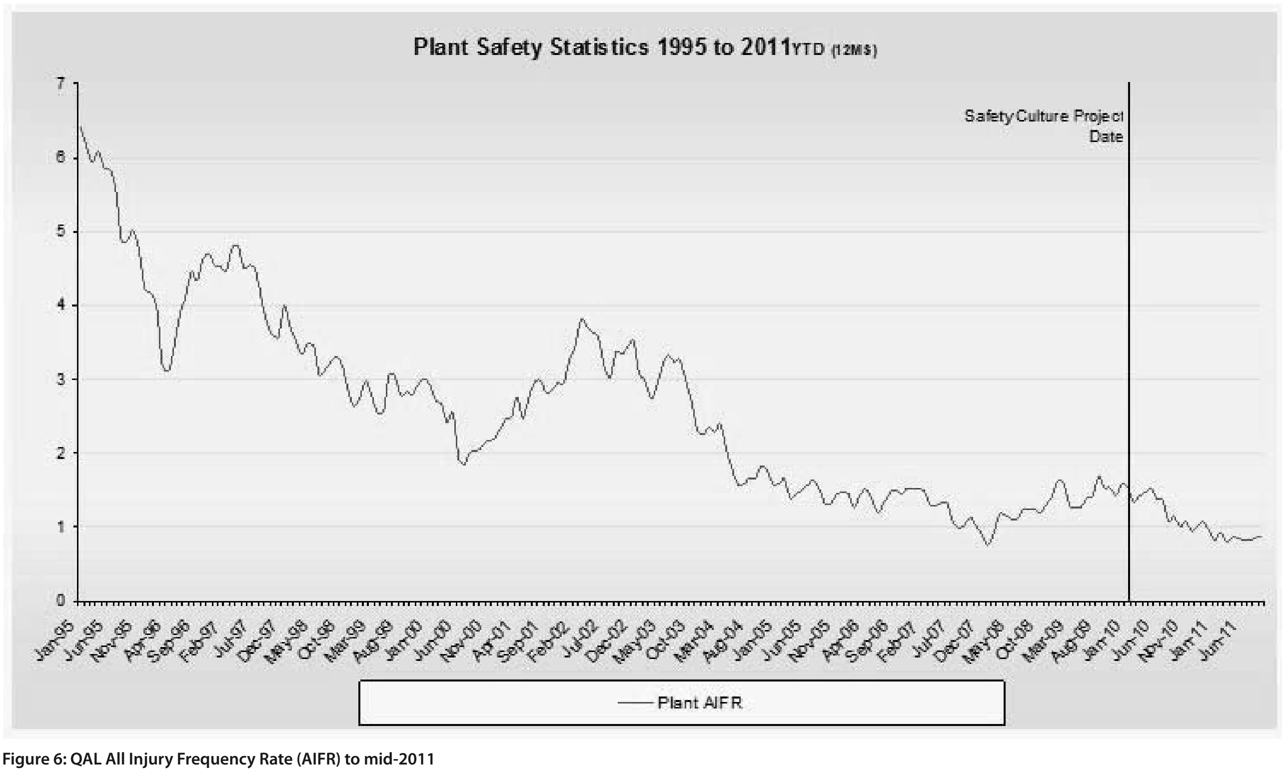

Figure 6: QAL All Injury Frequency Rate (AIFR) to mid-2011

6. Recommendations

This paper presents an approach to improving safety performance within the Australian, heavy industry. Further, the approach taken has provided discrete, quantifiable, statistically-significant areas to address that can improve safety performance. However, as all industrial sites have their own unique safety cultures, the key items to consider before employing the above techniques are:

a) Consider your site's historical (lag) data. Undertake a rigorous statistical analysis of this data.
b) Should a measure of site culture be required, utilise your own internal personnel, but ensure the appropriate skill-sets are there, including the subjective skill-sets (ie. good people skills).
c) Should a survey be undertaken, to ensure good participation rate, pay close attention to delivery and receipt of your survey. Ensure communication streams are readily and easily available to your workforce (use intranets, phones, emails, bulletins etc)
d) Prior to distributing a survey, ensure that detailed consideration is given to how the resulting data will be utilised, including data-entry and data-interpretation. Using a knowledgeable statistician is extremely beneficial PRIOR to undertaking this work.
e) When the programme is concluded, make a special attempt to feedback the findings and action plan to your workforce.
f) As an outcome of the work, only pursue programmes that address the statistically-significant items identified in your work: but also don't neglect the subjective comments from your workforce as this shows an empathetic response to their concerns.

References

Hewitt, M. 2011 'Relative Culture Strength – A Key to Sustainable World Class Safety Performance' Retrieved: 2nd September, 2011, from http://www2.dupont.com/Sustainable_Solutions/en_US/assets/downloads/A_Key_to_Sustainable_World-Class_Safety_Performance.pdf