SAFETY EFFECTIVENESS INDICATORS (SEIs): MEASURING CONSTRUCTION INDUSTRY SAFETY PERFORMANCE.

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ABSTRACT

The current application of Positive Performance Indicators (PPIs) in the construction industry largely measures numbers of disparate safety activities. Generally, PPIs are seen by industry stakeholders as not providing generalizable indicators of safety effectiveness. Further, they do not provide consistent data useable by industry to target areas of focus and improvement in safety performance. Notwithstanding efforts by NOHSC since 1994 to encourage the uptake of PPIs, industry at large has rejected these attempts. Yet, currently PPIs are the only ‘lead’ indicators measuring success as opposed to ‘lag’ indicators which, increasingly, since the mid 90s have been criticized as largely measuring failure eg, the raw number of injuries sustained in an organization per year or their frequency obtained by dividing the number of injuries by (a notional) one million hours worked per annum (Lost Time Injury Frequency Rates) (LTIFRs). Another issue that militates against the uptake of PPIs is that for legislative purposes, such as recording and reporting injuries, only LTIs and the like are required under the nine Australian OHS jurisdictions. Generally their format is guided by Australian Standard AS 1885.1-1990, which is non-enforceable at law, but nationally and internationally recognized as an authoritative conformance document. There is no equivalent for PPIs.

Another inadequacy common to lead and lag indicators is that neither measure essential leadership attributes, communications and desired safe behaviours as necessary elements of safety culture and safety performance. The Construction Innovation CRC research project on which this paper is based proposes that the measurement of safety effectiveness is a requirement for measuring safe behaviours and safety performance. In other words, as well as requiring positive safety behaviours, these need to be measured according to the positive safety actions they generate. Currently, there are no standard national or international safety effectiveness indicators (SEIs) that are accepted by the construction industry (nor any other industry). The purpose of this research is to explore the applicability of SEIs to the construction industry.

Keywords: PPIs, SEIs, lag indicators, safety performance measurement,

1.0 SAFETY EFFECTIVENESS INDICATORS (SEIs): MEASURING CONSTRUCTION INDUSTRY SAFETY PERFORMANCE.

1.1 INTRODUCTION

This paper investigates the potential of the development and applicability of measuring safety performance in the Australian construction industry based on a newly proposed 'tool', Safety Effectiveness Indicators (SEIs). Its development emanates from a recently commenced research project funded by the CRC for Construction Innovation in partnership with Leighton Contractors, John Holland Group, Thiess Contractors and the Office of the Federal Safety Commissioner (OFSC). Construction industry workers' compensation premiums are generally the highest in each of the state and territory jurisdictions of Australia. Nationally the construction industry has far more injuries and ill-health than the Australian average, and pays one of the highest workers' compensation premium rates in Australia. Yet, other than lost time injuries (LTIs) or similar 'negative' 'lag' performance indicators, reliable, comparable and standardised performance indicators are not available. An evaluation below of Positive Performance Indicators (PPIs) as an OHS performance measuring tool, based on a brief overview of its limited uptake in Australian industry, suggests that it does not reliably measure OHS performance. Similarly, other 'positive' or 'lead' indicators, which owing to word length limitations are not discussed in this paper, have parallel shortcomings. However, based on current workers' compensation claims and incidence of injury and illness there is a clearly demonstrable need to measure safety performance on construction sites in order to improve industry performance. Likewise, in the post construction facility management phase of completed projects there is a need for reliable safety performance measurement. In part, these issues of safety performance measurability were addressed by Biggs, Sheahan, Dingsdag and Cipolla (2006), who while conducting research for *A Construction Safety Competency Framework* (Dingsdag, Biggs, Sheahan and Cipolla, 2006 a; 2006 b), devised a matrix of safety cultural competencies determined by identified safe behaviours and safety management tasks (SMTs) for the Australian construction industry.

The research objectives for the current research project are to examine how safety cultural competencies and their associated safe behaviours, as well as leadership attributes and effective communication can be assessed predicated on whether or not they have a measurable impact on safety performance. It is suggested that, based on their current application in the construction industry, PPIs do not have the capacity to actually measure safety performance although some do recognise, safe behaviours, leadership and communication as measurable characteristics of safety culture. Rather, as discussed below, PPIs tend to measure OHS processes, but not safety performance *per se*. In Australia the unproductiveness of PPIs gradually became clear to industry, including the construction industry, after 1994 when the then National Occupational Health and Safety Commission (NOHSC) (also known alternatively as WorkSafe Australia) held two initial workshops to determine the viability of PPIs as an alternative to measuring OHS performance based on lag, or so – called negative indicators, such as LTIs. The difficulty of the measurability of safety performance by most known existing performance indicators is a recurring theme for this paper and the broader research framework of the current project. Arguably one of the most practical guiding principles of the measurability of safety performance is given in the Australian/ New Zealand Standard, *AS/NZS 4804: 2001 Occupational health and safety management systems—General guidelines on principles, systems and supporting techniques* (AS/NZS 4804) which defines safety performance as,

> the measurable results of the occupational health and safety management system related to the organisation's control of health and safety risks, based on its OHS

policy, objectives and targets. Performance measurement includes measurement of OHS management activities and results.

Perhaps ultimately, the most informative, yet simple, guidance for the efficacy of any performance indicator emanates from the UK HSE which prefaces one of the key sections of *A Guide to Measuring Safety Performance* by asking 'Why measure performance?' (HSE, 2001, p. 6). This simple question is possibly best responded to by Peter Drucker' s often quoted, maxim, 'You can't manage what you can't measure,' which may seem trite, yet its straightforward exhortation seems to contain invaluable advice when attempting to measure safety performance effectively.

1.2 PPIs AND THEIR IMPACT ON SAFETY PERFORMANCE

During the currency of the research project that produced *A Construction Safety Competency Framework*, aside from identifying essential leadership attributes, communication and desired safe behaviours as necessary elements of safety culture, Dingsdag, Biggs, Sheahan and Cipolla (2006a) identified the measurement of safety effectiveness as a requirement for measuring the influence of these elements of safety culture on safety performance. However, aside from positing that these have a positive influence on safety performance there is little validated evidence that the positive safety actions they generate actually influence safety performance positively. Other than anecdotal evidence from industry that safety culture impacts positively on safety performance and a plethora of academic literature that enthusiastically supports the implementation of safety culture, its benefits are largely predicated on an article of faith: It is not unusual to hear experienced OHS professionals claim that they know it works, but that their claims are based on intuition, not on measurable criteria. Further, currently, there are no standard national or international PPIs or any other lead indicators measuring safety culture or safety performance that are accepted by the construction industry (nor any other industry) notwithstanding that the application of PPIs was enthusiastically advocated in 1994 by the then WorkSafe/ NOHSC at a national symposium attended by all industry sectors' representatives (*vide* for example Shaw, 1994, pp. 15-27). A series of subsequent workshops and papers commissioned by NOHSC resulted in a consensus that, based on an industry wide framework, individual organisations should develop PPIs to achieve improved OHS performance. Unfortunately no guidance was established relative to the development, application and valid measurement of PPIs. Significantly for this research, even though safety culture change was identified during the symposium, the use of safe behaviours as performance indicators was considered, but not developed sufficiently. Essentially, the identified positive performance indicators were mainly (but not exclusively) linked to non-behavioural processes and typically measured numbers of OHS oriented activities and did not provide an indication of these activities' measurability. For example, these included;

- effectiveness of training programs;
- effectiveness of OHS structures;
- effectiveness of OHS representatives; and
- return to work rate (Sweeney, 1994, p. 39).

This endorsement of the development of PPIs was a reaction to the perceived inability of traditional 'outcome' safety performance indicators, LTIs or lag indicators to measure success: They were condemned as negative, largely measuring failure; eg, for Lost Time Injury Frequency Rates (LTIFRs), the raw number of injuries sustained in an organisation per year and their frequency obtained by dividing the number of injuries by (a notional) one million hours worked per annum. Conversely, the capacity of PPIs to show improvement in safety performance, rather than negative outcomes, was explored at length, and their implementation was strongly endorsed. The process of what PPIs should measure and how to devise standardized PPIs was also fully discussed eventually to the detriment of their implementation. Andrea Shaw, one of the NOHSC 1994 symposium's facilitators suggested that PPIs may not be sufficiently precise. Further, concerns were raised that PPIs may not be able to be generalized because there was no standardized application of PPIs (*vide passim*, Blewett, 1994 and Shaw, 1994). Briefly, common limitations of PPIs identified were that PPIs:

- may not directly reflect actual success in preventing injury and/ or disease
- may not be easily measured
- may be difficult to compare for benchmarking or comparative purposes
- may be time-consuming to collect and collate
- may be subject to random variation
- may encourage under or over reporting depending on how they are measured; and;
- that the relationship between PPIs and LTIs was arbitrary
- only measure the number of events and do not provide any indication or measure of effectiveness of each measured event

It is the last limitation that has particular relevance for the issues raised in this paper. Another issue that militated against the uptake of PPIs was that for legislative purposes, such as recording and reporting injuries, mainly LTIs and the like are required under the nine disparate Australian OHS jurisdictions. Generally their format was and is guided by Australian Standard AS 1885.1-1990, known as the National Standard for workplace injury and disease recording, which is non-enforceable at law, but nationally and internationally recognized as an authoritative conformance document. Other than a cursory mention of PPIs in AS/NZS 4804 there is no equivalent Standard for PPIs. The application of PPIs is and was strongly denounced in the performance measurement literature, most notably by Dr Edward Emmett, Chief Executive, WorkSafe Australia (1994) who officiated at the 1994 symposium. Conversely, the robust denunciation of lag indicators at the same symposium still has strong currency in the construction industry notwithstanding that no reliable, comparable and standardised lead performance indicators have emerged.

In 1999 NOHSC issued an extensive report on the development of PPIs for the construction industry entitled *OHS Performance Measurement in the Construction Industry.* Based on several industry case studies a tri-partite working group of industry, government and the union movement examined the possibility of implementing PPIs to measure safety performance in the construction industry. As with its 1994 strategy, NOHSC sought to develop a set of broad (and vague) PPIs that measured performance across the industry. Based on case studies of the various construction industry sectors the following PPIs were found to be commonly used:

§ number of JSAs conducted;
§ number of hazard inspections conducted;
§ number of tool box talks conducted;
§ number of OHS inductions conducted;
§ number of OHS meetings completed;
§ number of OHS training exercises held;
§ number of OHS audits conducted;
§ number of OHS bulletins issued;
§ number of OHS non-compliance reports issued;
§ whether OHS procedures for critical works have been submitted by subcontractors (rated either yes or no);
§ whether there is evidence that surveillance of sub-contractors is carried out (rated either yes or no);
§ the frequency of on-site inspections;

- the time taken to fix problems in accordance with the allocated time frame;
- general attitude to safety on site (subjectively assessed by the OHS coordinator);
- quality of records and documents related to OHS (subjectively assessed by the OHS coordinator);
- commitment to safety overall (subjectively assessed by the OHS coordinator);
- the consistency of project managers in relation to OHS as a measure of the quality of OHS management in contractors (used informally and subjectively assessed by the OHS coordinator);
- workers' rating of supervisors/project management's commitment to OHS
- percentage of injuries incurred for major hazards;
- percentage of sub-standard conditions identified and corrected as a result of safety audits;
- results of independent (by people in the same company, but from different sites) and external audits. Measured as number, regularity, quality, outcomes and action taken to resolve non-conformances;
- time taken to get hazards under control once they have been identified;
- assessment of the availability and standard of PPE; and
- number of hazard reports and feedback from toolbox meetings. (NOHSC, 1999, pp. 44, 45).

As well as suffering the common limitations of PPIs identified at the 1994 NOHSC workshops/ symposium, it is readily observable that those PPIs that merely measure a number of activities without follow up ('close out') actions, do not directly impact on safety performance. In fact, anecdotal evidence from the industry suggests that in some instances other than collecting and collating these indicators no follow up action may have occurred. Hence it's entirely possible that there was no impact on safety performance at all, let alone that they may, '…only measure the number of events and do not provide any indication or measure of effectiveness of each measured event (Blewett, 1994 and Shaw, 1994).'

The success of such an approach is further negated by the fragmented nature of the Australian construction industry which in the private sector consists of fewer than 30 very large principal contractor organizations and a similar number of 'second tier' large principal contractors. Typically these organizations rely on a substantial component of large contractors employing up to 100 employees who in turn employ subcontractors which may consist of two or three to less than 20 employees. It is also common to engage subcontractors who are the proprietor/ only employee. In this manner the construction industry employs approximately 900,000 people. Further, projects may last from a few months to a few years after which the project team moves on to another project and the safety culture and its safety performance dissipates. In addition, the industry is further fragmented, by the nature of the work undertaken, which includes the erection of commercial and residential high rise buildings, the cottage industry, building refurbishment and maintenance, facility management, road and bridge work, tunneling, rail infrastructure, energy infrastructure including electricity transmission lines, pipelines of various types as well as the development of open-cut mines. Quite clearly, the industry is not uniform in terms of the work performed and organizational size, and hence organizational resources: In addition, each part of construction work has its own particularized context relative to OHS risk, safety performance and performance measurement. Consequently there is broad agreement in the performance indicator and measurement literature that indicators should be based on the particular OHS risk exposure, the related safety performance and individual organizations' resource capability, specific industry position, the maturity of organizations' OHS and human resource (HRM) systems and that they should be based on the types of work and projects undertaken. Yet, in order to improve the industry's safety performance, other than the universally accepted lag indicators industry standardized lead performance indicators must be developed. In 2002 NOHSC held another workshop whose Report also reflects the lack of standardized construction industry PPIs and the difficulty of their measurement (NOHSC, 2002).

As a result of NOHSC's encouragement and support of the development of PPIs their adaption was taken up by other influential organizations, notably, Standards Australia, which, as noted above, advocated the use of performance measurement based on PPIs in AS/NZS 4804, but provided no framework for their implementation; WorkSafe Victoria in its SafetyMap audit 'tool' (1999) and the Minerals Council of Australia, in its *Positive Performance Measures; a Practical Guide* (2001). Notwithstanding, there is a paucity of research which on an evidence based examination supports the application of PPIs and performance measurement (*vide* for example NOHSC 2002), p.3, *passim*).

1.3 MEASURING SAFETY CULTURE

Relative to the measurability of safety culture Choudhry et al (2007, p. 1000) make the observation that,

> Traditionally, organizational culture is measured through the application of qualitative methods, such as observations and interviews. Nevertheless, the three main dimensions (psychological, situational and behavioral) can be measured through a combination of qualitative and quantitative methods (Cooper, 2000). The situational aspects of safety culture can be seen in the structure of the organization; policies, working procedures, management systems, etc. The behavioral aspects of safety culture can be measured through peer observations, self-reporting and outcome measures. The identified safe behaviors are placed on observational checklists, and trained observers regularly take observations which are then translated into 'percentage of safe scores' to provide feedback to those being observed. The psychological dimension is most commonly examined by safety climate questionnaires devised to measure people's perceptions of safety.

However, the examples of the models they claim do measure the essential elements of safety culture are all human resource intensive and some may also be capital intensive: For example Kennedy and Kirwan (1998) listed in Table 2,

> developed the Safety Culture and Operability (SCHAZOP) approach that focuses on the many aspects of safety management practices. It deals with day-to-day activities, including safety management, real roles and the personnel fulfilling these roles. One drawback of the SCHAZOP approach is that it is very resource intensive…(Choudhry et al, 2007, p. 1001).

Similarly, according to Choudhry et al;

> Cox and Cheyne (2000) incorporated behavioral indicators in their "Safety Assessment Toolkit" along with climate questionnaire and semi-structured interview schedule. Cox et al. (2004) conclude that behavioral safety is effective in increasing employees' confidence to challenge unsafe practices, as well as highlighting examples of best practice. Behavioral safety process (BSP) supports cultural realignment towards a "safety first" culture. They indicate that the BSP is an effective motivational tool that assists in both individual behavior and attitude change. Although measurement of safety culture depends on how it is defined (which in turn reflects the adopted perspective), ethnographic approaches are often costly and time consuming. Additionally, they tend to produce discovery data rather than hard data that can be incorporated into a management action plan (Choudhry et al, 2007, p 1001).

In other words, BSP is effective, but resource intensive and it may well be that, similar to PPIs, they may produce ‘discovery data’, or what was characterised above as mainly measuring process rather than ‘hard data’ which were defined as actions above. Further, the misgivings about the usefulness of the data produced by Choudhry et al align with the concerns expressed above about the capacity of PPIs to influence safety performance significantly if at all.

1.4 THE DEVELOPMENT OF SEIS

As a consequence of the vagueness and broadness of PPIs and their measurement, what is undertaken for this research is the investigation of the development of a guidance framework for performance measurement that can be applied by individual organizations based on an industry standardized set of performance indicators suited to their particular organizational objectives and environment. At this stage of the research process we propose to develop a mechanism which may incorporate lead indicators that have demonstrated capacity to measure their impact on safety performance and combine those with measures of safe behaviours and safety cultural competencies. Simply stated, this research project seeks to create a mechanism to standardize and customize the measurement of safety effectiveness with valid and user-friendly industry supported indicators that measure the effectiveness of specific proactive safety activities each company undertakes.

Even though since the 1994 NOHSC symposium and workshops lag indicators have been repeatedly denounced in some academic literature and government reports (e.g., NOHSC, 1999) as being negative and reactive and by some academics (e.g. Hopkins, 1994) and practitioners as merely measuring failure, it may well be that LTIs, LTIFRs and a raft of other lag indicators give the most accurate measurement of performance or, in some instances, the lack of performance (see Table 1, Table of suggested lag indicators, below). At this stage of the current research project it is envisaged to examine a range of lag indicators as dependent variables with proposed lead indicators (which have not yet been definitively identified) as independent variables. The proposed methodology, based on a range of suggested lag indicators and lead indicators will be industry trialled and modified according to industry feedback.

Table 1 Table of suggested lag indicators

Acronym	**Rates**
FAIFR	(first aid injury frequency rate)
FIFR	(fatality incidence frequency rate)
LTIFR	(lost time injury frequency rate)
MTIR	(medically treated injury rate)
NMTIR	(non-medically treated injury rate)
NDOR	(notifiable dangerous occurrence rate)
NII	(non injury incident) or near miss/ near hit
RTWR	(return to work rate)
WCCR	(workers’ compensation claim rate)
WCPR	(workers’ compensation premium rate)

Data from the two year national research project (mentioned above) that investigated the motivators of safety culture and safety behaviours in the construction industry has provided a data base (Dingsdag, Biggs, Sheahan, Cipolla 2006b) which identifies measurable safety behaviours informing the future formulation of SEIs. Based on approximately 70 interviews with managing directors, other senior management, construction site managers, union officials and semi-structured focus groups consisting of line management of Australia’s eleven largest principal contractors Dingsdag, Biggs, Sheahan and Cipolla (2006b) have identified 39 safety management tasks that are considered critical to enhancing safety performance by the industry. Two survey instruments consisting of a management and worker questionnaire were administered nationally to the participating construction companies. All of the findings were validated through interviews with senior officials of the ACTU, the principal construction sector union, the CFMEU, and senior managers of each of the OHS regulators in every State and Territory. After the qualitative and quantitative data were collated and analysed the results were taken back to each participating organisation for comment, suggestions for change and or validation. To create SEIs was outside the scope of the research project, but the standardised measurement of safety actions and associated safety behaviours is seen by industry as a necessary complement to the 39 SMTs. Further, notwithstanding the above opinion that other than anecdotal evidence from industry that safety culture impacts positively on safety performance, the research project's investigation of the motivators of safety culture and safety behaviours in the construction industry data suggested that measurable safety behaviours had the capacity to formulate SEIs (Dingsdag, Biggs, Sheahan, Cipolla 2006).

Other recently conducted research notably Choudhry, Fang and Mohamed, (2007) strongly endorse the measurability of safety culture elements. Further, this important article provided a useful (but incomplete) typology of the major safety culture/ safety climate methodologies (Table 2 below) of the principle of which some of the entries also incorporate suggested methods of measuring safety culture actions.

Table 2	**List and summary of prior safety culture research**
Reference	**Summary of Research**
Thompson et al. (1998)	Presents a model that links management support, organizational climate, and self-reported safety outcomes such as safety condition/safety compliance.
Kennedy and Kirwan (1998)	Focuses on aspects of safety management practices called the Safety Culture Hazard and Operability (SCHAZOP), and provides a qualitative analytical approach to identify detailed vulnerabilities and the means for their prevention.
HSE (1999)	Produces and utilizes a Health and Safety Climate Survey Tool that helps establishing what employees think of their organization's health and safety issues, and provides a basis on which to improve health and safety, involving employees in the process.
Hale (2000)	Elaborates on the complex aspects of safety culture, and suggests the elements of a good safety culture.
Pidgeon and O'Leary (2000)	Refers to the pioneering work of Barry Turner whose book *Man-made Disasters* (Turner, 1978) was one of the first to draw attention to the organization processes needed for learning from past incidents and mistakes, in order to achieve a good safety culture.
Rundmo (2000)	Presents mental images of risk and the results of a survey addressing issues such as safety climate, employee attitudes, risk perception and behavior among employees within an industrial company Norsk Hydro. The presented model links safety climate factors to actions related to the control of risk.
Lee and Harrison (2000)	Addresses attitudes, perceptions and reported behaviors. It provides reliable measurement scales and examines the issues of culture difference, not only between organizations as well as sub-populations within a single organisation.
Neal et al. (2000)	Presents a model that links organizational climate to safety climate. The model demonstrates that organizational climate predicts safety climate, which in turn is related to safety performance.
Cox and Cheyne (2000)	Describes the development of two elements of a toolkit, which combines audits with questionnaires assessing employees' perceptions and attitudes.
Grote and Kunzler (2000)	Presents a socio-technical model of safety culture and then shows that attitudes and perception surveys produce parallel results to auditing.
McDonald et al. (2000)	Explores the relationships of different aspects of safety culture and safety management systems and presents a revised model of safety management systems.
Glendon and Stanton (2000)	Presents the useful distinction between strategic top–down, functionalist perspective and data-driven bottom-up, interpretive approaches to safety culture.

Guldenmund (2000)	Postulates safety as the central object of organizational culture and presents an excellent review of 15 studies indicating the complexity of the safety climate concept
Clarke (2000)	Clarifies the term safety culture, and proposes a theoretical model by which safety culture affects safety behaviors in organisations.
Cooper (2000)	Presents a reciprocal model of safety culture to understand its dynamic, multi-faceted and holistic nature.
Glendon and Litherland (2001)	Presents the factor structure of safety climate and develops a behavioral observation measure of safety performance. However, it fails to find any relationship between safety climate and the behavioral observation measure of safety performance.
Mearns et al. (2001)	Reveals benchmarking strategies for monitoring safety climate and presents the relative weaknesses and strengths of organizations' safety-climate profiles in a readily accessible format.
Neal and Griffin (2002)	Presents a model identifying the linkages between safety climate, safety knowledge, safety motivation, and safety behavior demonstrating that knowledge and motivation mediate the relationship between safety climate and self-reported safety compliance and participation.
O'Toole (2002)	Identifies safety culture as a critical factor that sets the tone for the importance of safety within an organisation.
Mohamed (2002)	Presents a model where safe work behaviors are consequences of existing safety climate in construction site environments.
Maloney and Smith (2003)	Presents two models i.e. modified behavior model and model of safety performance
Mohamed (2003)	Promotes adopting the balanced scorecard tool to benchmark organizational culture in construction and argues that selecting and evaluating measures in four perspectives: management, operational, customer, and learning, would enable organizations to pursue incremental safety performance improvements.
Silva et al. (2004)	Tests the reliability and validity of the OSCI (organization and safety climate inventory) questionnaire to address the characteristics of both organizational climate and safety climate within 15 industrial organisations.
Richter and Koch (2004)	Discusses perspective of integration, differentiation and ambiguity in safety culture.
Reiman and Oedewald (2004)	Presents a survey methodology for studying organizational culture in complex socio-technical systems.
Cooper and Phillips (2004)	Determines the relationship between the measurements of the safety climate and safety behaviour.
Fang et al. (2006)	Identifies the dimensions of safety climate to improve the safety culture in construction.

Source, Choudhry, Fang and Mohamed, 2007, pp. 997, 998.

1.5 CONCLUSION

The challenge for the current project is to develop reliable, comparable and constant indicators that measure safety performance without the drawbacks commonly attributed to PPIs: In other words, they must be easily measured and be able to be compared for benchmarking purposes within sections of an organization and across industries without being subject to random variation. For the construction industry specifically, they must be able to be implemented uniformly from project site to project site notwithstanding the disparate sectors of the industry, the variability of the work undertaken and the diverse risk contexts these generate. Further, they must be simple to implement so that they are not capital and human resource intensive: They must not be so complex that they are time-consuming to administer and collate and they must measure effectiveness instead of simply measuring a number of events which have no demonstrated effect on safety performance.

1.6 REFERENCES

Aitken, K. and O'Driscoll, M. (1998) 'A goal-setting intervention to enhance organisational safety: implementation problems and implications', *Journal of Occupational Health and Safety – Australia New Zealand*, 14 (3) pp. 245-254.

Archer, B. (1994) 'Towards a systems approach in the management of health and safety in the Australian construction industry,' *Positive Performance Indicators: Beyond Lost Time Injuries: Part 2—Practical Approaches,* Worksafe Australia, National Occupational Health & Safety Commission, Canberra, pp. 15–20.

Biggs, H. C., Dingsdag, D. P., Sheahan, V. L. & Cipolla, D. (2006) 'Using Safety Culture to Overcome Market Force Influence on Construction Site Safety,' K. Brown, K. Hampson and P. Brandon (eds.) *Clients Driving Innovation: Moving Ideas into Practice,* Cooperative Research Centre for Construction Innovation, Icon.net Pty Ltd, Brisbane, pp. 201-213.

Biggs, H. C., Sheahan, V. L. & Dingsdag, D. P. (2006) 'Improving Industry Safety Culture: The tasks in which safety critical positions holders must be competent,' *Proceedings, Global Unity for Safety & Health in Construction Conference, International Council for Research and Innovation in Building and Construction*, Tsinghua University, Beijing 28-30 June, pp. 181-187.

Blewett, V. (1994) 'Beyond Lost Time Injuries: Positive Performance Indicators for OHS, Summary Paper,' *Positive Performance Indicators: Beyond Lost Time Injuries: Part 1—Issues,* Worksafe Australia, National Occupational Health & Safety Commission, Canberra, pp. 1-55.

Choudhry, R., Fang, DP. and Mohamed, S. (2007) 'The nature of safety culture: A survey of the state-of-the-art,' *Safety Science* (on-line), 45, pp. 993–1012.

Costigan, A & Gardner, D. (2000) 'Measuring Performance in OHS: An investigation into the use of positive performance indicators,' *Journal of Occupational Health and Safety – Australia New Zealand*, 16, pp. 55-64.

Dingsdag, D. P., Biggs, H. C. & Sheahan, V. L. (2006 a) 'The carrot and the stick: Driving Safety culture in the Construction Industry,' K. Brown, K. Hampson and P. Brandon (eds.) *Clients Driving Innovation: Moving Ideas into Practice,* Cooperative Research Centre for Construction Innovation, Icon.net Pty Ltd, Brisbane, pp. 214-223.

Dingsdag, D. P., Biggs, H. C., Sheahan, V. L, & Cipolla, D. J. (2006 b) *A Construction Safety Competency Framework: Improving OH&S performance by creating and maintaining a safety culture,* Cooperative Research Centre for Construction Innovation, Icon.net Pty Ltd, Brisbane.

Emmett, E. (1994) Foreword, *Positive Performance Indicators: Beyond Lost Time Injuries: Part 2—Practical Approaches,* Worksafe Australia, National Occupational Health & Safety Commission, Canberra.

Hopkins, A. (1994) 'The Limits of Lost Time Injury Frequency Rates,' *Positive Performance Indicators: Beyond Lost Time Injuries: Part 1—Issues,* Worksafe Australia, National Occupational Health & Safety Commission, Canberra, pp. 29-35.

HSE (2001) *A guide to Measuring Health and Safety Performance*, London.

HSE (2002) *Health and safety performance in the Construction Industry*, London.

Minerals Council of Australia (2001) *Positive Performance Measures; a Practical Guide*, Canberra.

Mitchell, R. (2000) 'Development of PPIs to monitor OHS performance in the Australian construction industry,' *Journal of Occupational Health and Safety – Australia New Zealand, 16*, 325-331.

NOHSC (2002) *Extending the Use of OHS Positive Performance Indicators in Australian Industry*, Canberra.

OECD (2003) Guidance on Safety Performance Indicators; *OECD Environment, Health and Safety Publications Series on Chemical Accidents No. 11*, Paris.

Redingera, C.F., Levine, S.P. Blotzer and M.J. Majewski, M.P. (2002) 'Evaluation of an Occupational Health and Safety Management System Performance Measurement Tool—III: Measurement of Initiation Elements,' *American Industrial Hygiene Association Journal* 63: pp. 41–46.

Shaw, A. (1994) 'OHS Performance Indicators for Benchmarking: Report on the literature review conducted as stage 1 of the Worksafe Australia project to develop a benchmarking methodology for occupational health and safety', *Positive Performance Indicators: Beyond Lost Time Injuries: Part 1—Issues,* Worksafe Australia, National Occupational Health & Safety Commission, Australia, pp. 15–27.

Simpson, I and Gardner, D. (2001) 'Using OHS performance indicators to monitor corporate OHS strategies,' *Journal of Occupational Health and Safety – Australia New Zealand*, 17, 125-134.

Sorensen, J. R. (2002) 'Safety culture: a survey of the state-of- the art,' *Reliability Engineering and Systems Safety*, Elsevier, 76, 189-204.

Standards Australia, (1990) Australian Standard AS 1885.1-1990 *Measurement of occupational health and safety performance - Describing and reporting occupational injuries and disease*, Homebush.

Standards Australia and Standards New Zealand (2001) *Australian/ New Zealand Standard, AS/NZS 4804:2001 Occupational health and safety management systems—General guidelines on principles, systems and supporting techniques,* Standards Australia, Homebush, Australia, and Standards New Zealand, Wellington, New Zealand.

Sweeney, S. (1994) 'Opportunities/Strategies and Tactics for Going Beyond Lost Time Injuries,' *Beyond Lost Time Injuries: Part 1—Issues,* Worksafe Australia, National Occupational Health & Safety Commission, Australia, p. 34.

Victorian WorkCover Authority (1999) *SafetyMap: Auditing Health and Safety Management Systems*, Melbourne.