

**Safety Culture within the Australian Coal Mining
Industry: Identifying the Critical Factors and
Measuring the Construct**

Presented By

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Statement of Originality

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968.

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* Note: The author was married on October 06, 2007 and subsequently changed her name from Rebecca Jane Atkins to Rebecca Jane Allen.

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Dedication

For my family.

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Abstract

Coal mining has been internationally recognised as a high risk industry (HRI). Safety investigations within HRIs have revealed safety culture to be at the core of safety outcomes: both accident causation *and* error prevention. Safety culture investigations have not however, held a prominent role in safety management within Australian coal mines. The aim of the current research was to identify critical safety issues within Australian coal mines in order to develop and test an industry appropriate measure of safety culture to determine a baseline from which to direct safety management strategies. The thesis presents a multi-phased research project based on a review of the role and measurement of safety culture within HRIs. Review of the literature produced a model of the factors underlying safety culture within HRIs. Focus groups were subsequently conducted across 3 coal mines ($N = 69$) from NSW, Australia to examine the critical factors underlying safety culture and safety outcomes within the industry. The findings upheld the model derived from the literature while identifying several context-specific safety issues. An existing measure of safety culture, the Safety Management Questionnaire (SMQ: Fleming, 2000), was selected for re-development for the current research due to a high level of similarity in the underlying components. The Australian Coal Safety Questionnaire (ACSQ) was subsequently developed across three studies. The first iteration of the ACSQ (ACSQ-1) was tested across 3 coal mines ($N = 152$), the ACSQ-2 across 5 coal mines ($N = 363$), and the ACSQ-3 examined across 12 coal mines ($N = 679$). Factor analysis revealed a 5-factor model of the issues underlying safety culture in Australian coal mines. The management of safety was identified as the principal factor. A baseline of safety culture for the Australian coal mining industry was determined to be 80.60%: a moderately strong level of safety culture. The current research provides the Australian coal mining industry with increased knowledge of the critical safety issues, a baseline level of safety culture, and a psychometric tool from which to pursue management strategies to further enhance the safety culture and safety outcomes of the industry.

Executive Summary

The complexity of the interactive relationship between humans, machinery, and the environment that is characteristic of high risk industries (HRIs) precipitates the need for advanced safety strategies and effective safety management systems. Coal mining has been internationally recognised as an HRI with high fatality rates in comparison to other occupations. Safety investigations within complex domains such as coal mining have revealed safety culture to be at the core of safety outcomes: safe, efficient, and effective operations are dependent upon a high level of safety culture across the entire workforce. While the psychological, behavioural, and situational elements of safety culture have been shown to hold a combined critical role in both accident causation and error prevention within HRIs, safety culture investigations have not held a prominent role in safety management within Australian coal mines. The aim of the current research was to identify safety critical issues within Australian coal mines in order to develop and test an industry appropriate measure of safety culture. An additional aim was to determine a baseline of safety culture from which to direct future strategic interventions and proactive safety management. The multi-phased research is presented in sequence throughout this thesis. Prior to this research there was minimal measurement of safety culture within the Australian coal mining industry, no industry or nation specific measurement tool, and no benchmark from which to pursue effective management strategies.

The theoretical underpinnings of the current research are presented in Chapter 1 which highlights the theoretical models defining safety culture and empirical studies investigating and identifying critical safety factors in HRIs. A review of existing safety culture inventories is also presented. Chapter 1 concludes with a derived factorial model of safety culture within safety critical industries. Expanding on the theoretical foundations of the current research, Chapter 2 presents a review of safety culture and the current approaches to safety measurement within the Australian coal mining industry. An overview of the research program is also provided.

In determining the appropriateness of the factor model, derived in Chapter 1, for the Australian coal mining industry, Chapter 3 details the research methodology to ascertain industry perceptions of critical safety factors within Australian coal mines. Sixty-nine individuals representing all levels of the workforce participated in this phase of the research sourced from both open-cut and underground coal mines from the

Hunter Region of New South Wales: a major coal mining region of Australia. Chapter 3 also reports the statistical analysis for this phase of the research. The findings uphold the model of critical safety factors identified from the literature while identifying several additional safety issues characteristic of the industry. The results suggest a level of homogeneity across open-cut and underground coal mines despite the differences in environmental conditions and degree of physical risk and in comparison to an identified industry perception of the existence of heterogeneity among the mining domains.

Through the establishment of a core set of critical safety factors contributing to safety culture within Australian coal mines throughout Chapters 1, 2, and 3, Chapter 4 commences with the rationale for selecting an existing measure of safety culture for re-development for the Australian coal mining industry. The Safety Management Questionnaire developed for the United Kingdom Offshore Oil and Gas Platform Industry was adapted for the current research due to a high level of similarity in the underlying components. Chapter 4 details the research methodology and findings for developing and testing the first iteration of the Australian Coal Safety Questionnaire (ACSQ-1) developed specifically for the Australian coal mining industry. One hundred and fifty-two individuals representing two underground coal mines and one open-cut mine participated in this phase of the research by completing the 65-item inventory. The chapter further reports the statistical analysis of the data. The results revealed a 6-factor model of the underlying safety culture critical factors further revealing homogeneity across the sample. The psychometric properties of the tool including validity and reliability are also addressed in Chapter 4 leading to several recommendations for future revision of the tool.

Chapter 5 presents the adaptation and testing of the second iteration of the Australian Coal Safety Questionnaire (ACSQ-2), the research methodology, and the results. Three hundred and sixty-three individuals representing four underground coal mines and one open-cut mine participated in this phase of the research by completing the revised 63-item inventory. The findings suggest a further refinement of the 6-factor model of safety culture and provide additional support for the homogeneity of the sample and the generalisability of the results. The psychometric analysis of this developing tool is also presented in Chapter 5 addressing the issue of validity and reliability and also those areas for adaptation in the third iteration of the ACSQ.

Chapter 6 presents the development and testing of the third and final iteration of the measure for the current research: the ACSQ-3. The chapter commences with the

psychometric adaptation of this final iteration and a description of the research methodology. Six hundred and seventy-nine individuals participated in this phase of the research by completing the revised 60-item inventory. The sample represented four underground coal mines and eight open-cut mines. The chapter reports the descriptive statistics, factor analysis, and other comparative statistics for the dataset with an emphasis on the identified critical safety issues and an examination of between group differences. The results reveal a refined 5-factor model of the core critical safety issues underlying safety culture within Australian coal mines. The psychometric properties of the tool are also addressed in Chapter 6 as well as presenting a final version of the tool for future industry use.

The collective research has revealed the core issue of safety culture within Australian coal mines to be an organisational, team, and individual balance between production and safety. This reflects the dynamic relationship between humans, machinery, and the environment that is characteristic of HRIs. In addition to effective safety management systems, the balance between production and safety has proven essential, together with a positive workforce perception of management's commitment to safety. These core safety issues are outlined in the general discussion presented in Chapter 7 together with research conclusions, industry applications, and specific recommendations. Chapter 7 highlights the role of safety culture in assessing current safety attitudes, perceptions, and behaviours, predicting future safety outcomes, and evaluating the effectiveness of current safety management strategies. Ongoing use of the tool holds the additional capacity to evaluate the effectiveness of safety training and other such interventions through repeat administration and the examination of safety culture levels as they fluctuate over time and in comparison to the industry baseline determined through the current research. Administration of the tool further enables increased effectiveness of training which can be targeted at specific areas of identified need. The development and application of the Australian Coal Safety Questionnaire as an innovative safety culture tool represents a renewed resourcefulness for the Australian coal mining industry, directing a strategic and proactive approach to effective safety management. The current research provides the Australian coal mining industry with a baseline and a psychometric tool from which to pursue management strategies to further enhance its safety culture as an adjunct to improving the effectiveness of safety management through increased knowledge of the critical safety issues across the domain.

Abbreviations

ACSQ	Australian Coal Safety Questionnaire
ACSQ-1	Australian Coal Safety Questionnaire Revised Version 1
ACSQ-2	Australian Coal Safety Questionnaire Revised Version 2
ACSQ-3	Australian Coal Safety Questionnaire Revised Version 3
ACSNI	Advisory Committee on the Safety of Nuclear Installations
CFMEU	Construction, Forestry, Mining and Energy Union
CVR	Content Validity Ratio
EFA	Exploratory Factor Analysis
ESC	Employee Services Coordinator
FA	Factor Analysis
FB	ACSQ Section B (Safety Behaviour) Factor Score
FC	ACSQ Section C (Safety Climate: Attitudes & Perceptions) Factor Score
FG	Factor Global (Overall Safety Culture Score)
FG-WT1	Focus Group Written Task 1
FG-WT2	Focus Group Written Task 2
HF	Human Factors
HREC	Human Research Ethics Committee (The University of Newcastle, Australia)
HRI	High Risk Industry
HRM	Human Resource Manager
HSC	Health and Safety Commission
HSD	(Tukey) Honestly Significant Difference
I&I	Industry & Investment
IAEA	International Atomic Energy Agency
INSAG	International Nuclear Safety Advisory Group
JCBHST	Joint Coal Board Health and Safety Trust, Coal Services Pty Limited
LTI	Lost Time Injury
LTIFR	Lost Time Injury Frequency Rate
NSW	New South Wales, Australia
NZ	New Zealand
OC	Open-cut
OE	Open-ended

ORPQ	Offshore Risk Perception Questionnaire
OSMQ	Offshore Safety Management Questionnaire
OSQ	Offshore Safety Questionnaire
PCA	Principal Components Analysis
PPE	Personal Protective Equipment
SC	Safety Culture
SCQ	Safety Climate Questionnaire
SMQ	Safety Management Questionnaire
SMQ-2	Safety Management Questionnaire Revised Version 2
SMQ-3	Safety Management Questionnaire Revised Version 3
SPSS	Statistical Package for the Social Sciences
SSMQ	Supervisor Safety Management Questionnaire
SOP	Standard Operating Procedures
STC	Safety Training Coordinator
UG	Underground
UIC	Uranium Information Centre
US	United States