Safety Science 66 (2014) 27–35

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Safety in machinery design and construction: Performance for substantive safety outcomes

Elizabeth Bluff *

National Research Centre for Occupational Health and Safety Regulation, Regulatory Institutions Network, The Australian National University, Australia

ARTICLE INFO

Article history:
Received 3 December 2013
Received in revised form 30 January 2014
Accepted 6 February 2014
Available online 26 February 2014

Keywords:
Safe design
Machinery
Hazard recognition
Risk control
Safety information
Legal obligations

ABSTRACT

This paper presents the findings of qualitative research which examined how manufacturers addressed safety matters in the course of designing and constructing machinery, and the factors shaping their responses. This topic was investigated in 66 Australian firms that supplied machinery into local and international markets. Based on in-depth interviews, observation of machinery and review of documentation, firm performance was evaluated for three substantive safety outcomes – hazard recognition (types and instances), risk control measures (type and quality) and provision of safety information (scope and quality). The paper discusses differences in firm performance for these outcomes and concludes that there is a need for greater and more effective attention to safety in machinery design and construction, in order to advance the goal of preventing death, injury and illness arising from machinery.

1. Introduction

Eliminating hazards or minimizing risks early in the life cycle of machinery, equipment, structures, and other items and materials is the goal of a series of public policy and safety professional initiatives (Kletz, 1998; Manuele, 1999, 2008; NOHSC, 2002; Safe Work Australia, 2012; Schulte et al., 2008). At the heart of these initiatives is the strategy of designing out hazards or minimizing risks through safety measures that are integral to the design or at least not easily removed, weakened or rendered ineffective.

This paper presents the findings of research with Australian-based machinery manufacturers. The aim of the research was to examine how firms addressed safety matters in the course of designing and constructing machinery, and the factors shaping their responses. The 66 study firms produced a wide variety of machinery including cranes and other lifting equipment, horticultural and agricultural machinery, boilers and pressure vessels, industrial cleaning systems, and machinery for processing, handling or packaging food, timber, minerals and other products or waste materials. The firms supplied their machinery into local and international markets in Europe, Asia, North America and the Middle East.

A key reason for focusing on producers of machinery was the compelling evidence that machinery can endanger health and safety through a diverse array of risks, and that poor design is a contributing factor in a high proportion of machinery-related deaths and injuries (Backstrom and Döös, 1997, 2000; Driscoll et al., 2005, 2008). A further reason was the legal obligations for the safe design and construction of machinery. In Australia these were the general duties established in the occupational health and safety (OHS) statutes in each of nine Commonwealth, state and territory jurisdictions, which were underpinned by regulations and approved codes of practice for machinery and other plant (Bluff, 2004; Johnstone, 1997, pp. 260–263, 2004, pp. 275–280).[1] For firms supplying machinery into global markets the pre-eminent regulatory regime was (and continues to be) that based on the Machinery Directive, and separate directives for specific types of machinery or hazards (European Commission, 1995, 1997, 1998, 2000, 2006).[2] As well as applying to firms supplying into the European Economic Area (EEA), the European regime also has

* Address: Coombs Extension, Building 8, The Australian National University, Acton, ACT 0200, Australia. Tel.: +61 2 6125 1514; fax: +61 2 6125 7789.

E-mail address: Liz.Bluff@anu.edu.au

[1] Australian OHS law has changed since data collection but general duties for design and construction of machinery and other plant, underpinned by regulations and approved codes of practice, are key elements in the reformed laws. Note also: as the study firms produced machinery that was not used for personal, domestic or household purposes, the separate law for consumer product safety did not apply (Johnstone, 2004, p. 291).

[2] The Machinery Directive of 1998 was revised and reissued in 2006 for application in 2009. The revised Machinery Directive 2006/42/EC does not introduce any fundamental changes but consolidates and improves the application of the previous Directive (Bamberg and Boy, 2008; Fraser, 2010).

http://dx.doi.org/10.1016/j.ssci.2014.02.005
0925-7535/

standing in other global markets (IMS Research, 2009; and see Lacore, 2002).

At the level of broad principles the Australian and European regimes shared a substantive regulatory goal of preventing death, injury and illness (the regulatory goal of prevention) (European Commission, 1998, recital 4, art. 2, 2006, art. 4, recital 2; Johnstone, 1997, pp. 100–102, 2004, pp. 99–101). For the European regime this is expressed as preventing machinery that endangers health or safety from being placed on the market and put into service in the EEA, and a core principle is to reduce the social cost of accidents by inherently safe design and construction of machinery.

The Australian and European regulatory regimes also shared some core elements. The first set of core elements concerned the management of risks to health and safety, encompassing recognition of a wide range of hazards, a process of assessment (conformity assessment in Europe), implementation of control measures to eliminate or minimize/reduce risks, and attention to risks arising in different aspects of use and stages of the life cycle of machinery. Other core elements were testing and examination of machinery, and design verification for prescribed high risk items (the European process involving notified bodies). Both regimes also required provision of safety information, and both were underpinned by technical standards (harmonized standards in Europe) which might be applied in any of the preceding elements.

Three of the core elements were applied in this research as the conceptual framework for evaluating manufacturers' performance. These were the elements for hazard recognition, risk control and provision of safety information. They were critical for complying with the regulatory goal of prevention in the sense that machinery could not be regarded as safe and without risks to health unless manufacturers had comprehensively recognized the hazards of the machinery, eliminated the hazards or incorporated effective control measures to minimize the risks arising from them, and provided safety information to support and reinforce risk control measures. The research set these three core elements as substantive safety outcomes and assessed manufacturers' performance for each of these outcomes.

This paper presents the findings of the research for firm performance for these three substantive safety outcomes. The paper is structured as follows. First, the qualitative research methods are presented, including the approach to analyzing data and classifying firm performance for the substantive safety outcomes (Section 2). Then the research results for hazard recognition, risk control and safety information are presented (Section 3), and their significance for the safe design and construction of machinery is discussed (Section 4).

2. Methods for data collection and analysis

The qualitative research design incorporated empirical studies with manufacturing firms and with OHS regulators, which were underpinned by a review and analysis of relevant literature, legal obligations and case law. The focus of this paper, and the methods outline below, is the study with manufacturing firms.

2.1. The sample of manufacturing firms

The sampling frame for the manufacturers' study was firms that designed and constructed[3] machinery for use at work and were based in two Australian states (Victoria and South Australia). The workers' compensation agencies in these two states provided lists of businesses classified as manufacturers of industrial machinery, together with the location and remuneration for each firm (Victorian WorkCover Authority, 2003; WorkCover Corporation, 2000). This enabled the researcher to classify the listed firms according to some key characteristics and attributes: state of operation (Victoria or South Australia); location of the business within the state (capital city or regional); and firm size – small (<20 employees), medium (20–99 employees), and large (100 or more employees).

This stratified, purposive sampling strategy was designed to capture major variation according to these key characteristics and attributes. Other factors of interest, such as the type of machinery, whether it was custom made or produced as standard models, and firms' markets could not be determined reliably prior to data collection and were explored in interviews. Firms were randomly selected from within each state/location/size stratum. Sampling was to the point of saturation, when no new information was forthcoming from interviewees and the data were of sufficient depth and scope (Flick, 2006; Richards, 2005). Table 1 presents the sample of firms. The participation rate was 72% in Victoria and 69% in South Australia.

2.2. Methods for data collection

In-depth, face-to-face interviews were conducted on site at manufacturing firms according to accepted principles for qualitative interviews (Berg, 2007; Gillham, 2000; Minichiello et al., 1995). The interviewees were key individuals who were responsible for making and implementing decisions about machinery design and construction as directors, owners or managers overseeing production, engineering or other technical and specialist functions.

A semi-structured schedule was used to ask interviewees about consistent topics through open-ended questions designed to elicit detailed responses. Interviewees were first asked general questions about their experience and qualifications, the firm's operations (the machinery produced, how it was designed and made), and the markets for the firm's machinery (the industries and locations supplied in Australia and other countries). Interviewees were also asked about sources of knowledge about machinery safety, how safety matters were addressed including the firm's actions, practices and processes for design and construction, and specific practices for risk management, testing and examination, and provision of safety information. Other topics canvassed were factors motivating or constraining attention to safety matters, awareness and understanding of relevant legal obligations, and experience of inspection and enforcement. Interviews were audio taped and subsequently transcribed verbatim.

Observation was applied to examine the safety of machinery including potential sources of harm (hazards), whether risk control measures were incorporated and the nature of these, and any safety information in the form of decals, signage or other markings. Access to various forms of documentation and audio-visual materials was requested at the time of interviews including product brochures, CDs, videos, machinery safety information, technical standards and other information resources, risk assessments,

Table 1
Sample of manufacturing firms.

	<20		20–99		100+		Total
	Met	Reg	Met	Reg	Met	Reg	
Victoria	12	4	8	4	4	0[a]	32
South Australia	12	6	8	4	4	0[a]	34
Total	24	10	16	8	8	0	66

Note: In the table, Met is capital city location and Reg is regional location.
[a] No firms in sampling frame for this stratum.

[3] The firms were involved in both design and construction even if they outsourced some aspects of design, component production or supply, or assembly.