A report prepared for the National Occupational Health and Safety Commission

# SAFE DESIGN PROJECT

## Review of literature and review of initiatives of OHS authorities and other key players

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# Foreword

In seeking to achieve Australian workplaces free from injury and disease NOHSC works to lead and coordinate national efforts to prevent workplace death, injury and disease.

We seek to achieve our mission through the quality and relevance of information we provide and to influence the activities of all our parties with roles in improving Australia's OHS performance.

NOHSC has five strategic objectives:

- improving national data systems and analysis,
- improving national access to OHS information,
- improving national components of the OHS and related regulatory framework,
- facilitating and coordinating national OHS research efforts,
- monitoring progress against the National OHS Improvement Framework.

This publication is a contribution to achieving those objectives.

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# Preface

# A National Solutions Project

NOHSC initiated in 1998-99 five National Solutions projects as part of its strategic approach. The National Solutions projects are seen as providing key elements of a framework that will assist governments, employer and employee representatives and workplace players to better target their priorities and investments in prevention of occupational injury and disease. The framework aims at building OHS understanding within society and developing a systematic approach to sustainable change and OHS improvement.

This review of literature and review of initiatives of OHS authorities and other key players is one of a number of data and information gathering activities being undertaken in the first phase of the *Safe Design Project*. It was commissioned to review relevant Australian and international literature; and describe past, current or planned initiatives by OHS authorities and other NOHSC stakeholders. VIOSH Australia, at the University of Ballarat, was commissioned in 1999 to undertake the review.

Associate Professor Steve Cowley has been with VIOSH Australia at the University of Ballarat since 1985 and Director for the past five years. Steve has been involved in the initiation, execution and supervision of a large number of research projects. He has had wide industrial experience in health and safety as well as academic experience in universities in the UK. He has a Master of Applied Science in Occupational Hygiene, Bachelor of Science and a Graduate Certificate in Education.

Dr John Culvenor is a researcher, consultant and lecturer with VIOSH. John has a Bachelor of Engineering, Graduate Diploma in Ergonomics and PhD in Occupational Health and Safety. John has participated in and led a number of research and consultancy projects. John's PhD research investigated the application of creative thinking techniques and the improvement of workplace, process and equipment design.

Mr John Knowles is a researcher, consultant and lecturer with VIOSH. John has extensive experience in the conduct and supervision of literature-based research both at the University and elsewhere. John has a Bachelor of Science, a Master of Environmental Science and a Graduate Diploma in Occupational Hazard Management.

A reference group comprising representatives from OHS authorities from a number of States and Territories, ACCI and ACTU provided expert and industry advice and assistance to the project.

The assistance of Leanne Pitman (Manager, Information Literacy & Research Services, University of Ballarat) is also acknowledged.

# Executive Summary

This Report is one part of the National Occupational Health and Safety Commission's (NOHSC) *Safe Design* project, which aims to develop a greater recognition of the role of safe design in improving occupational health and safety performance in the workplace. The Safe Design project has targeted the following groups:

- designers, manufacturers, importers and suppliers of plant and equipment;
- designers, constructors and installers of buildings and structures; and
- designers, manufacturers, importers and suppliers of materials and substances

The project aims to stimulate target groups to address the incorporation of occupational health and safety in its designs and activities, and to embrace continuous improvement in design.

The aims of this aspect of the project were to:

- review relevant Australian and international literature; and
- describe past, current or planned initiatives by OHS authorities and other NOHSC stakeholders.

The specific research questions were:

- What approaches have the stakeholders taken in order to help the target groups understand and implement safe design?
- What do the target groups currently know about their OHS obligations in regard to safe design?
- What do the target groups currently do to meet their OHS obligations?
- Who are the key intermediary/contact groups or individuals who influence the target groups on safe design issues?
- What are the overall implications of these findings on possible strategies for influencing the target groups?

A literature review was conducted and 56 items were reviewed and summarised. Telephone interviews were conducted with stakeholders on advice from the NOHSC and as referred by others as the process proceeded. Through the interviews and by way of written comment, representatives from all Australian States and Territories, employee and employer bodies were included.

The following summarises some of the findings of the research:

1) The level of knowledge and perception of safety law and the knowledge and use of safety concepts (such as hazard management, hierarchy of control, practicability) among the target groups is thought not to be optimal in many respects. However, these matters are not known for certain and the particular areas of need are not clear either in Australia or abroad. Research is needed to determine levels of knowledge of legal responsibilities and importantly the key underpinning concepts among all the target groups to establish a baseline.

2) Designers in particular are important targets and there is evidence of a need for improvement in their knowledge of occupational health and safety both in terms of legal responsibilities and in terms of the underpinning concepts.

a) Information is needed about designers' knowledge of occupational health and safety responsibilities and about the concepts of safe design. Survey-type research could be a way to obtain this information and would seem to be a relatively straightforward task given that the groups of designers (e.g. engineers, architects) are readily identifiable and accessible. This research could inform changes to undergraduate education and professional development (mentioned below).

b) Undergraduate education is seen as an ideal opportunity to influence designers. The current level of incorporation of safety into design courses needs to be assessed. In all probability the assessment will reveal a need for improvement and therefore a plan will need to be put in place to make improvements.

c) Professional development could provide a means of updating knowledge obtained via undergraduate education and provide a means to bring current practitioners up to date with the principles of safe design and occupational health and safety in general.

3) Consumers are seen as an important avenue of influence on safe design. Consumers include users of plant or substances in a workplace, owners of a building development. Consumers should be encouraged to build safety into purchasing decisions. Research could be undertaken to determine the best ways to assist consumers in improved purchasing in the three areas of plant and equipment; buildings and structures; and materials and substances.

4) In terms of safe design of buildings and structures, the style of building law is somewhat different to occupational health and safety law. It is possible that designers in this field (e.g. engineers and architects) become accustomed to this style of regulation and are thus be unaccustomed to the process-based model that lies at the heart of workplace safety. It is worth considering the inclusion of the hazard management process-based approaches in, for example, the Building Code of Australia. By this method, designers would apply this model and therefore perhaps by default achieve some of the aims of the workplace safety law without necessarily being aware of that law. Teaching of the process-based model could probably be incorporated in design courses.

5) Awareness of the need and benefits of safe design could be improved by a number of methods such as:

a) creation of special awards schemes that are based on safety interventions that improve safety downstream of the applicant;

b) target groups be given prominence in public information, such as the Internet sites of the authorities; and

c) prosecution of target groups would be a way to enhance awareness of safe design issues. The value of focussing attention on upstream parties could be included in guidelines used by the regulatory authorities to determine matters for prosecution.

6) Information about safe design could be improved. For instance, there is a vast resource of safe design material contained in the collections of hazard alert material produced by the State authorities. These hazard alerts could be pooled in a national database that is accessible to the target groups. Also people could subscribe to an automatic system that would e-mail alerts that relate to their interest depending on their role, industry, .

7) The life-cycle approach seems to have great merit and research could be undertaken to determine how achieve diffusion amongst the various industries. Existing programs like 'Responsible Care' in the chemical industry and the pilot program in the NSW construction industry *based on the* British *Construction (Design and Management) Regulations 1994*, are worthy of further evaluation.

8) Reference to safe design issues in the Australian literature is scarce and research activity in safe design needs to be increased and should be better documented/publicised. Funding agencies should give priority to safe design issues and encourage research and publication in the area.

# 1. Introduction

This Report is one part of NOHSC's *Safe Design* Project, which aims to develop a greater recognition of the role of safe design in improving occupational health and safety performance in the workplace. The Safe Design project has targeted the following groups:

- designers, manufacturers, importers and suppliers of plant and equipment;
- designers, constructors and installers of buildings and structures; and
- designers, manufacturers, importers and suppliers of materials and substances

The project aims to stimulate target groups to address the incorporation of occupational health and safety in its designs and activities, and to embrace continuous improvement in design.

Australian workplace safety law now places responsibilities on parties 'upstream' of the user. These parties include designers, manufacturers, suppliers, importers, constructors and installers. Their inclusion recognises the powerful role they play in influencing the safety of people who later work with plant, buildings or substances that they have designed, manufactured, Gunningham, et al. (2000) have addressed the obligations of these parties in an earlier component of the NOHSC's *Safe Design* Project. As such there is little need here to cover the legal aspects in any detail. It suffices to say (drawing on Gunningham, et al.), that there is a great deal of similarity throughout Australia and to summarised briefly in the short outline contained in Appendix A.

Note: some terms used in this report are described below in Table 5, Appendix B.

.

# 2. Aims and Objectives

The aims of this aspect of the project were to:

- review relevant Australian and international literature; and
- describe past, current or planned initiatives by OHS authorities and other NOHSC stakeholders.

The objectives were to answer the following research questions:

- What approaches have the stakeholders taken in order to help the target groups understand and implement safe design?
- What do the target groups currently know about their OHS obligations in regard to safe design?
- What do the target groups currently do to meet their OHS obligations?
- Who are the key intermediary/contact groups or individuals who influence the target groups on safe design issues?
- What are the overall implications of these findings on possible strategies for influencing the target groups?

# 3. Methodology

The project was conducted in two parts:
(A) literature review; and
(B) stakeholder interviews.

A draft of this report was provided to the NOHSC in December 1999. Following circulation to the Project Reference Group, comment was received in January 2000, and the report finalised in March 2000.

## 3.A Literature review

With the assistance of the Information Services Branch at the University of Ballarat, the following databases were searched in order to conduct the literature review:

- Applied Science Abstracts;
- Austrom: Arch;
- CISDOC;
- Dissertation Abstracts;
- Eng: Build;
- Eng: Engine;
- Eng: Scanfile;
- HSELINE;
- ISI Current Contents;
- NIOSHTIC; and
- WorldCat

The strings shown in Figure 1 were used for the searches:

- *Safe Design* and py>1984
- *Designers* not *ergonomics* and py>1984 (where too many items in response to this string: *Occupation** or *health* or *safe* and *designers* not *ergonomics*, 1985-);
- Contractor* and py>1984 (where too many items: *Occupation** or *health* or *safe* and contractor*, 1985-);
- *Contrac tor** and py>1984 (where too many items: *Occupation** or *health* or *safe* and *contractor**, 1985- (variation: safe and contractor*));
- *Installer** and py>1984 (where too many items: *Occupation** or *health* or *safe* and *installer**, 1985- (variation: *safe* and *installer**));
- *Supplier* and py>1984 (where too many items: *Occupation** or *health* or *safe* and *supplier*, 1985- (variation: *safe* and *supplier*));
- *Importer* and py>1984 (where too many items: *Occupation** or *health* or *safe* and *importer*, 1985- (variation: *safe* and *importer*));
- *Safe* and *manufacturer** and py>1984 (where too many items: *Occupation** or *health* or *safe* and *manufacturer**, 1985-);
- *Safe* and *manufacturing* and py>1984 (where too many items: *Occupation** or *health* or *safe* and *manufacturing*, 1985-);
- *Survey* or *questi on** and *designer* and py>1984 (where too many items: *Occupation** or *health* or *safe* and *survey* and *designer*, 1985-; *Occupation** or *health* or *safe* and *question** and *designer*, 1985-; (variations: *safe** and *question** and *designer*; *safe** and *survey* and *designer*));
- *Survey* or *question** and *manufacturer* and py>1984 (where too many items: *Occupation** or *health* or *safe* and *survey* and *manufacturer*, 1985-; *Occupation** or *health* or *safe* and *question** and *manufacturer*, 1985- (variations: *safe** and *question** and *manufacturer*; *safe** and *survey* and *manufacturer*)); and
- *Survey* or *question** and *manufacturing* and py>1984 (where too many items: *Occupation** or *health* or *safe* and *survey* and *manufacturing*, 1985-; *Occupation** or *health* or *safe* and *question** and *manufacturing*, 1985-; (variations: *safe** and *question** and *manufacturing*; *safe** and *survey* and *manufacturing*)).

**Figure 1 Search strings**

## 3.B Stakeholder interviews

Telephone interviews, as listed in Table 1, were conducted on advice from NOHSC and as referred by others as the process proceeded. As can be seen representatives from all States and Territories were included[1] and representatives of employee and employer bodies were included.

Each interview included the information, and followed the approach, outlined in Table 2. In summary, each interview consisted of:

- introduction;
- explanation of the project and the University's role; and
- a set of questions that sought information about:
  - approaches that have been taken throughout Australia in order to help designers, understand and achieve safe design;
  - associations that would be useful bodies in order to influence designers and
  - perceptions of the designer's knowledge of OHS and their approach to safe design (these questions are broad and were only designed to potentially identify issues rather than provide any definitive information).

[1] An interview with Peter Shaw could not be arranged however written comments were received.

**Table 1 Interviews with NOHSC stakeholders**

| Name | Authority | Referred by: | Date |
|---|---|---|---|
| George Barnulf | Work Health Group (NT) | NOHSC | 29/10/99 |
| Michael Costello | WorkCover NSW | NOHSC | 5/11/99 |
| Sandra Cowell | Australian Chamber of Commerce and Industry/Australian Industry Group | NOHSC | 10/11/99 |
| Wayne Creaser | ACT Workcover | NOHSC | 8/11/99 |
| Richard Franklin | Australian Centre for Agricultural Health and Safety | NOHSC | 8/11/99 |
| Ian Furness | SA WorkCover Corporation | NOHSC | 15/11/99 |
| Dennis Gazlay | ACT WorkCover/Australian Manufacturing Workers' Union | NOHSC | 5/11/99 |
| Katrina Hansen | Victorian WorkCover Authority | NOHSC | 4/11/99[2] |
| Tom Heron | Division of Workplace Health and Safety (Qld) | NOHSC | 1/11/99 |
| Graeme Hunt | Building Standards and Regulations, Workplace Standards Tasmania | NOHSC | [2] |
| Michael Little | Victorian WorkCover Authority | Rene Vodstrcil | 17/11/99[2] |
| Sharon Lee | Victorian WorkCover Authority | Rene Vodstrcil | 15/11/99 |
| Daren McDonald | WorkCover NSW | NOHSC | 1/11/99 |
| David Ness-Chang | Building Services, Department of Administrative and Information Services (SA) | Ian Furness | 2/11/99 |
| Robert Pearce | Workplace Standards Tasmania | NOHSC | 1/11/99 |
| Sue Pennicuik | Australian Council of Trade Unions | NOHSC | None[3] |
| Roger Perfrement | Work Health Group (NT) | George Barnulf | 3/11/99 |
| Pat Preston | Construction, Forestry, Mining and Energy Union | Sue Pennicuik | None [4] |
| Bala Rajadurai | Engineering Unit, Victorian WorkCover Authority | NOHSC | [2] |
| Tony Rowell | Building Standards and Regulations, Workplace Standards Tasmania[5] | NOHSC | 27/1/2000 |
| David Shaw | Australian Chamber of Commerce and Industry | NOHSC | 8/11/99 |
| Peter Shaw | WorkSafe WA | NOHSC | None [4 2] |
| Rene Vodstrcil | Victorian WorkCover Authority | NOHSC | None [6] |
| Steve Ward | Road Traffic Authority NSW | NOHSC | 1/11/99 |
| Peter Wong | Workplace Services, Department of Administrative and Information Services (SA) | Ian Furness | 3/11/99 |
| Brett Young | Work Health Group (NT) | George Barnulf | 29/10/99 |

[2] Comment on draft received.

[3] Referred to P. Preston

[4] Contacted but interview not arranged at time of writing.

[5] Follow-up interview (in place of Graeme Hunt, who commented on draft but was unavailable for interview).

[6] Referred to M. Little and S. Lee

## Table 2 Interview outline

| | |
|---|---|
| **Project** | The Safe Design Project funded by NOHSC. |
| **Project aims** | The project aims to develop a greater recognition of the role of safe design in improving OHS performance in the workplace.<br><br>The groups who are seen as important in safe design are:<br>• designers, manufacturers, importers and suppliers of plant and equipment;<br>• designers, constructors and installers of buildings and structures; and<br>• designers, manufacturers, importers and suppliers of materials and substances. |
| **Interview purpose** | The university is performing part of the research: a literature review and a set of telephone interviews with OHS authorities and other stakeholders.<br><br>The purpose of the interviews is to:<br>1. gain an understanding of the approaches that have been taken throughout Australia in order to help designers understand and achieve safe design;<br>2. develop a list of associations that would be useful bodies in order to influence designers;<br>3. gauge your perceptions of the designers' knowledge of OHS and their approach to safe design. |
| **Questions** | Q1. What initiatives has your authority taken to influence the following groups?<br><br>• Designers, manufacturers, importers and suppliers of plant and equipment.<br>• Designers, constructors and installers of buildings and structures.<br>• Designers, manufacturers, importers and suppliers of materials and substances.<br><br>Q2. What bodies, associations do you think would influence the following groups?<br><br>• Designers, manufacturers, importers and suppliers of plant and equipment.<br>• Designers, constructors and installers of buildings and structures.<br>• Designers, manufacturers, importers and suppliers of materials and substances.<br><br>Q3. Knowledge of OHS obligations: from your experience, and speaking generally, how would you describe the level of knowledge of OHS obligations among the target groups.<br><br>1 Non-existent<br>2 Poor<br>3 Reasonable<br>4 Comprehensive<br><br>Q4. Approach to safe design: from your experience, and speaking generally, how would you describe the approach that the target groups would take toward safe design.<br><br>1 Do not consider that safety is an issue<br>2 Safe design is not needed as the user simply must use/operate the item correctly<br>3 Safe design should consist of add-on/optional extras<br>4 Safe design is a core aspect of design |

# 4. Results

## 4.A Literature review

The literature search yielded over 6000 abstracts. These were examined briefly to identify potentially relevant items. This process resulted in a total of 255 items, including 12 books that were identified as potentially relevant. These 255 items were requisitioned but, at the time of writing, 9 books and 32 other items are outstanding. Of those obtained, 134 were considered worthy of review because they were reasonably substantial in nature and of relevance to safe design. This set of documents was too large to review given the scope of this project. Therefore, each of the 134 items was perused and 56 items that were considered representative and of most value were selected for detailed review. Table 3 shows the items included in the review (and also notes the number of items retrieved but not reviewed). All items reviewed are summarised in Appendix A to this report (annotated bibliography).

## Table 3 Items reviewed

| | Plant & equipment | Buildings & Structures | Materials & substances |
|---|---|---|---|
| **Awareness** | • Major, M. n.d.<br>• National Institute of Design 1992<br>• Swackhamer, R. 1995<br>• (1 other not included) | • Anonymous 1991<br>• Anonymous 1993<br>• The Consultancy Company 1997<br>• Lunch, M. 1994<br>• Risser, B. 1995<br>• Timura, M. n.d.<br>• (23 others not included) | • 'Government has only words for gas safety – Corgi', 1985<br>• Oakes, L. c.1986<br>• Parkinson, G. 1996<br>• (15 others not included) |
| **Practices** | • Bender, J. & Hadley, J. 1994<br>• Eisma, T. 1990<br>• Evans, S. & Chaffin, D. 1986<br>• Gornick, T. 1997<br>• Hitchcox, A. 1996<br>• Morris, R. 1994<br>• Wierenga, E. 1997<br>• Whitaker, J. 1989<br>• Wortham, S. 1997 | • The Consultancy Company 1997<br>• Fagan, J., Monte, T., Powell, D., and Cronici, J. 1998<br>• Gambatese, J., Hinze, J. & Haas, C. 1997<br>• Guteri, F. 1992<br>• Madison, R. 1996<br>• Mongeau, E. 1999<br>• Morris, R. 1994<br>• Wilkinson, S. 1999<br>• (12 others not included) | • Ainsworth, S. 1993<br>• Anonymous 1991<br>• Anonymous 1993/4[7]<br>• Barker, R. 1991<br>• Brack, K. 1999<br>• Flores, A. 1983<br>• National Institute of Design 1992<br>• (6 others not included) |
| **Influences** | • European Hygienic Equipment Design Group (EHEDG) 1992<br>• Griffin, H. 1999<br>• Haag, W. 1988<br>• Kletz, T. 1999<br>• Lorenzi, N. 1998<br>• Troup, J., Tomes, W. & Golinveaux, J. 1996<br>• Wortham, S. 1997<br>• (2 others not included) | • Anonymous 1998<br>• Appleton, R. 1994[7]<br>• Bowes, J. 1994<br>• Bressington, P., Fire, A., Arup, O. & Partners 1996<br>• Buchanan, A. & Cosgrove, B. 1996<br>• Carter. T. 1994[7]<br>• Gulvanessian, H. & Holický, M. 1996<br>• Lorenzi, N. 1998<br>• Meacham, B. 1996<br>• Meeks, C. & Brannigan, V. 1996<br>• Quaglia, C. 1994[7]<br>• Roodman, D. & Lenssen, N. 1995<br>• Sinnott, R. 1985<br>• Swane, R. 1994[7]<br>• (9 others not included) | • Anonymous 1999<br>• Brack, K. 1999<br>• Halligan, J. & Hall, R. 1995<br>• Lorenzi, N. 1998<br>• Peaff, G. 1996<br>• Russell, R., Maidment, S., Brooke, I. and Topping, M. 1998<br>• (10 others not included) |

[7] Australian literature (note: a further five items of Australian origin were among those items retrieved but not included for detailed review)

## 4.A.i Plant and equipment: awareness, practices and influences

At a broad level, engineers are committed to safety ahead of competing interests (not only with regard to plant and equipment, but in general). For instance, the first of nine commitments in the Institution of Engineers Australia (IEAust) *Code of Ethics* (1994) states that "members shall at all times place their responsibility for the welfare, health and safety of the community before their responsibility to sectional or private interests, or to other members".

However, a general acknowledgment of the priority of community well-being over other interests does not indicate an awareness of the importance of the ongoing effects of their design decisions. Evans and Chaffin (1986) surveyed 40 engineers/designers and found that ergonomic principles were more likely to be considered by engineers at the plant level of a manufacturing or assembly company, than by divisional (higher in the organisation) engineers. Plant level engineers were found to be more likely to appreciate their influence and were more likely to consider the needs of operators in designing workstations (Evans & Chaffin 1986).

There are individual examples of organisations that emphasise the important role of engineers in safe design. A clear statement about the role of engineering in safety was made by Eurotunnel, the English Channel tunnel contractors, which had as their first safety strategy: “Drive to design, engineer, manufacture safe equipment and safety systems, planning out hazards” (Morris 1994).

Likewise, Owens-Corning, a building products manufacturer, uses a ‘safety through design’, which gives a clear indication of the role they expect engineers to play in the minimisation of workplace hazards via: equipment purchases, workstation layout and ergonomics, production and maintenance procedures (Wortham 1997).

There are other isolated reports of manufacturers who adopt safe design principles:
- manufacturers of gas and air connectors have developed non-twist connections, to prevent maintenance personnel developing carpal tunnel syndrome (Gornick 1997);
- personal protective equipment manufacturers recognise that comfort, and even style, will encourage workers to wear safety protective devices and hence design equipment with these issues in mind (Eisma 1990); and
- valve manufacturers have diversified their fail safe designs, in response to the promulgation of OHSA lock out/tag out regulations (Hitchcox 1996).

Kletz (1999) promotes ‘inherently safe design’ and innovative design practices. He advocates overcoming the barriers of:
- companies no longer specifying an individual or group as responsible for innovation;
- engineers not seeing themselves as innovators, due to lack of a research background;
- large inventories of equipment held in factories, dampening the desire for change;
- ignorant senior managers;
- lack of assessment tools to assess inherent safety;
- lack of information from manufacturers on the characteristics of the equipment and plant they supply to other manufacturers; and
- lack of ‘inherently safe design’ components in engineering courses.

Other influences on designers and manufacturers include:
- *education* (e.g. the NOHSC's *Occupational Health and Safety for Engineers* (Worksafe 1990); and the USA Accreditation Board for Engineering and Technology proposal for

'safety' as a topic in the Engineering Criteria 2000, to be implemented in 1998 (Wortham 1997));

- *purchasing power* of consumers (Haag 1988);
- *industry bodies*, such as the European Hygienic Equipment Design Group ('European Equipment Design Group (EHEDG)' 1992) and the Group A Plastics Committee (Troup, Tomes & Golinveaux 1996); and
- *court decisions* (e.g. American courts have ruled that adequate warnings of a product's dangers are not a substitute for a reasonable safe design that would eliminate the product's hazards (Griffin 1999).

In summary, the literature contains examples of safe design in manufacturing and yields information on some influences on designers and manufacturers. The potential avenues for influencing manufacturers are likely to be influenced by their industry bodies, purchasers and court decisions whereas the ways of influencing designers would include similar means with the addition of education. With regard to education, the points of Kletz (1999) should be well-regarded in this field and he makes comments about teaching innovation in the principles of inherent safety in engineering courses.

## 4.A.ii Buildings and structures: awareness, practices and influences

In the European Union, 35% of construction site fatalities were found to be solely due to the designer. As a response, the EU has introduced the Temporary and Mobile Sites Directive. As a result of an 'alarming number of accidents' due to poor designs by civil engineers, the UK has introduced the *Construction (Design and Management) Regulations 1994* (CDM Regulations) (Anon. 1993).

About two years after the CDM Regulations were introduced a review was undertaken to determine the effect on various stakeholders (The Consultancy Company 1997). Interviews were conducted with:

- clients (4 in pilot study and 29 in main study);
- designers (3 in pilot study and 56 in main study; 21 architects and 38 engineers); and
- contractors (13 in pilot study and 96 in main study).

With regard to clients, the results indicated that pre-tender health and safety plans that must be prepared by the clients caused excessive paperwork on their part, however the clients viewed the plans as beneficial. Many designers saw the benefits as including 'better planning and co-ordination' and 'increased awareness' but most designers agreed that it was too early to judge whether accidents had reduced. The review found that two thirds of contractors had modified their existing systems in response to the regulations and they generally agreed that the regulation had caused 'increased awareness' of health and safety issues. While tangible benefits at this early stage were not usually quantifiable, most saw future benefits in terms of: 'fewer accidents during maintenance'; 'reduced claims'; and 'a safer environment for users' (The Consultancy Company 1997).

The review suggested that architects lack experience in construction and maintenance, and so have a poor appreciation of the hazards of their designs. To record hazards and risks during the design process, some firms use 'Job books'. However, hazards, if assessed, are often determined once the full design is done when pressure of time often prevents alterations. In addition, some firms have been given legal advice not to note risks and hazards at design stage (The Consultancy Company 1997).

Engineers, although mainly concerned with structural integrity, tend to be more aware than architects of construction and maintenance processes and so can better foresee safety problems (The Consultancy Company 1997).

In the United States, the duties of architects and engineers regarding safety in construction have been emphasised in court decisions and designers have been fined for failures in the duties when in charge of construction sites. While construction supervision does not address the central issues of 'design', the imposition of substantial fines (e.g. up to $215,000 for failure to prevent a trench cave in) highlight responsibilities about occupational safety among engineers and architects (Lunch 1994). Somewhat paradoxically, a 1990 survey of American designers found that they were often given legal advice not to address construction safety, to avoid legal liability (Gambatese, et al. 1997).

A computer-based 'best practice' tool has been developed to help designers. From early 1994 to 1996, 400 design suggestions had been documented using Asymetric's *Multimedia Toolbook* (Gambatese, Hinze & Haas 1997).

In terms of their approach toward safe design, the Associated General Contractors of America want *employees* made liable for violating safety standards. They believe that contractors should not be legally responsible for the unsafe acts of employees (Timura n.d.). Contractors in Maryland are lobbying for the introduction of fines of up to $100 for employee breaches of health and safety laws, as has been done in Canada (anon. 1991a). The effect of the Canadian approach does not seem to feature in the literature. In addition, it is not clear whether the views of manufacturers indicate that they believe they have a very minor role to play in safe design or whether they simply reflect a desire to deflect blame.

In the USA, the magazine, *Concrete Construction*, interviewed an unspecified number of concrete contractors. The contractors relied heavily on their trade organisations to keep them aware of regulations. Of all regulations, those that dealt with matters of safety affected their business to the greatest degree. Like the contractors studied in the review of the UK CDM Regulations (The Consultancy Company 1997), US contractors felt that paperwork associated with safety regulations was too great. Somewhat like the process aimed at by the UK laws, in the US formal partnering agreements between owners, general contractors, subcontractors, architects, engineers and testing firms are popular (Risser 1995).

In terms of public/user safety, it is evident that some projects have featured extensive thought about safe design features. For instance, the safety systems of the 31-mile English Channel tunnel are based on an analysis of all major rail, metro and tunnel disasters. Eurotunnel, the build and operate contractor, has been criticised for being too conservative in simulating unrealistic disasters (Guteri 1992) and subsequently the project costs escalated because of the expense of designing safe systems to account for very low probability events (Morris 1994).

Consideration of safety in design can also be found at lower levels, for example, the use of a *consultative design review team* on a university residence project that included the university's plant, maintenance, fire safety, and public safety sections with the architects and the general contractor.

The move from prescriptive-based building standards to performance-based standards is causing some controversy world wide, especially with regard to fire safety (Appleton 1994, Buchanan & Cosgrove 1996, Meacham 1996). The fire engineering approach, based on performance criteria, is cheaper than using prescriptive legislation when the building is large, and/or complex, or old (Bressington, Fire, Arup & Partners 1996). The US Society of Fire Protection Engineers is concerned that the US will adopt performance–based building fire codes, before the necessary documented engineering practices and tools and methodologies are well-known by engineers (Meacham 1996). Similarly, the stakeholder interviews (elsewhere in this report) found belief that engineers and architects were unprepared for process or performance– based law because of their extensive experience in the use of prescriptive rules.

The influences on designers can be summarised as follows:

- textbooks on safety and security (Sinnott 1985);
- regulations, including national regulations on fire safety (Appelton, 1994), European Union international building regulations (Gulvanessian & Holický 1996), environmental standards on energy use and recycling of materials (Roodman & Lenssen 1995);
- Industry body awards (Anon. 1998);
- training programs by industry bodies (Lorenzi 1998);
- the growth of design and construct work (Swane 1994);
- more off-site prefabrication (Swane 1994);
- changing technologies (Swane 1994);

- materials research (Swane 1994); and
- undergraduate education (Cowley & Murray 1992).

In summary, there is more published material in the area of safe design in the buildings and structures area than in plant and equipment. There are examples of projects that emphasise user/occupant/public safety at the design stage and the *Construction (Design and Management) Regulations 1994 (UK)* are an example where the importance of planning and safe design have been extended to include employee safety during construction, maintenance or demolition. Otherwise there are few examples. In response to the regulations, designers in the UK seem to have adopted the requirements without perhaps at the moment being convinced of the benefits to safety. Depending on how this is viewed it could emphasise the need for education of designers. In addition to education, which is mentioned often as an important avenue to be used to improve safe design, the incorporation of non-prescriptive models into building law could be a useful influence in that these models would then better match those employed in occupational safety.

## 4.A.iii Materials and substances: awareness, practices and influences

Flores (1983) describes a survey of 200 engineers in a large chemical company. One third agreed that their employer's corporate safety practices enabled them to meet their ethical responsibilities for safety. An additional one third said corporate practices made it easy for them to meet these responsibilities. Only four per cent believed corporate practices had a negative influence on safety, whereas 78 per cent felt they had sufficient organisational protection to go over the head of their supervisor on safety issues.

Flores (1983) suggested that engineers need organisational support to fulfil their ethical obligations. He calls on professional societies to support engineers in conflict with their employers and use their resources to get employers to improve the levels of safety in the products and technologies they market.

In the State of California, chemical manufacturers must provide a ‘clear and reasonable warning’ about their products to employees and the public. Anyone can file a suit against companies, and retain up to 25 per cent of the fine. Four hundred and fifty complaints have been lodged and all except three were settled out of court. The chemical manufacturers have taken the State of California to the federal court, alleging that ‘clear and reasonable’ warning is vague and that the State law contradicts federal worker safety and hazardous substances law and hinders interstate commerce (the outcome of this action is not clear) (Parkinson 1996).

Similarly, UK manufacturers must provide information about the hazards of substances, however users often do not have the knowledge to check the adequacy of the information. The information may, for example, be too technical, play down the real risks, or omit chronic effects (Oakes 1986).

Manufacturer warnings, such as those described by Parkinson (1996) and Oakes (1986), are not core aspects of safe design, i.e. in its ideal form safe design is about making the product inherently safe and the warnings would therefore be redundant. Nevertheless one could speculate that requirements to disclose all information about the hazard brings the problems under greater scrutiny and may create a motivation to eliminate those hazards.

In the United States, the major influences on chemical manufacturers are thought to include:

- public opinion (Peaff 1996);
- communities close to their factories(Peaff 1996);
- environmentalists (Peaff 1996);
- politicians (Peaff 1996); and
- large consumers (Brack 1999).

For example, Paulsen and Roles is a manufacturer of commercial cleaning products that has worked closely with large companies such as Intel, Nike and Boeing to introduce less toxic cleaning agents. To enhance safety at the user stage, the manufacturer installed dispensing stations in 'custodial closets' in workplaces (Brack 1999). Clearly large consumers like Intel have knowledge of hazards and have the purchasing power to demand alternatives. Small consumers may not have this knowledge or power, however the benefits of new products developed for large companies may well flow on to these smaller consumers. Furthermore it is recognised that small businesses (in the UK) do not have the expertise to comply with the risk assessments needed for the control of employees exposures to chemicals (e.g. under the UK *Control of Substances Hazardous to Health Regulations 1994*) (Russell, Maidment, Brooke & Topping 1998). Therefore, the influence of large consumers who cause improvements in products and encourage manufacturers to generally have a greater involvement in the product at the user stage could have useful benefits for small business.

Public opinion is of such great influence that the Chemical Manufacturers Association has recently established a $100M research program about the general effects of chemicals on people and the environment (Anon. 1999). The association also adopted a *Responsible Care* program in 1988 that consists of six codes of practice (Ainworth 1993). The code relating to distribution aims to protect the general public, carriers, distributors, contractors, employees and the environment. The code is an example of a product stewardship approach where risks at all stages of handling chemicals must be evaluated. Similarly, individual manufacturers such as Owens-Corning, a manufacturer of glass fibre products, manages risk via *product stewardship*, through all stages of: research and development, raw materials selection, manufacturing, packaging, transport & distribution, fabrication & installation, use, reuse & recycling, and waste management (Bender & Hadley 1994).

In summary, from the available literature it seems that 'design' of materials and substances is less well individualised when compared to, for example, buildings and structures. Most of the literature that covers safe design in materials and substances relates to manufacturers and the approaches that they have taken. This was also evident in the stakeholder interviews (else where in this report) where many people commented when asked to gauge target groups knowledge of OHS responsibilities and the approach they took toward safety design, that designers and manufacturers of materials and substances were often one and the same people. That is, designers are perceived to be embedded in the large chemical firms. In terms of influence, from the literature it is evident that requirements to disclose hazard information and pressure that can be applied by large customers may be the most useful avenue of influence.

## 4.B Stakeholder interviews

The results of the telephone interviews are organised in the following fashion:

- first, the recent approaches taken by the stakeholders (mainly the workers' compensation and regulatory authorities) to influencing 'upstream' groups about safe design are listed and briefly described;
- second, the methods of influencing the upstream target groups (designers) that the interviewees suggested are listed; and
- third, the outcomes of the relatively informal survey designed to gauge the stakeholders impression of the target groups in terms of the target groups' knowledge of OHS responsibilities and their approach to safe design are described and discussed.

## 4.B.i Approaches to influencing 'upstream' groups about safe design

### *4.B.i(a) Ad-hoc approaches (all jurisdictions)*

At a minimum all jurisdictions employ an issue-by-issue, reactive approach to influence safe designs. Through the conduct of accident investigations, issues about plant, buildings, materials are often brought to light. Sometimes design issues are highlighted and these can be fed back to the particular manufacturer concerned. Where the issue concerns a class of equipment, rather than an individual model, then most jurisdictions seem to take an approach where they would develop a 'hazard alert' or similar and provide this information to suppliers and manufacturers of that type of plant.

There is a degree of sharing of these hazard alerts (R. Pearce; G. Barnulf) and the Northern Territory Work Health Group regularly check interstate web sites for hazard alerts and make use of email lists to keep abreast of issues arising throughout Australia (G. Barnulf).

Clearly some of the hazard alerts are relevant to upstream groups but the target is usually employers. The issue-by-issue approach does not seem to improve the general approach of the manufacturers (W. Creaser). Manufacturers, suppliers are usually responsive to the requests of the authority, but seem to take the view that the authority is doing the hazard identification and assessment for them. Consequently, manufacturers tend not to learn anything about the processes that they should undertake in order to integrate safety into other products (W. Creaser).

### *4.B.i(b) General projects about/involving safe design*

The following is a brief description of the recent or current projects that aim to influence safe design, or include aspects of safe design in a general sense.

- **SAfer at the Source (SA)**

The SA inspectorate, Workplace Services (P. Wong; I Furness) are currently working on the *Safer at the Source (Plant) Project*. The project aims to form networks including manufacturers, suppliers and inspectors. The focus is on practical application of the *Occupational Health, Safety and Welfare Regulations 1995* including improving the understanding of legal obligations and basic hazard management processes. Inspectors deliver the information on a one-one basis through visits to suppliers.

Industry reference groups have been established to liaise with suppliers and a Reference Group has been established comprising representatives from Workplace Services, WorkCover Corporation and industry. The Group's role is to act as a consultative mechanism with industry and to assist dissemination of information to/from industry.

Issues identified to date include importers of plant (given the large volume of plant manufactured abroad), second-hand equipment dealers, and the agriculture industry in general.

### ❖ Safety award schemes (various)

Various OHS authorities conduct awards for good practice in health and safety, for example:

- Victorian WorkCover Authority *WorkCover Awards 2000* www.workcover.vic.gov.au/vwa/projects.nsf/html/WorkCover+Awards
- WorkCover SA *Safety Awards* (I. Furness) www.workcover.sa.gov.au/
- ACT WorkCover safety awards (D. Gazlay)
- WorkSafe Western Australia *WorkSafe Award* (P. Shaw)

The WorkSafe Western Australia awards (conducted since 1990) have attracted many solutions that have offered the potential to impact on safety of users, customers, (P. Shaw). However, often the prevention awards have attracted applications based on solutions developed at the workplace for the improvement of employees at that workplace rather than solutions that impact on those 'downstream' users (D. Gazlay ACT; I. Furness, SA).

Over past years there have been some notable examples of good design features in the ACT applications (e.g. 1999 winner being a device to prevent needle injuries and blood contact). However some applications tend to demonstrate only basic requirements with the legislation in terms of workplace systems, or are ideas that address problems that have been created by poor design (D. Gazlay).

South Australia have had a category for *Safe Design* in 1998 and 1999 however while some applications in 1999 were classed as 'commendable' no winner was adjudged because the applications did not meet all of the following criteria:

- Is it a SA design developed in the last 12 months?
- Does it address a key hazard?
- Is it transferable across the same industry and/or across a number of industries/large number of workplaces?
- Will it have a significant impact on claims and costs?
- Is it produced by or relevant to small business?
- Was it developed through a consultative process?
- Are they willing to share this with their industry?

The mining industry operates a number of similar awards. These include the following:

- Minerals Council of Australia "National Safety and Health Innovation Awards". The national mining innovation awards were first conducted in 1999. The awards are selected from winners of state/territory awards and specifically recognise and promote safety and health innovation including design of plant. The web site is at www.minerals.org.au. The relevant web sites for some of the State/Territory branches of the Council are:
  www.nswmin.com.au
  www.qmc.com.au
  www.tasminerals.com.au

- The Minerals Council of Australia also conducts the 'National Minerals Industry Excellence Awards for Safety and Health' (MINEX). The MINEX awards have been conducted since 1994. The award criteria include (among a broad range of workplace safety issues) consideration of safe design in the implementation of new plant, equipment and materials.
  www.minerals.org.au/pages/page2_170.asp

### *4.B.i(c) Industry/problem based projects about/involving safe design*

By far the largest body of information concerned projects that were focussed on either a specific industry or a specific problem. Some of these projects addressed safe design as a key element whereas others included safe design as an aspect of the project. The projects mentioned that are of relevance here are as follows.

#### ❖ ***Guidelines for Construction and Maintenance Safety in Design for Major Projects* (NSW)**

*Guidelines for Construction and Maintenance Safety in Design for Major Projects* (WorkCover 1999) have been developed (D. McDonald). The guidelines are an outcome of a Memorandum of Understanding (MOU) which aims to implement strategies to improve the safety performance of the industry by fostering a working partnership between the NSW Government, 17 of Australia's largest construction contractors and the industry's trade unions and employer associations. Safe design is one of the objectives of the MOU. The guidelines provide a methodology for the inclusion of safety considerations at project conception and planning stages for design and construction projects. They aim to make what is currently an ad-hoc and incomplete approach to safe design more systematic. To some degree the guidelines are based on the 1992 European Directive (mentioned elsewhere). The guidelines are being evaluated by the 'Safety in Design Working Party' which includes contractors, unions, employer organisation, architects and engineers, and are to be piloted early in 2000.

#### ❖ **Ergonomics of sheep handling equipment - plant (NSW)**

WorkCover NSW recently funded VIOSH Australia (University of Ballarat) to undertake a research project about the safe design of sheep handling equipment that is used for sheep shearing and crutching (M. Costello). A set of resources regarding the *Ergonomics of sheep handling equipment for shearing and crutching* was developed including a *Design Guide* (available via www.workcover.nsw.gov.au). The design guide was intended primarily for designers and manufacturers and secondarily for users (to aid purchasing and usage decisions) and was posted directly to manufacturers.

### ❖ Backwatch program (NSW)

The NSW WorkCover 'Backwatch' program highlighted design issues, some of which were fed back to manufacturers (M. Costello). For example, surveys of nurses identified a design improvement in the brakes on hospital beds and manufacturers were notified of this design improvement.

### ❖ Plant safety specifications - plant (RTA - NSW)

The Road Traffic Authority (NSW) specifies plant safety requirements - for example extra safety equipment such as amber beacons, handrails, access features such as stairs (S. Ward). The most common type of injury among RTA employees is sprain, strain, slips, trips and therefore access issues are of great importance. The plant requirements apply whether the plant is to be hired or purchased. In this way the specifications help improve plant design for other users of the hire equipment.

### ❖ Life-cycle safety planning - structures & plant (RTA - NSW)

The Road Traffic Authority (NSW) is trialing an 'OHS Plan' that will be current for the life of the structure (e.g. bridges) (S. Ward). At planning stage the objectives and background of the project are described and the OHS hazards are identified. At the design stage there must be plans put in place to address those hazards. This follows on to the maintenance stage, where those responsible for maintenance can find out about how the hazards were controlled by design and find out about the processes needed to undertake work with these features.

The 'OHS Plan' concept follows broadly the idea of the approach to addressing environmental effects at the conception of a project (i.e. Environmental Impact). Recent investigation of OHS issues highlighted opportunities for using design to address problems at the construction and maintenance phase, for example:

- designing the landscape and vegetation around bridges to allow access for inspection and maintenance without tripping;
- specifying vegetation that discourages snakes and spiders;
- specifying lower maintenance bridge materials that avoid the need for maintenance;
- anticipating the need for maintenance to bridges such as providing lighting and ventilation in hollow beams to allow safe access for changing bridge bearings; and
- allowing space when designing roads for maintenance vehicles, equipment.

In general, project clients (whether that be the RTA or otherwise) are required to be specific in relation to safety requirements. There is a trend at present to simply specify 'minimise injuries' or 'comply with all relevant law' or something similarly general. There is a need to identify the specific issues, e.g. in the case of bridges: minimise or provide for safe access to confined spaces; provide access where maintenance is needed; provide attachment points if fall-arrest equipment will be needed.

### ❖ Safer Industries (SA)

The WorkCover SA, *SAfer Industries program* (I. Furness) brings together people involved in various industries in order to formulate strategic plans and then put those plans into action with the aim of improving workplace safety (www.workcover.com/safer/index.html).

There are strategic plans developed for the following industries: meat; road freight transport; hospitality; aged care; building construction; plastics and rubber; and cleaning and property services. The following strategies include aspects of safe design:

- **Horticulture Industry.** Design of plant (e.g. tractor design; tractor attachments; guarding of power take-offs; elevated work platforms; picking bags; and ladders) has been targeted as an area for improvement in the horticulture industry. Various bag designs were trialed and design information fed back to manufactures. The investigation regarding falls from ladders is under way (I.Furness).

- **Transport Industry.** Design issues that influence manual handling, in particular the location of spare wheels, are being addressed in the transport industry. Solutions have been developed and fed back to manufacturers and made available on the Internet (I.Furness).
  www.workcover.com/safer/road/index.html

- **Meat Industry.** Aspects of the Meat Industry strategic plan could impact on safe design such as a project to investigate the design, selection and use of cut-resistant gloves (personal protective equipment might not be the main item that comes to mind under the definition of plant, however the definition is very broad in most statutes and usually includes "equipment"). The industry has also obtained a grant for an ergonomics review that has led to recommendations for the improvement of workstations.
  www.workcover.com/documents/meat.pdf

- **Hospitality Industry.** The Hospitality Industry strategic plan includes a goal (among others unrelated to safe design) to develop guidelines for safe design of facilities and equipment and to establish a register of safe designs (I. Furness).
  www.workcover.com/documents/HospStPlan.pdf

- **Aged Care Industry.** The Aged Care Industry strategic plan includes a goal of improving buildings, equipment and the working environment. The main goals consist of contributing to the development of the Victorian WorkCover Authority's design guideline (mentioned elsewhere) and facilitating the implementation of that guideline (I. Furness). A review of the latest patient manual handling equipment and workplace design features used in Europe has been undertaken and the results publicised (I. Furness).
  www.workcover.com/documents/agedcare.pdf

### ❖ Noise reduction in mining project (SA)

The Faculty of Engineering and the Environment, University of South Australia has been funded by the Mining and Quarrying Occupational Health and Safety Committee to assess noise exposures from existing plant in the South Australian mining and quarrying industry (I. Furness). The project includes liaison with manufacturers to obtain their latest solutions for equipment's noise control measures. Design modifications for noisy equipment will be recommended and applied, with the resultant control measures evaluated for effectiveness.
www.maqohsc.sa.gov.au

### ❖ Health and aged care project - plant (Vic)

The Victorian WorkCover Authority (K. Hansen) recently completed a project regarding safe equipment design in the health and aged care sector. In that sector, recent attention has been paid to minimising manual handling and this has led to the introduction of more patient handling

equipment. Facility operators needed information about the range of available equipment and needed guidance material on the selection of equipment. A working group consisting of direct care workers, employers/facility managers, and an equipment manufacturer, was established. The group produced a lst of sources of available equipment and a checklist to use when evaluating the suitability of equipment. The checklist covers physical features, as well as implementation issues, such as suggestions to trial the equipment before purchase and to consider the training needs associated with implementation. The resources were distributed to key groups, are available on the internet, and have been promoted through the VWA newsletter, "Workwords" and conferences. The focus has been on assisting and educating facility management - which will in turn influence the manufacturers. In addition, some manufacturers have been in contact and obtained the information.
www.workcover.vic.gov.au/vwa/projects.nsf/html/AgedCare

### ❖ Health and aged care project - buildings (Vic)

The Victorian WorkCover Authority (K. Hansen) is in the final stages of a project to develop guidelines on the design of health and aged care facilities to be used in design of facilities before they are built or refurbished. A working party consisting of direct care workers, employers/managers, Department of Human Services, an architect, and people with health planning roles in facilities was established. An ergonomist and architect were engaged to perform the project work under direction from the working party. The outcome was a "Design Guideline" providing guidance on how to minimise manual handling in the main areas where people handling occurs e.g. bedrooms, bathrooms, corridors, storage areas. Related matters, such as floor-covering, doorways, door-handles, were also considered. Guidelines about the importance of consultation with staff in the planning process were also included. The “Design Guidelines” provide guidance on functional space required to perform manual handling tasks safely rather than specifying a room size as such. The guide should provide benefits to occupational health and safety and also improve patient safety. Comment on the guide was received through two public workshops. The guide has been published and will be marketed through the key industry groups as well as the Royal Australian Institute of Architects and by direct contact with well-known facility planners. A submission has been made to the Australian Building Codes Board regarding their proposed new class of building: "Aged Care Facilities" with the potential of the inclusion of the “design guidelines” as a reference. All Australian OHS jurisdictions signed this submission.
www.workcover.vic.gov.au/vwa/projects.nsf/html/AgedCare

### ❖ Forklift facility design project (Vic)

A project by the Victorian WorkCover Authority about safe design of areas where forklifts operate is forthcoming (S. Lee). The project will cover the design of facilities having regard to the interaction of forklifts with facilities, storage racks (hence is also a plant design issue), people.

### ❖ Best practice in Injury Prevention in the Carpet Manufacturing Industry (Vic)

The Victorian WorkCover Authority and the Victorian Employers' Chamber of Commerce and Industry conducted a project in 1996 to identify risk control measures for common causes of injury within the carpet manufacturing industry. This included identification of some design solutions (S. Lee).

### ❖ Industry Best Practice Program: TruckSafe (Vic).

The Victorian WorkCover Authority (S. Lee) conducted a project to trial the approach of identifying and transferring best practices to all companies within the road transport industry to improve safety and reduce occupational injury costs. The book "Safety by Design", that highlights areas to consider in good design for safety and manual handling work in transport, was developed and distributed.

### ❖ Operation safety (Vic)

"Operation Safety" was a project of the Victorian WorkCover Authority (S. Lee). The project aimed to test the impact of the use of media and practical demonstrations on the incidence of manual handling injuries in transport and nursing. The project resulted in a set of features that could be incorporated into transport vehicles in order to minimise manual handling - these were incorporated into the "Safety by Design" book (Larsson & Rechnitzer c. 1997) prepared under the TruckSafe project (mentioned elsewhere).
www.workcover.vic.gov.au/vwa/projects.nsf/html/operation+safety

### ❖ Work-Related Fatalities Prevention Project (Vic)

The Work-Related Fatalities Prevention Project is funded by the Victorian WorkCover Authority and conducted in cooperation with VIOSH Australia (University of Ballarat) and the State Coroner's Office (S. Lee). The project aims to trial and evaluate targeting interventions aimed at fatality prevention. Three areas have emerged: tree felling; hydraulics; and falls (from trucks). Hydraulics (especially) and falls will involve plant issues and will be directed primarily toward control at source - hence a focus on manufacturers in order to achieve the incorporation of safe devices into equipment. This project aims to evaluate the success of the interventions.

### ❖ Occupational Health and Safety Group (construction) (Vic)

The Occupational Health and Safety Group, located in the Monash University Accident Research Centre is funded by the Victorian WorkCover Authority (S. Lee). The group is undertaking a number of projects including:

- role of regulation (project is about how the regulations are applied in practice – 'upstream' issues will be included but are not a particular focus - the report is expected early 2000); and
- targeted interventions (construction is the first industry - the project will involve site visits (current stage); identifying problems and solutions; and then conducting the intervention. The preliminary construction issues are falls, power tools, manual handling and electrical hazards. The interventions may well involve mainly job design but could also involve upstream plant issues).

### ❖ National Farm Machinery Safety Strategy

Farmsafe Australia developed the *National Farm Machinery Safety Strategy* in 1998 (R. Franklin). The strategy centres on safe design of a number of items of hazardous farm equipment (e.g. tractors, grain augers, post-hole diggers, power-take-off equipment) and has a clear purpose of influencing upstream parties, such as manufacturers.

❖ **Solution-sharing projects**

NOHSC's current *National OHS Solutions Database Project* will develop an Internet database of practical safety solutions.
www.nohsc.gov.au/work/search/solutions-search.htm

This project is an extension of other solutions projects such as the SHARE project that began in the late 1980s funded by the Victorian Department of Labour and continued by the Victorian WorkCover Authority.

By their nature, solutions of the SHARE type tend to be 'design' solutions although they often are retrofit solutions undertaken in the workplace that overcome initial design inadequacy. Nevertheless they represent a set of design ideas that could influence safety.

### *4.B.i(d) Educational approaches*

There are a small number of projects that have the potential to influence designers regarding safe design. These are as follows:

❖ **Integration of safety with Industrial Design course (SA)**

WorkCover SA (I. Furness) has a program for integrating OHS into tertiary courses. Although this does not include an initiative relating specifically to safe design there is scope to evaluate and provide input to Mechanical Engineering and Industrial Design courses on this subject.

The Industrial Design program at the University of South Australia has an ergonomics component. A partnership between the University and WorkCover Corporation would allow students conducting design projects to address practical case studies in industries targeted under the SAfer Industries Strategy. Product information provided by designers is an area which could also be given attention.

❖ **Plant Design - Making it Safe (NOHSC)**

The NOHSC developed this guide to risk management for designers, manufacturers, importers, suppliers and installers of plant in 1995. The guide includes steps for each party to take. The basic risk control process of: identification; assessment; and control is outlined and information is included to assist with each State. The guide includes prompts for the design to consider safety during installation, use (including potential unintended uses or misuse) and maintenance.
www.nohsc.gov.au

❖ **Plant Safety Trainer's Guide (SA)**

WorkCover SA (I. Furness) developed a *Plant Safety Trainer's Guide* (WorkCover 1998) that covers legal obligations, general plant safety information and follows a 'life cycle' way of thinking (i.e. the guide covers the responsibilities of designers, manufacturers, importers, suppliers, owners, installers and erectors). The guide has been very popular with sales in the thousands. Purchasers have mostly been trainers and others interested in plant safety.
www.workcover.com

### ❖ Trainee/apprentices, OHS practitioners and other professionals (NOHSC)

The NOHSC Education and Training Committee has been working on a number of programs that could influence safe design (D. Shaw). The materials complement the existing *National Guidelines for Integrating OHS Competencies into National Industry Competency Standards* (NOHSC 1998). Input of OHS matters should be made at all educational levels in order to educate people about occupational safety covering issues that will affect their own health and safety through to the role they might play in design in order to improve the safety of others. There are three main areas of interest:

- schools, trainees and apprentices (material has been prepared over the past 18 months in the area of trainee/apprenticeships. Competencies have been established and guidelines created for training developers);
- OHS practitioners; and
- other professions (e.g. engineering, architecture, commerce).

In general the emphasis is on safety 'at the workplace'. Although these materials have the potential to involve issues of safe design, 'safe design' does not seem to be an explicit feature.
www.nohsc.gov.au/work/education/guides99_toc.htm

### ❖ Occupational Health and Safety for Engineers (NOHSC)

In 1990 the NOHSC produced a resource for teaching engineering students about the engineering/design role in improving occupational health and safety (Worksafe 1990; Cowley & Murray 1992). The resource was endorsed by The Institution of Engineers Australia, The Association of Professional Engineers Australia and the Association of Consulting Engineers Australia. The resource followed a similar approach in the United States known as *SHAPE* (Safety and Health Awareness for Preventative Engineering; Talty 1986; 1995).

### ❖ Seminars about safe design (various)

Many jurisdictions have conducted seminars and produced general information about safe design of plant (e.g. Tas, R. Pearce; Qld, T. Heron; Vic, M. Little) or dangerous goods and hazardous substances (NT, B. Young).

For instance, as well as general information about plant hazard management, Workplace Services, Department for Administrative and Information Services provide the following information about the roles of the upstream groups:

- *Plant Regulations Guidance for Suppliers (Provision of Information)*
- *The Plant Regulations for Designers, Manufacturers, Importers & Suppliers of Plant*
- *Do you design, manufacture, import or supply plant in South Australia: Information Applying to You*
- *Plant Regulations Guidance for Suppliers (Auctioneers)*
- *Plant Regulations Guidance for Suppliers (Secondhand Dealers)*

www.eric.sa.gov.au/safety/plant/default.htm

Often these activities are conducted with some vigor around the introduction of new regulations. For instance, NSW WorkCover are planning a range of activities with designers (especially related to plant) with the forthcoming *Occupational Health and Safety Regulation 2000* (M. Costello). Similarly, the Victorian WorkCover Authority is planning awareness-raising activities in association with the implementation of the *Occupational Health and Safety (Hazardous Substances) Regulations 1999* (M. Little). The authorities use their own journals, such as

*Workplace Issues* in Tasmania, to advise of seminars and the availability of material (R. Pearce).

The Division of Workplace Health and Safety (Qld) (T. Heron) makes contact with industry on a regular basis. Tom Heron has ongoing regular meetings with the CEOs of consulting firms and major industries that undertake design work (especially plant).

### *4.B.i(e) Ideas for regulatory approaches*

A number of ideas were put forward that relate to possibilities for intervention in the regulatory scheme in order to influence safe design. These two ideas concern: the European Union directive relating to the inclusion of health and safety considerations in construction planning; and potential enhancements to the Building Code of Australia. These are described as follows.

- **"EU model of Construction, Design and Management"**

NSW WorkCover (D. McDonald) is exploring adoption of the European Union 1992 directive relating to planning for health and safety in construction [probably *Council Directive 92/57/EEC of 24 June 1992 on the implementation of minimum safety and health requirements at temporary or mobile construction sites*]. They say that the UK first adopted the directive (*Construction (Design and Management) Regulations 1994*) and more recently France and Germany have followed.

- **Building Code of Australia**

Building Services, Department of Administrative and Information Services, SA (D. Ness-Chang) and the Work Health Group, NT (R. Perfrement) commented about building law (or quasi-law) such as the Building Code of Australia (BCA) or the (now repealed) *Construction Safety Act 1978* (NT) and its role in influencing/impeding safe design with regard to workplace safety. This body of law, such as the BCA, does not employ some of the approaches that are used in workplace safety statutes. To explore this further a brief discussion of the BCA follows.

The BCA is produced by the Australian Building Codes Board (ABCB) on behalf of the Commonwealth and the state and territory governments (ABCB 1996, p. 1001). The BCA has no independent legal status, other than being evidence of good practice (Gunningham, et al. 2000, p. 27). The BCA is given legal effect by legislation in each State and Territory (ABCB 1996, p. 1003), for example the *Building Regulations 1994* (Vic) (reg. 1.7). The BCA could be thought of as much like the national standards and codes developed by NOHSC (Gunningham, et al. 2000, p. 27).

The BCA provides a uniform base set of building standards throughout Australia. However, the BCA contains appendices that allow for individual state variations and additions. Some of these relate to occupational safety. For instance, the Tasmanian provisions, Tas H101 [p. 50,303] *Special Use Buildings* 'Objectives' states that "Every workplace must be constructed in a manner that will provide for the safety, health and welfare of workers using that workplace." Specific provisions follow that relate to: floor area [Tas H101.2]; floor surfaces [Tas H101.3, p. 50,403]; floor drainage [Tas H101.4, p. 50,404].

The BCA is "…drafted in performance format to provide greater flexibility for the use of new and innovative building products, systems and designs. A user may choose to comply with the

*Deemed-to-Satisfy Provisions* or may use an *Alternative Solution* that satisfies the *Performance Requirements*" (ABCB 1996, p. 1002).

Using either, or a combination, of the following methods the performance requirements can be met:
1. by complying with the deemed-to satisfy provisions; or
2. by formulating an alternative solution that complies with the performance requirements or is at least as good as the deemed-to-satisfy provisions. [BCA, A0.5]

Through this structure the BCA retains some of the features of a prescriptive-style code in that it provides detailed solutions to building problems (e.g. as in the case of Section D. *Access and Egress*) or reference to solutions elsewhere (e.g. Section B. *Structure* where the deemed-to-satisfy provisions refer to Australian Standards). From a building designer's point of view, the deemed-to-satisfy provisions provide certainty as well as guidance (G. Hunt). Flexibility is built-in because these solutions are only one way of meeting the performance standards. Building practitioners are not obliged to follow the prescriptive-style solutions, providing they meet the performance standards or propose an alternative as least as good as the relevant deemed-to-satisfy provisions.

Therefore, there is a level of similarity between building law (specifically the BCA) and workplace safety law. The similarity is that they both allow flexibility in determining solutions for building problems and OHS problems alike. The differences are in the area of the type of problem-solving models that must be employed by users of the codes. With regard to building law, designers, and others, can be certain they have applied the appropriate <u>technical solution</u> (through the deemed-to-satisfy provisions). In contrast, with regard to OHS law, they can only be certain they have applied the proper <u>problem-solving process</u> (i.e. identify, assess, control, hierarchy of control).

Building law (the BCA) provides practitioners with the option of applying ready-made solutions. When these deemed-to-satisfy provisions do not suit a particular application, then there is scope to develop alternative solutions. However, even when the deemed-to-satisfy provisions are not applied exactly, they are important in that comparison of the alternative solution deemed-to-satisfy provision is one method (the other being comparison with the performance requirement) of testing the adequacy of the solution. Furthermore, it seems likely that deemed-to-satisfy provisions would also be used as a starting point for developing an alternative solution.

In contrast, while there is specific guidance as to control measures for certain problems, there is generally an absence of ready-made solutions within workplace safety law. The main approach that the majority of OHS regulations follow is to engage duty-holders in a problem-solving process. While there is less need to explain this (compared to building law) in any detail as the main audience for this document will be familiar with the contents of OHS law it is addressed briefly as follows.

The main hazard management problem-solving process usually consists of[8]:
1. identification (what hazards exist) (reg. 302);
2. assessment (what is the magnitude of the hazard and the associated risks) (reg. 303); and

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[8] *For example Occupational Health and Safety (Plant) Regulations 1995* (Vic.) Part 3. *Duties which apply specifically to designers of plant*, Division 2, *Designer's duty in regard to hazard identification, risk assessment and control of risk generally*

3. control (developing the solutions and putting them in place) (reg. 304).

Within the control stage, a hierarchical problem-solving model is almost always to be followed. Again, most readers will be familiar with this model. The hierarchy relies on the identification of the hazard and then follows a model whereby the hazard should be eliminated if possible. If elimination of the hazard is not possible, the risk associated with the hazard should be reduced as far as practical using controls 'at the hazard' rather than controls that rely on personal protective equipment, safe behaviour. For instance, the *Occupational Health, Safety and Welfare Regulations 1995* (SA) reg 3.3.3 (this regulation applies to designers and others) mandates the following hierarchy in relation to the control of risk:
1. elimination;
2. engineering controls (substitution, isolation, modifications to design, and guarding);
3. administrative controls (including safe work practices); and
4. personal protective equipment.

One could argue that building practitioners essentially go through the same process: that is, they identify a problem; assess the magnitude of the problem; then develop a solution that meets the performance requirement. While this may occur in some cases, there is no obligation to do so - they can simply adopt the deemed-to-satisfy solution without any in-depth thought about the level of risk posed by given problems. Somewhat similarly, occupational health and safety law is not devoid of information about specific issues, for instance even at a basic level, one could say that the existence of regulations about individual hazard types recognises the need for specific guidance. In many of these regulations there are provisions where duty holders such as designers are prompted to consider certain issues. For example, reg. 304(4) *Occupational Health and Safety (Plant) Regulations 1995* (Vic.) states: "If a designer of plant--(a) uses guarding as a control measure; and (b) the plant to be guarded contains moving parts and those parts may break or cause workpieces to be ejected from the plant--the designer must ensure, so far as is practicable, that the guarding will control any risk from those ejected parts and workpieces." However, this provision is governed by practicability and hence designer must be familiar with that term and its underlying concepts. Furthermore, one can say that a designer, or any other duty-holder will generally need to be familiar with the process-based models (e.g. identification, assessment and control model, and the hierarchy of control model) in order to successfully fulfil these requirements.

Not all stakeholders agreed that the differences are particularly large (e.g. T. Rowell). Further it was suggested that an apparent lack of knowledge about 'safe design' could be because designers are often not called upon to provide design advice in relation to 'buildability' (B. Rajadurai). This second point may be worth exploration in its own right. Nevertheless, the issue about the differences in the style of regulation to which engineers and architects are accustomed compared to the style of OHS legislation seems to be one that is worthy of exploration. There seems to be some reasons to say that different thinking approaches are needed in the practical application of these two types of law. One can see that there are parallels, but nevertheless some more thought in this area seems warranted to assess the size and importance of these issues and to develop ways to overcome any difficulties that are shown to exist.

## 4.B.ii Methods of influencing target groups

The following list covers the bodies suggested by interviewees as having potential influence with the target groups and/or having the potential to act as a channel of information. Interviewees generally suggested that an industry-based approach was needed. That is, the process would be to identify the industry and from there identify the relevant parties. However the following were noted as potential bodies/associations that may influence the upstream groups.

### *4.B.ii(a) General bodies:*

- AusIndustry www.ausindustry.gov.au
- Australian Chamber of Commerce and Industry www.acci.asn.au
- Australian Industry Group www.aigroup.asn.au
- Institute of Consulting Engineers
- Institution of Engineers, Australia www.ieaust.org.au
- Safety Institute of Australia www.sia.org.au
- Standards Australia www.standards.org.au

### *4.B.ii(b) Plant and Equipment*

- Boiler and Pressure Vessel Manufacturers' Association
- Crane Manufacturers' Association
- Lift Manufacturers' Association
- Tractor and Machinery Association www.tractormachinery.com.au

### *4.B.ii(c) Buildings and Structures*

- Australian Institute of Building Surveyors www.aibs.com.au
- Australian Institute of Building www.aib.org.au
- Building Design Professionals' Association
- Building Designers' Association of NSW
- Housing Industry Association
- Institute of Consulting Architects
- Master Builders' Association of Victoria www.mbav.com.au
- Northern Territory Construction Association
- Royal Australian Institute of Architects www.raia.com.au

### *4.B.ii(d) Materials and Substances*

- Agsafe
- Australian Petroleum Production and Exploration Association www.appea.com.au
- National Registration Authority for Agricultural and Veterinary Chemicals www.dpie.gov.au/nra
- Plastics and Chemicals Industry Association
- Royal Australian Chemical Institute www.raci.org.au
- Therapeutic Goods Administration www.health.gov.au/hfs/tga

### *4.B.ii(e) Other suggestions*

The following are general suggestions that were made:

- use peak bodies for machinery dealers;

- use industry magazines (e.g. in agriculture the Kondinin magazines);
- use inspectorate to identify relevant groups;
- education system (industrial design, engineering, architecture);
- conduct seminars/awareness raising (perhaps use 'best practice' or 'model' designers');
- influence purchasers (who will put pressure on suppliers and so on) which could be done through identifying high hazard equipment and developing purchaser's guidelines/checklists or perhaps through the inclusion of safety/or by making safety more prominent in product evaluations (e.g. industry magazines); and
- conduct safe design seminars, short courses. These could be designed as approved professional development activities for engineers, architects.

## 4.B.iii Perceptions of target groups' OHS knowledge and approach to safe design

The interviews included a question about perception of the target groups' knowledge of OHS responsibilities and perception of their approach to safe design. Table 4 outlines the result of this 'informal' survey. **Figure 2** and **Figure 3** respectively illustrate the 'OHS law knowledge' and 'approach to safe design' results.

### *4.B.iii(a) Knowledge of OHS obligations*

Interviewees were asked the following question in relation to all the target groups (i.e.: designers of plant and equipment; manufacturers of plant and equipment):

*"From your experience, and speaking generally, how would you describe the level of knowledge of OHS obligations among the target groups, where:*

*1. = non-existent;*
*2. = poor;*
*3. = reasonable; or*
*4. = comprehensive"*

The responses (Table 4 and Figure 2) showed that, in terms of knowledge of OHS legal obligations, those groups involved with materials and substances were perceived to be the most knowledgeable (average rating = 3. equating to 'reasonable' knowledge). Other groups rate somewhere between 'poor' and 'reasonable' with the exception that importers of plant are poorly regarded being perceived as having between no knowledge and poor knowledge. Of concern is the low perception of the knowledge of designers of both plant and equipment and buildings and structures when we consider the important role these groups could play in safe design.

### *4.B.iii(b) Approach to safe design*

Interviewees were asked the following question in relation to all the target groups (i.e.: designers of plant and equipment; manufacturers of plant and equipment):

*From your experience, and speaking generally, how would you describe the approach that the target groups would take toward safe design, where:*

*1. = do not consider that safety is an issue;*
*2. = safe design is not needed as the user simply must use/operate the item correctly;*
*3. = safe design should consist of add-on/optional extras; or*
*4. = safe design is a core aspect of design.*

The options presented were broadly intended to gauge an approach to safe design that range from being disinterested; through a behavioural model; and finally to an 'intrinsic' approach to safety. The options (1-4 above) were most directly applicable to plant and equipment although the same responses were used for buildings and structures and materials and substances.

The responses (Table 4 and Figure 3) showed that, in terms of their approach to safe design, there is some commonality with the perception of ‘knowledge’ and some differences. Designers, manufacturers and suppliers are thought to take an ‘optional extra’ view of safe design (average rating about 3.0) which corresponds to their good rating in terms of OHS legal knowledge. Designers of plant and equipment and buildings and structures are perceived in a similarly good light despite their low rating on ‘knowledge’ - designers are thus thought to take an approach of including safety features (although perhaps as optional extras rather than intrinsic features) even though they have little knowledge of responsibilities. The lowest ranked group was importers of plant and equipment who rated 2.5 being seen therefore as somewhere between the behavioural option (rating = 2) and the ‘optional extra’ way of thinking (rating = 3.0).

**Table 4 Perception of target groups' OHS knowledge and approach to safe design**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Q3. Knowledge of OHS Obligations** | | | | | |
| Designers of Plant and Equipment | 11 | 1.5 | 3 | 2.3 | 0.5 |
| Manufacturers of Plant and Equipment | 10 | 2 | 3 | 2.7 | 0.4 |
| Importers of Plant and Equipment | 11 | 1 | 2.5 | 1.8 | 0.5 |
| Suppliers of Plant and Equipment | 11 | 1.5 | 3 | 2.3 | 0.5 |
| Designers of Buildings and Structures | 11 | 1.5 | 3 | 2.2 | 0.5 |
| Constructors of Buildings and Structures | 11 | 1 | 3.5 | 2.5 | 0.7 |
| Installers of Buildings and Structures | 8 | 2 | 3 | 2.4 | 0.5 |
| Designers of Materials and Substances | 7 | 2 | 3 | 2.9 | 0.4 |
| Manufacturers of Materials and Substances | 7 | 2 | 4 | 3.0 | 0.6 |
| Importers of Materials and Substances | 7 | 2 | 3 | 2.7 | 0.4 |
| Suppliers of Materials and Substances | 8 | 2 | 4 | 3.0 | 0.8 |
| **Q4. Approach to Safe Design** | | | | | |
| Designers of Plant and Equipment | 11 | 2 | 4 | 2.9 | 0.6 |
| Manufacturers of Plant and Equipment | 11 | 2 | 4 | 3.0 | 0.5 |
| Importers of Plant and Equipment | 11 | 1.5 | 4 | 2.4 | 0.8 |
| Suppliers of Plant and Equipment | 11 | 1.5 | 3.5 | 2.6 | 0.6 |
| Designers of Buildings and Structures | 11 | 1 | 4 | 2.9 | 0.9 |
| Constructors of Buildings and Structures | 11 | 2 | 4 | 2.7 | 0.8 |
| Installers of Buildings and Structures | 8 | 2 | 3 | 2.6 | 0.5 |
| Designers of Materials and Substances | 7 | 2 | 4 | 3.4 | 0.9 |
| Manufacturers of Materials and Substances | 7 | 2 | 4 | 3.1 | 0.9 |
| Importers of Materials and Substances | 8 | 1 | 4 | 2.5 | 1.0 |
| Suppliers of Materials and Substances | 8 | 2 | 4 | 2.9 | 0.8 |

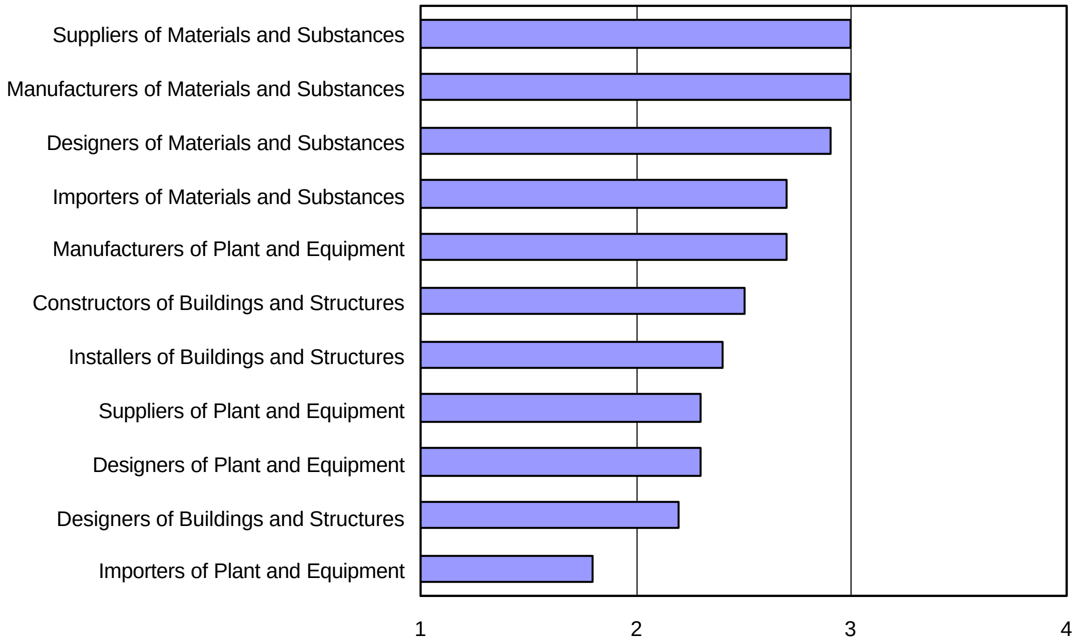


**Figure 2 Knowledge of OHS obligations (1=none, 2=poor, 3=reasonable, 4=comprehensive)**

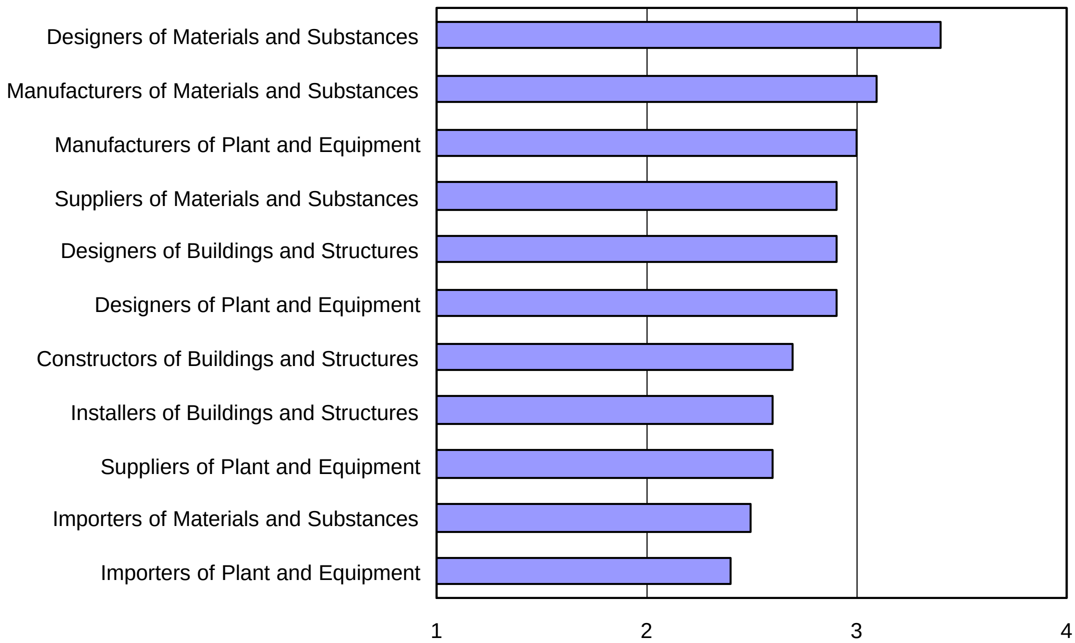


**Figure 3 Approach to safe design (1=not important, 2=behavioural, 3=add on, 4=intrinsic)**

# 5. Conclusion: responses to research questions

***What approaches have the stakeholders taken in order to help the target groups understand and implement safe design?***

The authorities that regulate workplace safety and the compensation authorities (often the same organisations) have undertaken and are currently engaged in a number of methods to inform upstream groups of their responsibilities and assist them in putting safe design in place. It seems that most of this activity has been around manufacturers and suppliers.

At a basic level this consists of reactively following problems upstream on a case-by-case basis. Where these individual issues have broader implications there seems to be a practice of producing a ‘hazard alert’ and making an effort to notify other manufacturers (for example) of this particular problem. Authorities make an effort to make these alerts public and cumulatively, there is now a large pool of this knowledge that by and large seems to be freely available on the various Internet sites.

At a second level, sometimes there are issues within industries that cause special projects to be undertaken or funded that seek to identify issues and to develop solutions. Some of these projects are purposefully aimed toward safe design and the role of upstream groups while many are more broadly oriented but nevertheless include aspects of safe design.

Attempts to raise awareness about upstream duties seem to coincide with the proclamation of regulations that expand on the duties described in main statutes. While the duties of designers duties have been present in the main workplace safety legislation for some time, the introduction of, for example, plant regulations, is usually seen as an opportunity to highlight the upstream roles. This occurs within a reasonably well-defined context and with the added impetus of some forthcoming changes in law.

One could speculate that enforcement could be used to highlight the role of upstream groups and emphasise the consequences for failing to meet duties. However, there was little mention among the stakeholders of enforcement [e.g. notices, prosecution] being used as a way to influence upstream groups. Information about enforcement was not specifically sought, but of course was not precluded either. Prosecution has been rare (Johnstone 1997, p. 267), although it is likely that enforcement activity short of prosecution (e.g. notices) has been of some influence - although the extent to which this has taken place is not clear. Gunningham et al. (2000) discuss some difficulties and indicate that some of the barriers include problems with the working of the duties and the typical time delay between, for example the actions of a designer and a subsequent accident. Gunningham, et al. (2000, p. 64) encourage occasional use of ‘upstream’ prosecution in order to emphasise the issue of safe design among the target groups.

***What do the target groups currently know about their OHS obligations in regard to safe design?***

Two problems seem to exist with professionals such as engineers and architects. Firstly it was perceived that they know little about safety law. It would seem that this could be addressed by awareness-raising through seminars. Secondly, if they know about safety law, it was commented that they will struggle with the underpinning 'process-based' concepts and probably also have a low knowledge of the important role that they can play.

In the USA, architects, engineers and contractors want employees to be legally responsible for their unsafe acts. This indicates that, to a degree, they fail to appreciate the importance and the potential of good design to ameliorate the likelihood and effects of so-called unsafe acts further downstream of their design decisions.

It seems that design practitioners are accustomed to prescriptive law and this too is a problem. If made aware of safety law, they are likely to gravitate toward the peripheral features of the law that offer a prescriptive guide and struggle with foreign concepts such as practicability, hazard management and the hierarchy of controls problem solving model. If this is so, then their awareness of safety law will have little effect as they are unlikely to apply the most important aspects of the law.

There is great support among interviewees and in the literature for improvements in education of influential professionals such as engineers and architects. While the enthusiasm is evident there are few notable examples of where this has taken place to any great effect. This remains then an unfulfilled opportunity to exert influence.

Other targets, such as manufacturers, are seen as being better versed with their responsibilities, especially those involved with materials and substances, although there remains room for improvement. For instance, the literature review suggested that chemical manufacturers often fail to provide adequate and understandable information about their products.

***What do the target groups currently do to meet their OHS obligations?***

The US Chemical Manufacturers Association 'Responsible Care' program ensures that manufacturers take responsibility for their product from manufacturing to eventual disposal. It compels carriers and distributors and others to meet audited industry standards. The 'better' manufacturers are 'closing the loop' of safe design and safe use of products, by engaging with distributors, suppliers, installers and end users. Product stewardship, mentioned in the literature, and including the education and training of end users, should be extended, especially to construction. Figure 4 shows a general model of product or building development. The initiative by WorkCover and the construction industry in NSW is along the lines of a product stewardship model. In the case of the NSW project, aspects of safety are to be incorporated in all aspects of the design process. Similarly the Road Traffic Authority in NSW adopts a life-cycle approach and is exploring systems to track safety aspects through the life of a project.

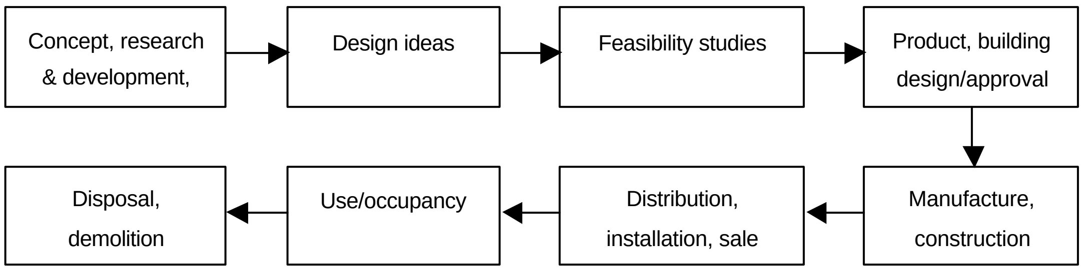


**Figure 4. Life-cycle of product or construction**

***Who are the key intermediary/contact groups or individuals who influence the target groups on safe design issues?***

A suggested model representing the parties involved from the designer to the user and the other parties with regard to plant and equipment and materials and substances is shown in **Figure 5**.

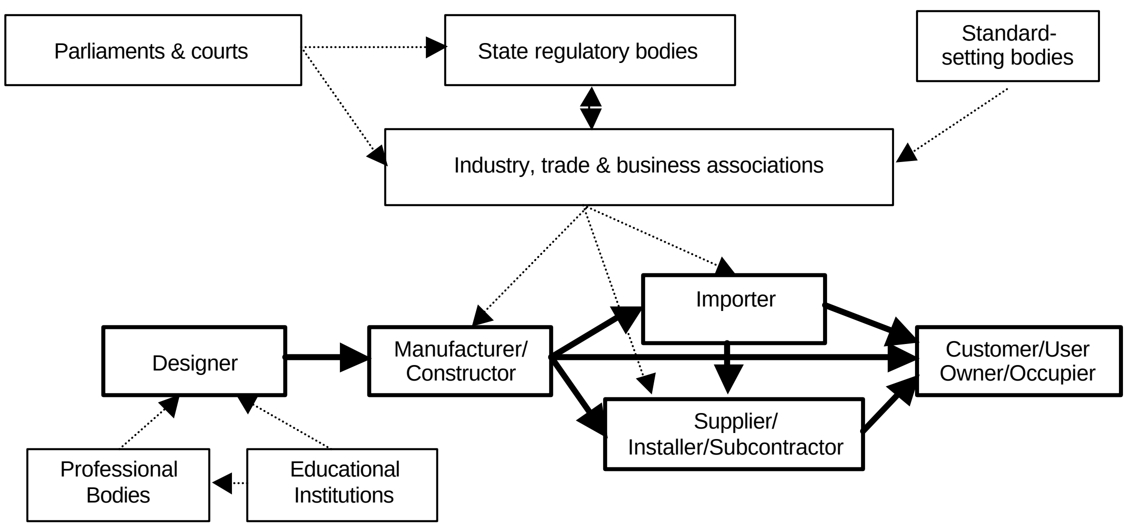


**Figure 5. Parties in the safe design process**

Parliaments and courts create law, however it is the State regulatory bodies that work with industry, trade and business organisations to work out how the law is to be enforced and give guidance on safety. Further guidance often comes in the form of national and international standards that can be invoked in regulations, especially in the construction industry. From the literature review, it is the industry, trade and business organisations that play the pivotal role in determining whether safe designs are promoted or not.

Designers, being engineers of various disciplines involved in plant and equipment, buildings and structures, and materials and substances; architects; and other design practitioners are influenced by: textbooks; regulations, especially codes such as the Building Code of Australia and Australian and international standards; and industry bodies. Of these potential avenues of influence, the greatest regarding the encouragement of safe design includes professional bodies and educational institutions. Further there is potential to guide design practitioners toward the models utilised in occupational safety by including models of this type in the standards and codes to which they customarily refer.

The chain between the constructor and end users of the building or structure may be short, but it is often very remote in time. Although there is limited information in the literature, given the relationships involved it seems likely that the builder and the principal contractor will take the lead role in the safe design process. For instance, the principal contractor can influence the designer, sub-contractors and installers. The principal contractors seem like a useful body to target in that they are relatively small in number in comparison to either the designers (who also are often obscure) or sub-contractors/installers.

Similarly, while there may be a number of parties between the manufacturer and customer, the literature suggests that manufacturers may be under most pressure from public interest groups and are practically in the best position to take the lead role (by setting standards, imposing auditing). Thus it seems that the approach of targeting manufacturers in the plant setting could parallel an approach of targeting principal contractors in construction. There is one important difference in these areas when compared with construction and it is that many manufacturers of plant and equipment and materials and substances are located outside Australia. In these cases it will be difficult to influence these players directly and another avenue will be needed, such as via end users.

In addition, with regard to materials and substances, there are alternative forms of influence. Manufacturers of materials and substances, more so than manufacturers of plant or construction businesses, are likely to be influenced by public opinion, communities close to their factories, and environmentalists. Thus these represent further avenues to address occupational health and safety, even if occupational safety remains a second order issue behind public safety and public concern.

***What are the overall implications of these findings on possible strategies for influencing the target groups?***

The following are a set of ideas that arise from this research. They could be termed recommendations although they are probably better formed into recommendations (including identification of bodies that should be responsible for carriage of the recommendation) at the point where the wider safe designs project is completed.

1) The level of knowledge and perception of safety law and the knowledge and use of safety concepts (such as hazard management, hierarchy of control, practicability) among the target groups is thought not to be optimal in many respects. However, these matters are not known for certain and the particular areas of need are not clear either in Australia or

abroad. Research is needed to determine levels of knowledge of legal responsibilities and importantly the key underpinning concepts among all the target groups to establish a baseline.

2) Designers in particular are important targets and there is evidence of a need for improvement in their knowledge of occupational health and safety both in terms of legal responsibilities and in terms of the underpinning concepts.

   a) Information is needed about designers' knowledge of occupational health and safety responsibilities and about the concepts of safe design. Survey-type research could be a way to obtain this information and would seem to be a relatively straightforward task given that the groups of designers (e.g. engineers, architects) are readily identifiable and accessible. This research could inform changes to undergraduate education and professional development (mentioned below).

   b) Undergraduate education is seen as an ideal opportunity to influence designers. The current level of incorporation of safety into design courses needs to be assessed. In all probability the assessment will reveal a need for improvement and therefore a plan will need to be put in place to make improvements.

   c) Professional development could provide a means of updating knowledge obtained via undergraduate education and provide a means to bring current practitioners up to date with the principles of safe design and occupational health and safety in general.

3) Consumers are seen as an important avenue of influence on safe design. Consumers include users of plant or substances in a workplace, owners of a building development. Consumers should be encouraged to build safety into purchasing decisions. Research could be undertaken to determine the best ways to assist consumers in improved purchasing in the three areas of plant and equipment; buildings and structures; and materials and substances.

4) In terms of safe design of buildings and structures, the style of building law is somewhat different to occupational health and safety law. It is possible that designers in this field (e.g. engineers and architects) become accustomed to this style of regulation and are thus unaccustomed to the process-based model that lies at the heart of workplace safety. It is worth considering the inclusion of the hazard management process-based approaches in, for example, the Building Code of Australia. By this method, designers would apply this model and therefore perhaps by default achieve some of the aims of the workplace safety law without necessarily being aware of that law. Teaching of the process-based model could probably be incorporated in design courses.

5) Awareness of the need and benefits of safe design could be improved by a number of methods such as:

   a) creation of special awards schemes that are based on safety interventions that improve safety downstream of the applicant;

   b) target groups be given prominence in public information, such as the Internet sites of the authorities; and

c) prosecution of target groups would be a way to enhance awareness of safe design issues. The value of focussing attention on upstream parties could be included in guidelines used by the regulatory authorities to determine matters for prosecution.

6) Information about safe design could be improved. For instance, there is a vast resource of safe design material contained in the collections of hazard alert material produced by the State authorities. These hazard alerts could be pooled in a national database that is accessible to the target groups. Also people could subscribe to an automatic system that would e-mail alerts that relate to their interest depending on their role, industry.

7) The life-cycle approach seems to have great merit and research could be undertaken to determine how to achieve diffusion amongst the various industries. Existing programs like ‘Responsible Care’ in the chemical industry and the pilot program in the NSW construction industry based on the British *Construction (Design and Management) Regulations 1994*, are worthy of further evaluation..

8) Reference to safe design issues in the Australian literature is scarce and research activity in safe design needs to be increased and should be better documented/publicised. Funding agencies should give priority to safe design issues and encourage research and publication in the area.

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# Appendixes

# Appendix A: Annotated bibliography

**Ainsworth, S. 1993, 'Chemical transportation & distribution: Responsible Care provides a framework for good safety practices, guiding manufacturers, distributors, and carriers', *Chemical and Engineering News,* vol. 71, pp.8-10, 14,16, 20-26.**

The Chemical Manufacturers Association (CMA) Responsible Care program was adopted in 1988. It unites members to address safety and public relations issues. It involves six codes of management practice, which have caused drastic changes in policies and procedures for many of their 178 members. It includes safe manufacture, transport and distribution of chemicals. Carriers, distributors and contractors have become Responsible Care partners.

The Distribution Code of Management Practices aims to protect: general public, carrier, distributor, contractor, employees and the environment. Compliance to the Code is costly, but saves money in the long term. The Code calls for: regular risk evaluation of chemical distribution; risk to people and the environment; implement preventative measures. Monitoring and training in regulations and standards – and providing guidance for carriers, distributors and contractors. Employees, carriers, distributors and contractors to be regularly reviewed for compliance. Carriers to be qualified and their performance regularly reviewed. Documented procedures: selection and use of containers; loading of chemicals; unloading safely; cleaning and returning tankers & containers. Selection, performance evaluation, information and feedback systems for: distributors and chemical handling operators. Process to respond to emergencies, accidents and incidents involving the company's chemicals. Consultation with emergency response agencies re facilities and hazards. Dialogue with public on their concerns & safety measures taken.

Companies now working with all carriers, not just those handling hazardous chemicals.

Member companies involve senior management and field workers in the Responsible Care program.

Few companies had assessed the risk for the distribution of all of their chemicals, prior to the code. Quantifying all risks has been difficult. A four year CMA Inter-industry Rail Safety Task Force has recently developed software to help with the calculations.

Companies are now training their sales representatives in 'product stewardship', using compliance kits, as well as staff involved in distribution.

Carriers are now assessed for: emergency preparedness, waste stream management, training of their employees, and legal compliance. One chemical company assesses the carrier's equipment and drivers. Price is now a minor consideration. CMA is considering a third party audit system for carriers. Carriers welcome the idea of joint audits –-to save being audited separately by different chemical companies. Problem is each company has a different risk profile for its chemicals.

Some customers pay their own freight and want to use their own unqualified carriers. They become offended when the chemical company refuses to load their carrier.

Similarly, distributors have welcomed the CMA's self-assessment protocol – because they have been assessed separately by different chemical companies.

Manufacturers now provide education material for all their products, not selected ones, for distributors and customers. Manufacturers are also scrutinising the containers they use more – Dow is considering a fully drainable steel container, that, when used, can go to landfill as a non-hazardous substance, as there are no residues. Monsanto has stopped using disposable drums in favor of reusable ones.

For emergency response, chemical companies and emergency service agencies are training each other's people in emergency response. MSDSs are being given to railroad companies by chemical manufacturers.

In response to the Chemical Manufacturers Association Responsible Care program, the National Association of Chemical Distributors has developed a parallel Responsible Distribution Process. Thirteen memberships of companies were discontinued by NACD because they would not comply. Most other companies completed their first self-assessments by July 1992. NADC can give their suppliers a nine page booklet that explains this parallel process. A cooperative relationship is being built between CMA and NACD.

Carrier companies welcome safety audits by chemical manufacturers, as they then have an additional safety component to their sales pitch. It also gives a shared risk reduction language between carriers and their customers. Communications have become two way, rather than top-down from the manufacturers to the carriers and distributors.

The economic costs of Responsible Care have been the costs of auditing, training and new computer systems. These costs have been passed on to customers.

**Anonymous 1991a, 'Contractors make case for small worker fines', *ENR: Engineering News Review,* 18th March, pp.13-14.**

Safety contractors in Maryland want employees fined, up to $100, for their individual breaches of the law; cf. the employer contractor fined. Similar provisions occur in Canada. The employer is fined if the employee is unsafe at work, but the employee is personally fined if they speed in the company truck. Maryland is amending its OHS laws as a State approved by US (federal) Dept of Labor to run its own safety programs. The 26 States so approved are amending their laws to comply with increased safety fines approved by Congress.

**Anonymous 1991b, 'Lifting the lid on users', *Hazardous Cargo Bulletin*, May, pp.43-49.**

Surveyed 12 multinational chemical manufacturers about how they decide what drums to buy to ship their chemicals in. Regulations: international shipment of hazardous goods must go using UN-marked drums; 2 cases starting to prefer bulk shipment using tank container or rail car, to UN marked drums; steel or plastic drums preferred over fibre ones – depending on nature of product to be shipped. The criteria used to specify drums: Safety first – thus use of specified or overspecified UN-marked drums; then compatibility with product (plastic vs. steel drums); then marketing – modified drums for new product; then what the customer wants. Three companies perform their own tests on UN drums (e.g. drop from 18 foot). Others take drums 'on approval' and test them in ordinary shipping. Performance is used above the following criteria: price, quality, lead time, delivery, service. Quality assurance: would inspect factory of new drum supplier. Usually 2 to 3 local drum suppliers used. Drum residues a design problem yet to be

overcome. Lack standardisation of drums to freight containers – need for international standards. Companies loath to use reconditioned drums. Drum and residue disposal contestable between chemical company and customer – Germany will require the chemical company to take the drum back. Companies concerned that drums may be re-used, with their company logo still on them. Drum incineration becoming preferred disposal option.

**Anonymous 1993, 'Design causes 35% of European site deaths',** ***New Civil Engineer,*** **18th February, p.4.**

EU has introduced Temporary and Mobile Sites Directive; and UK has introduced Construction (Design and Management) Regulations, because of deaths due to design faults. In the EU, 35% of site fatalities are due 'solely to the designer' and 28% are due to 'the interface between the engineer or architect and the project contractor'. In the UK there had been an 'alarming number of accidents' due to designs of civil engineers.

**Anonymous 1993/4, 'Homeowners misled by insulation claims',** ***BCME Building and Construction Materials & Equipment,*** **vol. 35, no. 22, p.15.**

The Fibreglass and Rockwool Insulation Manufacturers Association of Australia (FARIMA) claims that sheepswool insulation products are being sold by manufacturers and distributed with a 31% less insulation performance than advertised. Advertising includes CSIRO testing figures, not authorised by CSIRO and based on samples of different insulation value to what is sold. Sixty per cent annual power bill cuts by using insulation not realised. Miniscule amount of wool stockpile involved. Good name of wool being brought into disrepute. They call for Consumer Affairs Ministers to warn consumers and compensate homeowners and for the wool insulation to be withdrawn from the market.

**Anonymous 1998, 'Association Agenda',** ***Engineering Systems,*** **vol.15, issue 4, p.26**

Sheet Metal & Air Conditioning Contractors' National Association has won the Business Roundtable's Industry Excellence Award for Safety – for leadership in improving construction site safety.

**Anonymous 1999, 'US industry unveils chemical exposure study',** ***Chemistry and Industry,*** **no.4, p.131.**

Chemical Manufacturers Association, representing 90% manufacturers, is coordinating $100M research program on effects of chemicals (in general) on: exposure assessment, risk measurement, hormone disruption, carcinogenicity, respiratory toxicology – for humans and the environment. 'In a bid to silence critics once and for all…'. The research will be carried out by Chemical Industry Institute of Toxicology, the CMA's independent research institute. All research to be peer reviewed and made public. Welcomed by US EPA.

**Appleton, R. 1994, 'Using a performance-based approach to meeting the fire safety objectives of the Building Code of Australia',** ***Proceedings of the 7th National Conference of the Australian Institute of Building Surveyors,*** **Australian Institute of Building Surveyors, Perth, Western Australia, pp.7-24.**

Shows the influence of engineering research and modeling work on fire in buildings on changing the Building Code of Australia from prescriptive to performance based.

**Barker, R. 1991, 'Safe explosions in the home!', *Health and Safety at Work,* December, pp.38-39.**

Safe design features of Christmas crackers in UK include:

- all the 'snaps', the explosive cracker in the middle, are manufactured and quality control tested in southern China
- they consist of two overlapping cards – with adhesive on one side, and the explosive, silver fulminate, on the other.
- the UK importer, Sohni (Esco) uses ships to transport these lowest class explosives, in bulk.
- Sohni (Esco) stores the bulk snaps in a government-licensed munitions factory; in isolated strong areas, with flimsy roofs. Minimum quantities are stored and regularly inspected by HSE.
- The Christmas cracker manufacturer, Damio, also stores minimum quantities of snaps, in lockable, fireproof storeroom in a site remote from the main factory.
- Damio adds a reinforcing center card, to stop the snap moving beyond the cracker's outer foil, and glues it firmly in place.
- Novelties in the crackers conform to European standard for harmless, no sharp or toxic toy.
- The manufacture of Christmas crackers is a cottage industry. Outworkers in China and UK use simple, hand-operated machines, to assemble the crackers. Accidents are rare.
- Extensive storage facilities in UK are needed, as crackers are manufactured all year round. Damio has compartments of brick, steel and concrete, with sprinkler systems.

**Bender, J. & Hadley, J. 1994, 'Glass fiber manufacturing and fiber safety: The producer's perspective', *Environmental Health Perspectives,* vol. 102 (supplement 5), pp.37-40.**

Owens-Corning has manufactured glass fibre-based materials for over 50 years. Safety in manufacturing and use is an important issue. Over 30,000 products use glass fibres; and glass fibre insulation saves US 4 billion barrels of oil a year. Biological activity of fibres is related to: their physical dimensions, durability and biopersistence in the lung.

Respirable fibres are <3 mm diameter, and >5mm in length. Airborne asbestos counted in tens to hundreds of fibres per cubic centimeter. Compare that to glasswool fibres 3-10mm in diameter, airborne measurements of 1 fibre per cubic centimeter. It has been shown that fibres < 1 mm in diameter and >8 mm in length greatest chance of inducing tumours. Inhaled glass fibres can reach intraperitoneal, but do not cause tumours. Not clear if inhaled fibres can reach further in, where tumours occur.

Biopersistence of fibres in the lung a function of:

- whether normal, enhanced or overloaded clearance process of the lung invoked;
- length of inhaled fibre compared to size of macrophage;
- dissolution rate if fibre is neutral to acid environment;
- mechanical properties of intact and digested fibres.
- chemical composition of the glasswool, especially $Al_2O_3$, $K_2O$.

Long glass fibres dissolve more quickly than short ones; glass fibres dissolve more quickly in neutral than acid environments.

Exposure studies of workers over the last 50 years show low exposure rates and no causal relationship to malignant or nonmalignant disease. Intracavity injection of fibres into animals produces tumours.

The authors propose 60-90 day biological tests to compare new fibres to glass fibres; followed by long-term animal studies, focusing on tumour production and fibrosis. They advocate an exposure standard in the workplace of 1 fibre per cc.

Product stewardship is Owens-Corning 'cornerstone in managing these uncertainties [biological activity, risk assessment, hazard management of products].' Product stewardship encompasses: R&D, raw materials, manufacturing, packaging, transport & distribution, fabrication & installation, use, reuse & recycle and waste management.

**Bowes, J. 1994, 'The role of building product appraisals, and the influence of quality management on their production', *Proceedings of the 7th National Conference of the Australian Institute of Building Surveyors,* Australian Institute of Building Surveyors, Perth, Western Australia, pp.31-38.**

The move from prescriptive local government by-laws to a national New Zealand performance-based building code is noted. Part of the building code is a requirement to obtain a building product appraisal. Building Technology Limited does this appraisal and issues certificates. It has adopted quality management as its philosophy (customer satisfaction and continuous improvement) and has been accredited under ISO 9002 by Standards Australia.

**Brack, K. 1999, 'No coasting along', *Industrial Distribution,* vol.88, no. 9, pp.62-64.**

Intel Corp. banned glycol ether-based cleaning agents in its chipmaking plants, to protect pregnant women and other workers. Paulsen & Roles Labs. produced a new cleaning agent in 3 months. Customer complaints about odours made the firm develop 'ultra low odour' floor care products.

The company supplies: 110 products, including industrial and commercial cleaning chemicals, wax strippers, finishers, sealers, restorers, disinfectants. Their clients do not have to store chemicals, as they supply on a just-in-time stockless basis. They provide product training and install dispensing stations in 'custodial closets', to ensure safety. They are initiating CD-ROM and online training for cleaning staff, including testing and performance tracking. They provide workshops on 'issues like improving indoor air quality and the science of hard floor care.' They have conducted needs analysis in four companies. Their scientists have helped solve complex issues for Intel, Nike, Boeing. They have lost market share to some companies that provide cheaper products.

**Bressington, P., Fire, A., Arup, O. & Partners 1996, 'Fire Safety – The Design Process', *Proceedings of the Interflam '96 Conference,* University of Cambridge, England, pp.665-670.**

Good fire safety design must overcome impressions that it is costly and intrusive; and must balance pressures of: cost, aesthetics, programming, and requirements of approving authority. There must be a level of safety for people and property in proportion to risk and hazard.

Prescriptive codes address: escape distances, compartmentalisation, fire resistance. Prescriptive and fire engineering approach: fire dynamics, human behavior, risk. Only real test of adequacy of design is a real fire.

Make choice between prescriptive and fire engineering approach using factors: building function, architectural features, size, cost, existing building. E.g. transport terminal – large, multi-occupancy = fire engineering needed. E.g. large atria, and historic buildings need special attention. E.g. fire engineering approach often cheaper than prescriptive design.

Cost. Prescriptive codes allow greater escape distances, compartment volumes where sprinklers are fitted. Seven storey building, sprinklers can save 20% costs. Greater cost savings using fire engineering – which can demonstrate only high fuel load areas need sprinklers.

Program. It takes longer to get approval for fire engineering design than a prescriptive design. There have been a number of construction site fires on nearly completed buildings. Need sequential commissioning of building, and fire pumps installed at an early stage.

Presentation. Presentation of proposals to all parties must strike a balance between too little and too much detail. Preliminary strategic report should include: design standards & codes used, equations, main criteria, means of escape, compartmentalisation, fire resistance, firefighting provisions, fire systems, management and any waivers being sought. Later, full report will include: smoke production, egress calculations, fire loads, occupancy figures. A scale model can be constructed.

Approval. Problem: lack of expertise in approval offices in fire engineering techniques and experience. Need for education and training in fire engineering basics. Using prescriptive codes and precedent designs makes approval easy. Fire safety design: must validate equations, calculating techniques, key assumptions. Can support with referred papers and opinions of other professionals.

**Buchanan, A. & Cosgrove, B. 1996, 'Fire design of industrial buildings', *Proceedings of the Interflam '96 Conference,* University of Cambridge, England, pp.951-957.**

New Zealand, single storey industrial buildings store unpredictable variety of goods and substances. NZ Building Code requires: 1. Safe egress for occupants, 2. Fire resistant walls, with openings and separation distances to stop fire spreading to adjacent buildings, 3. Safeguard environment. Fire damage to contents or structures responsibility of building owner. Where energy density greater than 1500 MJ/m$^2$, Approved Documents require specific fire engineering design methods. But no accepted design tools available to determine fire resistance of external walls.

Scenario analysis basis of fire engineering design. After calculations made, qualified engineer must make professional judgement – code not quantified.

Most common industrial building structure: steel frame, roof steel sheeting & 15% clear plastic skylights. Most active measures used (in order): fire hoses, manual call points, alarms, heat detectors, automatic sprinklers, smoke detectors.

Typical fire development:

1. Where no venting or sprinklers: after 20 min. fire Flashover (via radiation), all racks on fire; 30 min structural failure.
2. Where smoke vents: after 20 min. adjacent racks only on fire; 30 min structural failure.
3. Where sprinklers & no smoke vents: after 20 min. smoke filled building but fire under control.

Heat release in a fire will grow until limited by ventilation. Ventilation increases when skylights melt, and again when roof collapses. Radiant heat at roof collapse impinges on top of adjacent building. Radiant heat falls directly on adjacent building when building walls collapse.

FPE tool used to calculate burning rates when building content known. Zone modeling can be used to calculate ventilation-controlled fire, and post-flashover, ventilation-controlled fire. When roof collapses, flame and smoke heat proportional to fuel surface area, but cannot calculate temperature adjacent to remaining walls. For contained fires, can use Eurocode Formula for duration of burning, but not for fires where walls have collapsed. Occupant safety estimated from evacuation times compared to onset of untenable conditions. Sprinklers with roof vents and smoke detectors offer best combination to allow occupants to escape.

Fire resistant walls, with small openings to control radiant heat, can prevent fire spreading to adjacent building. Compare fire severity to wall fire resistance, using:

1. Time equivalent formula.
2. Duration of burning.
3. Real fire calculations. Where high fire loads, many hours resistance rating for walls are reduced by assumption that fire fighters will attend the fire. NZ code uses rating of after-fire load of 0.5kPa; steel support columns are encased in concrete resisting collapse and wind throw.

Where walls collapse out, calculate radiant heat flux for a vertical rectangular emitting source. If wall panels are tied together, they will fall inward not outward.

If assuming fire service will attend, need to calculate beforehand water resources needed to suppress a fire, allowing for wastage and difficulties of accurate application.

Compartmentalisation may be required by insurance, but does not affect calculations of effects of fire on adjacent buildings.

Move to performance-based codes in NZ has lead to greater discussion on fire scenarios and likely effects of fire, rather than a book of rules.

**Carter. T. 1994, 'The general insurance industry and building regulation', *Proceedings of the 7th National Conference of the Australian Institute of Building Surveyors,* Australian Institute of Building Surveyors, Perth, Western Australia, pp.39-54.**

Insurance industry used to police the fire safety of buildings. Early 1970s, following changes in the Trades Practices Act, they now compete, and offer advisory services. They still influence governments, e.g. Building Regulation Review Taskforce. They want totally independent and qualified building certifiers. Fire Brigades should have the final say on the fire safety of buildings. They prefer a prescriptive building code to a performance-based one; and are concerned about the watering down of the Building Code of Australia.

**The Consultancy Company 1997, *Evaluation of the Construction (Design and Management) Regulations (CDM) 1994,* for Health and Safety Executive, UK.**

Interviews were used to construct a questionnaire, which was used to conduct face-to-face and telephone interviews with people in the construction industry, to determine the impact, costs and benefits of the introduction of the *Construction (Design and Management) Regulations 1994*.

Twenty-four face-to-face interviews were conducted with the duty holders: clients, designers, planning supervisors, principal contractors, contractors, multiple discipline enterprises. A 27-item questionnaire was constructed from the responses to these interviews. Ninety-eight face-to-face and 136 telephone interviews with the duty holders were conducted, using the questionnaire.

CLIENTS.

Four interviews were conducted with clients in the pilot, 29 in the main study. Fifteen were from large firms (>£500m), 8 large (£50m to £500m), 7 medium, 3 small (<£500,000). Before CDM regulations, 1 was 'attempting to comply' with OHS policy, 1 'absolute minimum necessary', 5 'good progress' and 14 'fully developed OHS policy'. Prior to CDM – attitudes to H&S were: 1 'need to comply', 14 'supportive of objectives' and 6 'welcome H& S legislation'.

Responses to CDM legislation were: 2 no change necessary, 10 modified existing system, 9 amended existing system, and 1 completely revised system. The effect of CDM regs was: 2 'no effect', 7 'small +ve effect', 13 'reinforced compliance'.

Most client firms understood the role of the planning supervisor; though 7 out of 22 respondents did not see a role in forwarding information about H&S to designers. Seven to 14 firms had added roles beyond CDM regs for planning supervisor: risk assessment, auditing, monitoring site standards, managing project for client.

Clients were asked to rate the degree of impact the CDM regs had on the 8 areas covered by the regs: appointment of Planning Supervisor, competence assessment of Planning Supervisor, competence assessment of Principal Contractor, client information, appointment of Principal Contractor, Competence assessment of designer, pre-tender H&S plan, designer's design with safety in mind. Least impact was on assessing the competence of the Principal Contractor. Greatest impact on the clients' business was appointment of a Planning Supervisor; the requirement to make all client information on safety available, and the requirement for a pre-tender H&S plan. Most firms were adopting ISO9000, so competence assessment of Planning Supervisors and Principal Contractors was not a problem.

Experience of beneficial effects of CDM regs: 5 no benefit, 8 said pre-tender H&S plan, appointment of planning supervisor and requirement to make all h&s information available.

Majority of clients saw documentation for pre-tender H&S plan was excessive. Also problem of storage of the voluminous H&S information required. There was some uncertainty about what was required to be documented; including distinction between significant risks and standard risks.

H&S benefits: 17/18 said increased awareness on site, 13 behavior changes, 12 better planning, 2 less incidents. Awareness due to total volume of H&S legislation, not just CDM regs.

Most saw no benefit to: reduced accidents, reduced claims, fewer maintenance accidents– most due too early to tell. Saw some future benefits of reduced maintenance accidents and reduced long term damage; including reduced expenditure. Most saw no benefits from CDM regs for efficiency, specifically: homogenous design process, ease of construction, ease of adoption or demolition, improved flow of info or ease of maintenance.

Expenditure had only reduced for the large companies who had already conducted a large number of building projects – from 'ease of maintenance' and 'improved flow of information'.

Effect on business of their company: 8 / 17 no effect, 3 good and bad effects, 4 positive effects and 2 negative only effects (especially paper work and costs of compliance).

No clients had actual costs of introduction of CDM, although 3 had to train staff and 2 very large companies had to update their management systems. There were no real increases in staff. Archiving material was thought to be a substantial future cost. Costs of engaging a planning supervisor were estimated at between 0.25 and 0.73 percent of project costs. As a percentage of on costs, the range was from 0.21 to an outlier of 7.98, with an average of 1.1%.

Client perception of full compliance of self and others with CDM regs: clients, planning supervisors and principal contractors; but NOT designers (50%) or 'other contractors (35% fully compliant).

CONTRACTORS.
13 pilot study interviews, 96 main interviews with questionnaire. Most in demolition business (37) rest in 'design and build' (31), 'construction' (30) and 'Engineering construction' (25).

Before CDM policy toward H&S: 53 fully developed policies, 24 'good progress' and 1 absolute minimum. 36 supported the objectives of H&S legislation, 34 welcomed H&S legislation and 7 said they needed to comply. 51/78 respondents needed to change their existing systems as a result of CDM regs, only 6 needed no change.

Response to CDM regs: 54 / 76 said it reinforced compliance to H&S, 16 small positive effect, 4 'transformed approach' and 2 no effect on their approach to H&S issues. Concern expressed about excessive paperwork.

75 contractors responded to the functions of the "planning supervisor". Most contractors understood the role. But – one third did not see a role in providing information to designers or contractors; including 57% not see role as forwarding information to designers, and 29% not see role as ensuring designers complied with duties. Roles ascribed to Planning Supervisors which they do not have: risk assessment for all stages of construction (ascribed by 29%), auditing H&S plan during construction (24%) and monitoring site standards (28%).

68% of 479 responses to the 8 roles of Planning Supervisor and Principle Contractor (see last section) said the CDM. The least impact was on the need to assess the competence of the Planning Supervisor. Greatest impact: need to appoint a Planning Supervisor (61/75 respondents). Highest 'significant impact' was requirement for pre-tender H&S plan (15/75). Future impacts: least on assessment of competence of designer, most on assessing the competence of principal contractor, second greatest the need for pre-tender H&S plan (64/76).

The beneficial impacts Contractors saw as those impacts that had already been the greatest impacts on their business. There was a small and mixed response to the question of documentation needed for the 5 components: pre-tender H&S plan, competence assessments, pre-qualification assessment, H&S file and Project H&S file. The documentation needed for the pre-tender H&S plan and the pre-qualification assessment were seen as excessive. Because contractors misunderstand the roles of the Planning Supervisor and Principle Contractor, they may be preparing more documentation than needed.

Greatest H&S benefit was “increased awareness’ (68 respondents), least thing experienced as a benefit flowing from CDM regs was ‘less incidents’. 3 very large contractors do not collect incident data & believed small contractors not reporting ‘near misses’. 44% believed there was no overall benefit for contractors; usually too early to tell. However, 83% of respondents saw future benefits: ‘fewer accidents during maintenance’, ‘reduced claims’, ‘a safer environment for users’ (out of 7 options). Some economic benefits from these. Relatively high level of non response.

30 / 90 respondents had had accidents, being those who had carried out most projects per respondent.

Of 5 efficiency benefits, greatest ‘no benefit’ response was for ‘ease of construction’ and greatest benefit was for ‘improved flow of information’. 18 respondents, mainly demolition people, indicate ‘substantial benefit’ for ‘ease of adaptation/refurbishment/demolition’. Most saw no financial benefits from these changes. The 37 who indicated a reduction in expenditure had carried out the most projects.

Business effects: 19 / 77 said neither +ve or –ve impacts from introduction of CDM on their businesses; 17 / 77 both +ve and –ve; 38 only +ve; 3 only –ve.

Contractors wanted more enforcement of the regs, and more inspectors.

Actual $ costs of introduction of CDM not available from respondents. 32/41 demolition contractors saw little costs. 4 / 77 companies had experienced very significant costs for training. Overall, most cost to industry was from ‘updating management systems’ followed by ‘training’ and ‘change of procedures’.

Only one respondent expected ‘very significant’ continuing compliance costs from CDM regs, most ‘substantial’ compliance costs being in competence assessment and training.

Contractors believed: principal contractors in full compliance with CDM (56% of respondents) and only duty holders to be fully compliant. Planning Supervisors were seen as having the greatest rate of ‘do not comply’ (20.7%). Client, designer, principal contractor were the other categories.

DESIGNERS

3 pilot study interviews, 56 questionnaire interviews. 21 were architects and 38 design engineers.

Before CDM, over half respondents had ‘fully developed H&S policy’ and none were in category ‘attempt to comply’. 3 ‘absolute minimum’. 24 were ‘supportive of objectives’ of H&S legislation, 22 welcomed H&S legislation and 7 accepted the need to comply.

Most had ‘modified their existing systems’ in response to CDM, only 4% had made no changes. 32/52 had response of ‘reinforced compliance’ to CDM, 12 had small positive response, and 4 each: ‘transformed approach’ and ‘no effect’.

Most understood and had experienced the regulated role of the Planning Supervisor. However, they did not think the advice of the Planning Supervisor to designers or contractors was of much use, as they are too much of a generalist. 23/51 incorrectly said role of Planning Supervisor was to conduct risk assessments during construction; 12 said auditing and monitoring site standards and 4 – project management. Some commented that the Planning Supervisor was appointed too late in the process to have an effect.

73% of responses to the impact of CDM on 8 impacts said an impact had occurred. Most said "some impact" on all 8 categories; including "designers to design with safety in mind". Appointment of Principal Contractor had least impact. 49 / 52 said appointment of Planning Supervisor had most impact on their business. For 17 / 52 pre-tender H&S plans had a significant impact.

Impacts were anticipated to decline over time. Appointment of Principal Contractor least future impact, "designers to design with H&S in mind: the greatest future impact, pre-tender H&S plan second greatest impact.

Five out of forty-seven said no beneficial impacts on their business from introduction of CDM. Beneficial impacts matched the list of greatest impacts on their businesses. Degree of documentation needed by introduction of CDM largely a non issue. Volume of documentation function of project size and complexity. Architects saw higher volume of documentation needed compared to design engineers. H&S plan documentation perceived as excessive. Architects also concerned about size of H&S file; and design engineers the pre-tender H&S plan.

Greatest benefits from introduction of CDM seen as 'better planning and co-ordination' (42/48 respondents) followed by 'increased awareness' (40/48). 'Less incidents' was the least benefit.

Forty-four per cent saw 'no benefit' (of 7 options) from introduction of CDM, and none a 'substantial benefit'. 'Reduced accidents' was seen by the rest as of 'marginal' to 'some' benefit. Too early to tell most often said.

Eighty-two per cent saw benefits (mainly 'some benefit') in the future. Some saw a marginal reduced expenditure from introduction of CDM. Of 5 possible efficiency benefits, most of the 50 respondents said there was 'some' to 'marginal' benefit, mainly for 'improved flow of information'. There was little reduction in expenditure now or in the future.

Business Effects. Thirteen out of forty-nine respondents said neither +ve or –ve effect on their business for introduction of CDM regs; 3/49 both +ve and –ve; 29 +ve only and 4 –ve only.

Costs. Actual $ figures not available. Most costs were from "updating of management systems", followed by "change of procedures" and "training". Cost of ongoing compliance: none anticipated "very significant cost" and most just a little cost. Costs incurred would come from: systems and procedures, training and competence assessment.

Forty-seven designers perception of 'fully compliant' was: designers 55%, planning supervisors 66%, principal contractors 59%, clients 50% and contractors 45%. However, 19% said contractors and 13% of clients do not comply with CDM.

Chapters 7 to 9 summarises the data collected, above, into the following Categories, which are the key new elements of the Construction (Design and Management) Regulations:

- competence assessment;
- pre-tender health and safety plan; and the
- role of planning supervisor.

Competence Assessment. Competence assessment of contractors was not seen to cause a major impact on business. However, irritation was expressed by contractors because assessment questionnaires were not well focused, and tended to overlap with pre-tender assessments. Pre-qualification assessments were regarded as creating too much paperwork, compared to competence assessments. There is a lack of standardisation of paperwork. Over half of the 198 interviewees saw positive benefits from the regulations. Price and reputation may be more important than risk management in selecting contractors.

Pre-tender Health and Safety Plan. This requirement was seen as having 'much' or 'significant impact' on businesses; but also the most beneficial aspect of the regulations. The length of the documentation was regarded as excessive – especially by half of the contractors. Non-health and safety issues were said to be included in the plan.

Role of Planning Supervisor. Three enterprises had sole role of Planning Supervisor and 52 of remaining 195 firms performed the function of this new role. Interviewees thought Planning Supervisors were not fully carrying out their functions. However, they mistakenly thought Planning Supervisors had the following roles: risk assessment for all stages of the project, auditing against the H&S Plan, monitoring site standards, and managing the project for the client. Sometimes attempts to do these things cause conflict with Principal Contractors.

The role needs to be clarified. The appointment of Planning Supervisors was judged to have little impact now, but more impact on business in the future. Appointment was seen as the second most beneficial aspect of the regs.

Appointment of Planning Supervisor varied: in-house person, different external person for each contract, part of design team, part of job of Principal Contractor. Often PS appointed too late to make a difference. Many lack professional backgrounds. EU does not require appointment of a separate PS.

More details of the following issues are given in the Appendixes: Role of Planning Supervisor, The Health and Safety File, Competence Assessment of Duty Holders, Competence Assessment of the Contract Chain, Application of regulations to offshore sector, and Building Control regulations. One Appendix (Designing with Safety in Mind) was summarised:

Designing with Safety in Mind. The researcher's aim was "to identify practices used by designers to determine and assess risks".
Face-to-face interviews were conducted with key people from:

- large design practice with international clients;
- medium-sized design practice, with EU clients;
- 2 small specialist practices;
- Royal Institute of British Architects.

Telephone interviews were conducted with 2 consulting engineers firms.

Most engineers focus on: physical strength of form and structure. Most architects on: form, fit, function.

Design engineers are trained in: scientific/mathematical approach to structural integrity during construction and in the final structure. They know more about fabrication and construction processes than architects. Engineers better equipped "to identify and deal with the risks and hazards of their design." than architects.

Architects are creative, innovative, and do not work in teams; and do not work with engineers.

Design engineers approach to risk and hazard identification. Engineers use CAD computer programs, some of which “will automatically correct the design to eliminate conflicts, risks and hazards.” CAD used to assess ’what if‘ scenarios. Design process is fully documented. To overcome over-reliance on CAD, engineering firms conduct regular formal design reviews. Easy to extract documented risks and hazards for Health and Safety Plan. Formal design reviews also ensure the structure can be built and maintained.

Architects approach to risk and hazard identification. Architects create the overall design concept and outline. Less experienced architects or technicians fill out the detail. Risks and hazards cannot be identified until the whole design is complete. Lack of experience in construction and maintenance means risks and hazards of individual parts are often not identified. Commercial pressures toward the end of the process prevent risks and hazards being addressed. “One of the major issues affecting the implementation of a more structured approach to the identification and elimination of risk and hazard is the professional arrogance of many architects.” Smaller and medium size firms use ’job books‘ to record hazards and risks throughout the design process, addressing outstanding hazards and risks during regular design reviews. A more structured approach is taken in larger firms – so they can provide planning supervisor services and comply with CDM regs. Some firms use a CDM process handbook, which designers use during their design (including checklists and standard forms). Legal advice to some firms is to NOT annotate risks and hazards to drawings. Royal Institute of British Architects is urging firms to invite in construction professionals, to overcome ignorance of construction materials and processes.

**Eisma, T. 1990, ‘Manufacturers develop safety gear for worker comfort, style acceptance’, *Occupational Health and Safety*, June, pp.48-50.**

Safety is the first consideration in the design of personal protective equipment (eyewear, ear protectors and chemical resistant suits); they must meet or exceed standards. Comfort is the second consideration for all, although in suits, function may come before comfort. For eyewear, fashion has now been taken into account. Ear protectors are now designed so they can be worn with other protective apparel. Chemical suits now look more like normal clothing, using resistant films, which are less durable.

**‘European Hygienic Equipment Design Group (EHEDG)’ 1992, *Trends in Food Science & Technology,* Vol. 3, November, p.277.**

The European Hygienic Equipment Design Group has just formed, and includes equipment manufacturers, food industry reps and government organisations from across Europe, but especially UK and Germany. They will: publish guidelines, conduct research and write journal articles. Their aims - specify conditions equipment is microbiologically safe for processing and packaging food; ensure hygienic production of foods; provide specialist views on hygiene and equipment to standards organisations; and encourage R&D where gaps in knowledge on hygienic and aseptic design have been identified.

**Evans, S. & Chaffin, D. 1986, Proceedings of the Human Factors Society, 30th Annual Meeting, pp. 734-737.**

Forty engineers in 5 companies were surveyed, half from manufacturing or assembly, quarter from machine design and a quarter from continuous processing. Forty per cent were managers, 60% were staff engineers. The survey focused on when ergonomic design information was acquired during the design process.

From survey responses, it was possible to build a 'Design Model for Manufacturing Workspace Design' (Figure 6). The sources of information for **preliminary design** were: experience at the corporate and division level. The source of information for **detailed design** was at the plant and division level. Plant level designers and continuous process designers were mainly involved in detailed design.

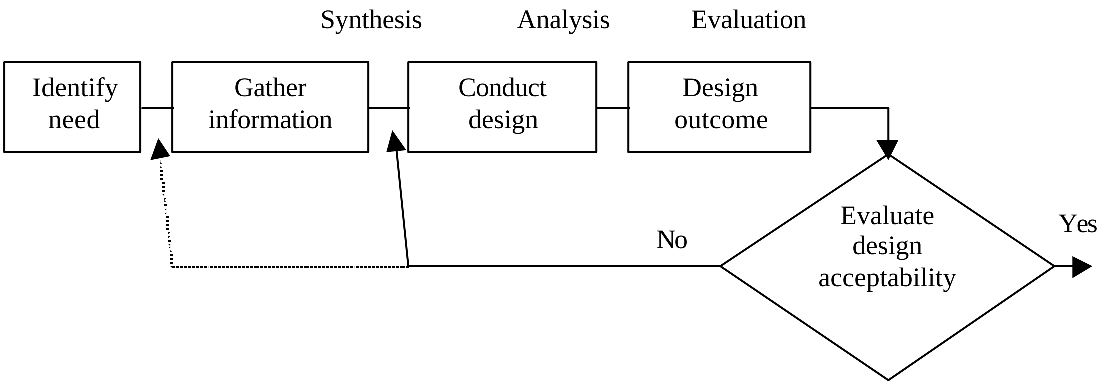


**Figure 6. Design Model for Manufacturing Workspace Design**

Eight points distinguished plant and division level designs, including:

- 62% of plant work is redesign; 32% at division level.
- 70% of plant work was from plant production, health and safety or worker initiated; c.f. little at division level.
- Source of design specifications for plant work was plant or division; plant, division or corporate for division level design.
- Plant had no computer aids for design, division did.
- Production supervisors gave immediate feedback to plant level, whereas division level received little feedback at all, from plant engineers.

In mature production industries, communication was formal and vertical, limiting interaction between design groups; making collection of information related to ergonomic considerations very difficult. Plant engineers often had to fix up bad designs made by division level, to take account of the design's impact on operators.

No one person or group was designated a 'workspace designer' – this responsibility was usually shared between: plant and division groups and individual engineers.

Redesigns at plant level were rarely documented; division level often relied on previous documented designs.

The authors propose an alternative design process model: observation of operators and collection of information → design analysis → alternative evaluation → possible implementation.

**Fagan, J., Monte, T., Powell, D., and Cronici, J. 1998, 'Contractor review committee: One hospital's approach to facilities development quality & safety', *Professional Safety,* vol.43, issue 5, p.33-35.**

Details how Hartford 879 bed hospital addressed concern about lack of quality and safety in facilities development, especially contractors. Began with fire marshal and safety officer initiating a work permit – not successful. Employed more experts – also not successful. Developed contractor review committee – expertise: project management, blueprint reading, specification writing, personal protective equipment, includes depts engineering, industrial hygiene, facilities development, security, real estate, parking, fire safety, infection control, telecom. Services. Contractors must use American Institute of Architects' contractor qualification; be interviewed, sign off on Hartford Contractor Regulations Handbook, and visit site with committee member. Individual members often visit site, committee less so. Contractor review committee can issue evaluations to contractor, and teach them how to comply. Can be fined for second offence. Problems continue removed from site or strictly supervised +/- unable to bid for future projects. Contractor benefits from improved safety processes.

**Flores, A. 1983, 'Safety in Design: An Ethical Viewpoint', *CEP*, November, pp.11-14.**

The American Institute of Chemical Engineers' Code of Ethics requires: "Engineers shall hold paramount the safety, health, and welfare of the public in the performance of their professional duties." Two hundred engineers, including chemical engineers, were interviewed and surveyed. The chemical company was in the top six in 1979 for workplace safety. The company has 7 organisational mechanisms to deal with safety:

1. Executive level Social Responsibility Committee & Environmental Policy.
2. Committee – setting OHSE policy.
3. Senior level coordinators, one for each major law on worker and environmental safety.
4. Engineering specific policies, specifying safety requirements and levels of acceptable risk.
5. Safety organisation and environmental policy staff groups.
6. Coordinated, periodic design review process for all design projects. All safety hazards and risks are controlled or eliminated.
7. Department of Medicine and Environmental Health –staffed by scientists and technicians.
8. Accident investigation and safety information network – informs people of developing trends in product safety, industrial safety, environmental protection.

Survey found that engineers felt no inconsistency between their social responsibilities and what their employer allowed. Three quarters had not taken a college course where safety was a major topic. Eleven per cent had taken 2+ college courses in safety, but doubted their usefulness. Most said their education did not properly expose them to industry and government safety standards affecting plant safety, worker health, or environmental protection.

One third agreed that corporate safety practices enabled them to meet their ethical responsibilities for safety. An additional one third said corporate practices made it easier for them to meet their ethical responsibilities. Four per cent believed corporate practices had a negative influence on safety.

Six per cent said formal safety programs frequently reduced their personal responsibility for the safety of processes they helped design; 20% said this sometimes occurred. 44% said organisational practices never undermined their sense of personal responsibility and 30% said it never had a negative effect.

78% felt there were sufficient organisational protections to go over the head of their supervisor on safety issues.

95% had participated in design reviews of their projects. This involves 3 stage evaluation of process and plant designs at critical times in the project. 50% said reviews very effective, plus 25% said generally effective. Reviews: identify and resolve hazardous conditions, define levels of acceptable risk, satisfy design safety standards and government regulations.

The author speculates that engineers need organisational support to fulfil their ethical obligations and that the professional society should provide education about their social responsibilities to protect public safety. Professional society needs to support engineers in conflict with their employers. Professional societies should use their institutional, technical and financial resources to get employers to improve levels of safety in products and technologies they market. Government regulation necessary to promote safety in design in competitive markets.

**Gambatese, J., Hinze, J. & Haas, C. 1997, 'Tool to design for construction worker safety', *Journal of Architectural Engineering,* vol.3, pp.32-41.**

Designers have not traditionally addressed construction worker safety; but contractors may be bound by designs that place specific hazards on construction sites. Designers lack training to assess worker safety, and no central body of knowledge to assist them.

The Construction Industry Institute has created a database of safety ideas and design tools, based on "best practice" examples; and housed in a computer program. 1990 survey of design firms showed designers did not address construction safety and many commented they had legal advice not to do so, to avoid assumption of legal liability. Design-build firms often addressed construction safety at design phase. Construction owner surveys – 1991 52% of owners reviewed safety records of contractors; 1993, 54% and 1994, 57%. In 1993/94, 45% owners said designers did not take account of worker safety and 29% said only occasionally addressed.

Design ideas collected, no discards due to: cost, schedule, or design or construction performance criteria. Conducted literature search on academic research and industry publications. Industry personnel were also interviewed (in person or by telephone) and in Seattle they were surveyed by questionnaire. Personnel: owners, designers, constructors, design-builders, construction managers; all levels in firms large and small.

Large companies have safety design manuals. These were reviewed – to apply "techniques used for enhancing end-user safety to construction phase safety."

Worker safety manuals and checklists from government agencies and Construction Industry Institute members were reviewed, with a view to eliminate the hazards and so the need to apply the safety measures in the manuals & checklists.

Design suggestions were elicited from CII Design for Safety Research Team members.

Asymetric's Multimedia Toolbook has been selected as the authoring computer program to put the safety design practices in. This program met the criteria: graphics capability, multimedia support, supports data structures for users' records, user-friendly, mouse-driven, Windows environment.

Since early 1994, accumulated 400 design suggestions – most from manuals and checklists, researchers and those interviewed. Personnel in architectural and consulting engineering firms have little knowledge or concern for safety, as no training and minimal overseeing of jobsite safety, and little legal liability.

The database solutions can be sorted by discipline, e.g. architects (40% of suggestions)civil, coatings and insulation. They can be sorted by project component, e.g. piping, Mechanical/HVAC, earthwork, furnishings, handrails. They can be sorted by hazard, e.g. falls, fire, cave-in, lighting, and by project system, e.g. mechanical, sitework, finishes, and masonry.

10 examples given. E.g. 10. Suggestion: do not allow schedules with sustained overtime. Purpose: Workers will not be alert if overtime is maintained over a sustained period.

The Design for Construction Safety ToolBox was built to carry the following features and functions:

- variety of approaches to review a project;
- identification of hazards;
- present suggestions to eliminate or reduce hazards;
- usable format for reports; and
- allow more design suggestions to be added.

**Gornick, T. 1997, 'Making lasting connections', *Appliance*, July pp.41-42.**

Manufacturers of gas and air connectors make safety their top priority in design. As workers manipulate these connectors up to 200 times a day, its important they can connect and release connectors without twisting them – avoiding carpal tunnel syndrome. Worker comfort, workers being more happy, increases productivity. Maintenance people have standard connectors that they do not have to puzzle about when reassembling the system. Leak proof tests ensure equivalence of 1 oz. of Freon lost in 100 years. Connectors are pressurised to several hundred psi of helium pressure, in a vacuum chamber. They are checked for the presence of helium outside the connector. Other tests pressure them to 500 psi.

**'Government has only words for gas safety – Corgi', 1985, *Gas World*, January, p.17.**

10,000 gas installation companies registered with CORGI by September 1984, in a response to the Minister's announcement that "The form of regulations for the control of gas installers is under consideration" in early 1984. Installers recognised that registration would involve more costs, but saw it as a way of getting rid of irresponsible firms. The politicians then identified the Health and Safety Executive as the body responsible for gas safety, following a series of deaths in gas accidents. Colleges, for commercial reasons, are closing down gas training departments, and the black market in gas installers continues to rise. The politicians are yet to bring in any regulations.

**Griffin, H. 1999, 'Courts ruling warnings are not acceptable alternative to safe design', *Trial,* vol. 35, no.1, pp.18-19.**

The Texas Supreme Court and the District of Columbia courts have ruled that adequate warnings of a product's dangers are not a substitute for a reasonably safe design that would eliminate the hazards. However, the prosecution must show that a reasonable alternative design existed. In both cases, manufacturers were fined for injuring users of their product.

**Gulvanessian, H. & Holický, M. 1996, *Designers' Handbook to Eurocode 1: Part 1: Basis of design,* Thomas Telford, London.**

The Eurocode suite "describes the principles and requirements for safety, serviceability and durability of structures…" Eurocode 1 Basis of design is for designers, contractors, code drafting committees, clients, public authorities and regulators – concerned with design of buildings and civil engineering works.

The EN structural codes (e.g. design of concrete structures, design of steel structures) will replace national standards in the CEN group for design and execution for building and civil engineering works.

Chap 1. General. Eurocode 1 provides guidelines for structural reliability and geotechnical aspects of buildings and civil engineering works. It is not for assessing existing structures, nor for construction of unusual reliability considerations, such as nuclear structures, offshore structures, defense works, flexible structures that, e.g. bend in the wind.

Assumptions:

- choice of design and structural system made by qualified and experienced personnel;
- structure executed by appropriately skilled and experienced personnel;
- there is adequate supervision and quality control;
- materials and products used comply with Eurocodes or equivalent;
- structure absolutely maintained;
- structure used in accordance with design assumptions;
- design procedures valid and in accordance with codes.

Principles – must be followed.
Application rules – generally acceptable methods, for which there are alternatives.

Definitions based on ISO 8930:1987. Symbols based on ISO 3898:1987

Chap. 2 Requirements.
Principals: structure and structural elements should be designed, executed, maintained during their intended life, and with appropriate degree of reliability, and in an economic way:

- perform adequately under all expected actions - serviceability
- withstand extreme and frequent repeated actions during construction and anticipated use – ultimate limit state
- not be damaged by fire, explosion, impact, human error – i.e. robust.

Consideration of ultimate limit state and serviceability takes into account the relationship between load and deformation of structures and structural elements.
To ensure robustness, use the following:

- avoid, eliminate or reduce hazards;
- select structural form and design that has low sensitivity to hazards;
- allow survival if individual element or limited part of structure accidentally removed or damaged;
- will not collapse without warning; and
- structure is tied together.

The degree or level of reliability can be adjusted, taking into account:
- cause and mode of failure, ensuring elements that might collapse without warning are given very high reliability;
- the consequences of failure: risk to life, injury, potential economic loss, level of social inconvenience;
- expense, effort, procedures needed to reduce risk of failure; and
- social and environmental conditions in particular location.

Can classify structures as very high reliability (needed for nuclear reactors, dams), high (bridges, grandstands), medium (residential and office buildings) and low (e.g. buildings people do not normally enter).

Design should take account of “all conditions that are reasonably foreseeable or occurring during the execution or use of the structure”: persistent situations (normal use), transient situations (short term construction, repair, exposure), accidental situations (fire, explosion, local failures), seismic situations.

Design working life: e.g. 1-5 years is temporary; 25 years need to replace structural elements; 50 years are most buildings; 100 years are monuments or important structures; 120 years are bridges. BUT – not possible to predict life; maintenance and structural replacement can be related to:
- material properties, e.g. fatigue, creep;
- life cycle costings and relative costings of different solutions; and
- evolving management procedures and strategies for systematic maintenance and renovation.

Clients need to take account of costs: design, construction, use, failure, planned renewal, inspection, maintenance, disposal, environmental aspects.

Durability –fit for use during design working life. Design should give access to structural elements for periodic inspection. The design and selection of structural materials should take account of:
- intended and future uses of structure;
- required performance of elements: whether will be replaced, maintained or long design life;
- environmental influences: wind, snow affect on deterioration of concrete, timber, corrosion of metals;
- composition, properties, performance of materials: use of preservatives and chemical resistant substances;
- structural system: redundancy in structure, and flexibility to withstand changing environmental conditions;
- shape of members, structural detailing: angles that retain moisture to be avoided.
- quality of workmanship, level of control;
- particular protective measures: preservatives, coatings, galvanising; and
- maintenance – considered during design.

Quality assurance.  Use ISO 9000 series.

Quality policy: meet a well-defined need, use, purpose
- satisfy client expectations
- comply with standards and specifications
- comply with statutory and other social requirements.
- ensure quality over total design working life cycle of building or structure.

Quality management.  The quality management selected will take account of:
- type and use of the structure
- structural failures and other consequences of quality deficiencies
- the management culture of the involved parties.

The quality management activities associated with structural reliability are listed; from establishing performance levels and design specifications, to sampling and testing in the execution phase, to certification of maintenance work.   The full life cycle of the building is considered.

The remainder of this publication takes up the engineering design technicalities, under the headings: limit states, actions, material properties, geometric data, modeling for structural analysis and resistance, design assisted by testing, and verification by the partial factor method.

**Gunningham, N., Johnstone, R. & Burritt, P. 2000, *Safe Design Project: Review of Occupational Health and Safety Legal Requirements for Designers, Manufacturers, Suppliers, Importers and Other Relevant Obligation Bearers, A Report for the National Occupational Health & Safety Commission*, NOHSC, Sydney.**

The following is a direct extract from the Introduction of the report (p. 1):

*"This Report provides a review of relevant occupational health and safety (OHS) literature, legislation, regulations and case law in order to provide a commentary on the legal landscape in Australia of a number of obligation bearers with responsibility for safe design.*

*The Report forms a part of the National Occupational Health & Safety Commission (NOHSC) Safe Design Project. The overall aim of that project is to develop a greater recognition of the role of safe design in improving OHS performance in the workplace. The identified principal target groups are:*

- *designers, manufacturers, suppliers, importers, erectors and installers of plant and equipment:*
- *designers, constructors, suppliers, erectors and installers of buildings and structures; and*
- *designers, manufacturers, suppliers and importers of substances.*

*The Project aims to influence these target groups so that they are actively addressing the application of safe design principles from an OHS perspective with the aim of achieving best design solutions which eliminate hazards in the workplace; actively incorporating continuous improvement processes in safe design; and actively promoting safe design principles to their members.*

*A key component of the Safe Design Project is the legal dimension, and in particular the legal requirements laid down by different jurisdictions in Australia. Legal requirements provide* *minimum standards that obligation bearers are required to comply with and indicate the minimum acceptable behaviour expected from obligation bearers. Compliance with legal requirements will usually be the most fundamental driver for all obligation bearers and as such, an understanding of legal obligations and trends and strategies for reform provide a necessary foundation for any exploration of broader strategies to enhance safe design."*

The report addressed the matters described above. In summary, the duties of the target groups could be described as follows.

The "safe plant design" duties of designers, manufacturers, suppliers, importers, and installers/erectors are basically universal, with some exceptions, such as the absence of a designer duty in the Commonwealth and ACT (pp. 22-23).

With regard to the "safe design" of substances, the manufacturer duty is present in all statutes except Tasmania. The supplier and importer duties are also reasonably universal (no supplier duty in Queensland, no importer duty in NSW, and neither in Tasmania). The designer duty is only a feature of the NSW, Northern Territory and Victorian legislation (p. 35).

In the area of the "safe design" of buildings and structures, the provisions differ considerably. In Western Australia and South Australia there are specific designer duties (*Occupational Safety and Health Act 1984* (WA) s. 23(3a); *Occupational Health, Safety and Welfare Act 1986* (SA) s. 23A(1)) (pp. 10-11). However in most jurisdictions, specific "safe building design" provisions are much less apparent or absent. Theoretically, the "public safety" provisions in some jurisdictions (e.g. *Occupational Health and Safety Act 1985* (Vic.) s. 22), could impose a "safe building design duty" however this point may not be clear to those duty holders (pp. 44-45; also see Johnstone 1999). In short, the safe design duties with regard to buildings and structures are not as uniform as those regarding plant and substances

**Guteri, F. (1992) 'Fire down below: The Channel Tunnel's builders prepare for what they hope never happens', *Omni,* vol. 15, no.3, p.24.**

The Channel tunnel runs 31 miles from Dover to Calais, without intermediary access. Eurotunnel has been criticised for allowing passengers to stay in their cars and for the lack of realism in their simulations. All major rail, metro and tunnel disasters were studied, and their lessons systematically applied to the tunnel safety systems.

**Haag, W. 1988, 'Purchasing power', *Applied Industrial Hygiene,* vol.3, no.9, p.F-22 to F-23.**

OHS practitioners should press their organisations to have purchasing policies that specify plant and equipment should be quiet (< 90dBA – NIOSH standard). Purchasing power can be exerted via: selecting noisy equipment needing replacement; develop noise database – using manufacturers, suppliers, trade associations, standards associations. Work with engineering and procurement sections to specify buy quiet in purchasing contracts. Do an evaluated bid price – comparing cost of quiet machines to non-quiet ones, per unit, and determine how much extra company willing to pay for quieter equipment.

**Halligan, J. & Hall, R. 1995, 'FEMA GRAS – A GRAS assessment program for flavor ingredients', *Regulatory Toxicology and Pharmacology,* vol. 1, no. 1, pp.422-430.**

Congress passed the Food Additives Amendment in 1958, requiring the food additive industry to demonstrate their products were safe; requiring the Food and Drug Administration to test and do premarket approval of additives UNLESS they were "generally recognised as safe" (GRAS). To be declared GRAS, congress provided 4 criteria: 1. Safety recognised by qualified experts 2. Experts to be scientifically trained and experienced 3. Judgements must be based on scientific procedures, 4. Intended use of substance to be taken into account.

The Flavor and Extract Manufacturers Association of the United States (FEMA) appointed a panel of experts from outside the industry to determine GRAS status. 1959 industry survey to determine what additives commonly used – most highly complex mixtures of low concentration ingredients. Expert panel considered: adequacy of knowledge of composition of additive, risks of biologically active components, margins of safety. Panel decisions were published as lists, plus data and explanation of panel's decision – in FEMA Scientific Literature Reviews. By 1988 via Food and Drug Admin had recognised the private determination of GRAS status was permissible – put in regulations. Did challenge some decisions by private agencies. By 1976 had recognised the FEMA lists and Reviews as valid. 1994 FDA recognised that absolute safety was an impossible concept.

Substances can only be declared GRAS if the data is interpreted by the experts in the same way and there are many experts who know about the ingredient.

The "Delaney Clause" in the Food Additives Amendment prohibits inclusion of any food additive that induces cancer in man or animals. The courts (1994) have found that GRAS substances need not comply with this absolute requirement – the risk being trivi al. Expert Panels have concluded that substances causing tumors in animals is GRAS for the intended use.

Courts have not defined who an expert is and have accepted panels to date. Panels have included experts in: toxicology, pharmacology, chemistry, biochemistry, medicine, statistics. Scientific procedures usually backed by published studies. Courts have required publication, preferably peer reviewed, and put emphasis on completeness of toxicology studies and degree of investigative control.

Foods eaten for many years with additives are presumed safe. Common use in another country or as a drug or folk remedy or used in only one product is usually not accepted for the "common use" test for GRAS.

Expert Panel uses following criteria for GRAS status: 1 Exposure to substance in specific foods, total amount in the diet, total poundage, 2. Natural occurrence in food, 3. Chemical identity and chemical structure, 4. Metabolic and pharmacokinetic characteristics, 5. Animal toxicity.

Intended use is an important criteria – an additive can be GRAS for one purpose but not generally. Applicants wishing to broaden the use of GRAS substance must ask the Expert Panel for a reevaluation and approval. Uses and use levels are specified in the Review reports.

Panel reviews all GRAS flavor ingredients. Panel reviews individual substances when new data is available. First systematic reevaluation was completed in 1985, and was called GRAS Affirmation. 1993 initiated a 5 year systematic reevaluation program.

**Hitchcox, A. 1996, 'Safety valves help lock out accidents', *Hydraulics and Pneumatics,* vol. 13, no. 6, pp.45-46.**

Following OHSA rule 29 on lock out/ tag out regulations, valve manufacturers have produced valves that disable a machine's compressed air system and allows padlocking, to prevent energising of the machine. Some examples: Swagelok Co. produces valves that can be locked: only closed, or only open, or open and closed and can be padlocked. Watts FluidAir had 3-way valve accepting hasp padlock or scissors safety lock. Schrader Bellows – by pushing the red handle and installing padlock, locks valve in closed position, blocks inlet flow and exhausts to atmosphere. DynaQuip Controls has tamper resistant lock, locks only in closed position, venting down-stream air to atmosphere, and can be fitted with a muffler. Ross Controls valve can block inlet flow and exhaust down-stream pressure to atmosphere when locked in closed position, but "provides safe, gradual buildup of downstream pressure once valve is opened."

**Kletz, T. (1999) 'The constraints on inherently safer design and other innovations', *Process Safety Progress,* vol.18, no.1, pp.64-69.**

Post Flixborough 1974, looked for alternatives to adding on protective equipment. Now: use little hazardous materials (intensification), safer materials (substitution), and materials in least hazardous form (attenuation or moderation). Inherently safer plants cheaper and safer; intensification the best method.

Inherently safer designs adopted more slowly than HAZOP, due to constraints on all innovation. Innovation in plant design takes longer than construction using a previous design. People resist change, as they fear new designs create unknown problems. Following problems from chemical plants in 1960s, due cost cutting innovations, current managers do want innovation.

Despite Flixborough and Bhopal, many managers believe large inventories not hazardous. Inherent safety requires change in design process, not just new technology. Universities do not teach engineers innovative approaches to inherently safe designs. Innovation costs licensors and contractors time and money compared to old designs. Innovations requires selling new ideas.

Companies organise in business areas, not functions (e.g. R&D), so not clear who should be innovating. ICI has developed mechanisms so innovative scientists can cut across business areas.

Industrial chemists see themselves as innovators, chemical engineers, who have not done research degrees, do not.

Innovations now have to get through a bureaucracy, they cannot be implemented by the inventor alone. Large inventories of equipment dampen down desire to change processes or do repairs. Designs with moving parts perceived to be disadvantageous, when they may be safer. Design organisations and senior managers are ignorant and so do not support inherently safe designs (cf. OHS advisors). There is a lack of investigative tools, to assess designs for inherent safety. There is lack of information from manufacturers on the characteristics of their equipment. Design packages do not list equipment inventories and their cost. Chemists do not build in safe designs into chemical processing.

Companies have been moving offshore, to cheaper countries, reducing incentives to develop inherently safe design plants.

Chemical engineering students may have safety in their courses, but rarely “inherently safe designs”.

Companies want to build big plants, not smaller inherently safe plants.

Action needed:

- consider next plant while building this new one;
- need more data on equipment;
- senior management must ask regularly how inventories are being reduced, and the impact of new technologies and allocate monies to innovation; and
- designers must want to innovate within an organisational culture that encourages innovation. Procedures are needed to help designers intensify (using smaller amounts of hazardous materials) – at conceptual, business analysis stages and when developing flowsheets for process design – chemists, chemical engineers and mechanical engineers must be involved in all stages, not sequentially. Hazop studies of line diagrams come too late in the process.

**Lorenzi, N. 1998, ‘Regulatory news’, *Professional Safety*, vol.43, no. 9, pp.8-10.**

Lists 13 manufacturers' recollections of potentially hazardous products, involving 100,000s of items. Associated Builders and Contractors is conducting seminars on fall protection, for metal building systems industry. American Society for Testing Materials is conducting compliance training on paint volatile organic compounds and complying with EPA and state authority regs.

**Lunch, M. 1994, ‘ “Safe place” laws may entrap designers”, *Building Design & Construction,* March, p.29.**

In Illinois, USA, some architects and engineers have been fined (up to $215,000 each) for being “in charge” of a construction site where an accident occurred – 1 a trench cave in injury; another a bosun’s chair collapsed. Most recent decision: architect found not liable, applying 7 factors to determine “in charge”: party 1. supervised or controlled work, 2. Retained the right to supervise or control, 3. Participated in ongoing activity on site, 4. Supervised subcontractors, 5. Responsible for on-site safety, 7. Had right to stop the work.

**Madison, R. 1996, ‘Abstract. Fire Safety in Airport Traffic Control Towers’, *Proceedings of the Interflam ’96 Conference,* University of Cambridge, England, pp.875-879.**

Most air traffic control towers were built before the Life Safety Code, ensuring employee safety in the workplace, was devised. The Occupational Safety and Health Administration enforces the code, and found many towers nonconforming, in 1989. A licensed fire protection consultant surveyed these towers, and recommended Fire Safety Guidelines 1991 and 1993. The Federal Aviation Administration codes are more stringent than some fire codes on some matters. E.g. the internal exit stairwells are well pressurised, to ensure that smoke does not accumulate in the stairwells, allowing quick evacuation by occupants. Smoke is actively ventilated to outside, at each level in the tower.

Base buildings are fire rated from the towers for 1 to 2 hour fire resistance. Emergency electricity supplies keep key traffic control equipment going, and maintain the air pressure fans in the stair wells. Safety systems include: an alarm, fire control panel, annunciation panels and auto dialer.

**Major, M. n.d., 'The end-user's vital question: How safe is safety equipment?', *Occupational Health and Safety,* pp.48, 50, 52.**

Purchasers of safety equipment in USA are unsure how safe the equipment is. Testing, setting of standards, certification and enforcement are usually done by different agencies. Standards for safety eyewear, fire protective clothing, disposable clothing and respirators are devised by different agencies. American National Standards Institute and National Fire Protection Association write processes or performance standards, leaving it to third parties to provide the detailed data. Manufacturers can claim approval from standards organisations when it is not approved, but the standards organisations cannot take legal action. The Industrial Safety Equipment Association has called for enforcement of claims. Cabot Safety Co. has found up to 30% of the safety equipment they were importing was defective. State enforcement agencies are influenced by the political trend for "less government" and so enforce little.

OSHA is the major enforcement agency – but lacks funds and manpower. Its enforcement enabling Act has not kept up with the number of standards it has otherwise recognised. It does not inspect many factories, except where accidents are reported.

Du Pont uses dynamic testing of its asbestos safety clothing and requires its garment manufacturers to be third party certified. Sellstrom Manufacturing has educational programs through farmer organisations and schools – promoting standards for safe eyewear. 3M tests its respirators in workplaces.

Many companies insist on third-party certification of the manufacturers of the products they sell – but end users are not aware of certification. Certification is still voluntary. Certification does not stop manufacturers sending inferior products to market.

Testing is expensive. Hearing standards testing is so complex, there are only 3 labs in the USA that do it.

ISO 9000 process may be part of the answer.

**Meacham, B. 1996, 'Performance-based codes and fire safety engineering methods: perspectives & projects of the Society of Fire Protection Engineers', *Proceedings of the Interflam '96 Conference,* University of Cambridge, England, pp.545-553.**

The USA is considering replacing prescriptive fire codes with performance based fire codes. The Society of Fire Protection Engineers is concerned that a performance based code may be introduced before the necessary documented engineering practices (e.g. acceptable design approaches) and the documented tools and methodologies (e.g. equations, correlations and fire behavior models) are available.

The requirements of performance based codes may be satisfied in two ways: carrying out the prescriptions in regulations OR by proving that the proposed design meets the performance standards. The performance standards are a reflection of the health and safety needs of the community.

The performance standards should be written by a broad cross section of key parties, including: building owners and managers, architects, engineers, construction contractors, building officials, fire officials, product manufacturers and insurance companies.

In contrast, the engineering practices, tools and methodologies should be written by fire engineers and fire scientists. The practices, tools and methodologies need to be researched and peer reviewed.

The Society of Fire Protection Engineers has promoted performance-based codes via its bulletin and journal. It has put together performance-based design methods in its Handbook. Its members have formed Engineering Task Groups to develop practice documents, e.g. on thermal hazards of flames, and tools, e.g. on computer fire model evaluation. It has yet to develop practices on such matters as: active and passive system designs, risk and hazard assessment techniques and building fire safety analysis and design.

**Meeks, C. & Brannigan, V. 1996, 'Performance based codes: economic efficiency and distributional equity', *Proceedings of the Interflam '96 Conference,* University of Cambridge, England, pp.573-580..**

Governments regulate the building industry as tacit recognition that the market place will not deliver an economically efficient level of safety. There is no agreement on what level of safety is desired, but "society wishes to realise the maximum social benefit while minimising the joint sum of the cost of injuries and the cost of injury avoidance activities."

A performance based building code will seek to force companies to internalise the cost of the risk of injury to people from the failure of the building. There is an insurance anomaly: workers compensation insurance is high cost, people injured by building failure is low cost. Buildings usually only carry a $ 1million or so risk insurance, but risks of employees' injuries are insured for several million. Statute of limitations for claims against builders relate to time after construction, not time after a disaster. Courts do not pay the full cost of injuries to damaged occupants, and do not award costs of damage to property.

To overcome these problems – performance based building codes should require building owners or operators to carry compulsory, strict liability insurance, based on adequate building design risk analysis.

Prescriptive codes create economies of scale for standardised fire safety systems, performance based codes do not. Performance based codes increase information search costs. Fire brigade costs, and injuries to firemen are not included in the cost of buildings.

Engineering analyses of risk can produce overall low risk and low cost, while, for example, sacrificing one third of a stadium crowd and the handicapped, while allowing complete protection for the remainder of the crowd. Fire risk must be distributed equitably.

Social factors also determine design: local interpretation and enforcement of codes. In hurricane areas, insurers want the standards raised, builders do not, due to increased building costs. The USA government regulates insurance costs, but not building costs. Performance based building codes allow for greater miscalculation of risk, and so insurance uncertainty, than prescriptive codes. Workplace health and safety and environmental toxic exposures are frequent events, compared to natural disasters. Insurance costing is harder for buildings than workplaces and environmental pollution. Mathematical models of risk cannot take account of new technology, encouraged by performance based codes. A level of uncertainty should be calculated for the risk estimate of the building design.

The economic efficiency of performance based building codes should be questioned.

**Mongeau, E. 1999, 'Building a fire-safe dorm', *NFPA Journal,* January/February, pp.60-64.**

Northeastern University, USA, has built 165 flats (for 600 students), in two buildings, 13 storeys and 6 storeys high. The design takes account of students ability to circumvent and abuse safety devices. Fire safety, personal safety and physical security are design features. The design project team included people from the University's departments: plant, maintenance, fire safety, public safety, and residences, with the external architect and general contractor. Fire safety and security are in the one department, ensuring a balance between the 2 needs.

Safety and security features include: trained receptionist, 24 hour a day, to check id cards of student residents and guests. Entry is only via one entrance in each building; emergency exits have crash bars, local alarms and are linked to the fire alarm system. Smoke doors, often jammed open by students, are held back magnetically. When a fire alarm goes off – it overrides the magnet hold, closing the door. The fire detection system is linked to individual alarms, sprinklers, smoke detectors and speakers in each flat. There are also push-alarms in flats and communal areas. These are linked to systems that move all lifts to the first floor, unless the emergency is on the first floor. There are connections to the local police and local fire brigade stations. The central control panel also registers when an alarm has been disabled or needs cleaning. Strobe lights are associated with fire alarms in the flats for disabled students. 2 full time staff and 180 student employees do weekly building inspections, monthly fire extinguisher inspections and quarterly fire drills.

**Morris, R. 1994, 'Safety in depth', *Railway Gazette International,* vol. 150, no. 5, supplement, pp.14-17.**

A Safety Authority gives independent advice to the Intergovernmental Commission for the Channel tunnel, between France and England. Costs escalated for the Eurotunnel construction group, because the Safety Authority sought to eliminate any risk or combination of risks, even if they had an extremely low probability of occurrence. Subsequently, Eurotunnel's concession was extended by 10 years.

The Eurotunnel group's response was a culture that promotes safety at every level. In reality, tunnels are very safe, eliminating level crossings, vandalism and the weather. Tunnel accident figures are given.

It was decided to build 3 parallel tunnels – a railway running tunnel for each direction and a central service tunnel. The 3 tunnels are linked every 375 m. Air is supplied to all 3 tunnels via the central service tunnel, keeping it at positive air pressure all the time. At 6 points in tunnel, train can cross over from one running tunnel to the other.

Eurotunnel developed 5 safety strategies: 1. Drive to design, engineer, manufacture safe equipment and safe systems, planning out hazards, 2. Recruit high-caliber staff, with right personality and trained in pro-active safety culture, 3. Produced first Safety Case for transport,

4. Rules for operating the tunnel approved by independent safety experts, 5. Dynamic safety management system & quantitative audit process, 6. Root cause analysis of accidents and incidents.

Incident investigation essential, as 600:1, incidents to accidents. Assumes culture of trust. Gross misconduct or disregard of safety rules still disciplined.

60 kg per meter rails laid on raised concrete blocks, on rubber boots, cast into solid concrete base; the withstand the estimated 240 million gross tons p.a. at high speed. Walkways will keep derailed trains upright.

Electricity: 360 MVA for traction and 60 MVA for pumps, fans, lighting. Provisions allow electricity from both grids, one grid and emergency diesel generator.

Signaling system tracks braking of trains. Driver cannot go faster than display allows, but can drive up to 35 km/hr. when receiving no code.

3 control rooms: one for road and terminal traffic flows, one for trains and power and plant, and one emergency control room.

Communications. 3 optic fibres, one in each tunnel, in steel pipes. Can still work when cut. Telephones connected to national grids. 4 radio systems: Concession for Eurotunnel staff, Track-to-Train Radio for railway cab to control room, Shuttle internal radio for crew and passengers, tactical radio for emergency services.

Fire response: detectors on trains and in tunnel; fire barriers between wagons and underneath each wagon. Fire resistant and minimum smoke materials used.

5 lines of defense: 1. Prevention on train patrolled by 6 attendants, ensure no smoking and car bonnets not lifted. 2. Detection – devices linked to evacuation messages on train, fire proof shutters at each end close, but passenger pass beside these. 3. Suppression – fuel drains into holding tank with smother agent; in carriages halon 1301 discharged if fire life threatening. 4. Containment, fire contained within wagon for 30 minutes, while reaches emergency siding. 5. Evacuation of passengers to: another part of train, or burning wagons uncoupled or safe haven in service tunnel.

Trouble free transport of vehicles on open wagons in Europe – so NOT used enclosed wagons with Halon 1301. Hazardous goods banned from tunnel. If fire – status 1. Trains following stop, train speed reduced to 100 km/hr so tunnel interconnections closed, train air intakes close, suspect train to emergency siding at terminal. Status 2. Suspect train stops, uncouples cars and exits, or if unable to uncouple, personnel evacuated to service tunnel; trains behind reverse.

Staged evacuation if accident: 1. From burning vehicle to adjacent vehicle, 2. From burning section to non burning and uncoupling, 3. Immobilised train to service tunnel, 4. All trains cleared from tunnel.

Service tunnel has special diesel powered vehicles which can be used for maintenance or evacuation. Travel at 80 k p h and reach mid point of tunnel within 20 minutes.

Bi-national emergency simulated, to avoid problems arising from different emergency response control systems in France and UK.

**National Institute of Design 1992, *Reflections on Design: Twelve Convocation Addresses*, National Institute of Design, Ahmedabad, India.**

Safety is mentioned twice in this 131 page document. There is a concern that professional designers assist the poor of India; that “design” takes into account: the environment people work in, the life style of the people and that the details are attended to. Helping the nation of India is one of the aims of design.

**Oakes, L. c.1986, ‘Suppliers’ health and safety information on substances for use at work’, n.p. pp.26-33.**

Section 6 of the Health and Safety at Work Act 1974 requires manufacturers of substances to provide information. 11 years later – manufacturers and suppliers still not providing adequate safe-handling information about substances.

Users do not have the knowledge to check the information provided. For complex substances or where its composition is unknown – even experts depend on experience of manufacturers and suppliers. The Draft Code of Practice on Substances Hazardous to Health refers to section 6, when users want more information than is on label or supplier’s information sheet.

Experience of users:

- no information is provided when requested under section 6, or product technical data provided;
- information supplied is incomplete, or does not tell you what to do about the hazard identified;
- information is unreliable or inaccurate, playing down the risks;
- information is incomprehensible;
- information is out of date;
- no references are given, or chemical composition is not given – preventing verification of the information;
- content and format of information varies, making safety comparisons between substances difficult;
- precautions are given, but their basic chronic effects not indicated; and
- no testing data mentioned.

Barriers to good information:

- section 6 too vague to legally enforce and Health and Safety Executive enforcement powers are weak, there is no Code of Practice, so onus is on prosecution, not defense, to prove their case where information is inadequate;
- section 6 information does not have to be provided to HSE;
- ignorance of suppliers and users – large companies lack expertise, and medium to small companies do not even know their H&S duties and obligations;
- those who write the information often do not fully understand the implications of the raw data they are trying to interpret, resulting in such terms as “provide adequate ventilation’;
- if your competition is not complying with section 6, there is no incentive for you to comply;

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- trade secrecy is often used as a reason to supply data on a strictly confidential basis, or to provide no information at all, especially the components of the substance. Trade names are also often supplied; and
- chemical composition is a prerequisite of adequate knowledge.

USA hazard ratings, placarding, labeling, MSDS and accessible data all part of legislation. All MSDSs must be made available to government agencies. Guidance is given on the wording in MSDSs, to ensure lack of ambiguity, specifies a minimum standard of information, and makes comparisons between substances easier.

Need a simple guide from HSC/E using categories on how to handle specific substances. Each substance can be coded to relate to a specific handling category. There could be separate categories for: fire & explosion, reactivity, first aid, toxicity.

**Parkinson, G. 1996, 'Proposition 65 lawsuit targets 'bountyhunters', *Chemical Engineering,* March, p.46.**

A group of chemical manufacturers have taken the State of California to the federal court, alleging the law based on proposition 65 contradicts and violates federal worker safety and hazardous substances laws and the large number of private lawsuits hinders interstate commerce. Proposition 65 was passed in 1986 by referendum; it says manufacturers must provide a "clear and reasonable" warning about their products to employees and the public. Anyone can file a legal case, and collect up to 25% of the fines, which can go up to $2,500 per violation per day. 450 complaints have been lodged, only 3 gone to court, rest settled out of court. Law is vague on what a "clear and reasonable" warning is.

**Peaff, G. 1996, 'C|MA initiatives set activists agenda', *C&EN*, November, pp.23-24.**

US Chemicals Manufacturers Association is improving the credibility of chemical manufacturers with local communities via their Responsible Care program and with environmentalist via the Chemical Transport Emergency Center. They will increase the impact of their science and influence by spending more on their political action committee, lobbying politicians at all levels. They will spend money on health and environmental research. They are embracing sustainable development.

**Quaglia, C. 1994, 'Engineering systems versus prescriptive systems', *Fire Engineering – the hot issues, Southern Engineering Conference,* paper 11, The Institution of Engineers, Australia Queensland Division, 22 pages.**

In 1994, 70% of the Building Code of Australia index had titles related to fire, most of them prescriptive. Prescriptive systems comply strictly to the code; fire-safety systems are fire-related features of design. The latter are cheaper. Technical fire codes go back to 1666, but science based ones, open to performance testing, are only from the 1920s. The fire safety system method: determine likely fire scenarios, calculate level of hazard, adjust system to overcome excessive hazard.

Prescriptive requirements in the building code are determined by fire people, who draw on: experience, empirical knowledge, common sense and science. Details are then prescribed in Australian Standards. Central to the code is the occupancy classification, which takes account of more factors than fire risk. Prescriptive regulations easy to enforce by authorities and building industry worked comfortably within them, looking for trade-offs and cost savings. Problems with prescriptive approach: high cost, limited trade-offs, difficult to interpret for complex buildings.

Fire engineering approaches are not necessarily engineering systems. For example, fire engineering approaches that work within the prescriptive framework: smoke extraction systems designed within a prescribed smoke flow rate; sprinkler systems designed within prescription of delivering given amount of water.

Engineering systems: a system of fire-safety features that theoretically delivers Building Code objectives. Engineering science and calculation predicts the control of forces, replacing trial and error and empirical methods. Only last 6 years has fire-safety engineering been established as alternative to prescriptive Code. The designer defines the objective to be achieved, the magnitude of the hazard needed to match a given performance. E.g. the hazard "amount of smoke produced" must be matched with the performance "a room configuration and exhaust fan removing that smoke".

7 key fire-safety objectives: 1. Safety of irreplaceable individuals, 2. Safety building occupants, 3. Effectiveness of Fire Brigade intervention, 4. Stop fire spreading to other buildings, 5. Business continuity, 6. Protection of irreplaceable items, 7. Protection building contents and structures. 5, 6 and 7 not in Building Code of Australia.

For each scenario associated with an objective, a hazard loading and performance are calculated.

E.g. of hazard loading: heat output versus time = fire scenario. Experimentally determine the calorific value at various times for given room configuration. 4 quadratic curves been identified to express the fire development over time. Then calculate effect of activating sprinklers at various times. CSIRO research: sprinklers will stop a fire growing, but will not put it out; but need more statistical information.

Performance specifies the measurable outcome from an objective; e.g. Objective: safe egress; Performance: hot-smoke layer remains above occupied levels; Measure (e.g.) smoke at least 2 m above floor.

Calculation methods: embodied in computer programs. E.g. CSIRO's FireCalc, with 24 modules. E.g. can calculate exposure temperatures, by inputting: heat of fire, burning area, temperature, optical density of smoke and enclosure ceiling height. Other examples given.

Research still being conducted on under-developed area of risk-based design, based on alternative strategies, such as life-safety parameters or unacceptable events. Risk-based design methodologies arises from: risk analysis embedded in engineering process of key components; and relies on deterministic engineering methods.

Not good to mix prescriptive and engineering systems approaches in one building, except: where in independent parts of the building, prescriptions no impact on objectives of engineered system, prescription has satisfactory engineering basis.

**Risser, B. 1995, 'How concrete contractors deal with government regulations', *Concrete Construction*, January, pp.34-37.**

*Concrete Construction* interviewed an unstated number of concrete contractors. Of all government rules, compliance to safety regulations affected their business the most. There is more inspection and greater fines than 10 years ago. However, the industry has found safe jobs are efficient jobs, and are good for the industry and for economic income. Contractors find they have to remind employees of safety all the time. Paperwork and bookkeeping requirements have gone too far. However, insurance is a greater driver than OSHA standards. Many contractors are full time safety directors.

Concrete contractors prefer private inspectors to government ones; the latter do not understand field operations. Contractors are developing internal quality control programs and forming partnerships with testing laboratories. Greater control over their operations helps contractors bid for work.

Local contracting organisations are essential to keep contractors up to date with regs. Contractors use these organisations to change specifications to reflect latest technology. Similarly they rely on groups like the Associated General Contractors to lobby federal regulatory agencies.

Formal partnering agreements becoming popular, between: owner, general contractor, subcontractors, architects, engineers, testing firms.

**Roodman, D. & Lenssen, N. 1995, *A Building Revolution: How Ecology and Health Concerns are Transforming Construction,* Worldwatch paper no. 124, Worldwatch Institute, Washington.**

Buildings that use less energy, use water more efficiently, use non toxic materials and building projects that include bike paths are better for the environment and for people; and often save on running costs. Otherwise buildings damage the environment and human health. The size of houses has increased as size of families have decreased.

The production of energy and materials has become specialised and remote from house designers and engineers who must make climate compensations for houses that use energy inefficiently. Owners of buildings rarely build them. Fear of financial loss and litigation keep building designs conservative.

Natural disasters, hurricanes and earthquakes, show that many buildings do not conform to local building codes. US 1 in 3 houses well maintained, due shifting work population. Buildings in Japan often demolished after 17 years, due to rising property values. Beijing – people do not like the new housing, as it destroys the sense of extended family and local community.

US – mass assembled parts linked by semi-skilled workers to make homes. Sweden – smaller parts are assembled by skilled workers using specialised tools = quality product, environmentally friendly and healthy. Quality office buildings cut absenteeism by up to 15%.

Buildings need to be flexible – e.g. floor plans change up to every 3 years, plumbing and wiring 7-15 years, exteriors every 20 years.

Buildings originally derived their aesthetics from local materials being used to suit local climates. Now buildings ordered and designed in non-local places. The same design is used repeatedly. Economics has lead to office blocks and industrial buildings being made in simple geometric shapes.

Materials used for building require quarrying, refining, giving off pollution. German and US health ministries are considering banning plastics in buildings, due carcinogenic by products of incineration. Use of timber in housing has lead to forest destruction. It is hard to dispose of materials from demolished buildings and newly constructed buildings.

Running buildings is taking over 34% of the World's energy use, and its rising. Water is diverted from agriculture to cities and to cool electricity generators.

"Sick building syndrome" occurs in 30% of new or renovated buildings; including the recycling of Volatile Organic Compounds from synthetics in carpets and furnishings.

Criteria designers use to select materials: ease to work with, insulation, block air leaks, strength in compression & tension, fire resistant, moisture damage, biodegredation, aesthetics, & cost. Ecological concerns: pollution history of product, minimise transport & processing, avoid toxin emitting products, use renewable and recyclable materials. Design buildings to be durable & flexible. Earthen dwellings should be preferred.

Recycling: in Sydney, glass, steel and concrete were sorted during demolition of a skyscraper, and sent to recyclers.

Need more buildings that the design results in nil artificial energy inputs for air conditioning to control the indoor climate. Ken Yeang, Malaysia, has adapted climate control in skyscrapers to tropical conditions: building orientation minimises solar input & maximises breeze capture, vegetation on above ground balconies and courtyards provides sun shade. Fresh air is ducted into the inner parts of buildings via the courtyards.

By identifying leaks, regular maintenance and using efficient fluorescent lights and appliances, energy usage can be dramatically cut. Use of solar hot water systems, solar generated electricity and recycled grey water add further savings.

Environmentally sound house designs and housing projects adds $ value to the properties.

Energy efficient and environmentally sound offices increase productivity by 6 to 16% and reduce absenteeism.

New government regulations, in various countries, have: reduced death tolls from earthquakes (Kobe), saved energy costs via energy codes (California) and improved indoor air quality (European Union). Codes and standards do not educate, nor do they encourage innovation. Need for value changes by engineers and architects, and more post occupancy evaluations. Education, demonstration projects and design competitions needed for architects, engineers and the buying public. Points can be awarded for features that go beyond the rating code. Real estate agents, and money lenders need to understand the lower risks from energy innovative projects. Canada – can get lower mortgages for energy efficient rated homes. Some energy and water utilities also give rebates.

Some government agencies, e.g. EPA USA, enter into partnerships with industry, to increase knowledge of energy efficient designs. Governments need to stop subsidising waste of energy via tariffs and taxes.

Nederlands, 1989 and 1993 National Environment Policy Plan (NEPP):

- improve energy efficiency in new and renovated houses, 25% by yr. 2000
- increase reuse and recycling construction and demolition waste, 60% by yr. 2000
- half use of toxic materials
- eliminate use of unsustainably produced tropical timbers.

"Since 1990, the Dutch government has worked with architects, developers, contractors, building associations, and residents' associations to assemble an action plan to meet NEPP goals." A non-government agency has set up an information center.

**Russell, R, Maidment, S., Brooke, I. and Topping, M. 1998, *Annals of Occupational Hygiene,* vol.42, no.6, pp.367-376. NOTE: only 3 pages, 367, 375, 376 supplied.**

From abstract: The Control of Substances Hazardous to Health (COSHH) Regulations 1994 require employers to conduct risk assessments and control exposures. Small firms need simple advice on control measures. The UK Health and Safety Executive has developed generic risk assessments and control guidance sheets, which identify good-practice examples. HSE has identified key intermediaries to disseminate this information.

Detail (p.367): UK Health and Safety Commission has identified occupational exposure limits for about 600 of estimated 100,000 substances of commercial chemicals. Small firms lack expertise and monitoring equipment to conduct risk assessments. A 1997 survey found exposure limits not used for most workplaces risk management.

pp.375-376. HSE's guidelines use R-phrases, simple definitions of physical properties and scale of use, and avoids technical jargon. Suppliers are the key intermediaries used to disseminate information. A cautious approach has been adopted in writing generic controls – not over-precautious, which would deter dissemination and use of the controls proposed; but cautious enough to protect most workers. R-phrases assign a chemical to a hazard band, for use in deciding labeling, packaging and determining the level of exposure needed to be achieved. The scheme relies on suppliers to accurately use the R-phrase scheme.

Problem that this simple scheme may replace the use of "occupational exposure levels"; which should be used by firms with expertise, or who can buy in expertise. Given the low awareness of these exposure levels, and lack of resources by small firms, best that exposure levels be restricted to "widely used substances of concern" and that small firms use the simplified, generic system. HSE working on electronic version.

Exposure best reduced at source – the equipment designed to use the chemicals. The European Community's "Use of Work Equipment Directive" seeks to do this, but is primarily aimed at improving safety, not health risk.

**Sinnott, R. 1985, *Safety and Security in Building Design,* Collins, London.**

In general, building related accidents and ill-health, crime and vandalism must be built into the ergonomic design of the building.

*Chap. 2 Fundamentals of Safety Design.*

Ergonomics – relationship of people to machines they use, including buildings (US – human factors, human engineering, engineering psychology). Principles: comfort, efficient use, lack of fatigue. Primary safety: freedom from accidents; secondary safety minimise effects of accidents (e.g. rounded corners on columns, where people might fall); tertiary safety: minimise long term effects of accidents. Accident type (fall from heights, struck against) and environmental conditions (noise, ventilation) useful data to designers from accident data. Author produced own checklist that includes these and consideration of bodily characteristics (e.g. jewelry that could catch in things). The example of the horizontally hinged window used in high rise flats was used to illustrate the use of the checklist.

*Chap. 4 Anthropometrics and Physical Performance.*

Designers must consider:
- prevent over-exertion, stooping, over-reaching, working off the ground;
- body size and physical capabilities of building's users
- impairments of aging, temperature, alcohol
- children and their behavior.

Many human characteristics distributed via bell shaped curve – few at measured extremes, most in the middle. If designing for majority – individual may be near middle on one dimension, but more extreme on another. Usually use 90th or 95$^{th}$ percentile. Lack anthropometric figures for various ethnic, regional and socio-economic groups.

Balustrades – center of gravity is pelvic area, problem for taller men. Heights of work benches, including kitchen working surfaces, must take account of muscle fatigue – and that bending puts strain on back ligaments, not back muscles. Extreme temperatures and alcohol makes us clumsy.

*Chap. 5 Health Hazards.*

Sources: materials and equipment in buildings and restricted means to disperse the pollutants. Symptoms: headaches, stuffiness. Serious illness includes respiratory infection, heart disease. Houses more sealed up, e.g. removal of chimneys, but outside air drawn in is cleaner.

UK, radon in buildings: 50% from the ground, 25% from building materials, 25% from outside air. Granite twice as much radon as clay brick. Trade off between ventilation flow and heat loss. Can use sub floor ventilation, and seal off areas. Nitrogen dioxide (from vehicle exhausts), carbon monoxide and carbon dioxide (gas fuel combustion products) are other building gases needing good ventilation and flues on heaters. Formaldehyde comes from insulation materials, particle board, carpets, furniture, humans. 10-20% population irritated by low concentrations of formaldehyde. Lead is taken up in food and drink. In buildings from: car exhausts, paint, plumbing. Asbestos is a carcinogen. Found in asbestos-cement, mastics, textured paints. All right if products are sealed and cannot weather. Unknown health hazards from other mineral fibres.

Need washbasin for every toilet, to prevent spread of gastro-intestinal infections. Planned water tower maintenance should prevent Legionella's disease.

*Chap. 6. Glass and Alternative Materials.*

Annealed glass most extensively used in buildings and most dangerous – splinters and produces shards on impact. 32 000 injuries from unrepaired glass per year in England & Wales – 47% people under 15 years old. Windows, louver windows and glass in doors major problem. Most danger from glass less than 1500 mm from floor. Annealed glass vulnerable to vandals and burglars.

Considerations for installing glass; in this area of the building does it have to resist – impact, accidental penetration by a human body, vandals, determined criminals, armed criminals, explosion, fire? No standardised test for glass – usually a ball falling against it. Test for "not break" and "break safely" glass, using 100 lb. of lead shot in a leather ball described (BS 6206-1981). Based on 100 lb. child. Can calculate grade of glass needed by knowing weights of individuals and speed they are likely to impact the glass at.

BS 5544-1978 is a test for anti-bandit glazing – uses 5 lb. steel ball dropped vertically onto the glass.
BS 5051 Security glazing, specifies gun shots various types of glass will resist.

Factors, other than safety and security, to consider: optical quality, stability, durability, maintenance, fire resistance, cost, insulation.

Alternatives: wired glass, toughened (tempered) glass (high compression strength – breaks into small cubes), laminated glass (2 + layers of glass with toughened plastic in between – when smashed, glass stays stuck to plastic, cracks easily). Can wire laminated glass be used to make it more visible? Class B safety glass produced by using polyester resin rather than plastic. Laminated glasses used to resist sledge-hammer attack, and resist bullets. Polycarbonate layers or sheets can be used to intercept flying splinters. Need engineer designed framing for explosive proof glazing.

Plastics as alternative to glass: tougher, optically inferior, less stable and durable, need more maintenance, combustible, expensive. Will bow if temperature or humidity differential on either side. Will distort under expansion and contraction. Will deteriorate under UV exposure. Not scratch resistant. Detailed analysis of polycarbonate, acrylic, PVC and polystyrene & glass given. Thickness and glazing considered.

*Chap. 8. The Spatial Environment.*

Examples of vulnerable areas of buildings: kitchens for accidents, public toilets for vandalism and storerooms for theft.

Safety: keep walkways from buildings, else pedestrians walk into open windows or doors. Keep pathways away from fuel inlets.

Around tall buildings, wind speed increases, so provide railings or protective walls to stop elderly being knocked over, especially when there is a frost. Separate pedestrians on raised pathways from vehicles. Vehicles should only go one way.

Earth bank or barrier necessary at bottom of hills where trucks go, or on bends.

Do not allow workshops or kitchens to be throughways. Minimise distances people have to walk. Where cars exit from blind spot in building, provide road hump, to they don't hit pedestrians.

Kitchens and workshops need to be ergonomically laid out, each work activity separate, with sufficient room to do the job. Put cooking appliances 300 mm from edge of bench, to prevent child access. Most frequent kitchen trips are between sink and surface cooking areas – should be adjacent. Work triangle: sink – cooker – refrigerator. Slide pots and pans from hob onto adjacent surface.

Service ducts and pipes – avoid, e.g. pipes running from pathology dept through kitchens in hospitals.

Keep customer car parks separate from employees, and good distance, but visible, from buildings. If car park close to building – put in small wall, to prevent vehicles breaching the building.

Vehicles carrying cash have to be near building – so use lockable posts that otherwise prevent vehicle access.

*Chap. 9. Lighting, Power Outlets.*

Eye adapts more quickly to increased brightness and more slowly to decreased brightness; even slower in the elderly. Good lighting produces absence from glare and models shapes to show their solid form. Glare most common from: windows on stair landings, skylights, artificial lights in user's view, highly reflective surfaces. Use additional interior lighting, set window in splayed frame, baffles, tinted glass. Keep when want to dazzle intruders.

Stairs – greatest problem is lighting from below, from front door. Need lighting above or beside, to show edges of each stair. Shadow over part of stairs leads to mis-stepping.100 lux for most safety applications, including stairs, circulating areas.

Need 0.2 lux over center line of emergency escape routes. Can use photoluminescence outlines of emergency features (including stairs).

Electricity and gas outlets covered by regulations. Avoid electrical adapter plugs. Busbar tracks with outlets every 100-200 mm allows for flexible delivery of power.

Electrical outlets 300 mm above floor put within stooping distance of elderly, 1 m most comfortable for everyone.

*Chap. 10. Walls, floors, roofs, balconies.*

Safety: rough textured surfaces and edges (e.g. on bricks) dangerous for children. Light reflecting from glass buildings can dazzle motorists. Floors – to avoid slipping, friction between the sole-heel of the shoe and floor surface must resist maximum horizontal forces. As people walk faster, need a higher coefficient of friction (horizontal force / vertical force = a constant). Recommend 0.4 for normal safety, and COF of 0.5 in industry. Must consider: footwear worn, degree of floor wear, wetness or waxiness, maintenance. Moving from slip-resistant surface to one less resistant, and when changing direction may result in domestic slipping. Details of material of flooring vs. degree of slip resistance given. Need extra traction on ramps, e.g. roughened or grooved concrete, plus handrails and wide enough for wheel chairs.

Roofs: If no stairway to roof needing maintenance, provide fixed ladders within cage, preferably at 15 degrees to building. Where not using fixed ladder – provide bracket for tying or resting of ladder.

Where roof will not support person's weight – need warning signs and guard rails around or protective coverings. Walkways on roofs must be constructed according to regulations. Balustrades and barriers at edge of roofs and balconies where building occupants have access – assume involves children and so sphere of 100 mm should not pass through gaps.

Chap. 11. Stairways and Escalators. Steps and stairs in houses result in 250 000 hospital treatments p.a. in UK. Design features:

- direct attention to presence of stairs
- clearly define steps
- steps should be of a suitable dimension
- handrails for support, balustrades to prevent falls
- limit distances people can fall, and remove anything they could hit against
- avoid need to decorate or do maintenance above the stairs.

*Chap. 12 Doors.*

Glazed doors – can be fatal if uses annealed glass; especially where push or strike door to close it. Children: can dispute access or fall against glazing; and doors slammed by the wind. People can walk into glazed doors. If must use translucent material -–plastics best. If must have glazing, not below 1500 mm for children.

Swing doors – must be able to see shortest person on other side – vision at 750 mm above ground. Fingers can be caught on hinge side of door. Heavy swing doors can injure the elderly – should be electro-mechanically operated, and slow closing.

If have to squat to use oven or cupboard, should not be near a door. Doors on adjacent walls should not be near each other. Bottom of stairs and doorways should not open onto same space, nor open onto stairs without a landing. Door handles and height of cupboard doors considered.

*Chap. 14 Windows.*

People can walk into a glazed window. 300-800 above floor, use safety glass/plastic to stop injury to children. Pivoting and inward opening windows should not be used in thoroughfares. People can fall out or be damaged when window stuck and they push too hard to release it.

Should not be able to lean out of upstairs windows. Windows should not be above stoves or other dangerous places.

Cleaning and maintenance of windows leads to people falling out of high rise flats and being killed. Even when window can be opened for cleaning, people lean out too far and fall. A tilt and turn window – tilts and held by a stay at the top for ventilation, and turns inward for cleaning – but whole window should not be more than 600 mm deep – to allow reaching of whole window for cleaning by occupant.

Better to use professional cleaners on a safety balcony, with a lifeline attached. Details given. Travelling ladders, anchored and travelling on the roof, provided a caged ladder that allows access to large angled or vertical window areas. A few automated washing heads for cleaning entire high rise windowed buildings.

Window may be held on to when fixing a banner or by children – should be able to hold perpendicular force of 500 N for one minute without shock; and 1000 N for one minute with some damage.

**Swackhamer, R. 1995, 'Responding to customer requirements for improved frying system performance', *Food Technology,* April, pp.151-152.**

Quality Function Deployment is a technique to examine what the customer wants with how those wants can be satisfied. A series of more detailed matrices can be set up, ranking the 'hows' to the wants of the customer. In the case of the customer needing to commercially fry their food products, a matrix of Wants and Hows would include:
<u>Wants</u>
Quality food products
Proper product handling
Long oil life
Proper cooking
Minimum processing costs
Initial costs
Operating costs
Long equipment life
Adequate capacity
Flexibility
Social responsibility
Safety
Environmental issues

<u>Hows</u>
Conveyor design
Effective filtering [of oil]
Remote oil heating
Systems analysis
Field support
Effective controls
TQM & ISO programs
Sensors
Thermal insulation
Emission devices.

**Swane, R. 1994, 'A building revolution in Australia', *Proceedings of the 7th National Conference of the Australian Institute of Building Surveyors,* Australian Institute of Building Surveyors, Perth, Western Australia, pp.177-183.**

Design of buildings in Australia is being influenced by: more design & construct work; more off-site prefabrication; drive for quality by re-engineering building processes and practices;

changing technologies; and research of materials leading to more performance based regulations. Building surveyors need to be more flexible. Calls for a privatised system.

**Timura, M. n.d., 'Construction workers should be part of effort to improve workplace safety', *Occupational Health and Safety*, p.74.**

Construction contractors are concerned that US legislation makes employers liable for employee injury and death – but does not "hold workers accountable for violating safety standards or for working while chemically impaired". Du Pont – 90% of all workplace injuries caused by "unsafe acts" of workers. Ontario, Canada, made employees liable to fines if violated established safety standards. Construction related deaths halved over 2 decades, as workforce increased; injuries dropped less dramatically. U.S. Navy "for cause" drug testing found 48% enlisted men under age 25 using illegal drugs when 1981 plane crashed on U.S.S. Nimitz. Figure dropped to 3%, six years after random drug testing introduced.

**Troup, J., Tomes, W. & Golinveaux, J. 1996, 'Full-scale fire test performance of extra large orifice sprinklers for protection of rack storage of group A plastic commodities in warehouse-type retail occupancies', *Proceedings of the Interflam '96 Conference,* University of Cambridge, England, pp.405-413.**

A USA Group A Plastics Committee formed a research committee, representing retailers, product manufacturers, fire service, insurance industry and a sprinkler company – to test 9 variations on the effect of Extra Large Orifice (16 mm orifice diameter) on fires in stacked plastic product. The conditions for "warehouse" retailers of products were replicated, with product stacked to 4.2 or 4.7 or 5.8 or 6.1 meter tall.

The research found that where solid wooden shelving was used, the shelving shielded lower burning shelves from the sprinklers, creating large, unacceptable fires. Ceiling draft curtains changed the spread of the fire fumes, extending the fire and the number of sprinklers set off – also unacceptable. Otherwise ceiling mounted large orifice sprinklers contained the fire.

**Whitaker, J. 1989, 'Load lines: Jim Whitaker, Chairman of the Association of Lorry Loader Manufacturers and Importers, writes about the safe use of these machines', *Occupational Health and Safety*, vol.19, no.7, pp.10-12.**

The Association of Lorry Loader Manufacturers and Importers has published a *Code of Practice for the Safe Application and Operation of Lorry Loaders.* These are trucks with a crane device on the back of them, that can lift loads as diverse as: waste slurry, packages on pallets and tree trunks. The loader should have a label saying it has been installed, inspected and tested according to the above code. The Code reflects British Standards, e.g. requiring stability testing according to the Standards. Operators must be properly trained, e.g. by loader suppliers or independent training organisations; slinging also needs special training. It is essential that stabilisers be fully extended on secure ground, away from ditches, excavations, buildings, manholes, culverts. Overhead electric cables can kill. Instructions on safe loading of loads is given. Loaders have controls on both sides of the vehicle. It is important that operators are never under the load nor within swinging distance of it. Frequent inspection and maintenance of hydraulic hoses is essential.

**Wierenga, E. 1997, 'Safety: a manufacturer's perspective', *Perfusion,* vol. 12, pp.229-231.**

Safety in disposable products for cardiac surgery is a concern of the manufacturer, product user and patient. Medtronic manufacturer is concerned for: safety, quality, reliability, dependability as minimum requirements e.g. for oxygenators. Must consider safety during: design phase, manufacturing, production, sterilisation, handling, delivery. Education and clinical support also needed.

E.g. during design of oxygenators consider: shear stress, haemolysis, biocompatability for clinical use. Now use Cray 3 D computer modeling, rather than repeated testing of prototypes. Cray ensures minimise areas of high shear, high velocity, areas of possible recirculation. Cray used in design of Boeing 777.

To get the CE mark, device must conform with European Union medical device directive, which has extensive safety, quality assurance and good design requirements. Extensive testing requirements ensures patients protected; e.g. heat exchanger is double tested so there can be no water to blood leak. Medtronics does conservative internal review of product after it has passed CE mark testing. Internal tests include 3 production runs, to ensure reproducibility.

Quality is statistically checked: ensures product meets specification, sterilisation process is validated and shipping and packaging do not cause damage. A tracing system ensures complaints can be related to lot numbers.

Internal employees and customers are educated, e.g. employees visiting the cardiac operating theatre.

**Wilkinson, S. 1999, 'Building for success: Lab designers nurture research with views, quiet nooks, coffee, and a dash of whimsy', *Chemical and Engineering News,* vol. 77, pp.53-64.**

Practicing architect and ex-scientist, Joseph Phillips designs science laboratories "to make sure it is productive, reliable, safe, and pleasant environment for people to work and be creative."

Cold Spring Harbor Laboratory is a set of converted single storey, connected village houses, allowing scientists to walk out among trees, grass and water; and see outside easily.

The Beckman building has a spectacular open area 5 storeys high atrium, with a skylight on top. It is uplifting for scientists, who feel special.

Architects, chemists, engineers and executives agree that there needs to be a place for employees to mix. Cold Springs Harbor has free coffee in small areas; and connecting doors between labs. Seating and writing boards can be put in corridors and atria to allow people to meet easily and exchange ideas – recently prohibited by changes in the fire code.

Labs are now being placed on the outer side of buildings, to maximise natural lighting, while offices are being placed in the interior. Offices are used as quiet places where thinking takes place. Laboratories are where activity occurs, where ideas are put into practice.

Scientists no longer need back to back benches with shelves for reagents. They need computer workstations, benches for electronic equipment and apparatus, with access to the back of the equipment. An increasing emphasis on safety has lead to more hoods being put into laboratories. Safety, economy and capability has to more micro-experimentation rather than macro-experimentation. Vacuum and gas facilities are localised, not centralised.

Equipment must be electomagnetically shielded and vibrations minimised.

Labs are often obsolete by the time they are constructed – so more open design is required to allow adaptation to new requirements.

University of Wisconsin, with little money, will have rooms closed off from labs by glass petitions – to allow social interaction while students can keep an eye on their experiments. Cost constraints mean scientists share equipment more – so need larger spaces.

Traditionally separately housed sections are now being housed together: R&D staff, technical services, marketing, businesspeople.

**Wortham, S. 1997, 'Safe design improves your bottom line', *Safety and Health,* July, pp.66-71.**

Safety through design is an engineering approach that minimises workplace hazards via: equipment purchases, workstation layouts & ergonomics, production and maintenance. It includes safe processes as much as safe plant. Unauthorised modifications to plant are the result of management not listening, says David Milner or Stepan Co.

The Institute of Safety Through Design was founded by the US National Safety Council in 1995. Safety through design leads to improvements in productivity, cost-effectiveness, greater competitiveness and sometimes quality.

Owens Corning, manufacturing building materials used safety through design, focusing on: fitness-for-use, engineering design safety reviews, and walk-through of installed equipment and process before release to production.

Fitness-for-use included: potential safety hazards, regulatory compliance, ergonomics, exposure to hazardous materials, noise, and impact on other installations and processes.

The engineering design safety review occurs when people can visualise plant from the design drawings and specifications. Hazards and deficiencies are identified during the walk-through of installed equipment.

Engineers receive too little education in safety. The Institute for Safety Through Design held a symposium, to identify what OHS topics were missing from the engineering curriculum. The Accreditation Board for Engineering and Technology has proposed safety as a topic in the Engineering Criteria 2000, to be implemented in 1998 – but has not set specific requirements.

Reader survey (number not specified) by *Safety and Health* on Safety Through Design, found 80% of companies responding have retrofitted workstations or equipment; 98% were familiar with the concept of safety through design; 52% of safety professionals only had some input into design decisions and 30% "not much". Design criteria were ranked mainly on economic factors (54%), with health and safety the second most important criterion (18%).

# Appendix B: Terminology

## Table 5 Terminology

| Term | Definition |
|---|---|
| **Stakeholder:** | *Means the occupational health and safety compensation authorities and others listed in Table 1.* |
| **Target group:** | *Means*<br>• *designers, manufacturers, importers and suppliers of plant and equipment;*<br>• *designers, constructors and installers of buildings and structures; and*<br>• *designers, manufacturers, importers and suppliers of materials and substances* |
| **Upstream:** | *Means backward in the design/supply chain.* |
| **Key intermediary / contact group:** | *A body, authority, association, that could serve to influence the target groups.* |
| **Designer, manufacturer, importer, supplier, constructor, installer:** | *These terms are used as per the ordinary definitions. In many statutes they are not specifically defined. Where that are defined (usually in regulations) the definitions are usually the same as the ordinary definition of the words, for example:*<br>• *"designer", "manufacturer", "importer" or "supplier" is a person who "designs", "manufactures", "imports" or "supplies" plant for use in a workplace [Occupational Health and Safety (Plant) Regulations 1995 (Vic.) r 105(2)(a)]*<br>• *"installer" means a person who "installs" plant or structures [Occupational Health, Safety & Welfare Regulations 1995 (SA) r 1.1.5(1)]*<br>• *"importer" means a person who "imports" any article or substance [Workplace Health and Safety Regulations 1998 (Tas.) Schedule 1]* |