DON’T FREEZE!
DESIGNING SAFER WORKPLACES USING PARTICIPATIVE ERGONOMICS APPROACHES - CASE STUDIES FROM THE MEAT AND COLD STORAGE INDUSTRIES

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Abstract: This paper outlines two case studies of designing workplaces where one of the aims was to reduce the exposure of workers to cold environments. In both projects, participative ergonomics tools and techniques were used, but to quite different extents. Particular characteristics of the industries and workplaces involved determined both the level of participation and the level of implementation of outcomes. In one case, a committed owner prepared to take the time and put in the requisite resources meant that broad participation and effective implementation was achieved. The challenge in this case was for the technical experts such as architects and engineers to work effectively in a participative framework. In the other case, tight margins and a difficult industrial relations climate meant that the work aimed to build capacity for participation in the future. Both case studies provide important lessons for the application of participative ergonomics techniques in workplace design.

1. INTRODUCTION

Legal obligations for safe design of workplaces have become more common around the world. In Australia, the Victorian OHS Act (2004) now requires designers of buildings or structures that will be used as workplaces to control the risks that may result from the design. However, strategies to achieve effective risk control have generally been limited to published guidance for design professionals on how to apply risk management processes to building design processes. The effectiveness with which this approach can achieve sound risk control is limited – building designers may have no understanding of how the building will be used as a workplace nor consequently have any capacity to identify design solutions to risk problems that may arise from design features.

Participative processes hold the promise of addressing such barriers. Using industry and workplace knowledge along with design competence to develop workplace designs allows all the requirements of workplace design to be met. Unfortunately, the opportunity to use the full range of participative design processes is often limited – by definition, in designing a new workplace, employees are not already working and therefore are not available to participate in the design process. This paper describes two examples where participative processes were able to be applied to the design process in an attempt to address such issues. In the first case, an industry-wide OHS intervention in the cold storage industry allowed industry players to participate in preparing industry-specific design guidance that provides explicit solutions to design needs for industry workplaces. In the second case, a new development at an existing meat industry workplace provided the opportunity for the existing workforce to participate in the design process.

In both cases, a key design aim was to address exposure to cold environments. While in both cases, the need for cold environments could not be designed out, the need to reduce the consequent risks of musculo-skeletal disorders meant that workplace design became a critical OHS issue.

2. WHY IS COLD IMPORTANT?

2.1 Health effects of working in a cold environment

Working in cold environments has negative effects on the human body. Cold environments cause impaired muscular performance by reducing dexterity and sensitivity. At cooler temperatures muscular strength is reduced because the power and duration of muscular contraction is reduced and greater viscosity of muscle tissues increases friction. Joints stiffen because the temperature of the joints decreases faster than the temperature of muscles and the synovial fluid in the joints increases in viscosity. This deterioration in
performance becomes worse as exposure is increased both in amount (i.e., decreasing temperature) and duration (i.e., for longer periods at one time or over a longer period of time) (Oksa, 2002). The reduced reach and mobility caused by these physiological effects are only exacerbated by the bulky and inflexible protective clothing required in these working environments.

Resulting adverse health consequences include skin irritation (Lehmuskallio E. et al., 2002, Bang et al., 2004), respiratory inflammation (Holmér, 2001) and musculo-skeletal disorders (Pienimäki, 2002). Finally, cold environments also reduce mental alertness, create distraction because of the necessary actions to cope with the cold environment and therefore the likelihood of accidents is increased (Vogt et al., 1998).

### 2.2 Extent of cold-related ill-health in the Victorian cold storage industry

As part of one of the projects, a survey of the health of cold storage workers was conducted to determine the extent to which these health problems were evident in the workforce. In summary, the survey of health effects of working in cold identified significant differences in health and injury outcomes between workers in cold environments and workers doing very similar work in ambient temperatures. These differences related to the key health outcomes suggested in the literature and strongly suggest that cold exposure as currently experienced in cold storage workplaces in Australia creates significant risk of ill-health.

Cold storage workers were more likely than ambient temperature workers to have experienced a work-related injury or illness. This was worse for those who work in freezers or mixed temperatures. Considerably more cold storage workers had experienced musculo-skeletal disorders (MSDs), specifically neck, shoulder or upper extremity pain or back or hip pain. Again, this outcome was temperature dependent, with well over half of all workers in freezers reporting MSDs.

Mental functioning was also significantly worse in cold storage, with the worst outcomes reported by those working in mixed temperatures, mostly in freezers. Nearly two thirds (62%) of these workers reported that their concentration was worse because of the cold. This was most concerning, since these workers were the most likely to be operating mobile equipment as they moved in and out of freezers. In general, workers in cold storage reported between 15 and 20% worse outcomes on factors such as concentration and fatigue than those who worked in ambient temperature warehouses.

This preliminary health survey provided empirical evidence that the health effects identified in the literature exist in the Australian cold storage industry and reinforced the importance of effective risk control measures to address the exposure to cold, not just the general risks of storage work such as manual handling. This required more rigorous attention to the design of cold storage facilities.

### 3. WHY IS DESIGN AN ISSUE?

#### 3.1 Poor existing designs

Despite the impact that workplace design has on risk in cold workplaces, such workplaces in Australia are characterised by poor design. Key design issues such as air movement, thermal insulation, working heights and traffic flows have generally not been considered in designing cold storage facilities and meat processing plants. As a result, workers in these facilities face risks even greater than necessary. For example, poor design of thermal insulation in cool rooms leads to snowing and ice build up around doors. These conditions make it extremely dangerous for operation of forklifts and other mobile equipment. The workers must chip the ice away with a pick creating a manual handling and safety issue for those workers. Lack of attention to traffic flows can mean that pedestrians must share busy and often slippery thoroughfares with trucks and forklifts, which has resulted in fatalities around the world, including Victoria.

Facilities that are required to be maintained at specific temperatures are also more expensive to build. The insulation and refrigeration requirements add considerably to the costs of construction. Rather than encourage innovation, this has made the designers more conservative, since experimentation is very expensive and failed experiments could be disastrous. The age of some facilities both exacerbates these problems and makes design modifications difficult without enormous expense.
3.2 Significant manual handling issues

The work undertaken in these facilities requires hazardous manual handling. In cold storage facilities, workers must manually handle frozen packages up to 75kg in weight, often picking them from racks above shoulder height or below knee height, as illustrated in Figure 1 below.

![Manual handling risks in cold storage facilities](image)

In meat processing plants, awkward postures, considerable force and machine-paced work all contribute to that industry’s significant manual handling risk. In boning, workers are required to use repeated forceful gripping and turning motions when handling knives, usually with their wrists in a twisted position. They use prolonged awkward postures when they need to bend or stretch to reach a carcase.

Both the cold storage and meat processing industries experience a disproportionate number of workers’ compensation claims for MSDs. Well over half the injuries in both industries are MSDs and the overall rates of injury in these sectors is above the state average in Victoria. Meat processing has one of the highest rates of workers’ compensation claims of any industry in the state.

4. PARTICIPATIVE WORKPLACE DESIGN

The need for participative techniques for ergonomic interventions is well-established. However, the techniques themselves are sometimes less than satisfactory, at times being more accurately characterized as consultative rather than participative. Participative ergonomics as a field has not received substantial research attention, acting more as a tool kit of techniques rather than a research tradition in its own right. Haines et al (2002) describe a framework for characterizing participative ergonomics interventions that has seven dimensions: permanence; involvement; level of influence; decision-making; mix of participants; requirement; focus; remit; and role of ergonomics specialist. The approach taken in participative ergonomics interventions can have a variety of features in each of these dimensions, but fundamentally must provide the participants in the process with control over the outcomes if participation is to be legitimate rather than token.

The value of using participative ergonomics techniques in workplace design processes has also been well-recognised (Wilson, 1995). While there are clearly OHS and other standards that the design must achieve, there is always a multitude of ways these standards can be met. The most effective design is one that achieves the required standards but has been developed by those who do the work within these parameters. Participative ergonomics provides an effective framework for undertaking this work, achieving safety, production and quality standards as well as meeting the needs of stakeholders.
Building on the Socio-Technical System design tradition (Emery, 1980), the following six steps set out a useful process for undertaking a participative design process:

- **Step 1 - Scope the project**
  This step involves establishing design criteria that meet organisational and human needs.

- **Step 2 - Examine the range of alternative designs**
  This involves reviewing the range of potential designs that would potentially meet the established criteria.

- **Step 3 - Develop basic design proposal**
  Using the information collected in Step 2, a basic design proposal is developed in this step.

- **Step 4 - Prepare mock up of design proposal**
  This involves preparing a mock up of the design proposal. This can be achieved in a variety of ways – a physical prototype using a replica of the design, whether scaled down or life-size, or a virtual reality model allowing computer-based testing.

- **Step 5 - Testing, refining and validation of design**
  The preliminary design can be tested, refined and validated by “walking through” the process in the mock up. This allows for potential problems to be identified and further changes to be developed.

- **Step 6 - Finalisation and execution of design**

In a participative process, users of the design, namely employees who will work in it and the operator of the workplace, are involved in each step and determine when the step has been satisfactorily completed.

5. BACKGROUND TO THE CASE STUDIES

As a result of the OHS issues identified above, two projects were undertaken to seek to develop more effective workplace designs for workplaces in the different industry sectors. A participative design process was chosen on the basis of the considerations set out in Section 4 above. The design issues in both industry sectors shared key features. Both projects also sought to address greenfields sites, in an attempt to limit the scope of the work. Both industry sectors are also characterised by poor workplace relationships: industrial relationships between key stakeholders are poor and generally confrontational.

The differences between the projects were, however, considerable. The meat industry project consisted of work at one specific plant, where the owner’s commitment to improving workplace design allowed scope for an extensive participative design process. In contrast, the cold storage project was unable to engage a specific workplace to trial participative design processes. Instead, this project applied participative processes to the preparation of industry-specific design guidance. As this suggests, the commitment of key players differed considerably. Despite this, both case studies provide useful lessons for the application of participative design processes to address OHS issues in workplace design.

6. DESIGNING COLD STORAGE FACILITIES

6.1 Introduction

As the above describes, cold storage workplaces have been characterised by poor existing designs. OHS has typically been of little or no interest to workplace designers. At the same time, industry players agree that there are design features that create more effective risk control and were able to readily identify key aspects of good design for OHS. Initially, this project sought to contribute to the design or renovation of sites. Unfortunately, this was not possible. The cost of facilities makes ‘experimental’ modifications unattractive to enterprises. Instead, this project resulted in guidance for the industry on the design features more likely to control OHS risks.
6.2 Participative processes used

Both formal and informal participative processes were used. Initially, I sought to engage with employers, employees and industry experts through site visits and meetings. The site visits also enabled the identification of design features that create or exacerbate risk and those which reportedly effectively controlled key risks. Through this engagement, key players were invited to participate in a series of workshops, some of which also included representatives of suppliers of equipment such as racking. This series of workshops was designed to mimic the processes that would have been used had a participative design process been able to be applied to a specific site.

Initial scoping was undertaken at a workshop involving employer and employee representatives which aimed to identify the key design issues of concern to the industry. On the basis of this information, a literature review, including grey literature, sought to identify existing solutions, building on information already collected in the industry and imitating the process of examining the possibilities. From this, a list of design factors with the most significant impact on OHS was developed, acting as a preliminary design proposal. This was used to inform consultations with recognised industry experts in this area, including architects and project managers that resulted in a draft guideline, imitating a mock-up of a design proposal. This was reviewed in a final workshop that involved industry representatives and design experts, analogous to testing the design. The draft guidance was then sent out for comment to industry players and finalised for publication by the OHS regulator in Victoria, in a validation process.

6.3 Project outcomes

The guidance that has resulted from the project sets out a four step design process:
- Getting started
- Develop design
- Build design
- Consult the workforce throughout

It provides clear guidance on the design features that are more effective in controlling risks addressing the following eight design factors:
- General
- Structure
- Docks and roadways
- Entrances and exits
- Staging areas
- Storage areas
- Racking
- Order picking

Figure 2 provides an example of the kind of information provided in the guidance.

<table>
<thead>
<tr>
<th>Design factor</th>
<th>High risk</th>
<th>Low risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction integrity</td>
<td>Work surfaces that are not strong enough for the work, including product, workers Ceiling cavities with no access capable of supporting the weight of a worker. Construction not capable of bearing the load of ice and water.</td>
<td>Ceiling cavities with access capable of supporting the weight of workers. Construction capable of bearing the load of ice and water</td>
</tr>
<tr>
<td>Air flows</td>
<td>Placement of evaporators increases air flows Layout of work areas does not take airflow into account</td>
<td>Placement of evaporators to reduce airflows, limit formation of snow, ease of access for maintenance Work areas laid out to reduce airflows Barriers between where humans work and where goods are stored – electronic curtains, air curtains or rapid rollers – allowing humans to be in a warmer work environment than product</td>
</tr>
</tbody>
</table>

Figure 2. Examples from Cold Storage Facility Design Guidance
The guidance was widely distributed across the industry and will shortly be made available on the OHS regulator’s website. While a formal impact evaluation has not yet been undertaken, informal review has shown that a number of designers have used the guidance to review and amend their designs for cold storage workplaces and one major client (Australian’s largest supermarket chain) has adopted the guidance as their standard for design of their cold storage facilities.

7. DESIGNING BONING ROOMS

7.1 Introduction

This project involved working with a rural meat processing facility to achieve a safe design for their new boning room and to construct a state of the art facility. The project focused on internal design and layout of the facility. The company wanted to take advantage of the opportunity presented by constructing a new boning room to develop a design that more effectively controls OHS risks. Because the operator did not face time or production pressure for the new boning room, this was a unique opportunity to try out and fine tune a different design. There was also a strong commitment to involve the workforce in the process to ensure that the best possible information was available.

7.2 Who was involved?

The working group consisted of the following individuals:
- Manager and owner of the business
- Employee-elected health and safety representative
- OHS and quality assurance officer
- Boning room supervisor
- Builder
- Engineer/designer
- Independent technical adviser
- Union OHS officer & organiser
- Labourer (who would work in the new system)

7.3 The process

7.3.1 Step 1 - Scope the project

This involved a number of meetings with the working group, including the selected designer, to scope the project in detail. This included identifying key design features to be achieved:
- Capable of processing between 120 and 130 bodies per day;
- Flexible enough to be able to change processing numbers and species;
- As safe as possible with minimum bending, twisting, handling;
- Required food quality, food safety and organic certification specifications;
- High food safety and quality standards;
- Temperature requirements for humans and hygiene; and
- Easy to clean.

7.3.2 Step 2 - Examine innovative and effective alternative designs

This involved:
- Reviewing previous investigations into boning room design and email contact with relevant researchers overseas;
Identifying boning rooms locally that were using alternative designs to those common in Australia using contacts of the business, the consultant and industry stakeholders; Assessing whether these alternative designs had potential to meet the requirements for the project; and The working group visiting the most promising sites to collect data to inform our design process.

The information collected in this step was collated and analysed to produce ideas for possible designs that were considered by the working group.

7.3.3 Step 3 - Develop basic design proposal

Using the information collected in Step 2, a one day workshop was conducted with the working group to develop the basic design proposal, with as much detail as possible. The group listed all of the items and processes that had to be included in the design. This design sought to eliminate or reduce:

- Lifting
- Throwing
- Twisting
- Double handling
- Bending the back 45 degrees
- The need to reach too high or low
- Exerting force at the end of the range of movement of joints.

Using different coloured paper and marking pens, the group developed a proposal, as represented in Figure 3.

Once the draft design was prepared, the group had a number of further meetings to consider it and examine the equipment needs of the design. As a result of these discussions, it became apparent that the current physical space would not be sufficient to allow for a design with the required features. Specific changes that were consequently made included:

- Increasing the width and length of the room by 4m, providing enough space for future expansion;
Providing space underneath for a carton store, a forklift-accessible collection point for fat and bone and space for three blast freezers and one storage freezer.

In addition, the working group decided that a Carni boning aid system would be used. This system raises the carcase up and down as the major boning functions are performed, as well as aiding in separating the meat from the bones using hydraulics.

7.3.4 Step 4 - Prepare mock up of design proposal

This involved preparing a mock up of the design proposal. A life-size replica of the basic design was created in an area near the working group’s meeting place, enabling the process to be “walked through” allowing testing and validation in Step 5. There are several options for mocking up a design proposal; including scale model, drawings or physical recreation of the room. The working group agreed that it would be best to create something of the same size of the finished boning room to allow direct testing of the functioning of the room. A suitable area was identified outside the building where the working group held its meetings. The preliminary design was drawn on the ground using spray paints. Different colours were used for different design features: white for rails, blue for slicing tables, lime green for equipment (e.g. band saw, lazy susan). This allowed the working group to “walk through” the design, as described below. The following photograph indicates the appearance of this mock up, showing the proposed arrangement of meat and bones conveyors:

Figure 4  Mock up of design

7.3.5 Step 5 - Testing, refining and validation of design

The preliminary design was tested, refined and validated by “walking through” the process in the life size representation of the boning room. This allowed for potential problems to be identified and further changes to the design were developed. The process used in the testing consisted of:

- Walking through the process from the point of view of a carcase - what’s happening to the carcase? Which bits are going where? We used a large, flat cardboard box, of roughly the correct width, to represent a carcase as the following photograph represents.
- Reviewing the process from the point of view of the boners and slicers - what’s happening to their bodies? Postures? Static loads? Twisting? Working space?

As we amended design features as a result of our considerations, we were able to redraw them on the ground using a rake to remove the earlier arrangement and then spray painting the new arrangement. This allowed testing of the new arrangement.
Figure 7  Modifying the mock up

We were also able to review the height and position of the rails, using stands that were able to represent where the chain would be.

Figure 8  Testing working heights

The testing was very successful, identifying the need for a number of significant design amendments. For example, we identified that the bone belt needed to be moved to the other side of the chain, away from the slicing tables (it had originally been between the slicing tables and the chain). We were able to build in greater flexibility for the positioning of the band saw, needed for mutton and lamb boning.
7.3.6 Step 6 - Finalisation and execution of design

After the workshop, the design was finalized and the operator is currently constructing the facility.

7.4 Observations about the process

The participative design process creates challenges for those trained in traditional approaches to design. The working group often asked *why does it have to be done that way?*, requiring design professionals to explain and justify design features. This resulted in many changes to the details of the design, all of which would have been necessary at some stage (eg moving the bone belt). The owner was very pleased that these changes were achieved simply by changing lines on paper or on the ground in a car park using spray paint, rather than the much more expensive process of post-construction modifications.

The process did take quite a long time. All of the usual delays of participative processes in workplaces occurred (eg not being able to release people because of work load). However, there was an added delay created by the need to achieve consensus about key features of the design and layout. In particular, those in the group not used to participative processes where a range of expertise and experience is valued often found it challenging to have to explain and persuade others about their points of view, rather than simply have others accept their advice on face value. Gaining their trust in the process and preparedness to move forward was challenging.

Interestingly, members of the working group found testing the mock-up the most useful part of the project, where we gained the most valuable information. It had originally been planned for earlier, but the working group was persuaded by one of the professional advisers that they should not proceed to the mock up until certain details had been agreed. As expected, testing the mock up acted as a circuit breaker, allowing those details to be tested and determined in a physical rather than an abstract manner.

The process worked very well, ensuring that all members of the working group were able to contribute and gain the necessary information in an effective way. Ergonomics input was useful for the designers as well as the employees. The design outcome is far better than originally proposed, with much better use of space and technology. The challenge of achieving a flexible design capable of dealing with different volumes and species has been achieved while also more successfully designing out the usually significant manual handling risks of boning rooms.

8. CONCLUSION

While the meat industry process had more substantial results and more thoroughly realized the participative process, both examples demonstrate the value of a participative approach to workplace design. In the cold storage industry, despite the lack of structured testing, the guidelines have influenced practice in a variety of settings. Without the substantial consultation and involvement in preparing the guidelines, these changes would have been unlikely. In the meat industry, the input of the workplace parties was absolutely essential to creating a workable design without expensive post construction modifications.

These two case studies demonstrate the robustness of the participative processes used. In the cold storage industry, despite negative industrial relations and lack of preparedness to involve the workforce in workplace design, a detailed and specific guideline is now available, built on significant industry input from all levels. In the meat industry, despite the lack of a permanent workforce for the new facility, the voice of workers was heard through key representatives. The designer acknowledged that the experience opened his eyes to the contribution that can be made by the workforce to design processes. In particular, he found testing the mock up with those who would ultimately work in the new workplace particularly helpful.

This imposes some obligations on ergonomics professionals to reflect on our practice to ensure that we guard against the ‘mother knows best’ tendency. These two projects show the extent to which participative processes allow the whole family to make the best decisions together.

9. REFERENCES


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