SAFETY IN DESIGN: CURRENT STANDARDS FOR SUGAR MILLS

By

STEPHEN CUTTING

Connell Hatch, Mackay
cuttings@connellhatch.com

KEYWORDS: Safety, Design, Risk, Health and Safety.

Abstract

The Queensland Workplace Health and Safety Act 1995 prescribes the obligations of owners, designers, manufacturers, importers, suppliers and constructors of industrial plants. The obligations of designers are generally to: ensure sugar mill is designed to be safe and without risk to health when used properly; ensure mill undergoes appropriate levels of testing and examination and is safe and without risk to health when used properly; take all reasonable steps to ensure appropriate information about the safe use of the sugar mill is available. Recently the Australian Commonwealth Government and Queensland Government have released new legislations that outline further guidance on the principles of safe design for plant and equipment. ‘Safety in Design’ processes are an integral part of plants upgrades, and need to be budgeted for, and scheduled into project milestones, to ensure documentation of the applied risk control measures is thoroughly carried out. This paper aims to provide a summary of how to embed ‘Safety in Design’ into the various sugar mill upgrade design phases, so as to meet statutory obligations, as well as aiming for zero harm to personnel through the life cycle of the project.

Introduction

Safe design is a process defined as the integration of hazard identification and risk assessment methods early in the design process to eliminate or minimise the risks of injury throughout the life of the product being designed. It encompasses all design including facilities, hardware, systems, equipment, products, tooling, materials, energy controls, ergonomics, layout, and configuration.

A safe design approach begins in the conceptual and planning phases with an emphasis on making choices about design, materials used and methods of construction to enhance the safety of the finished product. Safe design will always be part of a wider set of design objectives, including practicability, aesthetics, cost and the functionality of the product. Safe design is the process of successfully achieving a balance of these sometimes competing objectives, without compromising the health and safety of those potentially affected by the product over its life.

The current climate in engineering, and the markets it serves, dictates a new approach to safety in design theory and an unprecedented focus on safety compliance in the sugar industry. This refocusing is driven by new legislation and recognition from industry that safe work practices are fundamental to protecting employees from harm. Current expectations are
for ‘Zero Harm’. For sugar mills, this brings added responsibilities to all stakeholders in the process for plant upgrades. This paper examines the regulations pertaining to owners, designers, and constructors in discharging their ‘Safety in Design’ obligations.

The paper will outline strategies, principles and tools available to sugar mills in meeting Zero Harm best practices through design processes, and providing deliverables to control project risks.

Regulations


There are several levels of obligations for designers, manufacturers and suppliers when designing or modifying plants that are defined in the Queensland Workplace Health and Safety Act and Regulations. These include:

- ensure plant is designed to be safe and without risk to health when used properly and tested;
- take all reasonable steps to ensure operating instructions and appropriate information about the safe use of plant is available;
- take steps to prevent the use of unsafe plant, including recall if necessary.

Updated obligations of designers to provide information

The new legislation (Queensland Government, 2005a,b,c; Commonwealth of Australia, 2006) passed in Queensland identifies the need for the designer to provide information to the intended users, constructors, operators, maintainers and visitors to the design. This information must state:

- ways that plant should not be used, including specific prohibitions;
- the results of tests carried out on the plant;
- residual risks that cannot be eliminated or sufficiently reduced by design or safeguarding;
- use of control measures, for example, personal protective equipment, to reduce risks associated with the plant;
- the correct method for transporting, assembling, erecting, installing, commissioning, inspecting, testing, using, maintaining, repairing, dismantling and disposing of plant;
- the items or components which require inspection and testing, as well as the acceptance criteria for inspection, testing and frequency;
- special tool requirements for use or maintenance;
- any specific conditions or associated high risks relating to the method of manufacture.

Figure 1 outlines the information processes required by all stakeholders to eliminate hazards.

Sugar industry code of practice and sugar mill safety supplement

The mill safety supplement details issues specific to sugar manufacturing operations. These include emergency shutdowns, biological risks, hazardous substances like asbestos and
sugar dust, machine guarding, and falling objects. It also has example work permits and hazard registers.

**Standards and Codes of Practice**

Plant is deemed to be safe and without risks to health and safety when designed in accordance with a Standard referred to in the Workplace Health and Safety Regulations or code of practice. When a Standard is not specified in the Regulations for a particular item of plant, the designer must use reliable engineering principles to ensure that the plant is so designed as to be safe and without risks to health and safety so far as is practicable.

**Intended use and reasonably foreseeable misuse**

When designing plant the risk of reasonably foreseeable misuse should be assessed and appropriate control measures incorporated in the design (Queensland Government, 2000). For instance:

- where plant is used intentionally for applications other than those for which it was designed and originally intended. For example where an excavator designed to excavate is used to lift and transport concrete pipes
- operator error due to carelessness or deliberate misuse.

**National safety in design strategy**

The national Occupational Health and Safety (OHS) vision is for Australian workplaces to be free from death, injury and disease. National priorities have been set across a spectrum of safety related areas including elimination of hazards at the design stage. Improvement strategies include:
• reduce risk for all hazards and potential hazards to as low as reasonably possible by involving all of the decision makers at the design stage;
• all designers to assess the risk, document it, and report to relevant parties;
• safe design should consider all major issues throughout the life cycle of a building/plant, from design to demolition (see Figure 2);
• Safety in Design is a continual improvement process.

Obligations for designers

All stages of plant life

The owner of sugar mill, the designers, and the constructors have obligations to stakeholders through all stages of plant life, from cradle to grave.

Whose safety are we concerned with?

The designer needs to consider the breadth of individuals that they have safety obligations to.

For sugar mills these include employees, constructors, transporters, users/operators, occupiers, visitors, bystanders/passerby, trespassers, operators, maintainers, demolishers and disposers.

Design criteria

Sugar mills now have an extended range of design criteria. These include suitability, sustainability, maintainability, reliability, compatibility, constructability, operability, functionality, and interface with people and the environment.

Enforcement of designer obligations

The designer can now face up to two years imprisonment for critical design flaws, so it is integral for the designer to meet their obligations, and leave a record of the safety journey of each project.

Safety in design principles

Cradle to grave approach

Using the ‘cradle to grave’ approach of safety thinking ensures safety problems addressed in the short term, do not lead to potentially higher risk activities being required to operate, maintain or decommission the plant.

Safety in design integration with project evaluation

Integrating safety in design with project evaluation phases is critical in order to establish the total scope of work for a project, a comprehensive capital estimate, and a risk based approach to the project evaluation.

Figure 2 identifies the interface for designing for safety and the environment with business life cycles.

Early intervention

The cheapest and most effective time to make changes to a design is in the earliest stages. Making safe decisions from the start in the design stages is far more effective approach than having to modify and add control measures after, which in turn is far better than the worst case scenario of cleaning up after an accident.
Project front end loading safety considerations

Project Managers must demonstrate that the level of front end loading (FEL) for safety in design considerations is adequate to support predictable project outcomes planning.

How to achieve best practise in safety in design

Sharing knowledge between major stakeholders

The major stakeholders (owners, designers, constructors, shareholders, millers, and operators) each have unique knowledge that will improve the safety of the project.

Facilitating meetings between all parties early in the design process means an accurate and comprehensive overview of cradle to grave risks will be generated (which can be used in the project front end loading).

This early intervention is particularly advantageous for the stakeholders who will rely on the information to complete the design.

Furthermore, the healthy flow in information between stakeholders will ensure that risk mitigation procedures are carried out to their full potential in all stages of the project (see Figure 3).
Industry best practice guidelines

Engineers Australia and the CRC for Construction Innovation promote six principles that should be entrenched at all stages of project life, (Fleming et al 2007a) and at all organisation levels, to give rise to a robust safety culture throughout industry. These are illustrated in Figure 4. The *Engineers Australia 2007, Guide to Best Practice for Safer Construction: Implementation kit* (CRC for Construction Innovation, 2007) is a useful tool that outlines the best practice by listing tasks specific to each principle that should be undertaken in four main stages of the project e.g. incorporating in the design process a safety review of feasibility options or at post construction, evaluating the effectiveness of safety in design. Detailed explanations of these are found in ‘Guide to best practice for safer construction: tasks’ (Fleming et al., 2007b).

Safety in design tools

Using safety in design tools and formulating solutions in a holistic manner

There are many tools that assist designers to develop an intrinsically safe end product. But there can be a tendency to over-complicate the design processes by detailing solutions for hazards that should be designed out first. Superseded designs can result from jumping to solutions too quickly without root cause analysis, drilling into too much detail too soon, and looking to solve problems that are not yet an issue. To avoid ‘perfectly engineering the wrong solution’, the designer should ask some basic questions before deciding on the plan of action:
What is the fundamental purpose of this project?

What outcomes are must haves?

What outcomes are nice to haves?

Why design it this way?

Why not get rid of the root cause of the issue?

Why not think outside the square?

It is important to systematically attack problems in a logical order from highest risks to lowest. The highest safety compliance is achieved by holistically looking at the project from the top down, and identifying the key drivers and issues that must be solved to meet the project outcomes. Use the 80/20 rule to design for prioritising what is needed and keep the ‘Safety in Design’ process focussed on the big issues.

**Assess and quantify risk levels**

Designers should undertake Risk Management (Standards Australia/Standards New Zealand, 2004) to ensure control measures are in place and are suitable for the plant being designed. To prioritise safety risks a safety risk ranking matrix should be used that gives a risk rating from the product of likelihood and consequence.

**Risk registers**

Following a defined process of risk mitigation (Figure 5) is always essential to ensure successful completion (Commonwealth of Australia, 2006). This process has several key steps that must be documented. The best way to ensure these are satisfied is to use a risk register (see Figure 6) as a tool to facilitate client communication, and change to a design that eliminates the risk.

![Fig. 5—The risk management process (Queensland Government, 2005b).](image)

The risk register comprises three main components: identification of risk, rating of that risk, and risk responses, actions and responsibilities. Its formulation is an essential component of risk management, and can be populated by using a list of hazard word prompts,
or typical safety in design documentation. The most powerful risk register will be a live document initiated by clients in the planning stage, easily accessible, shared and updated regularly by all major stakeholders. The early intervention principle dictates for best practice an alignment meeting early in the design process involving all stakeholders should be undertaken to populate the risk register.

**Safety in design facilitation tools**

The following tools can be useful when facilitating Safety in Design processes, in order to systematically assess key issues that should be considered:

**RAMBO checklists**

‘RAMBO’ stands for Reliability, Accessibility, Maintainability, Buildability, and Operability. The ‘RAMBO’ principle is concerned with the practical steps designers take to eliminate and mitigate risk over the life of the plant. By following the RAMBO principle designers are able to ensure their plant is one that is easy and safe to install, operate and maintain. Reviewing drawings using the RAMBO checklist is a quick way to test the intrinsic and extrinsic safety devices within the design are adequate.

**Risk analysis tools**

**Check Lists**

Check lists provide a list of common hazard sources and scenarios to prompt the designer to address each. The lists are also used in checking conformance with relevant legislation.

**‘What If’ analysis**

The ‘What If’ analysis is a series of questions about unexpected events or failures and can be effective when used by experienced designers. By asking ‘what if’ both hazards and consequences are identified.

**Hazard and Operability Study (HAZOP)**

The study is in depth and looks at multiple, unrelated failure scenarios. It is very through and requires a team of experts, each analysing small sections of the detailed design drawings for possible failure scenarios. The output will be possible design changes or control procedures to avoid failure.

**Failure modes and effects analysis (FMEA)**

This method calculates risk, cause and effect of component and equipment failures, and tracks down which can lead to a full system failure. It does not take into account human interface with the equipment.

---

**Fig. 6—Example risk register.**

<table>
<thead>
<tr>
<th>HAZARD DESCRIPTION</th>
<th>CURRENT ARRANGEMENT</th>
<th>ALTERNATIVE ARRANGEMENT</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Description</td>
<td>Possible Cause</td>
<td>Persons Affected</td>
<td>Possible Consequence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Fault Tree Analysis (FTA)**

The fault tree follows a top-down approach. System failure is the start point, then, working backwards, all contributing factors to this must be identified. The fault tree looks at the probability of the hazards, from general plant failure, down to the specific factors.

**Event Tree Analysis (ETA)**

The event tree analysis begins with only one initiating event and moves onwards in chronological order to develop the hazard scenario.

**Impact of safety in design legislation on industrial plant costs**

The impact of safety in design legislation is to provide a robust design process that aims for Zero Harm. A safer design may mean that the initial capital value and design costs for plant may be higher than higher risk alternatives, but the life cycle return on investment may justify an optimum engineering design. Figure 7 provides a graphical summary of the overall benefits of a thorough ‘Safety in Design’ approach to risk management.

**Safety in Design**

Fig. 7—Safety in design cost benefit relationship.

**Example: Bagasse conveyor**

The following example provides a typical breakdown of how ‘Safety in Design’ tools should be incorporated into each of the phases of a project’s life.

‘Reconfiguration of the bagasse conveyor system as part of sugar mill cogeneration.’

Considerations in design of new equipment:
1. Compliance with current codes
   - Does the conveyor meet current standards in its modified form? Most notably AS1755 ‘conveyors – safety requirements’.
2. Automation
   • How will the new and existing conveyors interact in either emergency or sequence stop situation?
   • In the event of blackout does the design fail safe?
   • Are the controls ergonomically designed and does the system use intrinsic safeguards to prevent operator error?

3. Transportation to site
   • Are there special requirements for any bulky or fragile equipment?

4. Installation
   • Will there be abnormal loads produced during the installation of equipment (either on existing structures or new equipment itself)?
   • Can the new equipment only be installed safely in a specified sequence?

5. Commissioning
   • Can all the required commissioning checks be done safely? e.g. measuring temperatures, currents, observing material flows.

6. Operation
   • Is it readily accessible for inspection and operation?
   • Is there safe access for spill or choke clean up?
   • Are industry-specific risks considered and controlled? e.g. heat stress or risk of bagassosis transmission (for more information see Sugar Industry Code of Practice 2005).

7. Maintenance
   • Is there sufficient access for components to be installed, are all lubrication points safely accessible without removal of guards.
   • Is there adequate space and strength in the structure to perform belt splicing?
   • Can maintenance activities be performed without resorting to unsafe work practices?
   • Is there adequate fixed lifting equipment in place?

8. Dismantling and disposal
   • Have any hazardous materials been used that require special disposal?
   • Does removal of equipment jeopardise integrity of remaining structure?

Acknowledgements

The author wishes to acknowledge the assistance of Connell Wagner and Hatch Associates staff when preparing this paper.

A large body of information has been presented at recent Safety in Design Seminars and training sessions, and several diagrams and design processes have originated from these.

The sharing of Safety in Design information is seen as a critical process to ensure that Zero Harm is achieved for all.
REFERENCES


