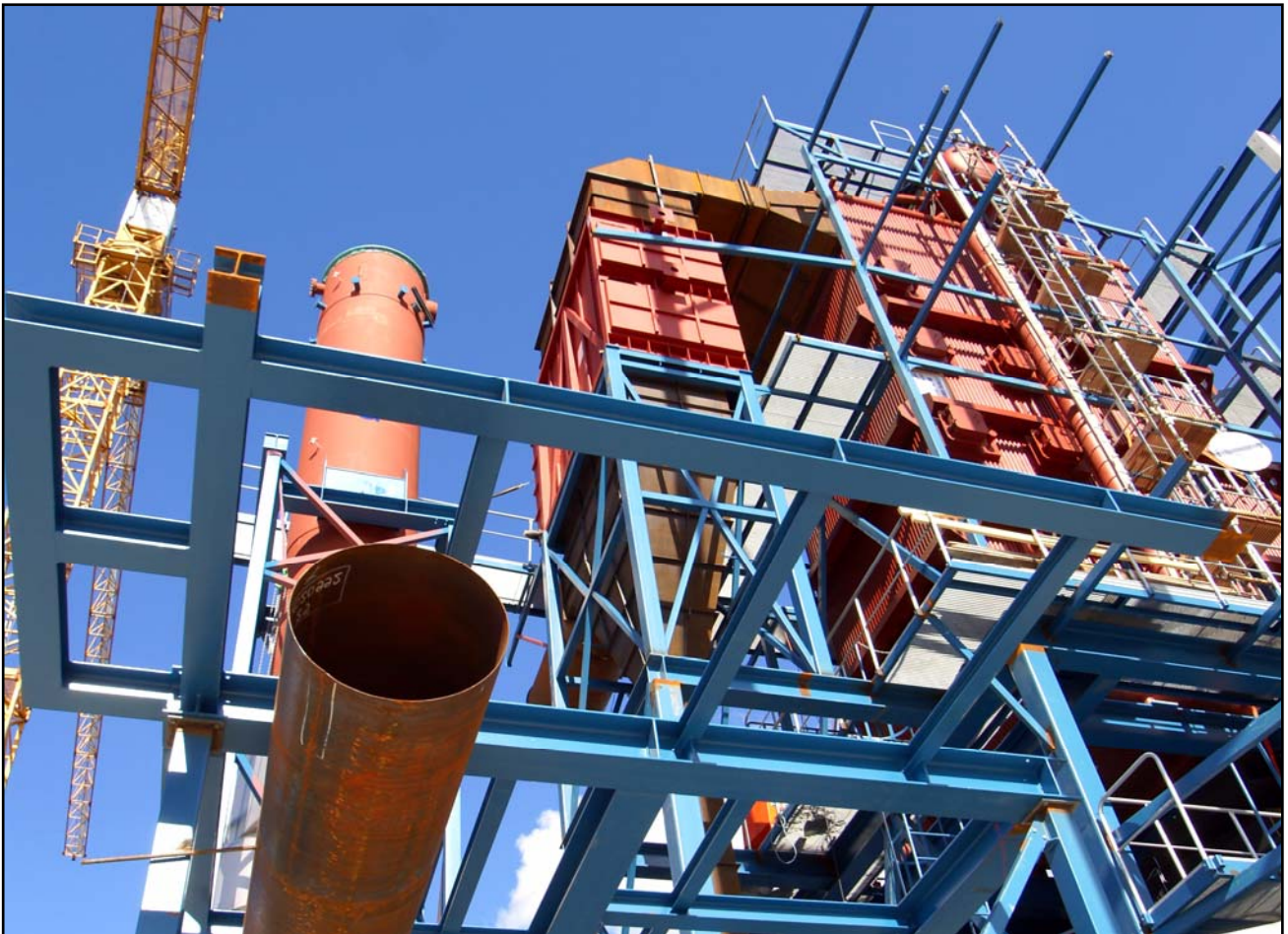


Hazardous Industry Planning Advisory
Paper No 7

Construction Safety



January 2011

HIPAP 7: Construction Safety
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Foreword

Since the 1980s, the New South Wales Department of Planning has promoted and implemented an integrated approach to the assessment and control of potentially hazardous development. The approach has been designed to ensure that safety issues are thoroughly assessed during the planning and design phases of a facility and that controls are put in place to give assurance that it can be operated safely throughout its life.

Over the years, a number of Hazardous Industry Advisory Papers and other guidelines have been issued by the Department to assist stakeholders in implementing this integrated assessment process. With the passing of time there have been a number of developments in risk assessment and management techniques, land use safety planning and industrial best practice.

In recognition of these changes, new guidelines have been introduced and all of the earlier guidelines have been updated and reissued in a common format.

I am pleased to be associated with the publication of this new series of Hazardous Industry Advisory Papers and associated guidelines. I am confident that the guidelines will be of value to developers, consultants, decision-makers and the community and that they will contribute to the protection of the people of New South Wales and their environment.

A handwritten signature in black ink that reads "S Haddad". The signature is written in a cursive style with a horizontal line underneath the name.

Director General

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Executive Summary

Background

The orderly development of industry and the protection of community safety necessitate the assessment of hazards and risks. The Department of Planning has formulated and implemented risk assessment and land use safety planning processes that account for both the technical and the broader locational safety aspects of potentially hazardous industry. These processes are implemented as part of the environmental impact assessment procedures under the Environmental Planning and Assessment Act 1979.

The Department has developed an integrated assessment process for safety assurance of development proposals, which are potentially hazardous. The integrated hazards-related assessment process comprises:

- a preliminary hazard analysis undertaken to support the development application by demonstrating that risk levels do not preclude approval;
- a hazard and operability study, fire safety study, emergency plan and an updated hazard analysis undertaken during the design phase of the project;
- a construction safety study carried out to ensure facility safety during construction and commissioning, particularly when there is interaction with existing operations;
- implementation of a safety management system to give safety assurance during ongoing operation; and
- regular independent hazard audits to verify the integrity of the safety systems and that the facility is being operated in accordance with its hazards-related conditions of consent.

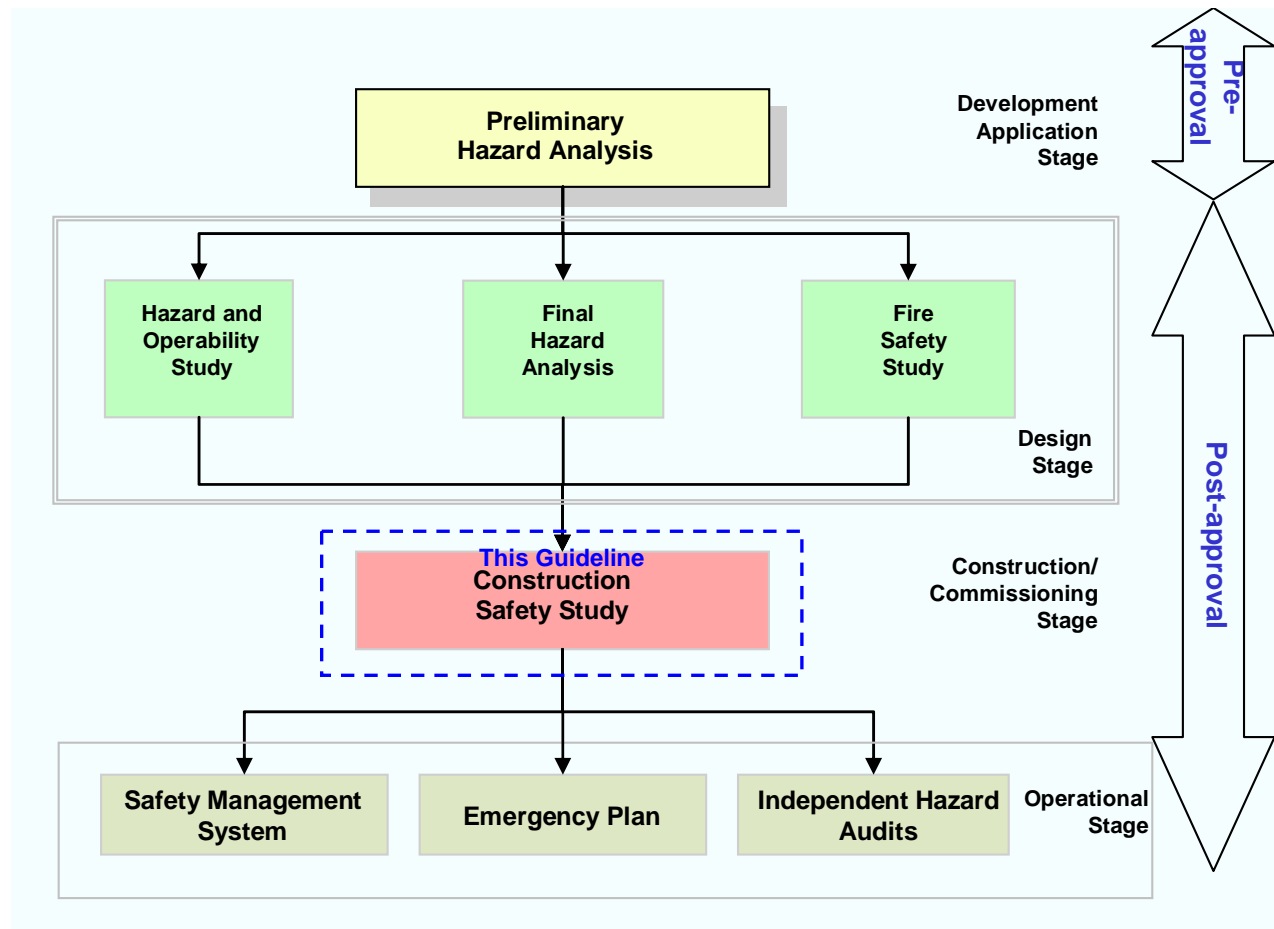
The process is shown diagrammatically in Figure 1.

A number of *Hazardous Industry Advisory Papers (HIPAPS)* and other guidelines have been published by the Department to assist stakeholders in implementing the process. All existing HIPAPs have been updated or completely rewritten and three new titles (HIPAPs 10 to 12) have been added.

A full list of HIPAPs is found at the back of this document.

The part of the process covered by this guideline is highlighted in Figure 1.

Figure 1: The Hazards-Related Assessment Process



The Construction Safety Study

Construction safety study is an integral part of the approval process and is typically carried out after project design has been completed. The Construction Safety Study focuses on construction-related hazards with the potential to affect site operations, which may in turn lead to off-site impacts, rather than on occupational health and safety (OH&S) issues, which are dealt with outside the planning system. The requirement for a construction safety study in no way decreases the need to meet the requirements of other authorities.

Construction and commissioning safety assurance should act as a final check on the appropriateness of the design and specification and should ensure that the facility is safely built and commissioned in accordance with the design intent.

The Construction Safety Study identifies all hazards which are specific to demolition, construction and commissioning activities associated with proposed development. The study also identifies the safeguards that will be put in place to ensure those hazards are controlled.

The Construction Safety Study is relevant to new development and modifications and additions to existing development. It also applies to the demolition of a facility at the end of its operating life, whether or not it is to be replaced.

The following areas are given particular attention:

- demolition of existing plant and structures;

- contamination;
- hazardous materials for demolition / construction;
- excavation hazards;
- interaction with continuing operations;
- drainage arrangements;
- natural events;
- hazardous materials during commissioning; and
- sequencing of commissioning activities.

The guidelines also provide guidance on the form and content of construction safety study reports for submission to government authorities.

1 Introduction

SECTION SUMMARY

The purpose of a construction safety study is to ensure that potential land use safety impacts associated with construction and commissioning of a facility are properly addressed. Experience shows that, even where the design and operation of a plant are carefully considered, potential incidents in the construction phase are sometimes overlooked.

This document describes a systematic approach to the identification and management of construction and commissioning hazards. It is complementary to other programs, whose primary focus is on occupational health and safety or environmental protection issues.

The guidance may be applied to new facilities, modifications to existing facilities and to demolition activities.

KEY MESSAGE

- Careful control of construction and commissioning safety is a prerequisite for safe ongoing operation.

It is fundamental to land use safety planning that all hazards are identified and appropriate safeguards employed to address them. The construction phase of a development, including demolition and plant commissioning, is critical to overall plant safety in two important respects:

- the hazards which arise in the construction process can result in significant levels of risk to surrounding land uses; and
- for the plant to operate safely, it is essential that it is constructed in accordance with design intent, and to an appropriate level of quality.

Under the Department's integrated approval process for potentially hazardous development these matters are addressed through the requirement for a construction safety study.

This paper provides guidance on the requirements and the approach to be adopted for construction safety studies. It is not intended to provide the basis for a group or individual without relevant knowledge or experience to carry out a construction safety study.

It also provides guidance on the form and content of construction safety study reports for submission to government authorities.

The approach applies to new development and major modifications of existing plant. It also applies to the demolition of a plant at the end of its operating life, whether or not it is to be replaced.

1.1 Construction Period Safety

The circumstances and the potential incidents during demolition, construction and commissioning can be significantly different to those under normal operating conditions. Experience in Australia and world-wide, shows that, even where the design and operation of a plant are carefully considered, potential incidents in the construction phase are sometimes overlooked. Examples of incidents are provided in Appendix 1.

The study should identify any deficiencies, and recommend necessary changes in:

- the demolition, construction and commissioning programs;
- the safety and emergency procedures; and
- safeguards required to ensure safety on site and in surrounding areas during the construction phase.

While some of the matters that need to be considered directly relate to the on site safety of workers, it is not the purpose of the study to address normal construction safety/occupational health and safety issues such as scaffolding safety and the wearing of protective clothing. Nor is it the purpose of the study to address air, water or noise emissions which would be subject to normal pollution control measures.

The study should complement the requirements of statutory authorities responsible for occupational safety and environmental protection issues. The requirement for a construction safety study in no way detracts from the need to meet the requirements of other authorities.

1.2 Commissioning Period Safety

The construction and commissioning stage is a critical time in ensuring the operational safety of the plant. Many incidents around the world have resulted from the failure of incorrectly fabricated or installed equipment or through the use of materials which are inappropriate or other than those specified for the use. The problem may not show up for many months or years, until wear and tear, corrosion or deterioration have had their effect; or when the component is stressed beyond its normal operating condition or has to operate in an emergency. Appendix 1 contains some incident examples.

The study should develop or verify quality assurance, inspection and pre-commissioning safety review procedures. It should also review the adequacy of the commissioning program and construction procedures and practices; and ensure that sufficient time is allowed for all 'safety assurance' steps.

During construction and commissioning, safety assurance measures should act as a final check on the appropriateness of design and specification and ensure that they are complied with.

The timing of submission of the study report should not constrain the use of study outputs at earlier stages. It may be appropriate to put fabrication quality control/safety assurance arrangements in place well before commencement of construction.

1.3 Benefits

The key elements of the construction study process are:

- familiarisation with past, existing and proposed operations and preliminary review of construction program;
- identification of hazards specific to construction operations and assessment of associated safeguards. Assessment of operational safeguards for the construction period.
- review of safety assurance system;
- finalisation of demolition/construction/commissioning programs; and
- review of procedures for management of change during construction/commissioning.

The construction phase of a project can be costly and time consuming. The total return from a project can be significantly affected by delays and ineffective construction operations. In this environment, safety critical procedures and controls can be overlooked or circumvented. To ensure against this, safety critical procedures and controls should be built into the scope of the project.

One of the benefits of a construction safety study, particularly when carried out early enough in the development of construction planning, is that sufficient time can be allotted for necessary tasks and appropriate programming and sequencing ensured. In particular, scope must be allowed for variation to construction and commissioning to allow problems identified in these processes to be resolved.

2 The Study

SECTION SUMMARY

The elements of the construction safety study are described in detail. Aspects that should be covered in the study include:

- **general familiarisation** with past and proposed operations and a review of demolition, construction and commissioning programs;
- **review of construction period safety:** identification and analysis of hazards and review/revision of construction period operational safeguards;
- **safety assurance:** verification that the design intent is maintained throughout construction, review of the safety management system and final pre-commissioning checks; and
- **management of change** during construction.

KEY MESSAGE

- The construction safety study should not be conducted in isolation. It should draw on the results of the design time safety studies and requires an experienced study team with a broad understanding of the project.

This section describes the elements of the construction safety study.

The study need not be elaborate. For simple facilities simple studies are appropriate.

The relevance of particular stages and the extent of detail required in each part will vary from case to case. For example, if there is no demolition to be carried out, then this aspect will not be relevant. Similarly, if construction is on a greenfield site, consideration of interactions with existing activities would not be necessary.

The main objectives of a construction safety study are:

- to identify potentially hazardous incidents during demolition, construction and commissioning and to identify appropriate upgrading and revision of programs, safeguards and safety and emergency procedures; and
- to ensure that all measures are in place, so that the selection, checking, fabrication, construction and commissioning of all the safety critical elements of a facility are in accordance with design intent and specifications, consistent with requirements and findings arising from other safety studies, and that design and specifications are appropriate.

The study process is illustrated in Figure 2.

Note 1: The Study Team

The study should be carried out by a small, technically competent group of people who are directly involved with the project. It should be managed by a person with sufficient authority to ensure that recommendations are implemented. The group should possess comprehensive knowledge of the process and a good understanding of safety management principles and practices.

Ideally, the study should be conducted entirely in-house, provided that the appropriate expertise is available. If not, it would be beneficial for expertise to be developed using external assistance.

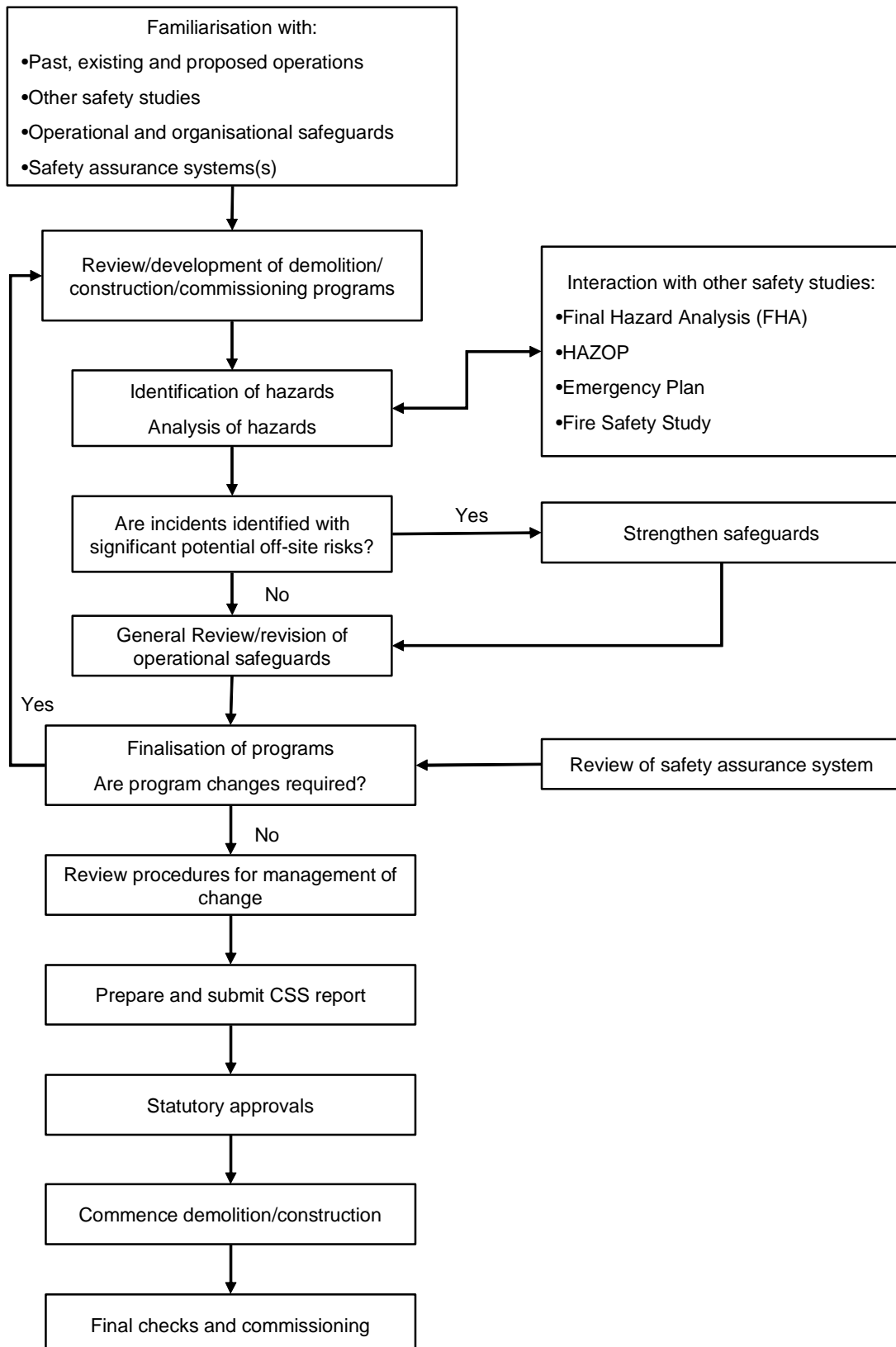
Depending upon the nature of the development and available resources, the study may be carried out by a group of people working closely together, or by coordinating expert input from individuals familiar with specific aspects of the project.

Typically the group might include:

- project manager,
- safety manager,
- design engineer,
- commissioning engineer, and
- operational personnel.

In addition, it is important that there is access to the people involved in all other relevant safety studies such as the hazard analyses, HAZOP, fire safety study and emergency planning.

Figure 2: The Construction Safety Study Process



2.1 Familiarisation and Preliminary Review

2.1.1 Familiarisation with Past, Existing and Proposed Operations

The first step in the study is the familiarisation of the participants with:

- past, existing and proposed operations;
- other safety studies;
- relevant operational and organisational safeguards; and
- safety assurance arrangements.

The study may be fundamentally flawed if some critical aspect of the nature and history of the development is not properly understood.

Past, Existing and Proposed Operations

The location of the site, surrounding uses, topography, and the nature and extent of existing operations should be carefully noted.

It is essential that the study team understands past and continuing operations on the site.

Knowledge of materials that may be present or were previously used on the site and their location is critical.

The design and layout of the facility and all associated works should be reviewed. This will enable the study participants to understand the nature and location of future process and storage areas, access ways and services, and the nature and requirements of construction activities.

Other Safety Studies

The reports of any safety studies relevant to the proposed plant, or to adjacent facilities, or to operations which have previously been carried out, should be examined. As a minimum, a preliminary hazard analysis should be available. Outputs of other studies such as HAZOPs, fire safety studies, or emergency plans might also be available at this stage.

Operational and Organisational Safeguards

In the familiarisation process, an understanding should be developed of the proposed technical, operational, and organisational safeguards for the proposed construction activities. A comprehensive review is not appropriate at this stage. The study participants should, however, understand the safeguards sufficiently to enable subsequent parts of the study to be carried out effectively.

Safety Assurance

Arrangements and procedures to ensure that the design and specification intent is met should be considered at an early stage. This is important where significant parts of the plant or equipment are fabricated or acquired well before construction commences. An outline of the requirements for an effective safety assurance system is provided in section 2.3. Further details may be found in Hazardous Industry Planning Advisory Paper No 9: *Safety Management*.

2.1.2 Review of demolition, construction and commissioning programs

When the construction safety study is commenced, detailed construction planning may not have started. For major projects, it would be expected that construction planning would be well advanced at the time a development application was lodged. However, for smaller projects, construction planning may not commence until development approval is granted.

If they do not exist, provisional demolition, construction and commissioning programs should be developed. In practice, the finalisation of these programs needs to take into account the safety considerations derived from the study. Therefore, at this stage the programs must be flexible enough to allow for any modifications.

The programs should incorporate:

- sequencing and timing of demolition, construction and commissioning activities including interactions with existing operations; and
- critical verifications including pre-demolition and pre-startup safety reviews.

Once provisional programs have been developed, a preliminary review should be undertaken. This should allow obvious deficiencies to be identified, while ensuring that relevant study participants are familiar with the proposed activities and schedule.

Particular attention should be paid to the proposed sequencing of activities and to ensuring that all critical verifications are scheduled. The optimum sequencing of the commissioning of plant components (relative to ongoing construction activities) should also be identified.

For projects with a long construction phase, the commissioning program may not be well developed at the time demolition or construction is commenced. Usually, however, the basic sequencing would be known. In such cases the construction safety study may be submitted in stages. This should only apply when the necessary information is not available. An understanding is needed of the constraints placed by potentially incompatible construction and commissioning operations not being able to proceed concurrently.

2.2 Construction Period Safety

2.2.1 Identification of Hazards

The objective of this part of the study is to identify all hazards which are peculiar to demolition, construction and commissioning activities. These may not have been considered as part of the preliminary hazard analysis.

The following areas should be given particular attention in the hazard identification process:

- demolition of existing plant and structures,
- contamination,
- hazardous materials for demolition/ construction,
- excavation hazards,
- interaction with continuing operations,
- drainage arrangements,
- natural events,
- hazardous materials during commissioning, and
- sequencing of commissioning activities.

Demolition and Construction

The following matters should be included when considering demolition and construction hazards and safeguards. However, they should not be regarded as a definitive listing.

Demolition of existing plant and structures

Having previously noted all equipment and structures to be demolished, all hazardous incidents which may occur during demolition activities should be identified.

Consideration should be given to the possibility that the existing equipment may contain residual quantities of hazardous materials due to inadequate decommissioning.

For the safe operation of the plant, it is preferable to remove all equipment no longer in use. Removal of lines should avoid the creation of dead-end lengths of piping still routinely in service or capable of becoming charged.

Where some live equipment is to remain in place, it is important that there is an effective identification and tagging system. This will ensure that such equipment is not damaged or mistakenly removed. Upon completion of isolation activities, it is essential to have a safety review prior to commencement of demolition. If existing plant is temporarily shut down during demolition activities, a further safety review should be undertaken after demolition and before the plant is re-started.

Where demolition activities are to take place in proximity to live equipment, consideration should be given to the possibility of damage due to falling structures or the movement of heavy demolition equipment.

Consideration should also be given to the possibility that structures to be demolished may include hazardous materials. For example, equipment or structures may be contaminated, or may incorporate asbestos lagging. Wherever hazardous materials are identified, proper disposal arrangements should be made, and all relevant authorities notified.

Contamination

The study should consider the possibility of soil contamination due to previous or surrounding operations, and the possible impacts on people and the biophysical environment from dust, runoff, transportation and inappropriate disposal.

Where contamination is identified, arrangements should be made for appropriate clean-up and disposal, consistent with the ANZECC & NHMRC document *The Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (1992)*.

Hazardous materials

In many instances hazardous materials will need to be stored on site for the purposes of demolition or construction. For example, temporary storage and use of liquid fuels, LPG, explosives or pesticides may be required. In such cases, the study should identify all potential hazardous incidents and ensure that risks are minimised. All hazardous materials must be stored in compliance with regulations.

Where explosives will be used for demolition or excavation, it is necessary to assess the possibility that existing operations and surrounding land uses will be adversely affected by overpressure, missiles or vibration.

Excavation

Careful consideration should be given to the possible existence of underground pipework or cables. Gas pipelines, power cables and pipes carrying hazardous materials from one plant to another are easily severed during excavation as a result of inadequate signage.

If an unidentified substance is found in the ground, or elsewhere on the site, work should be stopped until the source and nature of the substance is identified and it has been properly disposed of.

Interaction with Continuing Operations

Where existing operations, either on site or on neighbouring sites, are to remain active during the demolition or construction phases, the possibility of incident initiation through mechanical damage or interference with safe operation must be considered.

Incidents could arise from:

- cutting into live lines;
- hot work in the vicinity of flammables;
- damage to pipework, vessels etc from falling demolition materials/structures;
- impact/mechanical damage from cranes or digging equipment;

- equipment falling from cranes during lifting operations; or
- interruption of electricity, water or other supplies.

Site access for mechanical equipment and construction workers should be assessed. This will identify any potential for increasing risk (for example due to heavy equipment impact on structures). Access to the site and designated internal routes should be clearly marked.

The possibility of demolition or construction personnel or equipment entering operational areas without authorisation or clearances might also warrant consideration.

As far as practicable, employees and contractors should be made aware of hazards associated with neighbouring facilities and be familiar with associated emergency procedures. Likewise, operators of neighbouring sites should be advised and should ensure that their personnel are familiar with emergency procedures for the subject site.

Drainage Arrangements

During construction the drainage arrangements for existing operations may be affected by excavations or earthworks, or by alterations to drains, sewers or retention pits. Where this is the case, careful consideration should be given to the possibility of the integrity of the drainage system being compromised.

As an example, earthworks might lead to the rerouting of stormwater to existing retention tanks. This may result in retention capacity becoming insufficient to safely contain contaminated water.

Care should also be taken to ensure that drains carrying potentially hazardous materials are not disturbed without making alternative drainage arrangements. The possibility of damaged drainage pipes affecting future operational integrity and possibly seeping undetected for some time should also be considered.

Natural Events

The exposure to natural hazards such as flooding and windstorm should be considered. For example, cranes or partially complete structures could collapse onto live equipment. Soil stability, particularly where construction is on grade or on fill, should be considered for structures and movement of mechanical equipment.

Commissioning

Materials to be used during the commissioning of the plant would usually have been identified in the studies covering the fully operating plant. However, for a variety of reasons, in some circumstances different materials may be introduced.

The commissioning of a plant would typically involve some incomplete processing. Batches of intermediates which, in normal operational mode, would be immediately processed into another material may need to be stored or disposed of. Likewise, hazardous materials may need to be imported in order to commission or prime plant sections, or for testing purposes. Unusual reaction products may also be formed due to routine commissioning or plant malfunctions during commissioning.

In any of these instances all unusual materials or uses must be identified and care taken to ensure that incident potential is understood and documented. Appropriate methods for handling and disposal of all hazardous materials should be identified.

The sequencing of commissioning activities should also be considered. The provisional commissioning program should be reviewed with a view to ensuring that the appropriate sequencing is proposed and that all necessary equipment integrity checks are specified.

An important aspect of the construction safety study is that it should complement other safety studies being carried out concurrently. It would typically be carried out at about the same time as the HAZOP study, fire safety study, final hazard analysis and development of emergency plan.

in particular:

- where hazards are identified which have not been considered as part of the preliminary hazard analysis and which may present significant levels of risk, their consideration must be included in the final hazard analysis;
- for the identification of commissioning phase incidents, the individuals undertaking the HAZOP study should be consulted in order to ensure that no relevant hazards have been omitted;
- potential incidents should be considered in the development of the emergency plan; and
- fire hazards during construction/ commissioning should be appropriately protected.

2.2.2 Analysis of Hazards

When all hazards peculiar to the demolition, construction and commissioning phases are identified, each incident should be analysed with the aim of either eliminating the hazard or ensuring that safeguards are in place so that the associated risks are acceptable.

The first stage in this analysis should be an estimate of the consequences of the identified incidents. This should include consideration of the possibility of escalation of the incident to include neighbouring plant and equipment.

The consequence estimation then provides a mechanism by which the identified incidents can be provisionally ranked.

Those incidents with the potential for only minor consequences need not be considered in detail. Judgement is required as to exactly which incidents warrant further scrutiny. As a guide, detailed consideration should be given to incidents:

- with the potential for fatalities - both onsite and offsite personnel should be considered;
- with the potential for injury at or beyond the site boundary;
- which could result in the evolution or release of toxic gases; and
- which could result in significant releases of flammable gases.

Major fire incidents, explosions, and incidents with the potential for significant damage to the biophysical environment should also be given detailed consideration.

When an understanding is gained of the magnitude of the identified hazards, methods of dealing with them must then be developed. Ideally, the hazards should be designed out. This may be achieved through using alternative materials, equipment or techniques, or through altering the programs.

Where elimination of the hazard is not practicable, an assessment should be made of the adequacy of safeguards. This will involve considering the acceptability of the associated risks.

Detailed quantification of risk would not normally be necessary. In most cases it should be possible to make a qualitative judgement as to the acceptability of the risks provided that the analysts:

- appreciate the likelihood and consequences of the incident; and
- are familiar with the concepts of risk and with the applicable risk criteria.

The judgement on the acceptability of risk should use the criteria set out in Hazardous Industry Planning Advisory Paper No. 4, *Risk Criteria for Land Use Safety Planning*.

Where risks are in the unacceptable range, additional safeguards must be employed. Irrespective of the assessed level of the risks, they should always be minimised through the implementation of cost-effective risk reduction techniques.

The possibility should be considered that risk during the construction/commissioning phases could significantly contribute to the annual risks in the preliminary and final hazard analyses. These activities would not normally be considered through the hazard analysis process. If it is considered that risks during this period are likely to be significant, the relevant incidents should be factored into the final hazard analysis.

There are a number of ways in which temporary risks such as those during construction and commissioning could be assessed. However, the following assessment approach should be adopted:

- the quantitative and qualitative criteria detailed in Hazardous Industry Planning Advisory Paper No. 4, *Risk Criteria for Land Use Safety Planning*, will apply; and
- as the quantitative criteria are based on risk per annum, the plant life should be treated as commencing from the start of demolition/ construction activities, and risks summed for each year that involves demolition/ construction/commissioning. The risks for each of these periods should be calculated and summed together where they occur in the same 12 month period, and together with operating phase risks where operations also occur in the relevant year.

In assessing the adequacy of safeguards for the commissioning phase, study participants should be aware that protective systems are likely to be less effective than in normal operating mode since:

- operators are not likely to be familiar with the plant at this stage; and
- control, alarm and interlock equipment may be less reliable.

It should be noted that plant should not be commissioned without first commissioning and testing alarm systems.

It is essential that appropriate procedures for all identified incidents are incorporated into the site emergency plan.

Procedures should also be developed to ensure that safeguard requirements are communicated to all relevant sections of the workforce and that an auditing system is established to ensure implementation.

2.2.3 Review/revision of construction period operational safeguards

Adherence to safe working practices is essential if risks (both onsite and offsite) are to be minimised. If critical elements of the safety management system are missing, it jeopardises the integrity of the facility's assessment.

Therefore any deficiencies in operational or organisational safeguards must be identified and necessary changes made. As a guide, the following safety related documentation and operational safeguards should be considered (for demolition/ construction/commissioning activities):

- work and entry permit systems;
- hot work procedures;
- isolation and tagging procedures;
- procedures for control of onsite work by contractors;
- access arrangements for external personnel and vehicles;
- emergency procedures;
- availability of materials safety data sheets for hazardous materials;
- operating procedures for demolition/ construction/ commissioning activities;

- operating procedures for adjacent plant, along with any additional procedures required during construction activities;
- arrangements for security of PLC/DCS logic;
- fire safety and fire fighting arrangements;
- incident/injury reporting systems; and
- training/qualifications requirements.

The review of proposed emergency procedures is particularly important. Emergency procedures should be integrated with those for operations onsite and for neighbouring sites. All potential incidents which have been identified should be catered for in the emergency plan. Head count arrangements must account for fluctuating numbers of contractors on the site.

Responsibility for each of these safeguards must be clearly assigned. Commitments should be sought as part of the review process.

2.3 Assurance of Operating Period Safety

For a facility to operate safely (in accordance with the risk levels estimated as part of the hazard analysis process) it is essential that it be built according to design intent and to the required level of quality; Incorrect fabrication or installation, or the use of inappropriate construction materials, account for a significant percentage of major industrial accidents.

2.3.1 Elements of the Safety Assurance System

To ensure that the plant is properly built and commissioned, a safety assurance system must be developed in the form of a systematic Safety Management System (SMS), as described in Hazardous Industry Planning Advisory Paper No 9: *Safety Management*.

Key elements of the system are:

- **involvement of all participants**

The safety assurance program must apply to the entire project. All project participants (including external fabricators and contractors), who are involved in work which could affect safety must be included, no matter how small their role. The program must have the support of senior company personnel.

- **Documentation**

All procedures, authorisations and inspection/ certification reports must be well documented, kept in a secure location, and traceable. Systems must be in place to ensure that all construction personnel are working from the most up-to-date drawings.

All documentation necessary for safe installation, operation and maintenance must be provided to the relevant personnel. For example, fitters must be supplied with manufacturers' recommended installation procedures; operators must be supplied with operating manuals; and recommended maintenance schedules and procedures must be passed on to maintenance personnel. All documentation, particularly certification documents, should be held on site and be available for inspection by auditors during the operating life of the plant.

- **Materials of construction**

Specification of construction materials should generally be undertaken as part of the design process. Systems should be in place to ensure that the materials utilised are those specified. Such systems might include assessment of fabricators' quality assurance programs; the requirement for material verification documentation; independent testing; or the introduction of sophisticated material tracking programs. Field inspections should ensure (and record) that smaller

components are made of the specified materials (for example, gaskets, bolts, earthing straps, welding rods).

- **Fabrication**

Where fabrication is complex, or when the integrity of the component is important for safe operation, the safety assurance system should extend to fabrication workshops. It should ensure that fabricators are furnished with adequate specifications; that qualified trades people are used; that fabrication techniques, materials, and testing and certification requirements are appropriate; and that the quality of the delivered product can be assured. Where there is no direct involvement with fabricators, quality of safety critical components must be assured either through independent testing upon receipt, or through the selection of suppliers conforming to quality assurance standards such as AS 3900-3904.

- **Installation**

A detailed installation schedule should be developed and adhered to. It should emphasise critical stages and identify critical verifications. Supervisors and the installation team should be made aware of how critical jobs are. The roles and responsibilities of field inspectors should be specified, identifying inspection and documentation requirements.

Inspectors should check for the following during installation:

- correct installation and dimensions;
- correct labelling;
- proper documentation;
- maintenance of up to date P&IDs;
- use of appropriate tools, techniques and tradesmen;
- equipment integrity (including welds);
- materials of construction;
- compliance with codes and standards; and
- that there has been no inappropriate modification of adjacent operations or utilities.

The installation phase provides a final opportunity for inspectors, and all other technical personnel, to consider the appropriateness of design specifications, specified equipment and materials. Systems should be in place to challenge the suitability of materials and equipment and to ensure that any changes are made in a controlled manner. Management of change in the construction process is covered in Section 2.5.

- **Critical verifications/safety reviews**

Critical verifications which are required before further work is undertaken should be identified in the work schedule. Safety reviews should also be planned. Typically, these would be required after the completion of discrete sections of the plant.

It is important to have a pre-startup safety review. The purpose of this is to ensure that all elements of the safety system are in place prior to commissioning, including hardware and software and emergency response equipment. Operating personnel should be familiar with the plant and all relevant procedures. Appendix 3 has further details on pre-startup matters.

- **Training/Qualifications.**

The safety assurance system must address the training requirements for the plant's proper construction and operation and specify the degree of expertise required for safety critical functions. It must include company personnel and contractors. Systems must be in place to ensure that work will be undertaken by qualified personnel. Additionally, checks should be made to ensure that qualified personnel will be available to maintain the plant during the operating phase.

- **Definition of responsibilities.**

The persons (or positions) responsible for each of the above issues must be unambiguously identified. Their responsibilities, and the lines of responsibility, must be clearly defined.

2.3.2 Scheduling of Safety Assurance

It is important that safety assurance issues are addressed at an early stage of the project, ideally immediately after development approval is granted. Safety assurance may have an effect on activities occurring before construction, such as selection of contractors or fabricators.

The safety assurance program must be integrated into the project programs. Time must be allocated for carrying out safety reviews and inspections, otherwise the integrity of the safety assurance system will be jeopardised.

Project planners should be aware that time will need to be set aside for regulatory inspections and authorisations, such as those required for pressure vessels and fire fighting equipment.

2.3.3 Review of Safety Assurance System

The adequacy of the safety assurance system should be assessed as part of the construction safety study. Those responsible for this review should assure themselves that each issue raised in the preceding two sections has been adequately addressed.

While full details of the system need not be presented in the study report, documentation must exist to demonstrate in an audit that the appropriate checks have been carried out.

2.4 Finalisation of Programs

A final review of the proposed demolition/construction/commissioning programs should be undertaken, drawing on the information gathered through the preceding parts of the study. It is likely that a number of small changes to the original programs will be required, based on detailed analysis of hazards. Often changes will be incorporated with little effect on the project schedule. For example, re-routing heavy vehicles away from existing plant or pipe racks should not significantly affect scheduling of construction activities.

In some instances, however, the hazards assessed through the study as unacceptable may require substantial alterations to the program. For example, if a section of the site was contaminated it would be necessary to integrate remedial operations into the demolition/construction Schedule. This may alter the sequencing and timing of the project and the resultant changes may introduce new hazards with knock-on effects to the commissioning phase.

As well as reviewing the programs individually, it is essential to undertake a holistic review of the project program. **Particular attention should be paid to the interfacing between programs.** This is important where commissioning activities commence before completion of construction. The aim is to ensure that there is adequate provision within the programs to accommodate a rigorous safety assurance system, as indicated in Section 2.3.

The output of this part of the study should be updated demolition/construction/commissioning programs accompanied by a comprehensive and up-to-date set of safety related procedures and safeguards.

2.5 Management of Change during construction

After commencement of construction, some modification of the project program may be necessary. During commissioning, it may become apparent that permanent modifications to hardware or operational safeguards are necessary. In either

circumstance, it is essential that changes are controlled to ensure that safety will not be compromised.

Where changes will be beyond the scope of the development approval, or will create additional risks which significantly contribute to the risks from the facility, the relevant authorities should be consulted.

Those undertaking the construction safety study should satisfy themselves that appropriate procedures are in place for the management of the following matters.

- **Modification of project program**

The project schedule is likely to be disrupted, for instance due to delivery deadlines not being met, industrial action or bad weather. Procedures must be predetermined to ensure that schedule modifications do not have an adverse impact on safety.

Personnel involved in the construction safety study must be available to review the safety implications of any modifications. Responsibilities must be clearly defined and relevant authorisations given.

- **Permanent modifications of hardware/Operational safeguards**

Problems which will necessitate permanent modifications are likely to be encountered during construction and commissioning. Modifications may involve physical changes to plant hardware or layout, changes to operating or emergency procedures, changes to control logic, or changes to operating parameters such as temperature and pressure. The boundaries of safe operating parameters must be predetermined to allow operators to identify what constitutes a change to operating parameters.

To avoid delay at this critical stage, procedures for managing change should be developed prior to commissioning. They must define the extent of the review, the personnel involved, and authorisation processes required for the likely types of modifications.

The review process must include reference to all relevant safety studies. Depending on the nature of the modification, this might include review of the hazard and operability study, final hazard analysis, fire safety study and emergency plan. The modifications must also be incorporated into the facility's Safety Management System.

3 The Study Report

SECTION SUMMARY

This section provides guidance on the content and structure of the construction safety study report. The guidance is written from the perspective of the needs of a regulator requiring evidence that construction and commissioning of the facility being studied will not pose a significant risk to the surrounding community.

The Executive Summary should provide a brief overview of the project, indicate significant hazards and proposed control measures and summarise the main findings.

The remainder of the report follows a similar order to section 2 of this guideline. The description of the proposed project and its operations must be sufficient to provide a context to allow the reviewer to understand the information provided on hazard identification and control measures. A hazard identification word diagram (Appendix 3) may be useful.

To aid clarity, the demolition, construction and commissioning phases should be considered as distinct topics.

KEY MESSAGE

- The focus in the report should be on significant hazards that have been identified and the measures that are proposed to ensure they are effectively managed.

The purpose of the study report is to provide evidence to relevant authorities that all issues related to safety during construction operations have been adequately addressed.

This section outlines the recommended content and structure of construction safety study reports.

3.1 Title Page

The study title should be shown on the cover and on a separate title sheet. It should identify the facility covered by the study and its location.

The title sheet should indicate who carried out the study, on whose authority the study was prepared, and the date of the report.

3.2 Table of Contents

The report should include a table of contents with page numbers. The table should include a list of figures and appendixes.

3.3 Executive Summary

The executive summary should include the following:

- a brief description of the proposal;
- the purpose and scope of the study;
- the identification of major, potential hazardous incidents and proposed control measures; and
- the major findings.

3.4 Outline of Proposed and Existing Operations

A brief outline of the proposed operation and of the existing operations (if appropriate) should be included.

It should describe:

- the site location in relation to surrounding land uses;
- site layout;

- the purpose of the proposed operation and the major steps in the process;
- existing operations; and major contractors to be used.

Where these aspects are adequately described in documents such as the preliminary hazard analysis or environmental impact statement, cross referencing would suffice.

3.5 Study Methodology

there should be a brief description of the methodology used and the relationship with safety studies being undertaken concurrently.

3.6 Hazards Identified and Proposed Safeguards

the results of the hazard identification process and the review of associated safeguards as outlined in sections 2.2.1 and 2.2.3 should be presented in this section. Separate presentations are appropriate for the demolition, construction and commissioning phases.

A list should be included of the hazardous-materials to be used. Where interactions with proposed construction activities are possible, details should also be presented of hazardous materials stored or handled in adjacent plant or on adjacent sites.

Details should be provided of the hazardous incidents identified, their potential consequences and the proposed safeguards. This can be achieved through using a hazard identification word diagram similar to that presented in Appendix 3.

The section should comment on the adequacy of the safeguards proposed to protect against specific hazards. If there are significant hazards identified which have not been previously addressed as part of the hazard analysis process, then it must be demonstrated that the associated additional risks are acceptable. **Hazards which could contribute significantly to risk levels must be considered as part of the final hazard analysis and the risks must be added to those from normal operations before presenting final risk results.**

For the next two parts of the study, reliance may need to be placed upon statements in the report that checks and reviews have been carried out, and that the situation is satisfactory. It is not practical to submit every detail of the system to authorities for approval.

Where such statements are necessary, there should be a trail which could be followed by external auditors that would demonstrate that the review has been undertaken. This should enable approving authorities to satisfy themselves that the review has been carried out competently. Authorities will undertake random audits of these aspects of the study as part of the assessment process.

3.7 Assessment of Operational Safeguards

This part should demonstrate that all operational safeguards necessary for safe construction and commissioning are in place and adequate as described in section 2.2.3. A list of all operational safeguards and documentation reviewed should be included. Detailed descriptions of the safety systems in place are not required.

3.8 Safety Assurance

The report should demonstrate that a satisfactory safety assurance system is in place. It should provide a description of the safety assurance philosophy and a brief comment on each of the issues mentioned in section 2.3.1, and other relevant issues.

3.9 Demolition/Construction/ Commissioning Programs

Details of the proposed programs should be presented in an easily understandable format. Fine detail is not required. However, sufficient information must be supplied to

allow authorities to judge whether the hazards issues have been adequately addressed. Critical steps and safety reviews should be highlighted. The proposed sequencing of activities and interfacing between programs should be clear.

An indication of the proposed timing of statutory inspections and approval requests should also be provided.

Diagrammatic presentation of programs would usually be appropriate. These should be accompanied by brief descriptions of each stage of the project.

3.10 Management of Change during Construction

An outline of arrangements for the management of changes should be presented, as described in section 2.5.

3.11 Glossary and Abbreviations

To ensure that the study can be understood, a glossary of any special terms, titles of personnel or names of equipment items and a list of abbreviations may need to be included.

3.12 Appendixes

The following should be attached to the report as appendixes:

- details of the study team and a brief synopsis of relevant experience; and
- a copy of any conditions of consent or other similar statutory requirements necessitating the study.
- A copy of the project Activity Flow Diagram (AFD).

Appendix 1

Examples of Incidents¹

The following incidents could have been prevented had a rigorous construction safety study been carried out.

- A new tank was being filled with water for hydrostatic test when an explosion occurred. Two welders who were working on the roof were injured.
The tank had been filled with water through a pipeline that had previously contained gasoline. A few litres left in the line were flushed into the tank by the water and floated on top of it. The vapour was ignited by the welders.
- A plug valve was supplied with a pure nickel plug instead of one made from 304L stainless steel. The valve body was made from the correct material. The valve was installed in a nitric acid line. Five hours later the plug had disappeared and acid was escaping through the stem seal.
The manufacturers had provided a test certificate stating that the valve was made from 304L steel.
- A small new tank was installed with an unused branch blanked off. A month later the branch was leaking. It was then discovered that the tank had arrived with the branch protected by a blank flange made of wood. The wood was painted the same colour as the tank and nobody realised that it was not a steel blank.
- A leak on a refinery pump which was followed by a fire was due to incorrect hardness of the bolts used. Other pumps supplied by the same manufacturer were then checked and another was found with off-specification bolts. The pump had operated for 6,500 hours before the leak occurred.
- A leak of liquid LPG occurred when an underground pipe was severed by a concrete saw.
- A natural gas pipeline was laid on top of concrete stanchions crossing a gorge. The pipeline was not held down. Some time later an earth tremor caused the pipeline to jump off the stanchions.
- Pumps were supplied for use in an ethanol plant with seals made of a material soluble in one of the process materials. Shortly after commissioning the seals dissolved and a significant leak occurred.

¹ Some of these examples have been taken from Kletz, T.A. 1988 *What Went Wrong*, Gulf Publishing Company, Houston, USA.

Appendix 2

Pre-Startup Safety Review Checklist

The following matters should normally be addressed as part of the pre-startup safety review. The list does not purport to be comprehensive. In some cases some of the issues may not be relevant.

- Have all recommendations arising out of safety studies been addressed?
- Has all equipment been correctly installed?
- Have all alarm, interlock and control set-points been correctly specified, set and tested?
- Has all computer control logic been tested? Have DCS/PLC logic access arrangements been defined?
- Are backup power supplies functional? Have they been rigorously tested?
- Are inert gas systems and other utilities hooked up correctly?
- Is all electrical equipment compatible with hazardous area specifications?
- Has a list of safety critical equipment been prepared?
- Have operating procedures been defined and approved, including commissioning and normal startup and shutdown?
- Have all operational personnel received training on the process, operating procedures and process safety?
- Have limits of safe operating parameters been defined and are field change authorization procedures in place?
- Have maintenance procedures been clearly specified?
- Are P&IDs up to date, representing the plant as built?
- Are statutory and Company requirements complied with and approvals granted?
- Have all relevant authorities been notified of intention to start up?
- Has an emergency plan been prepared?
- Are all operational personnel familiar with both the site emergency plan and any relevant emergency plans for neighbouring facilities?
- Has the emergency plan been practiced in conjunction with emergency services and personnel from neighbouring facilities, as appropriate?
- Is all fire fighting and other emergency equipment available and functional? Is water supply adequate?
- Have closure times and sequencing of emergency shutdown valves been set?
- Have all valves been stroked? Have all relief valves been tested?
- Have arrangements been made for safe disposal of hazardous products, wastes, intermediates etc?

Appendix 3

Sample Hazard Identification Word Diagram for Construction Safety Studies

Area/Activity	Hazard	Consequences	Proposed Safeguards
Onsite vehicle access route to construction area	Existing distillation plant pipe bridge exposed to impact from high vehicles	Pipe rupture, fire. Possible escalation to distillation plant	Divert construction traffic around boundary road
Northern boundary of construction area	Underground natural gas pipeline servicing boiler. Excavation hazard.	Pipe damage. Fire/explosion.	Hazard warning tape on poles. Route to be permanently marked & taped.
Nitric acid import facilities for commissioning,	Proposed temporary storage & handling facilities inadequate. Numerous brass fittings. Corrosion hazard.	Nitric acid spill. Environmental damage, occupational hazard.	Modify Tank T53. Pipework and fittings to be stainless steel,
Existing 20te diesel tank (to be removed)	Potential soil contamination	Environmental and human health risk	Test soil for contamination. Clean up to required standard, if required.

Additional Information

Relevant DoP Publications

Hazardous Industry Planning Advisory Papers (HIPAPs):

- No. 1 - Emergency Planning
- No. 2 - Fire Safety Study Guidelines
- No. 3 - Risk Assessment
- No. 4 - Risk Criteria for Land Use Safety Planning
- No. 5 - Hazard Audit Guidelines
- No. 6 - Hazard Analysis
- No. 7 - Construction Safety
- No. 8 - HAZOP Guidelines
- No. 9 - Safety Management
- No. 10 - Land Use Safety Planning
- No. 11 - Route Selection
- No. 12 - Hazards-Related Conditions of Consent

Other Publications:

Applying SEPP 33: Hazardous and Offensive Development Application Guidelines
Multi-level Risk Assessment
Locational Guideline: Liquefied Petroleum Gas Automotive Retail Outlets
Locational Guideline: Development in the Vicinity of Operating Coal Seam Methane Wells

Electronic copies of some of these publications are available at:
www.planning.nsw.gov.au