Industrial Safety Management

Hazard Identification and Risk Control

Industrial Safety Management

Hazard Identification and Risk Control

L. M. Deshmukh

Tata McGraw-Hill Publishing Company Limited
NEW DELHI

McGraw-Hill Offices
New Delhi New York St Louis San Francisco Auckland Bogotá Caracas
Kuala Lumpur Lisbon London Madrid Mexico City Milan Montreal
San Juan Santiago Singapore Sydney Tokyo Toronto

Tata McGraw-Hill

ISBN

Published by the Tata McGraw-Hill Publishing Company Limited,
7 West Patel Nagar, New Delhi 110 008, typeset in BaskervilleMT at e-PAGE Prepress Printing and Publishing Services, Bangalore and printed at Sai Print-O-Pack, A-102/4, Okhla Industrial Area, Phase-II, New Delhi 110 020
Cover Design:

Cover: De-Unique

RAXYCRLBDDCCY

The McGraw-Hill Companies

Foreword

By Dr. Trevor Kletz

Recent decades have seen great changes in our attitude towards industrial safety. Employees, regulators and the public now expect higher standards and, more importantly, the injured person or his or her fellow workers can no longer be held entirely or even chiefly responsible for accidents.

If someone did not follow instructions we are now expected to ask why. Did he understand them? Were they clear? Was he distracted by more urgent tasks? Did someone turn a blind eye to earlier non-compliance? Was the task within his physical and mental ability? Was the failure due to a momentary lapse of concentration, similar to those of everyday life? Industrial accidents are inevitable from time to time, particularly when people are distracted or under stress, as everyone is at some time. In such cases the only effective action is to change the design or method of working so as to remove or reduce opportunities for error.

Of course, some people and some companies are better than others and looking for ways to prevent accidents is a skilled task. There is a need for expert guidance on what we should do. Mr. Desmukh's book fills this need effectively. He provides detailed guidance with a list of tasks that will act as checklists and also describes the underlying philosophy. I recommend his book strongly to Safety Advisors and representatives and to Line Managers and hope it will be widely read and—more importantly—acted upon.

Dr. Trevor A. Kletz

After graduating in chemistry from Liverpool University in 1944, Dr. Trevor Kletz joined Imperial Chemical Industries (ICI) and spent eight years in research, sixteen in production management and the last fourteen as Safety Advisor to the Petrochemicals Division. In 1978 he was appointed Industrial Professor at Loughborough University, U.K. On retiring from ICI in 1982 he joined the University full-time; in 1986 he became a Visiting Fellow and is now a Visiting Professor.

He has written ten books and well over a hundred papers on Loss Prevention and Process Safety and is a Fellow of the Royal Academy of Engineering, the Institution of Chemical Engineers, the Royal Society of Chemistry (all UK) and the American Institute of Chemical Engineers. He was appointed OBE in 1997.

Advance Praise

Major accidents in industries across the world during the last two or three decades have led to generation of enormous interest in Occupational Safety and Health, as well as in the environment. The Bhopal disaster of 1984 in India and the major fire in a warehouse in Basel, Switzerland, in 1986, are two extreme examples of what can happen if we do not pay proper attention to the basics of safety. The Bhopal disaster affected a whole city, killing many, and the Basel fire accident, believe it or not, had international repercussions. The fire in Basel had broken out in a warehouse storing chemicals in an upstream area of the Rhein River. The water used to fight this fire contaminated the river, which flows through many countries in Europe. The company had to pay 100 million Swiss Francs, in compensation to Germany, France, and the Netherlands to cover their respective damages.

The Basel accident, like other major accidents, was blamed on insufficient preventive measures and countermeasures against potential disasters. It once again reminded us how human negligence can bring about such an awful disaster.

Modern plants are growing in scale and complexity. Serious large-scale incidents at these complex plants have been a source of increasing concern. This has led to an increasingly critical examination of the adequacy of the existing procedures and systems. Those who work in industry and those who aspire to work in industry must be properly trained. They must be made aware of how accidents occur, what can go wrong, how equipment or systems fail and how human error leads to incidents involving loss of life and property.

Mr. L.M. Deshmukh has a long and rich experience in the field of Safety. There are very few who make their experience available to others in the form of a book. His rich experience, as reflected in this book, would be a useful guide to professionals, students and all those who are working in the field of Safety. I am sure the book will receive the wide circulation it richly deserves.

H. N. Mirashi
Director (Retired)
Industrial Safety and Health, Maharashtra

L.M. Deshmukh's book provides managements in India with a comprehensive view of all aspects relating to safety at work. The techniques of Safety Management, tips on Planning for Improving Safety and the interesting and relevant Case Histories of Accidents, are extremely useful.

India's quest to achieve global standards in productivity and competitiveness calls for effective emphasis on the vital aspect of 'Industrial Safety Management'. This book would be most useful in bringing about such awareness.

Abhay Firodia
Chairman & Managing Director
Force Motors Limited, Akurdi, Pune

As I started reading this book, several questions and suggestions came to my mind. By the time I finished reading it, all were taken care of. The book is a wonderful blend of theory and practical tips. It is truly complete in every aspect of Safety Management and is a true distillate of Mr. Deshmukh's study, research and experience spanning several years.

This book is a 'must read' for every safety professional, as well as manager working in industry. It is to a safety professional, what a Bible is to a true Christian. It will surely serve as a handbook of Safety Management.

I wholeheartedly compliment Mr. Deshmukh for coming up with a book that will inspire the reader to make his workplace a lot safer than before. That, in essence, will be both the objective and the contribution of the book.

Best regards,

Satish Bapat
General Manager
Purolite, Romania

As a medical consultant in the field of Occupational Medicine and having conducted periodic medical check-ups in various companies all over the country for the last 25 years, I have been closely associated with the subject Mr. Deshmukh has discussed in this book, albeit from a slightly different angle. Having gone through it carefully, I must compliment him for two reasons. One—for filling up a wide, long-standing gap in information and knowledge in the field of Occupational Safety. Two—for presenting the subject in such a lucid manner, accentuated with relevant examples.

I strongly recommend the book to all safety professionals and industrial management executives. I wish Mr. L. M. Deshmukh and his book a grand success.

Dr. Pradeep K. Rane
M.B.B.S., D.P.H., D.I.H.,
Certifying Surgeon (Retired), Maharashtra State
Faculty in Dr. Rane's Diagnostic Centre
Mumbai

Preface

After thirty years of experience in plant operations as a safety professional, I started my career as a Consultant in Occupational Safety, Health and Environment and Training and Development. Many companies have retained me as a Safety Adviser, both chemical as well as engineering. My previous employment and recent retainership with these large and small manufacturing companies followed a number of incidents of various mishaps, accidents, injuries, near misses, fires etc. Therefore I was mainly concerned with establishing adequate norms and systems in safety at management level, and investigations, prevention of recurrence, provision of in-built safety devices and so on at line management level.

One of my tasks was to train and develop management executives, employees in establishing and developing Safety Management System, accident prevention and to pass on to design and operating staff details of mishaps that had occurred and the lessons that should be learned. This book contains a selection of the 'Surveillance Findings and Investigative Case Reports'; I have collected from many different Indian industries.

Many of the incidents did not actually result in death, serious injury or serious damage. They were near misses, but they could have had more serious consequences. We should learn from these near misses as well as from incidents that had serious and severe results. Most of the case histories described in this book are actual incidents that have been thoroughly investigated by me or by my professional staff, whereas the rest have been collected from other sources. It's my firm belief that these case histories will apply particularly to such or similar plants or situations. The incidents described could even occur in many different plants or locations and should therefore be of widespread interest.

It has been my experience that even qualified safety professionals lack a correct and clear understanding of the techniques, terminology, procedures and systems, essential for the assessment, measurement and application of the necessary tools to achieve the desired safety performance. I have been teaching professional safety courses which, in my opinion, need to be constantly evaluated and updated to make them applicable to the changing industrial scenario.

Based on the experiences I've had over last several years, I believe that the topics of vital importance, at least to the safety professionals and the management cadre who are in charge of safety management in the company, should be included with brief explanations and I appeal to them to read them carefully prior to the chapters on Case Histories and Case Studies.

Management responsibility, attitudinal problems and behaviour, desired concepts on 'safety thinking', motivation in creating a safety culture and communication lapses are the topics which have been dealt with from a practical aspect so that safety professionals will find them useful in administering day-to-day safety. Volumes of information and literature are available on motivation or communication but their applications in the field of occupational safety and loss prevention are rare.

Similarly, many courses are being conducted and many books have been written on the vital subjects of safety in general and identification, assessment, evaluation, measurement and control of process industry hazards in particular. Ample information, methods and procedures on advanced techniques is available. High ranking safety professionals, scientists and researchers in the field have drawn valuable lessons for us from the disasters of Flixborough, Basel, Mexico City, Three Mile Island, Seveso, Chernobyl, Aberfan, San Carlos, Oppau, Texas City and, the worst of all, the Bhopal Gas Tragedy.

I intend to present this book to safety professionals, safety advisors and representatives, and the line managers of the industries is intended to interpret and simplify the thinking of the world's leading Safety Management experts like F.P. Lees, T.A. Kletz, J.V. Grimaldi, R.H. Simonds, O.P. Kharbanda, E.A. Stallworthy, W. Handley, H.E. Roland, B. Moriarty and others. It exudes more down-to-earth commonsense than a whole library of learned and weighty books on Safety Management.

My experience prompts me to alert the safety caretakers of industries other than the major hazard installations. They seem to be ignorant of the standard safety norms and systems, in the absence of which they fail to adopt normal day-to-day identification, evaluation and control of hazards and ultimately prevent the accidents. Thus, I intend to provide only the keynote information on the meaning of an accident, its difference from an injury, prevention first, investigation techniques and procedures and accident-prevention programmes.

Identification of common potential hazards, associated with entry into a confined space, falls and slips, electrocution, uncontrolled release of hazardous energies, material handling, permit system, disposal of waste materials, working with tractors, forklifts, gas cylinders corrosive substances have been added. A thorough understanding of 'work-permit-system' and 'static electricity' is very essential at this level and as such these topics have been included, so as to make it understandable to prevent and control the risks assessed on identifying and evaluating the potential hazards. Last but not the least, the importance of adequate and effective training and development in safety and loss prevention has been emphasised. An attempt has been made to present in-depth case histories of ten true unfortunate incidents with complete narration and full information gathered, thoroughly investigated and properly analysed, with an intention to present sample 'Surveillance Findings and Investigative Case Reports' to the readers. These are different from each other in many ways. Underlying principles differ, causative factors are not the same, and the hazards involved, locations and situations are different. It will thus be realised that the only thing common to all, was a lack of management commitment to safety and the desired knowledge of prevention. This resulted in weakness in the management system. Appendices related to the topics discussed, glossary and bibliography appear as formal chapters at the end of the book.

The purpose of this book is to present what has gone wrong in the past and suggest how similar incidents might be prevented in the future. Unfortunately, the history of industries shows that many incidents are repeated time and again after a lapse of a few months. People move on and the lessons are forgotten. Among the various methods of teaching, learning by experience has been proved the most effective. It is a process in itself, which retains the subject matter for a longer period. This was the method adopted by the sages in India from Vedic times. Case Histories can also help improve the design of plant facilities, training of operation and maintenance staff and safe operating procedures.

In case you come across an incident described in this book that occurred in your plant, you may notice that some details have been changed. This has been done to make it harder for people to tell where the incident occurred or to make a complicated story simpler without altering the essential message. The more likely reason is that the incident did not happen in your plant at all. Another plant had a similar incident.

The knowledge I acquired in addition to my vast experience in this field is due to the valuable information I collected and applied in my long standing career in safety. I have also referred to materials received from NIOSH, from books, articles, lecture-notes of the authors, writers and lecturers to whom I owe all my dedication. Dr. Trevor A. Kletz and Dr. O. P. Kharbanda have not only taught me a lot but have inspired me to write this book in simple words essentially for the people involved in safety-related matters.

We haven't met, but I respect Dr. Kletz as my 'Guru'.

While making a polite acknowledgement in one of his books, Dr. Kletz says:

"Much have I learnt from my teachers, more from my colleagues and most of all from my students."

I agree with him but, at the same time, I sincerely wish to alter this quote in my case:

"—more than most of all, from my Guru."

I hope this book will help readers keep the memories of past incidents alive to prevent recurrence.

L. M. Deshmukh

How to Use This Book

Read and try to understand the entire information presented in Part One to Part Three. Understand the roles, functions, duties and responsibilities of the top management, line management, unit supervision, employees and the safety professionals in planning, organising, directing, controlling and monitoring the Safety Management System and safety-related activities. You may please note that responsibilities in Safety, assigned to various positions and categories in an organisation have been presented in Appendix D, detailing who is responsible for implementing the Safety Policy of the organisation, framed under the system to achieve the desired goal.

It is essentially important that our concepts and perspectives in regard to safety are clear. Understand the simple but apt philosophy explained in Appendix A, namely Safety Thinking. Try to grasp the ideas and use them in training for correct thinking of Safety.

The 'Accident Case Histories' discussed in Part Four will help you understand the methodology of thorough investigation with true findings, how to dig out proper causative factors and come to the conclusions for preventing it happening again. Take employees with you. Tell them. Teach them.

On understanding it thoroughly, use the matter, presented in Part One, Two and Three and the Case Histories from 'Part Four' and pick a subject for training, staff meeting, and discussions in safety committee meeting or after plant inspection rounds.

Use the 'Accident Case Studies' given in Part Five to train new staff, managers, supervisors, operators and other employees — inclusive those of contractors', so that they know what will happen if they do not follow established, recognised procedures and safe operating practice.

If you are conducting a safety training session, use the incidents to illustrate to your participants how and why the accident occurred. It may then be analysed according to the scientific principles, as explained in Chapter V, Part Three, namely 'Investigate Accidents and Prevent Recurrence'. Readers, especially professionals and the students, are advised to follow Kletz's ideal method of 'Layered Investigation' to analyse and arrive at all-round surveillance findings for the root causes of an accident.

The most powerful tool in establishing the safety system would be to educate employees in Risk Assessment and to rigorously follow the programme (Appendix L) to arrive at desired actions to minimise the risk and make it tolerable, if not trivial. Equally important are HAZOP study and Risk Analysis, which are beyond the scope of this book but are necessary mostly for process industries. (Refer to *Hazop and Hazan: Identifying and Assessing Process Industry Hazards* by Dr. T. A. Kletz.)

Both in the training of plant staff, employees and students, the material can be used as lecture material or, better, as discussion material. Ensure that those present discuss and agree among themselves what they think should be done to prevent similar incidents happening again.

Acknowledgements

I have referred extensively to a number of industrial accidents in this book. The book has thus become possible largely because of the co-operation readily extended by the staff of all those units in enabling me to unravel what went wrong.

My sincere thanks are due to Dr. Trevor A. Kletz, Visiting Professor, Department of Chemical Engineering, U.K., for going through the book on my request, offering his valuable comments and suggestions and writing a Foreword to this book. Dr. Kletz is an authority on Chemical Engineering and Safety in the Process Industry. His consultancy services and writings have been appreciated throughout the world. I feel proud and consider myself lucky to get a Foreword written by such an internationally acclaimed person. The bibliography contains the volumes of his publication.

Thanks to my reviewers: Mr. Abhay Firodia, Chairman & Managing Director of Bajaj Tempo Ltd., Mr. H.N. Mirashi, Director (Retired), Directorate of Industrial Safety and Health, Maharashtra State, Mr. Satish S. Bapat, General Manager, Purolite, Romania, Dr. Pradeep K. Rane, Certifying Surgeon (Retired), Maharashtra State, Practising Consultant in Occupational Medicines and Mr. Prashant Inamdar, Vice-President, Bajaj Tempo Ltd. Their valuable comments and suggestions have gone a long way in improving the quality of content in the book.

I am also thankful to my professional colleagues, past and present. To name only a few—Gauri Gupte, Shriram K., Santosh Kulkarni and Amit Patil all of whom assisted me right through this exercise.

Family support is critical when getting into an exercise like this. It is especially important for someone like me who has never written a book before. But for the unceasing support from my wife Charusheela, and daughters Amita and Sujata, this book wouldn't have come about. They wouldn't like it if I thank them formally.

Last, but not the least, I owe a word of gratitude to Mrs. Deepa Varadarajan, Manager, Professional Publishing, of Tata McGraw-Hill and her colleagues not only for approving the manuscript and accepting me as an author but also for the painstaking efforts taken by them to bring this book to its present form.

Contents

PART ONE

Techniques of Safety Management

CHAPTER I

INTRODUCTION

Elements of Safety Programming

"Today we're going to talk about fall protection"

Just How Unsafe are Indian Workplaces?

The latest broad accident statistics appeared under this title by Mr. N. Vidyasagar in the 'Business Times' supplement of the *Times of India*, dated September 19, 2003.

- Around 125 workers die every day.
- 50,000 are injured every day.
- India accounts for 32% of global mishaps and 37% of occupational injuries.

This is a grave situation which should alarm us — as progressive thinkers — and push us to investigate, in-depth, the causative factors responsible for the present day situation.

1 Awareness of Risk

While describing 'lessons from major disasters' in their book *Safety in the Chemical Industry*, Kharbanda and Stallworthy illustrate the preventable accident with a simple, everyday example:

A fall in the bathroom or shower

"A fall may cause only minor discomfort, but it can equally cause serious injury such as fractures, concussion and sometimes even death. It all depends on the nature of the fall and just where it takes place. The basic question from the point of view of accident prevention is: *why did I fall*?

Perhaps the floor was wet and I did not consider that the wet floor might be slippery. Had I been aware of the wet condition, I might well think that a fall would only occur if I were careless — and I am careful, not careless.

"In technical terms, the wet floor presents a *risk* against which precautions can be taken. For instance, a non-slip rubber mat could be provided. (But this introduces a new risk: tripping over a non-slip mat, especially those who are terribly clumsy.)"

This simple analogy introduces the concepts of hazard, assessment and evaluation of the risk and prevention of accidents or injuries by taking appropriate precautions in controlling the hazard. These are various elements that are always present and are required to be considered when we talk about safety.

It is shocking and surprising to note that the disaster at Bhopal (Accident Case History No. 1, Part 4) had its roots in simple causal factors, similar to those we have just outlined above in the fall in the bathroom.

Operators were over-confident and ignorant of the Safe Operating Procedures, which were not laid down and followed under strict supervision. The plant had been operating for years and they had taken safety and security for granted, despite a number of mishaps and accidents that sounded alarm bells to the management as well as the employees. Adequate in-built safety systems were not provided and those provided were not checked and maintained as scheduled. None of the five safety systems, viz. the *Vent gas scrubber*, *Flare stack*, *Water curtain*, *Refrigeration system and spare Storage tank*, which had been provided to the plant ever worked and could not prove to be of assistance in the emergency.

1.1 '*Accidents can lead to Safety*', may seem paradoxical, but it is true

A fall in the bathroom makes us more careful but, unfortunately, this only lasts for a while. As time passes and nothing happens we get careless and complacent — then we slip again. We learn by experience, but this can be a slow way to learn. We might better learn from the added experience of others so that we buy a non-slip mat when we have our first accident. The theme of *learning by experience* has been taken up in this trial thesis, since it is the basis of most of our knowledge. We learn a great deal through 'trial and error.' Hopefully the errors become fewer with more trials.

The desire for safety and security has existed since the dawn of humanity. Early people had good reason to exercise defensive caution — they feared the natural hazards around them because they did not understand what caused them. They perceived the obvious risks of predatory beasts and were always aware of the comparative strengths of their neighbours. Like the animals they hunted, they developed a keen, innate ability to sense a threat and learned to evaluate the dangers and react protectively.

Today we find that our safety is always at stake. Life is becoming more problematic day by day. The safety of each person at home, in transit, at play — in one's entire environment — is the common responsibility of the individual, industry, community and government.

The chemical and process industries of today have learnt a lot from the major disasters such as Opal of Germany, Honkeiko of China, Texas and Cleveland of USA, Calix of Columbia, Flixborough of UK, Chasnala and Bhopal of India. Valuable lessons drawn from the detailed analytical studies of these mishaps and disasters have definitely led to simpler and safer plants.

1.2 Experience Is the Best Teacher

Each accident, when investigated and studied systematically, can and should provide valuable lessons. The best way to increase in-built and attitudinal safety is to both learn and then apply lessons from the accidents that have already occurred.

How does one learn from and draw a lesson from an experience? As regards the experience, which may be categorised as one's own proper conclusions of the causative factors, it should be drawn by systematically and methodically investigating the incident. The lessons learned would teach prevention of recurrence of the incident. Cases based on the experience of others should be studied carefully and investigated thoroughly as if they were one's own experiences.

An in-depth study of accident case histories is very essential. What has happened before will happen again. What has been done before will be done again. There is nothing new in the whole world. And this is where I wish to emphasise that what is wrong, when identified, can be corrected and eliminated. The only thing that is needed is the will to do so. Or else we remain where we were.

Let us now try to understand the underlying direct and/or indirect causative factors that are involved in an industrial mishap on the consideration of an actual incident. We may, perhaps, be able to find out answers to the usual questions being asked.

- Where do the accidents happen?
- How do the accidents occur?
- Why do the accidents occur?
- How strong and how much effective is the legislation?

2 An Incident to Examine

It is essential to get to know the manufacturing process in brief in order to assess the logical sequence of the various occurrences behind the unfortunate incident.

A *viscose process* is the method most frequently used for the manufacture of artificial silk and transparent paper. Viscose is produced either by a batch process or slurry continuous system. The *exposure of the workers to the hazardous gases and fumes is very high*. The principal raw materials are cellulose (in the form of wood pulp), sodium hydroxide, carbon disulphide and sulphuric acid.

The first stage of the manufacturing process is *steeping*, in which the wood pulp cellulose, in the form of a pulp-sheet, is steeped in sodium hydroxide solution, the excess liquid being squeezed out by compression. Alkali cellulose is thus formed. The hemi-cellulose and other impurities are removed during this stage and drained out.

Alkali cellulose is then torn into shreds (white crumbs) by rotating blades and aged for a few days under specific temperature condition. This process is known as *shredding and aging*. Next step in the process is *xanthation*, by which the shredded cellulose is transferred to a *churn* (specially designed rotating tank) where it is treated with carbon disulphide and converted into *cellulose xanthate*. The crumbs are now golden-orange in colour. Surplus carbon disulphide is then removed.

The xanthate is then dissolved in dilute sodium hydroxide and the resulting solution is the viscous orange liquid, known as *viscose*. The viscose is filtered, stored for several days under rigidly controlled conditions of temperature and humidity for ripening and then de-aerated by means of a vacuum.

The viscose is extruded through a *spinneret* with minute holes into a bath of about 10% sulphuric acid in the *spinning* process. Here the viscose, now in the form of pure cellulose, coagulates immediately into filaments, which are wound out of the bath and are collected in packages (cakes) as a continuous filament (as textile fibre or tyre-cord yarn) or cut into the required staple length (as staple yarn).

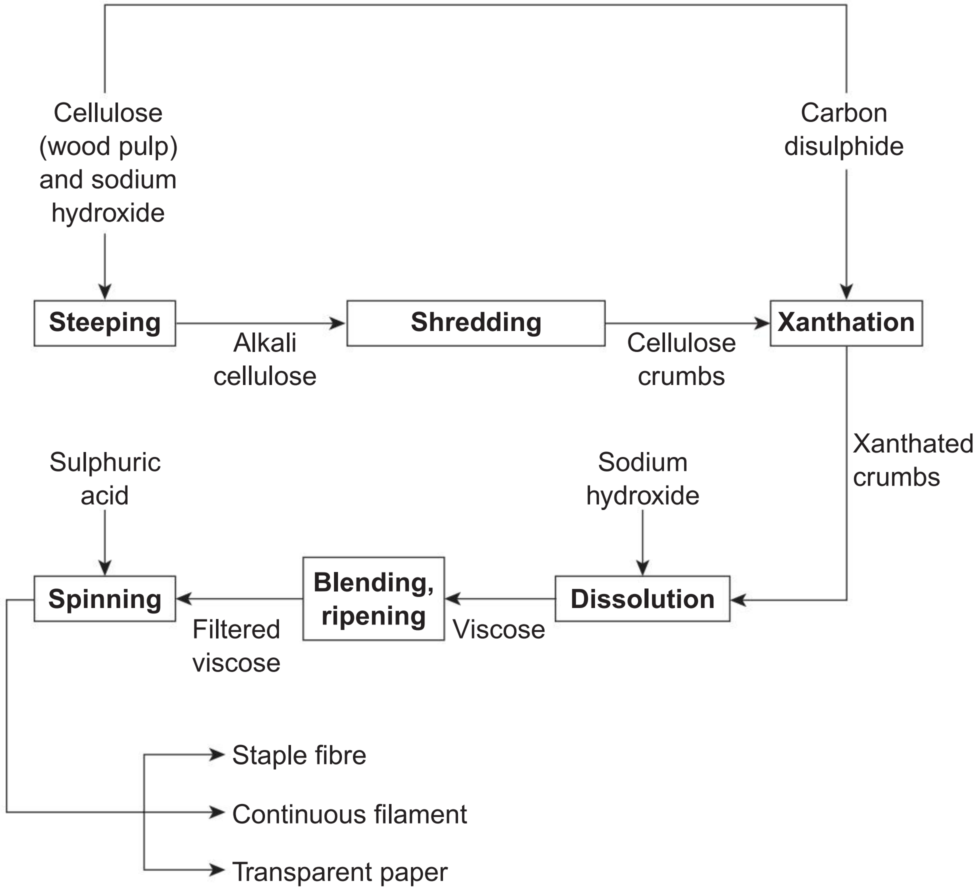


Figure 1-1 The viscose process flow sheet.

Alternatively, the viscose may be extruded through a narrow slit to coagulate in the form of a thin wide film, which is extensively used as transparent wrapping paper. During the reaction, carbon disulphide and hydrogen sulphide are evaluated and are given off.

Finally, during the *after treatment* process, the viscose materials are washed and chemically treated to remove acid, sulphur and other impurities and disposed off.

2.1 Assessment of the Hazards

Being conversant with the process sufficiently enough to understand the flow sheet, we now have to know the hazards involved in the process.

The principle hazards encountered in the viscose process derive from the *toxic nature* of carbon disulphide (CS_2) and hydrogen sulphide (H_2S). Carbon disulphide is a highly toxic substance, which affects the central nervous system and is accompanied by any of a wide range of symptoms depending on the part affected — from slight fatigue, giddiness, irritation of the respiratory tract and gastrointestinal disorders to profound psychic disturbances, auditory and visual disorders, *deep unconsciousness and death*. Moreover, since CS_2 has a flash point below –30 °C and explosive limits between 1.0 and 50.0%, *the risk of fire and explosion is very high.*

With H_2S too, there are serious health hazards and a fire and explosion risk. Its threshold limit value (TLV) is 10 ppm/10 min peak. Explosive limits: 4.3–46%. Inhalation of massive quantities of H_2S will rapidly produce anoxia resulting in death by asphyxia — epileptic convulsions may occur and the individual falls apparently unconscious and may die without moving again. This is a syndrome characteristic of H_2S poisoning in sewer workers.

To understand the application of the underlying principles of accident investigation and to study an accident case history, we will now take up a comprehensive accident case study, illustrated below in detail. We will also examine the lessons to be learnt from the incident or else our efforts will be incomplete and meaningless.

2.2 About the Company

It is also necessary to know the company and its topography.

A large chemical complex is situated midway between two rivers, almost flowing parallel, with abundant water throughout the year. The larger river is used by all the industries around to draw their potable and process water whereas the other one is used for letting off all sorts of treated chemical effluents and liquid wastes. The major product of the company is man-made synthetic fibre yarn. Quite a few chemicals, highly hazardous ones, are also being manufactured in large quantities in their auxiliary plants. An excess of chemical products in substantial quantities is being marketed regularly.

At the time the incident took place, the company had a strength of almost 10,000 employees, inclusive of 1000 supervisory and administrative staff and 100 management staff. It was a practice to recruit about 1000 or so temporary or casual workmen. Contractors were regularly engaged for different kinds and types of work and the number of contractor's workmen working daily was almost to the tune of 1000 to 1500. The annual turnover then, in the early eighties, was more than Rs. 110 crore.

The company had a well-set Safety Department, consisting of a senior manager, safety officers and adequate assisting staff. All the concerned employees were well trained in the established safety systems. Given norms and procedures were followed and monitored on time.

2.3 Background to the Incident

The effluent treatment plant has the main activity manufacturing plants on one side and auxiliary plants on the other. Huge main drains have been provided underground so that all the individual plant effluent and wastewater drains open into the main drains and flow into the effluent plant designated locations from either direction. The subject main drain's approximate dimensions are 2.5 m × 2.5 m × 600 m. Equidistant manholes are provided for maintenance purposes. All the effluent water thus collected from the main and auxiliary plants is treated and then led to join the river. The fact was that the entire main drain was damaged on the inside and needed to be repaired at the earliest to regain the smooth, unobstructed constant flow of drain water to the effluent plant. It was difficult for the management to plan the repair work by organising a total shutdown of all plants for a longer duration, the main plants being continuous process plants. Subsequently, even a thorough cleaning of the main drain, because of a number of damaged pockets, was overdue.

There had been an extremely unstable labour situation in the company for almost a year and half in the early 1980s. The situation went on deteriorating day by day; constant unrest arose out

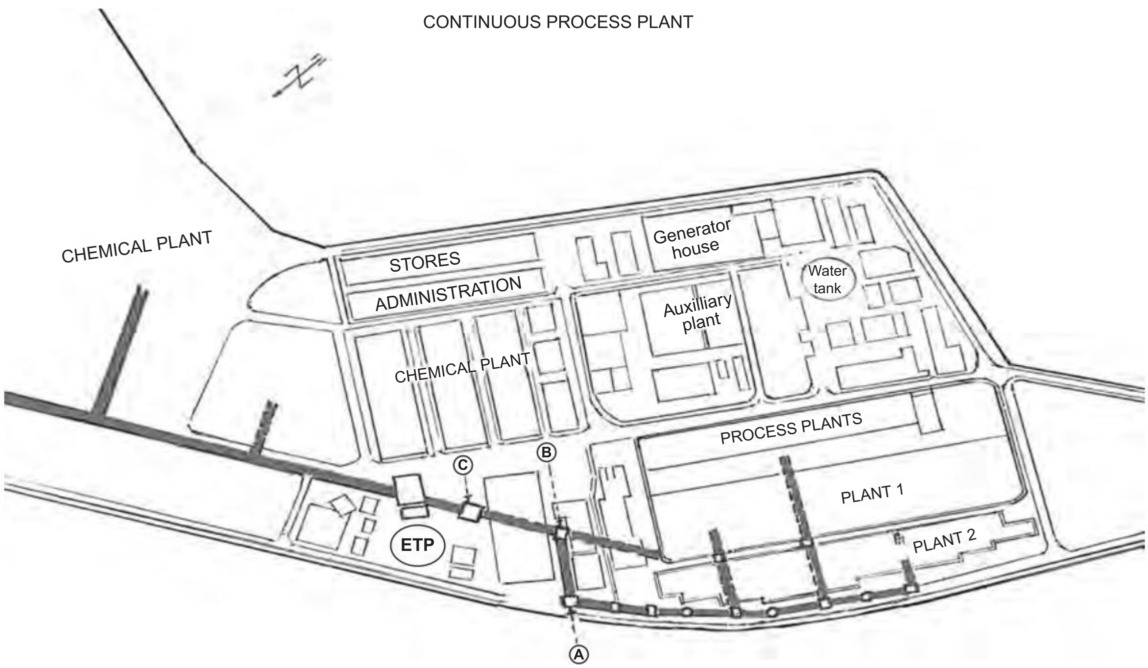


Figure 1-2 The general layout of the company.

of inter-union rivalry and disputes with the management. The problems got compounded and, two months prior to the incident, the company suspended all operations in the plants and declared a lockout with immediate effect. The lockout continued for over two months.

The Chief Civil Engineer, at this juncture, convinced the Technical Director that this was an opportune time to get the main drains cleaned and repaired. The Safety Department was consulted on getting the task performed on contract. Safety professionals examined the job required to be done in detail during the specified period and informed the civil engineering department on the various precautionary measures to be taken and insisted upon issue of specific safe-work-permits, namely 'safe entry into a confined space', every day and every time a team of contractor's workmen entered in either for cleaning or repairing. The work permit system, as administered for the 'safe entry', was required to be certified by the Safety Department on the stipulation that the noxious gas concentration inside the confined space was well within the allowable limits after conducting the test as and when required. Readers are requested to refer to the permit, given separately below in detail, for the precautionary measures recommended.

The width and height of the main drain are such that a person can easily walk or run straight through. Manholes provided are also large enough for any person to enter the drain. The general layout of the company is shown in Figure 1-2.

The three manholes directly related to the incident are marked 'A', 'B' and 'C' in the layout drawing. The 500 m long main drain running parallel to the fence wall is partially curved and turns at a right angle alongside plant II. At the manhole marked 'A', it further runs perpendicular for about 4 m and again turns at a right angle towards the manhole marked 'B', where it proceeds further for about 4 m, to a large sump of about 1.5 m × 2.5 m closed by chequered plate cover, marked 'C'. Here, the other main drain drawn from the opposite direction collecting effluents from auxiliary chemical plants joins the sump. Both the effluent streams then enter the effluent treatment plant, marked ETP, for treatment before joining the river.

The task of cleaning out the main drain was immediately undertaken according to the specific instructions issued by the Safety Department. All the necessary safety precautionary measures were taken and observed under strict supervision.

A safe entry permit was issued twice a day with certification that the conditions in the confined space at the entry were well within the threshold limit values of the prevailing hazardous chemicals and gases and that it was safe to enter and work in the location only within the specified period of four hours. The entire upstream portion of the drain was thoroughly cleaned within a week by 12 workmen of the contractor.

The employees of the company strongly objected to any work being carried out by outsiders while they had been laid off. Under the circumstances, the management was compelled to suspend and postpone the cleaning and repairing of the main drains. The lockout was lifted after about 45 days. Employees returned to their usual duties and functions. The sweeping of the plant premises and cleaning of machines and equipment were attended to. It was planned and organised to restart normal operations after a couple of weeks, as time scheduling is required for process industries.

The Technical Director, had recently joined the company and did not have experience in the hazardous nature and conditions of such a process industry and, in consultation with the Chief Civil Engineer, decided to take up the postponed cleaning and repairing of the drains. They also decided to ignore the precautionary measures, recommended earlier by the Safety Department (ref: safe-entry-permit) to carry out the work under the guidance and supervision of the civil department alone.

This was a culpable decision arrived at by inexperienced executives. They took things for granted, did not consult anyone — not even safety professionals — and assigned the contract to start the work with immediate effect, beginning with the cleaning work from the middle and downstream of the main drain which was to finish within two weeks. The episode took a vicious turn.

2.4 What Happened and How

The same contractor who had cleaned the upstream of the drain, was again given the contract to complete the cleaning of the main drains first and then was to hand over to the other civil team for repairs. He was asked to provide labour and skilled manpower to complete the work within two weeks. The contractor, in the initial stage, engaged eight *mazdoors* (workmen), five men and three women experienced in the job, and one *mukadam* (supervisor) who facilitated cleaning materials, tools and equipment. They were entrusted with cleaning the portion of the main effluent drain between manhole 'A' and manhole 'B'.

One of the male *mazdoors*, Appa (name changed), entered the drain through manhole 'A' along with his materials while another *mazdoor*, Raju (name changed) entered the large sump of the drain through manhole 'C'. Female *mazdoors* stood outside, between manholes 'A' and 'C' to collect the debris from the manholes. The *mukadam* was also present, distributing the material.

Within five minutes of Appa's entering the drain, the people around heard screams emanating from manhole 'A'. Appa was seen struggling to come out, shouting for help and screaming that he was gassed. The *mukadam* who happened to be in the vicinity, rushed to the manhole. He too inhaled the noxious gases and lost his strength and control, with the result that Appa fell into the drain, unconscious. The *mukadam* shouted for help. The contractors' and the company's employees rushed to the site to rescue him.

On hearing the cries of Appa and the *mukadam*, Raju hurried in their direction by running inside the tunnel from manhole C towards manholes B and A. The *mukadam* and others showed a light inside from C and tried to guide him to search for Appa. Unfortunately, soon after the *mukadam* lost trace of Raju, he emerged from manhole C and started shouting for help. In less than half an hour, safety professionals rushed to the accident site, as soon as they were informed of the mishap by telephone. The Chief Engineer and Security Officer along with the security personnel also arrived.

The safety professionals immediately took charge of the rescue operations with the help of the security department. Having no knowledge of the noxious gas concentration in the drain channel and of the chemicals that had accumulated at the base of the manholes, a quick decision was made to send one of the trained operators with self-breathing apparatus inside in search of the victims. Subsequently, in five minutes, Raju was traced and brought out of the drain through manhole B. Raju had been found lying in the accumulated water in the drain, unconscious. He was immediately shifted to the company hospital. Another trained operator, who had entered the drain through manhole C and walked inside towards manhole B, located the other victim, Appa. He was also found lying unconscious in a pool of effluent fluids. He too was brought out and rushed to the hospital. Both the victims were declared dead by the hospital authorities.

2.5 Investigative Findings

About 100 m of the upstream portion of the drain had been safely cleared of debris and cleaned out by the same *mazdoors*, only two months before with strict implementation of the safety precautionary measures under the competent and strict supervision of the civil engineering and safety departments in full co-operation with the contractor.

The first step in the investigation was to question the Technical Director and the Chief Civil Engineer as to why the work had been undertaken, ignoring all protocols required to organise and monitor the work safely.

1. All operations in the plants were suspended during the previous two months. The company had declared a lockout, and since no chemicals, wastes and effluents were ever discharged during this two-month period, it was presumed that the effluents in the drain were as clean and clear as plain domestic water effluent. The executives had taken the conditions for granted. They had discussed it and decided that there wasn't any need to consult any one or even organise and implement any safety precautions.
2. They concluded that planning, organising and implementing safety precautionary measures was a time-consuming process. They also failed to realise that even though the processes had been stopped for two months, the effluents embedded with hazardous chemicals had been flowing through the drains for more than 30 years.
3. Immediately after rushing the victims to the hospital, the drain between manhole A and manhole B was examined. The safety department and civil engineering personnel, using self-breathing-apparatus and gas masks, tested the atmosphere inside for gas concentrations.

   The semi-solidified sludge was about 600 mm thick and the accumulated stagnant effluent above the sludge was 300 mm high.

   The concentration of hydrogen sulphide gas was between 800 and 900 PPM. Other gases were present there in minor concentrations. In absence of a fresh air supply, the inhaling of the deadly hydrogen sulphide gas for 20 minutes or so proved fatal for both the victims.
4. None of the persons involved in the execution and supervision of the job on behalf of the civil engineering department or the contractor were aware of any such precautionary or preventive safety measures. They admitted that they knew all about the previous work undertaken but their excuse was that no one told them anything this time.

2.6 Remarks

1. Disregarding safety precautionary measures before undertaking dangerous jobs under hazardous situations endangering human life is highly objectionable. Plan, organise, monitor and strictly supervise tasks undertaken for the safety and health of your employees.
2. If you have no knowledge and experience of carrying out hazardous tasks safely, consult those who do.
3. Apart from not violating statutory provisions, as in this case, it is our moral responsibility to provide safe working conditions for everyone.

2.7 An Overview of the Employer's Safety Programme

The company had a full-fledged Safety Department, which had issued the following "Safe-Entry-Permit" and "Certificate" — a routine generally observed and strictly followed in the company. *(Refer to Chapter VI: 'Permit-to-Work System' & 'Confined Space Hazards'.)*

The following safety precautionary measures, to be taken before and during the cleaning and repairing operations of the main drain tunnel on the factory premises should accordingly be organised and strictly implemented.

1. No person will be permitted to enter the drain through any manhole unless the safe-work-permit is signed and issued by the civil engineering authorities clearing and endorsing the safety measures taken by them and to be taken by the contractor, who will then sign the permit in acceptance.
2. Both the initiator, namely the civil engineering department, and the job undertaker, namely the contractor, will remain responsible and accountable for the safety and health of people working therein. Competent and responsible supervisors, therefore, should ensure that all the safety measures have been taken, checked and examined and also certified as and when necessary.

Precautions Enlisted in the Permit

1. The entire drain should be washed thoroughly with hydrant water. An outgoing drain wash sample with a pH between 6 and 8 would indicate completion of washing.
2. Sufficient amount of steam should then be passed through the manholes where hazardous chemical sludge and residuals have been observed to accumulate as stagnant pockets.
3. The accumulated wash water with the effluent should be siphoned/pumped out from the outside.
4. It should be ensured during the operation that no wash or waste waters, acids, alkalis, any other chemical or residuals are drained from the sections/departments into the main drain. So also any accidental ingress of dangerous fumes should be prevented from entering the main drain by blocking off the possible sources.
5. The civil engineering department will issue a safe-entry-permit to the contractor with the following protocols. It is essentially a document which sets out the work to be done, the hazards involved and the precautions to be taken inclusive of necessary isolations made, connections removed and tests performed.

   * The authorised initiator will specify time limits between which the permit is valid.
   * Tests will be carried out by the safety department or laboratory to measure concentrations of the expected gases and fumes in the atmosphere inside each of the manholes just before entry and will certify whether it is safe to enter or not. Safe entry should only be permitted when the concentrations of the noxious gases have been confirmed within allowable limits (threshold limit values TLV) and accordingly certified on the permit.

* On ensuring the completion of steps and correctness of particulars, the permit will be signed by the initiator and issued to the contractor, who will check, understand and sign in acceptance.
* A fresh work permit will be issued to continue the work the next day or after the specified time limit.

6. The company's safety professionals will educate the contractors' workmen on the hazards involved and safety measures to be observed. Civil engineering and the contractor's supervisors will also be instructed on their task of strict supervision.
7. Fresh air should constantly be blown in by an air-blower through the manhole in which a person has entered, and all other manholes, in the entire length of the drain, should be kept open all the time while people are inside.
8. Only one person is allowed to enter the drain through one manhole and another through the adjacent one after testing.
9. Both the persons should be provided with safety belts approved by safety department in conformation with Indian standards. The free end of lifeline on each belt should be securely fixed onto a structural member by its lockable hook. An observer should be placed outside watching the person working inside so that he can pull him up in an emergency.
10. Flameproof torches and/or 24 volt hand lamps should be provided for inside use.
11. No single person should ever be allowed to work inside at a stretch for more than one hour. Two teams to work alternate hours should be planned for.
12. If someone comes out complaining of any noxious gas nuisance, fresh tests should be carried out to ensure that gas concentrations are below allowable limits. If not, work must be suspended and the pockets should be washed, the washings siphoned out and their pH tested. Safe entry will not be granted unless and until the wash water is cleared of alkalinity and/or acidity and gases are observed below TLV.
13. Testing of gas concentration inside the subject space is essential just before the person enters or when the person becomes too uncomfortable to continue to work inside. An important note was added to the above-mentioned measures, which stated that:

* Continuous flow of all sorts of hazardous process chemical effluents through the drain might have had accumulated at various places inside, especially wherever the tunnel was damaged and as such it should be taken into consideration that the work involved might prove to be more dangerous than expected.

The operation is covered under the provision of Section 36 of the Factories Act, 1948.

2.8 Investigation Report Based on the 'Layered Method'

Dr. Kletz has innovated a recent method of investigation, 'Layered Method of Investigation'. The above investigative findings have been converted as per the innovated methodology.

The investigator or the investigating team ought to be familiar with the following specifications.

1. The work to be done: Cleaning and repairing the main effluent drain, disposing debris and damaged/waste material.

2. Location: The entire effluent drain.
3. Period chosen: Dry season and plants' shutdown.
4. Hazards involved: Toxic, flammable and explosive chemicals, gases and fumes; inside areas and walkways dark and slippery; expected obstructions due to damaged construction material.
5. Responsibility for carrying out the job: The civil engineering department either departmentally or on contract.
6. Single top position bearing responsibility and accountability: The Chief Civil Engineer and the Technical Director to whom the department reports.
7. Planning and organisation: The Chief Civil Engineer in consultation with the Safety Department, Legal Department and the contractor.
8. Final approval: From the Technical Director on behalf of the Management.

The following is the re-investigation of the accident according to Kletz's method of 'layered' accident investigation.

First layer recommendations — Immediate technical recommendations preventing the recurrence of the accident or the mishap.

1. Block all inlets to the main effluent drains; ensure no effluent or waste water is allowed to be drained into the main drain.
2. Keep all manholes open.
3. Test the stagnant sludge and the atmosphere inside the main drain for toxic and flammable gases and fumes.
4 If the concentration of gases is found to be above TLV, flush the drain with hydrant water several times till the atmosphere inside is free from hazardous gases and chemicals.
5. Provide a ladder, 24-volt lamp, supply of fresh air and safety belt and assign an observer for the person entering.
6. A work permit and safe-entry-permit are to be issued by the initiator to the contractor. Both parties should satisfy the specified safety precautionary measures to be taken.
7. The interior atmosphere should be tested and certified just before the person enters.

Second layer recommendations — Avoiding the hazard.

Why were the hazards ignored?

All technical personnel working in chemical plants know that hazards continue to remain where they are unless totally eliminated or effectively treated.

Manufacturing activity having been halted for a couple of months does not assure a safe atmosphere within the enclosed space.

Why was this not confirmed with tests?

1. Perhaps it was the overconfidence of the wrong decision makers; or
2. Lack of commitment to safety; or
3. An egotistic attitude towards the functional areas of other department.

Third layer recommendations — Improving the management system.

1. Did the men on the job, including the top executives directing the job, understand that it was not only necessary but also essential to make and ensure that the conditions were safe inside the confined space before entry?
2. Is this point covered in their training?
3. What is the best way of putting it across so that people will understand and remember?
4. How should the management or the senior executives and managers be educated on this point?

The management system needs to improve in this aspect. Senior managers, just because they happen to head the respective departments, should not take decisions to carry out risky assignments unless they are totally committed to safely and are competent enough to get the work done safely. If not, they must consult experts in the field and organise the work accordingly.

The investigating team should invariably contain senior, knowledgeable and competent managers as it would not be normally expected of the unit manager or the unit supervisor to think of all the second and third layer recommendations. The senior-most managers should think of them when they read the reports.

Similar mishaps usually occur in the sewage or city drains and garbage pits or chambers.

3 Causative Factors

Having gone through the above incidents, perhaps we may in a position to discuss the questions which were posed at the beginning in Section 1.2.

3.1 Where Do Accidents Happen?

Accidents/mishaps/injuries/untoward incidents take place anywhere and everywhere that people come together — stay, travel, work or play — inclusive of one's home, at the door, on the road, in the water and in the air.

However, aviation, rail and road traffic, transportation equipment, pulp and paper production, mining, engineering and chemical process industries, theatres, playgrounds, pilgrimages, so on and so forth, account for most accidents.

The location of an accident is not important, unless the work is known to be hazardous.

3.2 How Do Accidents Occur?

Accidents occur because of the faults inherent within human beings. We create unsafe conditions or situations—inadvertently or intentionally. Simultaneously or in addition, we indulge in wrong or incorrect acts, i.e. we follow unsafe practices. Again such unsafe acts are a result of lack of adequate education and proper training or pressure from work.

Unsafe conditions and unsafe acts, may or may not be the fault of the injured and the others involved. Injury may occur directly because of unsafe conditions and acts without an accident. Also, accidents may or may not cause an injury. Accident causes differs from injury causes.

(Refer to 'An Overview of an Accident' and 'Accident' in sections 5 and 6, Chapter III, Part 2.)

3.3 Why Do Accidents Occur?

Accidents occur due to the following factors:

- Lack of risk awareness.
- Lack of knowledge on the activity being undertaken.
- Lack of safety aspects in design.
- Lack of commitment to safety.
- Lack of control.
- Lack of education, training and motivation.
- Lack of team-work and safety culture.
- Lack of discipline.
- Lack of social responsibility in general and personal responsibility and accountability to safety.
- Failure to learn from past experiences of similar incidents.
- Failure to inspect safety gadgets and devices and maintain them in order regularly and adequately.
- Failure to employ competent and well-trained people.
- Lack of continual efforts in training employees.
- No efforts to prevent hazards by employing safer designs or by adopting control methods.
- Failure to identify critical components and comply with the preventive maintenance requirements of the installation.
- Failure to sponsor candidates who are qualified, deserving and are interested in making safety profession as their career to professional courses in safety.
- Lack of instituting safety in the organisation. Out of all the various management functions, safety function remains the most neglected function — apparently, considered non-profitable.
- Safety profession is, at the most, given a subordinate position in the management hierarchy. It generally falls to the middle management level which is not aware of even the basic principles of safety.

3.4 How Effective Is the Legislation?

India has state-of-the art regulations, but they are not implemented. The basic reason for this is the total indifference towards safety by everyone — the Government, the Management and the Workers' Unions.

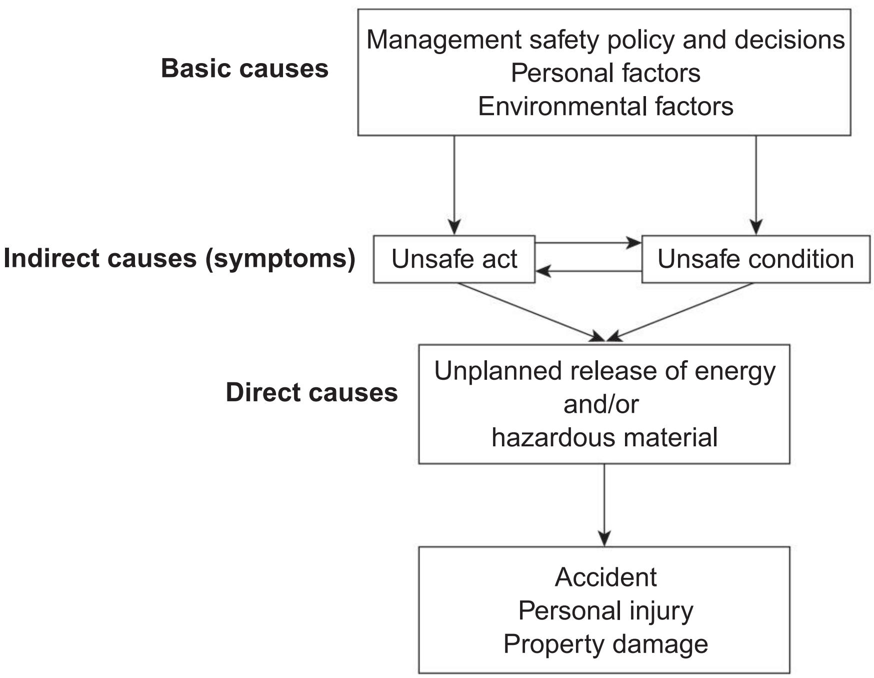
Statutory provisions are becoming more stringent day by day, but they aren't effective; they remain only in the books of statute. Those who are responsible for implementation of the industrial legislation hardly know of or are aware of the same.

Bureaucratic corruption has reached an extent that it is easy and convenient for any management to evade the law. Both the management offering and the authorities accepting the bribe to ignore the unlawful and unsafe act or condition are to be blamed for neglecting safety in an industry.

As could be inferred from the above incident and the discussion made thereafter, the top management should ensure that it remains committed to the safety and health of its employees throughout their term with them.

A commitment to safety by the management on paper, in a safety manual declaring the company's safety policy, has no meaning. It should be put into action.

Safety practice should be made a core culture of the organisation. The decision makers in the organisation need to have a thorough knowledge of various norms and systems in safety. (Refer to the next chapter on 'Safety Management'.)



A detailed analysis of an accident will normally reveal three cause levels: Basic, Indirect and Direct.

An important principle in safety, by Heinrich, states:
"The causes of the accidents are visible before the accident."

Figure 1-3 Stages to an accident.

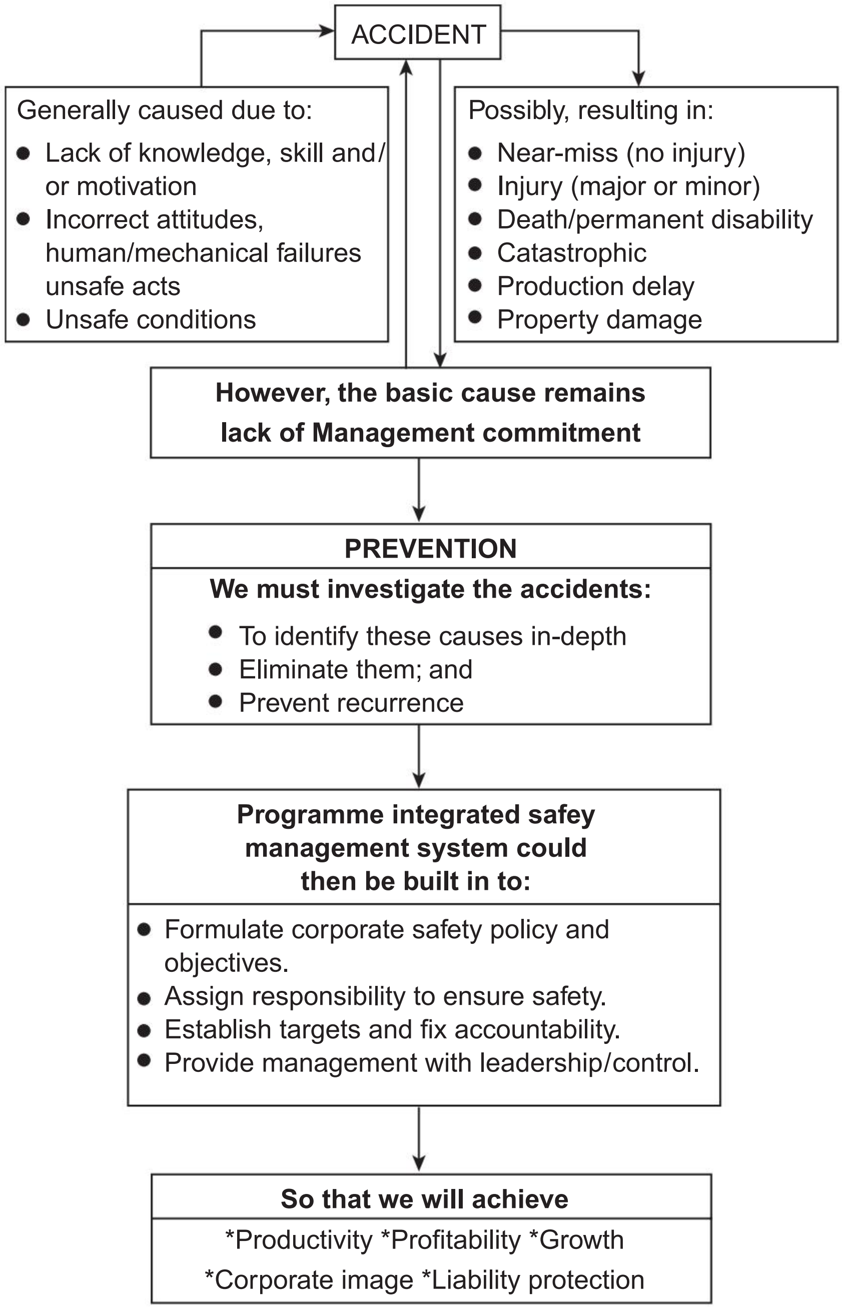


Figure 1-4 Accident cause and effect analytical SMBO model.

INTRODUCTION

Safety Management

1 Introduction

Case histories have been presented by way of investigations of various incidents and mishaps to the readers who are expected to study them and draw conclusions so that they are in a position to recommend corrective measures in order to prevent recurrence. Studies of these and other such investigations should ideally have been carried out when the plants were being designed, so that modifications to plant design or working methods could have been made thus avoiding the incidences altogether.

Samuel Coleridge described history as a lantern on the stern, illuminating the hazards the ship has passed through rather than those that lie ahead. However, being made aware of the hazards in retrospect is better than not noticing them at all. It is even better, though, to be aware and prepared for what lies ahead. There are methods available to help us foresee potential hazards.

Ample information has been made available all over the world. Various aspects of identification of hazards, their assessment, measurement and evaluation—both qualitative as well as quantitative—rectification, control measures—both technological and operational—management safety systems, administration and organisation in safety and loss prevention and control have been widely publicised. Education, training and development courses in safety are being conducted. The final requirement is an honest and sincere effort to bridge the gap first between the *unknown and known* and then, between the *uncontrolled and controlled*.

Amongst all the methods the most valuable and essential are as follows:

- Hazard and Operability Studies (Hazops)—to be conducted by a team at the flow sheet, P and I diagrams and detailed design stages. It is qualitative and identifies hazards. It is also known as 'What If?' studies.
- Hazard Analysis (Hazan), also termed as Risk Analysis, Risk Assessment, Probabilistic Risk Assessment (PRA) and Quantitative Risk Assessment (QRA)—It is quantitative and assesses hazards and is conducted by one or two experts in the field. It is a selective technique and is required to be used when other techniques fail or when decided by Hazops.
  (See section 9 for detailed information on Emergency Preparedness and Response and section 10 for Prevention of Accidents, involving Hazardous Substances, Chapter III, Part 2.)
- *A verification of the technique at the conceptual stage*—Detailed inspection during and after construction to make sure that the design has been followed and that details not specified in the design have been constructed in accordance with good engineering practice.
- *Regular safety audits internal as well as external on the operating floor*—The management must remain committed to safety not only to achieve its eventual goal of better corporate performance but to meet the expectation of its employees and their fundamental right—"when a man enters the employ of a company, he has a right to expect that he will be provided with a proper place in which to work, proper machines and tools to do his job and proper methods to perform his task, so that he will be able to devote his energies to his work, without any danger to his life, limb and health".

2 Organisation and Personnel

At the outset the industry has to decide and derive its *Occupational Health and Safety policy (OH&S)* in order to commit to its OH&S management system.

2.1 Management should ensure that appropriate organisational arrangements for implementing the corporate safety policy are established. The line of prime responsibility for the management of safety in the enterprise, as well as individual responsibility for safety, should be clearly defined.

2.2 Management responsible for an installation should be actively involved in developing and updating the local safety arrangements of that installation, which should be designed to satisfy the time bound broader *corporate safety objectives*, with the participation of the employees concerned.

2.3 Objective, targets and performance indicators cannot be established unless adequate planning is made to achieve them with the ultimate responsibility for OH&S resting with the top management. As a natural sequence, the organisation defines, designates, documents and communicates *OH&S responsibilities, accountabilities and authority* to act and report relationships for all levels of functionaries including subcontractors and visitors.

3 Planning

The identification of significant hazards and the assessment and control of risks associated with the activities of the organisation as well as any related legal requirements can be addressed by adopting a systematic planning procedure.

The following points can be taken into consideration during planning.

1. In planning staffing schedules, avoiding stress and overwork should be taken into consideration. For example, hours of work and rest breaks should be compatible with safety requirements. Overtime and rest day working by any individual should not be excessive. A record of all such abnormal hours should be maintained to maintain control on hours worked.
2. The need for greater levels of supervision during periods of stress should be taken into account. Special staffing requirements and technical skills made imperative by start-ups, shut-downs, abnormal or unique operating situations and emergency response situations should be identified and met by the management.
3. Attention should be paid to the physical fitness of employees with respect to their jobs, including those employees whose activities are largely sedentary such as managers and control room employees. Employees should not be assigned tasks if such assignments may compromise the safe operation of the installation. For instance, employees who are affected by substance abuse should not be assigned certain safety-critical tasks. Jobs which are unsuitable for assignment to challenged or restricted employees, pregnant women or young employees due to the risk of an accident involving hazardous substances, should be identified and, where necessary, special arrangements made on a case-by-case basis to ensure such employees can perform their tasks safely.
4. Employees, and their representatives where they exist, should participate in decision-making concerning the organisation of their activities and the staffing needs of the installation, to the extent that these may affect safety.
5. Consideration should be given as to whether certain tasks, because of their relationship to prevention of accidents, should be subject to specific management controls, for example, a requirement for a specific authorisation or licence for activities such as pressurising tanks and welding.

4 Safety Management System

This safety management system includes the organisation structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the organisation's Safety Policy. It demands critical and systematic assessment of the existing standards of safety achieved in the company with respect to the targeted goals to be achieved for the fulfilment of the system.

Health and safety is one of the most important aspect of an organisation's smooth and effective functioning. Good health and safety performance ensures an accident-free industrial environment. We therefore need to adopt a structured approach for the identification of hazards, their evaluation and control of risks. This system intends to assist the industry to develop a systematic approach to the Management of Occupational Health and Safety in such a way as to protect their employees and others whose health and safety may be affected by the organisation's activities.

5 Management Representative

The Management should appoint a Management Representative, i.e. a safety professional who by virtue of his knowledge, education, experience and position is able to evaluate and update the safety management procedure accordingly. Sufficient professional safety personnel should be available within an enterprise. They should remain impartial and independent of line management, provide expert advice and function as the enterprise's safety conscience.

In this regard, safety personnel should have the necessary authority to carry out their responsibilities, and be seen to have management support; interact with, and be respected by, employees at all levels in the enterprise; be technically competent, either through specialised training or adequate experience, or preferably both; and possess good interpersonal and communication skills.

The number of safety professionals needs to be appropriate to the size, technology and complexity of the enterprise. Management can consider rotating employees between line management and the safety function in order to increase understanding of safety-related problems, generate better solutions to safety-related problems and strengthen the "safety culture" within the enterprise.

(For details regarding the 'Scope and Functions of Professional Safety Position', refer to section 7, Chapter III, Part 2.)

6 Competence Mapping

The management should determine the competency levels of personnel performing work that affects safety. They should ensure that all personnel whose work/workplace involves significant hazard, receive appropriate training. Safety performance should be considered an essential component of every employee's overall performance and should be reviewed periodically.

Roles with respect to the safety of each employee, including managers at all levels, should be clearly defined so that safety performance can be appropriately monitored and reviewed.

The management and public authorities should encourage employees (belonging to the company as well as contractors) to fulfil their role and responsibility to safety. Employees may require the support of unions, confederations and their international organisations to assist them in this respect. Employee–management co-operation is a prerequisite to assuring safe operations at hazardous installations.

(For details regarding 'Education, Training and Development in Safety', refer to section 5, Chapter II, Part 1.)

7 Communication

OH&S information including significant risks and hazards need to be *communicated* to all the people in the organisation as well as the outsiders concerned.

Effective two-way communication channels for the transfer of safety information between management and other employees should be established at hazardous installations. This will help create and maintain a high level of motivation for all employees to operate the installation safely.

It is necessary to establish and maintain documented procedures for *relevant and timely reporting* of information required for monitoring and continual improvement of OH&S performance.

The elements of the OH&S management systems and their interactions and provisions of direction to the related *documentation* has to be established and maintained in a format by formulating a procedure.

8 Design

Hazard identification, risk assessment and risk control procedures should be incorporated in each of the *design cycles* namely development, review verification, validation and change. Design planning output should be updated as the design and development progress.

9 Emergency Preparedness

Emergency preparedness involves two important procedures, viz:

- *Contingency preparedness* and response should be planned in advance to periodically test plans to ensure an adequate response during the actual contingency.
- A *critical incident recovery plan* (CIRP) with a view to aid on-plant employee recovery as soon as possible after the cessation of the event.

10 System Audits

Periodic *OH&S system audits* should be carried out to confirm that procedures are achieved as planned and organised as per the OH&S management system.

11 Review

The top management should *review* the OH&S Management system to ensure continuous suitability, adequacy and effectiveness. The management, in its review process, should ensure that the necessary information as regards overall performance, performance of individual elements, findings of audits and adequacy of corrective and preventive action has been collected to allow an *evaluation*.

12 Safety Committees

Regular communication channels can be reinforced by the establishment of Safety Committees to provide a formal mechanism for consultation among employees on safety matters. The Safety Committees should support, but not be a substitute for, direct communication among management and employees, or for individual and line management responsibilities to safety. The use of such committees enables the maximum benefit to be obtained from employees' practical experience and knowledge, as well as furthering mutual trust and confidence through the actions taken to improve safety.

Safety Committees should operate at different levels in an enterprise and consist of:

1. employees at various levels (including Safety Representatives where they exist);
2. managers with the authority to implement the Committee's recommendations;
3. safety specialists; and
4. contractors.

Requirements of a Safety Committee.

1. Safety Committee members should receive safety training and specialist advice, as necessary.
2. Resources should be available to the Safety Committee for undertaking its activities.
3. Management should act upon the recommendations of the Safety Committee, recognising that the ultimate responsibility for safety remains with the Management.
4. Safety Committee members should not lose any earnings for time spent in activities related to the Safety Committee.
5. Safety Representatives can be established at the plant level. Safety Representatives, nominated by employees, represent those employees in consultation with the management on matters relating to safety. They should be given specific training related to their role.
6. No prejudicial measures to an employee should be taken if, in good faith, the employee complains to other employees with responsibilities for safety with what he/she considers to be a breach of statutory requirements or an inadequacy in the measures taken. The Management should support this approach if the "open" attitude to safety matters is to be achieved.
7. Employees should be required to report to the Management any situation which they believe could present a deviation from normal operating conditions, in particular situations which could develop into an accident involving hazardous substances. Management should investigate these reports. If the response is inadequate, the employee should be entitled to refer the matter to public authorities.

In addition to Safety Committees at individual hazardous installations, the establishment of parallel mechanisms at the corporate, sectoral, national or international level may be considered as a useful means of helping to disseminate safety information and provide input to the relevant decision-making processes concerning safety.

13 Corrective Preventive Action

The organisation has to establish and maintain procedures for corrective and preventive actions in the light of *findings, non-conformance, conclusions* and recommendations reached as a result of monitoring, audits and other reviews of the OH&S Management system.

14 Right of Employees

An employee should have the right to refuse to perform any task which he/she believes may create an unwarranted risk of an accident involving hazardous substances.

The employee should immediately report to Management the reasons for refusing to perform these tasks. In certain cases an employee, or a Safety Representative, where one exists, may interrupt hazardous activities in as safe a manner as possible when he/she has reasonable justification for believing that these activities present an imminent and serious danger to safety.

15 Personal Protective Equipment

Management should ensure that all employees have appropriate personal protective equipment and ensure that it is maintained in good condition. Management should also ensure that regular training is provided in its use. Employees should be responsible for using the personal protective equipment in accordance with safety procedures and policies.

16 Restrictions on Contract Work

Management should not engage contractors to perform jobs related to the operation of a hazardous installation if this would compromise safety.

The following guidelines can be considered in this regard.

1. Management should only hire those contractors who are competent to carry out work in accordance with all applicable laws and regulations, as well as the safety policies and standards of the enterprise and any additional practices particular to their task.
2. Compliance with laws, regulations, safety policies and standards should be an integral part of the contract with contractors.
3. Management should monitor the safety performance of their contractors and, in general, contractors should be subject to the same safety management systems as employees.
4. Contractors hired to perform duties related to the operation of a hazardous installation should have equivalent rights and responsibilities as employees with respect to safety. If necessary, special measures should be developed to ensure that contractors' employees are well informed of the hazards when operating at hazardous installations. Specific site safety information should be made available to contractors' employees.

According to Dr. Trevor Kletz, the situation in the UK and USA is no different from that in India in so far as the Managements' lack of knowledge is the prime reason for a majority of industrial accidents. The knowledge, about why accidents occurred in the past and how can they be avoided in future, has to be followed by suitable action.

Learning from experience highlights an additional area, namely that of correcting our incorrect knowledge.

16.1 Lack of Social Responsibility

Without social discipline, if we try to put in place new technology, it won't give results. Similarly, in the safety situation, if we keep bettering technology and techniques, they will not give us the desired results unless basic attitudes change. The basic attitude is adequate and proper understanding of 'social responsibilities'. In a country like ours, the obligation imposed on people is much less than it is elsewhere in developed countries.

Higher technologies bring with them an obligation to discipline. In the field of industrial working, in each area—productivity, efficiency, quality and safety—it is not merely the improvement of technology, techniques or training that gets us anywhere. That should be supplemented by some degree of social discipline. The higher the degree of technology, the greater is the degree of social obligation.

16.2 Discipline Is What Managers Make It

Authority is of two types, one that stems from the official position and one that results from personal knowledge, character and competence. If management executives and/or the managers are disciplined in their own work, the entire organisation becomes disciplined. If the manager is slack and slovenly in his work, people reporting to him also become indifferent towards their work.

CHAPTER II

UPGRADING DEVELOPMENTAL PROGRAMS

Safety Procedures, Arrangements and Performance Measures

1 Operations

1.1 Management should ensure that each installation in an enterprise has written operating procedures and instructions in order to establish the necessary conditions to satisfy the design intent of the installation and maintain its integrity. These should take into account the relevant standards, codes and guidance in order to ensure that equipment, plant and premises provide a safe place of work under both normal and abnormal operating conditions.

1.2 Before new products, processes or equipment are handed over from one department to another (for example, from research to production), management should ensure that there are written, agreed operating procedures and safety instructions in order that knowledge and experience gained in research, development, pilot plant and production are passed on. This handover should be formalised by an appropriately signed handover/clearance report.

1.3 Appropriate procedures should exist to ensure effective protection against accidents involving hazardous substances during abnormal conditions such as when critical instruments, alarms and emergency equipment are not available, and during periods of stress at the installation (for example, when there are unusual production demands or an economic decline that affects the installation).

1.4 Appropriate arrangements should be introduced at a hazardous installation for the prevention of fires, and should a fire occur, for the protection of personnel, buildings and equipment and fire fighting. These arrangements should make provision for the necessary equipment, procedures, training, testing and personnel.

1.5 Appropriate procedures should exist for the safe shutdown and decommissioning of a hazardous installation to ensure that hazards are controlled during the shutdown process and while the installation is out of operation.

During transition phases of operation of a hazardous installation which involve shutdowns and start-ups, for example, during maintenance of equipment, special efforts should be made to avoid potential causes of risk such as communication problems and split responsibility, since such phases may involve people who are not fully aware of the details of an installation's operation, policies and procedures.

1.6 Appropriate arrangements should be in place for maintaining the security of a hazardous installation to minimise the possibility of sabotage or vandalism. The management of the hazardous installation should specify those areas of the installation to which access should be restricted or controlled and implement measures to maintain control and prevent unauthorised access.

1.7 Management should endeavour to choose the safest practicable means of transport and routing of hazardous substances being taken from or delivered to an installation in order to minimise the number of people potentially affected in the event of an accident.

1.8 A high standard of housekeeping and operational efficiency should be maintained at a hazardous installation since there is a clear correlation between these functions and good safety performance.

2 Maintenance

2.1 Management, particularly of hazardous installations, should establish programmes for the regular maintenance, inspection and testing of equipment to ensure that it is at all times fit for the purpose for which it was designed.

1. Maintenance programmes should be adhered to strictly and reviewed periodically to ensure they continue to be appropriate in relation to safety requirements.
2. Maintenance standards should be developed to help guarantee the safety of each operation.
3. Maintenance jobs should be performed according to established maintenance procedures.
4. Records should be kept of all safety-related maintenance work carried out and equipment reviews and reliability assurance procedures should be established.
5. Records should be kept of any faults found during maintenance of equipment, which might materially affect safety, and prompt action taken to rectify the faults.

2.2 The local management at each hazardous installation should regularly inspect and maintain emergency alarms, protective and emergency devices and all devices critical to the orderly shutdown of operations in conjunction with the relevant public authorities, where appropriate.

3 Modifications

3.1 The management of a hazardous installation should establish formal procedures to ensure that no repair work or modifications to plant, equipment, processes, facilities or procedures compromise safety.

1. Modification procedures should apply to both permanent and temporary changes, and should be based on up-to-date process documentation and, where appropriate, a physical inspection of the installation.
2. All modification proposals should be registered and assessed so that the necessary hazard studies are carried out, the appropriate design considerations are made and the changes proposed are properly engineered and recorded.
3. Major modifications should be subject to the same notification and reporting requirements as new installations

3.2 Proposals for significant modifications require a review by competent technicians who are independent of those directly responsible for the proposal.

1. The level of management approval necessary for a modification should be based on the associated level of risk.
2. Supervisors having the authority to make a modification for example, to a manufacturing procedure or operating instruction, should be fully aware of the hazards involved and should consult competent specialist(s) before initiating such a change.

3.3 In the case of any changes made to a process which could affect safety for example, use of different process materials, alterations of conditions, increase in batch size, or use of larger/different equipment, the original hazard analysis should be reviewed and the process documentation file or plant dossier maintained accordingly. Techniques should be developed to assess how a series of minor changes, taken together, can affect safety at an installation and what could be done to mitigate any increased potential for accidents.

3.4 After repair, modification, and/or overhaul of plant and equipment, the necessary test runs and safety checks should be carried out in the presence of the supervisor responsible for the operation of the installation, who should be required to formally approve the restarting of operations.

3.5 Procedures should also exist to ensure that changes in management, other personnel and organisation do not compromise safety. Such changes should trigger review procedures to ensure safety has not been adversely affected.

4 Storage of Hazardous Substances: Special Considerations

All the Guiding Principles in this section apply to storage facilities for hazardous substances. Storage presents special risks or concerns which warrant additional guidance. These apply to both on-site (at the installation) and off-site (contract) storage, including bulk storage (for example, in tank farms) and non-bulk storage (for example, of packaged goods). The warehouse-keeper, for purposes of this text, is the person responsible for the storage facility, whether on-site or off-site.

4.1 The management of an enterprise seeking to store hazardous substances off-site—including products, raw materials and intermediates—should satisfy itself as to the suitability of the facility for storage of such substances and of the competence of the warehouse-keeper to undertake the storage required in a safe manner. This could involve the enterprise monitoring the storage facility and training employees of the off-site facility.

4.2 The warehouse-keeper should ensure that all relevant legislative requirements and applicable codes of practice for the safe storage of hazardous substances are strictly applied wherever necessary.

4.3 The owner/supplier of the hazardous substances being stored should provide the warehouse-keeper the information necessary to prevent accidents and to respond appropriately should an accident occur.

1. In this regard, the owner/supplier should provide a material safety data sheet (MSDS) or product data sheet so that the warehouse-keeper can ensure that physical, chemical and (eco) toxicological, and other properties relevant in the case of an accident are understood by all relevant employees working in the storage facility.
2. Particular attention should be given to proper labelling of hazardous substances, indicating any hazardous properties on labels and the appropriate precautions to be taken.
3. In addition, the owner/supplier of the hazardous substances should provide information concerning reaction and/or decomposition products formed in the event of a fire.

4.4 The owner/supplier of hazardous substances should consider reducing the amount of hazardous substances requiring storage, off-site and/or on-site, if this would reduce the adverse consequences of an accident involving the hazardous substances.

4.5 A storage facility should be designed taking into account the nature of the hazardous substances to be stored in the facility.

1. The design of the facility should allow for the separation of incompatible substances and subdivision of inventories by the use of separate buildings, fire walls, etc. and should enable access for inspection of hazardous substances, reduce the likelihood of domino effects should an accident occur and permit fire-fighting.
2. In designing such facilities, particular attention should be given to incorporating automated systems for handling hazardous substances, which reduce the risk of an accident involving such substances.
3. In order to prevent explosions and fires, consideration should be given to whether the conditions of storage (including, for example, temperature and pressure) create special risks. Consideration should also be given to avoiding potential sources of ignition such as smoking, welding, and shrink-wrapping equipment. All power equipment should be specially protected, as necessary.

4.6 Storage facilities should incorporate safety features to prevent accidents and to reduce the adverse effects in the event of an accident. For example, security measures should be in place and fire protection equipment should be available. Adequate catchment facilities should be provided for the activation of spill mitigation procedures to protect the environment in the event of an accident.

4.7 Storage plans should be drawn up by the warehouse-keeper showing the nature of the hazardous substances in each part of the storage facility. The storage plan can be made available to the relevant local public authorities for example, fire services. Information concerning hazardous substances held in a storage facility should be maintained up-to-date.

4.8 Procedures should be established at storage facilities to prevent the risk of degradation of hazardous substances or packages as well as labels or other markings. Good housekeeping practices should be initiated to prevent accidents.

5 Safety Performance Measurement

All objectives related to performance in production or sales are relatively measurable, whereas, performance in safety is not measurable in the, same sense.

The need for safety is a negative thing therefore the performance measurement in safety is negative. The 'performance in safety'—the negative yardstick—starts measuring the positive need for safety, making the accident the starting point.

The standard specified injury rates, acclaimed universally, enable us to measure where we stand in the field of activity of safety and thus compare our performance in safety with that of previous years on the whole, department or even section-wise, and with that of other industries of similar manufacturing activities.

5.1 'Practical and Effective' Safety Performance Measures

Doubtless, safety performance measures will be proposed and experimented until an acceptable evaluation method is standardised. The desirability of such a development is great. The ability to gauge with some precision the correct course to follow is necessary for assured progress. Equally important is the persuasive influence that is inherent in valid performance measures.

The general rule is what is measured is what gets done. It is no less important for safety achievement than it is for the accomplishment of any other objective or function.

The following are the significant criteria, amongst several which may be considered as the construction of the development of safety performance measures progress:

1. The measure should probably relate to the operation's effectiveness in fulfilling its total mission and in particular with respect to the operation's capability for limiting any serious consequence from hazards in its system.
2. The quantified values obtained by the measuring method should be replicable to anyone instructed in the use of the technique.
3. The variables quantified should be realistic and familiar and uncomplicated so that a minimum of instruction will be required to introduce the measure and obtain its acceptance.

4. The measurement data probably should not be drawn exclusively from harmful events, particularly over short time spans as it may not be sufficiently related to safety performance.
5. If possible, the measurement should enable valid comparisons of hazard control effectiveness between the operating components of an establishment as well as between classes of establishments.
6. The measure should be able to obtain the consensus approval of the Bureau of Indian Standards so that it can meet the needs for a ‘standard’ measure of safety performance effectiveness.

6 Computing Injury Rates

6.1 Frequency Rate of Disabling Injuries (F)

‘F’ relates the injuries to hours worked during the period and expresses them in terms of a million-hour unit by use of the formula.

$$F = \frac{\text{Number of disabling injuries} \times 10{,}00{,}000}{} .$$

The number of disabling injuries per million employee-hours exposure.

6.2 Severity Rate of Disabling Injuries (S)

‘S’ relates the days charged to the hours worked during a period and expresses them in terms of a million-hour unit by use of the formula.

$$S = \frac{\text{Total days charged} \times 10{,}00{,}000}{} .$$

The total man-days lost due to disabling injuries per million man-hours worked.

6.3 Incidence Rate (I)

‘I’ relates the number of occupational injuries and/or illness or lost workdays per full hundred full-time employees.

$$I = \frac{\text{No. of occupational injuries, illness or lost workdays}}{\text{Full 100 full-time employees}} .$$

The number of occupational injuries, cases of illness or man-days lost per100 full-time employees.

6.4 Safety Performance Index (SPI)

$$\text{SPI} = \sqrt{\frac{F \times S}{1000}}$$

This ratio includes both frequency rate, representing unit disabling injuries and severity rate representing unit days charged due to disabling injuries. Safety Performance Index has been standardised internationally. Safety Performance can be measured on the basis of index and compared periodically, area wise and similar activity.

Education, Training and Development in Safety

1 Introduction

1.1 Management should take measures to ensure that all those employed at a hazardous installation, including temporary employees and contractors, receive appropriate education and training and are competent in the fulfilment of their tasks under both normal and abnormal conditions. This education and training should cover:

- hazard identification and necessary corrective measures;
- basic emergency procedures;
- correct materials handling procedures; and
- any special hazards unique to their job.

To achieve this the management can ensure the following points.

1. Arrangements should be made to ensure that specialised training needs at all levels are properly identified, form part of a programme aimed at improving safety and are appropriately satisfied.
2. Employees, and their representatives where they exist, should be involved in the development of education and training programmes, the testing of these programmes and their subsequent revisions.
3. This approach to education and training should create the high level of awareness necessary not only to prevent accidents but also to respond to abnormal occurrences quickly and effectively. Ignorance or inadequate information can be a cause of incorrect action.

1.2 Safety considerations should be part of the initial induction training given to all new employees to create safety consciousness and commitment.

1. In addition to the education and training given before taking up normal duties, follow-up education and training should be given regularly.

2. During slower work periods, consideration should be given to using employees' free time for education and training activities.

1.3 Training should be well structured to give all employees the skills they need to do the job to which they have been assigned, and be sufficiently broad-based so that employees understand the workings of the plant, equipment and processes.

1. All employees should be encouraged and trained to think through their assigned tasks and how they can be carried out most safely, rather than just carrying them out mechanically.
2. Employees are likely to be more conscientious in their work, and in the application of safety systems and procedures, if their training makes it clear not only what they are required to do but also why the various systems and procedures are necessary.

1.4 Consideration should be given to training employees in groups rather than individually since group training can be an effective way of instilling good safety attitudes in employees, developing positive group behaviour, and establishing increased ability for group members to predict potential safety problems and to develop solutions.

1.5 Where appropriate, education and training should be available in languages other than the primary language used at the installation, for example where there are foreign employees or where the installation is located in a multilingual area. Where employees speak different languages, management should consider the need to establish a language as the one used in the event of an emergency, and then to provide the appropriate education and training so all employees can understand and respond correctly to commands during an emergency.

1.6 Records should be kept, and maintained up-to-date, of all safety-related education and training of employees including managers, supervisors, technicians and Safety Representatives.

1.7 The effectiveness of safety education and training should be regularly assessed to ensure that all employees can carry out the duties for which they are responsible in a safe manner. This assessment process is particularly important in times of change, such as when employees, including managers and supervisors, are being assigned to a new or different installation.

1.8 Education and training programmes should be modified to reflect changes in processes used, technology applied,and procedures followed at an installation.

1.9 Training should be considered part of employees' jobs for purposes of calculating working time and wages.

1.10 The management of hazardous installations should take all reasonable measures to inform on-site employees and contractors of the hazards to which they may be exposed. Adequate information on hazards (including emergency exposure levels) and on the procedures to be followed for safe handling of all substances used at the installation, manufactured as intermediates, or available for sale, should be obtained, kept up-to-date and disseminated widely, in a language(s) which all employees can understand.

1.11 Management of hazardous installations should provide technological information and assistance related to safety of hazardous substances to contractors, distributors, transporters and users as well as to employees.

1.12 Managers and supervisors should be made aware that they have a special obligation to be informed about safety standards and risks. They should fully understand the properties and behaviour of the hazardous substances being used and the limitations of the equipment and technology. They should be competent enough to implement the measures to be taken in an emergency.

1.13 Every supervisor should ensure that those on his or her team know how to safely carry out the tasks entrusted to them and how to maintain a high level of safety awareness. To achieve this, each supervisor should receive training in communication techniques, safety leadership, accident investigation and reporting procedures, safety and health analyses, and conducting of safety meetings.

1.14 Safety training should be included in the education of engineers and other technical specialists at both universities and schools. To this end, the safety aspects of the design and operation of hazardous installations should be integrated into the relevant curricula. Industry and public authorities need to promote this.

2 Human Factors

2.1 Particular attention should be given to the role of human factors in preventing accidents at hazardous installations, recognising that humans will, on occasion, fail and that the majority of accidents are in some part attributable to human error, meaning human actions which unintentionally exploit weaknesses in equipment, procedures, systems and/or organisations.

1. In planning all phases in the design, development, operation, maintenance, shutdown and decommissioning of a hazardous installation, management should take into account the possibility that human error can occur so that its effects can be minimised.
2. The human factor should be taken into account when hazard identification and assessments are carried out.
3. The human factor, including both positive and negative aspects of human behaviour, is applicable to all employees in a hazardous installation including managers and contractors.

2.2 The demands of each task, which may affect the safe operation of an installation, should be carefully analysed in order that employees and their tasks are mentally and physically matched and employees are not overloaded or excessively stressed so that they can make the most effective and safe contribution to the enterprise. Mental matching of a task involves consideration of the information and decision-making requirements as well as the perception of the task; physical matching includes consideration of the design of the workplace and working environment.

2.3 Employees should be encouraged to share their experiences in order to reduce the risk of human error. This can be accomplished through, for example, safety workshops, discussions of near-misses and other group discussions, as well as by inspection and observation of the workplace by employees and Safety Representatives.

2.4 Experiences relating to human error should also be shared among different companies and, to the extent possible, among public authorities.

2.5 Training and education programmes for all employees should deal with the issue of human errors, including the underlying causes and prevention of such errors. These programmes should also take into account ergonomics and the employee/machine interface.

2.6 Special care should be taken during periods of stress to avoid human errors, which could lead to accidents. Management should make it clear that safety considerations take precedence over other considerations. Stress affecting safety could result from pressure on individuals or groups of employees or on the enterprise as a whole, for example, to increase production or cut costs.

2.7 In their monitoring activities, both management and public authorities should consider the role human error might play in increasing the potential for accidents involving hazardous substances. They should consider the potential for errors both in the use of equipment and procedures.

2.8 It should be recognised that human error outside the hazardous installation can contribute to the increased risk of an accident or adverse effects in the event of an accident. For example, public authorities should take into account the fact that human error in land-use planning, in emergency planning, or in emergency response can affect the safety of a hazardous installation or aggravate the effects of an accident.

2.9 The model of safety thinking, explained below, enables a clearer perception of a mishap, which traditionally and conveniently, is always attributed to a 'careless', 'negligent' or ' ignorant' employee. In actuality, nearly all accidents originate from some kind of weakness in the management system.

For example, a missing rung of a cat ladder causes a descending helper to fall down. The investigation reports remark that the injured was 'careless' or 'was not attentive while coming down the ladder'. Furthermore, the corrective action suggests that ' the injured needs to be educated to be more careful'. The rung had been missing for more than six months. Everyone had seen it. No one reported it. Another easy attribution could be, 'neglected preventive maintenance procedure'. We hardly investigate in-depth to find out and assess the basic cause, which invariably would be 'weakness in management system' or 'lack of management commitment in ensuring safety'.

2.10 Almost all accidents and/or injuries can be traced to 'unsafe acts' and 'unsafe conditions' within the plant. [Reference: Accident, Injury and Incident.] Unsafe acts or practices are believed to be people-oriented, while the orientation of the unsafe conditions is attributed to machine, equipment, process, structure etc., in short the environmental situations.

3 Occupational Safety and Health Training

3.1 Broad Perspective

Occupational Safety and Health Training embodies instructing workers in recognising known hazards and using available methods of protection. Worker education, in contrast, prepares one to deal with potential hazards or unforeseen problems; guidance is given in ways to become better informed and to seek actions aimed at eliminating the hazard. The distinction between worker training and education programmes, on preventing illness and injury in the workplace, is often blurred and depends on the role that the worker is expected to assume in the process. The *narrower* the role, the more the instruction is termed as *training*, the broader the role, the more the instruction is termed as *education*.

The analysis of activities and objectives conducted on worker training and worker education suggests four types of programmes.

3.2 Programme Name

These programmes involve instruction in work-related injury and illness through proper use and maintenance of tools, equipment and materials; knowledge of emergency procedures, personal hygiene measures; requirements for medical monitoring; and use of personal protective equipment for non-routine operations or as an interim safeguard until engineering controls can be implemented.

3.3 Recognition Programmes

These programmes include instruction on awareness of workplace hazards, knowledge of methods of hazard elimination or control, understanding right-to-know laws and ways for collecting information on workplace hazards, recognising symptoms of toxic exposures and reporting hazards to appropriate bodies. Statutory Regulations and Hazard Control Standards spur training activities of this type. Employers are required to inform workers of hazards, especially chemical hazards, located in work areas and ways to reduce apparent risk.

Material Safety Data Sheets and labels along with training are the prescribed means for disseminating essential information.

3.4 Problem-Solving Programmes

Instruction is aimed at giving workers the information and skills to enable them to participate in hazard recognition and control activities, help identify and solve problems through team work, use union and management means and exercise rights to have outside agencies investigate workplace hazards when warranted.

Inviting worker input in company planning or in design of new operations or processes is recognised as a viable means for improving productivity, quality of products and worker motivation. Extending this approach to hazard control seems reasonable especially since workers, owing to their everyday job work experience, possess an intimate knowledge of the hazards connected with their jobs and can be a rich source for corrective ideas.

3.5 Empowerment Programmes

These programmes provide instruction to build and broaden worker skills in hazard recognition and problem-solving much like that noted above. Emphasis, however, is on worker activism with the goal of ensuring their rights to an illness-free and injury-free workplace. Hence, the programme aims at enabling workers to effect necessary control measures through educating co-workers and supervisors through committee processes or in health/safety contract negotiations. This approach is in accord with the current 'Total Quality Management' philosophy which relates to having rank-and-file workers along with their supervisors share greater roles in, and be more accountable for, addressing workplace hazard control needs.

The above programmes suggest a progression from a workforce learning basic forms of protection to known hazards, through instruction aimed at enhancing their awareness of potential problems and problem-solving skills, to learning how to make it all happen in their workplaces. Although treated separately, any given training programme may contain elements of these approaches in varying degrees.

4 Health Promotion Training

The above-mentioned training and educational activities are all directed to *work-site health protection*, that is, controlling occupational and/or environmental risk factors for disease or injury. They should not be confused with *work-site health promotion programmes* that also involve training/education activities, but whose objectives are to alter personal lifestyle factors that may pose risks to one's health and well-being. Instruction here targets smoking, substance (alcohol/drug) abuse, inadequate diet, poor physical fitness among other problems and the intent is to effect behaviour change, i.e. total change in personal lifestyle, for risk reduction.

Personal lifestyle and occupational risk factors may interact in ways that can increase the potential for adverse outcomes. For example, asbestos workers who smoke may have a 10-fold greater risk of lung cancer. Alternatively, exercise training for enhancing physical fitness has been suggested as an added means to limit strains from jobs imposing undue stress on the musculoskeletal system.

5 In-Situ Safety Training

5.1 Former Concept of Training and Education

Safety Education: A process of broadening and adding to one's safety knowledge for the purpose of developing a vivid awareness of eliminating accidents and a mental alertness in recognising and correcting conditions and practices that might lead to injury.

Education is primarily the broadening of knowledge and understanding.

Safety Training: The process of developing one's skill in the use of safe methods and in the application of safe practices to work activities.

Training is concerned with the development of skill in performance.

5.2 Concept of Training and Education Today

Training is widely understood as communication directed at a defined population for developing of skills, modifying behaviour (attitudinal change) and increasing competence. Generally, training focuses exclusively on *what* needs to be known.

Education is a longer-term process that incorporates the goals of training and explains *why* certain information must be known. Education emphasises the scientific foundation of the material presented.

Both training and education induce learning, a process that modifies knowledge and behaviour through teaching and experience. Therefore, in this book, training refers to both processes.

In contrast to informal training, formal training interventions have stated goals, content and strategies for instruction.

Direct and/or indirect training methods including classroom training, workshop training, on-the-spot training, shop-floor training, problem-solving sessions, brain storming meetings so on and so forth do bring results, but to a limited extent. The desired long-term effects are rarely achieved.

Training intervention effectiveness research is needed to:

1. identify major variables that influence the learning process and
2. optimise resources available for training interventions.

Logical and progressive study models are best suited to identify the critical elements and causal relationships that affect training effectiveness and efficiency.

Model

- Understanding the existing situation and allied position.
- System review for the required intervention.
- Worker practices—Have they formed the wrong habits? e.g. manual handling.
- Are the jobs in order? What does the worker want to suggest?
- Is it possible to correct him? Can he be disciplined? Will discipline not only be imbibed but followed?
- System modification—is it required? Who will modify it? When?

6 Brainstorming

Brainstorming is one of the weapons in the creative armoury available to managers. It is a means of getting a large number of ideas from a group of people in a short time.

The definition contains three aspects—a large number of ideas, a group of people and a short time. The definition does not specify good ideas. Brainstorming sessions that are well run will produce hundreds of ideas. These range from the brilliant to the totally wild, silly and useless. All ideas are acceptable, indeed, the wild and silly ideas have a number of uses, one being that they generate laughter. Silence will kill a brainstorming session very quickly.

6.1 The Four Guidelines

1. Suspend judgement.
2. Freewheel the session.
3. Quantity matters.
4. Cross-fertilise.

6.2 Stages of Brainstorming

1. State the problem and discuss.*
2. Restate the problem—'How does one go about solving it?'
3. Select a basic statement and write it down. 'In how many ways we can tackle the problem?'
4. Warm up the session.
5. Brainstorm.
6. Pick upon the 'Wildest Idea'.

* For example, discuss the hazards associated with LPG, commonly installed in an industry, such as the properties of LPG, testing, examination and certification, instrumentation, piping, leakage, remedial action and so on.

Participants heavily discuss the pros and cons of the suggestions received and try to come to a conclusion on the basis of logic put forward by the strongest argument made by the most knowledgeable and experienced participant.

Participants are likely to brainstorm on an issue like testing requirements and construction of an 'excess flow valve' or installation of a 'pressure relief valve' on a road tanker transporting hazardous chemical.

These are the six basic stages in running a brainstorming session. Each of these stages is important and care should be taken to complete one stage before moving onto the next. Apart from the warm up session the sequence is important and should be followed.

6.3 Tricks of the Trade

1. Keep the six stages of brainstorming discrete.
2. Enforce the 'how to' of restatement by making sense in a literal way.
3. Display and enforce the four guidelines.
4. Have a group of about twelve, with a mix of insiders and outsiders.
5. Write restatements and ideas on newsprint and display it on the walls of the room.
6. Generate noise and laughter.
7. The leader must be enthusiastic.
8. Use the repeat technique and minute of silent incubation.
9. End the session on a high note with laughter at the wildest idea.

6.4 Perspective

Firstly, brainstorming is one of the large numbers of problem-solving techniques which are both analytical and creative.

Secondly, a brainstorming session will give a large number of ideas—not all are practical.

Thirdly, it's to be realised that the brainstorming session is not the end of the process. It is further necessary to evaluate the many ideas obtained in the session.

6.5 Don'ts at a Brainstorming Session

1. Don't ever tape record.
2. Don't use blackboard or transparencies.
3. Don't pick on one person.
4. Don't allow observers.
5. Don't accept interruptions.
6. Don't flip over completed sheets.
7. Don't spend too long on the initial discussion, or allow too much detail.
8. Don't drag out a session that has dried up.

6.6 Evaluation

Evaluation is a hard process, requiring a good deal of drive and persistence to identify the few good amongst the many inappropriate ideas.

There are two objectives in the evaluation process. They are:

1. To identify the few good ideas and implement them.
2. To demonstrate to the participants that action is being taken.

Here are two hints to an effective evaluation. They are:

1. DO wait a day or two before starting the evaluation.
2. DON'T ever evaluate with all the participants together in a live group.

The session can be:

1. evaluated by all the participants or
2. evaluated by a small team.

It is important to ensure that all participants know the outcome of the brainstorming session. At the end, the evaluation team has three lists. They are:

1. The best ideas from the individual participants, i.e. those ideas with most votes.
2. The winners from the quick scrutiny of the lists by the evaluation team.
3. The best ideas from the evaluation team.

6.7 Brainstorming as a Tool for Training in Safety

Like any other management technique, brainstorming needs to be carefully introduced to the participants in evaluating desired solutions to the problems in safety. Apart from an understandable scepticism to a new management technique, there is a firmly rooted belief that existing techniques, such as classroom training programmes, are quite adequate for solving an organisation's problems, inclusive of those of safety.

'Can creativity be taught?' In the context of brainstorming, the real question should be: 'Can the creativity of managers and staff be improved?' This is more of a development programme rather than a training or education programme.

PART TWO

Safety Performance Planning

The McGraw·Hill Companies

CHAPTER III

SAFETY PERFORMANCE

An Overview of an Accident

1 Introduction

An accident may be defined as an unexpected and unplanned occurrence, which may or may not involve injury. The possibility of an accident occurring is present in every sphere of human life—at home, whilst travelling, at play and at work. The victims of an accident may not be directly involved in the activity that caused it—they may be other workmen on the scene, bystanders or those living in the vicinity. This book is mainly concerned with accidents, injuries, mishaps and dangerous occurrences in industrial occupations, but many similar risks and injuries occur in other spheres too.

It is obligatory to notify accidents, which disable or prevent the injured person from performing their normal duties for more than 48 hours, and those categories of accidents, which are specified as dangerous occurrences under the Factories Act that no injury or injury of particular severity, to specified authorities within the stipulated time.[28]

The number of notified accidents causing injury can be compared with the number of employees engaged in a particular activity to produce a ratio known as the *Safety Performance Index*, which is the square root of the product of Frequency and Severity Rates divided by 1,000. The Frequency Rate is the number of notified injuries per million employee-hours worked and the Severity Rate is total man-days lost due to the number of notified injuries per million employee-hours worked.

2 Causes of Accidents

Very rarely does an accident arise from a single cause; more frequently, it is a combination of factors that are simultaneously present. A potentially unsafe situation does not give rise to an accident until someone is exposed to it. A cloud of flammable gas cannot explode unless there is some means of ignition. In particular, accidents result from the combined effects of physical circumstances, which can often be recognised hazards engineered out of the working system, or human factors, which can be influenced by training, instruction or supervision.

However, it must be accepted that employees may be careless, make mistakes, lack concentration or even deliberately take risks, albeit with the best motives. These human factors may be aggravated by stresses in the physical environment especially temperature, ventilation and noise. Both physical and psychological factors have to be considered together to recognise that accidents result from unsafe systems of work, either by error in design or default.[8]

A hazardous situation, even if compounded by human factors, is not in itself the cause of an accident but the indicator of some other deficiency and the end product of an underlying malaise.

The crane that fails due to an overload is not simply the result of physical stress but the consequence of a system of work which failed to plan the operation and determine the weight to be lifted. The system of work failed to check the crane and its safety devices to ensure that it was suitable for the purpose and failed to see if the crane operator was trained for and knew what was expected of him.

Failure to maintain good housekeeping standards is responsible for a high proportion of falling, tripping and impact injuries. It also contributes to many machinery accidents—as when a slippery floor causes a fall onto dangerous moving machinery. Inadequate or unsuitable lighting, insufficient ventilation, dust, fumes, noise pollution, etc. are other contributory causes in many accidents.

3 Consequences

Damage, disorganisation, distress, disablement or death—any or all of these may result from a major or minor accident. Even where the consequences are restricted to damage of the plant or equipment, a machine or tool, or work in progress without causing personal injury, considerable disorganisation and loss will arise. In industries, time lost as a result of accidents at work often exceeds the time lost in industrial disputes (although these receive much more publicity).

Every injury brings with it a measure of distress to the victim while death or serious injury affects the members of his family. In cases where the accident results in permanent disability, the consequences are disastrous for the family and the victim, who loses his earning capacity and ability to enjoy a normal active life; and also for society, which will be deprived of his skill and contribution to production.

It is necessary to distinguish between the accidental occurrence and the injury sustained from it. Similar incidents or occurrences may produce diverse injuries and the extent of a personal injury is often dependent on chance, e.g. a man may fall 2 m and incur a fatal injury while another may fall 6 m and suffer no more than shock and bruising. A foreign body in the eye may cause only temporary discomfort for one while causing blindness in another. Failure of a guard on a power press may cause anything from loss of a fingertip to loss of a hand or forearm.

Sometimes, a dangerous incident may cause no personal injury at all, e.g. a falling crane jib or an exploding chemical storage tank (Case History 7), when no one is present in the danger-zone.

Is It an Accident, Injury or Incident?

"Today we're going to talk about fall protection"

1 Accident or Incident?

Was the overturned trolley an accident? (Ref: Illustrated Case History No. 10) What about the entanglement of the swivel wheels on the broken floor? While obviously not intentional, this may not have been an accident in the truest sense.

By definition—

An accident is unforeseen or unpredictable. It is something over which you have no control, and therefore it is unavoidable, whereas an incident is simply an event or occurrence, whether it is predictable or not.

Were the injuries from the overturned trolley predictable? Probably. We know the causes of such an imbalanced tall-trolley overturn and how to prevent them. In addition to safe handling of the trolley by pushing it from the swivel wheel and handle side, preventive measures include proper wheel spacing, proper ballasting, proper hitching, keeping the centre of gravity low, maintaining a safe speed for operating conditions, using the brakes properly, avoiding steep slopes and avoiding broken floors or obstacles.

We also know that fatalities from tractor overturns are virtually eliminated when operators are protected by a rollover protective structure (ROPS) and safety belt. While a fatal tractor overturn certainly is not intentional, it is avoidable and certainly survivable. It is an incident, not an accident.

Guards and shields on machinery are for operator protection. If damaged or missing, the risk of entanglement with the machinery increases significantly. Operators are also cautioned to keep away from moving parts. Guards don't just happen to go missing—someone takes them off. The operator can choose not to work near the moving parts, guarded or not. While not intentional, PTO (Power Take Off) unit entanglements are predictable and avoidable. These are incidents, not accidents.

What about being struck by lightning? Is that an incident or an accident? If you seek shelter in a safe location away from windows, wiring, plumbing and the phone, getting struck would be an accident. Staying out in a thunderstorm would be a risk you have control over, so being struck while playing golf or taking shelter underneath a wet tree in a storm would be an incident.

As seen from the examples given above, the terms *Injury*, *Accident* and *Incident* differ in meaning as well as in their causative factors.

2 Accident versus Injury

The terms *accident* and *injury* are often mistakenly used interchangeably. Their meanings however, are different and this difference is important for statistical accuracy and in the orienting of safety management objectives. Therefore, the number of accidents and injuries experienced by a given organisation for a period of time are unlikely to be equal. Further, an accident usually refers to only certain kinds of trauma.

Haddon et al* observed that with rare exception, an accident is defined, explicitly or implicitly, by *the unexpected occurrence of physical or chemical damage to an animate or inanimate structure*. It is important to note that the term covers only damage of certain types. Thus, if a person is injured by inadvertently ingesting poison, an accident is said to have taken place; but if the same individual is injured by inadvertently contracting the polio virus, the result is rarely considered accidental.

This illustrates a curious inconsistency in the approach to accidents as opposed to other sources of morbidity, one that continues to delay progress in the field. Although accidents are defined by the unexpected occurrence of damage, it is the unexpectedness, rather than the production and prevention of that damage in itself, that has been emphasised by much of accident research. This approach is not justified by present knowledge and is in sharp contrast to the approach on the causation and prevention of other forms of damage, such as those produced by infectious organisms, where very little (if any) attention is paid to the expectedness of the insults involved, and only their physical and biological nature is emphasised with notable success.

Webster's new international dictionary defines an accident as "an event or condition occurring by chance or arising from an unknown or remote cause". If this definition is considered, it is seen that damage need not accompany an occurrence for it to be given this label. Therefore a semantic problem emerges. While many people may view every case of unexpected damage as accidental, others will not. An auto mechanic, who washes engine parts in gasoline while smoking, will be said, by some, to have had an accident when burned in the inevitable fire this can cause. Others will say that the event could not be termed an accident, since it was predictable and therefore not unexpected. It is the experience all over that a substantial majority of so-called accidents that occur are of this type (i.e., the causes are readily identifiable but the precise point in time when their effects will be noticed is unknown).

Because of our inherent human faults, we continuously follow and get involved in various unsafe acts or practices, create unsafe working conditions and ignore conditions already created around us. Not that we do it intentionally. The creation of hazardous situations and our unsafe actions are likely to injure us and, more often, others.

However, hazards do not always occur as a result of our mistakes. So also, all the unsafe acts and/or conditions do not victimise people immediately or every time. There is no logic or any sequence to know when circumstances come together and produce their accumulated effect. Sometimes, depending on the situation, a person is injured, resulting from accumulated circumstances caused by unsafe actions or conditions prevailing at that time, without meeting with an accident in the process. Whereas, in an other setting, a situation may arise wherein a person may be victimised in an accident causing injury or injuries, the severity of which may vary from a simple cut, bone fracture to a fatality.

The following examples clarify the difference between accident and injury.

1. A person intends to sharpen a pencil. He holds the pencil in between his left index finger and thumb and a naked razor blade with his right index finger and thumb and starts sharpening the pencil. Being keen on making a pointed end, he places the lead end on his finger, sharpens further, and sustains a cut on his left index finger. In spite of being careful and cautious, he is injured. This injury was the direct result of the unsafe act and conditions, without any accident in between. On the other hand, take the same situation, where he is sharpening a pencil in a similar manner under the same conditions. A child playing around him happens to push against him and in the process he injures his finger. This injury resulted because of the accident caused by the child who struck against him.
2. Unguarded running machinery can cause an injury, not an accident, when a mechanic tries to perform an adjustment, knowing fully well that the machine is in motion and the guard has been removed.
3. Holding a wire-nail in between the thumb and index finger of one hand and then hammering the nail into a joint of wooden planks is an unsafe practice. Knowing fully well what could happen if the hammer slips from the head of the nail, it will not be termed an accident. It's an injury.

3 Carelessness

We generally come across a very common remark placed in an accident or an injury investigation report by the supervisor that 'the injured was careless', as the basic cause of the incident. The corrective action suggested is, 'the injured should be educated to be more careful'. Both the assessment of the cause and the recommended corrective action carry no meaning. We do not put in the effort to correctly assess whether it was an injury, an accident with or without any injury, a near miss, or a case of illness. All such findings should be thorough and clear and treated accordingly.

Perhaps the oldest and the most inaccurate attribution to an accident is that it was caused by carelessness. Mental and emotional factors do not only influence a person's outlook to the demands of society and the problems of living, but they may also make him or her more or less likely to sustain injuries.

Let us consider an example—a mechanic who adjusted a machine while it was in operation, even though the safe practice rule was to shut the machine down before making repairs, and lost the tips of his fingers would not agree that he was careless. His reasoning was that he did not want to take the time to turn the machine off and then start it again and did not expect to be injured in any event.

Carelessness, which is an inherent individual trait, is often emphasised as the only or the most important of the causes of accidents and injuries. Carelessness, however, has no value in injury prevention. The word explains little and, in fact, is a disarmingly simple and misleading concept that deserves thorough contemplation since its acceptance is so extensive. The connotations of 'personal neglect', 'calculated risk', 'forgetfulness' or 'habitual disobedience' are all adopted under the flag of carelessness.

In-depth and systematic investigation alone can unfold the root causes of a mishap which in turn, when sufficiently taken care of, can strengthen our efforts to prevent its recurrence.

Each of us needs to be aware of the risks we face, regardless of the activity we are participating in.

Adhering to the following suggestions should ensure a higher degree of safety.

1. Learn to operate and maintain machinery properly for maximum productivity and safety. Educate yourself on its intended uses and limitations. Don't take chances.
2. Know your limits. Don't try to keep going when fatigued or distracted. A good night's sleep is less costly than applying pesticides improperly or damaging equipment.
3. Act defensively to protect yourself, as when driving on the highway. Make sure you don't endanger others by taking unnecessary risks or operating equipment in an unsafe manner.
4. No occupation should ever be viewed as the most dangerous occupation. Quite a few major hazard industries have reduced illness, injury and death rates through a combination of worker training and maintaining safe working conditions. Besides preventing pain and suffering, we can increase our profits by reducing medical expenses, lost time, lost production, repair costs and insurance premiums.

The Safety Professional

1 Scope of the Safety Professional

Safety professionals need to have education, training and experience in a common body of knowledge including a fundamental knowledge of physics, chemistry, biology, physiology, statistics, mathematics, computer science, engineering mechanics, industrial processes, business, communication and psychology.

Professional safety studies include industrial hygiene and toxicology, design of engineering hazard controls, fire protection, ergonomics, system and process safety, safety and health programme management, accident investigation and analysis, product safety, construction safety, education and training methods, measurement of safety performance, human behaviour, environmental safety and health, and safety, health and environmental laws, regulations and standards. Many safety professionals also have backgrounds or advanced learning in other disciplines, such as management and business administration, engineering, education, physical and social sciences, and other fields. Others have advanced learning in safety. This extends their expertise beyond the basics of the safety profession.

As safety is an element in all-human endeavours, safety professionals perform their functions in a variety of contexts, in both public and private sectors, often employing specialised knowledge and skills. The typical settings are manufacturing, insurance, risk management, legal provisions, education, consulting, construction, health care, engineering and design. In addition are waste management, petroleum and hazardous material management, facilities management, retail, transportation and utilities. Within these contexts, safety professionals must adapt their functions to fit the mission, operations and climate of their employer.

Not only must safety professionals acquire the knowledge and skill to perform their functions effectively in their employment context, they have to stay updated with new technologies, changes in laws and regulations and changes in the workforce, workplace and world business, political and social climate through continuous education and training.

As part of their job requirement, safety professionals must plan for and manage resources and funds related to their functions. They may be responsible for supervising a diverse staff of professionals. Therefore, by acquiring the knowledge and skills of the profession, developing the mindset and wisdom to act responsibly in the employment context and keeping up with changes that affect the safety profession, the safety professional is able to perform his or her required functions with confidence, competence and respected authority.

2 Roles of the Safety Professional

The major functions relating to the protection of people, property and the environment are to:

A. Anticipate, identify and evaluate hazardous conditions and practices.
B. Develop hazard control designs, methods, procedures and programmes.
C. Implement, administer and advise others on hazard controls and hazard control programmes.
D. Measure, audit and evaluate the effectiveness of hazard controls and hazard control programmes.

A. Anticipate, Identify and Evaluate Hazardous Conditions and Practices

This function involves the following requirements.

1. Developing methods for—
   a. anticipating and predicting hazards from experience, historical data and other information sources;
   b. identifying and recognizing hazards in existing or future systems, equipment, products, software, facilities, processes, operations and procedures during their expected life; and
   c. evaluating and assessing the probability and severity of loss events and accidents which may result from actual or potential hazards.
2. Applying these methods, conducting hazard analyses and interpreting results.
3. Reviewing, with the assistance of specialists, entire systems, processes, and operations for failure modes, causes and effects of the entire system, process or operation and any sub-systems or components due to—
   a. system, sub-system, or component failures
   b. human error
   c. incomplete or faulty decision-making, judgements or administrative actions
   d. weaknesses in proposed or existing policies, directives, objectives or practices.
4. Reviewing, compiling, analysing and interpreting data from accident and loss event reports and other sources regarding injuries, illnesses, property damage, environmental effects or public impact in order to—
   a. identify causes, trends and relationships;
   b. ensure completeness, accuracy and validity of required information;
   c. evaluate the effectiveness of classification schemes and data collection methods; and
   d. initiate investigations.

5. Providing advice and counsel about compliance with safety, health and environmental laws, codes, regulations and standards.
6. Conducting research studies of existing or potential safety and health problems/issues.
7. Determining the need for surveys and appraisals that help identify conditions or practices affecting safety and health, including those which require the services of specialists, such as physicians, health physicists, industrial hygienists, fire protection engineers, design and process engineers, agronomists, risk managers, environmental professionals, psychologists and others.
8. Assessing environments, tasks and other elements to ensure that physiological and psychological capabilities, capacities and limits of humans are not exceeded.

B. Develop Hazard Control Designs, Methods, Procedures, and Programmes

This function involves the following requirements.

1. Formulating and prescribing engineering or administrative controls, preferably before exposures, accidents, and losses occur, in order to—
   a. eliminate the hazards and causes; and
   b. reduce the probability or severity of injuries, illnesses, losses or environmental damage when hazards cannot be eliminated.
2. Developing methods which integrate safety performance into the goals, operations and productivity of organisations and their management and into systems, processes, and operations or their components.
3. Developing safety, health and environmental policies, procedures, codes and standards for integration into operational policies of organisations, unit operations, purchasing and contracting.
4. Consulting with, advising individuals and participating in teams
   a. engaged in planning, design, development and installation or implementation of systems or programmes involving hazard controls; or those
   b. engaged in planning, design, development, fabrication, testing, packaging and distribution of products or services regarding safety requirements and application of safety principles.
5. Advising and assisting human resources specialists when applying hazard analysis results or dealing with the capabilities and limitations of personnel.
6. Staying current with technological developments, laws, regulations, standards, codes, products, methods and practices related to hazard controls.

C. Implement, Administer and Advise Others on Hazard Controls and Hazard Control Programmes

This function involves the following requirements.

1. Preparing reports communicating valid and comprehensive recommendations for hazard controls based on analysis and interpretation of the accident, exposure, loss and other data.

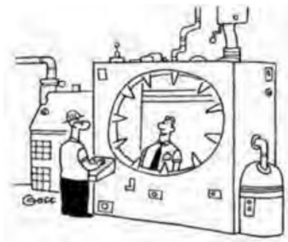
2. Using written and graphic materials, presentations and other communication media to recommend hazard controls and hazard control policies, procedures and programmes to decision-making personnel.
3. Directing or assisting in planning, developing educational and training materials or courses. Conducting or assisting courses related to designs, policies, procedures and programmes involving hazard recognition and control.
4. Advising others about hazards, hazard controls, relative risk and related safety matters when communicating with the media, community and public.
5. Managing and implementing hazard controls and hazard control programmes which come under the duties of the individual's professional safety position.

D. Measure, Audit and Evaluate Effectiveness of Hazard Controls and Hazard Control Programmes

This function involves the following requirements.

1. Establishing and implementing techniques which involve risk analysis, cost, cost-benefit analysis, work sampling, loss rate and similar methodologies for periodic and systematic evaluation of hazard control and hazard control programmes.
2. Developing methods to measure the contribution of system components, organisations, processes and operations toward the overall effectiveness.
3. Providing results of assessments, including recommended adjustments and changes in hazard controls or hazard control programmes to individuals or organisations responsible.
4. Directing, developing, or helping to develop management accountability and audit programmes which assess the safety performance of entire systems, organisations, processes and operations or their components, and involve both deterrents and incentives.

Occupational Health and Industrial Hygiene



1 Introduction

Industrial hygiene has been defined as 'that science and art devoted to the anticipation, recognition, evaluation and control of those environmental factors or stresses arising in or from the workplace, which may cause sickness, impaired health and well-being, or significant discomfort among workers or among the citizens of the community.' Industrial hygienists use environmental monitoring and analytical methods to detect the extent of worker exposure and employ engineering, work practice controls, and other methods to control potential health hazards.

There has been an awareness of industrial hygiene since ancient times. The environment and its relation to worker health were recognised as early as the fourth century BC when Hippocrates noted lead toxicity in the mining industry. In the first century AD, Pliny the Elder, a Roman scholar, perceived health risks to those working with zinc and sulphur. He devised a face-mask made from animal bladder to protect workers from exposure to dust and lead fumes. In the second century AD, the Greek physician, Galen, accurately described the pathology of lead poisoning and also recognised the hazardous exposure of copper miners to acid mists.

2 Worksite Analysis

A worksite analysis is an essential first step that helps an industrial hygienist determine what jobs and workstations are the sources of potential problems. During worksite analysis, industrial hygienists measure and identify exposures to substances, problem tasks and risks. The most effective worksite analyses include all jobs, operations and work activities. Industrial hygienists inspect, research, or analyse how particular chemicals or physical hazards at a worksite affect worker health. If a hazardous situation is discovered, they recommend appropriate corrective actions.

3 Recognising and Controlling Hazards

Industrial hygienists recognise that engineering, work practice and administrative controls are the primary means of reducing employee exposure to occupational hazards.

Engineering controls minimise employee exposure by either reducing or removing the hazard at the source or isolating the worker from the hazard. They include eliminating toxic chemicals or substituting non-toxic chemicals, enclosing work processes or confining work operations, and the installation of general and local ventilation systems.

Work practice controls alter the manner in which a task is performed. Some fundamental and easily implemented work practice controls include:

1. changing existing work practices to follow proper procedures that minimise exposures when operating production and control equipment;
2. inspecting and maintaining process and control equipment on a regular basis;
3. implementing good housekeeping procedures;
4. providing good supervision; and
5. mandating that eating, drinking, smoking, chewing tobacco or gum and applying cosmetics in regulated areas be prohibited.

Administrative controls include controlling employees' exposure by scheduling production and tasks, or both, in ways that minimise exposure levels. For example, the employer might schedule operations with the highest exposure potential during periods when the least number of employees are present.

When effective work practices or engineering controls are not feasible or while such controls are being instituted, personal protective equipment must be used. Examples of personal protective equipment are gloves, safety goggles, helmets, safety shoes, protective clothing and respirators. To be effective, personal protective equipment must be individually selected, properly fitted and periodically refitted; conscientiously and properly worn; regularly maintained; and replaced when necessary.

4 Examples of Job Hazards

To be effective in recognising and evaluating on-the-job hazards and recommending controls, industrial hygienists must be familiar with the hazards' characteristics. Potential hazards can include air contaminants, and chemical, biological, physical and ergonomic hazards.

4.1 Air Contaminants

These are commonly classified as either particulate or gas and vapour contaminants. The most common particulate contaminants include dusts, fumes, mists, aerosols and fibres.

Dusts are solid particles generated by handling, crushing, grinding, colliding, exploding, and heating organic or inorganic materials such as rock, ore, metal, coal, wood and grain. Any process that produces dust so fine as to remain in the air long enough to be inhaled or ingested should be regarded as hazardous until proven otherwise.

Fumes are formed when material from a volatile solid condenses in cool air. In most cases, the solid particles resulting from the condensation react with air to form an oxide.

The term mist is applied to liquid suspended in the atmosphere. Mists are generated by liquids condensing from a vapour back to a liquid or by a liquid being dispersed by splashing or atomising. Aerosols are also a form of mist characterised by highly irrespirable, minute liquid particles.

Fibres are solid particles whose length is several times greater than their diameter, such as asbestos.

Gases are formless fluids that expand to occupy the space or enclosure in which they are confined. They are atomic, diatomic, or molecular in nature as opposed to droplets or particles, which are made up of millions of atoms or molecules.

Through evaporation, liquids change into vapours and mix with the surrounding atmosphere. Vapours are the volatile form of substances which are normally in a solid or liquid state at room temperature and pressure. Vapours are gases in that true vapours are atomic or molecular in nature.

4.2 Chemical Hazards

Harmful chemical compounds in the form of solids, liquids, gases, mists, dusts, fumes and vapours exert toxic effects on inhalation (breathing), absorption (through direct contact with the skin), or ingestion (eating or drinking). Airborne chemical hazards exist as concentrations of mists, vapours, gases, fumes or solids.

The degree of risk from exposure to any given substance depends on the nature and potency of the toxic effects and the magnitude and duration of exposure.

Information on the risk to workers from chemical hazards can be obtained from the Material Safety Data Sheet (MSDS). The MSDS is a summary of the important health, safety and toxicological information on the chemical or the mixture's ingredients.

Other provisions of the Hazard Communication Standard require that all containers of hazardous substances in the workplace have appropriate warning and identification labels.

4.3 Biological Hazards

These include bacteria, viruses, fungi, and other living organisms that can cause acute and chronic infections by entering the body either directly or through breaks in the skin. Occupations that deal with plants or animals or their products or with food and food processing may expose workers to biological hazards. Laboratory and medical personnel can also be exposed.

Any occupations that can involve contact with bodily fluids pose a risk to workers from biological hazards.

In occupations where animals are involved, one deals with biological hazards in preventing and controlling diseases in the animal population as well as in caring for and properly handling infected animals. Effective personal hygiene, particularly proper attention to minor cuts and scratches especially on the hands and forearms, helps keep worker risks to a minimum.

Proper personal hygiene should be practised in occupations where there is potential exposure to biological hazards. Hospitals, for instance, should provide proper ventilation, proper personal protective equipment such as gloves and respirators, adequate infectious waste disposal systems, and appropriate controls including isolation in instances of particularly contagious diseases such as tuberculosis.

4.4 Physical Hazards

These include excessive levels of ionising and non-ionising electromagnetic radiation, noise, vibration, illumination and temperature. In occupations where there is exposure to ionising radiation, time, distance, and shielding are important tools in ensuring worker safety.

Danger from radiation increases with the amount of time one is exposed to it; hence, the shorter the time of exposure the smaller the radiation danger.

Distance is a valuable tool in controlling exposure to both ionising and non-ionising radiation. Radiation levels from some sources can be estimated by comparing the squares of the distances between the worker and the source. For example, at a reference point of 10 feet from a source, the radiation is 1/100 of the intensity at 1 foot from the source.

Shielding protects against radiation. The greater the protective mass between a radioactive source and the worker, the lower the radiation exposure. Shielding workers from non-ionising radiation can also be an effective control method. In some instances, however, limiting exposure to or increasing distance from certain forms of non-ionising radiation, such as lasers, is not effective. For example, exposure to laser radiation, which is faster than the blink of an eye, can be hazardous and requires workers to be miles from the laser source before being adequately protected.

Noise, another significant physical hazard, can be controlled by various measures. Noise can be reduced by installing equipment and systems that have been engineered, designed and built to operate quietly; enclosing or shielding noisy equipment; making certain that equipment is in good repair and properly maintained with all worn or unbalanced parts replaced; mounting noisy equipment on special mounts to reduce vibration; and by installing silencers, mufflers or baffles.

Substituting quiet work methods for noisy ones is another significant way to reduce noise—for example, welding parts rather than riveting them. Treating floors, ceilings and walls with acoustical material can reduce reflected or reverberant noise. In addition, erecting sound barriers at adjacent workstations around noisy operations will reduce worker exposure to noise generated.

It is also possible to reduce noise exposure by increasing the distance between the source and the receiver, by isolating workers in acoustical booths, limiting workers' exposure time to noise and by providing hearing protection. Industrial legislation requires that workers in noisy surroundings be periodically tested as a precaution against hearing loss.

Another physical hazard, radiant heat exposure in factories such as steel mills, can be controlled by installing reflective shields and by providing protective clothing.

4.5 Ergonomic Hazards

The science of ergonomics studies and evaluates a full range of tasks including, but not limited to, lifting, holding, pushing, walking and reaching. Many ergonomic problems result from technological changes such as increased assembly line speeds, adding specialised tasks and increased repetition. Some problems arise from poorly designed job tasks. Any of these conditions can cause ergonomic hazards such as excessive vibration and noise, eyestrain, repetitive motion, and heavy lifting problems. Improperly designed tools or work areas can also be ergonomic hazards. Repetitive motions or repeated shocks over prolonged periods of time as in jobs involving sorting, assembling and data entry can often cause irritation and inflammation of the tendon sheath in hands and arms, a condition known as carpal tunnel syndrome.

Ergonomic hazards are primarily avoided by the effective design of a job or jobsite and by better-designed tools or equipment that meet workers' needs in terms of physical environment and job tasks. Through thorough worksite analyses, employers can set up procedures to correct or control ergonomic hazards by using the appropriate engineering controls (e.g., designing or redesigning workstations, lighting, tools and equipment); teaching correct work practices (e.g., proper lifting methods); employing proper administrative controls (e.g., shifting workers among several different tasks, reducing production demand and increasing rest breaks); and, if necessary, providing and mandating personal protective equipment. Evaluating working conditions from an ergonomic standpoint involves looking at the total physiological and psychological demands of the job on the worker. Overall, the benefits of a well-designed, ergonomic work environment can include increased efficiency, fewer accidents, lower operating costs, and more effective use of personnel.

CHAPTER IV

UNDERSTANDING THE RISKS

Emergency Preparedness and Response

This section deals with the roles and responsibilities of all parties involved in emergency preparedness and response.

Emergency Preparedness Programmes and Plans

1 General Principles

A. Public authorities, at all levels, and the management of hazardous installations should establish emergency preparedness programmes concerning accidents involving hazardous substances. The requirements of such programmes are as follows:

1. The objective should be to localise accidents that may occur and, if possible, contain them, and minimise the harmful effects of the accident on health and the environment, including property.
2. These programmes should include commonly accepted principles and practices.
3. The risk of transport accidents should be taken into consideration.

B. Public authorities should develop guidelines and standards for off-site and on-site emergency preparedness plans. They should also ensure the development, implementation, testing and updating of these plans in co-ordination with the management of hazardous installations and with the participation of employees and neighbouring communities, recognising that the responsibility for the actual development and implementation of the plans differs among countries.

The on-site and off-site emergency plans should contain details of the technical and organisational procedures to reduce the effects on people, property and the environment, both on-site and off-site, in the event of an accident.

The off-site emergency plan and all relevant on-site emergency plans must be consistent and integrated, so that there is effective co-ordination, problems with overlapping responsibilities and complicated interfaces are resolved and it is clear as to who has the responsibility for various emergency response functions.

C. To form a basis for both off-site and on-site emergency planning, the management of a hazardous installation need to identify and assess the full range of accidents, including low-probability, high-consequence accidents, which could arise. This information can be available in the safety reports. (See Example of a Safety Report, Appendix 6, Major Hazard Control, A Practical Manual by International Labour Office, Geneva.)

Public authorities should pay particular attention in ensuring that all hazardous installations, including small and medium-sized enterprises and commercial users of hazardous substances, undertake this assessment and the appropriate emergency planning. Specific assistance should be obtained to ensure that such enterprises and users fulfil their responsibilities in emergency planning.

D. Emergency planning should take into account potential complicating factors associated with major accidents at hazardous installations such as extreme weather conditions, natural disasters, loss of power or water supplies, etc., as well as factors which complicate response, such as problems with communication and transportation systems.

To counter this, back-up systems can be built into emergency plans. For example, alternative communication lines, relief for key personnel and an alternative command centre should be available in the event that the primary centre cannot function properly.

All responsible parties should ensure that manpower, equipment (including communication equipment and personal protective equipment), and financial and other resources necessary to carry out emergency plans are readily available for immediate activation in the event, or imminent threat, of an accident. Specialised equipment can be obtained through joint co-operation at a regional level.

Provisions should be made for mutual assistance, in the event of an accident, among neighbouring hazardous installations and public authorities.

E. There should be a realistic assessment of the capabilities and resources of those involved in emergency response in relation to the skills and resources required.

The planning process can provide a learning experience concerning the potential for accident hazards based on an analysis of a range of accident scenarios, the possible implications of such accidents' response needs and capabilities and the roles and responsibilities of those involved with emergency response.

F. Public authorities responsible for emergency response, including fire and rescue services, should familiarise themselves with the relevant information concerning a hazardous installation, including the chemical and physical properties and the location of hazardous substances, as well as the location of water and foam supply points and other fire-fighting equipment at the hazardous installation.

On-site managers should ensure that employees are familiar with the capabilities and response plans of the fire authorities and other emergency responders.

G. All personnel involved in the emergency response process should be educated and trained on a continuous basis to ensure that a state of readiness for varying contingencies is maintained. Education and training programmes should be tested, assessed and revised regularly.

To facilitate this, exercises should be carried out on a regular basis to test both on-site and off-site emergency plans and their compatibility. The use of independent observers in these exercises facilitates an objective review of any deficiencies or defects in the plans. The exercises can separately test different components of a plan and can include, for example, simulations through tabletop computer exercises.

They should also be undertaken in adverse conditions (for example, outside normal working hours, during inclement weather, etc.), which stress the systems and, therefore, reveal the range of limitations and problems inherent in the systems.

H. Systems should be set in place for the rapid detection of an accident, or imminent threat of an accident, and for the immediate notification of emergency response personnel. The channel of communication should flow as directly as possible from the individual discovering the abnormal occurrence to the emergency responders.

I. Public authorities should consider undertaking emergency planning for hazardous installations and emergency planning for natural disasters and civil defence in an integrated way, since these activities involve almost the same requirements.

Public authorities and the management can also consider what requirements might be needed to avoid pollution of nearby water sources, both surface and underground. In this regard the Polluter-Pays Principle can be applied.

2 On-Site Emergency Plans

A. All hazardous installations should have an adequate on-site emergency plan, which is applicable to that installation and is based on a complete range of credible accident scenarios. The preparation and implementation of this plan should be the responsibility of management, financed by the enterprise, and be subject to review by public authorities.

B. An on-site emergency plan needs to contain a scale plan of the site along with a list of all hazardous substances handled, indicating the quantities involved and their locations relative to the surrounding area and population. The plan should also contain an evaluation of the hazards involved and include information regarding each substance and the conditions under which they are processed, handled and stored.

C. Emergency plans should provide for the orderly and phased shutdown of an installation when necessary.

D. Information and equipment for generating data should be readily available. This includes analytical methods and equipment for detecting hazardous substances and the protective measures to be taken in the event of the escape of a hazardous substance. Models should be prepared for the most likely accident scenarios and their possible effects in order to facilitate rapid response.

E. In establishing the responsibilities for various employees in the event of an accident, the on-site emergency plan should take account of such matters as absences due to sickness, holidays and periods of installation shutdown and be flexible in application to all foreseeable variations in staffing.
F. On-site emergency plans, while identifying the roles and responsibilities of all parties concerned, should clearly indicate the chain of command and co-ordination among the parties' lines of communication and the means of obtaining necessary information.

Individuals can be nominated for the following roles: a site incident controller to take control on scene in the event of an emergency and a site main controller to take overall control of an emergency from the emergency control centre. The role of these controllers in relation to community emergency response personnel should be clearly spelled out in order to avoid any potential conflicts.

G. All employees and contractors at a hazardous installation need to be fully aware of the on-site emergency plan provisions. In particular, they should be aware of what to do when taking action to limit the release of hazardous substances and/or evacuating the installation.

H. Visitors to a hazardous installation should be educated on what they should do in the event of an emergency.
I. The organisation of these activities can be integrated with the normal operation of a hazardous installation.

3 Off-Site Emergency Plans

A. Public authorities need to ensure that there is an adequate off-site emergency plan at hazardous installations. Such a plan must

- set out its objectives;
- provide relevant information on the installations and surrounding areas;
- evaluate the hazards (including transport hazards) which may occur in emergency situations in the community and;
- establish the procedures to be followed and identify the officials responsible in the event of an accident.

B. Public authorities at various levels have to adopt responsibilities related to off-site emergency planning.

1. Central authorities can establish the general principles concerning such planning, provide advice and assistance to local authorities and ensure that officials at all levels are motivated to develop emergency preparedness and response capabilities before an accident occurs.
2. Public authorities at the local level should ensure that off-site emergency plans are developed, consistent with the general principles.
3. The responsibility for the actual development and implementation of the off-site emergency plan can rest with local officials or with a designated committee, depending on the laws and policies applicable in the locality, and may include involvement by regional or national authorities. It should be clear, however, who has the decision-making responsibility in the development and implementation of the plan.

C. The management of a hazardous installation should provide information without reservation to those responsible in order to assess hazards and develop the plan.

In addition to information concerning the installation, the management should co-operate with public authorities in the routing and identification of pipelines, which carry hazardous substances, outside the boundary fence of the hazardous installation across public land to another part of the site.

D. Highly technical and specialised information in emergency plans should be presented clearly for emergency responders.

E. In the development of an off-site emergency plan, all emergency response participants should be identified. In addition, their roles, resources and capabilities should be established realistically and their commitment and participation ensured. These participants should include:

- police, fire, medical (including hospitals), transport and welfare services;
- emergency management or civil defence agencies;
- public works and utilities;
- the management of the hazardous installations;
- public information/communication outlets; and
- public health and environmental agencies.

F. Emergency planning must take into account the situation of local institutions which may have particularly vulnerable populations such as schools, hospitals and homes for the elderly.

G. The public should be given specific information on the appropriate behaviour and safety measures they should adopt in the event of an accident involving hazardous substances on a continuous basis.

The predictable reactions of the public should be taken into consideration when developing emergency response instructions. For example, their reactions to stressful, unanticipated events are often determined by instinct rather than as a consequence of training and information and, therefore, parents will instinctively want to collect their children from school even if this will put them and their children at a greater risk.

In view of this, procedures should exist for public input in the development of off-site plans.

H. For cases in which an accident at a hazardous installation may have effects in neighbouring communities, emergency planning and response should be co-ordinated among the potentially affected communities.

An up-to-date national network of experts on emergency preparedness and response should be maintained. In addition, there should be an international listing of groups of experts who can make themselves available to countries requiring assistance in the event of an emergency. The International Directory of Emergency Response Centres, which has been jointly published by the OECD and UNEP, forms a good basis for such a listing.

4 Medical Aspects of Emergency Preparedness and Response

A. Public health authorities should establish their own health sector plans at the national, regional and local level as part of the overall emergency preparedness plans.

Every country should establish an information centre capable of providing relevant information in an emergency on the diagnosis, treatment and rehabilitation of persons injured by chemicals. This information should be available on a 24-hour basis throughout the year.

B. Public health authorities, including experts from the information centre, should take part in exercises with other authorities involved in emergency response in order to test emergency plans and train emergency response medical staff. They should also be consulted when issuing statements to the media concerning health aspects of chemical accidents.

C. Adequate medical facilities including transportation facilities need to be made available, as, in an emergency, the rapid transformation of facilities normally used for other purposes is necessary.

The availability of up-to-date antidotes and other pharmaceutical substances necessary for the treatment of people injured by chemicals must be ensured. This includes an adequate supply of oxygen.

Where antidotes exist for treatment of people injured by chemicals produced or used, the industry should be required to ensure their availability if the health authorities have problems procuring them. The relevant emergency medicines have to be made available at installations handling toxic chemicals.

Decontamination equipment for on-site and hospital use and protective equipment for the medical emergency response personnel should also be available.

D. The health authorities and the relevant sectors of industry should encourage research into new antidotes and decontamination procedures for toxic chemicals.

5 Emergency Response

A. The management of a hazardous installation should promptly notify emergency response authorities of all incidents involving hazardous substances, which result or threaten to result in potential harm to employees' health or the environment. Notification should flow as directly as possible from the individual detecting the incident to responders. The initial notification can include the following information, if ascertainable:

- The nature of the incident;
- The hazardous substances involved;
- The potential severity of the incident; and
- The incident's potential off-site effects.

B. The notification from the hazardous installation should trigger the implementation of the off-site emergency response plan, beginning with an initial assessment of the situation leading to a decision on which response actions are required.

C. Handover of responsibility from management to public authorities, in the case of accidents with potential off-site effects, should be based on criteria contained in the emergency plan. These criteria should make it clear at what stage the handover should take place, and to whom.

D. The first responders to an accident should have sufficient information, training and experience to quickly assess whether they can deal with the situation or whether additional equipment and/or persons with particular expertise should be summoned. Mechanisms should be in place for the first responders to obtain additional personnel and equipment.

Specialists can be called in to assist with such matters as:

- identification of the hazardous substances involved;
- evaluation of the hazard;

- need for protective equipment;
- control and containment of the hazardous substances; and
- decontamination and emergency termination activities.

Such specialists need to be able to provide fast, reliable information under stressful conditions so that it can be understood and immediately acted upon by emergency services personnel.

E. The systems used for communication with the public in an emergency to provide initial and continuing information need to be well known and readily accessible and understood.

The media should have ready and continuous access to designated officials with relevant information, as well as to other sources, in order to provide essential and accurate information to the public throughout the emergency and help avoid confusion.

Official spokespeople should be as open as possible in providing information. In this regard they have to admit when information is not available, avoid making promises which cannot be fulfilled, be the first to give bad news, and ensure that the messages provided are consistent with actions taken.

Prevention of Accidents Involving Hazardous Substances[47]

1 General Principles

The primary objective of safety-related programmes at hazardous installations is the prevention of accidents resulting in harm to human health, the environment or property (recognising the fact that accidents involving hazardous substances may, nonetheless, occur).

The General Principles summarise the roles and responsibilities of public authorities, management and other employees with respect to prevention of accidents involving hazardous substances. These principles are elaborated upon in the subsequent subsections.

A. The prevention of accidents involving hazardous substances is the concern of all interested parties including the public authorities at all levels, industry, employees and their representatives, and the community. For accident prevention activities to be effective, co-operative efforts among all these parties is necessary. This co-operation, if based on a policy of openness, will help increase public confidence that appropriate measures are being taken to limit the risk of off-site effects.

B. With respect to the prevention of these accidents, public authorities have to set general safety objectives, establish a clear and coherent control framework and ensure, through effective enforcement measures, that all the relevant requirements are being met. In this regard, they should establish systems for the identification and notification of hazardous installations which monitor and ensure that there is adequate reporting and investigation of accidents.

Public authorities can also be proactive in developing new approaches for accident prevention, in addition to their more traditional reactive role. To do this, they need to take a lead role in motivating society to recognise the need for accident prevention, identifying the tools needed, developing a national culture which promotes accident prevention, co-operating with and stimulating industry (management and employees) to act for the safe operation of hazardous installations, and gaining the confidence of the public in that responsibly ensuring installations are being operated safely.

C. The management of hazardous installations hold the primary responsibility in operating their installations safely and developing the means to do so. Safety should be an integral part of the business activities of an enterprise, and all hazardous installations need to aim for zero incidents. A corporate safety culture, reflected in a corporate Safety Policy can be adopted.

This responsibility applies to all installations, which use, handle, store or dispose of hazardous substances, including those installations not considered part of the chemical industry.

D. The management should take special care to ensure that safety is maintained during periods of stress at a hazardous installation, such as during an economic slowdown or staffing problems.

E. Producers of hazardous substances have a responsibility to promote the safe management of such substances throughout their total life cycle, consistent with the principle of product stewardship.

2 Establishment of Safety Objectives and Control Framework by Public Authorities

A. Public authorities need to establish safety objectives as part of a long-term strategy, by developing a clear and coherent control framework covering all aspects of accident prevention.

The control framework should consist of binding requirements (laws and regulations) as well as standards, codes and guidance (such as codes of practice, quality assurance guides, etc.). These materials need to be designed in order to enable each interested party to determine whether the appropriate safety objectives are being met.

It should also include provisions for monitoring the safety of hazardous installations during all phases of their life cycle and the enforcement of requirements.

B. Public authorities should have available staff to carry out their roles and responsibilities in the prevention of accidents, and ensure that they are adequately educated and trained.

If the necessary expertise is not available on staff, arrangements can be made for that expertise to be provided as needed from external consultants or industry.

The contracts of external experts/consultants employed by public authorities will have to stipulate that they are not to disclose any non-public information obtained except to the public authority which has contracted their services.

C. A co-ordinating mechanism can be established in areas where more than one competent public authority exists, in order to minimise overlapping and conflicting requirements.

D. In establishing safety objectives, as well as the control framework, public authorities should consult with representatives of the other stakeholders including:

- Representatives from neighbouring communities or countries;
- Industry (management and other employees);
- Professional and trade associations;
- Independent experts;

- Trade unions;
- Interest groups; and
- Public.

A consultative committee can be established related to accident prevention, preparedness and response, consisting of, among others, representatives of the stakeholders listed above.

Special efforts can also be made to provide opportunities for public input into decision-making.

E. The control framework should allow flexibility in the methods used to meet safety objectives and requirements. An industry can be allowed to establish methods for meeting the requirements which are best suited to its particular circumstances.

In this regard, public authorities need to take into account the specific situations of small and medium-sized enterprises.

F. The requirements and guidance provided by public authorities can stimulate innovation and promote the use of improved safety technology and safety practices. The control requirements should be considered minimum requirements for industry which should be encouraged to achieve a higher level of safety than what would be achieved by adherence to established standards and guidance alone.

The requirements and guidelines need to be reviewed periodically and, amended where necessary within a reasonable amount of time to take into account technical progress, additional knowledge and international developments. Any amendments to the control framework requiring changes in technology or management practice needs a reasonable time period for implementation and compliance by industry.

G. The control framework can include provisions for the enforcement of requirements and adequate resources should be available to the public authorities for monitoring and enforcement activities. Enforcement mechanisms can include suitable sanctions with penalties applicable in the event of non-compliance with any of the requirements.

H. Public authorities can also establish a system for the submission of detailed information on certain categories of hazardous installations. Under such a system, the management of the relevant installations would be required to submit a report describing the major hazards and demonstrating the appropriate steps taken to prevent accidents and limit their consequences. (Such reports are known in some countries as safety reports.)

Public authorities may establish different information requirements for different categories of installations, becoming more stringent for those installations regarded as presenting the greatest potential risk. Any such reports should be reviewed regularly and updated as appropriate. They should then be evaluated examining their completeness, appraising the safety of the subject installation and carrying out on-site inspections to verify information contained.

This information may be made available to the public, with the exception of legitimate trade secrets.

As an alternative to this reporting system, public authorities should consider implementing one where detailed technical codes are established as binding requirements. Such codes may include requirements for the engineering design, the construction and the operation of hazardous installations. Public authorities should then monitor compliance with the codes.

Public authorities can also consider which installations, or modifications to installations, pose so much of a potential hazard that they should not be allowed to operate without the prior and continuing approval of an identified public authority. In these cases a form of licensing control could be utilised.

I. Public authorities can fix a requirement for the reporting of certain incidents by the management of hazardous installations.

Relevant information in these reports should be made widely available as a preventive aid to similar accidents at other hazardous installations.

They can also establish a system for maintaining accident statistics, carrying out analyses of collected information and disseminating relevant information derived from the analyses.

J. A worldwide network should be established to promote sharing of information related to the prevention of, preparedness for, and response to accidents involving hazardous substances. This is particularly important in providing access to information for those with less capability in the safe handling of chemicals.

Trade associations, local chambers of commerce and other organisations can be a useful means of disseminating chemical accident prevention information to smaller enterprises, which might be unaware of the existence of such information.

3 Establishment of an Industrial Safety Policy

A. Each enterprise should establish a corporate safety culture. This starts with the visible commitment of the Board members and senior executives of the enterprise, who need to set an example by being actively involved in safety issues. In addition to this “top-down” commitment to safety as a priority, there should be a “bottom-up” commitment through the active application of safety policies by all employees.

Essential elements of the safety culture are the belief that all accidents are preventable and the establishment of policies which set outer limits on acceptable behaviour relating to safety. This culture should encourage initiative and alertness in the interest of safety and guard against complacency which leads to unsafe acts or practices.

As part of the safety culture, there should be an obvious commitment to safety in the enterprise. This commitment is evidenced by such practices as:

- good communication on safety issues between management and other employees;
- positive feedback concerning actions taken to increase safety;
- quick response to remedy identified faults;
- financial and career incentives for good safety performance;
- participation of employees at all levels in developing and reviewing safety management procedures; and
- obvious management interest in safety performance through personal involvement in safety matters.

This safety culture can be enhanced by an open attitude on the part of management towards the public on safety issues.

B. Each enterprise should have a clear and meaningful statement of its **Safety Policy** agreed, promulgated and applied at the highest levels in the enterprise, reflecting the corporate safety culture and incorporating the "zero incident" goal as well as the safety objectives established by public authorities.

1. The Safety Policy should set out to protect the safety and health of all persons involved in, or affected by, the production, process, handling, use, storage, disposal or elimination of hazardous substances, as well as to safeguard the environment and property.
2. It should be widely communicated throughout the enterprise. The management should strive to ensure that the intent of the Safety Policy is understood and appreciated by all employees.
3. The management and other employees need to co-operate and comply with the enterprise's Safety Policy to meet its safety goal.
4. The Safety Policy should be reviewed regularly and amended as experience is gained.
5. In developing, reviewing and amending the Safety Policy, the management should consult with employees at all levels.

The development and implementation by an enterprise of policies and practices relating to accident prevention and preparedness should be co-ordinated and integrated with its activities relating to occupational safety, health and environmental protection as part of the enterprise's total risk management programme.

C. The responsibility for the day-to-day management of safety should be in the hands of the line management at individual installations.

Each site within an enterprise should develop its own safety programme which conforms to the enterprise's Safety Policy and which addresses safety concerns and requirements specific to that site.

The senior management should provide necessary support to the line management for safety-related decisions and actions. In turn, the line management should respond to, or relate the proposals and suggestions of other employees related to safety matters to their superiors.

D. Enterprises selling hazardous substances need to determine whether their customers have adequate facilities and know-how to handle the substances (including processing, use and disposal of the substances). If such determination cannot be achieved, judgment has to be exercised in deciding to accept such customers. If customers are found to be incapable of safely handling the hazardous substances, the seller of the substances should assist them in obtaining this capability or not accept such customers.

E. Smaller enterprises with limited resources need to examine the need for assistance on safety matters from external consultants, professional trade associations and public authorities as well as from suppliers. Suppliers of hazardous substances should be supportive in ensuring that people are available to provide advice to achieve an appropriate level of safety.

In turn, larger enterprises and/or trade associations should offer assistance to small and medium-sized companies in meeting safety objectives.

F. Enterprises and trade associations should take strong action to encourage enterprises which act irresponsibly to meet the appropriate safety objectives.

4 Planning and Construction

Hazard Identification and Assessment

When planning, designing and modifying installations and processes, the management should ensure that critical examination techniques such as hazard analysis, hazard and operability studies (HAZOP), and fault tree and event tree analysis are utilised in order to identify and rank hazards as early as possible at the various stages of the project (including the research stage). In addition, the most suitable means of eliminating or reducing the hazards can be instituted. These studies should take into account abnormal external events such as supply failures, power surges, earthquakes and extremes of weather as well as process hazards. Such studies will indicate where hazards may be reduced through engineering design (see Engineering Design in this section).

A. The nature and extent of the consequences of each significant hazard and its likelihood, should be assessed using techniques such as consequence analysis to ascertain the potential for harm. Reducing either the hazard or its probability reduces the risk and increases the inherent safety of the design.

Techniques such as Quantified Risk Assessment (QRA) can provide guidance for decision-making on such safety issues. QRA allows a relative ranking of risks and provides an aid for determining appropriate preventive measures. However, the numerical results of QRA have little absolute value, therefore, it should not be used indiscriminately.

B. For existing installations which have not been subject to critical safety examinations, hazard studies can be carried out in retrospect.

Such studies will ensure that all hazards have been properly identified and assessed, bearing in mind the existing state of affairs. In addition, such hazard studies will indicate where safety can be improved by substituting hazardous substances with less hazardous substances or less hazardous forms of the substances, reducing storage quantities of such substances, moving them to areas where an accident would have less severe consequences or by making process conditions less extreme. Any improvements which would increase the level of safety should be carried out as soon as practical.

C. The management of hazardous installations should collate all safety-related information on the process and associated equipment concerning design, operation, maintenance and foreseeable emergencies. Such a file or dossier is essential in training as well as operational purposes, and for developing safety reports, which may be required by public authorities.

This process documentation file or plant dossier should include updated information concerning:

- manufacturing procedures; process and operating instructions (including safe start-up and shutdown);
- line diagrams of process flow showing key equipment;
- results of safety tests and safety data on raw materials;
- reaction mixtures and products;
- data resulting from hazard studies; and
- waste treatment.

Engineering Design

Safety measures should be incorporated at the conceptual and engineering design stages of an installation to enhance its intrinsic safety.

D. The design of a hazardous installation should integrate equipment, facilities and engineering procedures that reduce the risk of hazards as far as is reasonably practicable (i.e., all measures be taken to reduce the risk until the additional expense is considered to exceed the resulting increase in safety).

To enhance safety in the engineering design of an installation, the design can minimise the use of hazardous substances, substitute hazardous substances with those that are less hazardous reduce inventories of hazardous substances, simplify processes, reduce process temperatures and pressures; separate people from hazardous substances and include means to contain hazardous substances in the event of an accident.

Systems designed specifically to increase process safety dealing with pressure relief and fire and explosion assessment, for example, should be included in the engineering design of new and existing hazardous installations. In addition, the engineering designs of equipment critical to safety (such as pressure vessels or control instruments) should be subject to a recognised certification or verification procedure. One must also consider redundant safety-related utility supplies (such as electricity for control systems).

E. Processes need to be designed to contain, control and minimise the quantity of hazardous intermediate substances. Where this is not possible, the quantity of hazardous intermediates produced can be reduced to only that required for use in the next stage of production so that quantities held in storage are kept to a minimum.

F. Systems should be designed so that individual component failures will not create unsafe process conditions (they should be "fail safe") and will be capable of accommodating possible human errors.

G. Although the emphasis should be on inherent safety in design, consideration also needs to be given to "add-on" protective systems, thereby assuring safety through mitigation measures.

Procedures can be designed to minimise the chances of failure and, should there be a failure, minimise any adverse effects. Systems to contain any leaks, spills or fire-fighting waters that might be released (for example, containment walls or catch basins) should also be incorporated in the design of hazardous installations, bearing in mind the quantity of hazardous substances which could be released. If there is a loss of containment, adverse effects may be minimised by other mitigation measures such as fire protection equipment and emergency procedures.

H. In the design phase, the management should ensure there is adequate attention paid to the site layout as guided by the overall safety goals. Particular attention should be given to:

- the establishment of safe separation distances in order to minimise a "domino effect";
- the location of hazardous processes and substances relative to the location of critical safety-related equipment and instruments; and
- the local community and environment (see Section C).

Construction

I. Safety checks and inspections should be routinely carried out right from the commissioning and start-up phase and throughout construction to ensure that the integrity of the original design is maintained, plans are being followed properly, requirements of the hazard studies are being fully met, associated equipment is being correctly installed, and that the correct materials, methods (such as welding techniques) and tests (such as pressure/leak tests) are being used by suitably qualified employees.

Any modifications to the original design should be documented, and these modifications should be reflected in quality assurance and safety reviews prior to commissioning and start-up of the installation.

J. An enterprise should only purchase equipment from reputed suppliers, and formally inspect equipment to ensure that it conforms to design specifications and safety requirements before being put to use.

Information concerning reliability of suppliers needs to be shared among enterprises. In addition, quality assurance (QA) systems can provide useful tools to ensure the conformity of equipment with standards and other requirements.

K. In the construction of a hazardous installation, an enterprise should conduct business with only those contractors who are able to assure the enterprise that their services will be carried out in compliance with all applicable laws and regulations, as well as with relevant safety standards and policies of the enterprise. Contractors should work to the standards set by the management of the installation and, to a rational extent, under the direct surveillance of management.

Transfer of Technology

Whenever an enterprise transfers process or other safety-related technology, the management of that enterprise has to strive to ensure that the technology will be applied so that its standard of safety is equivalent to that achieved in the enterprise's own installations using that technology.

L. Enterprises transferring process or other safety-related technology for hazardous installations have a responsibility to develop the technology and associated operating procedures to enable the installations to be operated to an acceptable level of safety.

All such transfers of technology should be accompanied by related safety information and the technology supplier should provide assistance to the receiver in education and training.

M. Prior to transferring process or other safety-related technology, an enterprise needs to ensure that a hazard evaluation of the application of that technology is carried out, incorporating local ecological, social, cultural, economic and demographic data that might affect the possibility, or consequences, of an accident involving hazardous substances.

The party responsible for carrying out this evaluation—which may differ depending upon contractual arrangements—should have access to all the necessary information and use currently accepted techniques for the identification of hazards and evaluation of the risks. In the process, the responsible party should involve local officials and community representatives and ensure that local officials are given the results of the evaluation.

N. Technology should not be transferred unless the supplier is satisfied, having conducted research, that the technology receiver can apply the technology in a safe manner taking into account the legal and administrative infrastructure necessary for its safe operation.

O. There can be a contract governing the transfer of the technology which, among other issues, clearly defines and regulates the division of responsibilities between the parties involved related to effective control of operations, prevention of accidents, and emergency preparedness and response.

If needed, this contract can also have provisions relating to the procedure for the handover of a turnkey plant.

The sections of the contract relating to the areas described above should be available, on request, to competent public authorities and employees and employee representatives.

P. All parties involved, including contractors, will be required to sign a handover document when a hazardous installation involving the transfer of technology has been built to the design specified and its capability to be operated safely (in accordance with specified procedures) has been satisfactorily demonstrated in an acceptance test run.

Acquisitions and Affiliated Operations

Prior to the acquisition of, or investment in, an existing or planned installation, an enterprise should carry out a hazard evaluation to determine the nature and level of hazards at the installation. The enterprise should also determine operating requirements in conformity with the standards of the enterprise.

The responsibility needs to be with the "seller" of an existing installation to disclose all known or suspected safety problems associated with the installation involved.

Q. All relevant corporate safety policies and guidelines for accident prevention, preparedness and response should be applicable to acquisitions. When an enterprise acquires an existing installation, conducts an assessment and concludes that the installation does not meet the standards of the enterprise or internationally accepted safety levels, it should be brought up to required levels within a reasonable period of time. In those cases where retrofitting cannot be accomplished to meet these levels, the investing enterprise should inform the public authorities, employees, and employee representatives of the situation and their intended plans in a timely manner.

R. Financial institutions, when determining the level of funding to be provided to enterprises for investment in a hazardous installation, should take into account the amount of resources needed to comply with safety requirements as well as corporate safety policies and guidelines.

S. Where an enterprise has an investment in, but not operational control over, another enterprise operating hazardous installations, the enterprise making the investment can consider the necessity of entering into contractual arrangements to assist in the establishment and maintenance of safety standards.

T. An enterprise should regularly audit the safety performance and emergency response systems of all hazardous installations of subsidiaries and, to the extent possible, affiliates to assure itself that the level of safety at these installations does not unreasonably endanger employees, neighbouring communities or the environment, and is consistent with acceptable safety standards (see subsection 5 on Safety Performance Review and Evaluation).

U. An enterprise should provide each of its affiliates and subsidiaries full access to all safety-related information including newly discovered information, research results, technology, and management techniques which could reduce the likelihood of major accidents or mitigate the consequences should an accident occur.

V. Enterprises should maintain records showing which hazardous substances are produced, used or stored at affiliates and subsidiaries, by location, on a world-wide basis in order to be able to effectively share information.

W. In the event of a major accident, an enterprise should immediately inform the management of relevant affiliates and subsidiaries of the accident, its probable causes, and recommendations for immediate safety checks. The accident report should also be provided to the management of these affiliates and subsidiaries.

Safety Performance Review and Evaluation

5 Safety Performance Review

A. Safety performance in hazardous installations should be periodically reviewed in order to assess achievements with respect to the general goals set, determine how well specific safety-related policies and decisions have been put into practice, focus resources where improvements are most needed, provide information to justify the adjustment or upgrading of goals and achieve further improvements by:

- demonstrating the management's commitment to safety and providing motivation for improvement;
- providing a basis for recognising good and inadequate performance;
- providing information on safety achievements to the public authorities, community, shareholders and non-governmental organisations; and
- providing input into education and training activities.

B. Public authorities and industry, with the involvement of employees, can develop proactive/positive indicators of safety performance as well as methods of assessing achievements in risk reduction. While changes in lost-time accident rates have been used and have some value in measuring safety performance, they are reactive indicators and provide only part of the total safety picture.

6 Monitoring by Industry

A. The approach to monitoring should be systematic. In this regard, a monitoring plan should be developed at each installation, "owned" and primarily implemented by the local management with flexibility built in to avoid it becoming routine.

It should include regular inspections at the workplace, periodic detailed checks on specific activities and procedures and an overall audit of performance.

B. The monitoring plan of an installation should form the basis of an hierarchy of annual safety assurance reports, from the manager responsible for an installation to division/business/company/enterprise executives and subsequently to the Chief Executive Officer of an enterprise.

C. Emphasis in monitoring should be on those aspects vital to the safety of the particular installation, as revealed by the hazard evaluations. Some general aspects will need to be covered such as organisation and management, training, plant integrity, fire protection and prevention, accident or dangerous occurrence investigation and reporting and emergency procedures.

The potential level of risk is a significant factor in determining the frequency of monitoring.

D. In addition to any changes in response to legal requirements, improvements suggested by monitoring should be made where they are reasonably practicable and contribute to the ultimate goal of "zero incidents".

E. The management should, as appropriate, utilise auditors independent of the local management and employees to monitor hazardous installations. Such an approach using expert consultants or the enterprise's central safety services can be a valuable means of raising safety performance by providing another, more independent, viewpoint. Insurance companies may provide a useful service in this respect, especially to small and medium-sized enterprises.

F. A statement of an enterprise's safety and health performance should form part of the yearly report to its shareholders and employees.

7 Monitoring by Public Authorities

A. Monitoring of existing installations should be carried out by means of both a planned sequence of announced or unannounced inspections and visits in response to accidents, complaints and other indicators that safety performance may be inadequate.

Public authorities should decide on the frequency and nature of planned inspections and commensurate with the resources available to them and the risks presented by the installation using some form of priority rating system.

They should have free access to hazardous installations and be provided with the information necessary to conduct inspections and audits.

B. Public authorities should be given sufficient resources and personnel to carry out their monitoring function. Inspectors should possess the necessary training and expertise to determine whether the approaches taken in a hazardous installation achieve the legal safety requirements.

Inspectors need to be empowered to initiate enforcement action to remedy any serious defects which they discover during monitoring.

C. Public authorities should ensure that guidance is prepared for those with compliance obligations on how they can best meet their obligations and satisfy the monitoring/enforcement authorities.

They can use monitoring as a means of providing support to the management of hazardous installations, consistent with the authorities' enforcement responsibilities. Monitoring provides an opportunity for the public authorities to help management identify weaknesses in their organisation and in their safety arrangements, as well as to provide advice or details on where further information and assistance should be sought. This may be particularly important in the case of small and medium-sized enterprises.

D. For monitoring to be effective and credible, the monitoring authorities should be publicly accountable. This can be achieved by making the system transparent. To this end, the monitoring authorities should publicise their objectives, procedures and the results from monitoring the safety aspects of hazardous installations.

PART **THREE**

Structured Exercises in Safety Management

CHAPTER V

INVESTIGATION AND PREVENTION: ACCIDENTS OF REASONS, RESULTS, REPAIR

The Door of Safety Swings on the Hinges of Commonsense

1 Introduction

Accidents are usually complex. An accident may have 10 or more events that caused it. A detailed analysis of an accident will normally reveal three cause levels: basic, indirect and direct. At the lowest level, an accident results only when a person or object receives an amount of energy or hazardous material that cannot be absorbed safely. This energy or hazardous material is the **direct cause** of the accident. The direct cause is usually the result of one or more unsafe acts or unsafe conditions, or both. Unsafe acts and conditions are the **indirect causes** or symptoms. In turn, indirect causes are usually traceable to poor management policies and decisions, or to personal or environmental factors. These are the **basic causes**.

In spite of their complexity, most accidents are preventable by eliminating one or more causes. Accident investigations determine not only what happened, but also how and why. Accident investigators are interested in each event as well as in the sequence of events that led to an accident. The accident type is also important to the investigator. The recurrence of accidents of a particular type or those with common causes shows areas needing special accident prevention emphasis.

2 Investigative Procedures

The actual procedures used in a particular investigation depend on the nature and results of the accident. The agency having jurisdiction over the location determines the administrative procedures. In general, responsible officials will appoint an individual to be in charge of the investigation. The investigator uses most of the following predefined steps:

1. Define the scope of the investigation.
2. Select the investigators. Assign specific tasks to each (preferably in writing).
3. Present a preliminary briefing to the investigating team, including:
   a. description of the accident, with damage estimates;
   b. normal operating procedures;
   c. maps (local and general);
   d. location of the accident site;
   e. list of witnesses; and
   f. events that preceded the accident.
4. Visit the accident site to get updated information.
5. Inspect the accident site.
   a. Secure the area. Do not disturb the scene unless a hazard exists.
   b. Prepare the necessary sketches and photographs. Label each carefully and keep accurate records.
6. Interview each victim and witness. Also interview those who were present before the accident and those who arrived at the site shortly after. Keep accurate records of each interview. Use a tape recorder if desired and if approved.
7. Determine
   a. what was not normal before the accident;
   b. where the abnormality occurred;
   c. when it was first noted; and
   d. how it occurred.
8. Analyse the data obtained in step 7. Repeat any of the prior steps, if necessary.
9. Determine
   a. why the accident occurred;
   b. a likely sequence of events and probable causes (direct, indirect, basic); and
   c. alternative sequences.
10. Check each sequence against the data from step 7.
11. Determine the most likely sequence of events and the most probable causes.
12. Conduct a post-investigation briefing.
13. Prepare a summary report, including the recommended actions to prevent a recurrence. Distribute the report according to applicable instructions.

An investigation is not complete until all data is analysed and a final report is completed. In practice, the investigative work, data analysis, and report preparation proceed simultaneously over much of the investigation.

3 Fact-finding

Evidence needs to be gathered from many sources during an investigation. Information can be obtained from witnesses and reports as well as by observation. Witnesses have to be interviewed as soon as possible after an accident. The accident site should undergo inspection before any changes occur. Photographs and sketches of the accident scene need to be taken. All pertinent data can be recorded on maps. Copies of all reports should be made. Documents containing normal operating procedures, flow diagrams, maintenance charts, or reports of difficulties or abnormalities are particularly useful. Complete and accurate notes must be maintained recording pre-accident conditions, the accident sequence, and post-accident conditions. In addition, the location of victims, witnesses, machinery, energy sources, and hazardous materials should be documented.

In some investigations, a particular physical or chemical law, principle, or property may explain a sequence of events. Laws can be included in the notes taken during the investigation or in the later analysis of data. In addition, data gathered during the investigation may lend itself to analysis by these laws, principles, or properties. An appendix in the final report can include an extended discussion.

4 Interviews

In general, experienced personnel should conduct interviews. If possible, the team assigned to this task should include an individual with a legal background. An interview can be conducted in accordance with the following points:

1. Appoint a speaker for the group.
2. Obtain preliminary statements as soon as possible from all witnesses.
3. Locate the position of each witness on a master chart (including the direction of view).
4. Arrange for a convenient time and place to talk to each witness.
5. Explain the purpose of the investigation (accident prevention) and put each witness at ease.
6. Listen, let each witness speak freely, and be courteous and considerate.
7. Take notes without distracting the witness. Use a tape recorder only with the consent of the witness.
8. Use sketches and diagrams to help the witness.
9. Emphasise areas of direct observation. Label hearsay accordingly.
10. Be sincere and avoid arguing with the witness.
11. Record the exact words used by the witness to describe each observation. Avoid "putting words into a witness' mouth".
12. Word each question carefully and make sure the witness understands.
13. Identify the qualifications of each witness (name, address, occupation, and years of experience, etc.).
14. Supply each witness with a copy of his or her statements. Signed statements are desirable.

After interviewing all witnesses, the team should analyse each witness' statement. They may wish to re-interview one or more witnesses to confirm or clarify key points. While there may be inconsistencies in witnesses' statements, investigators can assemble the available testimony into a logical order. This information can then be analysed along with data from the accident site.

Not all people react in the same manner to a particular stimulus. For example, a witness within close proximity to the accident may have an entirely different story from one who saw it from a distance. Some witnesses may also change their stories after they have discussed it with others. The reasons for the change may be additional clues.

A witness who has had a traumatic experience may not be able to recall the details of the accident. Another, who has a vested interest in the results of the investigation, may offer biased testimony. Finally, eyesight, hearing, reaction time, and the general condition of each witness affects his or her powers of observation. A witness may omit entire sequences because of a failure to observe them or because their importance was not realised.

Problem-solving Techniques

Accidents represent problems that must be solved through investigations. Several formal procedures solve problems of any degree of complexity. This section discusses two of the most common procedures.

5 Change Analysis

As its name implies, this technique emphasises change. To solve a problem, an investigator must look for deviations from the norm, consider all problems that can result from some unanticipated change and make an analysis of the change to determine its causes. The following steps can be used:

1. Define the problem (What happened?).
2. Establish the norm (What should have happened?).
3. Identify, locate, and describe the change (What, where, when, to what extent?).
4. Specify what was and what was not affected.
5. Identify the distinctive features of the change.
6. List the possible causes.
7. Select the most likely causes.

6 Job Safety Analysis

Job safety analysis (JSA) is part of many existing accident prevention programmes. In general, JSA breaks a job into basic steps and identifies the hazards associated with each step. It also prescribes controls for each hazard. The JSA has to be reviewed during the investigation if it has been conducted for the job involved in an accident. If one is not available, it has to be performed as part of the investigation to determine the events and conditions that led to the accident.

7 Report of Investigation

As noted earlier, an accident investigation is not complete until a report is prepared and submitted to proper authorities. Special report forms are available in many cases. Other instances may require a more extended report. Such reports are often very elaborate and may include a cover page, a title page, an abstract, a table of contents, a commentary or narrative portion, a discussion of probable causes and a section on conclusions and recommendations.

The following outline has been found especially useful in developing the information to be included in the formal report:

1. Background information
   a. where and when the accident occurred
   b. who and what were involved
   c. operating personnel and other witnesses
2. Account of the accident (what happened?)
   a. sequence of events
   b. extent of damage
   c. accident type
   d. agency or source (energy or hazardous material)
3. Discussion (analysis of the accident—how; why)
   a. direct causes (energy sources hazardous materials)
   b. indirect causes (unsafe acts and conditions)
   c. basic causes (management policies, personal or environmental factors)
4. Recommendations for immediate and long-range action to remedy:
   a. basic causes
   b. indirect causes
   c. direct causes (such as reduced quantities or protective equipment or structures).

8 Occupational Injury, Accident and/or Incident Reporting and Investigation

It is important that the investigation style should be 'fact-finding' and not 'fault- finding'. Fault-finding creates an environment that is not conducive to learning.

8.1 Incident Reporting: The First Intimation Report

Whenever an accident, dangerous occurrence (with or without an injury), occupational injury or property damage takes place, the first and foremost task is to ensure that the injured receives first-aid, medical treatment or, if required, hospitalisation. The incident should simultaneously be reported immediately to the personnel department to take immediate action for the treatment of the injured, further notifying the management (mainly the occupier and the factory manager) and the respective government authorities as the case demands. So also, copies of the report should be submitted by the department, where the incident took place, to the safety department and in case of fire to the fire department for information.

8.2 Incident Investigation Report

All the facts brought to light should be reported in an accident or incident investigation report even if no conclusions were drawn from some of them. The most obvious reason is that when experts from different backgrounds read the report, experience and interests can draw conclusions that were not obvious to the original investigators.

For example, the official report on 'Fan-Crash' (Illustrated Case History: 9), though outstanding in many ways, did not discuss the inherent possibility of a carbon monoxide explosion in the 'Fume-Extraction-System'. But the report did contain the information from which others could draw an important additional conclusion—the most effective way of preventing similar accidents is to design the 'system-plant' providing standard explosion-relief doors and avoid the building up of CO gas in its explosive range.

Another classic example would be the 'HCl tank explosion' (Illustrated Case History: 7). The original investigation report blamed 'static charge', but others went in depth to investigate how the explosive-mix was formed. It was the hydrogen atom (nascent H+) produced by corrosion that played havoc.

Perhaps the most extreme example, T.A. Kletz says, of a report which failed to draw the necessary conclusions, was one which stated, 'There was no need to recommend any changes in design, as the plant has been destroyed.'

8.3 Requirements of Accident Reporting

A. Employees and contractors need to be positively encouraged by their management to report all incidents to the managers in the enterprise. The following suggestion can facilitate this.

1. Employees should be given the appropriate training in hazard identification.
2. Employees can also be encouraged to discuss near misses among themselves immediately after they happen.
3. Efforts can be made to foster an environment where reporting incidents and discussing them are considered to be positive activities.
4. Employees should be given the assurance that there will be no adverse repercussions for reporting incidents to management or discussing incidents among themselves.

B. Public authorities require prompt notification of the key elements of major accidents involving hazardous substances. This notification should be followed up with formal written reports.

To promote this, public authorities should encourage enterprises to voluntarily report them about accidents and significant near misses beyond that legally required.

Similar information on incidents should be provided to relevant trade associations.

C. Public authorities and industry need to further their efforts to improve the exchange of information on significant accidents and near misses.

Efforts can be made to co-ordinate reporting by industry at the national and international level to facilitate information sharing.

D. Public authorities should also establish a structured national system for maintaining statistics on accidents involving hazardous substances. This will facilitate exchange of information, analyses of this information, and dissemination of the results of the analyses.

8.4 Requirements of Accident Investigation

A. The local management of an installation has to be responsible for prompt investigation and thorough analysis of all incidents.

The emphasis should be on identifying the underlying causes, the lessons to be learned and ways to prevent future accidents rather than identifying the person(s) responsible.

The use of a computer database for storing the key elements of incidents can facilitate their analysis. By this means particular trends can be highlighted and historical data can be used proactively in accident prevention, for example by orienting safety training towards the avoidance.

B. Public authorities should independently investigate all major accidents. Where required, this investigation can be conducted by a group of experts (for example, a specially designated commission), which includes different individuals from those responsible for inspection of installations and enforcement of the control framework.

All interested parties should have the opportunity to be involved in this investigation.

C. In all accident investigations, efforts should be made to determine the underlying cause(s) in the chain of events leading to an accident, and not limit the investigation to determining the apparent cause(s).

Where human error is involved, the cause should not automatically be recorded. Rather, investigators need to determine exactly what elements contributed to it. Such elements could include boredom, stress, overwork, lack of training, inadequate procedures, poor ergonomic design, poor system/technology design, communication problems, management inadequacies, inappropriate safety goals and similar factors.

D. Public authorities can publish accident investigation information for wide dissemination. This should include sufficient information to enable it to be useful in other situations, as well as any conclusions arising from the analysis of accident data.

Public authorities are in a position to correlate information, foster exchange of information, and provide credible analyses. Such information is important in order to gain knowledge useful for them and the management in their role in evaluating and making decisions related to regulation, monitoring, preparation of emergency plans, and development of risk assessment and management techniques.

9 The Kletz Investigation Technique

Till today, the tradition of investigating occupational injuries, industrial accidents or incidents, mishaps, dangerous occurrences, fires and so on and so forth has been oriented towards finding the immediate cause of the accident and suggesting measures to avoid their recurrence.

An important development has recently come up in improving the effectiveness of investigation techniques and methodology. The internationally acclaimed chemical engineer and safety advisor, Dr. Trevor A. Kletz, has brought in a new concept of accident investigation, known as “Layered Investigation”. It consists of techniques that significantly and remarkably improve upon the traditional method of investigation in which only relatively obvious or surface causes are identified. According to Kletz, the findings and recommendations in the traditional method are relatively superficial and do not reveal the root causes which are essential to investigation.

The Kletz technique is a far better method of investigation and finding sequential data with a deeper analysis of facts and figures. It helps dig out deeper information with more causative factors to pinpoint the extent of the weaknesses right up to the management system. It supplies additional levels of recommendations in which monitored prevention of recurrence is assured. In doing this a multi-layered solution to the problem of accident prevention is created.

Kletz emphasises a minimum of three levels of investigative findings and recommendations. He calls these levels—'layers'. He quotes the simile of an onion. According to him, accident investigation is like peeling an onion. Beneath one layer of causes and recommendations, there are other, less superficial, layers.

1. Outer layers—These layers deal with immediate technical causes.
   Recommendations also adhere to this level or layer.
2. Inner layers—These layers are concerned with:
   (a) ways of avoiding hazards; and
   (b) the underlying causes such as weaknesses in the management system. Recommendations are made according to the causative findings.

10 Methodology of In-depth Investigation[8]

Objective: To acquire as much pertinent information as possible concerning the causes in order to be thorough.

10.1 Finding the Facts

1. Try not to disturb the evidence that may be useful to experts called later. If it is essential to disturb it, photograph first.
2. Draw up a list of everyone who may be able to help such as witnesses, designers, technical experts etc.
3. Do not question the witness so that you put ideas in their minds.
4. Avoid questions to which the answer is 'Yes' or 'No'.
5. Avoid any suggestion of blame. Inform authorities through proper channels.
6. Record information, quantitative if possible, on damage and injuries so that others can use it for prediction.
7. Report all the facts detailing corrective action taken or suggested.
8. Prepare an action plan, clearly indicating by whom and when the recommendations should be implemented.

10.2 Information to Include in the Accident Investigation Report

1. Who is responsible for carrying out the recommendations?
2. When will they be complete?
3. How much will they cost, in money and other resources?

The nature of injury: As certified by the Medical Officer.
The severity of injury: Number of days lost due to accident not on account of the consideration of medical advice.

10.3 Collection, Analysis and Use of Factual Data

1. Begin as far back in the history of the events as practical to explore, i.e., inquire what an employee was doing at the time of the injury, but also try to know his activities prior to them.
2. Secure as many pertinent facts from as many reliable witnesses as can be found.
3. Examine the physical environment associated, as thoroughly as experience or conditions permit.
4. Use causal factors responsible for an injury, accident or damage, which are best uncovered when a defining guide, listing the common causal factors, is used for developing the pertinent information.

10.4 Who Should Investigate an Accident?

The first layer, i.e., on-the-spot investigation, should be executed and reported by the unit supervison. The second layer of the investigation can then be peeled off by the safety professionals and/or the experts in the field. As necessitated, a team, including a member from outside the department, should be drawn to collect relevant information and conduct an in-depth study.

The shop floor supervisors and the line managers play a key role in the accident prevention programme. They represent management on the spot, are well versed in local hazards and are familiar with the local rules and the work-people. They can 'suggest' rather than 'order' people around, as they know the culture and language of the shop floor people. They know that gentle persuasion works wonders.

11 Causal Factors

11.1 The Agency

The agency is the substance, object, radiation or person most closely associated with the event. It can include one or a combination of the following factors.

1. Animals: insects, wild or domestic animals, etc.
2. Boilers and pressure vessels: steam boiler, super heater, condenser, digester, pressure piping.
3. Chemicals: explosives, vapours, fumes, corrosives and poisons.
4. Conveyers: belt, sprocket, chains etc.
5. Dusts: asbestos, silica coal, lead and explosives.

6. Electric apparatus: motor, generator, rheostat lamp and circuit breaker.
7. Elevators: passenger or freight, electric, steam, hydraulic, hand powered, etc.
8. Hand tools: axe, cleaver, chisel, hammer, screwdriver, file, etc.
9. Highly flammable and hot substances: lacquer, steam, etc.
10. Hoisting apparatus: crane, derrick and dredges.
11. Mechanical power transmission equipment: drive shaft, bearing, pulleys, gears, etc.
12. Prime movers and pumps: engine, compressor, blower, fan, etc.
13. Radiation and radiating substances: radium, ultraviolet, X-ray, etc.
14. Working surfaces: floor, ramp, road, stair, ladder and scaffold.
15. Miscellaneous: floor openings, windows, welding and gas cutting.
16. Fire: ordinary, electrical or chemical.

11.2 The Agency Part

The agency part is the particular part of the agency directly associated with the injury, e.g., pulley, belt, gear, tool, saw, pump shaft, motor, etc.

11.3 The Accident Type

The accident type is the manner of contact of the injured person with an object or substance, or the exposure or movement of the injured that resulted in the injury. It is a classification of injury cases according to the source of injury.

1. Caught in or between: Where the injury is caused by the crushing, pinching or squeezing of an injured person between moving and stationary object or between two moving objects.
2. Struck by: Where an impact or blow produces the injury but the object causing the injury rather than the injured person provides the motion (moving or falling object strikes the injured).
3. Struck (or striking) against: Where the motion of the injured person rather than that of an object, substance or other person and so on causes the injury (the injured strikes against something or someone).
4. Fall of person (same level): Where a person falls on the supporting surface (floor, platform, ground and so on) and is injured by contact with the supporting surface or objects. Include slips and stumbles resulting in falls.
5. Fall of person (different level): Where a person falls from one level to a lower one, receiving an injury by contact with an object or substance at the second level (fall from a staircase, ladder or into a pit, etc).
6. Abraded, punctured, scratched: Involving damage to the tissue resulting from too long or forceful pressing against rough, pointed or hard substances such as stepping on penetrating objects, foreign matter entering the eyes and splinters tearing the skin.
7. Overexertion: Sprains, strains, ruptures, etc.

8. Contact (electric current): Accidental contacts with live electric conductors resulting in shock or burn.
9. Contact (temperature extremes): Contact with hot or cold solids, liquids or gases resulting in burns or freezing.
10. Contact (radiation sources, caustics, toxic and noxious substance): Where injury is caused by inhalation, ingestion or absorption (drowning, asphyxiation, infections, exposure to the sun's rays, etc.).

11.4 Unsafe Physical/Mechanical/Environmental Condition

These consist of factors present due to defects in condition, errors in design, faulty planning or omission of essential safety requirements for maintaining a relatively hazard-free environment.

1. Inadequate mechanical guarding.
2. Defective (i.e. rough, sharp, slippery, decayed, frayed, inferior composition, cracked, leaked) equipment such as ladders, floors, stairs, vessels, piping, etc.
3. Unsafe design or construction.
4. Hazardous process, operation or arrangement (i.e., unsafe piling, stacking, storage, congested aisle space, crowding, overloading, violation of desired norms of good housekeeping, etc.)
5. Inadequate or incorrect illumination.
6. Inadequate or incorrect ventilation.
7. Unsafe dress or apparel and PPE (loose clothing, absence of or defective gloves, aprons, shoes, respirators as required).

11.5 Unsafe Personal Acts or Practices

The following are the types of human behaviour which lead to injuries and/or accidents. No attempt has been made to probe the reasons why people behave so. The most common patterns have been listed below.

1. Working unsafely (i.e., improper lifting, hazardous placement, incorrect mixing of materials, performing maintenance or repairs on moving machinery, working under suspended loads, failure to take heed of warning, and any act violating accepted safe practice/procedure).
2. Performing operations without supervisor's permission, authority or training.
3. Removing safety devices or altering their operation thus making them ineffective.
4. Operating at unsafe speeds.
5. Use of unsafe or improper tools/equipment (i.e., using a chisel with a mushroomed head, removing chips from cutting m/c by hand and not by brush, etc.).
6. Using tools, equipment, safety gadgets and devices unsafely.
7. Horseplay, teasing, abusing and so forth.
8. Working under the influence of alcohol.
9. Failure to use safe attire or personal protective devices/equipment.

11.6 Unsafe Personal Factor

1. Unsafe improper attitudes
2. Lack of knowledge or skill
3. Bodily defects (faulty vision, poor hearing, etc.)
4. Mental state (nervousness, fatigue, slow reaction, etc.).

11.7 Nature of Injury

1. Incised wound (straight cut)
2. Laceration (irregular cut)
3. Confused wound (swelling)
4. Bruise (cut plus confusion)
5. Punctured wound (deep prick)
6. Burn (chemical, electrical or fire)
7. Scald (steam, hot liquids or solids)
8. Asphyxia (breathlessness)
9. Shock (nervous or electrical)
10. Abrasion (scratch or tearing skin).

11.8 The Severity of Injury

Unconsciousness, profuse bleeding, partial amputation, etc.

11.9 The Property Damage/No Injury Cases

For cost analysis and for the dual purpose of locating conditions or practices that are injury-producing and to prevent property damage and other losses, it is equally important to report and analyse:

1. Property damage along with an injury/injuries.
2. No-injury case but property damage due to accident.
3. Near-injury case with or without property damages.

The same format, analysis and classification framed and evaluated so far can also be applied to injuries.

12 Occupational Safety and Health

—Directives and Standards for Accident/Incident Investigation and Reporting

Purpose: To establish processes for accident/incident investigation and reporting:
The following accident/incident investigation and reporting activities will be reported:

1. Reporting and Logging System

A. The "Report of Accident/Incident" form, as specified below, can be used to document all accidents/incidents.

B. The Department Safety Management Information System (SMIS) can be used as the logging and statistical reporting mechanism for all accidents/incidents.

2. Reporting and Investigation Responsibilities

A. Employees

1. Notify their supervisor of every job-related accident/incident involving:
   (a) injury;
   (b) illness;
   (c) death;
   (d) property damage;
   (e) fire; or
   (f) an accident/incident which exposed or could expose individuals present to injury, illness, or death.

B. Supervisors

1. Act as the signatory "Reporting Official".
2. Immediately investigate each employee-reported accident/incident.
3. Notify their respective safety and health official of a work-related accident/incident, which involves personal injury, property damage or the public for which the respective safety and health official will determine the extent of investigation.
4. Immediately notify their respective manager and Director-delegated safety and health official of an accident/incident, which results in:
   (a) death,
   (b) hospitalisation,
   (c) public injury/illness (non-Company),
   (d) reclamation property damage, or
   (e) public property damage.
5. Submit, to their respective safety and health official, the timely documentation of elements necessary for the completion of the format which involves:
   (a) job-related injury/illness requiring any medical treatment or first aid provided by a medical professional;
   (b) employee submission of "Federal Employee's Notice of Traumatic Injury and Claim for Continuation of Pay/Compensation" or "Notice of Occupational Disease and Claim for Compensation";
   (c) job-related death;
   (d) vehicular accident while on duty;
   (e) property damage resulting from an accident/incident;
   (f) accident/incident, which exposed or could expose individuals present to injury, illness, or death.

C. Managers (Generally Personnel/Human Resource Managers)

1. Ensure that the authorities are promptly notified within four hours of a:
   (a) dangerous occurrence, as specified under the Factories Act, 1948;
   (b) death or accident causing a suspected imminent fatal injury of an employee.

2. Immediately notify their management and delegated safety and health officials of an accident/incident on Company-owned and operated facilities, which exclusively involve the public (non-Company) and result in death, hospitalisation, or property damage.
3. Submit, to their respective safety and health officials, the timely documentation of elements necessary for the completion of the formalities for a public accident/incident, which occurs on a Reclamation-owned and operated facility.
4. Ensure that non-Company operators of Company-owned facilities are required to submit timely documentation of elements necessary for the completion of the formalities for an accident/incident which involves the public (non-Reclamation) and results in death, hospitalisation or public property damage.

D. Each Contracting Officer or Contracting Officer's Representative

1. Require each contractor to immediately notify the contracting officer or representative of any accident/incident, which results in:
   (a) death;
   (b) job-related injury/illness requiring medical treatment other than on-site first aid, a physician's medical evaluation with no subsequent treatment, or first aid treatment only;
   (c) contractor property damage; and
   (d) non-contractors' property damage.
2. Immediately notify the Company-delegated safety and health official of an accident/incident, which results in:
   (a) death,
   (b) hospitalisation,
   (c) company or contractor property damage,
   (d) public property damage.
3. Submit to their respective safety and health official the timely documentation of elements required for the completion of the formality for reported contractor accidents/incidents.
4. Quarterly submit the following statistical information for each contract to their respective safety and health official:
   (a) specification number,
   (b) type of contractor,
   (c) number of employees, and
   (d) man-hours.

13 The Irrelevance of Blame[8]

If accident investigations are conducted with the objective of finding culprits and punishing them, then people will not report all the facts and who can blame them? If we want to know what has occurred, we have to make it clear that the objective of the inquiry is to establish the facts and make recommendations to prevent recurrence. Furthermore, we have to affirm that nobody will be punished for *errors of judgement* or *forgetfulness*. However, *reckless indifference to the safety of others* will have to be viewed seriously for punishment.

Occasional negligence may go unpunished, but this is a small price to pay to prevent further accidents. An accident investigation may reveal that someone does not have the ability to carry out a particular job and he may have to be moved to a suitable one, but this is not punishment and should not be made to look like one.

In fact very few accidents are due to negligence. Most human errors are the result of a moment's forgetfulness or an aberration, the sort of error we all make from time to time. Others are the errors of *judgement, inadequate training or instruction or inadequate supervision.*

Accidents are rarely the fault of a single person. Responsibility usually belongs to many people. The following is a quotation from an official UK report on safety legislation:

> The fact is—and we believe this to be widely recognised—the traditional concepts of the criminal law are not readily applicable to the majority of infringements which arise under this type of legislation. Relatively few offences are clear cut, few arise out of reckless indifference to the possibility of causing injury, few can be laid without qualification at the door of a single individual. The typical infringement or combination of infringements arises through carelessness, oversight, lack of knowledge or means, inadequate supervision or sheer inefficiency. In such circumstances the process of prosecution and punishment by the criminal courts is largely an irrelevancy. The real need is for a constructive means of ensuring that practical improvements are made and preventive measures adopted.

There is hardly any value for human life in our country due to various reasons—some within our control and some beyond—but they are all man-made. We must recognise that others have the right to live as we do. We cannot remain indifferent to the safety of others.

CHAPTER VI

SAFETY SYSTEMS

The "Permit-to-Work" System

The permit-to-work is essentially a document which sets out the work to be done, the hazards involved and the precautions to be taken. It predetermines a safety drill and is a clear record that all foreseeable hazards have been considered and that appropriate precautions are defined and put in correct sequence. *It does not in itself make the job safe.*

1 Application of 'Permit-to-Work' System

The classifications of systems and their requirements are as follows.

1.1 Hazardous Operation Permit

1. Work in confined-space. (Covered under the Factories Act, 1948, Section 36.) Refer to Section 13 in 'Confined-Space Hazards'.
2. Breaking or opening equipment or pipelines containing hazardous chemicals (liquids and/or gases). (Covered under the Maharashtra Factories Rules, 1963, Rule 73-C.)
3. Hot-work in areas or on equipment where flammables are stored or processed.
4. Work on high voltage electrical equipment.
5. Loading and unloading of hazardous substances.
6. Excavation: underground cables, pipeline-work, vessels, etc.
7. Operations involving disposal of hazardous substances.
8. Operations for testing of systems, equipment, pipeline, pressure plants, etc.

1.2 Hazardous Location Permit

1. Work on fragile roof or ceiling (e.g. A. C. Sheet) where workers are liable to fall. (Covered under the Maharashtra Factories Rules, 1963, Rule 73-F.)
2. Work at dangerous heights, on scaffolding/walls/tall chimneys.
3. Work on or below or in the vicinity of guarded or unguarded electrically operated and/or mechanically moving machinery or equipment.
4. Work on equipment that requires complete isolation.
5. Work involving propping and centring of RCC slab.

1.3 Hazardous Work Area Permit

1. Explosive building work.
2. Acid area work.
3. Flammable area work.
4. Noxious fumes area work.

1.4 Special Hazard Permit

1. Use of toxic materials, matches or lighter, flammables.
2. Use of repaired/modified electrical and other tools/equipment/application.

1.5 Equipment Operating Permit

1. Operating vehicle, fork-lift etc.
2. Sprinkler valve closing.

2 Basic Elements of the 'Permit-to-Work' System

The following should be considered, specified in precise detail and recorded on the permit.

2.1 Preparation

1. The job to be done.
2. The possible dangers involved. A checklist used.
3. The necessary isolations, disconnection and tests. A checklist used.
4. The safety precautions which must be taken. A checklist used.
5. The time limits between which the permit is valid.

When the above steps are complete, ensuring that the particulars are correct, the permit is signed by the authorised initiator and handed over to the job-undertaker.

2.2 Transfer and Acceptance of Responsibility

1. The job-undertaker assures the initiator that the permit has been properly completed and that he understands the work to be done and precautions to be taken.
2. The job-undertaker signs the permit.
3. He checks that the necessary safety equipment is available and ensures that the specified precautions are carried out.
4. He consults and obtains renewal or continuation of the permit if the job is delayed beyond the specified limit.

2.3 Completion of the Job

1. The job-undertaker signs to the effect that the job is complete, that all his men have withdrawn and normal safeguards effectively restored.
2. When more than one trade is involved in the work, the supervisor of each group signs.
3. The machinery or plant is handed back to the production initiator who signs accepting responsibility.
4. The permit is withdrawn from the display and normal working is resumed.

3 Considerations

1. The permit must be recognised as the master instruction overriding all other instructions.
2. Where the work continues beyond the specified time limit or end of the shift, the responsibility for the operation must be passed onto the responsible person of the succeeding shift by signing the permit.
3. Wherever necessary, more than one permit can be issued where more than one trade is involved or where there is a high level of risk.
4. Wherever there is high risk of fire or explosion, the issue of all permits should be notified to a central control point so that any possible danger can be averted.
5. Where the work is to be carried out by outside contractors, it is important that those involved should be made fully aware of the circumstances under which the permit is operated.

Safe-Work-Permit should be organised thoughtfully and issued only on due consideration of all the potential hazards involved in the job undertaken and the areas covered. The major considerations would be:

1. conditions that change after testing;
2. vapour coming out of drains and vents;
3. liquid left in lines;
4. service lines containing hazardous materials;
5. pressure trapped in equipment, line or jacket;
6. flammable gas or liquid leaking into a nearby area not covered in the permit; (For highly flammable liquids, distance of 15 m is often used.)
7. misunderstanding the meanings of words and phrases used in the permit; (Read permits carefully; don't just glance at them.)

8. procedures to be laid down should be complete and easy to follow;
9. provision of adequate protecting equipment and clothing.

When a job-undertaker, say a maintenance man or a contractor, signs a permit to indicate that the job is complete, he means that he has completed the job *he thought he had to do*. This may not be the same as the job he was expected to do. The process team needs to make sure that the job completed is the one wanted and therefore should always inspect the job.

When handing over or handing back the permit, the initiator and the job-undertaker (generally, the process and the maintenance people) should speak to each other. It is not good practice to leave a permit on the table for someone to sign when he comes in.

4 Application of the Work-Permit System

In general, it has been a practice to print separate standardised formats or a combined format of the work-permits as per the requirements of the system. Permit areas are chosen from:

- Hazardous operation permits (e.g., safe entry into a confined space).
- Hazardous location permits (e.g., work on fragile roof).
- Hazardous work area permits (e.g., flammable/explosive/corrosive).
- Special hazard permit (e.g., use of flammable/toxic materials).
- Equipment operating permit (e.g., vehicle operating/sprinkler closing).

Other areas, as and when found necessary to apply in the system, should also be promptly considered. All the permits that are established and administered on a day-to-day basis should be revised frequently to suit the needs of the effective safety management.

It is not necessary that only the document which has been standardised and printed by way of a format should be respected as a 'permit-to-work'. Any document which ensures responsibility on both sides to identify the potential hazards, organise precautionary measures and carry out the work safely is a safe-work-permit. Even a well thought out and adequately planned note, written in the case of an unusual odd job, signed by both the job initiating and undertaking authorities at senior levels, accepting responsibility should be taken as a 'permit-to-work'.

Confined-Space Hazards[49]

"Today we're going to talk about fall protection"

1 Introduction

NIOSH defines a confined space as one which, by design, has limited openings for entry and exit or unfavourable natural ventilation which contains or produces dangerous air contaminants and is not intended for continuous occupancy.[38] Confined spaces include but are not limited to storage tanks, compartments of ships, process vessels, pits, silos, vats, wells, sewers, digesters, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, tunnels, underground utility vaults, and pipelines. Confined spaces can be found in many industrial settings, from steel mills to paper mills, from shipyards to farms, and from public utilities to the construction industry. The hazards associated with confined spaces can cause serious injury and death to workers.

Two major factors lead to fatal injuries in confined spaces:

1. Failure to recognise and control the hazards associated with confined spaces,
   [and]
2. Inadequate or incorrect emergency response.

Confined spaces may be classified into two categories:

1. Open-topped enclosures with depths which restrict the natural movement of air (e.g., degreasers, pits, selected types of tanks, and excavations),
   [and]
2. Enclosures with limited openings for entry and exit (e.g., sewers, tanks, and silos).

The hazards found in any confined space are determined by the material being stored or used, the process-taking place inside the space and by the effects of the external environment. Worker entry into confined spaces may occur during construction activities or during necessary frequent functions such as cleaning, inspection, repair or maintenance.

2 Confined-Space Hazards

Atmospheric Hazards

2.1 Oxygen Deficiency

Oxygen deficiency occurs from chemical or biological reactions which replace or consume oxygen from a confined space. The consumption of oxygen takes place during combustion of flammable substances as in welding, cutting or brazing. A more subtle form of oxygen consumption occurs during bacterial action as in the fermentation process. Oxygen deficiency can result from bacterial action in excavations and manholes which are near garbage dumps, landfills, or swampy areas. Oxygen may also be consumed during slow chemical reactions as in the formation of rust on the exposed surface of metal tanks, vats and ship holds.

Ambient air has an oxygen content of 21%. When the oxygen level drops below 17%, the first sign of hypoxia is a deterioration of night vision, which is usually not noticeable. Physiologic effects include increased breathing volume and accelerated heartbeat. Between 14% and 16%, physiologic effects are increased breathing volume, accelerated heartbeat, poor muscular co-ordination, rapid fatigue, and intermittent respiration. Between 6% and 10%, the effects are nausea, vomiting, inability to perform and unconsciousness. At concentrations less than 6%, there is rapid loss of consciousness and death in minutes.

2.2 Oxygen Displacement: Inert Gases and Simple Asphyxiants

A simple asphyxiating atmosphere contains a gas or gases that are physiologically inert and which do not produce any ill effects on the body. However, in sufficient quantity, a simple asphyxiant will displace oxygen and may result in an atmosphere unable to support respiration. The ambient, or normal, atmosphere is composed of approximately 21% oxygen, 78% nitrogen and 1% argon with small amounts of various other gases.

For example, if 100% nitrogen—a non-toxic, colourless, odourless gas—is used to inert (displace oxygen) a confined space, it will cause immediate collapse and death to the worker if the confined space is not adequately ventilated before entry. Other examples of simple asphyxiants, which have claimed lives in confined spaces, include carbon dioxide, argon and helium.

2.3 Flammable Atmospheres

A flammable atmosphere generally results from vaporisation of flammable liquids, by-products of chemical reaction, enriched oxygen atmospheres, or concentrations of combustible dusts. Three components are necessary for an atmosphere to become flammable: fuel and oxygen in the proper mixture, gas to gas variation within a fixed lower flammable limit (LFL) and upper flammable limit (UFL) range, and a source of ignition. [The terms LFL & UFL are synonymous with the lower explosive limit (LEL) and upper explosive limit (UEL).]

The concentrations below and above the fixed range of each of the flammable/explosive gases are either very poor or too rich to support combustion. However, the introduction of air by starting forced ventilation in a confined space, having a rich concentration of the flammable gas (e.g., 27% methane—much above its explosive range between 5% and 15%) will be diluted in the confined space, taking the explosive gas in its explosive range.

An oxygen-enriched atmosphere (above 21%) will cause flammable materials, such as clothing and hair, to burn violently when ignited. Therefore, never use pure oxygen to ventilate a confined space. Ventilate with normal air.

2.4 Toxic Atmospheres

Toxic gases may be present in confined spaces due to the following reasons:

1. The manufacturing uses toxic gases. For example, in producing polyvinyl chloride, hydrogen chloride is used as well as a vinyl chloride monomer. The product stored in the space can be absorbed into the walls and give off toxic gases when removed or when cleaning out product residues.
2. There are biological or chemical processes occurring in the product stored in the confined space. For example, decomposing organic material in a tank or sump can liberate hydrogen sulphide.
3. Harmful gases, which evolve from tanks located in the vicinity, being heavier than air are likely to enter in the space.
4. The operation executed in the confined space can liberate toxic gases. For example, hot work such as welding, cutting, brazing, or painting, scrapping, sanding, degreasing etc. and also cleaning which releases vapour from solvents. Welding can liberate oxides of nitrogen, ozone, and carbon monoxide. Toxicants can therefore enter and accumulate in the space.
5. Toxic gases such as phosgene or carbon monoxide have poor warning properties. Carbon monoxide, hydrogen cyanide, hydrogen sulphide, arsine, chlorine and oxides of nitrogen and ammonia are dangerous in a confined space. Toxic gases may be evolved when acids are used to clean the interior of a confined space. For example, hydrochloric acid can react chemically with iron sulphide to produce hydrogen sulphide which, being heavier than air, settles down at the bottom of the space.

Hydrogen sulphide is extremely toxic and exposure can cause paralysis of the olfactory system (making the victim unable to smell the gas), loss of reasoning, respiratory failure, unconsciousness and death.

2.5 Solvents

Hydrocarbon solvents are frequently used in industry as degreasing agents and can cause unconsciousness by depressing the central nervous system. Certain chlorinated or fluorinated hydrocarbon solvents are toxic to the heart.

2.6 Physical Hazards

The nature of confined-space work may make it difficult to separate the worker from hazardous forms of energy such as powered machinery, electrical energy, and chemical, hydraulic and pneumatic lines.

Examples of physical hazards often encountered in a confined space include the following:

1. Activation of electrical or mechanical equipment can cause injury to workers in a confined space. Therefore, it is essential to de-energise and lockout all electrical circuits and physically disconnect mechanical equipment prior to any work.
2. Releasing the material through lines, which are an integral part of the confined space, poses a life-threatening hazard. All lines should be physically disconnected, blanked off or should use a double block and bleed system.
3. Falling objects can pose a hazard in confined spaces, particularly in places which have topside openings for entry through which tools and other objects may fall and strike a worker.
4. Extremely hot or cold temperatures can make work inside a confined space hazardous. If a confined space has been steam cleaned, for example, it should be allowed to cool before any entry is made.
5. Wet or slick surfaces can cause falls in confined spaces. In addition, wet surfaces can provide a grounding path and increase the hazard of electrocution in areas where electrical equipment, circuits and tools are used.
6. Noise within confined spaces can be amplified because of the design and acoustic properties of the space. Excessive noise is not only harmful to the worker's hearing but can also affect communication and cause shouted warnings to go unheard.

3 Prevention

The worker who is required to enter and work in a confined space may be exposed to a number of hazards. Therefore it is essential to develop and implement a comprehensive, written confined-space-entry programme, for which the following elements are recommended:

1. Identification of all confined spaces at the facility and/or operation.
2. Posting a warning sign at the entrance of all confined spaces.
3. Evaluation of hazards associated with each type of confined space.
4. A job safety analysis for each task to be performed in the confined space.
5. Confined-space-entry procedures.
6. Initial plan for entry.
7. Assigned standby person(s).
8. Communications between workers inside and standby.

4 Rescue Procedures

Specified work procedures within the confined space include:

1. Evaluation to determine if entry is necessary—can the work be performed from the outside of the confined space.
2. Issuance of a confined-space-entry permit—this is an authorisation and approval in writing that specifies the location and type of work to be done, and certifies that the space has been

evaluated and tested by a qualified person and that all necessary protective measures have been taken to ensure the safety of the worker.

3. Testing and monitoring the air quality in the confined space to ensure the:
   (a) oxygen level is at least 19.5% by volume
   (b) flammable range is less than 10% of the LFL (lower flammable limit)
   (c) absence of all toxic air contaminants.

4.1 Confined-Space Preparation

1. Isolation/lockout/tag-out
2. Purging and ventilation
3. Cleaning processes
4. Requirements for special equipment and tools.

4.2 Safety Equipment and Protective Clothing for Confined-Space Entry

1. Head, hand, foot and body protection
2. Hearing and respiratory protection
3. Safety belts, lifelines, harness
4. Mechanical-lift device—tripod.

4.3 Training of Workers and Supervisors

Workers and supervisors must be trained in the selection and use of

1. Safe entry procedures
2. Respiratory protection
3. Lifelines and retrieval systems
4. Protecting clothing
5. Training of employees in confined-space rescue procedures
6. Conducting safety meetings to discuss confined-space safety
7. Availability and use of proper ventilation equipment
8. Monitoring the air quality while the workers are in the space.

4.4 Recommendations for Confined-Space-Entry and Hot-Work-Permit

1. Although a confined space may initially have good air quality, any subsequent 'welding, brazing, and thermal cutting' in this space can cause a rapid build up of toxic air contaminants, a displacement of oxygen by an inert or asphyxiating gas or an excess of oxygen that might explode. Only through careful preparation can a worker be assured of safety within a confined space for carrying out a hot job.
2. Before workers enter a tank, reaction vessel, ship compartment or any other such confined space for performing any type of hot work, a permit entry procedure must be set up. Authorisation to permit entry and carry out hot work in should be assigned to a qualified person and access should be permitted only when all necessary precautionary measures have been taken to protect workers.

4.5 Precautions to be Taken Before Permission Is Given

1. All pipes, ducts and power lines connected to the space but not necessary to the operation must be disconnected or shut off. All shut-off valves and switches must be tagged and secured with a safety lockout device.
2. Continuous mechanical ventilation must be provided when welding or thermal cutting is conducted in confined spaces. ***Oxygen is generally not used for the purpose of ventilation.***
3. Initial air monitoring must be performed to determine the presence of flammable or explosive materials and toxic chemicals and also to determine if there is sufficient or excessive oxygen. Depending on the monitoring results and the adequacy of the mechanical ventilation, continuous monitoring may be necessary to hot work. Entry should be prohibited when tests indicate flammable concentrations greater than 10% of the lower flammable limit.
4. Gas cylinders and power sources for welding processes must be located in a secure position outside the space.
5. A designated worker must be stationed outside the confined workspace to maintain visual and voice contact and to assist or rescue the entering worker as and when necessary. The designated worker must be equipped with the appropriate protective gear and remain in the designated position for the full duration of time that any worker is within the enclosed space.
6. The worker entering the confined space must be outfitted with a safety harness, a lifeline and appropriate personal protective clothing and equipment, including a respirator. The lifeline must be attached so that the welder's body cannot get jammed in a small exit opening.
7. When not in use, torches and other gas or oxygen supplying equipment must be removed from the confined space. (Lamps should be of less than 24 volts.)
8. All welders and persons supporting them shall be trained in following areas:

- emergency entry and procedures;
- use of applicable respirators;
- first-aid;
- lockout procedures;
- use of safety equipment;
- rescue-operation procedures;
- permit-to-work system, and
- good and safe work-practices.

9. The type of respirator required depends on the concentration of oxygen and the contaminants that might be generated. Respirator requirements may range from none to a self-contained breathing apparatus with a full face-piece operated in pressure-demand or positive-pressure mode.

Even though continuous mechanical ventilation is required during welding processes in confined spaces, initial and continuous environmental monitoring is extremely important. Equipment used for monitoring of fumes and gases should be explosion-proof and continuous monitoring equipment should have an audible alarm or danger-signalling device to alert workers when a hazardous situation develops.

10. Oxygen deficiencies are of particular concern when welding in confined spaces. The normal 21% concentration of oxygen in air may be decreased in confined spaces by chemical or biological processes. When oxygen concentrations fall below 16.8% by volume, a worker may have difficulty remaining alert. Whenever the oxygen content falls below 19.5%, appropriate respirators must be used.

CHAPTER VII

SAFEGUARDING AGAINST COMMON POTENTIAL HAZARDS

Trips, Slips and Falls[48]

1 Introduction

Falls and slips from elevations, inclusive of those into a pit, or on the same level occur in all industries, in all occupations and in all work settings, from the ironworker connecting steel columns 200 feet in the air, to the labourer washing windows from a suspended scaffold 60 feet from the ground to the stock clerk retrieving goods from a shelf using a 4-foot stepladder.

One of the more serious and potentially deadly hazards are falls from elevations. However, falls and slips on the same level are equally injurious though not equally severe to result in fatality. Fall-prevention measures can be general, varied, specific or elaborate and the recognition, planning and implementation of a sound fall-prevention programme is the first step in reducing falls in the workplace. When fall hazards are recognised, provisions to reduce the hazards can be developed, implemented and reinforced on a timely basis to prevent deaths and injuries.

For the purpose of this section, falls from ladders, and scaffolding or from buildings or other structures and falls from one level to another will be discussed.

The management of a company can develop, implement and enforce a comprehensive, written fall-protection programme. The programme should include, but not be limited to, the following points.

1. Addressing all the aspects of safety and hazards in the planning phase of projects.
2. Identifying all fall hazards at the work-site.

3. Training employees in the recognition and avoidance of unsafe conditions and the regulations to control or eliminate the hazards applicable to their work environment. Fall-protection training is recommended to include classroom instruction supplemented by hands-on training with equipment. Training should commence at the time of appointment of new employees who will be exposed to fall hazards and continue periodically thereafter. Workers can be involved in identifying tasks that create fall hazards and methods used to eliminate these hazards. Employee participation and acceptance is crucial to implementing an effective fall-protection programme, as is true for all training programmes.
4. A job hazard analysis for each task to be performed.
5. Providing appropriate fall-protection equipment, training workers on its proper use, enforcing its use under strict supervision and conducting a daily inspection.
6. Conducting scheduled and unscheduled safety inspections of the worksite.
7. Addressing:
   (a) environmental conditions,
   (b) multi-lingual differences and
   (c) alternative methods/equipment to perform assigned tasks.
8. Establishment of medical and rescue programmes.
9. Encouraging workers to actively participate in workplace safety.

Fall protection equipment is very specific in its application, and great care should be taken in choosing the correct system for the application intended in accordance with industry standards or guidelines on specific worker needs. The manufacturer's instructions for correct use and maintenance have to be followed explicitly or injuries and fatalities can result. Compatibility of a fall-protection system's components is crucial. It should be realised that not all components are interchangeable.

OSHA regulations require employers to provide workers who are exposed to fall hazards of over 6 feet (in India over 10 feet (3 metres)) with adequate fall protection, which may involve the installation of either fall-prevention systems or personal fall-arrest systems.

2 Fall-Protection Programme

2.1 Ladders

Safety features that have been provided in some ladders are slip-resistant rungs or steps, positioning feet that fully articulate and top and bottom stabilisers. Fixed ladders typically have a glide-rail system through the middle that egresses while using a full body harness with a glide lock attached to a chest D-ring. Other fixed ladders have caging systems which are a less effective tool for fall protection. Some important factors to be considered before using or climbing a ladder are placement, securing or tying, climbing and descending style, angle of inclination, three-point contact and tasks to be performed.

Factors that contribute to falls from ladders are ladder slips (from top or bottom), overreaching, slipping on rungs or steps, defective equipment and improper ladder selection for a given task.

Every worker should be knowledgeable of the following when using ladders.

Prior to using a ladder, workers should visually inspect it for structural damage, such as split/bent side rails, broken or missing rungs/steps/cleats, missing or damaged safety devices, such as rung locks, lock spreaders or safety shoes/feet/spurs/spikes, grease, dirt, or other contaminants that could cause slips or falls and paint or stickers (except warning labels) that could hide possible defects.

Damaged ladders should be: tagged or marked for repair, replacement or destruction.

2.2 Climbing Guidelines

1. Wear slip-resistant footwear.
2. Keep the area around the top and bottom of the ladder clear.
3. Wear approved fall-protection equipment where applicable.
4. Never carry large objects while ascending or descending a ladder. Use a hoist or pulley mechanism to move heavy, large/awkward objects up to the working level or down to the ground.
5. Keep both hands free for climbing or coming down.
6. Face the ladder and maintain three-point contact (two hands and one foot or one hand two feet on the ladder) at all times.
7. Do not load ladders beyond the maximum intended load for which they were built, nor beyond the manufacturer's rated capacity. Use ladders only for the purpose for which they were designed.

"I'm holding the ladder for Bill. What are you doing?"

2.3 Portable Ladders

Classification: (1) self-supporting (step ladders) and
(2) Non-self-supporting (straight or extension ladders).

Important factors in choosing between the two is the bottom (working surface) and top support conditions.

2.4 Fixed Ladders

1. Should be used at a pitch no greater than 90° from the horizontal, as measured to the rear of the ladder.
2. Each step or rung should be capable of supporting a single concentrated load of at least 250 lb. (114 kg) applied in the middle of the step or rung.
3. The rungs or steps of fixed metal ladders should be corrugated, knurled, dimpled, coated with skid-resistant material.
4. Cages, wells, ladder-safety devices or self-retracting lifelines should be provided to fixed ladders, where the length of climb the equals or exceeds 24 ft. (8 m).

2.5 Scaffolds

Every worker should be knowledgeable of the following when using scaffolds.

1. The footing or anchorage for scaffolds should be sound, rigid and capable of carrying the maximum intended load without settling or displacement. Unstable objects, such as barrels, boxes, loose bricks or concrete blocks, should not be used to support scaffolds or planks.
2. No scaffold should be erected, moved, dismantled or altered except under the supervision of a competent person.
3. Guard-rails (2 by 4 inches, 42 inches high) and toe-boards (minimum 4 inches in height) should be installed on all open sides and ends of platforms more than 10 feet above the ground or floor except on needle-beam scaffolds and floats. Supports should be at intervals not exceeding 8 feet.
4. Scaffolds and their components should be capable of supporting, without failure, at least four times the maximum intended load.
5. Damaged or weakened accessories such as braces, brackets, trusses, screw legs, ladders etc. should be immediately repaired or replaced.
6. All scaffold platforms should be tightly planked with scaffold plank grade.
7. A competent person should initially inspect the scaffolding and, at designated intervals, re-inspect the scaffolding inclusive of components and accessories.
8. Suspension-scaffold rigging should be inspected periodically and the synthetic rope used should be protected from heat-producing sources.
9. Employees should be trained in using diagonal braces for climbing scaffolds.

2.6 Falls from Buildings or Other Structures (Inclusive of Roofs)

1. Designers of buildings, such as multi-tiered steel-framed structures should provide anchorage systems in the overall design of the structure.
2. Designers of tanks should incorporate anchorage points for securing scaffolds, lifelines and toe boards.
3. Permanent structural members are to be provided across the length and at the apex of the roof of large industrial activity sheds for anchorage of lifeline.
4. A competent person should evaluate potential tie-off anchorage points and determine if the available safety equipment (e.g., crawling board or safety belt) can work as designed. If not, to find what equipment suits the design.
5. A competent person should routinely inspect all protective devices (e.g., guard-rails, lifelines etc.).
6. Plant/facility owners/operators should identify areas that are hazardous to all and restrict or prohibit the use of, or access to, these areas.

2.7 Install Adequate Guarding and/or Fall Protection to or on

The following must be provided with guards and/or fall protection.

1. Roof openings,
2. Floor openings,
3. Skylights,
4. Fragile roof (e.g., A.C. sheet).

2.8 Falls and/or Slips on the Same Level

Slipping and tripping are the most common hazards for falls on the same level.

1. Maintenance of adequate and proper norms of *good housekeeping* is essential in preventing falls and slips on the same level.
2. Hazards include obstructions on the floor in the workplace or roads and outside ground. So also in the aisle, blind corners and intersections.
3. Regular cleaning and the clearing off of loose materials, grease, oil, dirt, sand particles, chemical and/or water accumulation or other contaminants is a must.
4. Work floors, passageways, aisles and areas around the workplace should be made and maintained with non-skid material.
5. Use of slip-resistant footwear should be encouraged and enforced.
6. Wet and/or oily floors are hazardous. Oil on the floor, when noticed, should be reported and wiped off after spreading sawdust.
7. Round-the-clock repair of floor cracks, floor joints, ditches, crumbling edges and other operating surfaces should add to the smooth manual handling of material and prevent falls on the same level.
8. The laid down procedure for manual handling should be strictly observed. Under no circumstances is a material, which is heavier than specified or large in volume or size, which requires help of others ever be carried by a single individual. This may imbalance him and cause a fall.
9. Ensure that workplace and surrounding area safety inspections are conducted at specified intervals by a competent person who can identify slipping and tripping hazards and conditions that are dangerous.
10. The person who conducts the inspections should have the authority to implement prompt corrective measures.
11. Identify and recognise factors that contribute to slips and falls in a section from information about housekeeping policies and practices, management style and behaviour and employees accountability for housekeeping and in effect safety.
12. Select recommendations likely to improve housekeeping and safety for a given section involving the factors mentioned above.

The McGraw-Hill Companies

SAFEGUARDING AGAINST COMMON POTENTIAL HAZARDS

Preventing Electrocution[50]

1 Electrical Hazards

1.1 Introduction

Electricity is an ubiquitous energy agent to which many workers in different occupations and industries are exposed daily. Many workers know that the principal danger from electricity is that of electrocution, but few really understand just how minute a quantity of electrical energy is required for electrocution. In reality, the current drawn by a tiny 7.5 watt, 120-volt lamp, passed from hand to hand or hand to foot across the chest is sufficient to cause electrocution.[11]

The number of people who believe that normal household current is not lethal or that power-lines are insulated and do not pose a hazard is alarming.

Electrocutions may result from contact with an object as seemingly innocuous as a broken light bulb or as lethal as an overhead power-line, and have affected workers since the first electrical fatality was recorded in France in 1879 when a stage carpenter was killed by an alternating current of 250 volts.

The information in the following two sections, namely 'Definitions' and 'Effects of Electrical Energy' is intended as a basic explanation of electricity and the effects of electrical energy. Unless otherwise indicated, information in these sections is derived from OSHA electrical standards,[62] the National Electrical Code (NEC),[40] and the National Electrical Safety Code.[39] Official definitions of electrical terms can be found in these same documents.

1.2 Definitions

- *Electricity* is the flow of an atom's electrons through a conductor.
- *Electrons* are the outer particles of an atom; they contain a negative charge.

- *Negatively charged* objects are those on which electrons are collected.
- *Electric current* is the *flow of electrons* from an object through a conductor.

The primary terms used in discussing electricity are:

- *Voltage:* The fundamental force or pressure that causes electricity to flow through a conductor and is measured in **Volts**.
- *Resistance:* Anything that impedes the flow of electricity through a conductor and is measured in **Ohms**.
- *Current:* The flow of electrons from a source of voltage through a conductor and is measured in **amperes (Amps)**.
- *Ground:* A conducting connection, whether or not unintentional, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.
- *Alternating current (AC)*: The current that flows back and forth (a cycle) through a conductor. In each cycle the electrons flow first in one direction, then the other. The normal rate is 60 cycles per second [or 60 Hertz (Hz)] at 120/220/240 volts. In India, it is normally at 240 V.
- *Direct current (DC):* The current which flows in one direction only (e.g., as in a car battery).
- *Electricity arc:* Flow of electrons through a gas, such as air.

AC is most widely used because it is possible to *step up* or *step down* (i.e., increase or decrease) *the current through a transformer*. For example, when current from an overhead power-line is run through a pole-mounted transformer, it can be stepped down to normal household current.

Ohm's Law: Current = Voltage/Resistance
i.e. Amperes = Volts/Ohms

1.3 Hazardous Effects of Electrical Energy

1. Electrical injuries consist of four main types—electrocution (fatal), electric shock, burns and falls caused as a result of contact with electrical energy.
2. Electrocution results when a human is exposed to a lethal amount of electrical energy.
3. To determine how contact with an electrical source occurs, characteristics of the electrical source before the time of the incident must be evaluated (pre-event).
4. For death to occur, the human body must become part of an active electrical circuit having a current capable of over-stimulating the nervous system or causing damage to internal organs.
5. The extent of injuries received depends on the current's magnitude (measured in Amps), the pathway of the current through the body, and the duration of current flow through the body (event). The resulting damage to the human body and the available emergency medical treatment ultimately determine the outcome of the energy exchange (post-event).
6. Electrical injuries may occur in various ways—direct contact with electrical energy, injuries that occur when electricity arcs to a victim at ground potential (supplying an alternative path to

ground), flash burns from the heat generated by an electrical arc, and flame burns from the ignition of clothing or other combustible, non-electrical materials.

7. Direct contact and arcing injuries produce similar effects. Arcing to the skin can cause burns at the point of contact with electrical energy, heating at the point of contact by a high-resistance contact or higher voltage currents. Contact with a source of electrical energy can cause external as well as internal burns.
8. Exposure to higher voltages will normally result in burns at the sites where the electrical current enters and exits the human body. High voltage contact burns may display only small superficial injury; however, the danger of these deep burns destroying subcutaneous tissue exists.
9. Additionally, internal blood vessels may clot, nerves in the area of the contact point may be damaged, and muscle contractions may cause skeletal fractures either directly or in association with falls from elevation.
10. It is also possible to have a low-voltage electrocution without visible marks to the body of the victim. Flash burns and flame burns are actually thermal burns. In these situations, electrical current does not flow through the victim and injuries are often confined to the skin.
11. Contact with electrical current could cause a muscular contraction or a startle reaction that could be hazardous if it leads to a fall from elevation (ladder, aerial bucket, etc.) or contact with dangerous equipment.

1.4 High Voltage

The NEC describes high voltage as greater than 600 volts AC[4]

Most utilisation circuits and equipment operate at voltages lower than 600 volts, including common household circuits (110/120/240 volts), most overhead lighting systems used in industry or office buildings and department stores, and much of the electrical machinery used in industry, such as conveyor systems and manufacturing machinery such as weaving machines, paper rolling machines or industrial pumps.

Voltages over 600 volts can rupture human skin, greatly reducing the resistance of the human body, allowing more current to flow and cause greater damage to internal organs. The most common high voltages are transmission voltages (typically over 13,800 volts) and distribution voltages (typically under 13,800 volts). The latter are the voltages transferred from the power generation plants to homes, offices, and manufacturing plants.

High-voltage electrical energy quickly breaks down human skin, reducing the human body's resistance to 500 Ohms. Once the skin is punctured, the lowered resistance results in massive current flow. Again, Ohm's law is used to demonstrate the action.

"Thanks for not telling anyone I was fooling around with the fuse box. What did you say your name was?"

Table 1 Estimated effects of 60 Hz AC currents.

Current	Effect
1 mA	Barely perceptible
16 mA	Maximum current an average man can grasp and "let go"
20 mA	Paralysis of respiratory muscles
100 mA	Ventricular fibrillation threshold
2 Amps	Cardiac standstill and internal organ damage
5/20 Amps	Fatal*

*As a frame of reference, a common household circuit breaker may be rated at 15, 20, or 30 Amps.

(For example, at 1,000 volts, Current = Volts/Ohms = 1000/500 = 2 Amps, which can cause cardiac standstill and serious damage to internal organs.)

Standard utilisation voltages produce currents passing through a human body in the milliampere (mA) range (1,000 mA = 1 Amp). Estimated effects of 60 Hz AC currents, when passed through the chest, are shown in Table 1.

When current greater than the 16 mA (let go current) passes through the forearm, it stimulates involuntary contraction of both flexor and extensor muscles. When the stronger flexors dominate, victims may be unable to release the energised object they have grasped as long as the current flows. If current exceeding 20 mA continues to pass through the chest for an extended time, death could occur from respiratory paralysis.

Currents of 100 mA or more, up to 2 Amps, may cause ventricular fibrillation, probably the most common cause of death from electric shock. Ventricular fibrillation is the uneven pumping of the heart due to the uncoordinated, asynchronous contraction of the ventricular muscle fibres of the heart that leads quickly to death from lack of oxygen to the brain. Ventricular fibrillation is terminated by the use of a defibrillator, which provides a pulse shock to the chest to restore the heart rhythm. Cardiopulmonary resuscitation (CPR) is used as a temporary care measure to provide the circulation of some oxygenated blood to the brain until a defibrillator can be used.

The speed with which resuscitative measures are initiated has been found to be critical. Immediate defibrillation is ideal. However, for victims of cardiopulmonary arrest, resuscitation has the greatest rate of success if CPR is initiated within four minutes and advanced cardiac life support is initiated within eight minutes (National Conference on CPR and ECC, 1986).[5]

The presence of moisture from environmental conditions such as standing water, wet clothing, high humidity, or perspiration increases the possibility of a low-voltage electrocution. The level of current passing through the human body is directly related to the resistance of its path through the body. Under dry conditions, the resistance offered by the human body may be as high as 100,000 Ohms.

Wet or broken skin may drop the body's resistance to 1,000 Ohms. The following illustrations of Ohm's law demonstrate how moisture affects low-voltage electrocutions.

Under dry conditions, Current = Volts/Ohms = 120/100,000 = 1 mA
—a barely perceptible level of current

Under wet conditions, Current = Volts/Ohms = 120/1,000 = 120 mA
—sufficient current to cause ventricular fibrillation

Wet conditions are common during low-voltage electrocutions.

2 Standards and Regulations

The Occupational Safety and Health Administration (OSHA) addresses electrical safety in Subpart S 29 CFR 1910.302 through 1910.399 of the General Industry Safety and Health Standards.[62] The standards contain requirements that apply to all electrical installations and utilisation equipment, regardless of when they were designed or installed. Subpart K of 29 CFR 1926.402 through 1926.408 of the OSHA Construction Safety and Health Standards[61] contain installation safety requirements for electrical equipment and installations used to provide electric power and light at the job-site. These sections apply to both temporary and permanent installations used on the job-site.

Additionally, the U.S. National Electrical Code (NEC)[40] and the National Electrical Safety Code (NESC)[39] comprehensively address electrical safety regulations. The purpose of the NEC is the practical safeguarding of persons and property from hazards arising from the use of electricity. The NEC contains provisions considered necessary for safety and applies to the installation of electric conductors and equipment within or on public or private buildings or other structures, including mobile homes, recreational vehicles and floating buildings, and other premises such as yards, carnivals, parking and other lots; and industrial substations.

The NESC contains rules necessary for the practical safeguarding of persons during the installation, operation or maintenance of electric supply and communication lines and associated equipment. These rules contain the basic provisions that are considered necessary for the safety of employees and the public under the specified conditions. Unlike the NEC, the NESC contains work rules in addition to installation requirements.

3 Elements of an Electrical Safety Programme

1. All workers should receive hazard awareness training so that they will be able to identify existing and potential hazards present in their workplaces and relate to the potential seriousness of the injuries associated with each hazard.
2. Based on an analysis of these data, to reduce occupational electrocutions, employers can:
   a. Develop and implement a comprehensive safety programme and revise existing programmes to thoroughly address the area of electrical safety in the workplace.
   b. Ensure compliance with existing regulations.[61]

c. Provide all workers with adequate training in the control of the hazards associated with electrical energy in their workplace.
d. Provide additional specialised electrical safety training to those workers working with or around exposed components of electric circuits. This training should include, but not be limited to, training in basic electrical theory, proper safe-work procedures, hazard awareness and identification, proper use of PPE, proper lockout/tag-out procedures, first aid including CPR and proper rescue procedures. Provisions should be made for periodic retraining as necessary.
e. Develop and implement procedures to control hazardous electrical energy, which include lockout and tag-out procedures and ensure that workers follow these procedures.
f. Provide those workers who work directly with electrical energy with testing or detection equipment that will ensure their safety during performance of their assigned tasks.

Ensure compliance with the National Electrical Code[40] and the National Electrical Safety Code[39]

4 Administrative Norms and Systems

1. Conduct safety meetings at regular intervals.
2. Conduct scheduled and unscheduled safety inspections at work-sites.
3. Actively encourage all workers to participate in workplace safety.
4. In a construction setting, conduct a job-site survey before starting any work to identify any electrical hazards, implement appropriate control measures, and provide training to employees specific to all identified hazards.
5. Ensure that proper personal protective equipment is available and worn by workers where required (including fall protection equipment).
6. Conduct job hazard analyses of all tasks that might expose workers to the hazards associated with electrical energy and implement control measures that will adequately insulate and isolate workers from electrical energy.
7. Identify potential electrical hazards and appropriate safety interventions during the planning phase of construction or maintenance projects. This planning should address the project from start to finish to ensure workers have the safest possible work environment.

The data, collected by NIOSH, indicate that although many companies had comprehensive safety programmes, in many cases they were not completely implemented. This underscores the need for increased management and worker understanding, awareness and ability to identify the hazards associated with working on or in proximity to electrical energy. It is the responsibility of the management to provide a safe workplace for their workers and to develop and implement a comprehensive safety programme.

5 Portable Electrical Tools

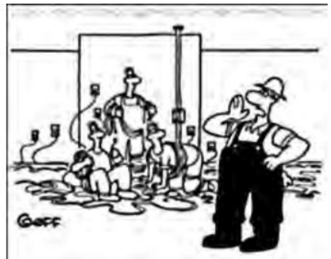
Portable electrical powered tools like electrical saws, drills, grinders, nut bolts and screwdrivers, polishers etc. are commonly used in our companies.

Although cases of permanent disability while handling portable electrical tools are relatively fewer when compared to those caused by stationary ones, the total number of accidents are very high.

Typical injuries inflicted by portable tools are electric shock, burns, sprains, eye injury and other injuries on account of falling of tools, fire, explosion of vapour or gases and falls from height. Each tool has certain specific hazards in addition to the hazards common to all portable tools. Indiscriminate use, lack of training and ignorance of hazards increase the chances of injury.

5.1 Electrical Hazards

Accidents while using portable electrical tools are caused due to the following reasons:



"Okay! Turn on the electricity!"

1. When bare live conductors are exposed and come in contact with damaged enclosure.
2. Insulation failures causing leakage of current make the metal works live if the equipment is not earthed properly.
3. If the earth wire is detached from the plug terminal because of loose or ineffective cord grip and comes in contact with the live terminal, the metal work of the apparatus can become live.
4. Metal work becoming live as a result of wrong electrical connections.
5. Damaged flexible cables used with the apparatus.
6. Badly made joints in flexible cables which lose their insulation or pull apart when strained.
7. Servicing tools without disconnecting them from the power supply.
8. Unauthorised repairs carried out by the operator or his associates.
9. Electrical leakage in damp or wet location increases the electrical shock hazard. Perspiration on the workman will lower his body resistance and hence permit a higher current through the body increasing the resulting injury. Usually, the operator is unable to release his grip on the electrical tool and gets a shock increasing the severity of the injury.

5.2 Mechanical Hazards

1. Particles flying from grinding wheels or drills can fall in operator's eyes. This can sometimes blind the person.
2. While working at heights with portable electrical tools, the chances of the tool falling and injuring people standing below or the operators themselves falling from a height are high.
3. The equipment connecting the electrical cable with the power supply, if left on the floor, may cause up passers-to trip, causing nasty injuries.

5.3 Fire Hazards

1. The heat and sparks generated from the tools can at times ignite combustible material nearby.

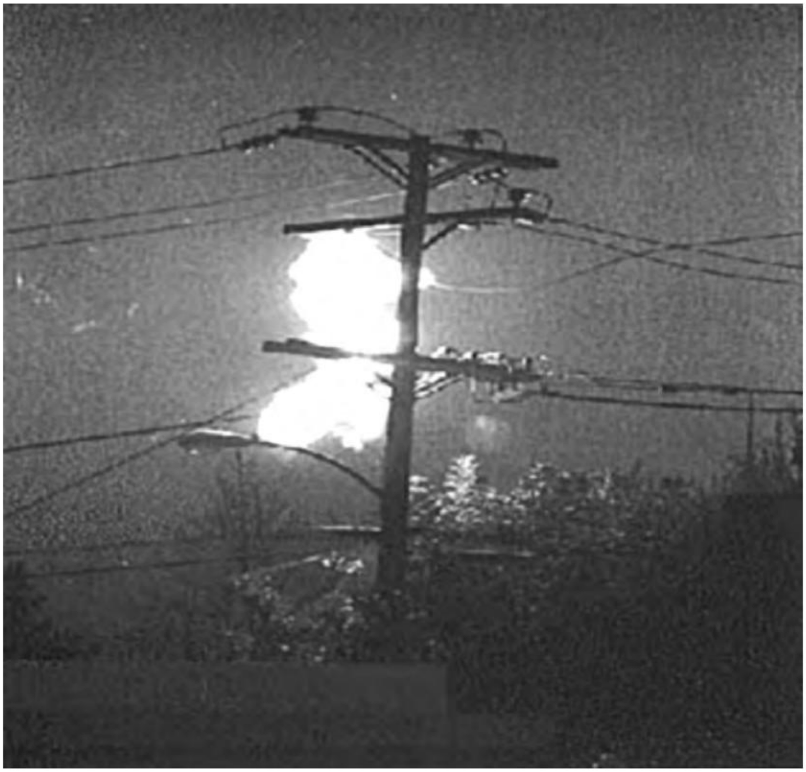


Figure 7-1 An operator is electrocuted while working on a High Tension line.

2. Work with portable tools should not be carried out in areas where hazardous gases are likely to be present. This is because the sparks and heat generated by the tools could cause an explosion and fire.
3. Overloading and short circuits in the electrical supply system of the portable electrical tools can give rise to heat and sparks resulting in fire when combustible materials are present in the vicinity.

5.4 Key Safety Measures for Power Tools

1. Select the right tools for the right job.
2. Train the worker to use tool correctly.
3. Keep tools in good condition.
4. Store tools in a safe place.
5. Ensure use of proper personal protective equipment.
6. Earth tools properly.
7. Use double insulated tools.
8. Use safety guards provided on tools.

Always use personal protective equipment.

SAFEGUARDING AGAINST COMMON POTENTIAL HAZARDS

Static Electricity


"Today we're going to talk about fall protection"

Static electricity ('static' as termed in short) has been blamed for many fires and explosions. Sometimes, however, if the investigator has failed to find any other source of ignition, he assumes that it must have been static even though he is unable to show precisely how a static charge could have been formed and discharged.[10]

A static charge is formed whenever two surfaces are in relative motion, for example, when a liquid flows past the walls of a pipeline, when liquid droplets or solid particles move through the air or when a man walks, gets up from a seat or removes an article of clothing. One charge is formed on one surface—for example, the pipe wall—and an equal and opposite charge on the other surface—for example, the liquid flowing past it.

Many static charges flow rapidly to earth as soon as they are formed. But if a charge is formed on a non-conductor or on a conductor, which is not grounded, they can remain there for some time. If the level of the charge, the voltage, is high enough the static will discharge by means of a spark, which can ignite any flammable vapours that may be present. Examples of non-conductors are plastics, rubbers and non-conducting liquids such as most pure hydrocarbons. Most liquids containing oxygen atoms in the molecule are good conductors.

Even if a static spark ignites a mixture of flammable vapour and air, it is not really correct to say that static electricity was the 'cause' of the fire or explosion. The real cause was the leak or whatever event led to the formation of a flammable mixture. Once flammable mixtures are formed, experience shows that sources of ignition are likely to turn up. The deliberate formation of flammable mixtures should never be allowed except when the risk of ignition is accepted—for example, in the vapour space of fixed roof tanks containing flammable non-hydrocarbons.

The terms 'bonding' and 'grounding' or 'earthing' often have been used interchangeably because of poor understanding of the terms. Bonding is done to eliminate a difference in potential static charges generated *between objects*. The purpose of grounding is to eliminate a difference in potential *between an object and ground (earth)*. Bonding and grounding are effective only when the bonded objects are conductive. Although bonding will eliminate a difference in potential of the objects that are bonded, it will not eliminate the difference in potential between these objects and the earth unless one of the objects possesses an adequate conductive path to the earth. Therefore bonding will not eliminate the static charge, but equalise the potential between the objects bonded so that a *spark will not occur between them.*

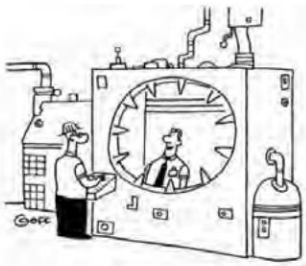
An adequate ground will always discharge a charged conductive body and is recommended as a safety measure. To prevent a spark from the discharge of static electricity during filling operations, a wire bond should be provided between the storage container and the container being filled. In addition, the bonding wire or one of the containers should be grounded.

When loading or unloading tank cars through open domes or storage tanks, it is advisable to use a downspout long enough to reach the tank bottom. Non-insulated wires should preferably ground above ground tanks used for flammable and corrosive liquids. Dipping an earth-rod down to the inside-bottom should also ground the contents in the storage tanks which are lined from inside—for example, a rubber-lined m.s. tank, used for storing hydrochloric acid. Otherwise a static charge may build up at the surface of the liquid in the container. The charge accumulates because static cannot flow through the liquid to the grounded metal. If this accumulated charge builds up high enough, a static spark with sufficient energy to ignite a flammable air-vapour mixture can occur.

The case history 7, in the 'Illustrated Case Histories' describes an explosion in an m.s. rubber-lined storage tank containing hydrochloric acid. The static was formed by the flow of a non-conducting liquid and the spark discharges occurred between the body of the liquid and the grounded metal container.

SAFEGUARDING AGAINST COMMON POTENTIAL HAZARDS

Hazardous Energy Control



1 Prevention

1.1 NIOSH recommends that employers implement the following steps to prevent injuries and deaths of workers who must work with hazardous energy in their jobs:

1. Comply with statutory regulations. (The Factories Act, 1948 and State Factories Rules, 1963.[28])
2. Employers should develop and implement a written hazardous energy control programme that, at a minimum,
   - Describes safe work procedures,
   - Establishes formal lockout/tag-out procedures,
   - Trains all the employees in the programme,
   - Enforces the use of the procedures, and
   - Takes disciplinary action for reckless indifference to the safety of self and others.
3. Hazardous energy control programmes should outline the following Safe work practices:
   - Identify tasks that may expose workers to hazardous energy.
   - Identify and de-energise *all* hazardous sources, including those in adjacent equipment.
   - Lockout and tag-out *all* energy-isolating devices to prevent inadvertent or unauthorised reactivation or start-up.
   - Isolate, block and/or dissipate *all* hazardous sources of stored or residual energy, including those in adjacent equipment.
   - Before beginning to work, verify energy isolation and de-energisation, including that in adjacent equipment or energy sources.
   - After work is complete, verify that *all* personnel are clear of danger points before re-energising the system.

4. Hazardous energy control among work groups must be co-ordinated when multiple employers are involved in large projects and when shift changes occur during such activities. Outside contractors should work with the facility owner to make sure that an adequate hazardous energy control programme is implemented specifically for contract workers.
5. Employers should use job-site surveys to ensure that *all* hazardous energy sources (including those in adjacent equipment) are identified before beginning *any* installation, maintenance, service or repair task. Hazardous energy includes mechanical motion, potential or stored energy, electrical energy, thermal energy, and chemical reactions. Energy-isolating devices such as breaker panels and control valves should be clearly labelled.
6. All forms of hazardous energy should be de-energised, isolated, blocked and/or dissipated before workers begin any installation, maintenance, and service or repair wok. The method of energy control depends on the form of energy involved and the available means to control it.

'Energy is considered to be isolated or blocked when its flow or use cannot occur.'

1.2 The following steps can be taken to isolate or block energy:
1. Disconnect or shut down engines or motors that power mechanical systems.
2. De-energise electrical circuits by disconnecting power source from the circuit.
3. Block fluid (gas, liquid or vapour) flow in hydraulic, pneumatic or steam systems by using control valves by clapping or blanking (slip-plate) the lines.
4. Block machine parts against motion that might result from gravity (falling).
5. Some forms of energy must also be dissipated after a system has been de-energised. System components such as electrical capacitors, hydraulic accumulators or air reservoirs may retain sufficient energy to cause serious injury or death—even though the component has been de-energised, isolated or blocked from the system and locked out.

1.3 The following steps can dissipate energy:
1. Vent fluids from pressure vessels, tanks or accumulators until internal pressure is at atmospheric levels. However, do not vent vessels or tanks containing toxic, flammable or explosive substances directly to the atmosphere.
2. Discharge capacitors by grounding.
3. Release or block springs that are under tension or compression.
4. Dissipate inertial forces by allowing the system to come to a complete halt after the machine or equipment has been shut down and isolated from its energy sources.

1.4 Lockout/Tag-out Programmes

Lockout/tag-out programmes should be based on the principle of *only one for each lock-the worker controls*. (Master keys should be reserved and preserved only under managerial control, for emergency or on misplacement of one under regular use.) This applies to the following:

1. Workers are assigned individual locks operable by only one key for use in securing energy control devices—breaker panels, control valves, manual override switches etc.
2. Each worker maintains custody of the key for each of his assigned locks.

3. Each lock is labelled with a durable tag, or other means, identifying its owner.
4. When more than one worker is working, each worker issues and deposits the key from and with the supervisor, who maintains a register ensuring that the worker signs both times and remains responsible.
5. All de-energised circuits and systems are clearly labelled with durable tags.
6. The worker who opens a lock is the one who locks it after all work has been completed. If the work is not complete when the shift changes, he signs in the register depositing the key and the next shift worker signs issue of the key for continuation of the work.
7. Because tags can be easily removed, they are not a substitute for locks. Workers are safest with a programme that uses *both* locks and warning tags to prevent systems from being inadvertently re-energised.
8. Verify that all energy sources are de-energised before work begins.

"And another thing -- be sure to not turn on machinery while I'm repairing it."

2 Hazardous Energy Control Programme Plus Confined-space Programme

When work requires entry into confined spaces such as utility vaults or tanks, the hazardous energy control programme should be incorporated as a part of the confined-space entry programme, as explained in section 13 on confined-space hazards.

3 Design Machines and Systems for Easy Control of Hazardous Energy

Employers should encourage manufacturers to design control valves, switches and equipment that are easy to access and lockout.

CHAPTER VIII

SPECIFIC HAZARD CONTROL MEASURES

Forklift Hazard Control

1 Introduction

Reducing the risk of forklift incidents requires a safe work environment, a safe forklift, comprehensive worker training, safe work practices and systematic traffic management.

NIOSH recommends that both the employers and the employees comply with regulations and consensus standards, maintain equipment, and take the following measures to prevent injury when operating or working near forklifts.

2 Employers/Management

2.1 Employee/Worker Training

1. Develop, implement and enforce a comprehensive written safety programme that includes worker training, operator licensure, and a timetable for reviewing and revising the programme. A comprehensive training programme is important for preventing injury and death. Operator training should address factors that affect the stability of a forklift—such as the weight and symmetry of the load, the speed at which the forklift is travelling, operating surface, tyre pressure and driving skill and behaviour.
2. Inform the operators that the overhead guard or another part of the forklift can crush them after jumping from an overturning forklift. The operator should stay with the truck if lateral or longitudinal tip-over occurs. The operator should hold on firmly and lean away from the point of impact.

3. Ensure that *operator-restraint-systems* are being used. The risk of being crushed by the overhead guard or another rigid part of the forklift is greatly reduced if the operator remains inside the operator's compartment. Because many forklifts are not equipped with a restraint system and operator compliance is less than 100% on forklifts equipped with a restraint system.
4. Train operators to handle asymmetrical loads when their work includes this activity.

2.2 Forklift Inspection and Maintenance

1. Establish a vehicle inspection and maintenance programme.
2. Retrofit old forklifts with an operator restraint system, if feasible and possible.

2.3 Lifting

1. Ensure that operators use only an approved lifting cage and adhere to general safety practices for elevating personnel with a forklift. Also, secure the platform to the mast or forks.
2. Provide means for personnel on the platform to shut off power to the truck whenever the truck is equipped with vertical only or vertical and horizontal controls for lifting personnel.

2.4 Workers on Foot

1. Separate forklift traffic and others where possible.
2. Limit some aisles to *workers on foot only* or *forklifts only*.
3. Restrict the use of forklifts where (main exits, canteen) and when the flow of workers on foot is at a peak (such as at the shift-end or during breaks).
4. Install physical barriers where practical to ensure that workstations are isolated from isles travelled by forklifts.
5. Provide overhead dome mirrors at the intersections and other blind corners for the visibility of forklift operators and workers on foot.
6. Make every effort to alert workers when a forklift is nearby. Use horns, audible backup alarms and flashing lights to warn workers and other forklift operators in the area. Flashing lights are especially important in areas where the ambient noise level is high and that of light is low.

2.5 Work Environment

1. Ensure that workplace safety inspections are routinely conducted for identifying hazards (blind corners, intersections, obstructions in isle etc.) and conditions that are dangerous to workers.
2. Install workstations, control panel and equipment away from the isle. Do not store bins, racks or other materials at corners, intersections and other locations that obstruct the view of operators or workers at workstations.
3. Enforce safe driving practices such as obeying speed limits, stopping at stop signs and slowing down and blowing the horn at intersections.
4. Repair and maintain cracks, crumbling edges and other defects on loading docks, aisles and other operating surfaces.

3 Employees/Workers

1. Use seatbelts if provided.
2. Report to your supervisor any damage or problems with a forklift during your operation.
3. Do not jump from an overturning forklift. Stay with the truck if a lateral or longitudinal tip-over occurs. Hold on firmly and lean in the opposite direction of the overturn.
4. Use extreme caution on grades, ramps or inclines. Normally you should travel only on level surfaces.
5. On all grades, tilt the load back and raise it only as far as needed to clear the road surface.
6. Do not raise or lower the forks while the forklift is moving.
7. Do not handle a load that is heavier than the rated weight capacity of the forklift.
8. Operate the forklift at a speed that will permit it to be stopped safely.
9. Slow down and sound the horn at intersections and other locations where vision is obstructed.
10. Look toward the path of travel and keep a clear view of it.
11. Do not allow passengers to ride on forklift trucks unless a seat is provided.
12. When dismounting from a forklift always set the parking brake, lower the fork or mast and neutralise the controls.
13. Do not drive up to anyone standing in front of a bench or other fixed object.
14. Do not use a forklift to elevate workers who are standing on the forks.
15. Do not elevate a worker on a platform unless the vehicle is directly below the work area.
16. Whenever a truck is used to elevate personnel, secure the elevating platform to the mast or forks of the forklift.
17. Use a restraining means such as rails, chains or a body belt with a lanyard or deceleration device for the person(s) on the platform.
18. Do not drive to another location with the work platform elevated.

If at any time the back of the forklift begins to rise, STOP.

The international standard forklift capacity is 3000 lbs including the weight of pallets or lifting equipment.

4 Load Centre

Load centre is an important concept in forklift operation. The standard forklift is equipped with bronze forks that are 48 inches in length. The load centre is half that distance (24 inches). Wide loads through which the forks do not completely penetrate are subject to instability through a fulcrum lever effect.

Such effects may be intensified for loads that need to be transported up an incline or down a ramp. Tilting the load backwards helps somewhat in this effect. However, forklifts should always be placed in such a manner as to centre the load and to engage the forks through the entire width of the load to be carried. Always drive the forklift backwards while on an incline.

5 Electric Forks

Electrical forklifts have many advantages and disadvantages. There is no exhaust and therefore they are the vehicles of choice for closed indoor work. Fumes from diesel or gas-powered vehicles will rapidly degrade indoor air quality. Electrical forklifts must be routinely recharged. An operator should never begin to use an electrical forklift for a job that does not have at least a ¾ charge on the battery. Further, operators must be aware that heavy loads [greater than 90% of load capacity] will significantly deplete the load charge on the battery in a rapid manner. This is because more work is being done on a heavy load than on a light load.

Topping off batteries must only be done when the battery is disconnected and in an area where there is adequate room for the task. Only qualified [trained] personnel should be permitted to oversee the task of recharging electrical forklifts. Having been certified as a forklift operator does not automatically confer the ability to recharge the forklift.

Inform your supervisor or facility manager if you feel your electrical forklift requires recharging.

6 Checking Controls

- Check that the horn functions.
- Check the steering mechanism with the engine running.
- Check the breaks (not more than ½ inch travel).
- Check the seat brake.
- Check that the clutch disengages the transmission.
- Check the hydraulic controls-lift and tilt levers.

All forklift work begins by going through a mental checklist. After checking tyres, make sure that the horn and warning backup lights perform as specified when the forklift is put in reverse. Check that the forklift steers properly both in the forward and reverse directions. Always check the foot brake to ensure it engages when pressed. The travel on a foot brake should be no more than ½ inch.

Seat brakes are provided on a forklift as a safety device. Only when someone is seated it is possible to operate the forklift. By lifting yourself out of the seat, you should no longer be able to move the forklift either in the forward or backward direction. Some forklifts are equipped with a clutch. This should always be checked to see whether it would disengage the transmission before making a lift.

Operators should test all hydraulic controls before attempting to pick up a load. This includes lift, tilt and horizontal [used for centring a load] hydraulic levers. At the same time, the operator can ensure that all chains move smoothly. All of these actions are required before attempting to lift a load. It does the operator no good to be stuck with an elevated load, which will not move because he or she neglected to test the controls before lifting the load. Operators should not bypass these important checklist items in an effort to save time. They should reschedule or pass on their responsibility.

7 Forklift Safety

- Cages offer protection
- Inspect all items before moving a load
- Check pallets and remove any loose items
- Wear a helmet for additional protection
- Make sure all the loads are secure
- Lower loads to move.

Forklift cages are designed to protect the operator from falling debris or to offer minimal protection during a rollover. Forklifts should be equipped with a seatbelt, which must be used at all times that the operator is in the forklift.

The forklift should also carry a portable fire extinguisher. The most important part of moving a load is to ensure that the load is stable and secure before beginning the task. All items to be lifted by engaging forks must be on a pallet. Pallets are designed to permit the forks to completely engage during the forklift operation.

Damaged pallets should never be used for forklift operations. Further, items on a pallet must be secured. This is normally accomplished by shrink-wrapping the items to be moved. Lifting straps or metal banding are also acceptable ways of securing large items. Before lifting, make sure the pallet is clear of any loose items such as screwdrivers, nails or other items that may have been used to secure the pallet. These unsecured items can act as projectiles during a lift. That is why helmets are recommended for additional protection.

Stability of loads is greatly enhanced by lowering the load before and during forklift movement. The forks should be placed so as not to scrape any low-lying obstacles and the pallet height (including load) must be low enough not to interfere with the forklift driver's vision.

Forklift operators must always be aware of overhead obstacles as well. Electrical power lines are the leading cause of death in forklift operations. On standard design, electrical power is distributed via cable trays. The cable trays are divided to separate high voltage and low voltage (signal) cables. However the height of the cable trays in the facility is only 7 feet. Therefore extreme caution must be used when using the forklift in the experimental hall. Always lower the load to be moved to decrease the possibility of interacting with the cable trays and increasing visibility for the forklift driver.

Always ensure that the designated area for load placement is of adequate square footage and that no individuals would be trapped between the load and other obstacles if the load were to be placed in the designated area.

The standard forklift is equipped with a horn, which sounds continuously while the forklift is moving in the reverse direction.

8 Checking Loads

- Check that the pallet is undamaged
- Check that the load is banded
- Check that the area is clear of people and debris.

Most forklift loads are moved on pallets. Alternately, loads may be lifted via sling onto a single or both forks. When using a sling care should be taken to ensure that the sling is fitted towards the back of the fork (i.e. closest to the forklift frame) to prevent or reduce the risk of sling slippage.

All pallets should be inspected for integrity. Broken or pallets of insufficient mechanical strength should be replaced. Small materials on pallets should be shrink wrapped in place before attempting to move any pallet. Pallet height should also be kept to a minimum in order to increase driver visibility and overall stability. If vision is impaired by the load height, the driver may elect to drive the load backwards.

Also check to make sure the forklift travel path has been cleared of all obstacles and personnel. Remember pedestrians always have the right of way.

9 Stacking

- Take precautions when loading or pulling from a stack
- Do not stack materials too high
- Make sure the area is clear of personnel.

Special precautions are necessary when stacking materials (as in a warehouse). The bottom pallet of the stack must be able to take the entire weight of the stack without damage. Many palleted materials are sensitive (such as equipment) and may be damaged if stacked. Materials should not be stacked so high as to become unstable (height to width aspect ratios are important).

Particular attention must be paid to centring each load on a stack. Uneven, non-centred loads present serious hazards, to life, limb and equipment. When pulling a load from a stack, extreme care must be taken to ensure that other pallets in the stack are not dislodged, moved or damaged during load removal. Stacks that are too high increase the risk for accidents as moving loads with extensions adds to instability. Further, if stocks are not evenly centred it may be impossible to completely engage the forks.

10 Moving Loads

Pallets should be level before stacking additional materials. Stacks that are not maintained level centred and even increase the risk for instability. Care should be taken to examine stack stability frequently, especially for those items that are stacked outside and may be susceptible to high winds, rain or other potential natural hazards. Wooden pallets left outside can degrade rapidly, endangering the stack and increasing the potential for collapse or stack slippage. Loads are most secure when lowered and tilted backwards.

During such forklift operations, it is necessary to tilt loads backwards to prevent the movement of the load forward, which would increase the effective mass of the load and to prevent load loss. Such slippage of a mass could cause the rear of the forklift to rise up and in extreme cases, cause the forklift to flip.

Before picking up a load, always apply the hand brake. This will ensure that the forklift does not move while picking up or putting down a load.

11 Driving a Forklift

- Never drive blind
- Be aware of overhead obstructions
- Never travel with load in raised position
- Make gradual accelerations and decelerations
- Do not exceed a speed of 6 mph.

Operators must ensure that all movements are made gradually for both accelerations deaccelerations and that movements are slow and deliberate.

Quick stops may cause a load to unbalance. Always plan ahead for the unexpected. If vision is impaired by the height of the load, the driver may elect to move the load by driving backwards and looking backwards with a clear line of sight.

12 Forklift Training

- Training reduces risk.
- Check controls before starting.
- Know how to handle situations.
- Wear proper equipment.
- Make sure you can see.

Forklift training is required for all individuals who wish to use the forklift. The manual should be presented as a guide and may be used for retraining or recertification only. Initial training in forklift safety requires a minimum of a two-hour time commitment to learn about general forklift procedures.

Forklift training is mandatory and requires both classroom and hands-on experience. Although the operation of a forklift is similar to that of a car, there are important differences. Such differences include the speed, visibility, load stability, lack of stability on inclines or declines, path smoothness (potholes etc), load height, load rigging etc. Training should also be provided to concerned personnel and users to help move heavy objects, usually on pallets that would otherwise be difficult to move. Using a forklift carries responsibilities. Individuals who do not wish to accept such responsibilities or who have physical limitations such as reduced peripheral vision may elect not to become forklift certified.

CHAPTER VIII

Tractor Hazard Control[58]

1 Introduction

Tractors are common to all farm operations. They also are the major cause of death in agriculture today. Tractors are linked to more than half of farm-related deaths, both nationally and internationally.

This high death rate associated with tractor rollovers is not a new problem. Since 1970, tractor rollover has been the leading cause of farm operator deaths, according to the National Safety Council.

Statistics from tractor rollover accidents show that during past two decades, about five people are killed each year for every 1,00,000 tractors in operation. The cumulative death toll from tractor rollovers is staggering since the development of the tractor.

2 Use Tractors with ROPS

ROPS, or **Roll-Over Protective Structure**, is a cab or frame that provides a safe environment for the tractor operator in the event of a rollover. Also called **anti roll-bars** or **ROPS cabs**, they are designed to prevent death and minimise injury.

However, the first ROPS device was not marketed on new tractors until 1965. Many old tractors used today do not have ROPS.

The ROPS frame must pass a series of static and dynamic crush tests. These tests examine the ability of the ROPS to withstand various loads to see if the protective zone around the operator station remains intact in an overturn. The tests are extensive and destroy the rollover protective structures.

A homemade bar attached to the tractor axle, or a simple sunshade cannot protect the operator if the tractor overturns. **Farm operators should not add their own rollover protection devices to tractors manufactured without ROPS.** Without proper design and testing, homemade devices offer a false sense of security and safety that can be more dangerous than operating a tractor without ROPS. The Occupational Safety and Health Administration and the American Society of Agricultural Engineers have standards on the design of rollover protective structures.

ROPS afford some safety during tractor overturns, but operators need more protection. ***All operators of tractors equipped with ROPS must wear seat belts.*** Without a seat belt, the operator will not be confined to the protective zone.

During an overturn, the operator of a tractor with ROPS could be thrown from the protected area and crushed by the tractor, or even the rollover protective structure itself, if the operator is not wearing the safety belt.

Never use seat belts on a tractor without ROPS. In this case, the operator has no chance of survival because the seat belts will keep the operator in the seat as the tractor rolls over and crushes the operator.

Caution

Only ROPS, which have been tested to meet specific standards, are acceptable. Tractors with a non-approved ROPS can split during the impact of an overturn. Anything less than an 'approved ROPS' provides a false sense of security. Likewise, any altering of the ROPS (welding, drilling holes or being involved in an overturn or collision) can affect the effectiveness of the ROPS itself. Due to the dynamic forces which act upon a ROPS during a tractor overturn, it is crucial that a ROPS is properly designed, manufactured and installed. Proper materials and mounting hardware are essential for **SAFE** performance in all temperatures and operating conditions.

3 Reduce Rollover Risks

There are several ways to reduce the possibility of tractor rollovers. However, these safety practices are not a substitute for ROPS.

3.1 Avoid Sharp Turns and Reduce Speed When Turning

A tractor has a high centre of gravity and can tip. Compare the shape of a tractor and a race car – race cars can turn at high speeds because they are low on the road; a tractor cannot turn quickly without overturning because it sits high above the road.

3.2 Avoid Driving on Steep Embankments, near Ditches and around Holes

These areas are prone to rollovers. The ground can give way, the tractor will lose support and roll over. When conditions require operation on steep slopes, always head down slopes and travel backward up slopes. This will place the tractor in a more stable position and reduce rollover risks.

3.3 Hitch Only to a Drawbar

Many accidents occur when loads are hitched to axle housing or other parts of the tractor. If you have a three-point hitch on your tractor, use only implements designed for a three-point hitch. Attaching implements to something higher than a drawbar can cause the tractor to roll over.

3.4 Avoid Extra Riders

Tractors are not passenger vehicles. They are built for one person to control and perform specific tasks. Passengers on tractors, in fact, can interfere with safe operation of the tractor. The extra rider can distract the operator, block access to controls or obstruct the operator's vision.

No other person should ever be allowed to sit anywhere on a tractor.

The tractor manufacturers should not provide any room or any facility on the tractor for extra riders to sit on and ride along with the driver. They should provide only one seat, comfortable only for the driver to operate the tractor and no one else.

In most accidents involving extra riders, victims fall off or are thrown from the tractor during a rough ride or an accident in which the tractor rolls over. When this occurs, extra riders can be run over by either the tractor or an implement being towed, or both. In an overturn, the tractor often falls on top of extra riders.

The use of 'seat belts' on tractors with 'ROPS' will protect only the operator and not the 'extra riders' from serious injuries.

Extra riders have no such protection as the operator of the tractor. There is no safe environment for extra riders on tractors. Many people have the mistaken idea that enclosed cabs protect extra riders.

3.5 Exception

The only situation in which an extra rider should be allowed on a tractor is during professional instruction of new operators. These conditions are strictly controlled and the trainer should have several years of experience in this area. Even in controlled situations, the professional trainer assumes some risk of being thrown off the tractor.

Major Reasons for Tractor Overturns

1. Horsepower
2. Tractor Age
3. Tractor Type

4 Tractor Manufacturers in India—Consideration of the Market More Than Safety

Their contentions are:

1. Provision of ROPS increases the price of the tractor, which they can't afford as they have to stand in competition with other manufacturers.
2. Dealers, clients and costumers demand additional sitting accommodation on the tractor, even on mudguards, to be provided for the purpose of carrying extra riders on the tractor.

3. It is convenient, profitable and suitable to make and market tractors without ROPS and seat belts by the Indian Tractor Manufacturers on the contention that it is the demand of the costumer, who happens to be a farmer and he wants to use the tractor as a passenger vehicle in addition to his needs of the tractor on the farm.

5 Recommendations

It is high time the Government executed legislation, confirming and enforcing the strict use of ROPS along with the use of seat belts and prohibiting taking any extra rider on a tractor, while operating the tractor in a farm or on a road.

1. The Tractor Manufacturers must compulsorily provide 'ROPS and seat belts' on tractors.
2. Standardise the tests and specifications for the ROPS to be approved and certified.
3. Only approved and certified ROPS to be allowed to be installed.
4. No arrangement should ever be provided on the tractor to accommodate any extra rider.
5. Encourage the use of tractors with ROPS for the tasks that are carry a higher risk for the tractor to overturn, which includes working on slopes, mowing pastures and roadway ditches, and roadway travel.
6. It will be the responsibility of the manufacturers to educate the farmers, who will purchase their tractors with ROPS and seat belts on:
   - Tractor rollover safety.
   - Use of seat belt.
   - Strict observance to prohibit extra riders.

It is advisable that the manufacturers come together to solve the problem of 'Changing the Tractor Usage Patterns', which will reduce the risk of death due to overturn, before the law enforces them to act accordingly.

6 Automotive Research Association of India Project on Safety Norms for Trailers

The Pune-based Automotive Research of India (ARAI) is spear-heading a project aimed at formulating safety norms for trailers. It has suggested that once designs for trailers are finalised, they should be vetted in terms of their safety and viability.

6.1 Road Accidents

Trailers, which are connected to a tractor or prime mover, have not received the kind of importance for safety issue that the prime mover has.

In India, commercial vehicles account for 41 per cent of road accidents and an estimated 10 per cent of these vehicles are tractor-trailers, which have been found to be directly involved in road accidents.

The President and CEO of PL Haulwel Trailers and panel member of Central Motor Vehicle Regulations (CMVR) apex cells, S. Ramasubramanian, says, "We need to ensure that prototype models are road-tested." He suggests that the certification for trailers need not be handled directly by ARAI but by agents it can authorise to do so.

"There are plans to issue specifically designed templates to check designs for different trailer models. This would facilitate a more standardised approach to carry out the necessary checks," he says.

He has highlighted the need to review existing standards using the expertise of a team comprising professionals from different industrial backgrounds. The existing norms, he adds, can be modified wherever required to take into account emerging technologies in the trailer transportation field.

According to him, the existing norms need to be implemented for various components in the truck-trailer transport vehicle including the fifth wheel coupler (the device that connects the kingpin of trailer to the prime mover), kingpins, axles etc. The Australian standards supported by the Australian Design Rules (ADR) are best suited for India.

6.2 Reality on the Roads

Only by formulating standards and ensuring that they are followed during production, can safety become a reality on the road.

1. The importance of this aspect has to be seen in the context of the golden quadrilateral project being implemented by the National Highway Authority of India and the need to reduce the high rate of accidents.
2. At present, approvals for tractor-trailers are given only on the basis of adherence to the dimensions of a trailer and estimated axle loads. However, the design norms need to be implemented as well. To an extent, the tyres on the trailer are taken as a safeguard against factors like overloading.
3. Other factors such as dynamic structural rigidity, braking adequacy and efficiency of brakes, load restraints and electrical circuitry do not figure prominently in the trailer design evaluation.
4. Should certification be made the responsibility of a separate evaluating agency, a key issue will be the competency of officials as well as proper training for the agency concerned. However, the parameters in providing approval for the design of trailers by the state transport authorities differ from state to state whereas the trailers themselves operate on inter-state roads and not only in the state where the permission is obtained.
5. In order to ensure uniformity in design especially for safety, the individual states must be advised to follow only the CMVR. The panel's recommendations were processed at various levels and, therefore, it could take a year for some of the recommendations to be made mandatory.

When compared to the developed countries, "we are about 20 years behind in terms of technology and establishing control measures for safe transportation".

6.3 Concerns

1. There is no formal fitness certification for the trailer, which is the actual 'load-carrying' vehicle.
2. The tractor alone is submitted to a fitness test and not the trailer, which is not a 'self-propelled-unit'.
3. Sourcing and selection of components does not get the required attention. It is not uncommon for trailers to be sold without wheels.

CHAPTER IX

SAFE HANDLING AND STORAGE

Material Handling[43]

1 Introduction

More than 50% of the total number of accidents resulting in injury or property damage are caused during material handling in engineering industries. Material handling, therefore, becomes the most important activity from a safety and loss prevention point of view.

Attempts should be made to eliminate/reduce material handling to the minimum as it does not add to the value but adds to the cost. Safety Precautions and Safety Procedures with respect to the various aspects of material handling, as given here, need to be followed to improve safety and reduce property damage due to accidents.

1.1 Basic Facts

1. Material handling does not add any value but adds to the cost of the product.
2. Material handling accounts for 36% of production costs.
3. Nearly 50–100 tons of material are handled and re-handled for every one ton of finished product.
4. About 2/5ths of manufacturing cycle time is spent on handling.
5. About 20–80% of the total labour cost go to labour used in handling.
6. Between 30–40% of industrial accidents are caused while handling materials. In other words, every third accident in industries is caused while handling materials.

1.2 Factors Influencing Selection of Handling Materials

1. Weight
2. Physical character
3. Size
4. Shape
5. Rate of handling
6. Distance to be moved
7. Purpose of moving
8. Obstacles if any in the pathway.

1.3 Mechanical Aids/Equipment

1. Hand tools (crow-bar, hook, mallet etc.)
2. Skids, rollers, or other devices for dragging or sliding.
3. Wheelbarrows, hand trucks, and special carrying devices
4. Lift trucks
5. Power trucks and tractors
6. Hoisting apparatus
7. Overhead travelling cranes (E.O.T.)
8. Conveyors
9. Mechanical shovels
10. Elevators and escalators
11. Chutes (gravity or under pressure)
12. Pipelines/pumps for liquids.

1.4 Unsafe Work Habits

The common unsafe work habits in material handling are:

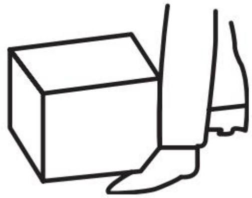
1. Lifting improperly
2. Carrying too heavy a load
3. Unsafe gripping and
4. Failure to wear personal protective equipment.

2 Manual Material Handling

Many accidents resulting in injury to employees and damage to cargo are caused by unsafe work habits, e.g., incorrect gripping, improper lifting etc. during manual handling of material.

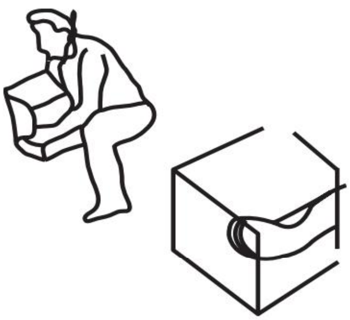
The following are simple safety precautions:

1. **Correct positioning of feet:** When lifting a load, space legs apart, with one foot by the side of the load and in front of the other foot in the direction of movement.



2. **Bent knee:** For a strong and steady position bend knees and not the back to reach for the load, as bending the back creates the risk of loss of balance and straining the spine.

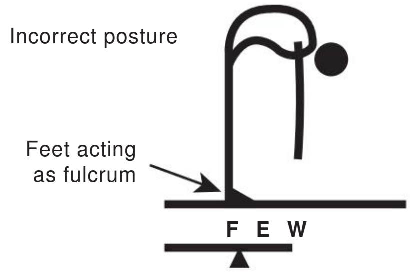
3. **Straight back:** The back needs to be kept straight (not necessarily vertical). It may be inclined from the hip, as the lifting posture requires.

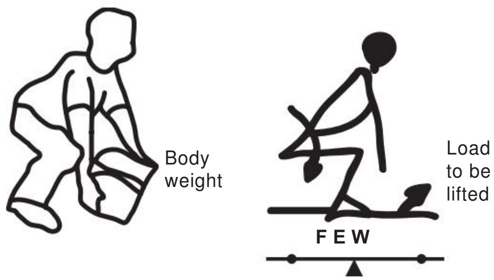


4. **Arms close to the body:** The farther the load is to the body, the greater is the strain.

5. **Correct grip:** The load should be properly grasped using the roots of the fingers and palm.

6. Raise head slightly before lifting.





7. Use of body weight: Position the body such that its weight counterbalances the load to be lifted.

3 Mechanised (Kinetic) Material Handling

Most material handling is done within the factory premises with the help of mechanical power. Usually, accidents during mechanised material handling are more severe. It is extremely necessary that the equipment/machines used for mechanised material handling are maintained in safe working condition and personnel engaged in the operation are trained in and aware of the potential safety hazards and precautions to overcome them.

3.1 EOT Crane/Goliath Crane/Jib Crane Safety Precautions

1. The crane should be centred over the load such that the hoisting ropes are vertical. It should not be used for angular lifting or pulling a load.
2. The crane should not be overloaded beyond the rated safe working load capacity which should be prominently marked on the machine.
3. Install limit switches for all three motions, i.e., up–down, longitudinal and transverse or cross travel should be provided such that power cuts off if movement goes beyond a specified limit. (A Jib crane may have only an upper and lower limit switch.)
4. Controls should be operated smoothly to avoid abrupt, jerky movements.
5. The hook block should never be lowered below the point where:
   (a) Less than two full wraps of rope remain on the hoisting drum; or
   (b) It is about to touch the floor.
   The lower limit should be adjusted accordingly.
6. Brakes should be checked when a near-capacity load is being lifted by actually lifting the load a few inches and switching off the controls. If the brakes do not apply and the load comes down, they should be repaired/set/adjusted first before lifting the load again.

7. Personnel in the immediate area should be cleared off when load is being lifted and moved.
8. Before shifting a load it should be lifted high enough to clear all obstructions on the floor.
9. A suspended load should never be left unattended.
10. Limit switches should not be used to stop the hoist under normal operating conditions. These are emergency devices and are not to be used as operating controls.
11. The upper limit switch should not be bypassed, adjusted or disconnected in order to go higher than the switch will allow.
12. The upper limit switch should be tested by actuating it at the beginning of the shift. If it is out of order, the crane must not be used till the limit switch is repaired.
13. The crane should be electrically isolated and the main switch should be locked or tagged and fuses removed before inspection, repairing, cleaning/lubricating etc. where an accidental start of the crane may result in a severe accident (refer to 'Electrical Isolation and Tagging').
14 When an E.O.T. crane or Goliath crane operates on one linear gantry or rail, safety devices should be provided which sounds a warning or cuts off the electric supply to crane movement so that collision between two cranes can be avoided.

3.1.1 Statutory Examination and Inspection

All E.O.T., Goliath, Jib and Yard cranes should be examined by a person declared "Competent" under the Maharashtra Factories Rules, 1963, once a year and, if found in safe working condition, certificates in Form 13 should be obtained and maintained.

The Maintenance Department can arrange to have the cranes examined and obtain and maintain the certificates. Besides the statutory examination, cranes should also be inspected periodically and preventive maintenance, a must for ensuring safety, should be scheduled and carried out regularly. The criteria of defects with respect to rope/hook/chain given in the subchapter 'Slings' would be applicable while inspecting a crane.

3.2 Chain Pulley Block Safety Precautions

1. A chain pulley block should not be overloaded while raising, lowering or suspending a load.
2. The hand chain and load chain should hang freely without any knot or twist.
3. The load chain should not be used as a sling, e.g., for tying a load.
4. Abrupt loading which results in jerks/shocks should be avoided. Loading should be smooth.
5. A suspended load must not be left unattended. If ever this is necessary, the area underneath must be cordoned off.
6. No one should pass below a suspended load.
7. A chain pulley block which is used for lifting loads must not be used for dragging/pulling loads.
8. A chain pulley block when not required for a considerable period of time should be cleaned, dried, provided with corrosion protection coating and stored properly. It should not be left lying on the shop floor or hanging.
9. While lifting a near-capacity load, it must be ensured that it does not slip by lifting the load a few inches. If it slips, the block should not be used unless it is repaired.
10. Chain pulley block should not be used for hoisting a person.

3.2.1 Statutory Examination and Inspection

All chain pulley blocks should be examined by a person declared "Competent" under the Maharashtra Factories Rules once a year and, if found in safe working condition, certificates in Form 13 should be obtained and maintained.

The Maintenance Department can arrange to have the chain pulley blocks examined, obtain and maintain the certificates.

Besides the statutory examination, chain pulley blocks should also be inspected periodically. The criteria of defects with respect to chain and hook given in subchapter 'Slings' would be applicable while inspecting a crane.

3.3 Forklift Truck: Safety Precautions

1. Only trained operators should operate a forklift truck.
2. Before starting the truck at the start of the shift the following equipment must be checked.
   (a) Tyres—for cuts, excessive wear, metal embedded in tread and pneumatic pressure.
   (b) Brakes—for effectiveness.
   (c) Leakage (if any) of fuel, hydraulic fluid or engine oil.
   (d) Horn and battery connections.
3. Quick and jerky starts, halts, load raising/lowering should be avoided.
4. The front view should be kept reasonably clear. In case a bulky load blocks the front view completely, the truck should be operated in reverse and the operator should carefully look out for people and other objects.
5. While travelling, raising or lowering the load should be avoided.
6. While travelling with a load the mast should be tilted backwards and the fork should be kept low (preferably 6 inches above the ground).
7. Overloading must not be attempted. The operator should be aware of the safe working load (SWL) and also the load centre of the truck.
8. While driving the forklift truck on ramps and inclines, the load must face uphill and the path should be straight.
9. Shut off the ignition while re-fuelling the truck.
10. Traffic rules should be followed by the forklift operator.
11. Forks should be adjusted to match the width of the load or pallet.
12. The mast should be partially tilted backward while raising or lowering the load.
13. Extra care should be taken to maintain the stability of the stack while stacking or de-stacking.

3.4 Slings and Slinging Practices

Slings are the devices used to connect a load to a lifting machine. The process of connecting the load and lifting machine with the help of a sling is known as slinging.

Commonly used slings are the Wire Rope Slings and Chain Slings. They can be single legged or multi-legged.

3.4.1 Wire Rope Sling

The main advantage of a wire rope sling over a chain sling is that it is lighter for equal capacity whereas the disadvantage is that it has a shorter life and is prone to damage during rough use.

Safe Working Load

The SWL of a wire rope can be calculated by dividing the catalogue breaking load by the factor of safety.

$$\textbf{SWL} = \frac{\text{Catalogue Breaking Load}}{\text{Factor of Safety}}$$

(Catalogue breaking load is the ultimate breaking load as given in the catalogue/certificate of the wire rope.)

Defects

1. Broken wires are a sign indicating the deteriorating condition of a wire rope. Replace it if 10 broken wires are seen on a length of 8 dia. It is very serious if all the broken wires are from the same strand (rare).
2. Reduction in wire-rope diameter can be due to:
   (a) excessive localised abrasion,
   (b) breaking of core support,
   (c) corrosion—internal or external, or
   (d) failure of inner wires.

If the reduction in diameter is about 6% or more, the rope should be discarded.

3. Corrosion: Difficult to detect as it develops inside. As far as possible, wire rope should not be used in a corrosive environment.
4. Stretch: Some stretch always exists initially due to tightening of wires and strands. If elongation is more than 5% of the original length (after a proof test) the wire rope should be replaced.
5. Worn-out wires: Due to friction with sheave drums etc., the outer wire wears out and looks flatter instead of circular. If wear is excessive and uniform, the wire rope should not be used.

Besides the above, the wire rope should also be checked for flattened strand, bird caging or bulging, kink, spark damage, protrusions of core, inlaying of strands, inadequate or damaged splicing, crushes etc.

3.4.2 Chain Sling

The main advantages of a chain sling over a wire rope sling is that it offers better resistance during rough use, is more flexible and has a longer life whereas the disadvantage is that it is heavier for an equal capacity.

$$\textbf{Safe Work Load} = \frac{\text{Ultimate Strength}}{\text{Factor of Safety}}$$

(The SWL of a chain is half the proof load. The formula for proof load is given in this chapter.)

Sr. No.	Material	IS Grade	ISO Grade	Grade Marking
1.	Mild Steel: About 0.2% carbon and mean stress of 300 N/mm^2 at the minimum specified breaking load.	30	L	
2.	Mild Steel: About 0.12% Carbon and 1.5% Manganese or Medium carbon Steel with but 0.29% Carbon. Mean stress at minimum specified breaking load—400 N/mm^2.	40	M	0.4. 4.0 when normalising is conducted.
3.	Alloy Steel: At least 1% alloying element e.g. Nickel, Chromium, Molybdenum and Manganese. Mean stress at specified minimum breaking load—630 N/mm^2.	60	P	06
4.	Alloy Steel: At least 2 of the 4 alloying elements. Mean stress at minimum specified breaking load—800 N/mm^2.	80	S	08

Proof testing is conducted before the chain sling is ready for use. Proof testing is a method to detect flows and not a method to determine strength.

Specification	Proof Load (Kg)
Wrought Iron or M.S.	$12d^2$
Grade 40	$16d^2$
Grade 60	$24d^2$
Grade 80	$32d^2$

d = dia of chain link rod in mm.

Chain Defects

1. **Stretch and Deformation:** If one or a few links are elongated dangerously or twisted badly the chain should be discarded. If stretch is more than 6% of the original length, the chain sling should be discarded.

2. **Wear:** Occurs on the surface subjected to rubbing with another surface. Found at the bearing surface or inter-link contact and outside barrel.

Usually up to 6% wear is allowed in case of Mild Steel and 8% in case of high tensile steel and alloy steels.

3. Nicks and Grazes: The outer surface of a link (barrel) may get damaged due to foreign objects. Most of them are found on the straight barrel. This causes stress concentration and should be removed by filing/grinding/sandering. After this, if the diameter is still under the permissible limit, the chain can be used or otherwise discarded.

4. **Twisting:** Severe twisting of one or a few link/s is unacceptable and the slings need to be discarded. Slight twisting may not require discarding.

An overall twist of half a round for the length of 4 metres is tolerable.

5. **Cracks:** A crack has a tendency to propagate, hence any chain with a cracked link is not permissible to be used irrespective of the size of the crack.

6. **Defects in Hook:** If the hook gets opened up by more than 15% and twisted by more than 10% from the original plane, the use of the same should be discontinued.

3.4.3 Load Limits

The SWL of the sling should be more than or equal to the maximum load to be lifted. In case of a multi-leg sling, the tension on each of the legs will depend on the geometry of the sling. Normally the included angle between two legs of the sling should not exceed 90°.

Type of Sling	**SWL of the Sling**
Single leg sling	1 ¥ SWL of single leg
Double leg sling	1.4 ¥ SWL of single leg
Three leg sling	2.1 ¥ SWL of single leg
4 and more legs	2.1 ¥ SWL of single leg

A sling can be used in many forms, e.g., straight lifting, chocker hitches and basket hitches.

Type of Sling	**Single Leg Sling**	**Double Leg Sling**
Straight lift	SWL will be the same as the rated SWL of the single leg.	SWL will be the same as the SWL of a 2-leg sling.
Choker Hitch	SWL would be half the rated SWL of single leg.	SWL would be half the rated SWL of a 2-leg sling.
Basket Hitch	SWL will be the same as the rated SWL of single leg sling in case the hook is placed on master link. But SWL will be twice the rated SWL of single leg sling if the sling has master links at both ends and both are rested on hook of the lifting M/c.	SWL will be equal to the rated SWL of a 2-leg sling.

3.4.4 Factor of Safety

By definition, the factor of safety is the ratio of the ultimate (breaking) strength of a member of piece of material to the actual working stress or to the maximum permissible (safe load) stress, when in use.

$$\text{i.e., } \textbf{Factor of Safety} = \frac{\text{Ultimate Breaking Strength}}{\text{Maximum Permisssible Safe Load}}$$

Example: In the case of a wire rope sling, the safety factor is five. This means for any general hoisting purpose, it is not advisable that the working load of a wire rope sling exceed 1/5th of its breaking strength.

Important Factors of Safety

	Apparatus	Safety Factor
1	Crane Hook	5
2	Wire ropes sling:	
	(Hoisting rope, ring, hook)	5
3	Chain Sling:	
	(Chain links, ring, hook)	5

3.4.5 Angle between Two Legs of a Sling

As the angle between two legs of a sling increases, tension on each leg also increases when the load remains same. The relationship among the angle, tension and load is given by the expression:

$$T = \frac{W}{2\cos\frac{A}{2}}$$

where
T = Tension on each leg kgf.
W = Load kgf.
A = Angle between two legs of the sling.

3.4.6 Use, Care and Maintenance of Chains and Wire Rope Slings

The strength of a sling depends on the weakest link. *It is the weakest part which decides the strength of a sling.*

The following are the precautions to be taken to prevent damage to/failure of a sling.

1. Only a sling in safe working condition should be used (defects and acceptability criteria with respect to wire ropes, chains and hooks given in this chapter.)
2. A sling should not be overloaded. Overloading may occur from:
   a) Lifting heavier weights than the capacity of the sling
   b) Jerk.

c) Hitches or
d) Excessive angle between two legs of the sling.

All the above possibilities must be taken into consideration while ensuring that the sling does not get overloaded.

3. A sling, when found unusable due to defect/damage/wear should not be de-rated for a lower SWL but should be discarded.
4. The effective length of all legs in a multiple-legged sling should be equal and equiangular. Otherwise the overloading of legs (which may occur) would be calculated and accordingly a higher capacity sling would be used.
5. A sling should be protected from mechanical damages, e.g., load rolling over sling, dropping from a height, dragging, sling resting against sharp corners without packing, twists, knots etc.
6. The chain should not be spliced by inserting a bolt between two links.
7. Only those attachments (rings, shackles, couplings, and end links) which are of adequate capacity and suitable for use should be used with the sling.
8. The load should rest in the saddle of the hook. Eccentric loading of the hook reduces its capacity.
9. Slings and attachments when not in use should be stored on a suitable hanger/rack.
10. A permanent identification tag along with SWL must be attached to each and every sling. Display a board showing the number of tackles available in the dept/shop. Their identification number, their SWL and last date of statutory examination are desirable.
11. Special precautions should be taken and a higher capacity sling (than normally required) should be used when:
    a) exact load is in doubt
    b) there exists chances of jerks/shocks
    c) conditions are abnormal/severe or
    d) their exists hazard to life and limb.
12. Periodic inspection besides statutory examination of slings is required.

3.4.7 Procuring New Lifting Tackles (Slings) and Maintaining Them in the Shop

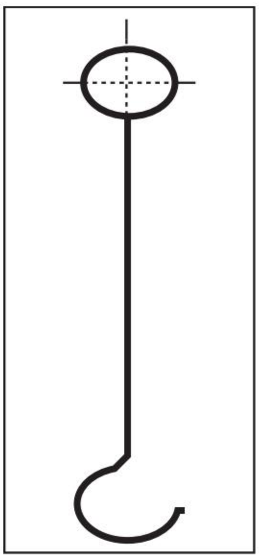
1. Every plant/department needs to have a record with respect to lifting tackles available with them. The record will indicate type, distinguishing mark, capacity and last date of statutory examination of the tackle.
2. A list of available tackles should be displayed in the shop/department. No lifting tackle other than the ones mentioned in the list should be used in the shop by the shop personnel.
3. The Maintenance Department will have the lifting tackles (as shown in the displayed list) examined as per the statutory requirements and maintain the certificates.
4. Whenever a lifting tackle is to be scrapped due to defects beyond the acceptability limit, the Maintenance Department should be informed in advance and necessary changes made in the record.
5. Tackles when not in use shall be hung in an orderly fashion. This ensures better housekeeping and fewer chances of the tackles getting damaged.

6. New slings would be procured on indents. While placing an order for a sling the following must be clearly mentioned.
   a) Type of sling, e.g., Two-legged wire rope sling both open ends provided with hooks.
   b) Length of leg/s.
   c) Material grade: In case of a chain sling, the grade of material of chain and hook and in the case of a wire rope sling, the grade of material of hook only if a special alloy steel material is needed.
   d) Safe Working Load: In case of a two-legged sling, the safe working load at a 90° included angle would be clearly mentioned.

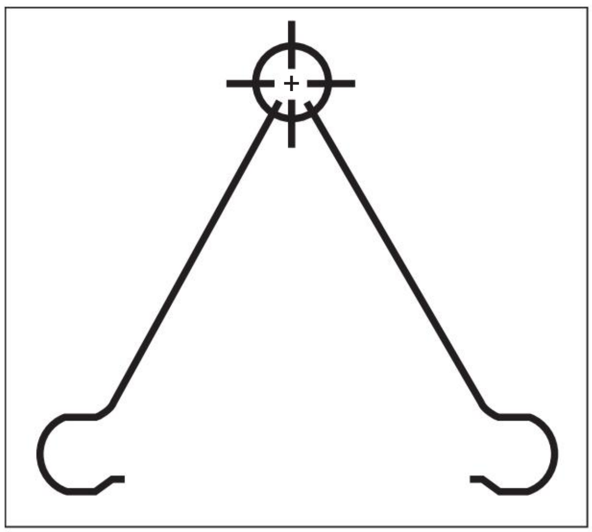
7. The shop/department will accept new slings only if a certificate of safety from a competent person on Form 12 of the Maharashtra Factories Rules is available. The certificate would be forwarded to the Maintenance Department once the sling/tackle has been accepted. A record of tackles would be updated accordingly to include the new tackle.

Note: A few self-explanatory sketches, showing various types of slings, correct usage of slings, hooks, shackles, plate-lifting clamps etc. are included for reference.

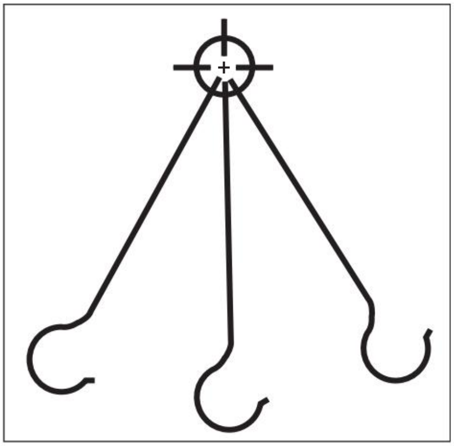
Single and Multi-legged Slings



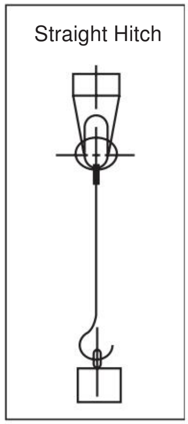
Single-legged tackle—SWL is equal to tension on the sling leg.



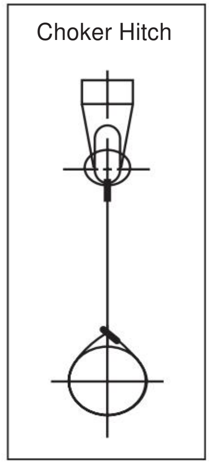
Two-legged sling—SWL is equal to 1.4 times the safe working tension on any leg.



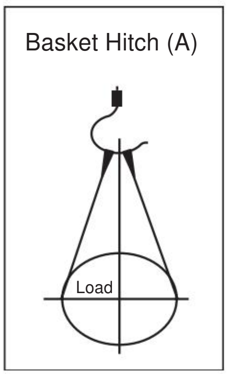
Three-legged (or more) sling—SWL is equal to 2.1 times the safe working tension on any leg.



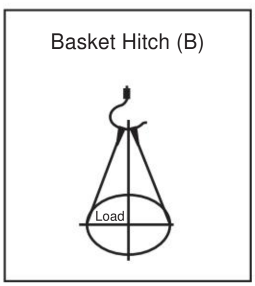
Load equal to 1 SWL can be safely lifted.



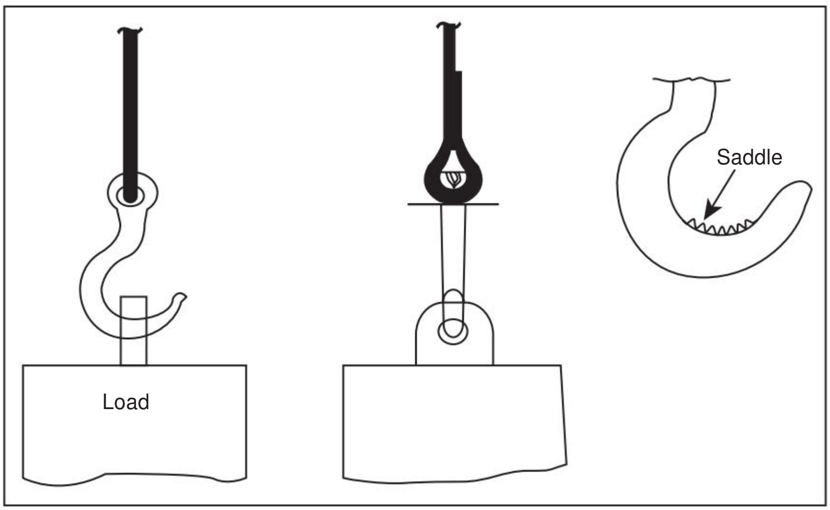
Load equal to 0.7 SWL can be safely lifted.



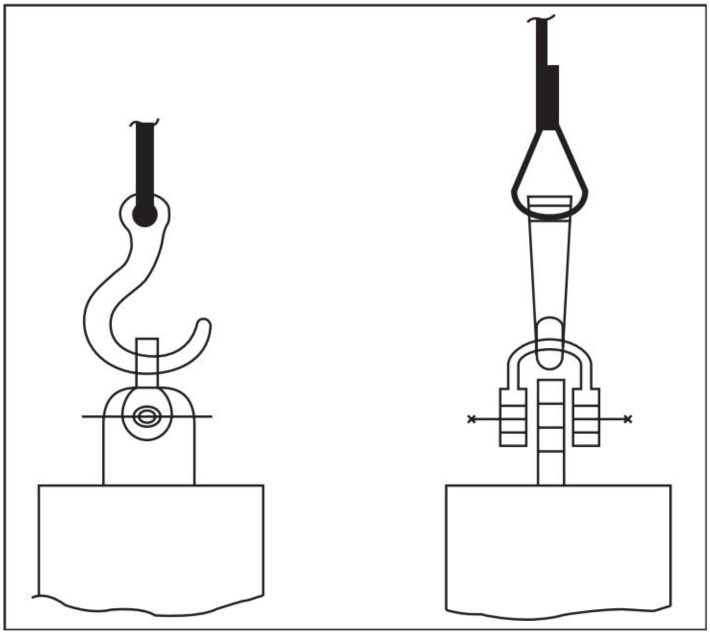
Load = 2 ¥ SWL can be safely lifted.



Load = 1 ¥ SWL can be safely lifted.



Load should rest on the saddle of the hook and not on the tip.



Suitable capacity 'D'—the shackle can be used to connect hook to the load.

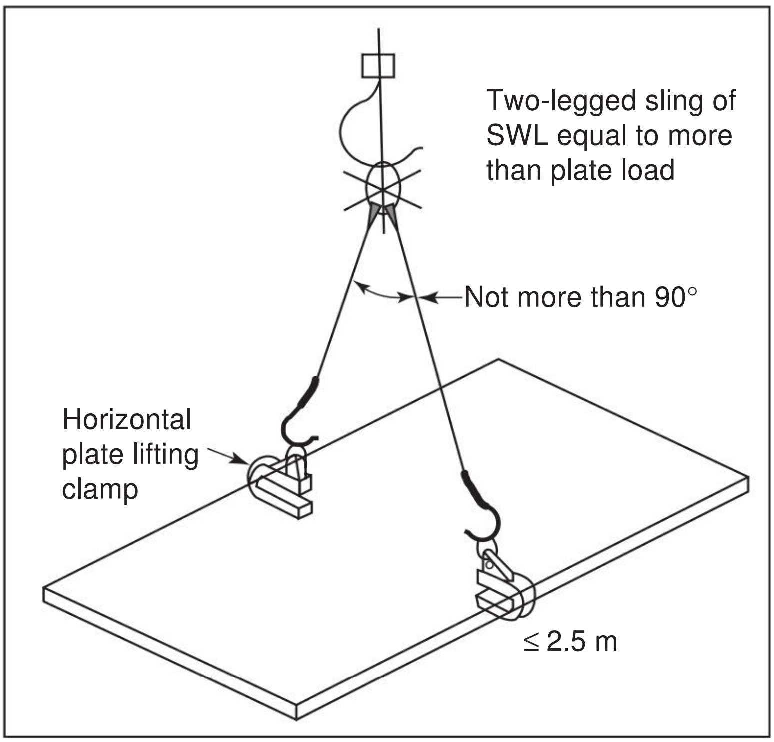


Plate handling with a two-legged sling.

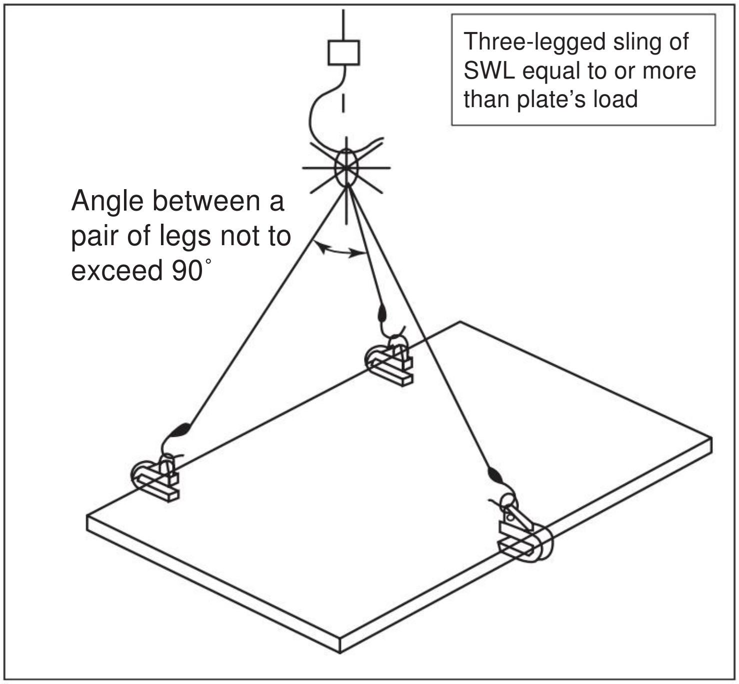


Plate handling with three-legged sling.

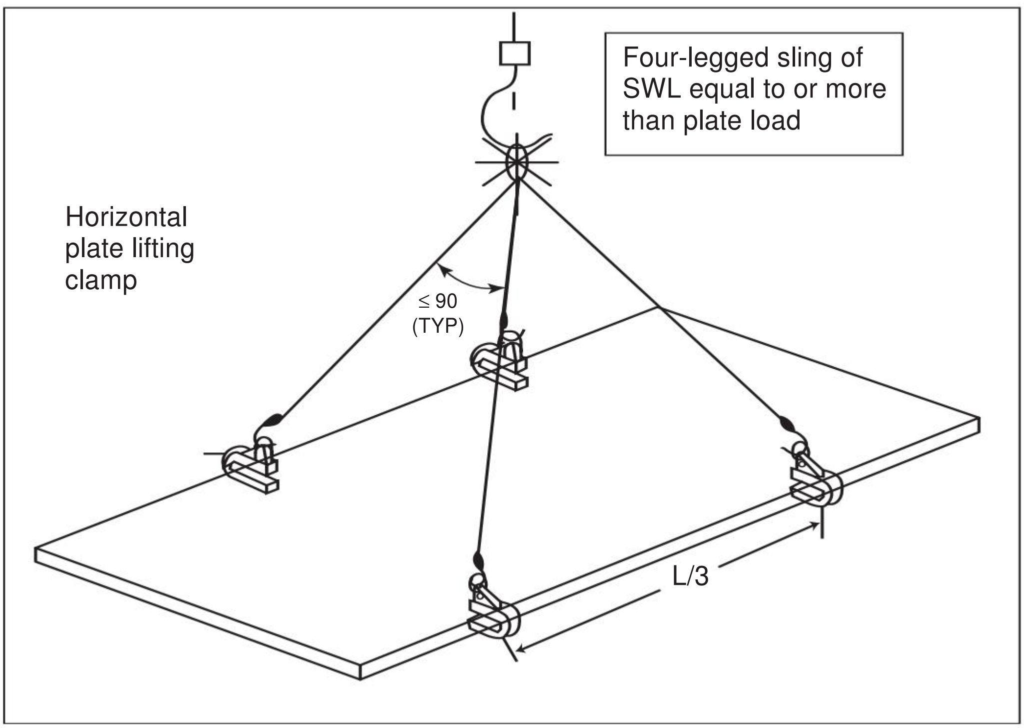
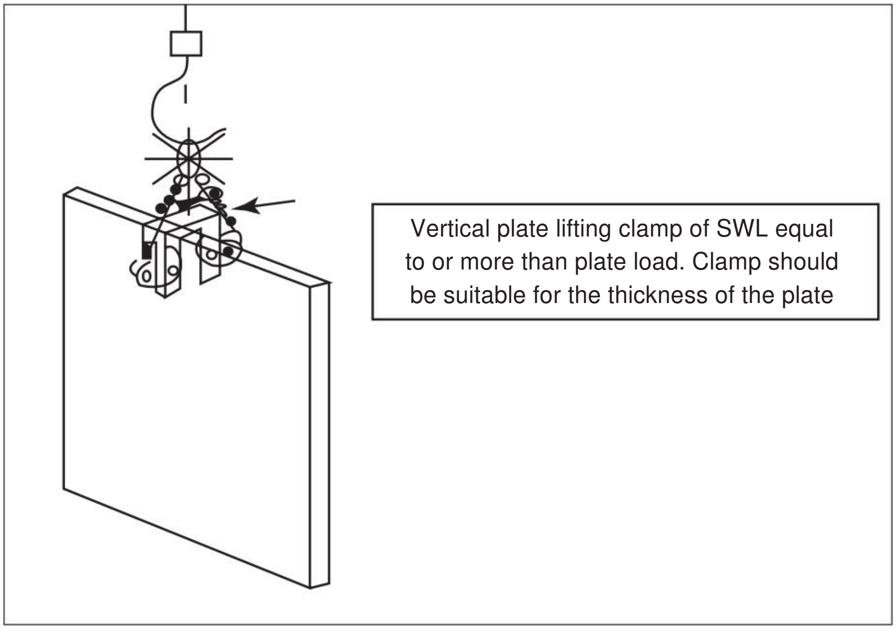
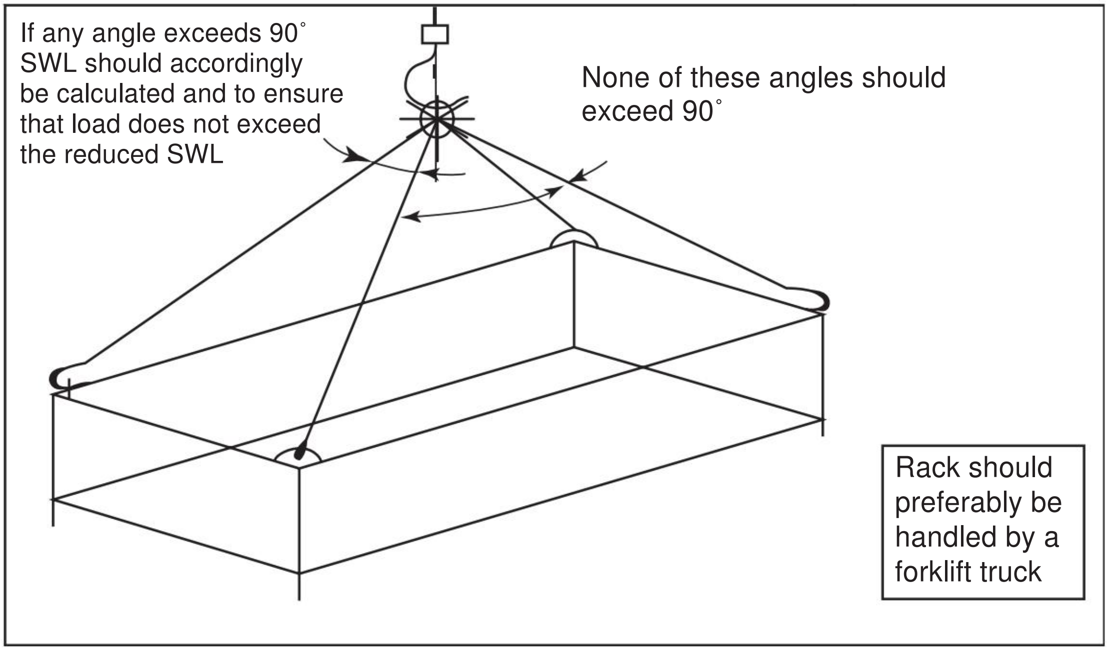


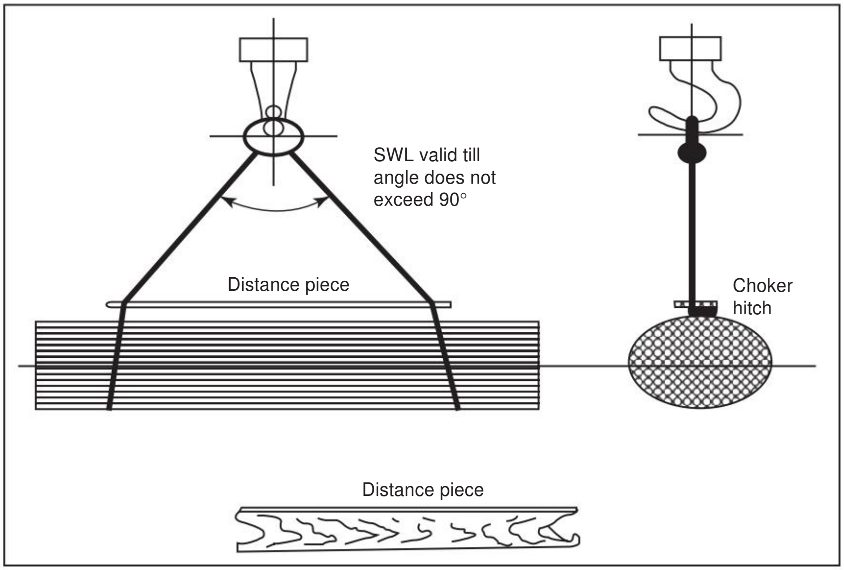
Plate lifting arrangement with four-legged sling.



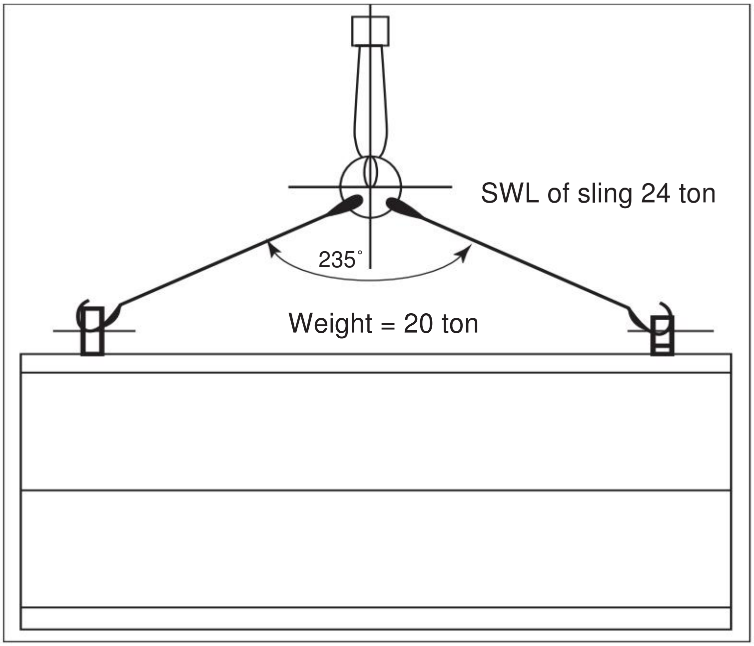
This arrangement is only acceptable when the vicinity around the load being lifted/handled is cleared of people and equipment as there is always a possibility of the plate sliding out of the clamp.



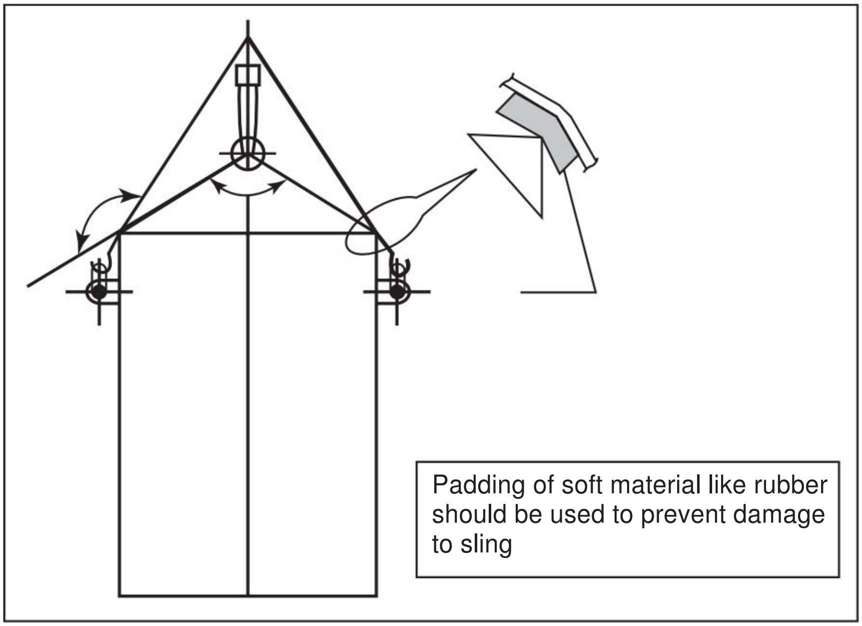
Tube/pipe rack handling



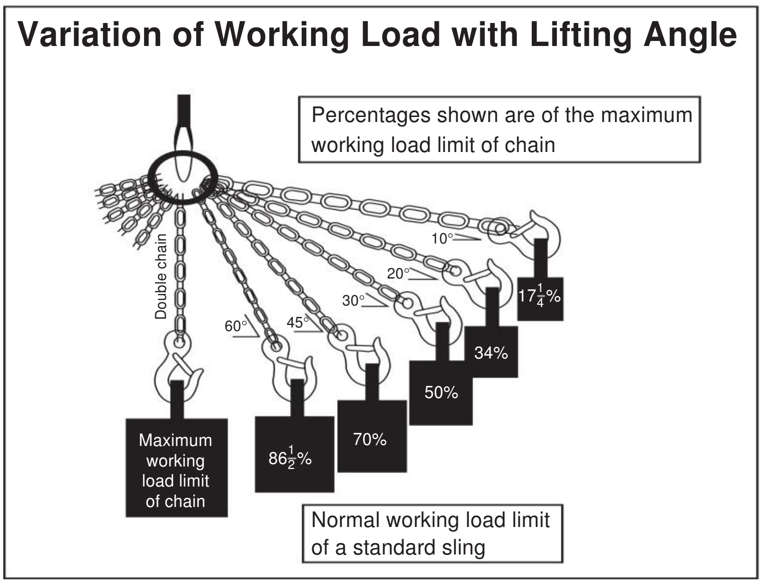
Typical arrangement for handling pipes/tubes (A tube rack for handling pipes/tubes is a better alternative).



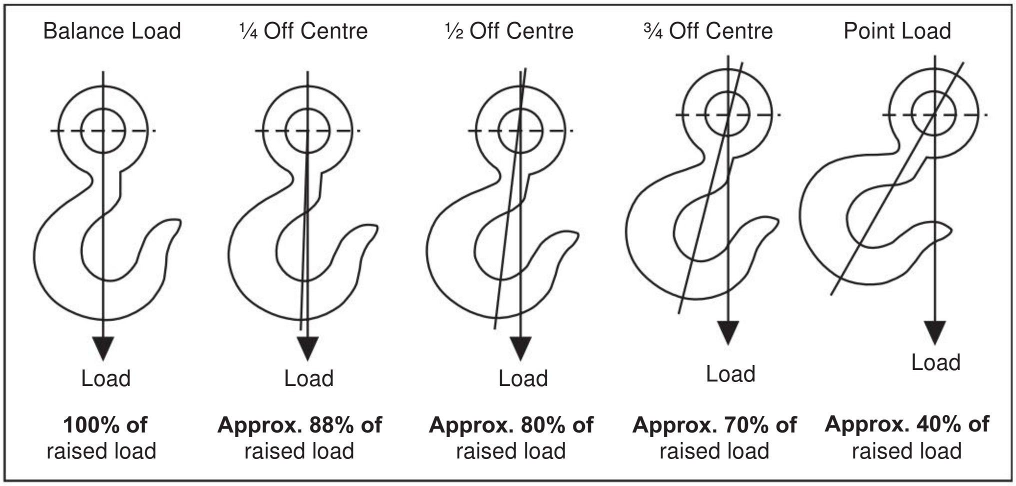
This arrangement is unsafe as the SWL of sling, i.e., 24 tons is valid only if the included angle between two legs is 90°. For this arrangement a sling of 37 tons of SWL will be required.



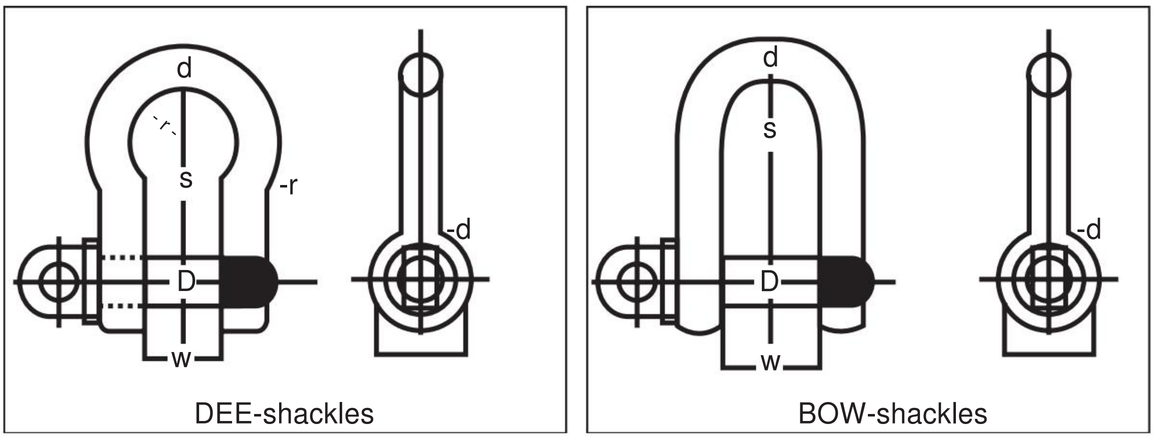
A commonly observed unsafe practice. The legs should either be cleared and set in a straight line or calculate the SWL, keeping angle CBA and angle BAB in view. Take the least value as SWL for the arrangement.



How the angle of the sling affects the working load limit.

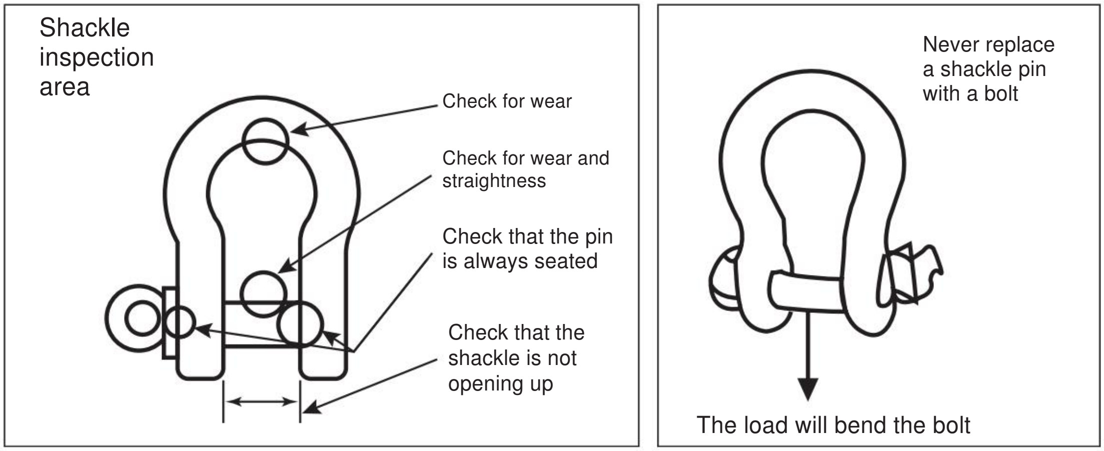


If the hook is eccentrically loaded or if the load is applied anywhere between the saddle and the tip the safe working load is reduced as shown.

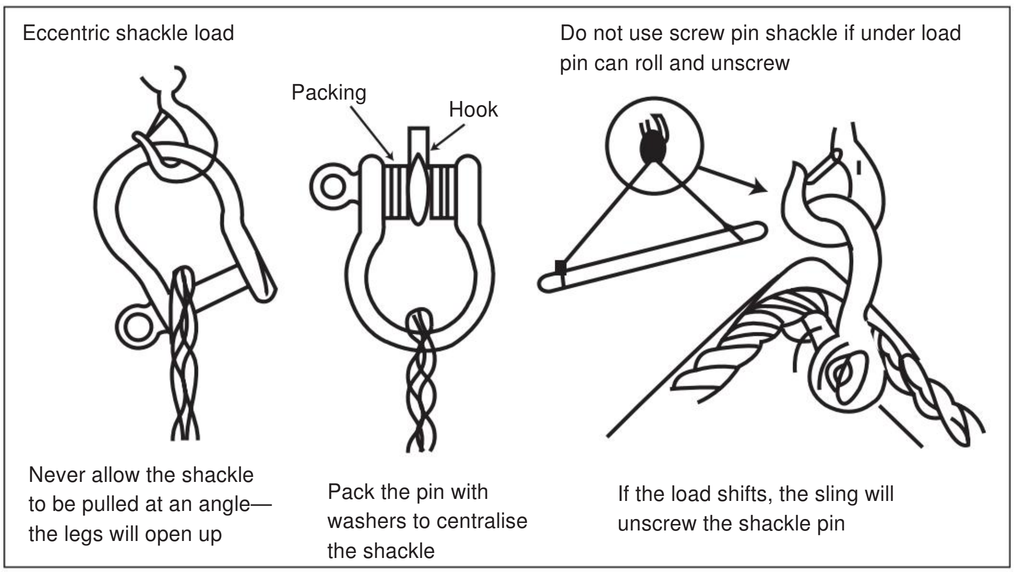


Approximate dimensions of BOW- and DEE-shackles for Safe Working Load (L = Tons) in mm.

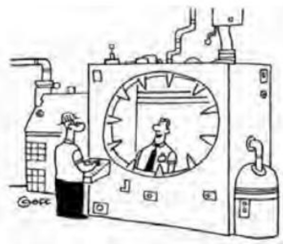
	d	D	W	s	e	2r
DEE	15 √ L	17 √ L	20 √ L	48 √ L	30 √ L	—
BOW	16 √ L	18 √ L	26 √ L	58 √ L	32 √ L	40 √ L



Safety tips for the user of shackle



Compressed Gas Cylinders



1 Introduction

Compressed gases in cylinders, e.g., oxygen, carbon dioxide etc., are used in bulk in factories. It is quite safe to use, handle and store compressed gases in cylinders if basic safety precautions are followed. However, if safety precautions are neglected, these cylinders have the potential to explode and cause severe accidents.

2 Storage

To minimise this hazard, it is advisable to store a minimum quantity of cylinders. If the number of cylinders containing flammable gases equals or exceeds 15, and those containing non-flammable gases equals or exceeds 50, permission for storage needs to be obtained from the Controller of Explosives. The department requiring such a storage facility would, in collaboration with the Maintenance Department, arrange for such permissions.

3 Safety Precautions in Storing Gas Cylinders

1. Cylinders should be stored in well ventilated spaces or room.
2. Gas cylinders kept in the open should be protected from the sun, rain or contact with corrosive substances, oil and grease.
3. Areas where gas cylinders are stored should be declared non-smoking zone.
4. If gas cylinders are stored in a closed room, the electric switches should be located outside the room and electric fittings should preferably be flameproof.
5. Oxygen and acetylene should be stored at least one metre apart from each other.
6. Acetylene cylinders must be stored upright since acetylene is stored in its dissolved form.

7. Never allow gas cylinders to come in contact with electrical apparatus or live wires.
8. Gas cylinders should be kept away from heat sources.
9. Cylinders, their valves, couplings, fittings, regulators, hoses etc., should be kept free from contamination from oily or greasy substances. (No oil- or grease-based lubricant should be applied on cylinder valves.)
10. Cylinders should not come in violent contact with each other or with any hard surface.
11. Cylinder should never be dropped.
12. It is illegal to tamper with numbers and markings stamped on cylinders.
13. Valves of empty cylinders should be kept closed and protected by caps.
14. Gas cylinders should never be used as rollers or support, whether full or empty.
15. For transporting cylinders, a suitable handcart should be used. The cart may be provided with a chain or belt to secure the cylinders so that they cannot fall in case the handcart happens to go over a bump.
16. If a cylinder has to be transported over a short distance, it can be rolled over its bottom edge but should never be dragged.
17. A fibre rope sling may be used to lift one cylinder. A chain sling should not be used. If more than one cylinder has to be lifted, a suitably designed cradle pallet should be used.
18. A lifting magnet or chain sling should never be used to lift a cylinder.
19. Full and empty cylinders should be marked and stacked separately. Empty cylinders can be marked “Empty” or only “MT” with chalk.
20. While placing a cylinder upright, it should be properly secured to prevent it from falling.
21. The valve of a cylinder is the weakest part, utmost care should be taken at all times to prevent it from being damaged.
22. When receiving a cylinder, it should be ensured that the valve protection cap is intact.

Corrosive Substances

"Today we're going to talk about fall protection"

1 Introduction

Acids and alkalis are corrosive substances and their contact with human body causes severe burns and irritation.

2 Storage

1. Corrosive substances may be stored in plastic carboys in small quantities. Metallic containers made of metals which do not react with the corrosive substance (or rubber-lined metallic containers) may be used, e.g., an M.S. tank may be used to store concentrated acid or a rubber-lined M.S. tank may be used to store concentrated acid or diluted acid.
2. The storage area should be tiled with acid-resistant tiles and have a drainage arrangement with a suitable slope, water tap and emergency floor shower-cum-eye wash fountain.
3. Only the minimum required quantity should be stored.
4. A hazard warning board should be displayed prominently in the storage area.
5. Containers should be suitably marked for the content or have information about the content pasted on them.

3 Safety Precautions

1. Only trained personnel, aware of the hazards of the corrosive substance, should be allowed to handle/use it. (Untrained persons should not be deployed to handle/use the corrosive substance. However, if it is extremely necessary to deploy them, they must be given specific safety instructions by the supervisor concerned and they must work under strict personal supervision to ensure that they follow all the safety precautions.)

2. Chemical splash goggles, face shields, PVC gloves, rubber/PVC gum boots and rubber/PVC aprons must be used by everyone handling/using corrosive substance.
3. To dilute acid, it must be slowly added to water while stirring. Never add water to acid or alkali.
4. In case of accidental contact with a corrosive substance, the affected area must be thoroughly washed with water for 15–20 minutes.
5. In case of a corrosive substance accidentally splashing into the eyes, they should be thoroughly washed with water. While washing, the eyes should be kept wide open. Washing should continue for 15–20 minutes. Washing with plenty of water is very most important and must be ensured before rushing the injured to medical help.
6. In case of a corrosive substance splashing on the floor, it should be washed with water.
7. Compressed air should not be used in loading, unloading and cleaning/splashing the corrosive substance.

Hydrocarbons

1 Introduction

Hydrocarbons (petroleum products) can be classified into three categories.

Class-A	-	Flash Point	<23° Celsius
Class-B	-	Flash Point	>23° but <65° Celsius
Class-C	-	Flash Point	>65° but <95° Celsius

(Flash Point is the temperature at which the liquid gives off sufficient vapour to form a flammable mixture with air, which would ignite if a source of ignition were introduced.)

Safety aspects with regard to storage/handling of hydrocarbons depends on the class of hydrocarbon.

2 Class-A

Several thinners, petrol, xylene etc. fall under this category.

2.1 Safety Precautions

1. More than 30 litres of Class-A hydrocarbon should not be stored on the shop floor.
2. Receptacles/carboys in which they are stored should have airtight lids and never be filled full. About 10% of the container volume should be left unfilled.
3. Storage exceeding 300 litres in carboys, barrels or in bulk needs a permission/licence under the Petroleum Rules.
4. The storage area should be a non-smoking zone, well ventilated, segregated and electric switches, lights etc. in the area should be flameproof.

5. Wherever a Class-A hydrocarbon is used, handled or stored, care should be taken to ensure that no possibility of ignition exists including static electricity.
6. DCP or CO_2 fire extinguishers should be available in the area where the Class-A hydrocarbon is stored/used/handled.
7. If stored in bulk in a tank, the tank should be segregated by fencing, earthed at two places, should have a vent and should have an inlet pipe going right down to the bottom of the tank. The vent outlet should be bent so that rain water does not enter the tank and it should be provided with a muffler. The dip stick and its stopper should be made of non-sparking metal. The bulk storage facility should be regularly monitored for safety.
8. Accumulation of combustible material, e.g., cotton waste, rags, wood etc. in the vicinity of storage must not be allowed.

3 Class-B and C

Diesel, kerosene, L.D.O. etc. fall under this category.

3.1 Safety Precautions

1. Storage of more than 5000 litres of Class-B and 25,000 litres of Class-C petroleum requires a licence under the Petroleum Rules.
2. The storage area should be a non-smoking zone and preferably segregated from the main work area.
3. The minimum quantity (maximum up to one day consumption) may be stored on the shop floor or main work area.
4. DCP, CO_2 or foam fire extinguishers should be available in the area where the hydrocarbon is stored/used/handled.
5. If stored in bulk in a tank (surface tank or underground tank), the following precautions must be taken.
   a) The tank should be earthed at least at two places (even underground).
   b) The area around the tank should be segregated by fencing and accumulation of combustible materials in the area must not be allowed.
   c) A dyke wall around the tank to contain spillage (if any) is a must.
   d) The tank must have a vent and level indicator (electronic indicator, gauge glass or dip stick). It is advisable not to fill the tank up to its maximum but leave about 5% of its volume unfilled.
   e) The bulk storage facility should be regularly monitored for safety.
6. Barrels/carboys containing Class-B or C hydrocarbons should be stored in specified places only and not in the general work area/shop floor.

4 Disposal of Empty Containers

The disposal of empty hydrocarbon containers can still impose a hazard if certain safety precautions are not observed.

The following procedures should be followed when disposing empty hydrocarbon containers.

1. The user should keep the empty containers at a specific place in his shop/department (where any kind of source of ignition does not exist) and inform the Conservancy Department to collect the containers.
2. The Conservancy Department shall arrange to collect the empty containers from the shops/departments, wash and shift them to the specified place in the scrapyard. Before putting the containers in the scrapyard, they need to be washed with water to ensure that no hydrocarbon vapour remains in the container.
3. A specified space to keep empty hydrocarbon containers should be allocated, segregated from rest of the scrap area. Personnel in charge of the scrapyard can ensure that combustible material, e.g., wood, cotton waste, rags etc. do not accumulate in the vicinity and that combustible scrap is kept away from the specified area. The area would be declared a non-smoking zone.
4. While selling the empty containers, the buyer needs to ensure that none of these containers contain hydrocarbon vapour and if necessary, he/she should wash the containers before collecting them from the factory.

   The seller, i.e., the employee responsible for selling the empty containers, should incorporate a suitable clause to this effect in the relevant document. The document should also make clear that the company will not be liable for any mishap involving empty containers once the buyer takes them from the factory premises.

Waste Drums and Containers

Safe operating procedures for storage, safe handling and disposal of waste containers of hazardous substances have been standardised.

1 Storage

1. A provision of a separate well-ventilated shed should be made for storage of containers used for hazardous chemicals such as flammables, explosives and toxins. Containers should be piled so as to prevent spillage of residuals.
2. The material of the container should be selected to suit the hazardous property and quantity of the material.
3. Electrical installations inside and outside the shed should be flameproof. A fire hydrant system and/or a sufficient number of fire extinguishers of the required type and size should be provided.
4. A trained and knowledgeable person should handle the store.

2 Handling of Drums

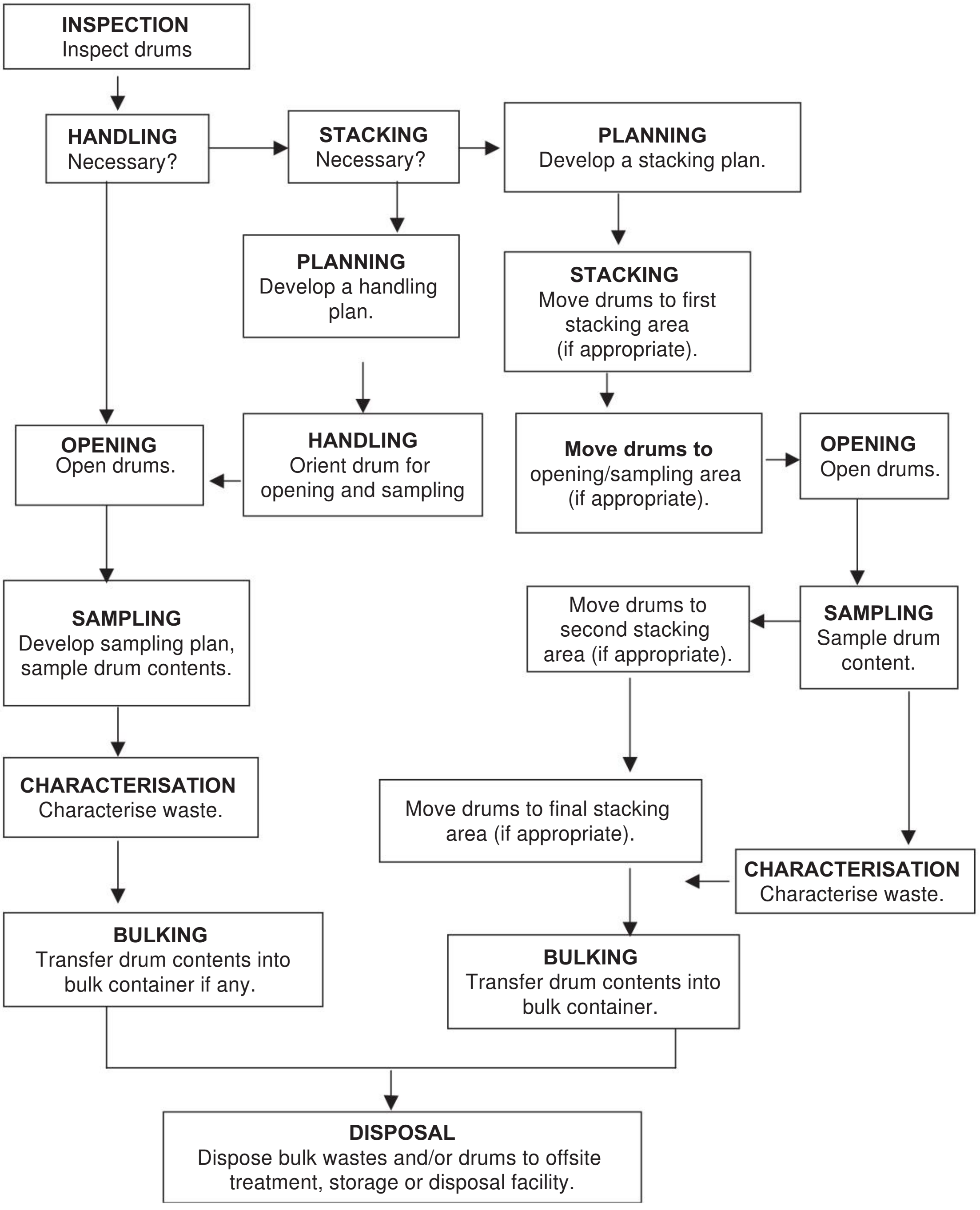
Drums or containers containing, or suspected to have contained, hazardous substances which are in use or declared as waste containers are to be handled and disposed as per the chart below.

3 Decontamination

The process of removing or neutralising contaminants that have accumulated on personnel and equipment is critical to health and safety at hazardous waste sites.

Decontamination protects workers from hazardous substances that may contaminate and eventually permeate their protective clothing, respiratory equipment, tools, vehicles and other

Safe Handling of Waste Drums



equipment used on site; it protects all site personnel by minimising the transfer of harmful material into clean areas; it helps prevent mixing of compatible chemicals; and it protects the community by preventing uncontrolled transporting of the contaminant from the site.

4 Decontamination Plan

A decontamination plan should be developed and set up before any personnel or equipment enter areas where the potential for exposure to hazardous substances exists. The decontamination plan should include the following controls:

1. Determine the number and layout of decontamination stations.
2. Determine the decontamination equipment required.
3. Establish procedures to prevent contamination of clean areas.
4. Establish methods and procedures to minimise worker contact with contaminants during removal of personnel protective clothing and equipment.
5. Establish methods for disposing clothing and equipment that are not completely decontaminated.

The plan should be revised whenever the type of personal protective clothing or equipment changes, the site conditions change or the site hazard are reassessed based on new information.

5 Prevention of Contamination

The first step in decontamination is to establish standard operating procedures that minimise contact with waste and thus the potential for contamination.

1. Stress work practices that minimise hazardous substances.
2. Use remote sampling, handling and container-opening techniques.
3. Protect monitoring and sampling instruments by bagging them. Make openings in the bag for sample ports and sensors that must contact site materials.
4. Wear disposable outer garments and use disposable equipment where appropriate.
5. Cover equipment and tools with a strippable coating, which can be removed during decontamination.
6. Encase the source of contamination, e.g., with plastic sheeting or overpacks.

In addition, standard operating procedures should be established that maximize worker protection. For example, proper procedures for dressing prior to entering the Exclusion Zone will minimise the potential for the contaminant to bypass protective clothing and escape decontamination.

6 Types of Contaminants

Contaminants can be located either on the surface of personal protective equipment or when they have permeated the PPE material. Surface contaminants may be easy to detect and remove;

however, contaminants that have permeated a material are difficult or impossible to detect and remove. If contaminants that have permeated a material are not removed by decontamination, they may continue to permeate to either surface of the material where they can cause an unexpected exposure.

Five major factors affect the extent of permeation:

1. **Contact time:** The longer a contamination is in contact with an object, the greater the probability and extent of permeation. For this reason, minimising contact time is one of the most important objectives of a decontamination programme.
2. **Concentration:** Molecules flow from areas of high concentration to areas of low concentration. As concentration of waste increase, the potential for permeation of personal protective clothing increases.
3. **Temperature:** An increase in temperature generally increases the permeation rate of contaminants.
4. **Size of contamination molecules and pore space:** Permeation increases as the contamination increases, as the contaminant molecule becomes smaller and as the pore specs of the material to be permeated increases.
5. **Physical state of waste:** As a rule gases, vapours, and low-viscosity liquid tend to permeate more readily that high-viscosity liquids or solids.

7 Decontamination Methods

All personnel, clothing, equipment and samples leaving the contaminated area of a site must be decontaminated to remove any harmful chemicals or infectious organisms that may have adhered to them. Decontamination methods either (1) physically remove contamination, (2) inactivate contaminants by chemical detoxification or disinfections/sterilisation, or (3) remove contaminants by a combination of both physical and chemical means.

7.1 Physical Removal

In many cases, gross contamination can be removed by physical means involving dislodging/displacement, rinsing, wiping off and evaporation. Physical methods involving high pressure and/or heat should be used only when necessary and with caution since they can spread contamination and cause burns. Contamination that can be removed by physical means can be categorised as follows:

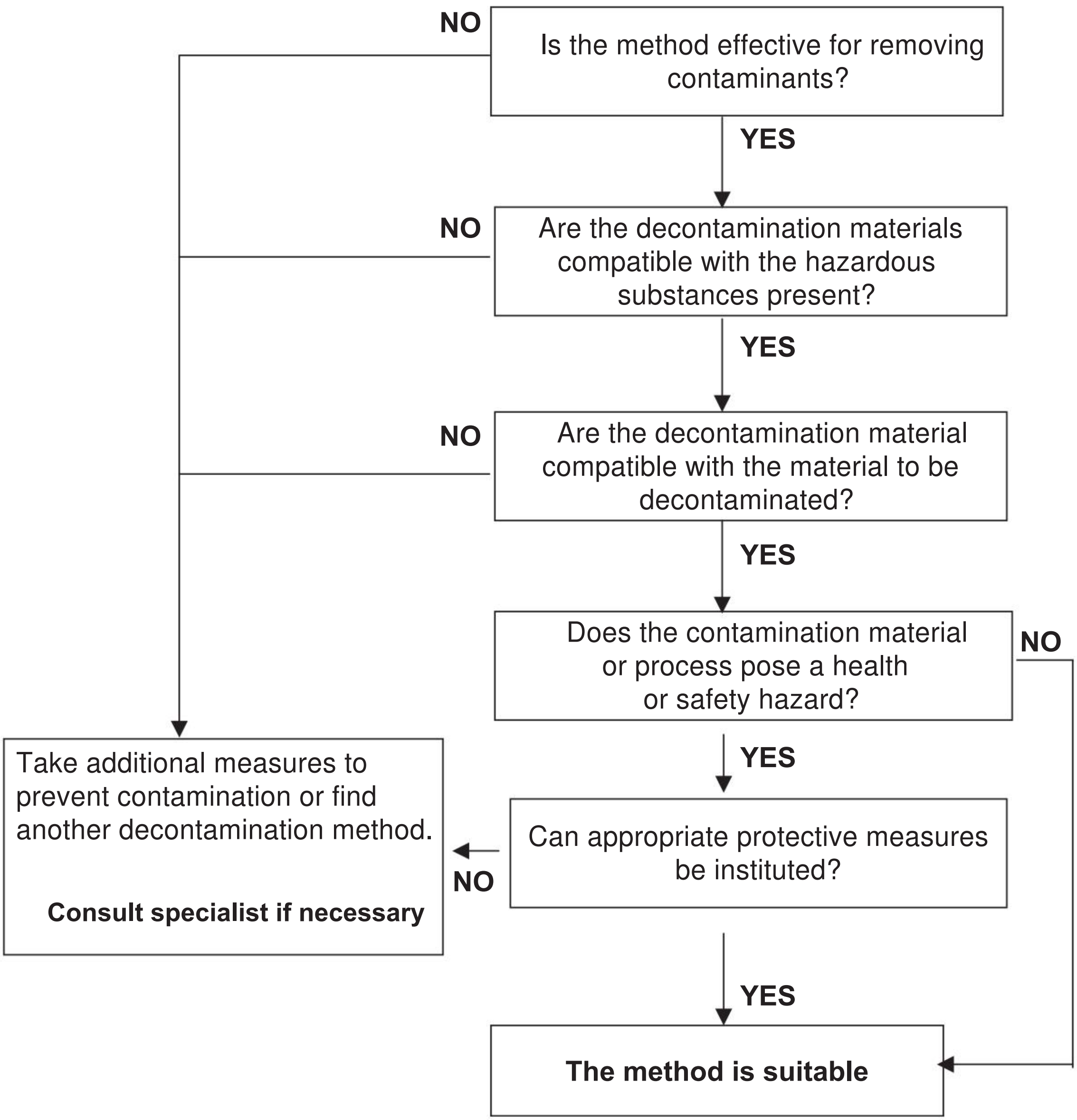
7.1.1 Loose contaminants

Dust and vapours that cling to equipment and workers or become trapped in small openings, such as the weave of clothing fabrics can be removed with water or a liquid rinse. Coating the clothing or equipment with anti-static solutions can enhance removal of electrostatically attached material. These are available commercially as wash additives or anti-static sprays.

7.1.2 Adhering contaminants

Some contaminants adhere by force other than electrostatic attraction. Adhesive qualities vary greatly with the specific contaminants and the temperature. Physical removal methods from gross

Decision Aid in Evaluating Health and Safety Aspects of Decontamination Methods



contaminants include scraping, brushing and wiping. Removal of adhesive contaminants can be enhanced through certain methods such as solidifying, freezing, adsorption or absorption.

7.1.3 Volatile liquids

Volatile liquid contaminants can be removed from protective clothing or equipment by evaporation followed by a water rinse. Using steam jets can enhance evaporation of volatile liquids. With any evaporation or vaporisation process, care must be taken to prevent worker inhalation of the vaporised chemicals.

7.5 Other Decontamination Methods

1. Contaminant removal—water rinse, using pressurised or gravity flow

1. Chemical leaching and extraction.
2. Evaporation/vapourisation.
3. Pressurised air jets.
4. Scrubbing/scraping. Commonly done using brushes, scrapers or sponges and water-compatible solvent cleaning solution.
5. Stream jets.

2. Removal of contaminated surfaces—disposal of deeply permeated materials
Disposal of protective covering/coating.

3. Chemical detoxification (inactivation)

1. Halogen stripping.
2. Neutralisation.
3. Oxidation/reduction.
4. Thermal degradation.

4. Disinfecting/sterilisation

1. Chemical disinfectants.
2. Dry heat sterilisation.
3. Gas/vapour sterilisation.
4. Irradiation.
5. Steam sterilisation.

PART **FOUR**

Accident Case Histories

CASE HISTORY 1

Bhopal Gas Tragedy

The worst accident in the history of the chemical industry occurred at the Union Carbide plant in Bhopal, India, on December 3, 1984[69].

1 About Bhopal and the Union Carbide Subsidiary

Bhopal is the capital city of the state of Madhya Pradesh with a population of about eight lacs at the time of the accident in 1984. The Union Carbide Corporation of USA established their Indian subsidiary, Union Carbide India Ltd. (UCIL) and a plant at Bhopal in 1934 to manufacture carbaryl.

Carbaryl is produced by taking methyl isocyanate (MIC), itself made by reacting methylamine with phosgene, and reacting it with alpha-naphthol, i.e.,

Monomethylamine (MMC) + Phosgene → Methyl Isocyanate (MIC)*
Methyl Isocyanate (MIC) + Alpha-Naphthol → Carbaryl.

* The storage of MIC is an integral step in the MIC process. However, it needs to be stored in minimal amounts, not more than half a ton at a time, as specified by the international standards. All over Europe the maximum permissible storage limit for MIC is observed as half a ton. The U.S. management forced the managers of their Indian subsidiary and insisted on keeping the MIC storage capacity hazardously high at over 90 tons. MIC was thus stored in three large tanks at the Bhopal plant. This led to its discharge in vapour and liquid form through the safety valve.

2 The Mishap

The shift supervisor asked an operator to wash the piping around one of the three MIC storage tanks at 10:15 p.m. on Sunday, December 2, 1984, suspecting a leak in the tank valve which was a usual phenomenon. Then the valve on the tank was blinded off to prevent ingress of water, entry of which would initiate a polymerisation reaction which is highly exothermic. (The investigation report states that water had already entered the tank.)

At 11:00 p.m. the night shift operator noticed a pressure rise in the tank. He ignored it on the assumption that it was pressurised in the previous shift for the purpose of transferring the contents to the next pesticide unit. At about 11:30 p.m. the operators sensed irritation in their eyes. They knew that it was due to a small leak of MIC. Again, that was not an unusual phenomenon to them, so they ignored it.

Temperature and pressure continued to build in the MIC tank, irrespective of water being sprayed over the tank. Pressure in the tank built up to several times the permissible limit.

3 Activities That Led To the Tragedy

The catastrophe actually began when the above-mentioned storage tank of MIC became contaminated with water and a runaway reaction occurred. The temperature and pressure rose, the relief valve lifted and MIC vapour was discharged into the atmosphere. The protective equipment, which should have prevented or at least minimised the discharge, was out of action or not in full working order. The refrigeration system, which should have cooled the storage tank, was shut down. The scrubbing system, which should have absorbed the vapour, was not immediately available. And the flare system, which should have burnt any vapour which got past the scrubbing system, was out of use.

4 The Disaster

At midnight, the undue pressure build-up in the tank burst a rupture disk, blew off the safety valve, and MIC gas rushed straight through an atmospheric vent line out into Bhopal's cool night air in the early hours of Monday, December 3, 1984, affecting innocent citizens and animals.

Many people died in their sleep because of the heavy gas cloud, which affected the greater part of the city in no time. Others woke up to intense irritation in their eyes, choking and suffocating sensation in their throats and lungs. They rushed out onto the streets, grasping for fresh air, only to make matters worse for themselves.

Over 8000 people died in the immediate aftermath. About 250,000 were left with permanent disabilities. In the year 1998, i.e., 14 years later, the death toll had risen to over 16,000. In this context numbers have little meaning as the actual figures are much more than the official figures. All the members of many families were completely wiped out. No one was left to claim anyone else. Since then 10 to 15 persons die every month from exposure-related diseases and their complications. Over 120,000 children, men and women continue to suffer acutely from a host of exposure-related illnesses and complications.

5 Management Apathy

Surprisingly, the authorities and also the top Union Carbide executives negated the seriousness of the disaster. They took the whole episode so lightly as if they were not directly concerned with it. Leave aside accountability, they were reluctant to share the responsibilities, which they obviously owed. The following are a few samples of their irresponsible actions.

1. The Chief Medical Officer and the Works Manager of Union Carbide maintained that 'MIC is an acute irritant, but certainly not lethal'.
2. The Director of Health, Safety and Environment of Union Carbide at their headquarters in Danbury, Connecticut, USA, openly denied the hazardous, poisonous and noxious effects of MIC and dismissed the chemical as 'a potent tear gas; nothing more than that'.
3. It was reported that the Managing Director of Union Carbide India Ltd., had said, 'It was an unusual incident, rather abnormal, which cannot be explained. Normally, when the gas pressure builds up it immediately gets diverted to the scrubbing system through the vent. The gas release was stopped as soon as the abnormal pressure level was detected, and the plant was shut down.'
4. The local medical professionals had to rush to the library to get the correct technical information and possible antidotes.
5. The information collected and investigations and enquiries made helped to conclude that there was no system safety engineering and management established and practised in Union Carbide, least of all in the plant at Bhopal, in spite of having a Directorate of Health, Safety and Environmental Affairs.
6. The Union Carbide management at their headquarters level as well as at their Indian subsidiary level mismanaged before, during and after the entire disaster to such an extent that there is no parallel in world history.

6 The Errors Committed by the Management

1. Adequate in-built safety systems were not provided and those provided were not checked and maintained as scheduled.
2. In all, five safety systems namely: *Vent gas scrubber, Flare stack, Water curtain, Refrigeration system and a spare storage tank* were provided in the plant. But none of these ever worked or came to the rescue in the emergency.
3. Safe operating procedures were not laid down and followed under strict supervision.
4. Total lack of 'on-site' and 'offsite' emergency control measures.
5. No hazard and operability study (HAZOP) was carried out on the design and no follow-up by any risk analysis.
6. Evacuation drills for fire and release of toxic gases were never held and practised.
7. The community living in the vicinity of the plant had never been alerted and warned about the dangers.
8. The local authorities had never been informed of the hazards so that they would know what to do in the event of such an emergency. It was the responsibility of both the local as well as

central authorities to request the management to disclose all the relevant information with regard to the major hazard installations and their control procedures, identifying key personnel responsible for taking the appropriate measures in emergency as per the provisions under the Factories Act, 1948*.

- *Danger signals and warnings were not observed and followed.*

7 A Review of the Episode

It has been reported that there were many warnings regarding the plant's potential hazards and inherent dangers from the day it was first commissioned in 1980. As a result of a serious accident in 1982 an elaborate *Safety Manual* was prepared, highlighting the various departures from recommended safe practices. The operation manual prepared for use in the Bhopal Plant, for example, spells out what can happen:

"…*The pressure in the tank will rise rapidly if MIC is contaminated.*
This reaction may begin slowly, especially if there is no agitation, but it will become violent; bulk systems must be maintained at low temperatures.
…*The low temperatures will not eliminate the possibility of a violent reaction.*
…*It will, however, increase the time available for detection of the reaction and safe disposal of the material before reaction reaches a dangerous speed.* …"

Obviously no safe operating procedures were ever followed. On the contrary such safety lapses were widespread. Warnings given by the earlier accidents, some of them fatal, had been completely ignored. While the US plant was fitted with automatic leak-detector alarms, the only leak detectors at Bhopal were the human nose and eye.

The local legislation on pollution and environmental control of chemical plant operation was extremely lax. Legislation in this regard has now become more stringent since the Bhopal tragedy. However, the implementation of the existing provisions under the law, framed by the Central Govt. act and State Govt. rules, was left to local inspectors and other such officers who did not really understand, much less appreciate, the gravity of the dangers that could arise. Moreover, bureaucratic corruption came as a convenient aid to the management to escape or shirk from the legal provisions.

8 Lessons to be Learnt

There are many lessons to be learnt from the Bhopal tragedy, but the most important is that the material, which leaked need not had been there at all. Dr. Trevor Kletz rightly says, "*What you don't have, can't leak*".

* Compulsory disclosure of information to workmen, general public, local authorities, district emergency controller and Directorate of Industrial Safety & Health.

A. *Wherever and whenever possible, we should reduce or eliminate inventories of hazardous materials, in process and in storage.* [69(I)]

At the Bhopal plant, it was an intermediate, not a product or raw material, and though it was convenient, it was not at all essential to store it. Originally MIC was imported and had to be stored but later it was manufactured on site. Nevertheless over 100 tonnes were in store, some of it in drums.

After this mishap, it was reported that Du Pont intended to eliminate intermediate storage from a similar plant they operated. Instead of storing, they now use the MIC as soon as it is produced, so that instead of 40 tonnes in a tank, there would be only 5–10 kg in a pipeline.

B. *An alternative to intermediate storage is substitution, i.e., using a safer material or route, especially when reducing inventories, or intensification as it is called, is not practicable.*

At Bhopal the product namely carbaryl was made from alpha-naphthol, methylamine and phosgene. The first two were made to react to make MIC, which was then reacted with phosgene.

The Israeli company Makhteshim worked out and used an alternative process, in which alpha-naphthol and phosgene react together to make a chloroformate ester, which is then made to react with methylamine to make carbaryl.

The same raw materials are used but MIC is not formed at all. Phosgene, of course, is hazardous and its inventory should be kept as low as possible or avoided altogether. If carbaryl has to be made via phosgene, perhaps another insecticide has to be manufactured instead.

C. *Just as "materials which are not there cannot leak", "people who are not there cannot be killed".*

A large shanty township, mostly consisting of shacks and huts, was allowed to grow adjacent and around the Bhopal plant. It was crowded and thickly populated. The death toll would have been much smaller if this town had not been allowed to grow up near the plant. In many countries planning controls prevent such developments, but apparently not in India. Though it is very difficult to prevent the growth of such hutments, it is essential to stop them springing up close to hazardous plants. Both the local government and industry should consider this issue sincerely and seriously.

D. *For major hazard installations like the Bhopal plant, hazard and operability study (HAZOP) should be carried out on the design as it is a powerful tool for identifying routes by which contamination and other unwanted deviations can occur.*

No water should had been allowed anywhere near the equipment, for washing out lines or for any other purpose, since it was well known that water reacts violently with MIC. A HAZOP study would have changed the design of water routes.

E. *Keep protective equipment in working order and size it correctly.*

- The refrigeration system, fitted with the storage tank, was not in use.
- The scrubbing system was not in full working order and incapable of absorbing the MIC discharged through the relief valve.
- The flare system was disconnected from the plant for repairs and hence MIC which got past the scrubbing system had not flared.

- The high temperature and pressure on the MIC tank were at first ignored as the instruments were poorly maintained and known to be unreliable.
- The high temperature alarm did not operate as the set point was altered and was maintained too high.

Maintain all protective equipment in full working order all the time, even when the plant is shut down.

F. *Safe Operating Procedures are to be maintained on regular schedule*

Managers at all levels should make a continuous auditing effort. There has to be a well-developed system for internal audit and it should be carried out on a regular basis, an action plan discussed and monitored. Experts in the field should carry out external audit, at least once a year.

G. *Training in Loss Prevention*

Loss prevention should be an integral part of design. Hazards should, whenever possible, be removed by a change in design, such as reduction in inventory, rather than by adding on protective equipment. The designer should not need to ask the safety adviser to add on the safety features for him; he should be taught to design a plant which does not require added-on safety features.

H. *Handling 'on-site' and 'offsite' emergencies*

A well-planned, organised and monitored 'on-site' emergency control plan is the responsibility of the individual industry, whereas the responsibility of the 'offsite' plan is with the local authorities. Unfortunately neither the industry nor the government seem to be keen on this vital aspect, far from implementing the plans or practising the drills.

CASE HISTORY 2

Gas-cutting a Contaminated Drum

1 Background

A production department supervisor of a chemical plant was in need of a medium-sized drum to use as a garbage can. He approached the stores department in search of a suitable container. The stores in-charge informed him that there were empty drums, piled behind the stores shed and he could help himself to any. Accordingly, the supervisor proceeded to pick up a small ten-gallon drum and took it to a maintenance service welder and asked him if he could cut the top off. The welder, accepting his request, told him to come after an hour or so and pick it up.

Unfortunately, the drum had been used to transfer carbon disulphide (CS_2) under the coverage of water several times from one place to another and was ultimately discarded. It was not labelled properly and if it was, the marking had been destroyed.

2 The Incident

The maintenance welder removed the top bung and was adjusting his torch to gas cut the top dish of the drum when the fumes ignited, causing an explosion and fire which blew the top off the drum. It struck the welder first on his shoulder and then the side of his neck causing severe lacerations, which partially cut his jugular vein. Fortunately his windpipe did not get cut.

Another maintenance man who was working in the vicinity had the presence of mind to rush to the injured person's assistance and hold the injured person's jugular vein tightly with his thumb and finger until the first-aid man arrived on site and treated him. They were able to stop the bleeding. Three weeks of lost time resulted.

3 Comment

The residual quantity of carbon disulphide had remained stagnant in the drum, forming a cake, trapping the CS_2. The water covering the flammable chemical, much less in quantity as compared to that of the chemical, might have evaporated. It can be deduced, from the immediate technical information available, that the CS_2 must have exploded on ignition.

The responsibility for this accident was laid at the door of the department responsible for emptying the drum and sending it for disposal without emptying it completely. The department didn't apply the laid down procedure of decontamination and proper labelling and properly instruct the stores person about the hazardous properties of the chemical for which it was used.

Furthermore, this drum was required to be set aside from the stack of other drums under a sign-board which clearly mentioned 'Not for Reuse' in a language known to all.

Standing instructions are required to be adopted and strictly followed in the case of such containers, drums or cans used for hazardous chemicals. The containers are required to be decontaminated, tested for complete decontamination and then rendered totally useless for any reuse by cutting into pieces to be disposed of in a safe place.

The maintenance department receives written instructions with regards to cutting. Under no circumstances should a waste drum used for flammable substance ever be gas-cut as was done in this case. Safe operating procedures or the standing order should emphasise that any such drum that is to be cut, must be completely filled with water first and then cut with a non-sparking tool (chisel) and not a torch.

The material and type of container used for storing or keeping the hazardous substance also plays an important role and should be considered on priority. For example, an empty mild steel drum, with bungs tightly closed, containing residual sulphuric acid, exploded with a loud noise in the vicinity of a gas-cutting and welding workplace and injured two persons with acid burns.

The drum was slightly warm from the flame used for carrying out jobs using heat in the vicinity. The heat accelerated the reaction of acid with mild steel, liberating hydrogen, which created sufficient pressure for the drum to explode. As can be inferred from the incident, a mild steel drum should never be used for acids. Also, the area around any work with heat should be kept sufficiently clear.

Tractor Overturn

1 Background

An authorised tractor dealer in North India had fixed a contract with a road-transport contractor to transport tractors from the manufacturer's base to his depot. They were also assigned the job of collecting tractors from the customers and bringing them to the workshop, attached to the depot, for repairs.

The dealer had made a two-level arrangement for loading and unloading the tractors on the truck trailer. The trailer was parked on pit-level ground with the entire length of the trailer body platform parallel and in alignment with the main ground level. With this arrangement, one side of the trailer platform remained close to and properly aligned with the ground.

This being the most convenient and safe practice to transport a maximum of six, seven or even eight tractors together at a time, the tractors were loaded onto the trailer platform from the side and kept across, at right angles to the length of the platform. On loading each of the tractors, accidental rolling forward or backward was arrested by strong wedges and by being tied together by chain slings or strong ropes.

The transporters had appointed expert tractor loaders, who were licensed tractor drivers, who had experience in loading and unloading the tractors. A cleaner to assist the driver used to travel along with the loader in the truck trailer.

2 The Incident

Six old tractors collected from the different clients for repairs in a truck trailer, were received at the dealer's depot, which had the capacity to accommodate eight tractors. The driver parked the trailer as usual in the designated place and left the premises for tea, leaving the loader to do his job of unloading the tractors.

The authorised loader was unloading the tractors from the truck trailer on to the ground in the area reserved for unloading. He unloaded three tractors from the front, i.e., engine side, of the trailer. The fourth tractor could not be moved out, possibly because the battery was down.

To solve this problem, he brought the last unloaded tractor in reverse to the front of the fourth tractor. He then tied the front of the fourth tractor, which could not be moved out, to the rear of this tractor, which he had brought in front, with a used manila rope that was found lying in the vehicle.

The loader then asked the cleaner to go and sit in the tractor that was to be moved out. The cleaner did not know how to operate a tractor or any other vehicle. The loader, therefore, showed him how to release the hand brake and bring the tractor engine to neutral.

The loader then started the tractor placed in the front and told the cleaner to put the gears in neutral while he drove his tractor to the ground to drag the tractor from the trailer platform onto the adjoining ground. In the process the rope gave way—possibly because of the jerk—and the tractor on the truck trailer rolled over in the opposite direction and overturned on the pit level ground from a height of about a meter or so.

The tractor fell on top of the cleaner, who was crushed. Apparent injuries as witnessed were crush injuries over both upper and lower trunk and limbs and contused injury to the head. A medical officer was summoned to attend to the cleaner who, after examination, was declared dead.

What exactly happened could not be ascertained as there was no direct witness.

3 Comment

It seems that the moment the loader started his tractor to drag the other tractor, it moved back breaking off the ropes. The tractor might have moved back leaving the horizontal platform of the trailer and subsequently overturned straight onto the pit ground. The cleaner might have jumped from the tractor to try and save himself and in the process might have fallen to the ground along with the overturning tractor. He screamed for help, but before any one could come to his rescue, his body was crushed underneath the entire load of the tractor.

4 Investigative Report

1. It was observed that the fixture prepared for the purpose of arresting the accidental movement of the tractor behind the trailer was not utilised at all.
2. It was further observed that the manila rope that was used to tie both the tractors was weak and old and had given way on both the sides.
3. The third tractor was positioned just in front of the tractor which rolled over and overturned.
4. The deceased was neither authorised nor instructed by the transporters or the dealers.

5 Important Note

Both the parties namely the dealer and the transporters were covered under the Shops and Establishments Act. The fatal accident was reported to the police, who were in charge of the investigation. The driver claimed that he was not present there at the time when the accident occurred. The loader did not commit to anything with regard to the factual situation. He was afraid of his own involvement and took advantage of the circumstances wherein the victim was dead and there was no direct witness to narrate what actually had happened. **This conclusion was drawn to close the case**.

The deceased, on his own will, tried to unload the tractor from the trailer without anyone's knowledge. While attempting to unload the tractor, it moved back and toppled down to the ground behind the trailer. During the unfortunate process the tractor subsequently overturned on top of him and crushed him to death.

CASE HISTORY 4

Uncalled-for Enthusiasm

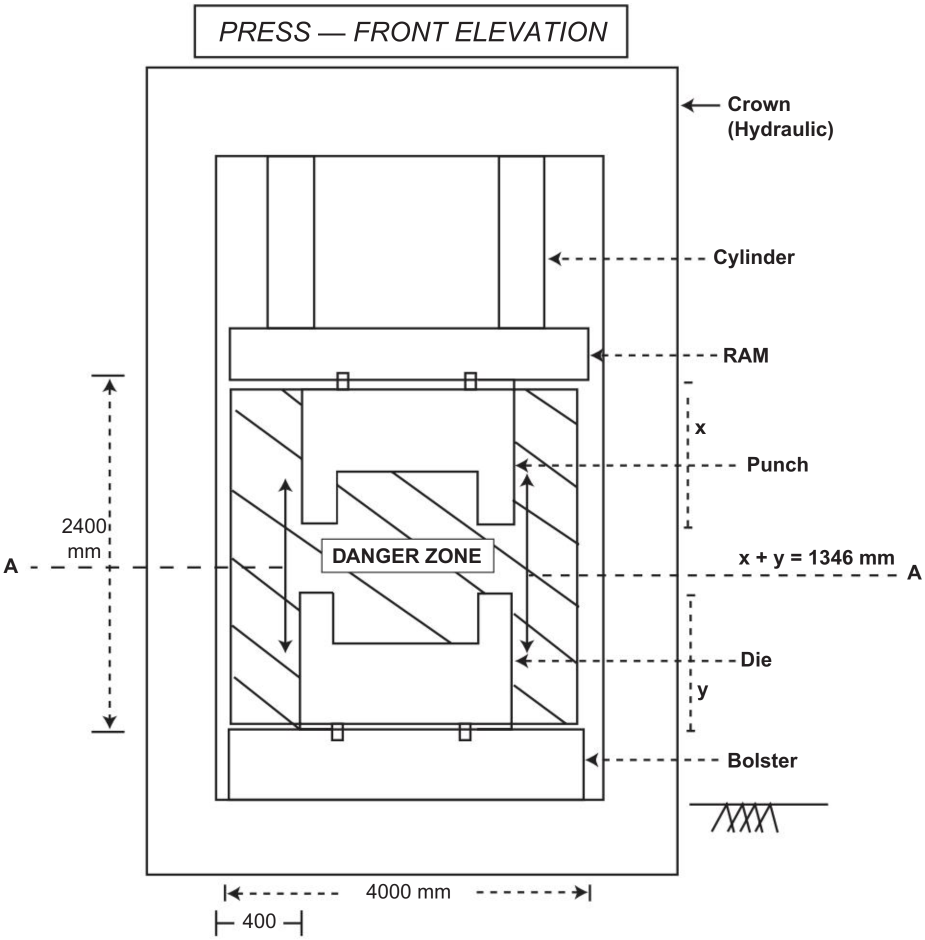
In this case history you will find that almost all the safety precautionary measures, known/studied/obligatory under the law, have been organised and implemented. In spite of which an untoward incident happened.

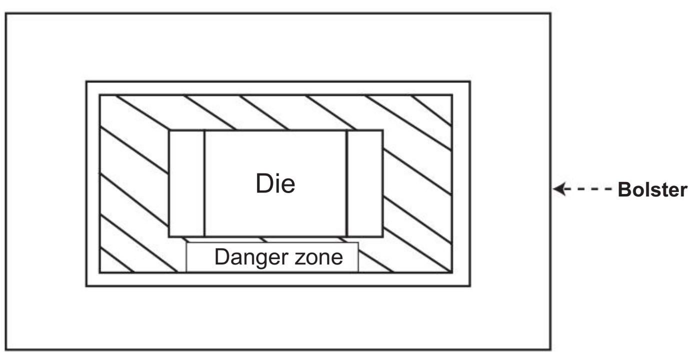
1 The Company

A large industry, manufacturing spare parts for other industries, engaged in producing hi-tech machines. The total strength of employees, including staff, is around 3,500. All the manufacturing units work in two shifts. The company procured the latest, mostly imported, equipment and machines. The senior technical staff was well trained in using them.

2 The Machine

A '1,500 Ton Press', with a crown possessing a hydraulic system, loaded with a couple of cylinders, a ram and a punch below. Down below, a die is adjusted and fixed on the bolster, measuring 3,000 mm × 2,500 mm. When a stroke is applied, the falling ram strikes the component placed on the die and the action of drawing the component as set gets completed. At this stage, the vertical distance between bottom of the ram and the top of the bolster is about 1,350 mm. [See figure given below.]





Section A-A (plan)

3 In-built Safety Devices

The press was provided with photoelectric cells which constantly cover both the front (i.e., loading) and the rear (i.e., unloading) sides of the press with light barriers so that any interruption brings the press to a dead stop in no time. There was also a provision to keep the ram locked at the Top Dead Centre [TDC]. Two sides of the press are physically locked and they always remain locked during press operations. In case they are opened—say, for the purpose of maintenance—the ram remains held up at its position.

The space between two columns of the press and the outer edge of the die was marked as a danger zone and totally prohibited for entry during the press operation. Four switches were provided at all four corners from the outside by way of an additional safety device so that the press would only be set in operation when all these four switches were simultaneously actuated by four operators located at four corners. In addition, an emergency switch was provided at all four corners. When any one was pressed, the machine tripped off.

4 Safety Training and Precautionary Measures Adopted

All the management staff and the employees operating the mechanical as well as hydraulic presses were well trained in press operation. They had adequate knowledge of all the in-built safety devices and about the safety precautionary measures to be taken, observed and monitored. Furthermore, they were not allowed to start and operate any press without strict supervision by a competent and trained engineer.

5 The Deceased

Rajaram was thirty-five years old. He was a qualified mechanical engineer and had almost ten years experience of working in industry, out of which the last five years had been spent working on presses and supervising his employees on press operation. He was safety conscious and was ever watchful to ensure that his operators never bypassed any of the safety devices and practices. Though he was very particular about his assigned tasks, his superiors, the production target and his own men, he was negligent about himself. He was in the habit of taking undue risks all the time.

He was married and his wife had delivered a child the month before. He came from a very poor family. He had to support his old parents, wife and now a child and a younger brother who was studying. No one else in the family had any income or money saved. Most of the time he was under pressure.

6 Background

With the help of his team of four operators, Rajaram had set a draw die on the press at the beginning of a morning shift. They were engaged in working with the press to draw the components to meet a deadline. After setting the die in order they started producing the parts at the usual speed.

Two operators were loading the components from the front and the other two were unloading the drawn components from the rear of the press.

After producing about a hundred or so parts, the unloading operators pointed out—as observed—that some micro dents had started appearing at various places on the surface of each of the finished parts. Rajaram immediately examined those defective parts and came to a conclusion that it could possibly be due to a deposition of some foreign particle on the die or the punch. Being conscious and sincere about quality control, he decided to search and remove the defect.

7 The Incident

Immediately, without thinking, eager to get rid of the defect and risking his life for the sake of timely quality production, Rajaram entered the danger zone inside the press crossing the light barriers around. He did not take care to lock the ram at TDC for his own protection. His experienced operators repeatedly requested him to lock the ram before entry. He neither listened to their requests nor safeguarded himself. On the contrary, he immediately instructed his men to put the press on a straight single operation panel, releasing the four corner operations, so as to make it convenient for him to survey, clean and restart the production without losing time.

He started cleaning the respective areas on the punch and the die with cotton waste and after each cleaning operation instructed the operator to apply the stroke. Surprisingly, as reported by the operators working with him, he repeated this cleaning and punching operation almost twenty times or so by entering the danger zone without locking the ram. His hurried efforts were in vain; the defect continued to appear on the production part.

On that day, at about 10:30 am, after producing almost 300 parts, it seemed that he must have got desperate to clean and remove the defect once and for all. So again he thoroughly cleaned both the punch and the die, as reported, and asked the operator to apply a stroke. The operator had moved to the panel when Rajaram must have suddenly observed something and leaned into the gap between the punch and the die when the stroke was applied. He got caught and his head and right forearm were dismembered. 'He died on the spot,' declared the Medical Officer.

8 Investigation

The subject press was thoroughly checked and re-examined for its shortcomings and pitfalls. All the safety gadgets and aspects required were provided and proved that they were in good and safe working condition. Even the experts and the implementing authorities certified so.

The deceased and the four operators assisting him were the only persons working on that press and that was the only press in operation on that day. They were the only five persons working at that time in the shop because of the urgency for that particular product that day. The only direct witnesses available were the four operators working with the deceased.

As witnesses they had undergone great mental trauma. It took a long time for them to recover. However, when they did, they confessed in confidence, individually and together, that Rajaram entered the danger zone of the press on his own, ignoring their repeated requests not to do so without locking the ram. They claimed that they were helpless as their boss was keen on removing the defect and at the same time meet the production target while maintaining the quality of the product.

9 What Was it?

1. *Was it an accident?*
2. *Was it a fatal injury directly resulting from unsafe practices by the injured?*
3. *Was it suicide?*
4. *Was it murder or culpable homicide?*

An in-depth enquiry was conducted. The direct witnesses—the four operators—were taken in confidence. All the concerned people, their relatives and the head of the department were contacted to record their psychological, social and economic background and conditions. Conclusions could then be drawn. No one in the company had ever a negative experience with the deceased. On the contrary, everyone respected him because of his sincere, honest, hardworking and helpful nature.

He was trying his best to build up his career and establish his family. Suicide was ruled out.

The deceased was under pressure. He, possibly, did not realise that he was going to sacrifice his life for taking an undue risk. To him it may have seemed a calculated risk.

"Production, Quality and Safety always go hand in hand", is a popular slogan. But, it should then be realised that under no circumstances should safety ever be sacrificed for the sake of production and/or quality.

The operator who was assigned with the job of giving the stroke merely by non-verbal signalling, had already performed the action about 18 or 20 times. The timing in between two strokes was almost the same, like a periodical cycle. When the incident occurred, the operator might have unconsciously applied the stroke, as an impulsive momentary action.

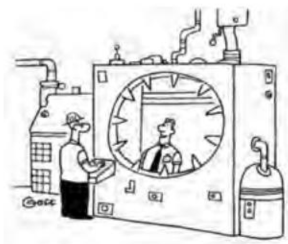
***If so, it was an accident*.**

Another probability could be that the engineer signalled the operator to apply the stroke and impulsively leaned into the gap between the punch and the die of the press, possibly noticing a foreign body on the surface of the die.

***If so, it was, a fatal injury/unfortunate incident*.**

CASE HISTORY 5

Lapse in Safety Organisation



In this case study a young person lost his life because of the ignorance of the management and the contractor.

1 Introduction

Shiva, aged eighteen years, had no formal education and got a job with a contractor on a daily basis.

A contract to replace the damaged pieces of an A.C. sheet roof on a large shed of a factory, located in the vicinity of his village was entrusted to the contractor, who accepted the contract merely on the strength of Shiva's painstaking nature. Neither the contractor nor Shiva had any experience and knowledge of carrying out maintenance work on a fragile roof. Being equally ignorant, the company management did not bother about any rules and regulations regarding the safety of the man and assigned the task to the contractor.

2 The Incident

On the very first day of this assignment, Shiva, along with an engineer of the company, climbed up onto the A.C. sheet roof of a godown, adjoining the main workplace shed. A bamboo ladder was put in place to gain access to the main shed roof. The engineer was standing on the top of the parapet skirt wall on the godown and was supervising Shiva's work.

While Shiva was trying to place the ladder properly on the fragile roof of the godown, he slipped and fell straight down onto an A.C. sheet, which broke open causing him to fall through to the concrete floor below. Unfortunately, the gunny bags stuffed with cotton waste that used to be always stored on the floor, were cleared away to make space for the idol of Lord Ganesh for a festival which was to commence within a few days.

Shiva fell head on to concrete floor from a height of about 15 ft. He sustained severe injuries on his scalp, head and other parts of his body.

The engineer shouted for help. The contractor and others rushed to the site and managed to take Shiva to a nearby hospital, where he was declared dead.

3 The Management System

None of the senior executives, namely the Works Manager, Production Manager and Personnel Manager, were available at the factory or in town. Information reached them very late.

Neither the management executives nor the contractor had any knowledge of carrying out work on a fragile roof. They were completely ignorant of the legal provisions. In addition, they did not notify the mishap to the authorities within the stipulated period.

3.1 Data That Should Have Been Collected

1. Were they, or anyone else, aware of the fact that walking or working on an A.C. sheet of a roof was unsafe and dangerous? Did they or did they not know that it was a fragile material and could give way to body weight?
2. None of the officers nor the supervisors had knowledge of the statutory provisions regarding 'working on a fragile roof', enacted under the Maharashtra Factories' Rule 73-F which requires the assigning and ensuring of the responsibilities with the job-assigners and the job-assignees by issuing and signing a safe-work-permit.
3. The provision of a 'safe walk ladder' or 'crawling board', telescopic ladder or safety belt with adequate length of lifeline and proper training to use them was not made.
4. Prompt first aid, medical help and hospitalisation were not made available.
5. Provisions of M.F. Rule 115 were not observed and followed. Notification was delayed for no reason. The occupier was served with different show cause notices.

4 Prevention of Recurrence

1. Study the provisions specified under M. F. Rule 73-F and 115. Evaluate proper work permit system for undertaking such hazardous jobs like 'work on fragile roof'.
2. Train and educate line management staff, the contractor and his workmen on the implications of the hazards involved and how to carry out the task safely.
3. Those who have been assigned the job of working on fragile roof should be well trained in the use of a 'safe-walk-ladder' or the 'crawling board'.
4. Provide, if the contractor is unable to, all the necessary safety equipment such as ladders, crawling board etc. and personal protective equipment.
5. Issue of the 'permit to work' specifying, in precise details, the job to be done, dangers involved, isolations/checks/tests to be made, safety precautions to be taken, time limits, etc., signed by the initiator and accepted and signed by the job taker.

6. Jobs are to be carried in the specified times only under competent supervision of both the management as well as the contractor.

Though this highly hazardous work has been covered under the law, it is either not known or the provisions are not properly understood. Rule 73-F of the Maharashtra Factories Rules, 1963, is also not that clear or even sufficient to protect a person from falling down. Among other omissions, it does not specify the use of safety belt while working on the roof. The terms and conditions necessary to observe during operation, are also not specified or mentioned.

The use of a safety belt with an adequate length of lifeline while working on a fragile roof might not have been made mandatory due to the problem of there being no anchor for the free-end hook of the lifeline. Is it correct on the part of the rule-makers to ignore such a necessary provision considering the number of existing fragile roof sheds at a large number of industrial civil structures? On the contrary, they should have made it obligatory to provide permanent structural members, say, a horizontal bar, a well installed pipe line or wire rope, along the length of the shed at the top of the fragile roof of every existing manufacturing shed. In addition, the new structures should not be passed without having such an important provision.

Because of ignorance, the weaknesses in the system and the law, a variety of causative factors have been observed in the following unfortunate incidents.

1. Two persons were working on an A.C. sheet roof. They were using safety belts as provided and were well anchored. All other safety provisions were taken care of. They were working under the supervision of a contractor. At about 12:45 am the supervisor signalled to them from the ground to stop work and have lunch and went away. One of the workers was sitting at that time on the crown of the king post structure with his safety belt well tied and anchored. He then removed the belt and inadvertently jumped onto the roof. Because of his bodyweight, the sheet gave way and he fell from a height of about 10 metres.
2. The Inspecting Authority was investigating a fatal fall from a fragile roof. The safety belt, which had been provided to the deceased, was exhibited as evidence. The standard hook with lock strip was missing and a wire rope coiled in the shape of a hook was used as a replacement instead. There were then many explanations that someone had changed the belt issued to the workman by mistake.

Work on a fragile roof, which is covered under the provisions of the law, is different from work undertaken at heights. Many a time they are confused. Work at heights, whether inside a factory shed (work on a crane) or outside (scaffolding—ranging from 3 metres and above, say around a tall chimney), require different precautions. Here, all possible protection is required to be provided to the persons working at such hazardous heights. Advanced safety belts with lock-in hooks, easy to anchor firmly, are required to be provided and used.

CASE HISTORY 6

Lack of Procedural System and Supervision

1 Background

In the laboratories of a large chemical plant, almost 5 litres each of concentrated sulphuric acid and caustic soda were consumed daily for the purpose of analysis.

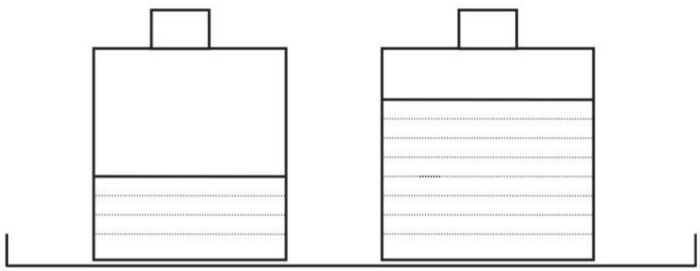
Two corked transparent glass bottles of equal size and shape were kept in a tray, at the end of a worktable in the laboratory. One helper was assigned the job of taking the empty sulphuric acid bottle in the morning to the acid storage tank, located in the sulphuric acid plant, refill it with acid and return it to the laboratory, in its place in the tray. Subsequently, he had to pick up the other empty bottle from the tray, go to the caustic soda plant on the other side, collect caustic soda in the bottle and return to the laboratory and keep it back in its place in the same tray.

The helper was fully protected as he was provided with gumboots, a rubber apron with full sleeves, hand gloves, goggles and helmet-cum-face shield. In addition, a wooden safe bottle carrier was provided for carrying the hazardous chemicals long distances to and from the lab.

2 The Incident

One day, the helper saw that the bottles were not completely empty as usual. The acid bottle was about 1/3 full and the soda bottle was almost 2/3 full. He was not aware of the hazardous properties of the chemicals nor did he even know that they were chemicals. He was not educated and the colourless, clear liquid chemicals were just simple plain liquid to him. He might have thought, instead of making two trips to go and collect the solutions from the tanks that were some distance apart, he could mix the contents of the two bottles in one and save on one trip.

This he did without asking or consulting anyone. The moment he poured the acid into the soda, a violent exothermic reaction took place and the reacted mixture splashed around. The helper was not affected because he was completely protected, but two chemists who were working in the vicinity at the analytical bench sustained severe chemical burns. One received burns on his face, neck, chest and shoulders. The other, who was not facing the bottle directly, received burns on his right arm and right thigh.



When the incident analysis was discussed in detail as a case study in the training session of an 'Accident Prevention Programme', participants came out with the following recommendations for preventing a recurrence:

1. The helper should be educated on the hazardous properties of the chemicals contained in those bottles.
2. The containers or the bottles should be kept in separate trays at separate places some distance apart.
3. The bottles should be different in size, shape and colour.
4. They should be properly labelled, preferably with a danger mark of two crossed bones and a skull.
5. Whenever a newcomer is assigned a job, it should be ensured that he is fully instructed about the hazards and the procedures.

The participants were asked, "What is your responsibility as supervisor to ensure the prevention of recurrence of such an incident?", "How do you control it in totality?" and, "Which system, management system, do you want to adopt?"

None of the participants, well qualified and experienced as they were, could suggest a proper system to ensure supervisory control to prevent recurrence.

One of the aims of the safety training programmes is to emphasise proper understanding and sharing of the responsibility in safety in unit supervision.

A simple and easy procedure, if established and followed in the safety management system, can control such a mishap.

1. A formal requisition could be printed in two different colours, one for acid and the other for caustic soda.

2. The laboratory chemist signs and issues the concerned requisition, confirming the container, label and the contents.
3. The chemist then permits the helper to take the respective container to the respective plant for collection of the required chemical.
4. The supervisor at the plant receives, signs and confirms the delivery.

CASE HISTORY 7

Static Electricity

1 Background

Hydrochloric acid was the by-product of a caustic soda manufacturing plant. It was being sold in the concentrated form. The acid was unloaded from a huge storage tank into road tankers belonging to a transport agency for delivering to clients. This was a regular practice.

The subject hydrochloric acid storage tank was laid down horizontally on a concrete foundation. It was about 40 ft long, 15 ft in diameter and was rubber-lined. It had all the safety gadgets, manholes, drain-valve and vent-lines and had been recently hydraulically tested and certified safe.

2 The Incident

On this occasion, the hydrochloric acid was being transferred to the road tanker, when there was an explosion.

The dished-end of the storage tank, fractured from its welded rim-joint, was dislodged as a result of the explosion and flew into the air in a parabolic curve to a distance of about 50/60 m from the storage tank across a road, busy with company traffic. Fortunately, no injury was reported. The dished end landed in a pile of common salt.

3 Surveillance Findings on Investigation

The exact cause of the mishap could not be immediately ascertained. A detailed investigation was conducted and a thorough study was made. Ultimately, chemistry literature on rare reactions helped. Hydrochloric acid reacts with iron and, under peculiar conditions, gives out nascent hydrogen (H^+) and forms a flammable mixture with air, which on receiving an ignition source explodes.

The entire vessel was examined from this point of view. It was found that, at some places inside the tank, the rubber lining had given way and the M.S. body was exposed to the acid inside the tank. The acid must have reacted with the mild steel (Fe^{++}) of the exposed body of the tank to evolve free hydrogen.

Static was formed by the flow of the non-conducting liquid and a spark discharged between the body of the liquid and the grounded metal container. The static spark provided the ignition source to the mixture of flammable vapour and air.

In this incident, static electricity was blamed as the cause because no other source of ignition was found. The investigators were, however, unable to show precisely how a static charge could had been formed and discharged. Thus, the corrective action emphasised on this aspect alone.

Though the tank was grounded, it was the outer M.S. shell of the tank that was grounded while the contents inside were insulated because of the lining. It was concluded that it becomes essential to earth or ground the contents inside the inner insulation of the vessel as well as the shell of the vessel, whether it is static or mobile.

Even if it was proved and concluded that a static spark ignited a mixture of flammable and/or explosive vapour and air, it is not really correct to state that static electricity was the cause of the explosion.

The real cause was the various events that led to the formation of an explosive mixture. It is the formation of a flammable or an explosive mixture that should be investigated in-depth and corrective action be monitored on this to prevent a recurrence. The frequency of examining, testing and checking the storage vessels, lining, vents, grounding, bonding and safety gadgets should be increased so that the desired safe conditions are maintained properly at all times.

4 Analysis of the Possible Causes

Hydrogen produced by corrosion is formed as *atomic hydrogen* or *nascent hydrogen* (H^+) which can diffuse through iron. This causes hydrogen to turn up in unexpected places such as hollow cavities. In this case, the rubber lining had given way at random inside the shell of the tank, exposing the inside M.S. surface to corrosion. When the acid was being unloaded from the tank into the tanker, the hydrogen could have diffused through the wall of the vessel with sufficient pressure to explode the dish-end of the tank.

$$2Fe + 3HCl = Fe_2Cl_3 + 3H^+ \uparrow \text{ (Nascent hydrogen)}$$

The other probability was that the hydrogen had leaked out and exploded due to the static that was formed by the flow of the non-conducting liquid and the spark discharges between the body of the liquid and the grounded metal vessel.

Corrosion usually results in a leak or failure of support because the vessel or support gets too thin and is not strong enough to withstand the pressure or load. However, rust can cause failure in another way. It occupies about seven times the volume of the steel on which it has formed. When rust occurs between two plates that have been joined together, by bolting, riveting or welding, a high pressure develops. This can force the plates apart or even break the bolts, rivets or welding. Taking this into consideration, another possibility could be that the welds between the dish-end and the tank body in the joint had been cracked and given way as forced by the high pressure created. It might have been a fatigue failure, caused by strain set up by repeated building up of pressure in the tank.

The exact cause of the mishap could not be ascertained immediately. A detailed investigation was conducted and a thorough study was made. Ultimately, chemistry literature on rare reactions provided a solution. Hydrochloric acid reacts with iron and under peculiar conditions, gives out nascent hydrogen (H^+), forms a flammable mixture with air which, on receiving an ignition source, explodes. From this point of view, the entire vessel was examined. It was found that at some places inside the tank, rubber lining had given way and the M.S. body was exposed to the acid inside the tank. The acid must have reacted with the mild steel (Fe^{++}) of the exposed body of the tank to evolve free hydrogen.

The surveillance findings of the experts and authorities in the field concluded that the static was formed by the flow of the non-conducting liquid and the spark discharges occurred between the body of the liquid and the grounded metal container. Herein, a static spark provided the necessary ignition source to the mixture of flammable vapour and air.

Failure to Anticipate Hazards

1 Background

A chemical complex had both sulphuric acid plants and caustic soda plants. Chlorine was a by-product of the caustic soda manufacturing plants. Concentrated sulphuric acid (98%w/w) was used to dry chlorine gas, and in the process, was diluted from 98% to 89–92%. After de-chlorination, the spent acid was returned to the acid plant, where it was concentrated again to the strength of 98% by re-processing it through an absorption tower. However, it became brownish in colour and therefore was termed as grade II sulphuric acid.

Some of the road tankers transporting sulphuric acid on contract were not kept clean on the inside and, as such, gave the clean and clear acid a faint black tinge. The occasional addition of a small quantity of potassium permanganate ($KMnO_4$) crystals into the contents of the tanker de-coloured the acid.

This ad-hoc experience, without any scientific or experimental basis, when proved result-oriented, prompted the concerned chemical engineers to experiment with de-colouring the spent or the grade II sulphuric acid. Accordingly, qualitative and quantitative tests were conducted and carried out to estimate the exact quantity of $KMnO_4$ required to de-colour the grade II acid recovered. The process control laboratory successfully estimated the addition of 0.15 kg of $KMnO_4$ crystals per metric ton of grade II acid.

The experiment was then conducted and carried out on a pilot plant scale with measured quantities of coloured acid collected in glass containers. It was quite successful as expected and was witnessed by all the seniors, including the Plant Manager and the Works Manager.

On receiving the approval from the management, it was decided to conduct this experiment on plant scale.

2 The Incident

The Sectional Head of the acid plant, a chemist, a senior and experienced operator and a helper were assigned with the responsibility of conducting this experiment on the plant scale within the acid plant itself. The helper had put on a rubber apron, rubber hand-gloves, gumshoes and face-shield, as he was to handle the acid. The others did not use any personal protective equipment.

The four climbed onto the platform located adjacent to the dome of the Grade II Acid Storage Tank with a 4-litre galvanised-iron bucket, acid sampling vessel and packs of commercial $KMnO_4$ crystals. The operator and the helper were on either side of the bucket, and the sectional head and the chemist were behind them. The helper was assigned the task of collecting the acid from the tank in the bucket by means of the acid sampling vessel through its nozzle.

About a litre or so of acid was transferred into the bucket at a time.

The operator then added $KMnO_4$ crystals to the acid in the bucket and churned the bucket along with the contents. The crystals, thus dissolved in the acid, were transferred into the tank through the same nozzle, while the acid in the tank was kept circulated by pumping. One litre of acid and two spoonsful of $KMnO_4$ crystals were successfully dissolved and added to the stored bulk quantity of grade II acid.

The third time, less than a litre was being transferred into the bucket by the helper and $KMnO_4$ crystals were simultaneously being added into the acid by the operator. This time, they decided to stir the contents inside the bucket with a stirrer instead of dissolving the crystals in the acid by churning the bucket along with the contents. In response to the decision taken by the head, the chemist turned back in search of a rod to use as a stirrer. The helper turned to the tank in order to collect the acid in the vessel for his third addition.

At that moment, some unknown violent reaction occurred in the mixture contained in the bucket and the chemicals splashed out violently, spurting all over the area and the four people.

The worst affected by acid burns was the operator. Most of the contents in the bucket had splashed directly on to his face, neck and into his eyes and, to a lesser extent, on his chest and arms. The reacting chemical mixture also spurted on the three other persons, who sustained comparatively less severe acid burns on their face, neck, chest and arms. After a thorough wash with water through a hydrant hose, they were immediately removed to a hospital for medical treatment. Subsequently, the operator had to undergo plastic surgery on his face and neck.

3 Analysis

The management called a meeting with the concerned people to discuss the cause of the mishap. The explanations offered were as follows.

1. Quite a few experiments in the laboratory, followed by those on the pilot plant scale, were carried out to de-colour the brown tinged grade II acid. To start with, standard 1 N $KMnO_4$ solution was prepared in the laboratory, which was added drop-wise to the known quantities of the spent acid collected from the acid plant storage tank. These quantities were taken in increasing order to assess the exact quantity of $KMnO_4$ crystals required for addition to a known volume of the spent acid.

2. None of these experiments ever showed any indication of an abnormal trend. No violent or spontaneous reaction ever occurred. Even on the day of the mishap, when the trial run of this experiment was conducted twice on the plant scale, the reacting chemical mixture did not splash out or even show an indication of spurting.
3. This seemed a simple and safe method of dissolving crystals of one chemical in an aqueous chemical. The only common point observed was that it required a good deal of stirring to dissolve the crystals.
4. No danger of any violent reaction was anticipated, and as such, no one anticipated the use of the required protective equipment. They provided safety wear to only the helper as he was to handle the acid.
5. The exact cause of the formation of the explosive mixture could not be ascertained at that time. It was decided to study further and stop the experiment at hand until an absolutely safe method was ensured to get the desired results.

4 Investigative Report

1. There has to be a proper sequence of charging the feed into such a large volume of a chemical contained in a tank. The persons on the job should be aware of the significance of what they are operating and the chemical properties of the chemicals they handle.
2. Any of the oxidising agents like $KMnO_4$ must first be dissolved in water and stirred well to make a homogenous solution before charging it even in a small quantity of acid in a bucket, which needs to be kept well stirred while the aqueous $KMnO_4$ is being added slowly and cautiously.
3. There is a possibility of formation of nascent oxygen, which is as explosive as nascent hydrogen.

$$2KMnO_4 + 3H_2SO_4 = K_2SO._4 + 2MnSO_4 + 3H_2O + 5O\uparrow *$$

* (Nascent oxygen)

Evolution of nascent oxygen (O^+) in the presence of moisture results in violent spurting. Addition of crystals of any oxidising agent with free moisture, as they contain water of crystallisation, should never directly be added into an acid, specially a concentrated one.

CASE HISTORY 9

Malfunction and Failure of an ID Fan

"Today we're going to talk about fall protection"

1 Background

The Fum-Ext Company from north India supplied Bharat Steel Company (BSC), located in a remote south Indian coastal area, with a Fume Extraction System (FES) Plant. Another company with a good reputation in manufacturing high capacity fans originally supplied the ID fan. A motor of 425 HP, supplied by a third reputed company, was connected to the fan through a fluid coupling of good make, supplied by a fourth reputed company.

The steel company had run the FES plant for more than six months with the originally supplied fan, which could never be run to its full capacity, as it used to create abnormal vibrations if run at more than 50% of its capacity. Thus, it was always operated to only 50% of its capacity.

The BS Company, in consultation with the Fum-Ext Company, decided to replace the fan with one manufactured and supplied by Fum-Ext Co. Subsequently, an RT-13-ID fan was supplied by Fum-Ext Co to the client with the following specifications—RPM: 1340, Motor: 425/4 pole, with standard 23 size fluid coupling.

The replaced fan was installed on the side of the previous fan using the original ducting at the inlet and outlet of the existing fan driven through fluid coupling.

The Fum-Ext Co. deputed a competent engineer to commission the plant, as requested. The fan had to be commissioned first and at the earliest so as to get the Dust Extraction System to work at its full capacity.

2 The Incident

The Fum-Ext Co engineer was in the control room. The supervisor of the contractor was adjacent to the fan. The maintenance engineer and trainee-engineer of the BS Company were moving around, observing the procedure, while the project engineer of the company was standing next to the erection contractor, away from the fan. After the installation of the fan assembly and the ducts, they were ready to commission the fan at about 11:00 pm.

After being commissioned, the fan was then run for half an hour at 50% of the speed, and was observed to be operating smoothly without any vibration. It was found satisfactory, as the previous one vibrated heavily at this speed.

They then increased the speed to about 60%, when there was a thudding sound, similar to that of an explosion. The fan broke. All the components of the fan such as the impeller, shaft, bearing, fluid coupling, fan casing, scroll etc. were shattered and scattered in a 10 m range.

The fluid coupling was thrown a distance of 3 or 4 m. The fan impeller blades had collapsed like a pack of cards. The top and sides of the fan casing were torn. The two-plummer blocks were uprooted and their castings were broken into pieces. The shaft was bent and the hub-ring was completely shorn off with the bolts intact.

The welded vanes had come clean off the fillets. The motor was observed to be moving freely as also were the plummer blocks on the shaft. The foundation bolts were not damaged.

The tragedy of the incident was that the coupling accutator hit the contractor's supervisor with such an impact that he died instantaneously.

The shattered debris of the fan including the accutator struck the others in the vicinity. They sustained minor injuries.

The RT-13 fan was installed by the side of the original fan. The new fan and a ducting were run separately. It was reported that the original fan impeller was observed to be idling slowly during the commissioning of the newly installed fan, possibly on account of the back pressure of the duct. One end of the plummer block was found thrown 4 or 5 m away and broken. The bearings however, did not seem to have been damaged.

The scroll had been ripped open at the top and bottom, indicating that the impeller had moved up and sideways before collapsing onto the shaft. Heavy rubbing was observed on the inside of scroll. However, no impeller rubbing marks were found on the drive and inlet side plates.

2.1 The Investigation Report

On receiving the information of the mishap and the fatal accident from the engineer-in-charge, a team consisting of the technical director, the works manager and the project manager of the Fum-Ext Co. visited the site to investigate.

The first part of their report described the fatal accident and the crash incident as reported by the eyewitnesses, their observations during the survey round and listed the loss of equipment and components.

They admitted that they were unable to ascertain the exact single cause or causes of the accident. However, as a result of their study and discussions, some conclusions were drawn:

1. Failure of the newly installed fan.
2. The fan hub was of cast design. The hub probably was sheared off because of its impact weakness, letting loose the impeller resulting in the crash.

3. Another probability was the sheared off plummer block castings at the mounting holes, making the impeller free.
4. Breaking of the impeller blades either due to a welding failure or a foreign body stuck in the way of its rotation. A twisted angle iron piece was found lying at the bottom of the casing.
5. Failure of the fluid coupling: The fluid coupling was connected towards the motor-side through a resilient plate. The fan-side connection was through a multiple disk assembly, fixed by six bolts. The resilient plate was completely twisted and sheared off. This could have been the starting point of the problem. Again, the same fluid coupling had been operated with the original fan for the previous six months, and proved successful in its performance, though it was always commissioned at a lower RPM.

The crash was a sudden one. There had been no prolonged noise as normally expected in a mechanical failure. No explanation was offered while analysing these cumulative factors.

3 The Probability of an Explosion

The following indications support the possibility of an explosion and not a mechanical failure.

1. Both the top and bottom portions of the fan casing were ripped off.
2. Collapse of the blades into two distinct parts.
3. The precise position of the damper openings and the suction pressure were not known though the furnace was on and some suction had already been achieved at the time of the accident.
4. The manner in which the debris scattered all around the site.

4 Surveillance Findings

A plant engineer, from a large steel company, who had experienced a similar accident at his fume extraction plant, was invited for advice and consultation. He explained the incident that had occurred at his plant, wherein the ducting had ripped open and the fan housing had bulged.

He was critical of Fum-Ext Co's erection quality and pointed out their poor workmanship in not tightening some of the foundation bolts or making use of 12 mm instead of 24 mm bolts on one of the foundation brackets. He made it clear however that this was not the cause of the mishap. On account of his experience and detailed study, he opined that the mishap was only an outcome of a CO explosion.

He had earlier advised the company management, when he was consulted and had visited them immediately after installation of the system-plant, to provide a minimum of 10 explosion doors in the ducting of the fume extraction system. He pointed out that only one explosion door had been provided on only one ducting in the entire fume extraction system despite his earlier recommendation. He added that the two explosion doors, which were provided in the scrap pre-heat chamber, were kept blocked for reasons unknown.

With all the information collected and reassessed, with the investigation reported, and discussions held, both the management of the system supplier and the user company were at a loss to assess the exact cause of the mishap, unable to take proper and adequate corrective action to prevent a recurrence.

The Fum-Ext Co's authorities contacted a Safety Advisor with the request to suggest the corrective action-plan only on the strength of their reports, sketches and photographs concerned with the mishap after a gap of almost two months, when it was too late to visit the site and the evidence was lost.

5 Comments of the Safety Advisor

With the information made available, the conclusion drawn by the consultant was that the possible cause of the mishap could only be the explosion of carbon monoxide gas which had built up in the fan chamber.

This conclusion was made from the following assumptions.

1. More information was required especially with regard to furnace conditions and operations.
2. The combustion stage on the furnace side was not known.
3. It was assumed that CO had sufficiently built up in its explosive range (12.5–74%), possibly because of incomplete combustion without maintaining a proper fuel-air ratio.
4. The passage was also obstructed by the layout of the ducting.
5. An angle-iron piece which was found damaged in the fan casing could have caused a spark, possibly after striking against other metal parts which resulted in friction.

The following information was essential for the sake of a thorough investigation and subsequent recommendations for the corrective action-plan.

- Fuel used in the furnace.
- Furnace operating procedure, inclusive of (i) firing and stopping of the furnace, (ii) auto or manual and (iii) purging cycle.
- Damper positions/locations—whether they are on both sides.
- Connection of the chimney to any other system.
- The exact situation of the furnace system condition at the time of explosion.
- Any malfunctioning of the fuel solenoid valve reported so far.
- Whether the original fan was isolated from the new fan in the complete system.
- Procedure of effective maintenance of fuel-air ratio.
- Whether all the parameters of the process conditions had been checked prior to commissioning the new fan in the absence of which a straight trial was not advisable.
- Whether the ducts had been checked for a clear and free passage and if the presence of any foreign body was ever located.

All the points mentioned above are important for an in-depth and thorough investigation as well as for a case study and hence have been included.

Personnel Management as well as Safety Professionals may perhaps be interested in the legal complications in this case—three or four companies from different states were involved. The interpretation of the state legislation differed from state to state. The main issue was twofold: (1) The payment of compensation to the family of the deceased in addition to the insurance amount. (2) Who should pay?—the supplier or the user of the fan? The exact cause—the mechanical failure of the fan or CO gas explosion—was also not properly assessed. The fatal accident occurred on the premises of the user company and under the provisions of law, they were the 'principal employer'. However, their argument was in favour of holding the supplier company responsible for the payment of compensation, not only because they were the suppliers of the equipment but they were also responsible, under their mutual contract, for erecting, commissioning and handing over the system-plant in satisfactory working condition.

6 Recommendations by the Safety Advisor of the Turnkey Project Product

A team of technical executives to be formed, preferably comprising of the Head of the Project Dept., Design Engineer, Chemical Process Engineer, Mechanical, Systems and Instrument Engineers and a Safety Professional. This committee should meet, discuss, study and make decisions on the product safety on the following lines.

6.1 In General

1. Conduct a Risk Assessment Programme, which is the process of estimating the magnitude of risk and deciding on its tolerance levels (Ref. Appendix L).
2. Every new or existing project design should be 'HAZOPED' before finalising it for its application at site. The team to evaluate and assess the hazards and recommend the necessary changes required to be incorporated in the design, rectify component failures and deviations from normal operating conditions should conduct this study.
3. Incorporate safety systems and establish control systems and safe operation procedures based on plant component design.

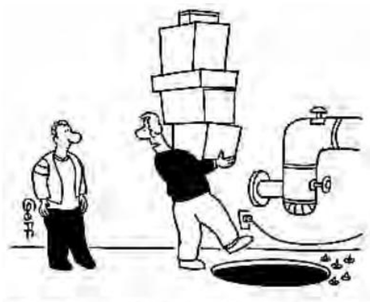
6.2 In Connection with the Subject System-Plant

1. Safe operating procedures (SOPs) of the entire system in totality inclusive of furnace and induced draft system.
2. Control measures—temperature, pressure, vents, purging, instrumentation, accidental friction probabilities and chemical process reactions—involved.
3. Safe furnace operation and complete combustion of fuel ensured prior to start-up of the fan.
4. Ensuring that the duct passages continue to remain free and clean.

5. All moving parts such as rotating blades etc should be maintained spark-proof (frictionless) by use of suitable technology such as application of non-sparking material on contact points.
6. Regular monitoring of bearing temperature.
7. Provision of standard explosion-relief doors, based on the rupture-disk principle in an adequate number of locations.
8. Total prevention of a build up of carbon monoxide in its explosive range.

CASE HISTORY 10

Faulty Handling of Equipment


"Don't worry. I know what I'm doing!"

1 Background

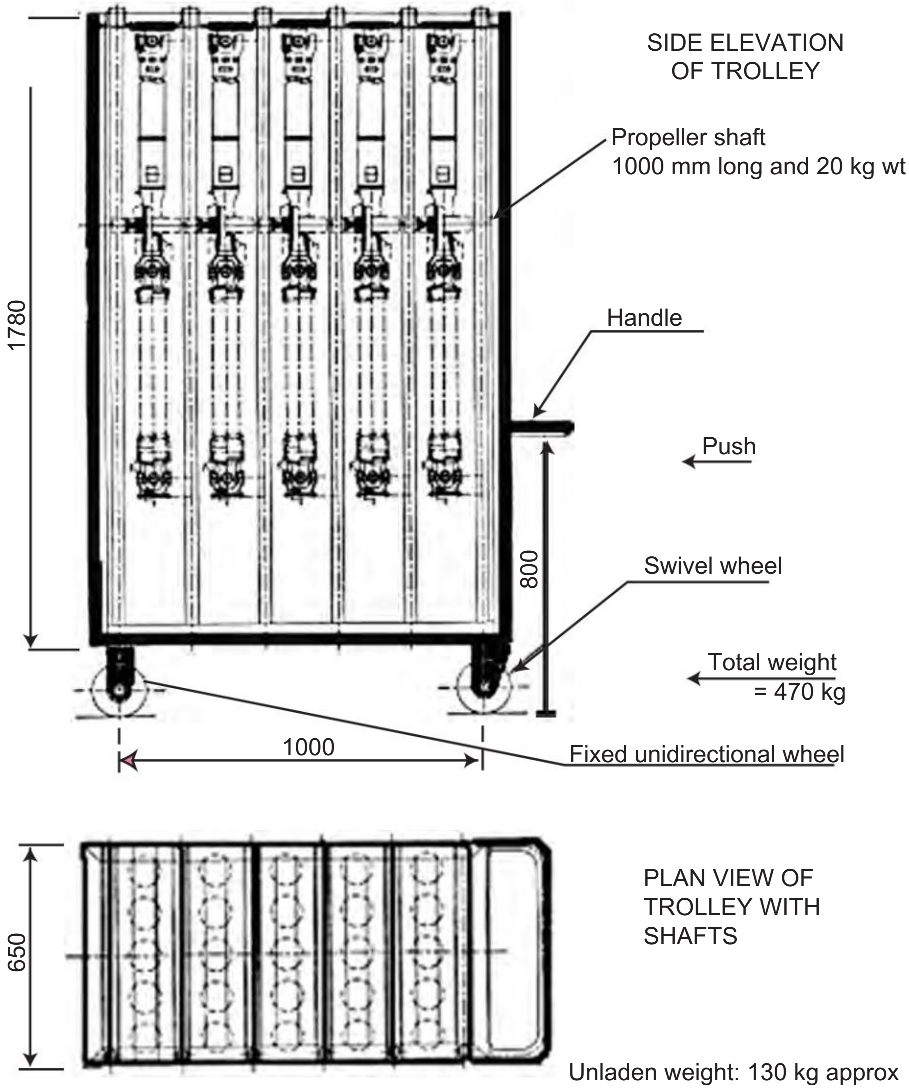
An angle-iron framed trolley (178 cm in height, 115 cm in length and 65 cm in width) weighing approximately 150 kg was designed and fabricated for transferring propeller shafts in a medium vehicle manufacturing plant. The propeller shaft, about 100 cm in length, weighed 20 kg. The trolley was designed to carry 25 shafts, vertically hung on 5 top crossed members—each holding 5 shafts. The trolley was provided with two fixed unidirectional wheels in the front and two swivel wheels at the rear. A handle, a horizontal crossbar welded across the vertical members of the trolley was provided at the height of about 110 cm for the purpose of pushing the trolley from the swivel wheel side.

2 The Incident

Two operators were assigned to transfer 20 propeller shafts, loaded in the trolley, from their section to another section. The total weight, including that of the trolley was approximately 470 kg. They did not follow the usual safe operating procedure laid down. Both the operators had never been on the job earlier and as such, the supervisor in-charge did not bother to instruct them on safe handling. They were only asked to transfer the material to the designated section.

One of them held the handle with his right hand and started dragging the trolley from the swivel wheel side while the other operator pushed it from behind, i.e., from the fixed wheel side. They pulled the trolley through their section, then entered the adjoining section on the same floor. A floor-joint in the marked passageway was damaged and had widened, creating a broken floor cavity. The trolley got stuck in this cavity and the swivel wheels turned at right angles and refused

TROLLEY CARRYING PROPELLER SHAFTS



Unladen weight: 130 kg approx
trolley for propeller
shaft assly component
trolley No. 8610
part No. YT-686 410 0102/0002
QTY. = 25 Nos.

to move. The front operator went to the side, held the trolley firmly with both hands and both of them tried to push it hard to get it moving again.

The front operator lost his balance and fell down on the side of the track. The trolley toppled over him. His back and lower limbs suffered acute contused injuries and he experienced numbness in the whole of his lower body. He was immediately taken to a hospital.

3 Observations

1. It was absolutely the wrong method of handling the trolley. The normal safe practice was to (have both operators) push the trolley holding the handle from the swivel wheel side.
2. The trolley design was faulty. The base was not sufficiently large and strong enough compared to its height, material weight and hanging lengths of the propeller shafts, to hold the centre of gravity within.
3. The floors in the entire passageway of the shop floors of different sections, and also from section to section in the plant, was not adequately straight and smooth. Quite a few floor-joints were broken.

The medical report was as follows:

- Physical examination and an X-ray of the operator's spine revealed that the operator had sustained a fracture of his L1 (Lumbar first) vertebrae. This was the basic injury sustained by him as a result of the mishap. There was no other external injury on his person.
- He was kept under observation for five days in the hospital as he showed swelling on the traumatised part of the spine. Magnetic Resonance Imaging (M.R.I.) conducted at this stage confirmed the fracture of L1 vertebrae along with spinal cord compression at the same level.
- The injured was then shifted to another hospital on the advice of the medical authorities, wherein his spinal injury was operated on by an eminent orthopaedic surgeon who specialised in spine surgery. During surgery, a lung injury on his right side was discovered and, hence, they had to put in an Inter-Costal-Drain (I. C.D.) on the same day.
- Subsequently, a Cardiac Vascular System (C.V.S.) examination, an E.C.G. and two-dimensional Echo-Card were administered which revealed that he had suffered an Antero-apical Infarction in the recent past. It proved to be a coincidental finding.
- Though it was a complicated case, he received the necessary treatment and attention. He was hospitalised for almost four months before he was declared fit.

4 Recommendations

As usual, immediate technical recommendations were made to prevent a similar accident in the future:

1. The design of the trolley was modified to broaden the base so that the trolley would not topple as it would be brought to the lowest energy state.
2. All the broken floors and floor joints were to be repaired immediately.
3. The operators were to be educated to push the trolley from the swivel wheel end by holding the handle and never to pull from the rigid wheel end.

Recommendations meant to prevent recurrence, though necessary, are not enough. If we look at the inner layers of the onion, as per the theory propagated by Trevor Kletz, more recommendations are necessary in improving the management safety system.

1. What had the system adopted for the original trolley design and the modifications suggested thereafter? Was just anyone who thought they could design such a piece of equipment allowed to do so?
2. Before any equipment is fabricated or even modified, a professionally qualified engineer who tries to make sure that the design is standard, meets the operation requirements and safety of the operator or operators, should approve the design or change. As regards modifications, he ensures that the change is to the same standard as the original design and that there are no unforeseen side effects.
3. After the equipment has been fabricated or modified, the engineer who approved it should inspect the completed work to make sure that his instructions have been followed and that the design or the change 'looks right'. What does not look right and should be checked and rectified accordingly.
4. Why was the design not carried out to a high enough standard? Who is, or should be made, responsible for specifying the standard of the original design, repairs, modifications and checking that the work has been carried out to the standard? Is anyone aware of the original design standard?
5. Earlier operators must have experienced the imbalance of the trolley. The modifications required could have been realised then and then.
6. Similarly the damaged floor-joints were also a known problem.
7. The company concerned had a separate scheme of 'internal safety audit', by which regular inspection was conducted and the findings were registered and recorded for the information of the management. Weakness in the management system is evident when they ignore or overlook such recommendations unless and until some untoward incident occurs. The questions that need to be answered here include: What can be done to improve the audits? What can be done to achieve the desired results? What would it take to get a proper response from the management on the recommended action plan resulting from the audit?
8. It is mandatory to get lifting gear (machines and tackles) and pressure vessels examined and certified by a competent authority in scheduled periods. The equipment that is neither a pressure vessel (operated at atmospheric pressure) nor lifting gear is generally ignored. Many other accidents have occurred because equipment was not recognised as fitting into the categories that should be registered and inspected or treated in some special way.
9. People should not normally drag a loaded trolley, by the handle, as if pulling a horse reluctant to move ahead. But they do. Those who designed, made or ordered, operated and supervised the trolley apparently did not know this.
10. Lack of proper education and training is an added factor. In absence of a regular operator, the job is given to a casual employee without any instructions. There was no supervision. Again it indicates a weakness in the control system.

In general, potential energy and trapped mechanical energy are as dangerous as trapped pressure and should be treated with the same respect. Before working on a forklift truck or any other mechanical handling equipment, in this case a high loaded trolley, we should make sure that it is in the lowest energy state, i.e., in a position in which it is least likely to move as it is being dismantled. If equipment contains springs, they should be released from compression or extension, as the case may be, before the equipment is dismantled.

PART **FIVE**

Accident Case Studies

CASE STUDIES

INTRODUCTION

"Today we're going to talk about fall protection"

Accident investigation and the prevention of recurrence have been discussed in detail in Chapter V, Part 3. Kletz's theory of investigation like the peeling of an onion has also been explained. Having talked about management responsibility, attitudinal problems, safety thinking, motivation, communication, training and development, the question, "How can we encourage employees to look for underlying causes?" remains to be answered.

It is essential, in the first place, that the employees be convinced that the underlying causes exist and that it will be helpful to uncover them. A good way to create awareness is by discussing accidents that have occurred and the action needed to prevent them from happening again.

The committee chairman or the discussion leader describes an accident very briefly. Those who are present question him to establish the rest of the facts, and then say what *they think* ought to be done to prevent a recurrence. The accident cases may be drawn from any source; cases in this book may also be used. It is better, however, to use incidents which have occurred in the plant where members of the discussion session work.

Some members may concentrate on the immediate causes of the incidents discussed. In this case the discussion leader should then encourage them to also look at the wider issues.

When fresh accidents have to be investigated, it is helpful to have at least one person from another part of the organisation in the investigating team. Such a person is more likely, than those closely involved, to see the wider issues and the relevance of the incident to other plants. In time, it becomes second nature for people to look for the less obvious ways of preventing accidents, either in discussions or in real situations and continue to do so without prompting.

While no index of the standard pattern or kind can hope to be infallible, the contents of the case studies provided have been compiled and organised to provide basic assistance to those searching for accident cases for the sake of study.

CASE STUDIES — A

Process and Chemical Handling

A-1 An Unexpected Chemical Reaction

At a certain plant carbon disulphide is manufactured by reacting sulphur with calcified charcoal at a very high temperature which is attained from an electric arc, produced between two electrodes—anode and cathode—in an electric furnace. The furnace is worked only for a scheduled period and then switched off for cooling and cleaning. When the temperature inside the furnace comes down to room temperature, two trained operators, well protected by necessary safety equipment, go inside through the manhole at the bottom to dig and shovel out the hardened residual mass from the furnace base. They work inside for half an hour and come out for fresh air while another team of two operators replace them and continue the work.

The hard mass thus dug and thrown out of the furnace is removed and collected a distance away so that it can then be gathered in bulk and be disposed of or dumped into the marked ditch yard. The mass of waste residuals from the furnace gets hardened over a period of days, forms a huge heap and requires further digging and shovelling to collect and load it into a truck to transfer it to the scrapyard.

On one of the monsoon days, a contractor's employee was found lying unconscious on the heap of furnace waste residues, with his equipment strewn around. No one knew how long he had been lying there in that condition as the place was isolated and remote. He was removed to the company's hospital, where he was declared dead. At that instance, it was assumed to be a natural death, possibly due to a massive heart attack.

The post-mortem report confirmed death due to asphyxia, caused by an overdose of poisonous gas. The waste material had always been dumped at that location. It was in the open and no other chemicals or chemical wastes were ever dumped there. The immediate inspection and investigation did not disclose any valuable clue to ascertain the exact reason.

Hydrogen sulphide gas, which evolves in the process of forming of carbon disulphide in the furnace, remains trapped in the residual mass at the bottom of the furnace. When the solidified mass is broken into pieces, hammered or dug out, the entrapped gas escapes. It is more likely to escape in wet conditions. On that day, it had rained heavily before the deceased had been there to work.

A-2 Expect the Unexpected

In a plant manufacturing rayon textile yarn, a viscose solution comprising alkali cellulose dissolved in caustic soda lye is passed through a spinning machine jet, immersed in the bath of clean dilute sulphuric acid.

$$\text{Viscose} + H_2SO_4 \rightarrow \text{Yarn} + Na_2SO_4 + H_2O + CS_2\uparrow + H_2S\uparrow$$

After the separation of sodium sulphate salt and sulphuric acid in the slurry collected from the spinning machine, through the filtration process in the Rotary Vacuum Filter, the recovered acid, spent acid, is stored in the spent acid tank and filtered through Columbia filters, concentrated to the desired level, stored in a clean acid tank and, from there, reused on spinning machines.

Four large rectangular tanks were provided in the basement of the spinning room, two for storing spent acid and two for clean acid, in a row adjacent to each other. One of the spent acid tanks was taken out of circulation for maintenance. The tank was thoroughly emptied, isolated from inlet lines, and was to be cleaned manually from the inside. A safe-entry-permit was procured with the gas concentration, tested and certified, to be within threshold limits.

After an hour or so of working inside the tank, the workman on the job of cleaning was observed, by the supervisor, to be lying flat. Realising the gravity of the situation, the supervisor rushed into the tank to rescue the workman. He also became unconscious and fell down inside the tank. Others working nearby rescued both the affected persons in time, making use of self-breathing apparatus during their rescue operation. Both victims survived on receiving immediate first aid followed by medical treatment in the hospital without any loss of time.

The hold up in the adjacent spent acid tank had increased to a greater extent during the one-hour period while the workman was cleaning the other tank. H_2S gas liberated from the tank, being heavier than air, spread out and entered the empty tank.

A-3 Lack of Safety Procedure

A road tanker filled with strong caustic soda (47%) lye was parked in the tank yard on the premises of a hazardous chemical factory at about 6:30 p.m. on a working day. The general shift was over and most of the responsible senior persons had gone home. This delivery was expected earlier or if delayed, the next day. However, for reasons not communicated, the tanker was sent by the transport agent late in the evening. Not only was it allowed to enter by the security but it was also allowed to unload by the production shift in-charge.

The driver parked the vehicle in its usual place and went away, asking the cleaner to unload the chemical into the tank of the factory. The vehicle had a compressor on its chassis. However, a compressor from the maintenance department was used for decanting the chemical from the tanker truck to the static tank. The cleaner, who was standing on the body of the tanker, inserted the free end of the hosepipe, connected to the compressor, onto the protruding vent pipe of the tanker. The caustic soda lye was to be decanted from the tanker to the tank under compressed air pressure.

With this arrangement, the cleaner shouted and signalled to the operator to start the compressor. The operator, without checking the procedures that were required to be followed, started the compressor. Within a minute or so, the hose end on the vent of the tanker body snapped off and the caustic solution splashed out, spurting all over the face and upper body of the cleaner who, at that time, happened to be leaning over the vent. Because of the sudden spray he panicked and jumped down to the ground.

A few workmen who were working in the vicinity rushed to help the injured. They washed him with water through a hose, connected to a water tap nearby. They did spray water on his face but neither he nor the rescuers tried to open his eyes during the wash.

The chemical burns he sustained on his face, neck, shoulders, arms and chest were minor compared to his eye injuries. He sustained minor scratches and cuts on his legs and buttocks because of jumping down onto the rough ground.

Proper first aid had not been administered to him in the absence of a medical officer, nurse or a qualified first-aide. Most importantly, his eyes did not receive the adequate and timely first aid they required. Quick arrangements to take him to a hospital to get him prompt medical treatment were not made. They first took him to a nearby clinic, where the doctor advised them to take him to a good hospital to ensure immediate treatment by an ophthalmic surgeon.

In spite of that, it was almost six hours later that the injured was admitted and examined by a competent ophthalmic surgeon, who after a thorough examination and adequate tests, arrived at the conclusion that his left eye was completely damaged and offered no guarantee of any recovery of vision, even after performing surgery on that eye. However, the surgeon opened that recovery of partial vision of the right eye was possible and immediately operated on it. As predicted, the injured lost the use of his left eye completely and regained about 50% of the vision in his right eye.

Investigative Report and Findings

1. The compressor was started without opening the bottom transfer valve.
2. The hosepipe end was only inserted on the vent-line and not clamped firmly onto the vent pipe.
3. The cleaner did not protect himself with helmet-cum-face visor, goggles, rubber apron, hand-gloves and gumboots as required.
4. There was no supervision by competent persons from both sides, the company as well as the supplier and/or the transport agent.
5. The security guards permitted the tanker to enter without written permission or any procedural authority.
6. The risk of unloading the tanker after the general shift was taken by the production chemist against the standing safe operating procedures without seeking permission from the department head.
7. No entry was ever registered as regards the tanker, driver, cleaner, supplier or transport agency. It was a task in itself to get the necessary details the next day in order to complete the notification formalities.

8. Pressurising the chemical by means of compressed air pressure started before opening the bottom transfer valve, which in effect pressurised the chemical and resulted in the snapping off of the loose hosepipe, leading to eruption of the chemical out of the vent which was the only available passage.
9. The tank of the truck was filled to capacity as against the standard practice laid down to leave minimum empty margin of about 20% for evaporation.
10. The standard safe procedure adopted and recommended is to transfer such a chemical by gravity, never under pressure.
11. The tanker was not well equipped with personal protective equipment and safety garments required by the operatives nor was the 'Hazchem' card carried in it. Security guards did not check for the same.
12. The 'Permit-to-work' system was not in force for 'Unloading Hazardous Chemicals'.
13. Neither the staff of the company responsible nor the driver and the cleaner were ever trained in carrying out such hazardous jobs.

Had there been someone who would have forcibly opened the eyes of the injured and washed them thoroughly with water by taking him to an eye-fountain or by pressurised water-jets, continuously for not less than 20 minutes, his eyes would not have been damaged to the extent that they were.

Secondly, the injured should have been taken to the eye-surgeon immediately after washing his eyes in opened condition. His eyes would have been saved to a greater extent, possibly by 90-100%.

A-4 Potential Hazard Not Considered

A horizontal concentrated sulphuric acid storage tank, measuring 9 ft in length and 5¾ ft in diameter, was located on the sulphuric acid tower at a height of 60 ft outside a chemical plant. It was to be replaced as it was old and corroded. Hence, it was emptied by draining off the acid completely, washing it over thoroughly and dismantling it from its structural members.

The sludge that remained at the bottom could not be flushed out nor could it be neutralised at that height. Hence, a metal tray was welded onto the lugs below the tank as a precautionary measure to collect the sludge, if it leaked down during transit while the tank was being lowered. All the pipelines connected to all the tanks on the tower were blocked and blanketed.

A team of 14 *khalasies*, one *mukadam*, one fitter and an assistant fitter was assigned the job of dismantling and lowering the tank from the top of the tower down to the ground under the direct supervision of the Deputy Chief Engineer and his Assistant Engineer.

An adjacent overhead projection structure was provided for the purpose of lowering the tank after dismantling it. Taking the tank down from the structure was organised with the help of a chain-pulley-block and the multiple-chain-pulley-block arrangement, tied firmly onto the projection structure. The tank was to be guided by means of guy wires (steel wire rope ¾ of an inch in diameter) taken through a crab. Plank pieces were provided, which were tied onto the cross members of the structure at a height of about 20 ft, for two *khalasies* to stand on and guide the lowered tank with the help of probe-rods.

As per the planning, organisation and various arrangements mentioned above, the tank was dismantled and was being lowered. When the tank was brought down successfully to about 20 ft above ground level, one of the corners of the welded metal tray dashed against the tee joint of a 1 inch diameter vertical acid inlet line that was running vertically parallel to the main tower structure. A horizontal branch inlet to one of the acid tanks installed on the same tower was also connected to this vertical line by means of the same tee joint. When the tray dashed against it, the tee joint gave way and the residual hold of strong sulphuric acid in that line splashed out onto everyone working there.

The two *khalasies*, standing on the plank platforms, received severe burn injuries on their face, arms, chest and legs. Their eyes were badly affected. Eight others sustained comparatively minor acid burns.

Comment

Adequate precautions were taken to dismantle and bring down the tank from such a height, after thorough thinking, planning and organising. Adequate spacing was also planned to keep the tank away from the main tower structure while lowering it. However, the possibility of the heavy tank swinging in transit was not considered.

A-5 Possibility of a Toxic Gas Leak Not Considered

A 40,000 gallon tank was located and joined to other process chemical tanks with all the necessary equipment and gadgets in a chemical complex. This tank was used to collect acids in measured quantities from other tanks for the purpose of mixing them. A power driven agitator was installed in the tank. The chemical operation involved evolution of hydrogen sulphide gas.

The mixing equipment projecting into the tank had to be repaired. A contractor was brought in to perform the necessary repairs. Prior to the entry of the contractor's men into the tank, it had been completely emptied of any residual chemicals, cleaned thoroughly, flushed and checked for the presence of hydrogen sulphide gas. A safe-entry-permit was issued with the certification that the gas concentration of H_2S was below the Threshold Limit Value and it was therefore safe to enter and work.

After being assured that the tank was clean and clear, the contractor's men, along with the plant's maintenance service people, entered the tank and worked on the equipment. At lunch time all the people, with the exception of one of the contractor's men, left to eat. During this time the production supervisor instructed his operator to fill in a head tank with H_2S. His intention was to be ready to start operations shortly after lunch.

Soon after the head tank had been filled, the supervisor happened to look into the tank only to find the contractor's man lying flat at the tank bottom. The operator stood by as the supervisor entered the tank to rescue the victim. The supervisor also collapsed at the bottom.

The operator shouted for help. Immediately people rushed to the site and managed to procure suitable gas masks and safety belts. With the use of gas masks and lifelines both the victims were removed from the tank into fresh air.

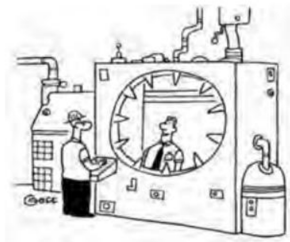
The contractor's man was pronounced dead on arrival at the hospital and the supervisor was in a very serious condition.

Investigative Findings

1. It was determined that hydrogen sulphide had leaked through a pump from a head tank and into the mix tank. Both men had been overcome by H_2S in almost a fatal dose.
2. The contractor's man died before reaching the hospital, possibly because of his prolonged exposure to the noxious gas in such a high concentration, whereas the supervisor survived as he was immediately attended to.
3. The Work-Permit-System was not up-to-date and systematic. The following were the shortcomings in administering and monitoring the desired norms and conditions of the Safe-Entry-Permit:
   a) Failure to disconnect and blank off all inlet lines to a vessel when required to be entered for cleaning or repairs.
   b) Failure to suggest and provide normal protective equipment to the men entering and working inside.
   c) Failure to supply fresh air inside the tank, by a forced ventilation draft, while the men are inside.
4. No observer was posted outside to watch and hold the free end of the lifeline for the person inside, to pull him out in case of emergency.
5. Proper controls and check procedures to be put into effect before allowing persons to enter the confined space were not set and implemented.
6. Lack of adequate education and training to the supervisors and employees, both of the company and the contractor, regarding the Work-Permit-System and the Emergency Control Measures.

CASE STUDIES — B

Machines and Equipment



B-1 Faulty Plant Layout

A moulder, employed in a foundry, was working in the second shift. He was assigned with his regular job of sand-mix preparation at a mixer located on a platform, at a height of 3.25 m above floor level.

He stopped at about 6:45 p.m. to go to the canteen for dinner. He returned to restart his work at about 7:30 p.m.

One of his co-workers realised at about 8:30 p.m. that the sand-mix operation was not in progress. Hence, he went to search for the moulder. He also wanted to find out why the routine operation was not commissioned. As there was no response from the moulder, even after shouting for him, he climbed up the cat ladder and went onto the landing platform, 0.75 m below the platform of the mixer.

The co-worker was shocked to see the moulder lying awkwardly on the end unit of the conveyor belt and drum assembly. The conveyor belt was installed parallel and adjacent to the intermediate platform. It was also observed that the conveyor system had already tripped off.

Sensing the horrible situation, the co-worker shouted for help. Immediately, the assistant manager, who was in charge of the shift, and others working in the vicinity rushed to the site and tried to rescue the victim. It was very difficult as his body was partly entrapped in between the belt and the drum. There was no alternative but to cut the belt. They did so and immediately took the injured to a hospital, where he was declared dead.

The sand-mix preparation plant was a highly congested place, located in one of the corners of the foundry. A cat ladder had been provided for approaching a platform at 2.5 m height. This was a landing platform with a provision of two further end steps leading to the intermediate platform, located at 3.25 m. The sand mixing equipment was installed on the same elevation but on the other side of the conveyer belt.

The deceased was assigned with his routine job of preparing a batch of sand-mix to feed the mixer. It was presumed that while approaching the mixer on the other side of the conveyor he might have had slipped on the steps leading from the landing platform to the mixer platform. Unfortunately, there was no one working with him and there was no direct witness to this mishap.

The conclusion was drawn on the following information collected during the investigation.

1. The conveyor system was in operation and, as a result, he might have been crushed in the belt and drum assembly.
2. One of his slippers was stuck between the two steps.
3. The layout of the plant was clumsy and congested.
4. Housekeeping was poor—steps, floors and platforms were slippery. The entire area was full of sand particles.
5. Lighting facilities were inadequate. It was dark at the time.
6. The cat ladder and the steps were not provided as per the standard provisions. They did not have the specified standard slope and side railings.
7. Safety shoes were not provided.
8. The moulder was the only person assigned with the job at that time.
9. There were no barriers or railing-cum-partition between the conveyor system and the platform to protect operators.

B-2 Lack of Adequate Communication

A water cooler tank was located on a huge I-beam structure, erected on the terrace of a five-storied plant. The cooler tank was 22 ft. in height and 15 ft. in diameter. The height of the M.S. structure foundation of the cooler was 20 ft., well grouted on the top of the terrace. It was provided with a cat ladder with steps, side railings on both sides and proper landing platform.

The diameter of the cooling fan was 12 ft. and that of the hub was 2 ft. It was well supported by a crossed I-beam structure. The parapet skirting on top of the tank was quite thick, about 1 ft. in width. A switch for the fan was provided at the bottom of the tank structure and the main switch was in the cabin of the shift-chemist on the first floor, just above the basement.

One day, as the cooler fan was noisy and distorted in its rotation, the production shift chemist complained of the problem to the maintenance department. The foreman inspected the fan and reported to the chemist that he would attend to it the next day.

The next day, the foreman and his assistant reported to the chemist. The chemist switched off the main switch located in his cabin and permitted the foreman to go ahead.

Both the maintenance people went up onto the terrace, climbed up the ladder and approached their place of work on top of the cooler tank. The fan had already come to a dead stop. The foreman, with his toolkit on his back, crawled over one of the crossed I-beams and positioned himself onto the hub. The assistant foreman sat on the parapet skirt wall of the cooler with the new fan blade and other tools.

While he was engaged in loosening the nuts and bolts of the damaged fan blade, the fan started rotating with a rattling noise. The foreman lay down grabbing the rotating hub and shouted for help. The assistant foreman panicked and, forgetting the switch below, ran all the way from the terrace down to the shift chemist's cabin. Another chemist had been there who had absolutely no knowledge of the problem with the cooler fan and the repair work being undertaken by the maintenance crew at that time. The main switch was switched off. The foreman was safely brought down.

B-3 A Makeshift Arrangement

An engineering company purchased a honing machine for its machine shop. As a part of after sales service, Freon gas was to be filled in the compressor of the hydraulic oil cooler units of the honing machine by the suppliers. The service engineer and a skilled operator of the servicing company attended to the job along with a maintenance engineer of the company owning the machine.

They suspected a leak in the system. In order to locate the leak, they filled the condenser copper coil assembly with oxygen under pressure of about 160 kg/cm^2. They filled up the copper assembly directly from the oxygen cylinder under pressure, dismantling the regulator assembly along with the pressure gauge. Hence, the pressure at which the gas was filled could not be properly assessed.

A minute hairpin leak at the bottom elbow joint of the coil was located. They then brazed the leaky portion with an oxy-acetylene brazing gun. During this process, possibly because of the sudden rise in temperature, due to the use of the direct oxy-acetylene flame onto the coil, the oxygen gas that was filled in the coil under pressure, exploded with a big bang, shattering almost all the copper coils of the assembly into pieces.

A few pieces of copper of aluminium struck both the engineer and the skilled operator of the servicing agency. Between the two, the operator sustained more severe impact injuries. The operator's eyes were directly affected. He was hospitalised and underwent surgery on his right eye. Even with all the medical treatment he received, he permanently lost sight in the eye.

The qualified, experienced and trained technical people attending to the hazardous job at the client's premises did not follow simple safety precautionary measures.

1. Oxygen under pressure was used in place of an inert gas like nitrogen, for example, to test a leak in the system. (Investigation revealed that they did not bring a nitrogen gas cylinder with them and when one was asked for from the client, it was not made available, whereas an oxygen cylinder was readily available. So they decided to use oxygen.)
2. Even though oxygen was used, they did not release the pressure after locating and before closing the leak by carrying out the hot work on the coil by brazing.
3. Testing by pneumatic pressure should be avoided. Testing by hydraulic pressure is safer and recommended. In case this is not possible, testing should never be carried out by pressurising the system or equipment by any gas other than an inert one like N_2 or CO_2.

Utmost care must be taken to ensure that the entire system or equipment has been thoroughly evacuated and freed from any residual gas, flammable or non-flammable, before carrying out any hot job like welding, gas-cutting or brazing.

B-4 Lack of Work Organisation

An earth-boring operation was in progress with a mechanised 'Voka' grinding machine. The workmen working on the machine placed a heavy mild steel structured stand with a platform at the top, 3 m in height and 500 kg in weight, nearby to use as scaffolding.

The grinder was equipped with a boom, capable of pivoting and telescoping. The victim was acting as the 'observer' for the persons working in the confined space and another skilled operator was operating the grinding machine. Both these experienced people inadvertently placed and positioned the heavy scaffold-stand in the path of the rotating boom. The morning shift was over and another skilled operator took over the charge of the grinding machine operation.

The second shift operator started changing over the grinding disks. As he attempted to re-position the grinder to facilitate the changeover, he had to rotate the boom to gain access to the grinder. The observer was facing the confined space with his back to the boom and the stand. It did not occur to any of them that the stand was in the path of the boom. The boom, in its usual rotation, struck the stand hard, toppling it onto the observer and striking him on the back of his neck. He collapsed and died on the spot.

B-5 Transfer of Technology Versus Suitability of Application

This incident occurred in a company that manufactured skin parts for automobiles. The company had a big press shop set up with a large capacity of Power Press machines. The press on which the accident occurred had a bolster size approximately 4 m in length and 2 m in width. The die, which was to be loaded, was approximately 3 m in length and 1.8 m in width.

The company had a huge number of dies, most of which were purchased through vendors or were custom made as per the part details from foreign vendors.

The operator had only five months of experience working on the Power Press and was loading the die on to the machine by means of an EOT crane. The die was about to be loaded from the rear of the press and the engineer, knowing the cushion pin layout, instructed the operator to turn the die on the EOT crane and load it on to the bolster. The operator turned the die on the swivelling hook of the crane and the upper and the middle shoes of the die came off and fell on the operator's feet. The operator, who was observing the die, was about to fall and tried to run away but stumbled against a material pallet in the path and fell down sustaining multiple injuries on his head.

Investigation

1. Prima facie, there was no evident fault on the die, but later on, when the die was again loaded on the EOT crane in a repeat action, it was observed that the lifters were not equidistant from the centre of the die. Due to this, the die became imbalanced when it was rotated, resulting in the upper and middle shoes falling down.
2. The guide was inadequate in length and it did not hold the middle and lower shoes intact.
3. The subject die, like a few others, was manufactured and used abroad. This die was transferred to the company during technology transfer.

B-6 Collapse of a Jib Crane

Two operators were operating a Goliath crane in an engineering shop which manufactured mini-boilers. When the crane approached the location of a Jib crane at the end of the huge shed, they heard a loud bang. The Jib crane had dislodged from its foundation and fallen down on its side with the base plate uprooted.

It was reported by the operators that the boom of the Jib crane, which was moved by them earlier, was found in its steady position in the gap between the structural members of the Goliath crane and the shed. An unusual clear distance between the vertical structural member of the Goliath crane and the tilted boom of the Jib crane was observed.

The plant manager and these skilled and experienced operators decided to lift the Jib crane to make it stand erect. They first unloaded the element from the Goliath crane without moving the crane further to prevent it striking the Jib crane. They then fixed the lifting hooks onto the span of the Jib crane. When they lifted the Jib crane, it gave way completely from its foundation plate and collapsed on its own. The free end of the boom struck against the floor in the gap between two structural members. This time the boom brushed heavily against the vertical structural members of the Goliath crane and ultimately got jammed in between.

The exact cause of the mishap could not be ascertained though many possibilities were considered:

- The Goliath crane may have struck against the boom of the Jib crane, pushing the hoist-chain-pulley block on the boom and dragging it which resulted in the collapse of the Jib crane.
- The unsafe practice of pushing the Jib crane boom aside with the help of the Goliath crane, instead of positioning the boom in its safe place prior to the movement of the Goliath crane.
- Constant mechanical stress on the Jib crane structure that accumulated due to abrupt hammering in one direction could have resulted in weakening the foundation fixtures or loosening the bolts. Scratched-off paint on the Goliath crane structure at the level of Jib crane boom and the boom itself support the unsafe practice being followed earlier.
- On examining the condition of the foundation structure of the Jib crane, it was found that the base plate holes were gas-cut to 35 mm in diameter, whereas the studs which were grouted were of 16 mm in diameter. It was also observed that different types of metal washers, more than two on each—ranging from 16 mm 25 mm id. and of 3 mm or 5 mm thickness—were used to fill the gap between the hole opening and the stud.
- No guards were provided on the wheel assemblies of the Goliath crane. The nuts, bolts and washers were rusted and damaged.

B-7 Fingers Trapped in Main-Loom-Drive

Defects were observed in one of the rayon tyre-cord textile looms at a factory. The maintenance foreman and two mechanics attended to it almost for a day and rectified the faults. Before handing it over, they observed that the clutch alignment was not in order and rectified the alignment. When the maintenance work was over, the foreman started the loom and kept it running for observation. He then asked one of the mechanics to stay there and watch the running of the loom for some time and left along with others.

After about 15 minutes, two other operators saw the mechanic, who was watching the loom operation, standing near the drive motor in an awkward posture. His left fingers were caught in between the gears. He urged them to move the gears in the reverse direction to release his fingers.

The operators were unable to do that. However, they immediately loosened the motor body by removing the nuts and bolts at the base, shifted the motor and released his trapped fingers. The foreman and others rushed to the site and took the injured man to the dispensary for first aid and then to the hospital for further medical treatment. The left index and middle fingers of the injured had to be amputated.

The main loom drive of the subject loom consists of a 2 HP-GEC motor, transmitting power first to a pinion gear (20 teeth) and then to a friction gear (142 teeth), which moved the crankshaft, further transmitting power to the drive mechanism of the loom through a cam shaft and secondary gear system at the end of the loom. The pinion and friction gears of the main drive were always kept well protected by a guard, fitted onto the foundation by bolting. A clutch system was provided after the main drive for stopping the loom but still keeping the drive running as required. A cut-out, followed by a starter with 'on' and 'off' push buttons, was provided under a locking device to keep it 'off' in a locked condition.

The injured was alone at that time and there was no direct witness.

Upon inquiry, the injured reported that he was watching the performance of the loom in running condition when he observed that the guard of the gears was lying outside the drive area. He thought of replacing it as the loom was on. As per routine practice, he clutched and stopped the loom. He then lifted the guard in his left hand, approached the main drive system, holding the guard above the gears and pushed the 'off' button of the starter in order to stop the motor to bring the gears to a dead stop.

He did not remember what happened exactly. What he could recall faintly was that the guard touched the gears in motion and was thrown off. His left hand might have slipped and subsequently his fingers were dragged in between pinion and friction gear sprockets and crushed.

The operators who attended to him immediately after the accident, observed that his left palm was facing the friction gear which meant that the dorsal was facing the pinion gear.

It was observed after thorough investigation that:

1. The cut-out was in the 'on' position.
2. The starter was in the 'off' position.
3. A lump of grease was stuck over the friction gear adjacent to the pinion gear.
4. The operators confirmed that he did have grease on both his hands.
5. His left hand was wrapped in a jacket cloth piece when the operators saw and attended to him.
6. No one could assess the exact location where the guard was lying. (It was found near the loom, as someone managed to keep it there.)
7. The guard was found in good condition, having no dent or scratch. It weighed 4 kg. The push button on the starter was at 13 inches from the floor level, whereas the centre of the motor was at 30 inches from the floor level.

8. The injured was right handed and it was not only uncomfortable but also difficult for him to hold the guard in his left hand above the gear assembly and simultaneously approach the push button of the starter with his right hand.

On consideration of the in-depth investigation, circumstantial evidence and the report of the injured, which had to be overruled as it was not found feasible and logical, the concluding cause was possibly that the injured might have tried replacing the guard with all good intention and before doing so he might have thought of greasing the gears. It seemed he switched off the starter, perhaps without operating the cut-out and had started greasing the gears that had not come to a dead stop and, because of the momentum of the gears, his fingers had been dragged in between them.

B-8 Wrong Position of Button

A turner was chamfering and deburring gears on a Chamfering and Deburring machine in the transmission shop of an auto engine manufacturing unit. The operation required that the gear be fitted onto the mandrel on headstock. The operator had to hold the gear, by applying a firm grip, in between his right thumb and his right index finger without bringing any other finger or a portion of his right palm in the path of the mandrel and the tailstock when placing and fitting it on the mandrel. After mounting the gear safely onto the mandrel, he had to close the door of the machine. Only then did the tailstock move forward and hold the gear, after which the operation of chamfering the gear began.

The turner had been instructed on the safe method of operating the machine and was removing the gear, which was clamped on the machine, after the deburring operation was completed. The tailstock moved forward and his right index finger was trapped and crushed in between the tailstock and the mandrel.

He was administered first aid and immediately removed to a hospital for further medical treatment. The proximal phalanx of his right index finger was amputed.

The only possible reason for the tailstock to move forward was that the emergency button might have been operated accidentally by his shoulder inadvertently touching the button. The rest of the operations were checked and found to be okay.

The emergency switch was relocated so that the possibility of accidental operation was reduced.

Recommendations

1. The tailstock operation/position needs to be checked during power failure to the machine.
2. Training and retraining of the operators should be conducted.

Note

Adequate 'norms and systems' were established in the company for attending to the injured at the earliest and for procuring the best medical treatment. Accordingly the injured was to be taken to a hospital and a hand surgeon was to be immediately contacted and called to operate on the injured to avoid amputation of his right index finger.

Unfortunately, the concerned executives of the personnel department did not take any cognisance of the set procedure as a result of which the injured had to undergo the amputation of his finger.

B-9 Safe Operating Procedure Not Followed

Face milling on cylinder heads of tractors is performed with a 'Lokesh' Milling Special Purpose Machine (SPM), the auto cycle of which was as follows:

1. The job is to be loaded manually onto the table of the machine.
   - On switching, the table is taken up automatically.
   - The job is to be moved manually to the adjacent table for further processes.
2. Auto cycle is started, wherein:
   - the job gets clamped;
   - the rapid feed starts;
   - at the end of the machine auto-operation, i.e., after stopping cutter rotation, the job is de-clamped;
   - a puller takes the job onto the conveyor by locating and inserting two pins in the holes of the cylinder head; and
   - the table returns to its home position for the next cycle.

An operator was working at face milling on a cylinder head of a tractor engine on the Lokesh SPM. He saw that the puller did not take the job ahead but returned, possibly because the pin did not match the hole size. He tried to pull the job ahead manually. As a result, his left middle and ring fingers got trapped in between the stationary cutter and the job.

He was hospitalized and had to undergo an amputation of his left middle finger at the base of the middle phalanx and left ring finger at the base of the distal phalanx.

Investigative Observations

1. The machine table was found at the home position with the job on.
2. Two lines of cutter scratch marks were observed on the finished job, indicating stoppage of cutter and return of the table with the job.
3. Usually, the cylinder head is brought from the transfer line to the home position on the machine for face milling. But, if the transfer line is busy, because of engaging other jobs, the cylinder head casting undergoes the operation of transfer line on another machine, called a Deckel Machine.
4. It was reported that the accidental casting was from a deckel line and during the drilling of this hole, the drill bit gave way, leaving the broken portion of the bit inside; consequently, the hole, wherein the pin is located to unload the job, did not open up completely.
5. This condition needed to be rectified and the broken piece of drill bit was removed on the sparkonix machine.

6. After removing the drill bit, the job was inadvertently passed on for milling operation. Had it been passed further, it wouldn't have been accommodated for the next operation, i.e., washing, because it has the same type of fingers (puller pins) locating the mounting holes.
7. When the machine was restarted, the machine cycle went on smoothly, indicating that there was no fault with the job sensing or fingers (puller pins) locating the mounting holes.

Dimensions: Hole length: 92 mm, Big hole dia: 13 mm, Small hole dia: 8 mm, Pin dia: 9 mm.

Comment

In spite of the observation that the fingers or the puller pins did not hold the job, the operator should not have tried to remove the job from the unloading end. On the mechanism of the auto cycle, the job would have travelled back safely to its home position, wherein it would have unloaded safely without damaging the cutter.

Recommendation

Guards with an interlock should be provided to the machine.

CASE STUDIES — C

Fire

C-1 Faulty Machine Connections

A die-casting machine was being operated in a pressure die-casting shop for regular production. During the process, one of the four bolts of the core-cylinder-mounting-bracket of the die on the machine got sheared off and the bracket assembly including the cylinder, dislodged from its base support, giving way in a tilted position. The rigid M.S. pipe nipple, connecting both the cylinder assemblies supplying hydraulic oil also gave way at the juncture of the coupling.

As a result of this, the oil under pressure of 1000 psig jetted out and spread all over in the area including on the machines and roof. It also splashed directly onto the LPG-fired holding furnace which was melting aluminium metal at a temperature of about 650 °C.

The oil vapour, on receiving ignition, caught fire. The fire intensified in no time because of the oil particles that had spread all over and the additional fuel received from the carbon particles and the oil deposits, which had been stuck to the roof for a long time.

On hearing the bang of the ignition, all the operators ran away. The line supervisor immediately switched off the machine and effectively stopped the further flow of oil from the reservoir. The fire-fighting crew brought the fire under control, initially by using DCP and CO_2 fire extinguishers and subsequently with hydrant water. Firetenders of that company and also from the neighbouring company were summoned. No injury was reported though there was intensive damage to machines, property and roof structure.

(The subject bolt was found to be loose, though the maintenance department claimed that it was tightened earlier during the scheduled maintenance. The possibility of overpressure was ruled out as the machine was provided with a pressure-relief valve. An over-current tripping-device was also incorporated in the electrical system of the machine, controlling the overdrawn current to protect the motor and the electrical installations.)

C-2 EDC Vapours Catch Fire

An operator was charging 8% co-polymer beads by vacuum transfer from a cardboard box into a Sulphonator Kettle. Ethylene Di-Chloride (EDC) distillation was being carried out at the same time in the adjacent sulphonator. The recovered EDC was being collected in drums by a hosepipe connected to the condenser. The drums for the collection of EDC were placed adjacent to the bead charging drums.

The EDC vapours from the drum suddenly caught fire. The operator immediately closed the valve on the condenser line and removed the hose from the drum. Activation of the fire hydrant system by the fire fighters immediately put out the fire. No injury was reported

The investigation revealed the following facts:

1. A cardboard drum, instead of an M.S. drum, was used for charging the beads, and the transfer into the sulphonator was done using a PVC pipe.
2. Electrical grounding of the drums was not carried out in spite of the provision for earthing cables with crocodile clips.
3. The bead charging drum and the EDC collection drums were kept together, almost touching each other.
4. The condenser for the sulphonator was observed to be full, resulting in the letting of EDC vapour, not considered, into the atmosphere from the collection drum.
5. The entire atmosphere close to the bead charging drum was full of flammable EDC vapours.

It was concluded that the EDC vapours possibly caught fire due to the sparking of static charges developed but not discharged.

C-3 Manual Transfer of a Flammable Chemical

The previous shift-in-charge of a carbon disulphide manufacturing plant had reported that the drain valve of the seal tank in the CS_2 finished building was faulty and as such, the crude CS_2 charge in that tank could not be drained into the stills. Hence, it was necessary to empty out the seal tank after distillation of CS_2 in both the stills below was over and then repair the drain valve of the seal tank.

The distillation of CS_2 in both the stills below was over by midnight during the night shift. The shift-in-charge undertook the responsibility of emptying the seal tank by manually transferring CS_2 along with water, meant to cover CS_2, to a catch tank with buckets. He then organised a team of one operator and three helpers to assist him. They were able to source two buckets, one made of galvanised iron and the other of a polyethylene material.

The seal tank was located on the upper floor, the condenser floor, of the CS_2 finished building and the catch tank, a spare stand-by tank, was located on the ground floor, outside but adjacent to the finished building. A staircase with a roof and landing platforms outside the building, approached the upper floors. The capacity of the seal tank was approximately 100 gallons and that of the catch tank was about 60–70 gallons. At that time, the total content of CS_2 and water to be gathered was not more than 30–35 gallons, the usual proportion being 70% of CS_2 at the bottom and 30% of water, covering the chemical.

Almost seven to eight buckets filled with mixed CS_2 and water were transferred from the seal tank on the upper floor to the catch tank on the ground floor manually through the staircase. At this juncture, both the shift in-charge and the operator came to the conclusion that the method adopted for the transfer would consume a lot of time and repairing of the drain valve would be delayed beyond their work hours. Hence, they planned to speed up the task of emptying the seal tank first and then transfering the mixed content to the catch tank.

As per their subsequent plan, they transferred the remaining content from the seal tank into a 45-gallon drum kept on the same condenser floor adjacent to the seal tank. They, thus, speedily finished transferring all the contents from the seal tank, emptying it out in the drum. A fitter from the maintenance department removed the gate of the drain valve of the seal tank, checked it and found it in order. Consequently, a choke in the drain line was suspected. With the help of the operator, the shift-in-charge removed the choke by first applying water and then air pressure.

The main task of checking the valve for repairs and removing the choke in the drain line was over. Hence, they started transferring the mixed content of CS_2 and water collected in the drum which was kept on the upper floor into the catch tank on the ground floor through the staircase. Two helpers were assigned collect the mixed content from the drum into the two earlier provided buckets, one by one. Two other helpers were asked to take the filled buckets, one at a time, bring it down the staircase and transfer the contents into the catch tank.

While descending the staircase, the helper who was carrying the iron bucket was ahead of the helper carrying the polyethylene bucket. When the man in front was on the landing of the staircase and the man behind was in the middle of the upper half of the stairs, the handle of the polyethylene bucket slipped off the body and splashed, spurting carbon disulphide all over in that area.

CS_2 splashed onto a steam condensate line adjacent to the staircase and caught fire. The flames gushed and ignited the other splashed traces.

CS_2 splashed on the man in front. His one-piece boiler suit instantly caught fire. He panicked and ran towards the plant office. The shift-in-charge, the operator and others rushed to him, tore off his clothes and washed him with water. The other helper was not affected from the direct splashing of the chemical to his body, but he sustained minor burn injuries to his face and right forearm due to the flames that gushed around on the staircase. They were taken to a hospital for treatment.

C-4 A Fire Can Breakout Anywhere—Even in a Toilet

A middle-sized private limited chemical company was engaged in producing textile auxiliaries, ONGC chemicals, polyols, pesticide emulsifiers, etc. Most of the chemicals used, processed and produced were hazardous, flammable, explosive or corrosive.

The layout of the factory was conducive to the process flow and requirements. Housekeeping was good. A full-fledged fire department, headed by a qualified and experienced fire officer, was alert all the time. Safety functions were looked after by a safety committee, chaired by the works manager. The production manager was assigned with the responsibility of day-to-day safety administration. The entire factory was declared a 'non-smoking' zone except for the canteen. Employees used to go out of the factory main gate and smoke.

The quality control laboratory was located on the ground floor of the main building. It had a toilet at the extreme end.

A chemist from the laboratory went to the toilet to change his trousers which were badly stained from chemical spurting. He then washed the soiled trousers in the basin located in the corridor outside toilet. The stains did not disappear simply with plain washing. So he collected a bucket, poured in a sizeable quantity of petroleum ether and dipped his trousers in the solution to soak. He went back to the laboratory to continue his work. When the lab chemist was returning, a chemist from the production department went to the toilet. He struck a match to light a cigarette. As he did this a fire broke out burning his face, wrists and hands. He came out shouting for help. Chemists from the lab rushed to him and immediately administered first aid and arranged to remove him to a hospital for further medical treatment. He had received second-degree burns and was under treatment for three weeks.

Investigative Report

1. The only possibility of the fire was the ether vapours evolved from the bucket in which the trousers were soaking in petroleum ether.
2. The fire was an instant one. Immediately after the injured sustaining burns, the fire was extinguished. The quantity of ether vapour only around his face seems to have caught fire on receiving the ignition from the match.
3. No indication of any fire or traces of burning were seen outside the toilet.
4. Smoking was prohibited in the toilets on the factory premises. The subject toilet was in the vicinity of a laboratory where hazardous chemicals, though on laboratory scale, were handled all the time.
5. Washing stained clothes in a workplace with such a hazardous chemical is not only unethical but also unsafe. It's a matter of commonsense and needs no education or instruction.
6. Though the factory was declared as a 'non-smoking zone', no arrangements were made to enforce the deposition of cigarettes, bidis, matchboxes, lighters etc at the gate under security control.
7. Similarly signboards saying 'no smoking' and giving relevant instructions, not only to employees but also to the guests and visitors, were not organised and administered as is necessary for a major hazard installation of this kind.

CASE STUDIES — D

Explosions

D-1 Oxygen Cylinder—A Potential Explosion Hazard

In an open area outside a mechanical workshop, a welder was cutting some steel plates with an oxy-acetylene gas cutter. The oxygen cylinder was about to get empty so, he decided to replace it with a filled one. He unscrewed the regulator from the empty cylinder and installed it on the new full cylinder.

When he opened up the cylinder valve, he noticed a leak at the union connection between the cylinder and the regulator. He therefore turned off the cylinder valve, unscrewed the union and examined the gasket. He found that there were two gaskets instead of one, which ought to be the case. So, he removed one of the gaskets. He then screwed up the union again and turned on the cylinder valve.

The moment he turned on the cylinder, there was an explosion in the regulator followed by fire. A jet of flame emerged from the back of the regulator and continued until the cylinder valve was shut off. A large portion of the regulator melted and burned during the incident.

There was no injury to anyone. The welder remained alert to save himself.

Surveillance Findings

1. An examination of the regulator revealed that there was some grease in the ball bearing in the front housing.
2. The explosion actually occurred in the rear high-pressure section and the grease was found in the front housing of the regulator.
3. It is concluded from both the above findings that:
   - ❑ An inexperienced person had overhauled the regulator.
   - ❑ There had been, in all probability, grease in the rear section too.
   - ❑ Grease or oil in the smallest quantity is sufficient enough for oxygen to have caused an explosion.

Recommendations for Preventions

1. Regulators are to be locked up in the attached box, when not in use.
2. The regulating screw is not to be removed unless it is essential.
3. The overhauled or examined oxygen cylinder is to be sealed and tagged with the name and signature of the person who works on it and the date and time.
4. Welders are not to use overhauled or checked regulators, which have not been sealed and tagged properly with signature.
5. Grease and oil should not come near any oxygen equipment.

Everyone concerned should be educated and trained on this.

D-2 Explosion of Condensate Receiver

In a normal preparation of a reactor batch, when the reaction is complete, the contents in the reactor are allowed to settle down at 60 °C. The gas evolution during the settling period is much less in comparison with that during the reaction itself. Any gas that evolves in the reactor passes through a Karbate condenser to a condensate receiver tank and then to a centrifugal exhauster and finally to the flare stack. This condensate receiver, a 2000-gallon Pfaudler vessel, was provided with two 6-inch rupture discs, rated for withstanding pressure up to 13 psig at 194 °F, through 6-inch explosion vent to the atmosphere. The exhauster maintains a negative pressure of about 30 inches of water on the system.

As was routine, the contents were settling down after the reaction was over, when two explosions occurred rapidly in consequence in the condensate receiver. The explosions burst open both the rupture discs and vented the tank to the atmosphere. Fortunately, no one was working in the vicinity.

Observations

1. The freeboard temperature recorder showed a rapid rise in temperature in the vessel, from a normal 20 °C to 90 °C in one 5-minute printing interval on the recorder.
2. The sight glasses on the vessel and piping were fogged.
3. There was discoloration on the underside of the rupture discs, possibly due to heat.
4. A loose fit 6-inch cylindrical vent cap of the explosion vent, closed at one end, was found on the side of the building and was presumed to have been blown off the vent in the first occurrence.
5. An identical rupture disc on the reactor was not burst, indicating that the Karbate condenser might have arrested the propagation of the flash back into the reactor.
6. All the equipment and piping in the reactor and receiver area were found in order, well grounded and the safety gadgets in good condition.
7. The rupture discs burst open properly and as such prevented personal injury and major equipment damage.
8. One operator had noted a flash in the flare-tower area but was unable to identify whether or not the flash gushed out from the emergency vent on the roof of the building or from the flare-tower.
9. An odour similar to that of burning black powder was noticed.

Review of the Process Conditions

As the exact cause of the mishap could not be ascertained, the process was reviewed to find out possible cause. The conclusions drawn were as follows:

1. Formation of an explosive mixture with hydrogen sulphide and/or methyl amyl alcohol. Both of them were present in the system.
2. Copious evolution of H_2S mixed with an air leak which resulted in a gas mixture too rich to ignite.
3. When the evolution of H_2S gas minimises or ceases during the settling period, the air ratio increases and an explosive mixture evolves.
4. The ignition source was considered to be a static spark, from the blower or a flash back from the fire. The easiest to blame was static charge and that was confirmed to be the most likely source.
5. The agitator shaft-packing gland was found pulled down to the maximum. This could indicate that the packing gland must had been leaking, perhaps more than normal, contributing to the formation of an explosive mixture.

Thirty batches had been prepared prior to the incident, without any trouble. What happened this time to cause two explosions in succession?

Such an installation could consist of controls to maintain only a slight negative pressure in the reactor as well as the receiver, in order of say, 2-inch rather than the present practice of upward of 30 inch.

D-3 An Air Compressor Explosion

In a plant the discharge lines of both compressors of a two-stage compressor joined in a single pipeline running into a common air-receiver equipped with a safety relief valve. Block valves were provided in each discharge line but no safety relief valves were provided between them and the compressors. Small air lines from the air receiver served the purpose of suction unloading valves for both the compressors.

A mechanic and a helper were assigned to clean the scales in the after-cooler on the operating high-pressure compressor. It was necessary to put the two-stage compressor in operation to maintain the plant air system. The mechanic asked the helper to shut down the operating compressor and close its discharge valve. Simultaneously, the mechanic started the two-stage compressor without opening the drain valves or closing the suction loader. He had not prepared himself or anyone to quickly open the block valves.

The compressor continued to operate in this situation for quite a long time until the casting at the discharge of the second stage blew off in many fragments. Several water-cooling lines were damaged and/or broken.

The mechanic, who was standing about eight feet away from the compressor, was struck by flying fragments of dislodged pipelines. He sustained compound fracture of lower right leg and several superficial wounds.

D-4 Explosion in a Chemical Raw Material Store

A continuous process chemical plant, manufacturing anion and cation exchange resins, used hazardous chemicals as their raw material. The process intermediates were also hazardous but the final products were not. The plant had a separate raw material store, which was maintained as per laid down standards, and a ring main fire hydrant system. However the inventories were more than the necessary consumption because of shortage of material as and when required.

One day in the afternoon at about 2:00 pm, a loud sound was heard and the workers observed dense white smoke coming out of the ventilators of the raw material store. The smoke disappeared in five minues.

Findings

1. The storeroom was immediately opened to inspect what had gone wrong.
2. A cardboard drum, containing Benzoil Peroxide (BPO) had exploded and spread all over the store.
3. The area was immediately cleaned and the drum was cut open, thoroughly cleaned, rendered to pieces and disposed of safely.
4. No one was reported injured because the place being isolated.

Investigative Report

1. The subject drum containing BPO happened to be in direct sunlight for a considerable length of time as could be assessed from the position where it was placed facing the sun from the ventilators and other openings.
2. It was concluded that the BPO was heated up continuously in the morning and, reached its confinement in the maximum temperature at 2:00 pm. This was in the month of May with hottest days in the year.
3. The stores department personnel did not know anything about the drum. They did not keep it there in that particular location in the storeroom.
4. The drum, which exploded, was not a packed one. Someone from production might had kept it there inadvertently without the knowledge of the store people. And it possibly remained there as a waste-drum in the open under in the sun, unattended.

CASE STUDIES — E

Electricity

"Okay ! Turn on the electricity !"

E-1 Electrical Equipment Not Isolated

The main unit of a refrigeration plant had tripped the previous night because of the defective low oil pressure trip cut-out device located in the relay compartment of the control panel unit in the refrigeration department.

The electrical maintenance service department was requisitioned to disconnect the power supply and replace the defective cutout.

The electrician who was entrusted with the job of replacing the defective cutout, was standing on an M.S. stand in front of the panel. He removed all the screws of the cutout, except one which was jammed. He was then trying to remove the jammed screw when his left wrist touched the live terminals of one of the auxiliary relays located just above the cutout. He received an intense electrical shock. His left hand was virtually dragged in. He managed to pull his hand out and get down onto the floor on his own.

All his co-workers rushed to rescue him. They laid him flat on the floor and massaged his left hand and arm. He was then taken to a hospital for further medical treatment. He was unable to lift and stretch his left arm and his left shoulder pained at the slightest movement of his left hand.

Medical authorities reported that he was experienced ‘shearing of spinouts muscle with haematoma’.

Observations during Investigation

1. As was a usual, the auxiliary relay for the heater was covered and that for the oil was not. But at the time when the injured was working on the pressure cutout both the relays placed above were open.
2. Though the pressure cutout was electrically isolated, the power supply at 230 V was on to both the oil and heater relays.

3. The fuse combination switch, which was provided on the panel for switching off electrical power supply to these relays, was also in the 'on' position.

E-2 Connection without Plug

In a sugar factory a casual worker was asked to carry out some grinding work at the bagasse elevator. The grinding machine he was using had no plug and the earth lead of the connection was cut at the terminal.

The worker asked the electrician standing nearby to insert the wires into the plug point. The electrician inserted the two bare wires (phase and neutral) into the point and switched on the power supply. Immediately, the casual worker received a lethal electric shock and died.

The worker was wearing neither protective rubber gloves nor shoes, which resulted in the accident being fatal.

CASE STUDIES — F

Other Categories

"Today we're going to talk about fall protection"

F-1 Collapse of a Factory Floor

The entire first floor of quite a sizeable factory collapsed along with the machines, equipment and the material stored on it. The mishap victimised 50 employees, 18 of whom were killed on the spot and 32 were injured severely. The condition of 11 persons out of the 32 injured was very serious.

The building structure was weak and the inclusion of heavy machinery, which also used to create undue vibrations caused the collapse.

The factory was situated near a business township. It had procured a licence for its manufacturing activities under the name of 'Beckman Fabrics Private Ltd.'. The original machine layout plans indicated only a ground floor civil structure which would only be used as a printing department.

In reality, a two-storeyed structure was erected and 32 power looms along with additional warping, winding and twisting machines and a raising machine were installed on the first floor.

The factory owners did not inform either the Department of Factories Inspectorate or the local authorities that the first floor of the factory was to be used for the purpose of such a manufacturing activity. No revised plans were ever submitted and as such no approval from the department was taken.

The building civil and mild steel structures were not examined and inspected for the required strength by a competent person. A Stability Certificate was not procured and produced for the concerned authorities for their records. They managed to evade submission of all these essential documents when asked by the various inspectors on their visits.

F-2 An Unplanned Operation

The feed line of spent acid to a coal filter in a recovery plant was dismantled and kept in its position by means of three hangers. A lead pipe nipple (8 ft long, 6 in dia.), with an elbow at one end and flanges at both ends, branched off from the main header. In order to bring it down from its location, a manila rope (25 ft long, ¾ inch diameter) was used to lower it down onto the floor near the coal filter. The ends of the rope were fastened tightly onto the farthest ends of the nipple by firm looping over and knotting. The rope was then carried over the main header.

Two labourers were entrusted with the job of holding the rope on either side, as it looped down from the header, with the intention of preventing any accidental swinging of the nipple which was being lowered. They first removed the middle hanger and then the hanger at the straight end. The freed end came down a little and exerted pressure due to the weight of the pipe at that end.

As soon as they tried to dismantle the last hanger, supporting the pipe on its elbow side, the rope end, which was held by a labourer, jerked violently and snapped off from the portion of the rope that was looped adjacent to the knot. The pipe end fell down, striking him against his right shin. He was thrown onto the floor by the impact.

He was immediately hospitalised and sustained compound fractures on the lower third of his right tibia.

Comments and Investigative Remarks

1. The rope, which was in use, might have given way at the weakest point. Had it been checked and examined for the required strength?
2. What was the frequency of examining and certifying the in-service ropes?
3. Manila ropes deteriorate in efficiency with splices, hitches and knots from almost 45% to 100%.
4. A manila rope, loaded to over 50% of its breaking strength (i.e., 1.5 times), is permanently damaged.
5. Storage, numbering, tagging, maintaining records, preventive maintenance and rejecting and rendering tools non-reusable are important aspects of maintenance.

F-3 Fall during Erection of a Pipeline

A 12-inch diameter cement coated M.S. pipeline, carrying soft water from the water works to the acid plant in a large chemical complex was required to be replaced as it was found to be leaking at several locations due to corrosion.

This soft water line was laid along with two other lines of raw and filter water, well installed on M.S. I-beams and a bridge channel structure, passing over a long distance on a rough surface inclusive of a long span of ditch. Trestles made of 4 in by 2 in M.S. I-beams were erected to support the lines passing over the ditch portion which was, about 400 ft in length.

On the day of the accident, a fitter along with six other workmen was working on the trestles. During the course of erection of the new line, the fitter was standing on one of the I-beams with his feet apart on either sides of a newly pipe piece placed on a trestle. He was attempting to align the ends of adjoining pipelines, when he slipped off the I-beam and fell into the ditch from a height of about 16 ft.

Investigation and Comments

1. A wooden platform and scaffolding were provided to a welder who was working about 10 ft below where the injured was working.
2. No such provision was made for the injured to stand safely on the trestle; a safety belt was also not provided.

F-4 Lack of Safe Operating Procedure

Eight coal-fired boilers were located in the boiler house at a large chemical complex. Quite often, a clinker formation used to take place on the striker of the boiler, resulting in undue collection of ash in the chamber. The collected mass of ash was normally drained out forcibly by means of water streams laid down in the chamber into the pits made for the collection and recovery of ash.

One day ash choked up somewhere inside in one of the boilers could not be drained out with the usual flow of water streams forced through the chamber. It was therefore decided to poke and push out the ash mass. Both the small manholes in the front and a large manhole on the side of the chamber were opened for the purpose. One fireman, with an assistant fireman, was entrusted with the job of removing the choke.

The fireman poked and pushed the ash with a long rod through both the front manholes alternatively and the assistant fireman shovelled out the pushed ash through the large side manhole when, all of a sudden, hot air with dust gushed out of the large manhole. Realising the danger, the assistant fireman ran away from the location, shouting and alerting his co-worker to leave the place.

Perhaps, not being cautioned adequately, the fireman continued to poke the mass and received the hot blast straight. He sustained acute scald injuries on his face, both the eyelids, both forearms and legs, abdomen and back—as he had turned around not knowing what else to do.

Comments

1. It was reported that this operation was essential whenever the flow of ash along with water got choked and remained stagnant.
2. In this case, the firemen were entrusted with the job of poking, pushing and removing the ash formation in the chamber just to make up the flow of water and ash.
3. The sudden gushing of hot air was possibly due to the sudden removal of the choke.
4. Normally this didn't occur, and that is why no planning was made for the provision of suitable protective safety wear like asbestos clothing, helmet-cum-face shield and so on.
5. In cases like this, immediate washing with a forced stream of water should be administered to save and/or reduce the severity of an eye infection.

PART SIX

Appendices

Appendix A

Safety Thinking

"Today we're going to talk about fall protection"

Dr. Trevor A. Kletz has explained preliminary hazard identification in a very simple way presenting an addendum, 'An Atlas of Safety Thinking' in his famous book *Hazop and Hazan, Identifying and Assessing Process Industry Hazards*. While describing the theme, Dr. Kletz says that he has tried to express the ideas of his book in simple drawings in the hope that they may be better recalled than when they have been expressed in words using technical terminologies.

A common and simple example has been selected to explain the most desired concept – Safety Thinking.

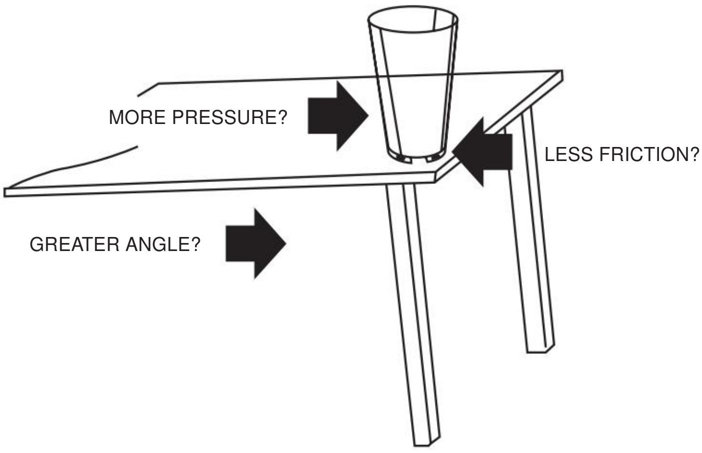
An effort has been made to recall the concepts described in this book with modified captions to suit the very purpose of this guidebook.

We have to LOOK for and THINK of:

- What can go wrong? Watch and Identify.
- How big the Consequences will be?
- How often it will occur?
- What is the remedy? – Solution.
- What should we do?
- Is it worth the cost?
- How to prevent recurrence?

The same drawings have been reproduced below with modified notes with a view to make the students of professional safety courses understand the theme thoroughly.

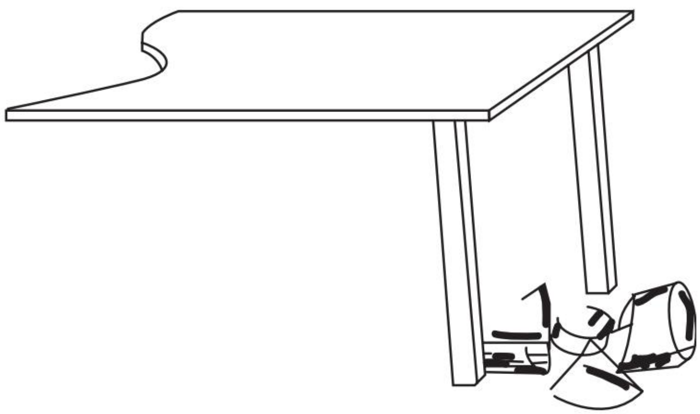
(1) Identify What can go Wrong?



What can go wrong? Obviously, the glass vessel is likely to fall down because of the various reasons mentioned in the above drawing. A glass vessel kept on the top of a table at its corner in itself is a hazard, capable of producing accidents or operating problems.

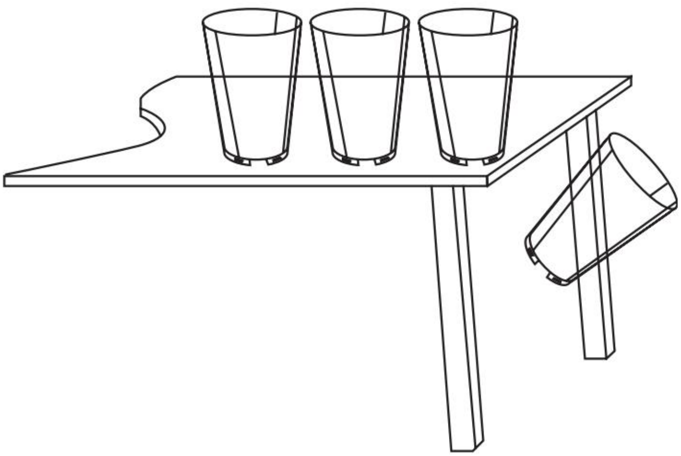
It is little use studying small hazards if we fail to realise that bigger ones are round the corner.

(2) How Big will the Consequences Be?



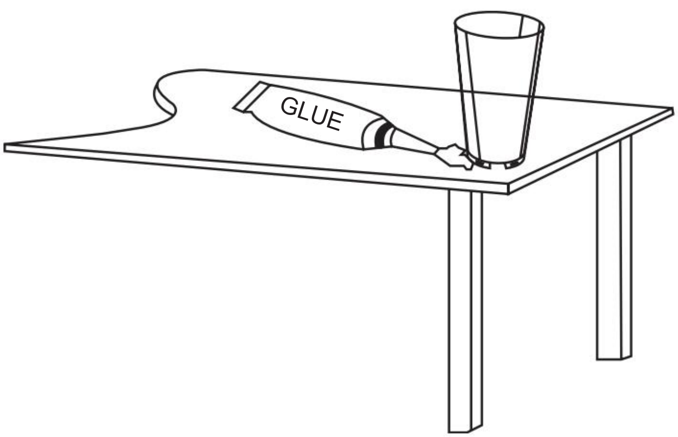
The vessel is likely to break into pieces and is further likely to hurt someone. We need to know of the consequences to employees, members of the public, plant and profits, now and in the long term. Past experience and past records prove to be the best guidelines for assessing consequences. Or else, we can use synthetic methods.

(3) How Often will it Occur?



This may occur 'n' number of times as long as we continue replacing the broken glass vessels at the corner of the table. Similarly, we need to know how often a hazard will occur. Again, the best way is to look at past experience but sometimes there is no experience and we have to use synthetic methods

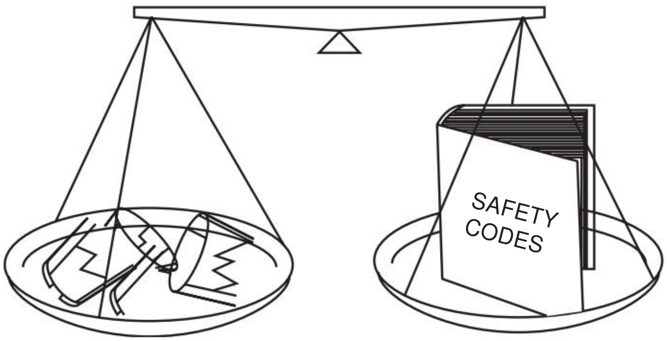
(4) Prevention



How can we prevent the vessel from slipping off and falling down? By using adhesive to paste it to the table? It may appear silly but it seems to be a solution to the problem.

How can we prevent the accident from occurring or make it less probable and protect people from the consequences?

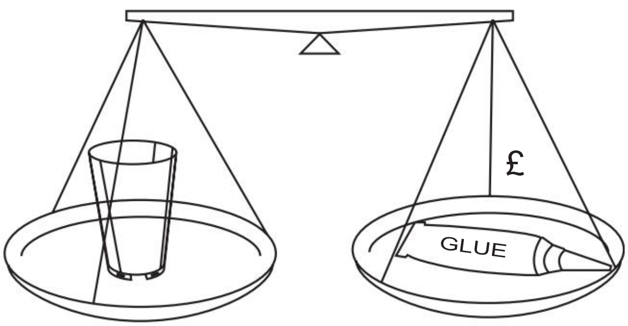
(5) What Should We Do? Find a Solution?



We should compare the ‘risk’ resulting from the identified ‘hazard’ with generally accepted safety codes, national or international safety standards or with other similar risks known to us – with a view to make the risk trivial or at least tolerable.

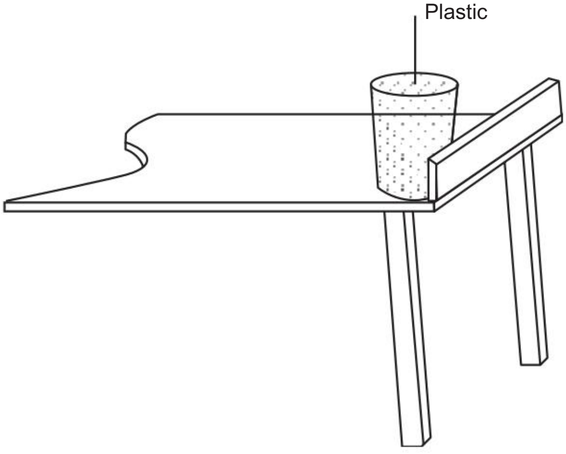
Technically, risk is a measure of both the probability and the consequences of all the hazards of an industrial activity. (Please refer to Glossary, page 348, for definitions.)

(6) Is it Worth the Cost?



We should also compare the cost of our recommended prevention or solution to the problem with the cost of expected losses due to the accident to verify whether the remedy suggested is practical and economical or if we should look for a cheaper and more practical solution.

(7) Prevention at Accepted Level



Perhaps our method of prevention has its disadvantages. Maybe we can think of better methods. We should answer this question for a final solution to the preventive method before the table is made or the glass vessels ordered.

Dr Kletz's atlas illustrates, by simple picturesque examples, the desired theme on Safety Thinking which forms the basis of Risk Management at large.

The atlas teaches us to think for the sake of safety in its correct perspective.

- Move around with open eyes.
- Watch out for what is wrong.
- Correct it if correction is possible.
- Or, report to those who can correct it.
- Follow it up till it is corrected.

(See the Glossary for definitions and Appendix L 'Risk Assessment' for application of the programme.)

Appendix B

Questions to Ask During Accident Investigation[8]

This questionnaire is intended to help us think of the less obvious ways of preventing an accident happening again. It will be more effective if a team rather than a single person answers the questions.

- What equipment failed?
  How can we prevent failure or make it less likely?
  How can we detect failure or approaching failure?
  How do we control failure (i.e., minimise consequences)?
  What does this equipment do?
  What other equipment could we use instead?
  What could we do instead?

- What material leaked (exploded, decomposed etc)?
  How can we prevent a leak (explosion, decomposition etc.)?
  How can we detect a leak or approaching leak (etc)?
  What does this material do?
  Do we need so much of it?
  What material could we use instead?
  What could we do instead?

- Which people could have performed better?
  (Consider people who might supervise, train, inspect, check or design better as well as people who might construct, operate and maintain better.)
  What could they have done better?
  How can we help them to perform better?
  (Consider training, instructions, inspections, audits etc. as well as changes to design.)

- What is the purpose of the operation involved in the accident?
  Why do we do this?
  What could we do instead?

How else could we do it?
Who else could do it?
When else could we do it?

While procuring the answers, the team leaders need to avoid accepting negative answers such as 'Nothing' or 'We can't'. Instead they can guide the team into constructive thinking by adding to the question or making the questions more leading.

Appendix C

Safety Policy and Objectives of a Company

A company, large or small, that attempts to prevent accidents without a definite guiding policy—one which is planned, monitored and promoted—will find itself continuously 'fighting fires'. Why should we write, declare and implement a safety policy?

- ❑ When a person enters a company, he has a right to expect that he will be provided with a proper place in which to work, safe machines and tools to do his job, and safe methods of operations, so that he will be able to devote his energies to his work without fear of any danger to his life and health.
- ❑ The management should consider no phase of operation or administration as being of greater importance than accident prevention. It will be the policy of the company, therefore, to provide and maintain safe and healthy working conditions and to follow operating practices that will safeguard all employees and result in safe working conditions and efficient operation.
- ❑ Total safety extends into three important areas—company personnel, products and customers, and the public. The safety policy should be designed in such a way that it is easy to implement it in these vital areas.
- ❑ Lack of knowledge is the root cause for not understanding what is required to be done to prevent an accident or a mishap. Policy provides proper scope for education, training and development for the managers, staff and employees.

Principles, basic to policy making, declaration and implementation are:

1. Safety of the company's contractors' employees, the public, and company operations.
2. Safety taking precedence over expediency or short cuts.
3. Every attempt will be made to reduce the possibility of accidents.
4. Compliance with all the possible legal provisions of various acts, rules and laws.

Safety, Health and Environment Protection Policy and Objectives: A Sample for Study

A. Policy on Safety, Health and Environment Protection

The Company will:

A.1 Conduct its activities in a manner that ensures the health and safety of its employees and its contractor's employees.
A.2 Ensure protection and safe operation to all plants, equipment, machinery and installations.
A.3 Conduct its operations so as to protect the environment and prevent pollution.
A.4 Establish adequate and appropriate norms and systems for safety, health and environment that are essential to practice and implement.
A.5 Provide safety education and training to bring awareness of the programme.
A.6 Fully comply with all the applicable statutory provisions pertaining to safety and health.
A.7 Provide a resume of safety performance of the factory in its Annual Report.

B. Objectives for Safety, Health and Environment Protection

The Works will:

B.1 Encourage, support and implement methods aimed at continual improvement of safety at work.
B.2 Maintain a safety department to assume an advisory, monitoring and training role in all aspects of Industrial Safety and Loss Prevention giving emphasis to participative safety management techniques and training.
B.3 Promote safety consciousness in employees and contractors through training, participation competitions, incentives, publicity etc.
B.4 Fix the responsibilities with respect to safety, with accountability for all accidents at departmental head level.
B.5 Ensure by procedures, techniques and surveys that facilities are operated and maintained to a high standard of safety such that they remain safe and reliable with a practical minimum risk of injury to person, breakdown or damage to property or fire.
B.6 Give due weightage to safety performance while appraising the overall performance of its employees.
B.7 Integrate health and safety in all decisions including those dealing with purchase of plants, equipment, machinery and material as well as selection and placement of personnel.
B.8 Encourage, support and promote a high standard of preventive, curative and public health programmes.

B.9 Ensure by design, auditing and quality assurance techniques that facilities are built to comply with national/international standards for safe production, working and fire and loss prevention.

(M.F. Rule 73-L: Health and Safety Policy specifies what the policy should contain or deal with—in particular, what the policy should specify.)

Appendix D

Safety and Loss Prevention and Control Responsibilities for the Implementation of a Safety Policy

1. Applicability: All Divisions and Departments located at the Works.
2. Purpose: To establish a consistent policy, objectives and programme to control occupational hazards and eliminate accidents within the activities of the Works of the Company, in order to prevent injury to the employees and damage to machine, equipment, installation, material, semi-finished, finished products, buildings/structures etc.
3. Aim: As per the declared policy and objectives, the Company would provide and maintain safe working conditions to emphasise safe operating procedures and practices and to comply with applicable statutory provisions, allied and appropriate safety codes and standards.

It shall be the aim of each division/department to strive continually to develop in each employee a sense of personal responsibility to himself and to those with whom he works towards safety and loss prevention.

(I) Occupier/Manager under the Factories Act

The occupier and the factory manager have the responsibility of compliance with Section 7 "Notice by Occupier" and Section 7-A "General duties of the Occupier" of the Factories Act, 1948 in which they are required

I.1 To periodically update the Company's safety policy and objectives.

I.2 To periodically update the assignment of responsibilities in safety with the concerned levels with proper feedback of their accountability.

I.3 To periodically review safety programme and performance.

I.4. To ensure that the Accidents/Dangerous Occurrences are promptly and properly notified to the concerned authorities. (Reference may please be made to the extract of Rule 115, the Maharashtra Factories Rules, 1963 under Section 88, the Factories Act, 1948.)

(II) Dept. Head/Section Head

The Division Head has the central responsibility for sound safety and health conditions within his division and in the administration of safety and health policies, programmes and procedures.

The responsibilities include the following:

II.1 To establish in conjunction with the Safety Dept., an Accident Prevention and Loss Control programme for the division in accordance with the policy and objectives of the company which effectively designate the safety, health and loss control responsibilities of supervisors and workmen.

II.2 To provide and enforce safety and health procedures and rules applicable to his division/department consistent with the Company's Safety and Loss Prevention Manual.

II.3 To ensure that accidents are properly investigated and action to correct the causes responsible follow immediately.

II.4 To comply with the recommendations of the statutory authorities and of the Safety and Loss Prevention Department.

II.5 To ensure that each plant, construction site or other location under his control has a safety and health programme.

II.6 To provide appropriate safety performance weightage in the overall performance appraisal of all employees in the division/department.

II.7 To ensure regular and effective functioning of the Safety Committee/s.

II.8 To plan for and maintain the desired standards for good housekeeping.

Line Management: Managers and Supervisors

The managers and the supervisors hold the prime responsibility of ensuring that the Company policy and objectives are followed. Therefore, all levels of management shall make accident and loss prevention control a matter of prime concern. Every individual who supervises, directs or controls the activities of others is responsible for the safety and health of each individual under his supervision, direction or control. This responsibility also includes the safety of equipment and property within his area of responsibilities.

(III) The Manager

III.1 Familiarise themselves with the Company's Accident Prevention and Loss Control programme and ensure its effective application in the area of their responsibilities.

III.2 Investigate accidents involving serious injury or property damage personally to ensure that accident causes have been investigated and proper corrective action is taken.

III.3 Review the periodic accident reports and statements of injuries in order to stay informed on the plant's accident record and implement appropriate action plan for correction of potential hazards.

III.4 Ensure that all proper safety precautions have been taken for the safe use of newly installed operations, new tools, equipment and new materials.

III.5 Lead and direct the administration of all safety activities within their area of control.

III.6 Assist in setting up and maintaining proper standards for all phases of good housekeeping and orderliness including matters such as safe floor loads, aisles, material piling areas, illumination, ventilation, proper storage, containers for waste and its subsequent removal and disposal etc.

III.7 Ensure that the work-permit-system, which has been set up, is regularly implemented wherever applicable.

III.8 Ensure that all the employees use appropriate Personal Protective Equipment as per requirement.

III.9 Ensure that all the machines, equipment and installations have a definite preventive maintenance.

(IV) The First Line Supervisors

IV.1 Educate each worker about the hazards on his job and on the precautions established to control the risks that arise from hazards.

IV.2 Impart to each employee the understanding that violation of safety rules will not be in his organisational interest.

IV.3 Ensure that Personal Protective Equipment and protective devices are provided and used for each job.

IV.4 Take prompt corrective action whenever unsafe conditions and unsafe acts are noticed.

IV.5 Impress upon the employees how accidents are caused and how they can be prevented.

IV.6 Investigate indepth accidents resulting in injury, property damage or creation of a dangerous condition.

IV.7 Ensure that all the injuries and property damage incidents are promptly reported detailing the corrective action plan in appropriate formats.

IV.8 Conduct regular safety inspection in the section under control for unsafe conditions and unsafe acts which are likely to lead to accidents or injuries. This includes checking all new and relocated equipment which may produce hazards that are unfamiliar to the operators.

IV.9 Ensure compliance with all applicable safety procedures, regulations and instructions.

IV.10 Ensure the preventive maintenance of equipment from a safety point of view.

IV.11 Ensure that machines, equipment and installations are maintained in safe working conditions.

IV.12 Give full support to all accident prevention and loss control activities and procedures.

IV.13 Ensure that:

(a) Every employee works in a safe manner and with the required protective devices, measures and procedures.

(b) Every employee uses appropriate personal protective equipment.

(c) Every precaution is taken for the protection of the employees and property.

(d) A safe-work-permit is issued wherever and whenever required for carrying out work in hazardous locations, departmentally or by any other department, agency or contract men.

(e) Ensure that the work is being carried out under the conditions specified in the permit under strict supervision of both the supervisors of the company and contractor.

(V) Safety Manager and/or Safety Officers

The Safety Manager and/or the Safety Officers will remain responsible and accountable for the organisation and administration of the Safety Management System.

The Safety Professional of the Company is an 'Advisor' to the management.

He has to establish various safety norms and systems, as are required to be implemented in the company and review and revise them periodically to suit the needs of the company .

V.1 Assist the management in forming, establishing and periodically reviewing and revising the Company's Safety Policy.

V.2 Advise the management on the safety responsibilities and accountability of the management, staff and workmen.

V.3 Advise and assist the line management in preparing their accident prevention and loss control programme.

V.4 Continuously monitor for Safety Training needs and accordingly design and conduct suitable training programmes in collaboration with the Training Department.

V.5 Provide and maintain an up-to-date Safety, Health and Loss Prevention Manual covering all the necessary administrative and technical information.

V.6 Perform periodic safety surveys of all company locations and recommend corrective action.

V.7 Arrange for safety audit as and when necessary for the assessment of strengths and weaknesses of the safety management of any location or operation.

V.8 Advise the management on the compliance of applicable statutory provisions.

V.9 Assist in setting up and updating proper standards for various norms of good housekeeping, shop floor storage and orderliness.

V.10 Advise on safeguarding dangerous equipment, machines and installations.

V.11 Periodically observe plant, property, equipment, machines, operations and personnel to determine unsafe conditions and practices and suggest corrective measures.

V.12 Assist the supervisor/line managers in investigating accidents to determine their cause so that corrective action can be taken to prevent recurrence.

V.13 Assist in educating workers in the use of protective clothing and equipment.

V.14 Stay familiar with all new tools, equipment and new materials so that recommendations for the prevention of accidents can be made.

V.15 Advise Safety Committee members in their functions and duties as an invitee.

V.16 Assist and advise the Personnel Dept. (HR and IR) in instituting and administering the induction programme for new employees on safety.

V.17 Prepare and maintain periodic records, accident statistics and injury classification, make special studies on trends and changes in accident frequency, severity rates, indices, costs, types of injuries and issue reports to discuss and follow through.

V.18 Co-ordinate and utilise outside agencies to assist in accident prevention training as and when needed.

V.19 Review all accident investigation reports for completeness and accuracy, paying particular attention to the accident causes and corrective action.

V.20 Prepare and issue monthly injury statements to the concerned plants and departments to keep them posted on the information and statistics.

V.21 Ensure that safety statistics are brought to the notice of the employees periodically.
V.22 Monitor functioning of the Department Safety Committee and advise them periodically on improving effectiveness.
V.23 Function as the Secretary to the Works Safety Committee.
V.24 Advise on fire prevention and protection.
V.25 Periodically design and conduct competitions, contests/drives which will help in enhancing employees' interest in safety.
V.26 Advise Purchase and Inspection Departments on procurement of appropriate personal Protective Equipment and Safety Garments as per the specified standards.
V.27 On scheduled programming, conduct internal audit of the inbuilt safety measures/norms such as good housekeeping, unsafe conditions, machine guarding, provision and use of the personal protective equipment and safety wears.

(VI) Personnel or Human Resource Managers and Officers

Compliance of various statutory provisions in general and those specified under the Factories Act, 1948 and Maharashtra Factory Rules, 1963 in particular with regard to safety will be the responsibility of the Personnel Management.

The functioning of Medical Department is the responsibility of the Personnel Manager.

VI.1 Maintain necessary and adequate liaison with Government authorities with respect to safety.
VI.2 Expedite compliance of related remarks made by the officers of the Directorate of Industrial Safety, Health and other Government authorities on their visit to factory from the concerned managers. Compile, arrange and promptly reply to the concerned authority on the report of total compliance.
VI.3 Arrange to send information regarding industrial injuries, accidents, mishaps and dangerous occurrences on time to the Government authorities as specified under law. (Refer: Annexure-V of Section E-2.)
VI.4 Arrange to obtain various licences required under the statue.
VI.5 Maintain up-to-date accident registers all the time.
VI.6 Submit time scheduled statements on injuries and rates to the Directorate of Industrial Safety & Health.
VI.7 Recognise and prevent fake or inflated absenteeism on account of industrial accidents and injuries.
VI.8 Follow up the administration of adequate and timely medical treatment to the injured due to accidents.
VI.9 Record the natural illness cases separately from those of accident/injury cases.
VI.10 Emphasise and ensure completion as per schedule of the periodic employee medical examination.
VI.11 Document the medical and health data of the employees.
VI.12 Advise the management on the proper placement/rehabilitation of physically affected or challenged employees.
VI.13 Participate in the Works Safety Committee meetings on all the industrial relations related safety issues and advise on the desired policy.

VI.14 Train a sufficient number of first aides so that a minimum of two well-trained first aides are made available per shift on each of the shop floor units.
VI.15 Ensure that the services of a Dispensary Room attendant, trained first aides and adequate ambulance arrangements are available round the clock.
VI.16 Ensure that first-aid boxes are maintained and replenished periodically in the Shop/Department.
VI.17 Assist the Safety and Loss Prevention Department in designing and conducting suitable training programmes.
VI.18 Co-ordinate the results of job analysis to assist proper selection and placement of personnel whose capabilities and/or limitations are suited to the operation involved.
VI.19 Ensure that newly recruited employees are trained in safety.
VI.20 Ensure that all the contractors entering the factory premises for any kind of work have been issued a copy of "Safety Instructions for Contractors" and a written undertaking has been obtained from them stating that they abide by the specified safety instructions.

(VII) Maintenance Manager, Deputies and Assistants

VII.1 Ensure preventive maintenance of various machines, equipment and tools on the consideration and experience of breakdown conditions and history.
VII.2 Get the equipment installed, tested, examined and certified.
(Refer Appendix E: "Daily Do's & Don'ts".)
VII.3 Maintain up-to-date records of the preventive maintenance jobs undertaken and completed, certified with copies from the competent authority wherever required.
VII.4 Maintain the equipment in safe working condition as may be requested by the Line or Safety Manager.
VII.5 Issue a safe-work-permit to work wherever and whenever necessary and carry out all such jobs under strict supervision.
VII.6 Ensure compliance with safety procedures and instruction particularly in case of LPG storage and distribution system, petroleum storage and electrical systems.
VII.7 Ensure that contractors and the employees working for them follow safe work practices, use equipment and tools in safe working condition and maintain a safe work environment.

(VIII) Purchase/Materials Manager

VIII.1 Develop suppliers who supply specified, high standard, quality personal protective equipments and safety wear.
VIII.2 Procure samples of newly introduced items or items supplied by the changed parties for approval from the Inspection/Safety Department. Maintain all the PPE and safety wear items in stock, minimum 10% in addition.
VIII.3 Consult the Safety Department on the demand for any unusual safety items or device, requisitioned by the plant or department.

VIII.4 Ensure that the safety devices, wherever required, are adequately specified in the purchase order of machine, equipment, tool etc.

(IX) Quality Assurance Manager

IX.1 Give due weightage to safety in all Quality Assurance and Control activities.
IX.2 Assist line managers in safely carrying out hydraulic tests.
IX.3 Ensure that safety practices regulations and procedures are followed while carrying out radiography and other non-destructive and destructive tests.
IX.4 Ensure safety in laboratory operations.
IX.5 Distinguish damage to material, semi-finished or finished products due to accidents from other quality defects during inspections and keep the Safety and Loss Prevention Department informed about the same.

(X) Manager Assigning Any Job To a Contractor

The contractor, appointed for any specific job in the factory, will be responsible for observing all the applicable statutory requirements pertaining to safety, laid down under various acts, rules and regulations.

X.1 Ensure that the Personnel Department has issued "Safety Instructions for Contractors" to the concerned contractor and has taken a written undertaking from the contractor stating that he will abide by the instructions stated therein.
X.2 Ensure that contractors' employees work under strict supervision of both the supervisors of the company as well as the contractor, and all the applicable safety rules/instructions are followed and all safety precautions are observed.

(XI) Security Manager

The Security Department will be responsible for Fire Protection Services.

XI.1 Design and conduct training for all security guards and select employees from the shop floor on fire fighting, rescue operations and fire emergency procedures.
XI.2 Ensure that adequate fire fighting equipment/apparatus have been provided at all locations.
XI.3 Arrange for periodic examination and maintenance of fire fighting equipment and maintain a record of the same for at least three years.
XI.4 Frequently take inventory of the fire fighting equipment/apparatus and maintain it with proper standby.
XI.5 Conduct regular demonstrations on the use of fire fighting equipment/apparatus for the benefit of the employees on the shop floor and in the offices.
XI.6 Conduct regular drills to keep the fire crew well trained and prepared to fight fire effectively.

XI.7 Periodically review fire prevention and protection needs in consultation with the Safety and Loss Prevention Department.
XI.8 Liaison and maintain cordial relations with local fire brigades.
XI.9 Investigate all fire incidents and recommend suitable preventive/corrective actions as per findings.
XI.10 Exercise strict control on the use of safety shoes by employees.

(XI) Office Employees

XI.1 Get acquainted with the location and use of a fire extinguisher. (They may take the advantage of demonstration on operation of fire extinguishers organised by the Security Department periodically.)
XI.2 Get acquainted with the location of the electric main switch for their section so that in case of an electric short circuit/fire it can be switched off (in case of any difficulty help from the Maintenance Department can be sought in locating the switch).
XI.3 Ensure that the aisle/corridor/exit route/passage staircase are never blocked/obstructed so that, in case of an emergency, they can evacuate themselves safely.
XI.4 Don't allow accumulation of combustible substances (e.g., waste paper, cotton waste, cardboards etc.) such that it creates a fire hazard.
XI.5 Maintain high standards of housekeeping in their respective areas.
XI.6 Correct/get corrected hazardous conditions, if any. Help, if required, may be sought from the Maintenance/Safety/Security departments in this regard.
XI.7 Comply with the advice rendered by the Safety Department with respect to improvement in safety in their respective areas.

(XII) Workmen

XII.1 Work in compliance with the rules and regulations and dos and don'ts provided in the Safety Instructions given, displayed or posted on the shop floor.
XII.2 Use and wear the personal protective equipment, protective devices or clothing required and provided.
XII.3 Report to their supervisors the absence of safety/protective device or a defect in any equipment which may endanger them or other workmen.
XII.4 Report to their supervisors any unsafe condition prevailing on the shop floor and any unsafe act being followed by other workmen. Observations thus made should immediately be reported and followed up with the supervisor for prompt rectification/correction and prevention of recurrence.
XII.5 Undergo medical examinations and tests as may be prescribed.
XII.6 Represent in the respective Safety Committee and participate in the desired functions as and when called for.
XII.7 Report accidents, injuries, near misses and property damages due to accidents.
XII.8 Participate in the safety training programmes as and when sponsored.

XII.9 Maintain safe, clean, tidy and orderly work areas.
XII.10 Do not remove or make ineffective any protective device or guard provided for his or her own protection.
XII.11 Use or operate any equipment, machine, device or thing or work in a manner that is safe and will not endanger himself or any other workmen and will not result in any damage to property.
XII.12 Always ensure disciplined behaviour to avoid endangering themselves and/or others. They should never engage in rough and boisterous conduct.
XII.13 Work on any machine, equipment and process, specifically identified as hazardous, with training aimed at developing skill to work properly and safely. They will also seek the proper authority to do such work.
XII.14 Co-operate with Safety Committee members in all possible respects.

Appendix E

Daily Dos and Don’ts

Daily Dos and Don’ts with Regard to Safety in the Factories Act, 1948. Read with the Maharashtra Factories Rules, 1963

Industrial legislation is fundamentally preventive in implication. It is the copiousness of it that, at times, makes it difficult for industry to cope with it.

This is an attempt to highlight the major statutory imperatives on ‘Safety’ alone, arranged and listed as far as possible in such a way that they would be easy to scan and to follow.

The Factories Act is the Central Act, which by law, tries to control and ensure safety, health and welfare of the employees working in the industries or factories as defined in the Act. The Act emphasises the right of employees to a safe and healthful environment in a workplace free of recognised hazards. It imposes a legal liability on employers to conform to certain standards.

In exercise of the provision under Section 112 of the Act, the Maharashtra Factories Rules were framed in 1963 and amended from time to time. It would, therefore, be appropriate to interpret the obligations on safety of the Act when read with the Maharashtra Factories Rules.

Even official opinion would concede that a legislation like this Act has to be taken ‘more in spirit than the letter’. However, what needs to be noted is that ‘even if a violation of a provision is made by a junior supervisor in a factory, it is the man at the top of the organisation who has to face the consequences’. The man at the top is the ‘Occupier’ or in his absence the ‘Manager under the Act’ as notified by the Company. Either of them is hauled up before a Magistrate when an accident occurs because of a slippery floor or when an injury results from an unguarded machine.

However, the provision of Section 101 of the Act offers Exemption of the Occupier or Manager from Liability in certain cases. A sense of well-informed responsibility is therefore required to be created at all levels at all times.

The object of this Act and the Rules framed is to ensure that workmen in a factory are not put to unduly long hours and stretches of work and are given necessary leave and rest, provided with comforts and facilities.

It also aims to reduce the health hazards and ensure the safety of the employees in context material and machine and provide reasonably good, safe and healthy conditions of work and requisite facilities.

The Provisions of the Law Envisage:

- Management Leadership
  —All-round support to the cause of safety.
  —Assumption of responsibility and accountability.
  —Declaration of Safety Policy—commitment to safety.
- Assignment of Responsibility to:
  —Line Management—Operating Officials—Utility and Service Personnel.
  —Professionals—Commercial Managers—Supervisors.
  —And employees at large.

Abbreviations Used in Reference to the Main Text:

F.A.: Factories Act, 1948.
M.F.R.: Maharashtra Factories Rules, 1963.
Sec: Arabic numeral after "sec" denotes the relevant "Section of the Act".
R: Arabic numeral after R shows the relevant "M.F. Rule."
(): Bracketed Arabic numerals following Sec or Roman numerals indicate the sub-sections of the Act or the sub-rules of the M.F.R. respectively.
(): Bracketed Roman italic numerals indicate the sub-clause of both the Act as well as M.F.R. Sch: Roman numeral after Sch indicate the relevant schedule.
F: Arabic numeral following F indicate the prescribed format.

A. Compliance Plan for Applicable Statutory Provisions

General Responsibility: The Management, and the Occupier/Manager, under the Factories Act, will remain responsible, through their respective departments, to Line Managers for compliance with the following:

F.A. & M.F.R.				Provisions
Sec	**R**	**Sch**	**F**	
2 (cb)				* Hazardous Process: interpretation (meaning)
2 (cb)		First		List of Industries Involving Hazardous Process: (2) Non-ferrous Metallurgical (aluminium) Industries (3) Foundries (ferrous and non-ferrous) (23) Grinding and Glazing of Metals

(*continued*)

F.A. & M.F.R.				Provisions
Sec	R	Sch	F	
				(29) Highly Flammable Liquids and Gases (LPG installation)
2 (n)				* Occupier/Manager under the Factories Act interpretation (Meaning)
6	3 to 15		1 to 5	Factory: approval, licensing and registration
7				Notice by Occupier
7-A				General duties of the Occupier
7-B				General duties of the Manufacturers
41-B				Compulsory disclosure of information by the Occupier
41-C				Specific responsibility of the Occupier in regard to hazardous processes
41-G	73-J			Safety Committee: formation, functions and duties
	73-L			Health and Safety Policy: written policy—containment guide
	73-M		Sch	Collection, development and dissemination of information
	73-N, O, P Q, R			Disclosure of information to: Workers, Local Authority, District Emergency Authority, Chief Inspector
41-H				Right of worker about imminent danger
92				General penalty for offences: Contravention of provisions
96-A				Penalty for contravention of provisions of Sec 41-B, 41-C and 41-H
101				Exemption of Occupier/Manager from liability in certain cases
111-A				Right of Workers (as regards health, safety and training)

Other than F.A. and M.F.R., the following are the additional provisions that need to be looked into:

The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989, framed under the Environment (Protection) Act, 1986:

Rule 4: Demonstration of safe operations.

Rule 5: Notification of major accident.

Rules 6 to 9: Notification of site—submission of report, updated to concerned authority as stated in Schedule 7.

Rules 10 to 12: Preparation of safety report (Schedule 8).

Rule 13: Preparation of On-site Emergency Plan.

Rule 14: Extending help in preparation of Off-Site Emergency Plan.

Rule 15: Information to the public.
Rule 17: Collection, Development and Dissemination of information (Schedule 9).

The Manager assigning jobs to the contractor will issue the copy of "Safety Instructions for Contractors" to the contractor and will take an undertaking to abide by the instructions stated therein. He will ensure the compliance by strict supervision.

B. Line Management Responsibilities for Compliance with the Applicable Statutory Provisions

F.A. & M.F.R.				Provisions	Compliance	
Sec	R	Sch	F		By	Once in
11(1) (a)	19			Cleanliness: Sweeping & disposal of garbage.	Admin.	A day
11(1) (b)				Washing, using disinfectant, every workroom.	Admin.	A week
11(1) (c)				Provision and maintenance of drainage.	Admin.	
11(1) (d)	20			Whitewashing and painting of all the civil and M.S. structures (register dates).	Civil Dept	5 yrs or as reqd.
11(1)	20		8	Record of white colour-washing, varnishing etc.	Civil Dept	**
11(1)	21			Surrounding compound to be maintained clean.	Admin.	**
12	22			Disposal of trade waste and effluents.	Generating Dept	**
13	22-A	Sch		Ventilation and temperature: Limits of temperature and air movement: air changes, dry and wet bulb temperature maintenance (Sch.).	Civil Dept	**
14				Dust and fumes: provision of exhaust system.	Civil Dept	**
17	36			Lighting: prevention of glare: standards specified.	Elec. Maint.	**
18	39 to 44			Drinking water: facilities & standards specified.	Welfare/ Maint.	**

(continued)

F.A. & M.F.R.				Provisions	Compliance	
Sec	R	Sch	F		By	Once in
19	45 to 53			Latrines & urinals: number type, cleanliness, and drainage.	Welfare/ Civil	
	51		8	White-colour washing of latrines and urinals.	Welfare Civil Dept	4 months
B.3.2.2						
21(1)				Fencing of machinery: all moving, projecting, electricity generating, transmitting, dangerously, exposed parts of machinery to be safeguarded and maintained all the time.	Mech. Maintenance Services	**
21(2)	57	III		Wood working machinery: safeguarding.	Stores/ Carpentry	**
21(2)	57	V		Centrifugal machines: Interlocking device.	Maint.	
21(2)	57	IX		Projection to be encased on power-driven machines.	Mech. Maint.	**
22 (1)				Work on or near machinery in motion.	Prodn.	**
22(1)	59 60			Provision of tight fitting clothing. Belts etc to be regularly examined.	Welfare Mech. Maint.	**
28	62		11	Hoist & lift examination by competent person, maintenance of register.	Mech. Maint	6 months
29	64		12	Lifting machines, chains, ropes and tackles: examination by competent person maintenance of register.	Mech. Maint.	12 months
30				Revolving machinery: controlling safe working peripheral speed.	Prodn.	**

(*continued*)

F.A. & M.F.R.				Provisions	Compliance	
Sec	R	Sch	F		By	Once in
31	65		13	Pressure plants: safety measures for operating vessels above atmospheric pressure. Examination by competent person, maintenance of register.	Mech. Maint.	Ext. 6M Int. 12M Hyd. 4 yrs
32				Floors stairs & means of access: ensure safety by fencing.	Maint./ Growth	**
34	66	Sch		Exessive weight: not to exceed as specified.	Prodn./ Stores	
35	67	I & II		Protection of eyes	Dept. Heads	**
36				Precaution against dangerous fumes. Gases.	Prodn.	**
36-A				Precautions regarding use of portable lights etc.	Users	**
	68			Minimum dimensions of manholes	Prodn.	
37				Explosive or flammable dust, gas etc.	Prodn.	**
38				Precaution in case of fire	Dept. Head	
	70			Fire protection: means of protection & escape.	Fire Dept.	
	71-B			Fire fighting apparatus & water supply.	Fire/Maint.	
	71-B	Sch		Equipment's for trailer pumps.	Fire/Traffic	
40,40A	3-A		1-A	Safety and maintenance of buildings and machinery: certificate of stability by competent person.	Civil Dept	5 yrs
41	72			Ladders in good condition with hooks and anti-skid device.	Maint./ Growth	
41/22	73		10	Protection of workers attending to prime movers.	Dept. Head	
41	73-C			Flammable material pipeline breaking: blanking/flushing/ opening precautions and work permit required.	Heat Treatment	When necessary

(continued)

F.A. & M.F.R.				Provisions	Compliance	
Sec	R	Sch	F		By	Once in
41	73-F			Work on A/C sheet/fragile roof: Provision of telescopic and duck ladders, issue of work permit.	Civil Dept	When necessary
41-B	73-S			Information on industrial wastes. Effluent treatment plant. (Quantities included in 73-N-O-Q-R to be considered.)	Heat Treatment	
41-B 41-C 87	73-V 114 73-W 73-X 73-Y 73-Z	Sch		Medical examination & facilities: (i) Pre-employment: physical fitness. (ii) Ascertain the health status—periodic. (iii) Record to be maintained: Health register. Occupational health centre Ambulance van Decontamination facilities Making available Health record to workers.	Personnel/ Medical Medical Medical Medical Medical Traffic Medical Medical/ Personnel	 6 Months
87	114	V VIII XXIII XXIV		Dangerous operations. Special provision. Grinding and glazing of metals. Cleaning or smoothening of articles by metal shot or grit by compressed air blast. Highly flammable liquids and flammable compressed gases (L.P.Gas Installation). Operation involving high noise levels.	Prodn. Foundry Heat treat. Heat treat. Prodn/Maint	
88,88-A 88 88-A 89	115 115 116	Sch 24-A 25		Notification of accidents and/or dangerous occurrences: Refer annexure-V, section – B-2. Report of accident by Manager. Notice of dangerous occurrence by the Manager. Notice of poisoning of disease by the Manager.	Dept. heads through Personnel Dept	As and when needed.

(*continued*)

F.A. & M.F.R.				Provisions	Compliance	
Sec	R	Sch	F		By	Once in
If the injured is covered under the ESI Scheme, the report of the accident in Form No.16 of ESI is to be sent to ESI.						
108	118		26	Display of notices: Abstract of F.A. and M.F.R. as prescribed therein.	Personnel	**
110	119(1)		27	Annual return for the year ending Feb. 1	Personnel	Year
110	119(2)		28	Half-yearly return before July 15	Personnel	Year
112	123		30	Maintenance of register of accident and dangerous occurrences, as prescribed.	Personnel	**
	124	31		Maintenance of Inspection book	Personnel	**
A copy of the above entries is to be submitted to the Directorate, Industrial Safety and Health.					Personnel	Year before Feb. 15

**As and when initiated, conducted, revised or updated and recorded.

In addition to Factories Act & Maharashtra Factories Rules, the Heat Treatment Dept. will also be responsible for the following provisions:

(I) Permission, approval, procurement and renewal of licence for the L. P. Gas Installation with the Department of Explosives, Nagpur, Govt. of India.

(II) The Water (Prevention and Control of Pollution) Act, 1981/The Hazardous Wastes (Management & Handling) Rules, 1989 under Env. (Protection) Act, 1986.
(Sec. 25: Consent to operate the Industry and Process before Dec. 31 every year.)

(III) The Environment (Protection) Second Amendment Rules, 1992.Rule 14, Form V: Submission of Environmental Audit Report to the State Pollution Control Board before Sept. 30, for the financial year, i. e., April to March, every year.

Appendix F

Safety Inspection Checklist for LP Gas Installations

"Today we're going to talk about fall protection"

Abbreviations Used

1. **SMPV (U) Rules:** Static and Mobile Pressure Vessels (Unfired) Rules, 1985.
2. **P.A.:** Petroleum Act, 1934.
3. **P.R.:** Petroleum Rules, 1976.
4. **I.S.I.:** Indian Standard.
5. **F.A.:** Factories Act, 1948.
6. **M.F.R.:** Maharashtra Factories Rules, 1963.
7. **M.S.I.H.C.:** Manufacture, Storage & Import of Hazardous Chemicals.
8. **M.H.C.M.:** Major Hazard Control Manual, International Labour Organisation (ILO), Geneva.
9. **NSS-RPS:** No Standard Specified—Required for Safety Purpose.

(A) Location and Spacing

S.N.	Inspection—Criteria	Specified Standard
1	Site: above ground and area/space well ventilated.	SMPV (U) Rule 21
2	a) Separation distance, required between vessels.	SMPV (U) Rule 22
	b) Vessels and compound boundary.	SMPV (U) Rule 22
	c) Boundary and fixed source of ignition.	SMPV (U) Rule 22
3	Ground below the bullet is concreted and given slope towards the catchment pit.	M.H.C.M.
4	LPG yard is free from grass, shrubs, etc.	

(continued)

S.N.	Inspection—Criteria	Specified Standard
5	Catchment pit, sufficient capacity to entail larger credible leak and is ventilated.	M.H.C.M.
6	Gas detectors given in the pits.	M.H.C.M.
7	Thermal radiation of burning LPG in the pit should not cause danger to the bullet.	M.H.C.M.
8	Storage vessels not placed in the space susceptible to flooding.	
9	Minimum separation distance between vessels is maintained.	SMPV (U) Rule 22
10	LPG vessels are not stored near any other flammable.	SMPV (U) Rule 21
11	Any vessels in one group have a minimum separation distance of 7.5 m from the nearest vessel in another group unless a firewall is oriented between two group.	SMPV (U) Rule 22
12	Long axis of the horizontal storage vessel do not point towards nearby occupied buildings/hazardous materials.	M.H.C.M.

(B) Mechanical Integrity

S.N.	Inspection—Criteria	Specified Standard
1	Vessels are designed, constructed, tested & certified to appropriate standards.	SMPV (U) Rule 12 & IS-2825
2	Maximum safe operating pressure is 14.5 kgs (210 psi.)	SMPV (U) Rule 16 & as per design standard
3	Minimum safe operating pressure is 480 absolute (7 psi).	SMPV (U) Rule 16 & as per design standard
4	Vessels are marked with minimum safe operating pressure.	SMPV (U) Rule 16
5	Safe operating limit of pressure, temperature at unloading.	
6	Are certified by competent person after installation of the vessel and before filling it.	SMPV (U) Rule 33
7	Periodic examinations are done by competent person in accordance with the prescribed codes.	SMPV (U) Rule 19
8	Maximum permissible fill (contents) and maximum permissible load on supports is included in the documentation.	SMPV (U) Rule 33

(C) Fittings

S.N.	Inspection—Criteria	Specified Standard
1	All fittings are suitable for use with LPG at the temperature and pressure likely to be encountered.	SMPV (U) Rule 18
2	Number of connections below liquid line is minimum. All other branches terminate to liquid space.	SMPV (U) Rule 12 (As per IS-2825)
3	Each vessel has the following.	
	a) Pressure relief valve directly connected to vapour space.	SMPV (U) Rule 18 & 12
	b) A drain or other means of emptying the liquid of vessel.	SMPV (U) Rule 18 & 12
	c) The maximum level indicator and content gauge.	SMPV (U) Rule 18 & 12
	d) The maximum level indicator is independent of the level gauges.	SMPV (U) Rule 18 & 12
	e) A filling connection.	SMPV (U) Rule 18 & 12
	f) A means of preventing excessive vacuum if dictated by vessel design.	SMPV (U) Rule 12
	g) A pressure gauge connected to vapour space.	SMPV (U) Rule 18
4	The pressure relief valves are designed to protect the vessel under fire exposure in accordance with code.	SMPV (U) Rule 12 (As per IS-2825)
5	Every relief valve is permanently marked with	
	a) Manufacturer's name & identification including catalogue or type number.	SMPV (U) Rule 16
	b) Start to discharge pressure.	SMPV (U) Rule 12
	c) Date of last inspection and setting.	SMPV (U) Rule 19
6	No isolation valve is fitted between the single pressure relief valve and vapour space of vessel.	SMPV (U) Rule 18
7	For multiple relief valve, if provision is made to isolate a relief valve for maintenance of testing, interlocks are provided to ensure that remaining valves continue being in use.	SMPV (U) Rule 18
8	The relief valve has a vent pipe which is adequately supported and has an outlet at least 1.8 m above the top of vessel.	SMPV (U) Rule 18 & 12
9	Vent pipes of relief valve are designed to ensure that if discharge product ignites, flame does not impinge on the vessels or any adjusting vessel, piping or equipment.	SMPV (U) Rule 18 & 12
10	Vent pipes are provided with loose-fitting rain cap and allow discharge of water.	SMPV (U) Rule 18
11	Drain connections are less than 50 mm in diameter and fitted with 2 shut off valves in series.	SMPV (U) Rule 12
12	The piping downstream of second valve does not discharge beneath the storage vessel.	NSS-RPS

(*continued*)

S.N.	Inspection—Criteria	Specified Standard
13	Sight glass is not used for measuring the liquid level in the LPG storage vessel.	NSS-RPS
14	All liquid and vapour connects on the vessel are fitted with a shut off valve (preferably fire safe).	SMPV (U) Rule 12 (As per design code)
15	Shut off valves are located as close to vessel as practicable (however where there are no mechanical joints between the shut off valve, flange and vessel and interviewing piping is designed constructed tested in accordance with the vessels design of code the shut off valve may be located at the down stream of that length of piping).	SMPV (U) Rule 12
16	Remotely operated emergency valves capable of local manual operation, are fitted to all piping greater than 19 mm internal diameter which carries liquid if any vessel is of 100T water capacity or greater.	NSS-RPS
17	Pumps are not sited beneath LPG vessel.	
18	Positive displacement pumps are provided with a bypass or other suitable protection against extra pressure.	SMPV (U) Rule-29
19	Vapour compressors are installed in a well-ventilated position (preferably in the open) at least 4–5 m from LPG vessel, building and boundaries.	NSS-RPS
20	Vapour compressor installed in a building—then the building is made of non-combustible material with length, width, roofs. The building is not used for any purpose other than compression and distribution of LPG.	NSS-RPS
21	The vapour compressors have at least one of the following a) High pressure cut off switch or similar device on the discharge of the compressor. b) Means to prevent liquid LPG entering the compressor.	Comes under compressor construction.

(D) Piping

S.N.	Inspection—Criteria	Specified Standard
1	All pipes carrying liquid are designed and constructed to any acceptable standard.	SMPV (U) Rule 12
2	Joints in piping are kept to a minimum.	SMPV (U) Rule 12

(*continued*)

S.N.	Inspection—Criteria	Specified Standard
3	Piping with more than 50 mm outside diameter is welded or flanged joints except when connection to equipment fitted with screw connection.	SMPV (U) Rule 12
4	Screwed joints in the piping, which are subjected to vibrations, are tag welded to prevent them from becoming loose.	IS-2825
5	Metal piping is electrically continuous, so that resistances to earth do not exceed 10 ohms.	PA-108
6	Piping is sized and routed to restrict the contents of the pipe to minimum to reduce potential hazard.	NSS-RPS
7	The route selected for piping minimises the possibility of physical damage particularly from vehicles.	NSS-RPS
8	Protective barriers are provided to the piping where damage from the vehicle is foreseen.	NSS-RPS
9	Piping is preferably run above the ground and routed away or protected from excessive heat.	NSS-RPS

(E) Underground Piping

S.N.	Inspection—Criteria	Specified Standard
1	Corrosion protection is provided wherever necessary.	NSS-RPS
2	All pipe joints are welded.	NSS-RPS
3	Isolation valves are provided at both ends of the underground sections.	NSS-RPS
4	Piping and covering corrosive or toxic material and steam are not laid in the same trench.	NSS-RPS
5	Electrical cables are not laid in the same trench, wherein LPG piping has been laid unless protected by other pipes or sleeve.	NSS-RPS

(F) Hydrostatic Relief Valve

S.N.	Inspection—Criteria	Specified Standard
1	Piping in which liquid LPG may be trapped are protected against excessive pressure by fitting hydrostatic relief valves. 2 Nos. Spring loaded.120% discharge.	SMPV (U) Rule 18 & IS-2825

(*continued*)

S.N.	Inspection—Criteria	Specified Standard
2	The discharge from a hydrostatic relief valve released in air does not endanger people or equipment.	NSS-RPS
3	The hydrostatic relief valves are not sited beneath the storage vessel.	NSS-RPS
4	Any relief valve located under the vessel is positioned so that escaping LPG is not directed towards the vessels surface or any adjacent access-way.	NSS-RPS

(G) Flexible Connections

S.N.	Inspection—Criteria	Specified Standard
1	Hoses for conveying LPG comply with the prescribed code or standard.	SMPV (U) Rule 29, Form V, Condition No. 10 and B.S. 4089-T
2	Emergency isolation valves are installed in piping conveying liquid LPG to which hoses are connected, to prevent prolonged discharge of LPG in the event of failure of hose.	NSS-RPS

(H) Fire Precaution

S.N.	Inspection—Criteria	Specified Standard
1	Electrical equipment installed near LPG vessels etc. meet the required standards & separation distance.	SMPV (U) Rule 31 IS-2148 & 2206
2	Plant design and layout take care of water supplies, fire protection, fire fighting equipments means of access for fire brigade appliances, protection of fire brigade personnel.	NSS-RPS
3	There is an arrangement to ensure an early call out to the fire brigade in the event of fire.	NSS-RPS
4	There is adequate supply of water for protection to use in emergency.	TAC Rule
5	On-site hydrants and fixed monitors are designed so that water flow can be controlled from safe position.	TAC Rule
6	There is adequate drainage to deal with water used for fire protection and fire fighting purposes.	NSS-RPS
7	Water sealed interceptors are filled where necessary, to prevent LPG entering from drain and sewer.	NSS-RPS

(continued)

S.N.	Inspection—Criteria	Specified Standard
8	The storage vessels are provided with fixed fully automatic water spray system capable of detecting a fire therein the vessel and operating without manual intervention.	TAC Rule
9	Fire detecting systems do not depend upon sensing of excessive vessel pressure.	NSS-RPS
10	For manually operated water, spray there is continuous supervision.	TAC Rule
11	Manual operation point of water sprinkler is situated at safe place.	NSS-RPS
12	Fixed water spray system is fitted to bulk vessels at cylinder filling installations and to rail loading and unloading gantries.	NSS-RPS
13	LPG installations are provided with portable fire fighting equipment.	F.A-71-B
14	People in the premises where LPG is stored have received adequate instructions with training to unable them to under stand the fire protection and action to be taken in the event of fire or leakage of LPG.	F.A. 7-A(C)

(I) Loading and Unloading Facilities

S.N.	Inspection—Criteria	Specified Standard
1	Written instructions are given which clearly define responsibilities for all personnel involved in the loading and the unloading operations.	M.S.I.H.C.-On-Site Emergency Plan
2	At least two persons are engaged in an LPG transfer operation. A competent person is present during unloading.	SMPV (U)-42
3	A responsible person on site checks that the quantity of LPG being transferred is suitable for the receiving vessels.	NSS-RPS
4	The maximum level device is used to ensure over-filling does not occur.	SMPV (U) Rule 18(3)
5	Excess LPG is removed immediately in a safe manner in the event of overfilling of tanker.	SMPV (U) Rule 30
6	The point of transfer, where connection and disconnection is made is located in a well-ventilated position.	SMPV (U) Rule 30
7	Flexible hose used for conveying LPG to and from road and rail tanker into fix piping or vessel: a) designed and constructed to an appropriate standard, b) has identification,	SMPV (U) Rule-29(4)

(*continued*)

S.N.	Inspection—Criteria	Specified Standard
	c) examined for links and wear on every occasion prior to use. Hose filling are similarly examined, d) hydraulically tested every year, e) periodically checked for electrical continue, f) have written record of tests in (D&E), g) kept so that it is not physically damaged or adversely affected by the weather when not in use or when being conveyed, h) have means of protecting their fitting against damage or ingress of foreign material, i) protected by a precoil or similar device to protect against external damage, j) replaced or repaired when damaged or worn.	
8	Loading arms which are flexible hoses in which liquid could be trapped between shut off valves are protected against excess pressure cause by the thermal expansion of the contained.	SMPV (U) Rule-29(4)
9	During loading and unloading the tanker, stand on an essential level site to minimise the risk of accidental movement.	NSS-RPS
10	Block is placed against the vehicle wheels or other means provided to prevent vehicle movement prior to loading and unloading.	NSS-RPS
11	The ground beneath the tanker drained cambered or has a shallow gradient to a safe place to carry the spillage from pipeline or vessel to a safe place.	NSS-RPS
12	The loading-unloading operations deter the traffic approaching the transfer operation by providing physical barriers.	NSS-RPS
13	For public safety warning, notices readable from a distance of 6 m are set up stating. a) LP gas transfer taking place. b) No smoking or naked flames.	M.S.I.H.C. Rule (Caution notice)
14	Any accumulated static electricity on road tanker is discharged to earth.	SMPV (U) Rule-39(3)
15	The tank of the road tanker is electrically bonded to the fixed installation before any LPG transfer operation is carried out	SMPV (U) Rule-39(3)
16	The electrical bonding connection is broken only after the liquid and vapour balance connection has been disconnected.	SMPV (U) Rule-26

(J) Maintenance and Examination

S.N.	Inspection—Criteria	Specified Standard
1	The installation is maintained to acceptable standards by a competent person of appropriate discipline with the objective of: a) maintaining the established safe operating limits, b) taking care of the features affecting the integrity of the installation or ability to take emergency measures.	SMPV (U) Rule-19 & F.A.-31 & M.F.R.-65
2	Maintenance has been prepared which includes protective devices and instruments and the format containing the details which reflect the need of particular installation.	M.S.I.H.C. Rule (As per the properties of chemical)
3	Suitable records are kept so that all maintenance schemes are properly monitored.	As per ISO procedure
4	All significant deterioration, defect, repairs of replacement is recorded.	SMPV (U) Rule-12
5	Vessels are examined at the intervals as required by Factories Act.	SMPV (U) Rule-19 & F.A.-31 & M.F.R.-65
6	Examinations of pressure vessel include support structure, holding down arrangement and foundation.	SMPV (U) Rule-23
7	Examination reports specify: a) The maximum safe operating pressure. b) The minimum safe operating pressure. c) The minimum safe operating temperature. d) The maximum permissible load. e) The date, when it is due (or, Due date) for the next examination.	SMPV (U) Rule-19 & F.A.-31 & M.F.R.-65
8	Repairs and modification undertaken are to a standard, equal to the original design and construction code.	SMPV (U) Rule-12

(K) Operational Procedure

S.N.	Inspection—Criteria	Specified Standard
1	Written operation procedures are prepared, which clearly define the action or the function required of the involved.	M.S.I.H.C. Rule & On Site Emergency Plan (Schedule 11)
2	Written operation procedures cover both normal and emergency operation and regularly review and modify if required.	M.S.I.H.C. Rule 4(2) NSS-RPS

(continued)

S.N.	Inspection—Criteria	Specified Standard
3	The procedure is readily available to the people on site including contractors entering or working at the site.	M.S.I.H.C. Rule & On Site Emergency Plan (Schedule 11)
4	Written operating procedure includes—	
	a) The transfer of LPG to or from the installation.	SMPV (U) Rule-30
	b) The transfer of LPG at other sites when the delivery tankers operate from the site.	
	c) Permit to work system.	MHC Manual, ILO
	d) Plant maintenance and modification.	SMPV (U) Rule-12
	e) Including maintenance of electrical equipment including the flameproof one.	SMPV (U) Rule-31
	f) Emergency procedures.	M.S.I.H.C. Rule 13(4)
5	Any deviation from the written procedures should only be undertaken with the written authority of the appropriate responsible person at the site.	NSS-RPS
6	Daily checklist of safety and fire hazard about the installation and its accessories pipelines maintained by the user dept.	NSS-RPS
7	Mock drill for LPG handling.	M.S.I.H.C. Rule 13(4)
8	Safety audit conducted.	M.S.I.H.C. Rule 10(4)

(L) Training

S.N.	Inspection—Criteria	Specified Standard
1	Employees concerned with LPG are familiar with its properties and hazards.	As per F.A. 41B & M.S.I.H.C. Rule (On Site Emergency Plan)
2	Employees are instructed about normal operation including loading and unloading procedures and emergency shutdown.	As per F.A. 41B & M.S.I.H.C. Rule (On Site Emergency Plan)
3	Training is a continuous commitment and includes refresher courses appropriately.	As per F.A.7-A(C) & On Site Emergency Plan
4	Emergency procedures are practised regularly.	As per F.A. & M.S.I.H.C. Rule 13(4)

Appendix G

Natural Gas (NG) and Compressed Natural GAS (CNG)

Natural Gas (Methane)

Natural gas is widely used as fuel for domestic heating and industrial processes. It is easily transported through pipelines and costs about the same or slightly less than gasoline. Vehicles converted for the fitment of Compressed Natural Gas (CNG) emit low levels of toxic—and ozone—forming hydrocarbons. But CNG must be stored under pressure in heavy tanks and the cost of accommodating these tanks has to be considered.

There are significant trade-offs for CNG vehicles with regard to emission, vehicle power, efficiency and range. However natural gas is already used in some fleet vehicles and appears to have a bright future as a motor vehicle fuel.

Safety Aspects of Piped Natural Gas Supply for Domestic Use

Natural Gas (NG) is a clean, versatile fuel in most of the major cities catering to domestic and commercial applications.

1. It is a mixture of hydrocarbons consisting of approximately 80 to 90% methane in gaseous form. It is colourless, odourless, non-toxic, flammable and lighter than air.
2. Natural gas has the narrowest flammability range in the event of leakage and hence is a safer fuel in comparison to other competitive domestic fuels. The combustible mixture of NG and air does not ignite, if the mixture is leaner than 5% and richer than 15% of the air-fuel ratio required for ignition. Thus it is one of the safest fuels in the world.
3. A large quantity of LPG is stored in liquefied form at high pressure in a cylinder, so that the fuel can last long over a period of 20 to 30 days with its user. This is a risk that the user takes in the event of any explosion causing damage to life and property.
4. With piped NG this possibility is remote as the pipeline inside the user's premises contains only limited quantity of NG and that too at a much lesser pressure, i.e., 21 mbr. Moreover the user

has the provision to switch off the appliance valve inside the kitchen and the main valve outside the kitchen premises, which will fully cut off the gas supply.

5. NG is lighter than air as compared to LPG which is heavier than air. This property of NG minimises the risk of accidents. In the event of leakage it will mix with atmospheric air and disperse. Whereas LPG, being heavier than air, does get trapped in the enclosures at floor level and thus remains a potent explosive mixture.
6. A piped NG connection has an in-built safety system which ensures trapping of the regulator in case a leak occurs more than the specified range already set.
7. Moreover, NG is non-corrosive, non-carcinogenic and eco-friendly in nature.

Appendix H

Safety Precautions for the Vehicular Use of Compressed Natural Gas

"Today we're going to talk about fall protection"

1. Check your cylinder and kit certificate.

- ❑ The workshop issues a safety certificate after the kit fitment that the conversion kit has been in safe and proper manner.
- ❑ The dealer issues a certificate stating the details of cylinder make and number and re-testing date.

All CNG users need to carry their fitment certificate for filling CNG.

2. Use only approved CNG kits.

- ❑ Use only CNG kits approved by the Automobile Research Association of India (ARAI), Pune, Vehicle Research and Development (VRDE), Ahmednagar or India Institute of Petroleum (IIP), Dehradun.
- ❑ Install your CNG kits at a workshop authorised by kit supplier or manufacturer.
- ❑ Install CNG cylinders approved only by Chief Controller of Explosives.
- ❑ CNG cylinders are required to be tested and certified for use after every five years.

3. Do not try to source the kit components separately.

- ❑ Do not make the CNG kit yourself as non-compatibility of components could be unsafe.
- ❑ Usage of spurious cylinders is an offence.
- ❑ Ensure your CNG conversion is authorised by the Regional Transport Authority.

4. CNG vehicles may be parked, serviced and repaired inside garages provided following conditions are observed.

- ❑ There should be no leaks in the fuel system.
- ❑ These vehicles should not be parked within 6 m of any source of ignition or fire
- ❑ Cylinder shut-off valve and service valves should be closed and CNG fuel in the service line exhausted by running the engine or depressurising the line in a well-ventilated area.

- ❑ In case of vehicles undergoing repairs involving any hot work (i.e., welding, gas cutting or any type of heat application to any part) within 1.5 m of the cylinder, the cylinder should be removed first.

5. Periodical inspection, testing schedule of CNG equipment and components.

- ❑ After initial conversion, the vehicle may have to be brought to the workshop for tuning on gas after 1,000 to 1,500 km as diaphragms and other parts require this much usage before settling down.
- ❑ As specified under the law by the Chief Controller of Explosives, the CNG cylinder must be hydraulically tested and certified by an authorised 'testing shop' once in every five years.
- ❑ In addition, the vehicle user is required to take the vehicle for annual inspection to a 'CNG Conversion Workshop', and obtain a certificate from the workshop that the CNG system, which has been installed, is satisfactory. It is necessary to produce this certificate at the time of CNG filling.

Dos and Don'ts

1. In case of an accident, get the vehicle thoroughly checked at an authorised workshop and obtain a fresh certificate.
2. Don't smoke or bring any source of flame near any of the components through which CNG is passing.
3. Don't park the vehicle in a non-ventilated area.
4. Handle all the valves and parts with due care. Any mishandling may flatten the CNG piping.
5. Do not install an LPG, propane or any other cylinder in the place of CNG cylinder. It is not only illegal but also unsafe.
6. For emergency handling of any CNG leak, users must be aware of the location and operation of the cylinder valve, master shut-off valve and the burst disc in the CNG system.

(Study the system and ask your mechanic to educate the user to identify these parts.)

(Ref: 1. CNG user's manual of Mahanagar Gas Ltd.
2. Indraprastha Gas Ltd. website – www.igliindia.com
3. National Safety Council, 2002 HSE Diary
4. National Safety Council, *Chronicle*, July–Sept. 1999.)

Appendix I

Fire Prevention Safety Audit

Fire Equipment

1. Ensure that no storage of material or equipment has been kept or scattered in such a way that it blocks the access to the following, which should always remain clean, clear and free of all obstructions:
   (a) Fire hose cabinet.
   (b) Fire extinguishers.
   (c) The standpipe system.
   (d) The sprinkler system and sprinkler heads. (Nothing should be kept hanging from the sprinkler system. There must be a minimum of 18 inch clearance under each of the sprinkler heads.)
   (e) Fire alarm devices (i.e., pull stations).
   (f) Fire alarm panel/fire enunciator panel.
2. Are the exit lights operating and positioned properly?
3. Ensure that there is no junk of unnecessary fire equipment in the area, obstructing the passage to the required equipment.

Egress Route

1. Is the corridor, passageway, aisle etc., through which rescue and fire-fighting crew walk or run in emergency, clean and clear of obstructions? Is the corridor clear of combustible or flammable materials?
2. Are the fire doors clear of obstructions? Do the fire doors close properly, as and when required?
3. Are the following kept and maintained wide open and clear of obstructions?
   (a) Exit-doors (b) Egress route (c) Staircases (d) Fire-exit-lanes.

Fire Hazards

1. Is the flammable storage cupboard being used for flammable storage?
2. Is there a breach in the walls or ceiling?
3. Are there any fire hazards due to electrical wiring? Are there proper outlets installed in areas where flammable materials or vapours may be present?

Housekeeping

1. Are the areas clean, clear and tidy?
2. Is the storage of flammable and/or combustible materials proper?

Appendix J

Confined-Space-Entry: A Sample Permit[56]

(Also termed as Safe-Entry-Permit and Safe-Entry and Hot-Work Permit)

Class: ______________

Location of Work: ____

Description of Work (Trades) ____

Employee Assigned ____

Entry Date: ________________________ Entry Time: _________________________

Outside Contractors____

Isolation Checklist:	Needed	Not needed	Done
Blanking and/or Disconnecting	☐	☐	☐
Electrical	☐	☐	☐
Mechanical	☐	☐	☐
Other	☐	☐	☐

Hazardous Work:	Needed	Not needed	Done
Burning	☐	☐	☐
Welding	☐	☐	☐
Brazing	☐	☐	☐
Open Flame	☐	☐	☐
Other	☐	☐	☐

Hazards Expected:	Needed	Not needed	Done
Corrosive Materials	☐	☐	☐
Hot Equipment	☐	☐	☐
Flammable Materials	☐	☐	☐
Toxic Materials	☐	☐	☐
Drains Open	☐	☐	☐
Cleaning (Ex: chemical or water lance)	☐	☐	☐

Spark Producing Operations	☐	☐	☐
Spilled Liquids	☐	☐	☐
Pressure Systems	☐	☐	☐
Other	☐	☐	☐

Vessel Cleaned:

Deposits ____________________

Method ____________________

Inspection ____________________

Neutralised with ____________________

Fire Safety Precautions: ____________________

____

Personal Safety:	Needed	Not needed	Done
Ventilation Requirements	☐	☐	☐
Respirators	☐	☐	☐
Clothing	☐	☐	☐
Head, Hand and Foot Protection	☐	☐	☐
Shields	☐	☐	☐
Lifelines and Harness	☐	☐	☐
Lighting	☐	☐	☐
Communications	☐	☐	☐
Employee Qualified	☐	☐	☐
Buddy System	☐	☐	☐
Standby Person	☐	☐	☐
Emergency Egress Procedures	☐	☐	☐

Training Sign Off: ____________________ (Supervisor or Qualified Person)

Remarks: ____________________

Atmospheric Gas Tests:

	Tests Performed	Location	Reading
	____________	____________	____________
	____________	____________	____________
Example:-	(Oxygen)	____________	(19.5%)
Example:-	(Flammability)	____________	(Less than 10% LFL)
	____________	____________	____________
	____________	____________	____________

Remarks: ____________________

Test Performed By: ____________________(Signature)__________(Time)

Authorisations:

Supervisor: ____________________

Prod. Supervisor: ____________________

Line Supervisor: ____
Safety Supervisor: ____
Etc.: ____

Entry and Emergency Procedures Understood:
Standby Person: ____
Rescue: ____
Telephone(s): ____

Permit Expires: ____
Classification: ____
____

Appendix K

Three Paradigms of Safety Performance

The Accident Cycle	The Performance Plateau	The Step-change to Continuous Improvement
No continuing efforts	*Partial continuing efforts*	*Continuing efforts*
No Improvement	Partial Improvement	Desired Improvement
Safety performance continually varies in the accident cycle.	Good improvement at first but inspite of continuing efforts, performance levels off and plateaus.	Performance improves continuously, step-by-step.
Management is inconsistent in its support to safety.	Management support for safety is obvious only when it suits its purpose.	Management support is consistent and it remains committed to safety.
No recognition of safety functions, responsibilities and implementation.	Lack of agreement on safety between levels of management and employees.	All levels of management and workers agree on safe work place and safe work habits.
The safety effort is reactive and crisis driven.	The safety pressure is constant and numbers driven.	Safety initiative is focused continually on upstream measures, prior to incidence.
Safety department responsible for safety organisation, norms and systems, and administration.	Line managers and supervisors accountable for shop-floor implementation of safety.	Meaningful employee involvement and performance accountability at all levels.

(*continued*)

The Accident Cycle	The Performance Plateau	The Step-change to Continuous Improvement
No continuing efforts	*Partial continuing efforts*	*Continuing efforts*
Special meetings for reactive training.	Training meetings, programmes, incentives committees—using descriptive statistics in an undirected way.	Ongoing data-driven problem solving and action planning by work groups in regular safety meetings.
Arbitrary numerical goals.	Sporadic, department-specific accident tools.	Proper use of statistical methods to evaluate results and direct site wide activities.
A history of programmes.	A history of programmes.	Site-specific adaptation of a process approach.
Reliance in games/ incentives.	Reliance on posters/ announcements/signs.	Reliance on inventory of objectively defined critical safety-related behaviours.
Inconsistent use of disciplinary action.	Accident investigations tend to focus on fault finding and fixing of blame.	Accident investigations use multi-level participation and are oriented to data gathering, establishing mechanisms to sum results for directed problem solving.

Appendix L

Risk Assessment

Risk assessment is a powerful tool in the system in line with IS 15001, which is the overall process of estimating the magnitude of risk and deciding whether or not the risk is tolerable. It suggests establishing and maintaining procedures to *identify hazards and assess and control risk* related to its activities,

Risk assessment is a statutory requirement for industrial activities involving certain hazardous chemicals of specified quantities as per the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989. It can be applied to any hazardous activity in industry, irrespective of chemical hazards.

Necessity

Risk assessment used to be conducted on an informal basis and was thought to be only an expert's job.

This is the key for building up an adequate safety management system. This is a necessary and workable programme. It is bound to succeed in preventing accidents as it has been based on shared perceptions of hazards and risks.

Risk assessment should provide the basis, in totality (inventory), for action and form the basis for implementing control measures. The aim is to tackle risk with a fresh pair of eyes and a questioning approach. It should be carried out by competent people who have practical knowledge of the work activities. Everyone should contribute in the assessment.

The example of 'A fall in the bathroom or shower' from chapter I, repeated here, will explain the steps involved in conducting the programme on Risk Assessment.

"A fall may cause only minor discomfort, but it can equally cause serious injury such as fractures, concussion and sometimes even death. It all depends on the nature of the fall and just where it takes place. The basic question from the point of view of accident prevention is: *Why did I fall*? Perhaps the floor was wet and I did not consider that the wet floor might be slippery. Had I been aware of the wet condition, I might well think that a fall would only occur if I were careless—and I am careful, not careless.

"In technical terms, the wet floor presents a risk against which precautions can be taken. For instance, replacing slippery tiles by means of matt-finish or non-slippery tiles. Or, a non-slip rubber mat could be provided by way of an instant arrangement. (But this introduces a new risk: tripping over a non-slip mat, especially those who are terribly clumsy.)"

This simple analogy introduces the concepts of:

- **The Hazard**—A source or situation with potential to cause harm in terms of human injury or ill health, damage to the environment or a combination of these. In this example it is the slippery bathroom floor.
- **The Risk**—It is the combination of frequency (or probability) of an occurrence and the consequences of a specified hazardous event. In this example the specified event is the slippery floor and the risk is a fall. The risk continues to persist as long as the bathroom floor is slippery. It is termed as a magnitude. Risk is also defined as a measure of both the probability and consequences of all hazards related to an activity.
- **The Risk Assessment**—It is an overall process of estimating the magnitude of risk. Whether the risk is tolerable or not is required to be assessed. It is certainly not tolerable in the given example.
- **The Risk Control Action Plan**— The prevention of accidents or injuries by taking appropriate precautions in controlling the hazard. These are various elements that are always present and are required to be considered when we talk about safety, the state in which the risk of harm to persons or damage to property is limited to a tolerable level. In the given situation, providing a non-slip rubber mat or permanent non-slip tiles could control the risk.

Risk Assessment Programme

Procedure for Conducting the Programme

1. Classify work activities, products and services.
2. Identify hazards.
3. Determine the risk.
4. Assess risk level. (Decide: if the risk is tolerable/intolerable.)
5. Prepare a risk control action plan. (If the risk is not tolerable.)
6. Review adequacy of action plan.

Therefore, the organisation establishes and maintains a procedure to identify hazards and assess and control risk related to its activities, products and services over which it has control and influence and keeps a proper track of legal and other requirements to maintain regulatory compliance.

Work Activity Information Requirements

Information required for work activities should not be limited but can include the items from the following lists:

1. Tasks being carried out, their duration and frequency.
2. Location where work is carried out.

3. Who normally/occasionally carries out the work.
4. Who else may be affected by the work—visitors, sub-contractors, the public etc.
5. Training personnel have received about the tasks.
6. Written systems of work and or permit to work. Procedures prepared for the tasks.
7. Plant and machinery that may be used.
8. Powered hand tools that may be used.
9. Manufacturer's or supplier's instructions for operation and maintenance of plant machinery and power tools.
10. Size, shape, surface character and weight of materials that might be handled.
11. Distance and height of the place where materials have to be moved by hand.
12. Services used.
13. Substances used or encountered during work.
14. Physical forms of substances encountered during work. (Fumes, gas, vapours, liquids, dust, powder/solid etc.)
15. Content and recommendation of safety data sheets relating to substances used or encountered.
16. Relevant acts, regulations and standards relating to work, the plant, machinery used and the materials encountered.
17. Control measures believed to be in place.
18. Available monitoring data gained as a result of information from within and outside the organisation, incident, accident and ill health experiences associated with the work being done.
19. Finding any existing assessments relating to the work activity.

Responsibilities Assigned to Conduct the Programme

Process of Risk Assessment	Responsibility
Classify work activities Identify hazards. Determine Risks (Ref. Table 1). Decide if risk is tolerable (Ref. Table 2). Prepare a risk control action plan (Ref. Table 2). Review adequacy of action plan. Approval of action plan. Implementation. Report on compliance.	Responsibilities are to be clearly documented based on the organisation structure, unless the Unit Supervision is actively involved in Hazard Identification and has an orientation towards achieving reduction of risk levels which calls for a process approach or the entire activity will lose its importance.

A Complementary Approach to Developing a Hazard Prompt List

1. Entry of body parts in moving machinery.
2. Slips/falls on the same level.
3. Falls from heights.
4. Fall of tools, materials etc. from heights.

5. Inadequate head room.
6. Hazards associated with manual lifting/handling of tools, materials etc.
7. Hazards associated with plant machinery associated with assembly, commissioning, operation, maintenance, modification, repair and dismantling.
8. Vehicle hazards.
9. Fire and explosions.
10. Substances that may be inhaled.
11. Substances or agents that may damage the eye.
12. Substances that may cause harm by coming into contact with or being absorbed through the skin.
13. Substances that may cause harm by being ingested.
14. Harmful energies (electrical, radiation, vibration, noise etc)
15. Lighting levels.
16. Slippery, uneven ground levels.
17. Sub-contractors' activities.

Hazard Identification for Analysing Risk

1. Is there a source of harm?
2. Who (or what) could be harmed?
3. How can the harm occur?

Broad Categories of Risks (By Topic)

1. Mechanical
2. Electrical
3. Radiation
4. Substances
5. Fire and explosion
6. Toxic release
7. Natural calamities.

Simple Risk Level Estimator-I

Probability of occurrence (1)	Slightly harmful (2)	Harmful (3)	Extremely harmful (4)
Highly Unlikely	Trivial Risk	Tolerable risk	Moderate Risk
Unlikely	Tolerable Risk	Moderate Risk	Substantial Risk
Likely	Moderate Risk	Substantial Risk	Intolerable Risk

Note—Tolerable here means that risk has been reduced to the lowest level that is reasonably practicable.

Simple Risk Level Estimator-II (Health, Safety and Environment—Risk Matrix)

Consequences					Probability of it happening again				
					V. Low A	Low B	Medium C	High D	V. High E
Severity Rating	P People Injury	A Assets Damage/ Loss	E Environment Total Effect	R Reputation Impact	Never heard of in Industry	Heard of in Industry	Incident has occurred in the Company	Happens >5 times per year in a Company	Happens >5 times per year at a Location
0	No Injury	No Damage	No Effect	No Impact			NEAR MISS		
1	Slight	Slight	Slight Effect	Slight Impact			LOW		
2	Minor	Minor	Minor	Limited Impact					
3	Major	Considerable	Localised	Considerable Impact			MEDIUM		
4	Single (Fatality)	Major	Major Effect	National Impact				MEDIUM HIGH	
5	Multiple (Fatalities)	Extensive	Massive Effect	International Impact					

Determination of Risks

Estimating the potential severity and the likelihood of consequences should determine the severity of risk from the hazard. Information obtained about work activities is vital to establish potential severity of harm.

1. Body parts likely to be affected.
2. Nature of harm, slightly harmful to extremely harmful.
3. Slightly harmful
   - Superficial injuries, minor cuts, bruises, eye irritation from dust.
   - Nuisance and irritation, ill health leading to temporary discomfort.
4. Harmful
   - Laceration, burns.
   - Contusion, serious sprains.
   - Minor fractures.
   - Deafness, dermatitis, asthma.
   - Work-related upper limb disorders.
   - Ill health leading to permanent minor disability.

5. Extremely harmful
   - Amputations, major fracture, multiple fractures.
   - Poisoning.
   - Fatal injuries.
   - Occupation-related cancer and other life-shortening diseases.
   - Acute fatal diseases.

Evaluation of Risk Tolerance Table

Risk level	**Action and Time Scale**
Trivial	No action is required and no documentary record needs to be kept.
Tolerable	No additional controls are required. Consideration may be given to a more cost-effective solution or improvement that imposes no additional cost burden. Monitoring is required to ensure that the controls are maintained.
Moderate	Efforts should be made to reduce the risk, but the cost of prevention should be measured and limited. Risk reduction measures should be implemented.
Substantial	Work should not be started until the risk has been reduced. Considerable resources may have to be allocated to reduce the risk. Where it involves work in progress, urgent action should be taken.
Intolerable	Work should not be started or continued until the risk has been reduced. If it is not possible to reduce the risk even with unlimited resources, work has to be prohibited.

Simple Risk-based Control Plan

An Action Plan has to be prepared in consultation with the members and submitted to the management for consideration and approval.

Finally the leader of the team can arrive at a thoughtful conclusion on the unanimous acceptance of the members of the team whether the activity considered and discussed is *trivial*, or at least *tolerable*, and declare it *acceptable* to live with.

Control measures and urgency should be proportional to the risk.

The outcome should be an inventory of the activities made tolerable and safe to work.

Suggested Format for the Action Plan on Completion of the Assessment of the Activity

S. No.	Activity	Hazard	Risk	Control in Place	Severity of Harm & Likelihood of Harm	Risk Level	Action Plan & Responsibility

Glossary

A

Abatement

- The reduction in degree or intensity.

Absorbed Dose

- The energy imparted to a unit mass of matter by ionising radiation. The unit of absorbed dose is the rad. One rad equals 100 ergs per gram.
- The amount of a substance absorbed into the body, usually per unit of time. The most common unit of dose is mg per kg body weight per day (mg/kg-day). [S.L. Brown]

Absorption

- The penetration of one substance into or through another.
- Specifically, the penetration of a substance into the body from the skin, lungs, or digestive tract.

Accident

- An accident is usually a dynamic event (fire, explosion, high energy release, destruction or separation of parts of the system and so on) since it results from the activation of a hazard and culminates in a flow of sequential and concurrent events until the system is out of control and a loss is incurred.
- Accident is that occurrence in a sequence of events that produces unintended injury, death, or property damage. Accident refers to the event, not the result of the event (see unintentional injury).
- It is an undesired event that results in harm to people and/or damage to property, process or the environment.
- It is also expressed as an unplanned, unwanted, and unexpected event, which because of an unsafe act or unsafe condition, results in property damage, injury, or death.

Accident Causes or Accident Causative Factors

- A series of unplanned events, in a sequence of occurrences, which directly or indirectly contribute to or produce an accident or incident.

Accident Costs

- The monetary losses associated with an accident or incident. These costs include direct and indirect costs.

Accident Investigation

- A detailed, defined and recorded review of an occurrence, made to uncover and record the factors, causes and their relationships which led up to and caused an accident or incident.

Accident Prevention

- The application of measures designed to reduce accidents or accident potential within a system, organisation or activity. An accident prevention programme is one which aims to avoid or prevent injury to personnel and/or damage to property.

Accident Records

- Recorded information in the form of reports and records, detailing what accidents or incidents have occurred, in a company or industry and what losses and injuries resulted.

Accident Report

- A document containing the information and facts about an individual accident or incident put in chronological order to provide a complete picture as to what happened. It also acts as a tool to help establish the root cause of the accident or the incident.

Acute

- Diseases or responses with short and generally severe course (often due to high pollutant concentrations).

Acute Respiratory Disease

- Respiratory infection, characterised by rapid onset and short duration.

Acute Toxicity

- Any poisonous effect produced within a short period of time following exposure, usually up to 24–96 hours, resulting in biological harm and often death.

Adsorption

- The attachment of the molecules of a liquid or gaseous substance to the surface of a solid.

Advanced Air Emission Control Devices

- Air pollution control equipment, such as electrostatic precipitators and high energy scrubbers, that are used to treat an air discharge which has been treated initially by equipment including knockout chambers and low energy scrubbers.

Advection

- Process of transport of an atmospheric property, or substance within the atmosphere, solely by the mass motion of the atmosphere.

Air Emissions

- The release or discharge of a pollutant (from a stationary source) into the ambient air. For anthropogenic sources this may involve release (1) by means of a stack or (2) as a fugitive dust, mist or vapour as a result inherent to the manufacturing or formulating process. Pollutants may also be discharged from mobile sources, from area sources such as roads and fields, and from non-manufacturing, stationary sources.

Air Monitoring

- The continuous sampling for, and measuring of, pollutants present in the atmosphere.

Air Pollutant

- Dust, fumes, mist, smoke and other particulate matter, vapour, gas, odorous substances, or any combination thereof; any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and by-product material) substance or matter which is emitted into or otherwise enters the ambient air.

Air Pollution

- The presence in the outdoor atmosphere of any dust, fumes, mist, smoke, other particulate matter, vapour, gas, odorous substances, or a combination, in sufficient quantities and of such characteristics and duration as to be, or likely to be, injurious to health or welfare, animal or plant life, or property, or as to interfere with the enjoyment of life or property.

Air Sampling

- The collection and analysis of air samples for detection or measurement of radioactive substances, particulate matter, or chemical pollutants.

Aliphatic

- One of the major groups of organic compounds characterised by a straight-chain arrangement of the constituent carbon atoms.

Alkalinity

- The measurable ability of solutions or aqueous suspensions to neutralise an acid.

Approved

- When a procedure, practice, equipment, etc. is said to be "approved", this means it complies with written company standards. Where no such standards exist, the applicable legislation is considered to be standard.

OR

- Complying with written I.S.I. standards, or where no such standard exists, complying with a recognised standard and applicable legislated standards.

Audit (Safety)

- A management tool used to measure the effectiveness and efficiency of a safety programme and company operations, which provides an accurate picture of the safety and health of an organisation.

Authorised

- Given the authority to act in the referenced manner by the responsible management.

B

Biochemical Oxygen Demand (BOD)

- The dissolved oxygen required for decomposing organic matter in water. It is a measure of pollution because heavy waste loads have a high demand for oxygen.

Biological Hazard

- A hazard that pertains to life organisms, including such things as viruses and toxic materials that living things produce, e.g., animals and bacteria in drinking water.

Boiling Liquid Expanding Vapour Explosion (BLEVE)

- It is a combination of fire and explosion with an intense radiant heat emission within a short time. This cloud ignites and a "fire ball" forms, causing enormous heat-radiation intensity in seconds.
- It is an accident generally involving release of flammable gas, liquefied under pressure of normal temperature in huge quantity following a rupture of a vessel. BLEVE is a result of rapid vaporisation of a large fraction of a liquefied flammable gas due to sudden loss of containment pressure. The causes of BLEVE are due to brittle failure, metallic

containers, corrosion, any damages due to external impacts or exposure due to external fires, etc.

- Among all these causes, the most common cause of BLEVE is fire around or in the vicinity of the tank, in which case the tank wall is exposed to the external heat, resulting in increased temperature and pressure of the flammable liquid.
- Simultaneously, if the roof or tank wall, which is exposed to vapour space, is affected by heat from the external flames, the metal can lose its strength at increased temperature and thereby result in tank rupture. Rapid vaporisation of its contents can take place in such a failure. The flammable content of the tank may ignite resulting in huge fireball whose radiation intensity can be felt even far off, depending upon the size of the fireball.

C

Carcinogen sis

- Development of carcinoma, or, in more recent usage, producing any kind of malignancy.

Carcinogen

- A substance or agent that produces or incites cancerous growth.

Carcinogenic

- Cancer causing.

Cases without Lost Workdays

- These are the cases that do not involve lost workdays but result in medical treatment other than first aid, restriction of work or motion, loss of consciousness, transfer to another job, or diagnosis of occupational illness.

Chemical Hazard

- A nonliving hazard that results from substances, including solids, liquids or vapours that could potentially interact. Some chemicals can damage the human body if people inhale, ingest or absorb them. Example chemicals are lead, alcohol and hydrocarbons.

Chemical Oxygen Demand (COD)

- Laboratory measurement of the amount of oxygen consumed under specific conditions in the oxidation of organic material by a strong chemical oxidant that decomposes both biodegradable (measured by biochemical oxygen demand) and nonbiodegradable organic matter.

Chronic

- Having a persistent, recurring or long-term nature. As distinguished from acute.

Chronic Respiratory Disease

- A persistent or long-lasting intermittent disease of the respiratory tract.

Cold Work

- Low-risk work in a non-restricted area (outside a 50 metre radius of a live surface facility). E.g., grading a road.

Company Rules

- An internally developed set of standards regarding company policies and requirements for safety and general conduct.

Company Worker or Person

- A person whose knowledge, training and experience qualified him or her to perform the work properly and safely.

Competent Person

- One who is capable of identifying existing and predictable hazards in the surroundings or working conditions, which are unsanitary, hazardous or dangerous to employees; and who has authorisation to take prompt corrective measures to eliminate them.

Confined Space

- A confined space is any space with restricted access or egress where (because of the construction, locations, contents or nature of the work done inside) hazardous gases, vapours, dusts, or fumes may accumulate, or where oxygen may be deficient.

Consequence Calculation Methods

- Calculations that are necessary to assess the consequences of major accidents such as tank rupture, pipe rupture, failure of a safety valve, fire and/or explosion in case of the Liquefied Petroleum Gas (LPG) installation are essentially required for hazard assessment, emergency control planning and monitoring. (Maximum Credible Loss Scenario (MCLS) – Impact Assessment (IA), consisting of Bleve/Fire ball and Vapour Cloud Explosion.)

Consultant

- A professional individual or firm hired by the Company solely to give professional advice with respect to the planning of specified tasks.

Contractor

- A company, partnership, or unincorporated proprietorship hired by the Company to perform a specified task or job or any company, partner, or person working on or around Principal Employer's equipment. May be one person or many and include all contractors and sub-contractors of the Company hiring them.

Contamination

- Contact with an admixture of an unnatural agent, with the implication that the amount is measurable.

Contractor's Representative

- The Contractor's Representative is a person at the worksite who represents the Contractor or is held responsible and accountable for ensuring that the required tasks are carried out as planned. (Foreman, engineer, operator, etc.)

Controlled Products

- The term used in WHMIS to describe hazardous materials.

Convection

- Atmospheric motions that are predominantly vertical, resulting in vertical transport and mixing of atmospheric properties.

Cost–Benefit Analysis

- A formal quantitative procedure comparing costs and benefits of a proposed project or act under a set of pre-established rules. To determine a rank ordering of projects to maximise rate of return when available funds are unlimited, the quotient of benefits divided by costs is the appropriate form. To maximise absolute return given limited resources, benefits-costs is the appropriate form.

Crawling-Boards, Chicken-Ladders or Safe-Walk-Ladders

- A plank with cleats spaced and secured at equal intervals, for use by a worker on fragile (A.C. sheet) roofs, corrugated or trafford, not designed to carry material.

Criteria

- As used in the Clean Air Act, information on adverse effects of air pollutants on human health or the environment at various concentrations. The information is collected pursuant to the Clean Air Act and used to set national ambient air quality standards.

Critical Work

- Any work that falls in the medium or higher risk area of the Risk Assessment Matrix. E.g., work that might be considered critical work (and where a critical safe-work agreement and full time safety watch is required) includes:
  - Critical lift in a non-restricted area.
  - Tasks done during major turnarounds that affect other workers.
  - Maintenance work in an area where toxic-gas amounts are likely to exceed occupational exposure limits.
  - Welding in a hydrocarbon production facility.
  - Confined space entry.

D

Damage

- Damage is the severity of injury or the physical, functional or monetary loss that could result if control over a hazard is lost.

Danger

- Expresses a relative exposure to a hazard. A hazard may be present, but there may be little danger because of the precautions taken.

Dangerous Goods

- The term used in TDG regulations to describe hazardous materials.

Death from Accident

- It is a death that occurs due to the accident, within the year of the accident.

De-energised

- A condition where something:
  - Is free from any electrical connection to a source of potential difference and from electrical charge.
  - Does not have a potential different from that of the earth.

  (**Note:** De-energised doesn't mean the same thing as disconnected, since the residual charge in such equipment as motors, cables, and capacitors, take time to delay.)

Deflagration

- It is a type of 'Explosion'. It generally takes place due to combustion of hydrocarbon and air; the pressure rise is approximately eight times the atmospheric pressure. The complete combustion process occurs in approximately 1/300th of a second. Usually deflagration explosion occurs in a vessel and pressure remains uniform throughout the vessel. Therefore, the failure occurs at the vessel's weakest point. The damage is manifested as tears and the point of ignition has no relationship to the ultimate point of rupture.

Detonation

- It is another type of 'Explosion'. The pressure rise in the detonation type of explosion could be 20 times that of atmospheric. The combustion process is much faster and it occurs within approximately 1/10,000th of a second. Normally detonation occurs in pipeline configuration. Usually, when the detonation occurs at pipe elbows or valves etc., the blast pressure that develops due to detonation, shatters the elbow or valve into small fragments. A detonation in light gauge ductwork may rip open the ductwork along the seams.

Disabling Injury

- An injury causing death, permanent disability, or any degree of temporary total disability on the day of the accident.

Disaster

- Any real or anticipated occurrence which endangers the lives, safety, welfare and well-being of some or all of the people and cannot be brought under control by the use of all regular Municipal or Government services and resources.

Disease

- A general term describing a morbid condition which can be defined by objective, physical signs (e.g., hypertension), subjective symptoms or mental phobias, disorder of function (e.g., biochemical abnormality), or disorders of structure (anatomic or pathological change). Existence of disease may be questioned in disorder of structure without associated disorder of function.

Dispersion

- A suspension of particles in a medium, the opposite of flocculation, a scattering process.

Direct Supervision

- Where the supervising worker is present at the jobsite and fully cognisant and in control of the activities of the less experienced workers.

Due Diligence

- It is the level of judgement, care, prudence, determination, and activity that a person would reasonably be expected to have under particular circumstances.

E

Ecological Impact

- The total effect of an environmental change, natural or man-made, on the community of living things.

Ecology

- The science dealing with the relationship of all living things with each other and with their environment.

Ecosystem

- The interacting system of a biological community and its nonliving surroundings.

Effect

- A biological change caused by an exposure.

Efficacy

- A measure of the probability and intensity of beneficial effects.

Effluent

- Treated or untreated waste material discharged into the environment. Generally refers to water pollution.

Emergency Planning

- The act of putting together an overall plan and developing it for response to emergency situations involving workers and equipment (e.g., logical sequence of events).

Emission

- Like effluent, but used with regard to air pollution.

Emission Rate

- The amount of pollutant emitted per unit of time.

Employer

- Any person who employs one or more workers, or a person who is self employed in an occupation.

Environment

- Water, air, land, and all plants and humans and other animals living therein, and the interrelationships which exist among them.

Environmental Impact Appraisal

- An environmental review supporting a negative declaration, i.e., the action is not a major Federal action significantly affecting the environment. It describes a proposed EPA action, its expected environmental impact, and the basis for the conclusion that no significant impact is anticipated.

Environmental Impact Statement

- A document required of Federal agencies by the National Environmental Policy Act for major projects or legislative proposals. They provide information for decision makers on the positive and negative effects of the undertaking, and list alternatives to the proposed action, including taking no action. For example, an environmental impact assessment report, prepared by an applicant for a permit under the Act to discharge as a new source, identifies and evaluates the environmental impacts of the applicant's proposed source and feasible alternatives.

Environmental Pathway

- All routes of transport by which a toxicant can travel from its release site to human populations including air, food chain, and water.
- The connected set of environmental media through which a potentially harmful substance travels from source to receptor. [S.L. Brown]

Epidemiology

- The study of the distribution and dynamics of diseases and injuries in human populations.
- Specifically, the investigation of the possible causes of a disease and its transmission. [S.L. Brown]

Event Tree Analysis (ETA)

- It evaluates the potential for an accident as a result of the general equipment failure or process upset, known as an initiating event. Unlike FTA (see below), which is a deductive reasoning process, ETA is an inductive process where the analyst begins with an initiating event and develops the possible sequence of events that lead to the potential of the accident.

Excess Deaths

- The excess over statistically expected deaths in a population within a given time interval. Attempts are made to relate excess deaths to specific causes. Note that since every person can (and must) die only once, there can be no excess deaths over all time.

Expected Deaths

- The number of deaths statistically expected in a population in a given time interval obtained by summing the product of age-, sex-, and race-specific mortality rates from a standard population and person-years in each age, sex, and race category in the study population.

Expected Loss

- The quantity obtained by multiplying the magnitude of health or environmental effect loss by the probability (or risk) of that loss and adding the products. The expected loss is the average loss over a large number of trials; one must reflect on the appropriateness of its use in cases for which there will be only one, or a few, trials.

Experience

- Statistical data recording of a company's accidents or incidents over a specific time period usually expressed in terms of frequency, severity rates and incident and safety performance index.

Experience Rating

- A process administered by the insurance companies usually based on a three-year time period, premiums paid and compensation rates. Experience Rating can create an incentive for an employer to facilitate the rehabilitation of a disabled worker.

Explosion

- It is a result of rapid combustion with a sudden, violent change of pressure involving the liberation and expansion of a large volume of gas.
- There are two types of air explosions, depending on the type of fuel that assists explosion—'Deflagration' and 'detonation'. (See the terms.) The magnitude of explosion observed could be a useful guide for determining the probable cause and recommendations during accident investigation.

Explosive Range

- It is the maximum and minimum concentrations, expressed as percentage by volume of a flammable vapour or dust in air, which must exist within definite upper and lower limits in order that the vapour or dust may burn when exposed to a source of ignition.

Exposure

- The time integral of the concentration of a toxicant, which is in the immediate vicinity of various ports of entry (such as lung, GI tract and skin).
- Qualitatively, contact between a potentially harmful agent and a receptor (e.g., a human or other organism) that could be affected. [S.L. Brown]

Exposure Assessment

- The process of measuring or estimating the intensity, frequency, and duration of human exposures to an agent currently present in the environment or of estimating hypothetical exposures that might arise from the release of new chemicals into the environment.

Extrapolation

- In risk assessment, this process entails postulating a biologic reality based on observable responses and developing a mathematical model to describe this reality. The model may then be used to extrapolate to response levels which cannot be directly observed.

F

Failure Modes and Effects Analysis (FMEA)

- A tool to systematically analyse all contributing component failure modes and identify the resulting effects on the system.
- This analytical method evaluates the ways in which an equipment can fail and the effects of such failures on an installation. The failure mode considered provides the analyst a basis to identify where changes are needed to improve the system or the design. During the analysis, single equipment failures, usually electrical or mechanical, are defined and the effects both locally and on the whole system are analysed. Individual failure is considered as an independent occurrence with no relation to other failures in the system except for the subsequent effects that it might produce.
- FMEA can be used to supplement HAZOP studies for critical equipment.

False Negative Results

- Results which show no effect when one is there.

False Positive Results

- Results which show an effect when one is not there.

Fatal Accident

- An accident which results in one or more deaths within one year.

Fault Tree Analysis (FTA)

- A fault tree analysis is a deductive reasoning process that illustrates a combination of failures that will cause one specific failure of interest, called a 'top event' such as 'an explosion in a reactor'. This analytical process, in addition to identifying the root causes of the top events, sometimes reveals alternate outcomes of those root/common causes of failure.
- A technique by which many events that interact to produce other events can be related using simple logical relationships permitting a methodical building of a structure that represents the system.

  Both FMEA and FTA are useful aids to hazard identification but they involve very detailed analysis of components and operations. Their use in the process industry is mainly limited to identification of special hazards in critical machinery where they form the basis for risk quantification.

Fine Suspended Particulate Matter (FSP)

➢ Airborne particles in the range of a diameter smaller than approximately 1 or 2 micrometres.

Fire

➢ It is a chemical reaction, namely combustion, which is the violent combination of oxygen or another combustion-supporter, with a combustible substance, namely fuel. This chemical reaction is exothermic. The reaction may occur at normal ambient temperatures due to either direct action of atmospheric oxygen or the promoting action of certain agents.

Fly Ash

➢ Small solid ash particles from the noncombustible portion of fuel that is small enough to escape with the exhaust gases.

Follow-up (Action)

➢ The term used to indicate an action (usually corrective action) that is supposed to take place after some kind of occurrence and based on an accident or incident report.

Food Chain

➢ Dependence of a series of organisms, one upon the other, for food. The chain begins with plants and ends with the largest carnivores.

Fossil Fuel

➢ Natural gas, petroleum, coal, and any form of solid, liquid, or gaseous fuel derived from such materials for the purpose of creating useful heat.

G

Gamma Rays

➢ High-energy, short-wavelength electromagnetic radiation emitted by a nucleus. Gamma radiation usually accompanies alpha and beta emissions and always accompanies fission.

Gaussian Distribution Model

➢ A commonly used assumption about the distribution of values for a parameter, also called the normal distribution. For example, a Gaussian air dispersion model is one in which the pollutant is assumed to spread in air according to such a distribution and described by two parameters, the mean and standard deviation of the normal distribution.

Genetic Effects

- Effects that can be inherited and appear in the descendants of those exposed.

Groundwater

- The supply of fresh water under the Earth's surface that forms a natural reservoir.

Guideline (Limited Definition)

- It is mended method that may be modified to meet the intent of policies and standards. For example, deviations don't have to be documented or approved.

H

Half-life

- The time in which half the atoms of a given quantity of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years.
- Similarly, the time in which half the molecules of a chemical substance disappear as a result of chemical or biochemical transformation. [S.L. Brown]

Half-life, Biological

- The time required for a living organism to eliminate, by natural processes, half the amount of a substance that has entered it.

Half-life, Effective

- The time required for a radio nuclide contained in a biological system to reduce its activity by half due to the combined result of radioactive decay and biological elimination.

Hazard

- A condition or physical situation with a potential for an undesirable consequence, such as harm to life or limb.
- A potential condition or set of conditions, either internal and/or external to a system, product, facility or operation, which, when activated by a stimulus, transforms the hazard into a real condition, or series of events which culminate in a loss (an accident).

Hazard Assessment

- An analysis and evaluation of the physical, chemical and biological properties of the hazard.

Hazard Identification

- The process of determining whether exposure to an agent can cause an increase in the incidence of a health condition.

Hazard and Operability Studies (Hazop)

- Whenever something new is carried out, there is a danger that some part of the process will not behave in the expected manner and that such a deviation could have serious effects on the other parts of the process. One technique designed to study deviations is known as a HAZOP study. It is: "The application of a formal systematic critical examination to the process and engineering intentions of the new facilities to assess the hazard potential of mal-operation or malfunction of individual items of equipment and the consequential effects on the facility as a whole." Remedial action is then usually possible at a very early stage of the project with maximum effectiveness and minimum cost. The technique can also be applied to existing assets.
- HAZOP study is a systematic structural hazard identification technique. Accidents may occur in a plant whenever there is any deviation from the design parameters during operation. In the HAZOP study, the Piping and Instrumentation (P&I) diagram of a process plant is scrutinised loop by loop with respect to the effects of deviations from design operating parameters like flow, temperature, pressure, level compositions, control gadgets, etc. with the help of guidewords NO. MORE, LESS. AS WELL AS, PART OF, REVERSE and OTHER THAN. A technique has been developed to examine the deviations in all the design-valued parameters. The consequences of such deviations are analysed and any further remedial measures that need to be taken are decided through discussions by a team of experts from design, operation, project, maintenance, safety and other concerned departments.

Hazard Control Audit (Assessment)

- A safety audit done to measure the effectiveness of existing hazard controls and documents them in order to prioritise them and determine if they need updating, revising, etc.

Hazard Recognition

- The act of recognising or becoming aware of a dangerous or hazardous situation or condition.

Hazardous Waste

- Any waste or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are non-degradable or persistent in nature or because they can be biologically magnified, or because they can be lethal, or because they may otherwise cause or tend to cause detrimental cumulative effects.
- Also, a waste or combination of wastes of a solid, liquid, contained gaseous, or semisolid form which may cause, or contribute to, an increase in mortality or an increase in serious

irreversible, or incapacitating reversible illness, taking into account the toxicity of such waste, its persistence and degradability in nature, its potential for accumulation or concentration in tissue, and other factors that may otherwise cause or contribute to adverse acute or chronic effects on the health of persons or other organisms.

Health and Safety Study

- Any study of any effect of a chemical substance or mixture on health or the environment or on both, including underlying data and epidemiological studies, studies of occupational exposure to a chemical substance or mixture, toxicological, clinical, and ecological studies of a chemical substance or mixture, and any test performed thereof.

Health Effect

- A deviation in the normal function of the human body.

Health Effect Assessment

- The component of risk assessment which determines the probability of a health effect, given a particular level or range of exposure to a hazard.

Health Risk

- Risk in which an adverse event affects human health.

Hot Work

- Use of open flames, other heat sources and/or spark-producing devices in areas where combustible materials may be or do exist, or where there is potential for explosion or fire.

OR

- Medium-risk work in a restricted area (inside a 50 metre radius of a live surface facility). For example: painting, pipe fitting in satellites, or excavating in a restricted area.

Hydrocarbons

- Compounds that contain carbon and hydrogen.

Hydrology

- The science dealing with the properties, distribution, and circulation of water.

I

Incidence Rate

- As defined by OSHA, it is the number of occupational injuries and/or illnesses or lost workdays per 100 full-time employees.

Indirect Cause

- A factor or occurrence which has taken place and contributes to an accident but is not a direct cause.

Industrial Hygienist

- An individual trained primarily in the sciences of health, through chemistry and biology and applying these disciplines in an industrial setting.

Injury

- It is physical harm or damage to the body resulting from an exchange, usually acute, of mechanical, chemical, thermal, or other environmental energy that exceeds the body's tolerance.

Inspection

- A systematic examination of a worksite or equipment which, in the process, is compared against an established standard.

L

Label

- Any mark, sign, device, stamp, seal, ticket, tag or wrapper which provides information on the contents.

Latency Period

- The period of time from exposure to an agent to the onset of a health effect.

Leachate

- Liquid that has percolated through solid waste and has extracted dissolved or suspended materials from it.

Leaching

- The process by which nutrient chemicals or contaminants are dissolved and carried away by water, or are moved into a lower layer of soil.

Lethal Concentration Fifty (LC50)

- A calculated concentration [in air] which when administered by the respiratory route is expected to kill 50% of a population of experimental animals during an exposure of four hours. Ambient concentration is expressed in milligrams per litre.

- A calculated concentration in water which is expected to kill 50% of a population of aquatic organisms after a specified time of exposure. Concentration is usually expressed in milligrams per litre or ppm. [S.L. Brown]

Lethal Dose Fifty (LD50)

- A calculated dose of a chemical substance which is expected to kill 50% of a population of experimental animals exposed through a route other than respiration. Dose is expressed in milligrams per kilogram of body weight.

Lock Out

- A positive method for disconnecting power, or making something inoperative, by using a physical lock to eliminate movement or operation.

Lock Out Procedure

- Written procedure dictating the manner in which the positive locking out of equipment or machinery is to be carried out.

Loss Control

- A system or programme designed to minimise accidents and reduce financial losses.

Loss Prevention

- A before-the-loss programme designed to identify and correct potential causes of accidents before they result in actual injuries or financial loss.

Lost Workdays

- Lost workdays are those days on which, because of occupational injury or illness, the employee was away from work or limited to restricted work activity. Days away from work are those days on which the employee would have worked but could not. Days of restricted work activity are those days on which the employee was assigned to a temporary job, or worked at a permanent job less than full time, or worked at a permanent job but could not perform all duties normally connected with it. The number of lost workdays (consecutive or not) does not include the day of injury or onset of illness or any days on which the employee would not have worked even though able to work.

Lost Workday Cases

- Cases that involve days away from work, or days of restricted work activity, or both.

M

Man Hours

- An industrial time unit relating to the number of hours worked per employee and often multiplied by the number of employees to establish the amount of time spent on a task or used in projections of costs.

Material Safety Data Sheet (MSDS)

- A bulletin of technical and hazardous properties dealing with handling, storage and use, protective measures and equipment.

Motor Vehicle

- It is any mechanically or electrically powered device not operated on rails, upon which or, which may transport any person or property upon a land highway. The load on a motor vehicle or trailer attached to it is considered part of the vehicle. Tractors and motorised machinery are included while self-propelled in transit or used for transportation. Non-motor vehicle is any road vehicle other than a motor vehicle, such as a bicycle or animal-drawn vehicle, except a coaster wagon, child's sled, child's tricycle, child's carriage and similar means of transportation; persons using these latter means of transportation are considered pedestrians.

Motor-Vehicle Accident

- It is an unstabilised situation that includes at least one harmful event (injury or property damage) involving a motor vehicle in transport (in motion, in readiness for motion, or on a roadway, but not parked in a designated parking area) that does not result from discharge of a firearm or explosive device and does not directly result from a cataclysm. [See Committee on Motor Vehicle Traffic Accident Classification, 1997 Manual on Classification of Motor Vehicle Traffic Accidents, ANSI D16.1-1996, Itasca, IL: National Safety Council.]

Motor-Vehicle Traffic Accident

- It is a motor-vehicle accident that occurs on a traffic-way, a way or place, any part of which is open to the use of the public for the purposes of vehicular traffic. Motor-vehicle non-traffic accident is any motor-vehicle accident that occurs entirely in any place other than a traffic-way.

N

National Safety Council, Mumbai, India (NSC, India)

- The council deals with various ongoing aspects of Occupational Safety, Health and Environment.

National Safety Council, New York (NSC, U.S.A.)

- International body dealing with various ongoing aspects of Occupational Safety, Health and Environment.

National Institute for Occupational Safety and Health (NIOSH)

- U.S. Department of Health and Human Services Centers for Disease Control and Prevention.

Near Miss

- An undesirable event which has the potential to cause a serious accident.

OR

- An undesired event that, under different circumstance, could have resulted in personal harm, and/or damages to property, process or the environment.

OR

- A specific unplanned event or sequence of events that has an unwanted and unintended consequence on the safety or health of people, property or the environment, or on legal or regulatory compliance.

OR

- An unplanned event or sequence of events that does not have actual consequences but that could, under slightly different circumstances, have unwanted and unintended effects on people's health and safety, on property, on the environment or on legal or regulatory compliance.

Nonfatal Injury Accident

- It is an accident in which at least one person is injured, and no injury results in death.

O

Occupational Health and Safety Act (OSHA)

- The Government department in Alberta that administers the Occupational Health and Safety Act and Regulations made under that Act.

Occupational Illness

- It is any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. It includes acute and chronic illnesses or diseases that may be caused by inhalation, absorption, ingestion, or direct contact.

Occupational Injury

- It is any injury such as a cut, fracture, sprain, amputation, etc. which results from a work accident or from a single instantaneous exposure in the work environment.

Operating Work Site

- The specific location of a work activity where work is not limited to office activities. For example, drilling sites, maintenance shops and laboratories.

P

Particle

- A tiny mass of material. Airborne particles, material that exist in the atmosphere as a solid or liquid, can be natural, caused by stirring of soil dusts, or anthropogenic. They vary in size from coarse (diameter >3 μm) to fine (<3 μm). Sometimes inhalable or respirable is used to describe those particles (<2 μm) which can be inhaled through the nose and enter the lungs.

Particulates

- Fine liquid or solid particles such as dust, smoke, mist, fumes, or smog, found in the air or emissions.

Pedestrian

- Pedestrian is any person involved in a motor-vehicle accident that is not in or upon a motor vehicle or non-motor vehicle. Includes persons injured while using a coaster wagon, child's tricycle, roller skates, etc. Excludes persons boarding, alighting, jumping or falling from a motor vehicle in transport who are considered occupants of the vehicle.

Percolation

- Downward flow or filtering of water through pores or spaces in rock or soil.

Permanent Disability (or Permanent Impairment)

- It includes any degree of permanent nonfatal injury. It includes any injury that results in the loss, or complete loss of use, of any part of the body, or any permanent impairment of functions of the body or a part thereof.
- Includes any degree of permanent impairment of the body such as amputation, permanent impairment of vision and other permanently crippling nonfatal injury ranging from the permanent stiffening of a joint or a finger amputation, to permanent, complete crippling.

Personal Protective Equipment (PPE)

- Protective clothes, when used properly, designed to reduce or eliminate injuries to a worker.

pH

- A measure of the acidity or alkalinity of a material, liquid or solid (pH is represented on a scale of 0 to 14 with 7 representing a neutral state, 0 representing the most acid, and 14 the most alkaline).

Photochemical Oxidants

- Air pollutants formed by the action of sunlight on oxides of nitrogen and hydrocarbons.

Physical Hazard

- A hazard that is neither biological nor chemical but that exists around us, or because of the things we do. For example, weather and personal work habits.

Plume

- The cloud of steam or smoke that comes from a chimney stack and blows downwind.
- The contaminated portion of groundwater that moves past a source of pollution. [S.L. Brown]

PM_{10}

- Particulate matter in air less than 10 μm in diameter. Currently used as the measure of exposure for potential effects on human health of particulate matter. [S.L. Brown]

PMR

- Proportionate mortality ratio.

Point Source

- A single isolated stationary source of pollution.

Pollutant

- Any material entering the environment that has undesirable effects.

Pollution

- The presence of matter or energy whose nature, location or quantity produces undesirable environmental effects.

Population at Risk

- A limited population that may be unique for a specific dose–effect relationship; the uniqueness may be with respect to susceptibility to the effect or with respect to the dose or exposure itself.

Potential Incident

- A condition (such as an unidentified hazard), or an event (such as a near miss), or sequences of events that do not have actual consequences, but that could, under slightly different circumstances, have unwanted consequences.

Ppm (parts per million)

- A measurement of concentration such as 1 μg per gram.
- A term often used to describe the intensity of a contaminant in an area. Often used in relation to H_2S and other gases.

Process Waste

- Any designated toxic pollutant or combination of pollutants, whether in wastewater or otherwise present, which is inherent to or unavoidable resulting from any manufacturing process, including that which comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, byproduct or waste product and is discharged into the navigable waters.

Property Damage Accident

- It is an accident that results in property damage, but in which no person is injured.

Proportionate Mortality Ratio (PMR)

- The fraction of all deaths from a given cause in the study population divided by the same fraction from a standard population. A tool for investigating cause-specific risks when only data on deaths are available. If data on the population at risk are also available, SMRs are preferred.

Prospective Study

- An inquiry in which groups of individuals are selected in terms of whether they are or are not exposed to certain factors, and then followed over time to determine differences in the rate at which disease develops in relation to exposure to the factor. Also called cohort study.

Public Accident

- It is any accident other than motor vehicle that occurs in the public use of any premises. Includes deaths in recreation (swimming, hunting, etc.), transportation except motor vehicle, public buildings, etc., and deaths from widespread natural disasters even though some may have happened on home premises. Excludes accidents to persons in the course of gainful employment.

Pulmonary Function

- The performance of the respiratory system in supplying oxygen to, and removing carbon dioxide from, the body (via the circulating blood). This requires that air move into and out of the alveoli at an adequate rate (ventilation), that blood circulate through pulmonary capillaries adjacent to alveoli at an adequate rate (perfusion), and that oxygen pass freely from alveoli to blood as carbon dioxide passes in the opposite direction (diffusion). Pulmonary function tests are used to try to identify and locate abnormalities in performance capability.

Q

Qualified

- Recognition of an individual's ability to perform a function by means of completion of the required training programme, permit, licence, or other accepted authority.

R

Radioactivity

- The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

Regulations

- A rule, ordinance, law or device by which conduct or performance is controlled.

OR

- A mandatory requirement imposed from outside the company that has legal implications for noncompliance.

OR

- An ordinance, a law, or a directive set by an outside agency such as government for the control of people and their environment. Infractions are punishable by fines and/or imprisonment.

OR

- See **Standard** below.

Relative Risk

- The ratio of the rate of the disease (usually incidence or mortality) among those exposed to the rate among those not exposed.

Release Rate

- The quantity of a pollutant released from a source over a specified period of time.

Reliability

- The probability a system performs a specified function or mission under given conditions for a prescribed time.

Respirable Particle

- Particle of the size (<5.0 μm) most likely to be deposited in the pulmonary portion of the respiratory tract.

Response

- The proportion or absolute size of a population that demonstrates a specific effect. May also refer to the nature of the effect.

Restricted Area

- A location that's within 50 metres of a live surface facility that might release hydrocarbons.

Risk

- The potential for realisation of unwanted, adverse consequences to human life, health, property, or the environment; estimation of risk is usually based on the expected value of the conditional probability of the event occurring times the consequence of the event given that it has occurred.
- Thomas Cool provides an alternative definition of *risk in the context of uncertainty*: "The possibility, of injury, loss or environment incident created by a hazard. The significance of the risk is determined by the probability of an unwanted incident, and the severity of its consequences."
- It is associated with likelihood or possibility of harm. It is the expected value of loss. Just as the activation of a hazard can result in an accident from stimulus, so the risk is related to the possibility that frequency, intensity and duration of the stimulus will be sufficient to transfer the hazard from a potential state to a loss.
- In simpler words risk means: "The probability times the consequences."

Risk Acceptability Criteria

- There is risk everywhere, from home to workplace, and there is risk in whatever we do. Statistical experience shows that there is a chance of death 1 in 1,00,000 or 10^{-5}, when we take the risk of driving, flying or smoking. Chances of death from lightning or falling aircraft is 10^{-7}. It is, therefore, generally accepted that the risk of death 1 in 1,00,000 or 10^{-5} per year. Action needs to be taken to reduce the risk below the level 1 in 10,00,000 or 10^{-6} per year.

Risk Analysis

- A detailed examination including risk assessment, risk evaluation, and risk management alternatives, performed to understand the nature of unwanted, negative consequences to human life, health, property, or the environment; an analytical process to provide information regarding undesirable events; the process of quantification of the probabilities and expected consequences for identified risks.

Risk Assessment Matrix

- A tool (part of a Risk Assessment Framework) used to compare assessed risk, based on the probability and consequences of a potential incident.

Risk Assessment

- The process of establishing information regarding acceptable levels of a risk and/or levels of risk for an individual, group, society, or the environment.

Risk Evaluation

- A component of risk assessment in which judgments are made about the significance and acceptability of risk.

Risk Identification

- Recognising that a hazard exists and trying to define its characteristics. Often risks exist and are even measured for some time before their adverse consequences are recognised. In other cases, risk identification is a deliberate procedure to review, and it is hoped, anticipate possible hazards.

S

Safety

- A quality system that allows the function under predetermined conditions with an acceptable minimum accidental loss. If we consult the dictionary, we find safety defined as: *The condition of being free from undergoing or causing hurt, injury or loss.*

OR

- Relative protection from adverse consequences.

OR

- To put it in a simpler way *total safety is freedom from potential harm.*

Safe Work Agreement

- A tool that helps workers understand the specific work to be done and the hazards they might encounter on the job. It's also an agreement on how hazards will be managed, who will manage them and what personal protective equipment will be required.

Safe-Work-Permit

- The Safe-Work-Permit is a written document (record) issued by the person in charge of a unit, equipment or building area, that authorises a worker and/or work crew to do a specific job at that work site on behalf of his Occupier. It identifies what precautions (safe work practices) were taken and/or will be taken to ensure that the working conditions are safe for the type of work to be performed, in a specific job location, during a specific time interval. It outlines the safety equipment required and to be used for that specific job location.

Safe Work Practices or Safe Operating Procedures (SOPs)

- Procedure for carrying out specific tasks which, when followed, will ensure that workers' exposure to hazardous situations, substances, and physical agents is controlled by the manner in which the work is carried out.

OR

- The procedures for performing specific tasks which, when followed, protect workers and others from illness or injury.

Safety Committee

- A group comprising employees, which has been formed to address safety and health issues at a worksite or multiple worksites.

Safety Inspection

- The act of examining both worksites and equipment, and comparing them against previously established standards specifically to determine if safety legislation and the company safety policies are being followed (looking for unsafe acts and conditions).

Senior Management

- Persons in a company or organisation who directly control the overall operation of that entire group or specific parts of it and are in a position to make decisions for the entire company or organisation.

Shoring

- A term used in construction to mean the act of using wood or metal components to support and counteract imposed pressures either vertically or horizontally (trenching or excavations).

Significant Potential Incident

- An incident without actual consequences where the coordinates of probability and potential consequence meet in the higher or medium risk area of the Risk Assessment Matrix.

Site Supervisor

- An employee or the contractor assigned by the Company to supervise a potential job.

Smoke

- The visible aerosol that results from incomplete combustion.

Source

- A place where pollutants are emitted, for example a chimneystack.

Source Term

- The release rate of hazardous agent from a facility or activity.

Source of Injury

- It is the principal object such as tool, machine, or equipment involved in the accident and is usually the object inflicting injury or property damage. Also called agency or agent.

Spiral Ferrel

- A reusable device attached to the tail chain end of a winch line to prevent the tail chain from sliding off the winch cable.

Stack Effect

- Used in reference to air, as in a chimney, that moves upward because it is warmer than the surrounding atmosphere.

Stack Emissions

- Effluents released into the atmosphere from the exhaust flue of a building; usually refers to pollutants but can refer to steam or other nonpolluting effluents.

Standard (Limited Definition)

- An accepted specification of something to which sites or employees must conform unless a deviation from the standard is documented and approved.
  (**Note**: Standards might apply to external industry standards and might include individual responsibilities, e.g., who will be held accountable for not meeting a standard.)

Standard Deviation

- A measure of dispersion or variation, usually taken as the square root of the variance.

Standard Geometric Deviation

- Measure of dispersion of values about a geometric mean; the portion of the frequency distribution that is one standard geometric deviation to either side of the geometric mean; accounts for 68% of the total samples.

Standard Normal Deviation

- Measure of dispersion of values about a mean value; the positive square root of the average of the squares of the individual deviations from the mean.

Standardised Mortality Ratio (SMR)

- The ratio of observed deaths in a population to the expected number of deaths as derived from rates in a standard population with adjustment of age and possibly other factors such as sex or race.

Stationary Source

- A pollution location that is fixed rather than moving.

Statistical Significance

- The statistical significance determined by using appropriate standard techniques of statistical analysis with results interpreted at the stated confidence level and based on data relating species which are present in sufficient numbers at control areas to permit a valid statistical comparison with the areas being tested.

Steady State Exposure

- Exposure to an environmental pollutant whose concentration remains constant for a period of time.

Stimulus

- A set of events or conditions that transforms a hazard from its potential state to one that causes harm to the system, related property, or personnel.
- A simple definition would be: "*It's one that activates the hazard to result into a loss.*"

Subcontractor

- Any person, firm or corporation, contracting with the contractor, to perform part of the work and includes partners and associates in a joint venture so contracting with the contractor.

Supervisor

- A supervisor is the knowledgeable executive of the company or of the contractor who will, supervise the work at the site.

Surface Water

- All bodies of water on the surface of the earth.

Surrogate

- Something that serves as a substitute. In risk analysis, surrogates are often used when data on the item of interest (a chemical, an industry, an exposure, etc.) is lacking. As an example, underground mining of coal and hard rock minerals can be used as a surrogate for underground oil shale mining.

Synergetic

- Working together; an agent that works synergistically with one or more other agents.

Synergism

- An interaction between two substances that results in a greater effect than both of the substances could have had acting independently.

Synergistic Effects

- Joint effects of two or more agents, such as drugs that increase each other's effectiveness when taken together.

Systematic Error

- A reproducible inaccuracy introduced by faulty equipment, calibration, or technique.

System

- A group of interacting, interrelated, or interdependent elements forming or regarded as forming a collective unity.
- A more operable definition of a system might be "*a series of events in time.*"

T

Tag Out

- A method of identifying and alerting persons to the fact that specific circuits or equipment have been de-energised or put out of service and should not be touched or have their positions changed.

Temperature Inversion

- Layer of air in which temperature increases with altitude; very little turbulent exchange occurs within it.

Temporary Total Disability

- An injury which does not result in death or permanent disability, but which renders the injured person unable to perform regular duties on one or more full calendar days after the day of the injury.

Threshold

- A pollutant concentration [or dose] below which no deleterious effect occurs.

Threshold Dose

- The minimum application of a given substance required producing an observable effect.

Threshold Limit Value (TLV)

- Refers to airborne concentrations of substances and represents conditions under which it is believed that nearly all workers are protected while repeatedly exposed for an 8-hr day, 5 days a week [expressed as parts per million (ppm) for gases and vapours and as milligrams per cubic metre (mg/m^3) for fumes, mists, and dusts].

Topography

- The detailed delineation of the geographic features of a locality.

Total Cases

- Include all work-related deaths and illnesses, and those work-related injuries that result in loss of consciousness, restriction of work or motion, transfer to another job, or require medical treatment other than first aid.

Total Suspended Particulate Matter (TSP)

- The total concentration of all airborne particles at a particular point in space.

Toxicant

- A substance that kills or injures an organism through chemical or physical action or by altering the organism's environment; for example, cyanides, phenols, pesticides, or heavy metals, especially used for insect control.

Toxicity

- The degree of danger posed by a substance to animal or plant life.

Toxicology

- The study of the adverse effects of chemicals on living organisms.

Toxic Substance

- A chemical or mixture that may present an unreasonable risk of injury to health or the environment.

Toxic Wastes

- Wastes that contain substances in sufficient quantity to impinge harmfully on biological systems.

Transportation of Dangerous Goods (TDG)

- Regulations established to cover transporting hazardous materials.

OR

- A legislated programme for information and training on the transportation of dangerous goods.

U

Uncertainty Analysis

- A detailed examination of the systematic and random errors of a measurement or estimate; an analytical process to provide information regarding the uncertainty.

Unintentional Injury

- It is the preferred term for accidental injury in the public health community. It refers to the result of an accident.

Unsafe Act

- The actions of a person in a manner which vary from the accepted or legislated safe practice and create a hazard to himself or herself, another person, or equipment.

Unsafe Condition

- A condition in which something exists that varies from a normal accepted safe condition and, if not corrected, could cause injury, death, or property damage.

Up Wind

- Towards the direction from which the wind is blowing: counter to the wind.

V

Vapour Cloud Explosion (VCE)

- A vapour cloud explosion occurs when an accidental large quantity release of explosive gas/vapour mixture comes in contact with an ignition source. The release of liquid or gas could be from storage tanks, process vessels or pipelines. The explosion is manifested as blast overpressure. This overpressure can cause severe damage to property, injuries to people to the extent of fatalities.

Visitor

- Any person temporarily on the worksite who is not regularly involved in the daily worksite activities. This includes, but is not limited to, delivery personnel, invited guest, the general public, etc.

W

Washout

- The removal of a pollutant by precipitation below clouds.

Water Pollution

- The addition of sewage, industrial wastes, or other harmful or objectionable material to water in concentrations or in sufficient quantities to result in measurable degradation of water quality.

Water Quality Criteria

- Levels of pollutants in bodies of water that are consistent with various uses of water, i.e., drinking water, sport fishing, industrial use.

Watershed

- Land area from which water drains toward a common watercourse in a natural basin.

Weathering

- The group of processes, such as the chemical action of air and rainwater and of plants and bacteria and the mechanical action of changes of temperature, whereby rocks, on exposure to the weather, change in character, decay, and finally crumble into soil.

- The disappearance of substances from vegetation or soil through the action of wind and precipitation. [S.L. Brown]

Wet Deposition

- The removal of atmospheric particles to the earth's surface by rain or snow.

WHMIS (Workplace Hazardous Materials Information System)

- A system (sometimes called right to know legislation) to protect workers from exposure to hazardous material.

OR

- A legislated hazard communication system including labels, Material Safety Data Sheets, and a worker-training programme.

Work

- The total construction and the performance of related services required by the contract documents as signed between the contractor and the Principal Employer.

Workers

- Workers are all persons gainfully employed, including owners, managers, and other paid employees, the self-employed, and unpaid family workers.
- All persons gainfully employed, including owners, managers, other paid employees, the self-employed, and unpaid family workers, but excluding domestic servants.

Work Hours

- Work hours are the total number of hours worked by all employees. They are usually compiled for various levels, such as an establishment, a company, or an industry. A work hour is the equivalent of one employee working one hour.

Worksite

- Any location where a worker is engaged in any occupation and includes any vehicles or mobile equipment used by the worker in an occupation.

OR

- The entire area required for the performance of the work including right-of-way and temporary working space, as designated by the Principal Employer.

Work Injuries (Including Occupational Illnesses)

- Work injuries, occupational illnesses are those that arise out of and in the course of gainful employment regardless of where the accident or exposure occurs. Excluded are work injuries to private household workers and injuries occurring in connection with farm chores that are classified as home injuries.

- Work/motor-vehicle duplication includes work injuries that occur in motor-vehicle accidents (see definitions for work injuries and motor-vehicle accident).

Industrial, Occupational or Work Injury

- The standard specifies that a work injury is any injury, including occupational disease and other work-connected disability, which arises out of and in the course of employment.

First-aid Injury

- When the injured person, after receiving first aid, resumes his work on the same or the following day (i.e., within 48 hours). This injury is termed as "Non-Reportable" under the law.

Disabling Injury (Reportable Injury)

- A disabling injury is one, which results in death, or permanent or partial impairment or which renders the injured person unable to work for a full, or any day after the day of injury, i.e., the person is unable to resume the work within 48 hours of the injury. This injury is also termed as "Reportable" under the law.

Classes of Disabling Injuries

- Death, which is any fatality, resulting from a work injury, regardless of the time intervening between injury and death.
- Permanent Total Disability, other than death, which permanently and totally incapacitates the employee from following any gainful occupation, or which results in the loss of (or the complete loss of use of) any of the following in one accident: (a) both eyes (b) one eye or one hand, or arm, or one foot, or one leg (c) any of the following not on the same limb: hand, arm, foot, leg.
- Permanent Partial Disability, other than death or permanent total disability which results in the complete loss or loss of use of any member or any permanent impairment of functions of the body or part thereof, regardless of any pre-existing disability.
- Temporary Total Disability is any injury which does not result in death, permanent, or partial impairment, but which results in one or more days of disability.

Z

Zero Energy

- The state of a piece of equipment when all sources of energy (i.e., electrical, mechanical, hydraulic, etc.) are isolated from the particular piece of equipment, or effectively blocked and all sources of stored energy are depleted.

Zero Order Analysis

- The simplest approach to quantification of a risk with a limited treatment of each risk component (e.g., source terms, transport, health effects, etc.).

Bibliography

1. Athreya N.H. and Shukla C.M., M.M.C. School of Management, Bombay. *Law for Factory Executives: A Manual of Daily Dos & Don'ts in Non-Legal Style.*
2. Ghag, Dr. Arvind S., Technical Director, N.R.C. Ltd, Mumbai. *Motivation: A Lasting Way to Introduce Safety Measures*, 1981.
3. Grimaldi, John V. and Rollin H. Simonds, *Safety Management.* Published by Richard D. Irwin, Illinois, 1989.
4. Handley, William, *Industrial Safety Handbook*, McGraw-Hill Publication, 1969.
5. Kharbanda, Dr. O.P. and E.A. Stallworthy, *Safety in the Chemical Industry: Lessons from Major Disasters*, Heinemann Professional Publishing Ltd., WC 1B 3HH, 1998.
6. Kharbanda, Dr. O.P. and Sudarshan Kharbanda, *Safety in Industry—A Top Management Function*, Article in *Times of India*, Mumbai, India, November 2, 1992.
7. Khera, Shiv, *You Can Win*, Macmillan India Ltd., 1998 (Motivation, pp. 97).
8. Kletz, Dr. Trevor A., *Learning from Accidents in Industry*, 3rd edition, Institution of Chemical Engineers, Rugby, Butterworths-Heinemann, Oxford, UK and Wobern, MA, 2001.
9. Kletz, Dr. T.A., *Hazop and Hazan: Identifying and Assessing Process Industry Hazards*, 4th edition, Institution of Chemical Engineers, Rugby, UK, 1999.
10. Kletz, Dr. T.A., *What Went Wrong?—Case Histories of Process Plant Disasters*, 4th edition, Gulf, Houston, Texas and Plymouth, UK, 1998.

Recommended Additional Publications by Dr. Trevor Kletz

I. *An Engineer's View of Human Error*, 3rd edition, Institution of Chemical Engineers, Rugby, UK, 2001.
II. *By Accident—A Life Preventing Them in Industry*, PFV Publications, London, 2000.
III. *Process Plants: A Handbook of Inherently Safer Design*, 2nd edition, Taylor & Francis, Philadelphia, PA and London, 1998.
IV. *Dispelling Chemical Engineering Myths*, 3rd edition, Taylor & Francis, Philadelphia, PA and London, 1996.
V. *Computer Control and Human Error* (with Paul Chung, Eamon Broomfield and Chaim Shen-Orr), Institution of Chemical Engineers, Rugby, UK, 1995.
VI. *Lessons from Disaster—How Organisations Have No Memory and Accidents Recur*, Institution of Chemical Engineers, Rugby, UK, 1993.
VII. *Critical Aspects of Safety and Loss Prevention*, Butterworths, Oxford, 1990.

11. Lee, R.H., *Safety in Industrial Plants*, Washington, DC: E.I. Dupont de Nemours and Company.

12. Peter, Dr. Laurence J. (with Raymond Hull), *The Peter Principle*, Souvenir Press Ltd., London and Rupa & Co., Mumbai.

13. Peter, Dr. Laurence J., *The Peter Prescription*, Souvenir Press Ltd., London and Rupa & Co., Mumbai.

14. Peter, Dr. Laurence J., *The Peter Plan*, Souvenir Press Ltd., London and Rupa & Co., Mumbai.

15. *Environmental Health*, Published by Academic Press Inc., New York, 10003, edited by Purdon P. Walton, Drexel University, 1971.

16. Pruthi, Dr. Surinder S, Economic, Management & Corporate Consultant, Mumbai, "Contemporary Environment & Role of Safety", Keynote Address, on the occasion of Observance of National Safety Day, NRC Ltd., 4 March 1975.

17. *In the Wonderland of Indian Managers*, 1974, Rangnekar, Sharu, Management Consultant, Stalwart Educator & Trainer, Mumbai. Vikas Publishing House Private Ltd., New Delhi 110014.

18. *In the World of Corporate Managers*, 1996, Rangnekar, Sharu, Management Consultant, Mumbai. Vikas Publishing, House Private Ltd., New Delhi 110014.

19. Rangnekar, Sharu, Management Consultant, Mumbai, "Problems in Instituting Safety in Indian Industry", Keynote Address, on the occasion of Observance of National Safety Day, NRC Ltd., 4 March 1974.

20. Rane, Dr. P.K., Certifying Surgeon, Government of Maharashtra, "The Organisation and Scope of Occupational Medical Services", 1978.

21. Rajwade, R.G., Management & Industrial Relations Consultant, "Industrial Relations in Relation with Safety", 1979.

22. Roland, Herold E. and Brian Moriarty, *System Safety Engineering and Management*, A Wiley-Interscience Publication, John Wiley & Sons, New York.

Associations, Institutions, Standards and Statutory Enactment

23. Hazard and Operability Studies (HAZOP) Chemical Industry Safety and Health Council of the Chemical Industries Association, London, SE 1 7 TU.

24. Indian Electricity Rules, 1956.

25. Environment (Protection) Act, 1986.

26. Manufacture, Storage and Import of Hazardous Chemical Rules, 1986, framed under the Environment (Protection) Act, 1986.

27. Hazardous Wastes (Management and Handling) Rules, 1989, framed under the Environment (Protection) Act, 1986.

28. Factories Act, 1948 with Maharashtra Factories Rules, 1963.

29. Gas Cylinder Rules, and Static & Mobile Pressure Vessels (Unfired) Rules, 1981, framed under the Explosives Act.

30. Indian Explosives Act, 1884, Government of India.

31. Indian Explosives Rules, 1981, under Explosives Act.

32. *Safety Audits—A Guide for the Chemical Industries*, 1987. Reprint of originally compiled by Chemical Industries Association, U.K. Indian Chemical Manufacturers Association: Mumbai 400023.

33. *Lessons from Typical Accidents in the Indian Chemical Industry*, 1988, Mumbai 400023, Indian Chemical Manufacturers Association.

34. *Manual of Safety—With Specific Reference to Chemical Industry*, 1970, Mumbai 400023, Indian Chemical Manufacturers Association.

35. International Labour Organisation (ILO), Geneva, *Encyclopaedia of Occupational Health and Safety*, volumes 1 and 2.

36. International Labour Organisation (ILO), Geneva: *Major Hazard Control: A Practical Manual.*

37. International Labour Organisation (ILO), Geneva: *Accident Prevention: A Workers' Education Manual*, 2nd edition, 1983.

38. Manufacturing Chemists' Association, U.K., *Case Histories of Accidents in Chemical Industries*.

39. National Electrical Safety Code (NESC), 1993, New York. American National Standards Institute.

40. National Electrical Code (NEC), 1993. ANSI/NFPA 70 Quincy, MA.

41. *Fire Protection for Chemicals*, National Fire Protection Associations, International, Boston 10, Massachusetts, USA, edited by Charles W Bahme.

42. National Safety Council, Chicago, Illinois, U.S.A., 60611, *Accident Prevention Manual for Industrial Operations, Administration & Programmes*.

43. National Safety Council, Chicago, Illinois, U.S.A., 60611, *Accident Prevention Manual for Industrial Operations, Engineering & Technology*.

44. National Safety Council, Chicago, Illinois, U.S.A., 60611, *Accident Prevention Manual for Industrial Operations, Fundamentals of Industrial Hygiene*, 1982.

45. National Safety Council, Chicago, Illinois, U.S.A., 60611, *Accident Prevention Manual for Industrial Operations, Supervisors' Safety Manual.*

46. National Safety Council, Chicago, Illinois, U.S.A., 60611, *Accident Prevention Manual for Industrial Operations, Accident Facts,* 1991.

47. National Institute for Occupational Safety and Health (NIOSH), Publication Dissemination, EID, 4676 Columbia Parkway, Cincinnati, OH 45226-8573, Fax: (513) 533-8573, E-mail: pubstaft@cdc.gov.

48. NIOSH, *Summary of Surveillance Findings and Investigative Case Reports: Worker Deaths by Fall*, DHHS (NIOSH) no. 2000-116.

49. NIOSH, *A Summary of Surveillance Findings and Investigative Case Reports: Worker Deaths in Confined Spaces*, DHHS (NIOSH) no. 94-103.

50. NIOSH, *A Summary of Surveillance Findings and Investigative Case Reports: Worker Deaths by Electrocution*, DHHS (NIOSH) # 2000-115 (CD).

51. NIOSH, *Preventing Worker Deaths from Uncontrolled Release of Electrical, Mechanical and Other Types of Hazardous Energy*, DHHS (NIOSH) publication no. 99-110.

52. NIOSH, *Pocket Guide to Chemical Hazards*, DHHS (NIOSH), 2000-130 CD.

53. NIOSH, *Preventing Injuries and Deaths of Workers who Operate or Work Near Forklifts*, DHHS (NIOSH) publication no. 2000-112 (Alert).

54. NIOSH, *A Guide to Safety in Confined Spaces*, DHHS (NIOSH) # 87-113.

55. NIOSH, *Injuries and Amputations Resulting from Work with Mechanical Power Presses*, Current Intelligence Bulletin 49, May 22, 4987.

56. NIOSH, *Working in Confined Spaces: Criteria for a Recommended Standard*, DHHS (NIOSH) publication no. 80-106.

57. NIOSH, *Assessing Occupational Safety and Health Training: A Literature Review*, DHHS (NIOSH) publication no. 98-145.

58. NIOSH, *A Model for Research on Training Effectiveness (TIER)*, DHHS (NIOSH) publication no. 99-142.

59. NIOSH, Alerts: 85-104, 85-111, 86-119, 87-100, 87-103, 88-104, 89-110, 91-110, 92-106, 93-105.

60. *Process Safety Management*, Occupational Safety and Health Administration, U.S. Department of Labour, no. 3132, 1993 (reprinted).

61. Occupational Safety and Health Act of 1970, Washington, D.C., USA.

62. Occupational Safety and Health Standards (1994, revised) under OSHA.

63. Petroleum Act, 1934 and Petroleum Rules, 1976.

64. Safety and Health Regulations for Construction (1994, revised)—OSHA.

65. Water (Prevention and Control of Pollution) Act, 1981—Indian Act.

Transactional Analysis

66. Berne, Dr. Eric:
   (i) *Transactional Analysis in Psychotherapy*.
   (ii) *Games People Play*.
   (iii) *What Do You Say After You Say Hello?*

67. Harris, Dr. Thomas A.:
   (i) *I'm OK—You're OK*.
   (ii) *Staying OK*. (with Amy Bjork Harris)

68. Jongeward, Dorothy and Muriel James:
   (i) *Born To Win—Transactional Analysis With Gestalt Experiments*.
   (ii) *Winning With People—Group Exercises in Transactional Analysis*.
   (iii) *Everybody Wins—Transactional Analysis Applied to Organisations*.

Websites

69. For Bhopal Gas Tragedy:
    (a) www.bhopal.net
    (b) www.ucagld.com.au/community/bhopal
    (c) www.bhopal.org
    (d) www.bhopalexpress.com/facts.html.2bk
70. For National Institute for Occupational Safety and Health:
    www.cdc.gov/niosh
71. For National Safety Council of India:
    www.nsc.org.in
    American Industrial Hygiene Association (AIHA):
    www.aiha.org
    American Society of Safety Engineers (ASSE):
    www.asse.org
72. Drucker, Peter F., *The Practice of Management*, Allied Publishers Pvt. Ltd., Mumbai, 1977.

Index

D

E

F

G

H

I

J

K

L

M

N

T

W

Laxmikant M. Deshmukh
E-mail: lm_deshmukh@rediffmail.com

After graduating in Chemistry in 1951 and then doing a post-graduation in education from the University of Pune, L.M. Deshmukh started his career as a chemist in the National Rayon Corporation, a giant chemical complex, near Mumbai. He later took up a course in chemical engineering, conducted by the Institution of Chemical Engineers, London. The management soon entrusted him with the responsibility of industrial safety in the company.

In the early years, he took quite a few courses on safety, fire prevention and other branches of management principles, behavioural and attitudinal practices, and industrial relations and personnel management, all sponsored by the company. In 1962, he became manager, industrial safety & hygiene, heading the safety management functions. He was soon put in charge of the education, training and development programme of the company.

After his retirement in 1984, he became a consultant in occupational safety, health and environment and education and training in safety to a number of leading Indian companies. Over the last 25 years, he has conducted regular lectures on safety management, safety organisation, safety in chemical industry, etc for students of the 'advanced diploma in industrial safety'. He also conducts training courses on safety for industrial employees at various levels.

In his long association with safety management, he has published several booklets, addressed seminars and done a considerable amount of promotional work to create an awareness on industrial safety in India.