

THE PROFESSIONAL ENGINEER AND HIS ENHANCED DUTY OF CARE

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INTRODUCTION

Up until 1974 engineering in industry was controlled by prescriptive legislation such as regulations under the Factory Acts and supplemented by Standards and Codes of Practice. These Standards and Codes were published by bodies such as British Standards, industry associations and by individual companies. The student engineer learnt at university the theoretical background and the application of the appropriate codes and regulations to achieve good practice. This was all changed when the 1974 Health and Safety at Work Act started a goal-setting self-regulation system to replace the prescriptive system.

The new legislation required the engineer to take reasonable care and risks had to be As Low As Reasonably Practical (ALARP) without specifying how this was to be achieved. The concept that all *reasonable* precautions had to be taken to make the workplace safe was introduced, the onus for which was placed on the factory owner. The professional engineer was now the member of the management team who had to interpret the new requirements. The new regulations introduced management systems to ensure that safety was managed. These new regulations also went much further than the old prescriptive ones and required the engineer to use new tools to achieve a safer system of work based on the ALARP principle. In this context *practical precautions* also meant that the professional engineer had to apply not only what he knows but what is also known in the industry.

The old tools of codes and standards previously developed by companies disappeared as the reliance on European or International standards took over and much safety information was now excluded from these standards. The pressure on company costs also resulted in the demise of the company expert on individual pieces of equipment and on processes. Furthermore, the proposed reduction in expertise in the regulatory authorities and the reduced use of Approved Codes of Practice requires the engineer to seek the information he requires elsewhere.

The enhanced duty of care now required by the new type of legislation has been accepted by engineers but the tools required to achieve best practice have not always been made available to them. The professional engineering institutions, industry associations and companies have a duty to provide the necessary tools for the engineers to carry out their work to achieve best practice and for the universities to teach students where to find these tools.

SAFETY AND THE NEW APPROACH

The movement away from prescriptive legislation led to a series of regulations and Approved Codes of Practice. Thus the HSE publication[1] "Successful Health and Safety Management" is probably the finest book on management and should be followed in many areas of endeavour. The Management of Health and Safety at Work Regulations 1992[2] and its Approved Code of Practice went further into the management of health and safety. Risk Assessment was covered in Regulation 3 and required:

(1) *Every employer shall make a suitable and sufficient assessment of:*
  (a) *the risks to the health and safety of his employees to which they are exposed whilst they are at work; and*
  (b) *the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking etc.*

The use of the words *suitable* and *sufficient* implies a higher level of attainment than just applying the regulations. It requires the engineer to seek and apply information from all sources. Other publications also indicate that information has to be sought but it is left to the initiative of the engineer or manager to carry it out and to use the necessary tools.

The Engineering Council[3] has an objective:

> "*. . . . to advance education in, and to promote the science and practice of engineering (including relevant technology) for the public benefit and thereby to promote industry and commerce. . . .*" and seeks to achieve this objective by a number of aims including "*Spreading best engineering practice to improve the efficiency and competitiveness of business.*"

In the Notes for Guidance to the Code and Rules of Conduct it is stated:

> "*Full compliance is required, not only in the letter but also in the spirit. Ambiguities or loopholes in the law, regulations, etc, must not be exploited in an effort to reduce costs if engineering judgement shows that safety or the environment would be jeopardised as a result. In safety and environmental matters the statutory requirements should be regarded as no more than minima. Even when these requirements have been satisfied, the Council still looks to the registrant to take such further measures as his or her engineering judgement shows to be necessary for securing public safety and preservation of the environment, in accordance with Rule 1.*"

Guidelines on Risk Issues[4] published by the Engineering Council in section 6, Communications, states:

> "*Engineers should pay particular attention to effective feedback on incidents and 'near misses', so that lessons can be learned.*"

The Royal Charter of the Institution of Chemical Engineers[5] Section 12 (ii) (b) of the By-laws states:

> "*Every Corporate Member shall at all times so order his conduct as to uphold the dignity and reputation of his profession and safeguard the public interest in matters of safety, health and otherwise. He shall exercise his professional skill and judgement to the best of his ability and discharge his professional responsibilities with integrity.*"

The Rules of Professional Conduct states in section 4:

> "*A member shall take all reasonable care in his work to minimise the risk of death, injury, or ill-health to any person, or of damage to property. In his work, a member shall respect all laws and statutory regulations applicable to the design, operation and maintenance of chemical and processing plant. In addition a member shall have due regard for the need to protect working and living environments, and the need to ensure efficient use of natural raw materials and resources.*"

The professionally qualified person not only has a duty of care under the Act but also has duties laid down by virtue of membership of his professional body. These duties clearly require a Best Practice approach.

The problem is complicated by the producing company having removed their design functions and left design safety considerations to the contractual design company who now have to consider all aspects of design.

GOOD PRACTICE AND BEST PRACTICE

Adhering to codes and standards is obviously good practice but it is a passive approach to safety, with improvements coming only when the code or standard is altered, usually a slow process. Best practice, however, calls for a pro-active approach to safety. Under self-regulation it is the responsibility of the engineer to be informed of all the factors affecting his ability to take all reasonably practical precautions, etc. Improvements in safety are thus made *before* an accident proves their necessity.

On the 20th September 2001 at the Sixth World Congress of Chemical Engineering the 20 organisations representing chemical engineers world-wide signed up to The Melbourne Communiqué[6]. In the field of safety this statement makes the following points:

> "*.... We are committed to the highest standards of personal and product safety.*"
> "*.... We will practice our profession according to its high ethical standards.*"
> "*.... We acknowledge both our professional responsibilities and the need to work with others as we strive to meet the challenges facing the world in the Twenty-First Century.*"

These aspirations clearly call for best practice.

THE TOOLS REQUIRED BY THE ENGINEER FOR BEST PRACTICE

In the field of safety, best practice requires the engineer to be committed to answering three questions:

- What can go wrong?
- What will prevent it?
- How can I ensure compliance?

To be able to comprehend these three questions the engineer needs initial training in safety awareness at university and ways of seeking information from the various sources available. Subsequently the engineer must be provided with the tools to enable him to answer the questions given above.

For best practice the engineer has not only to use his own knowledge but also the knowledge of many other engineers and to achieve this he requires a number of tools. For example in design work the engineer has to use current codes and standards and must know what accidents have occurred with the process and equipment that he is designing. For this he requires an accident database with lessons learnt and for it to be interactive with his software[7]. With operational and maintenance work risk assessment has to be carried out and the first requirement is to identify the hazards. Many of the hazards are within the knowledge of the engineer but there will be many hazards that are not in his knowledge but are known in the industry. A database of accidents is thus required. The second requirement is to eliminate or prevent the hazard becoming a reality and for this he requires the information on the lessons learnt from accidents and the database becomes the source of his information.

In the preparation of Safety Cases the engineer requires information on management systems, the probability and the consequences of accidents to adequately show that the process is under control. Additionally he requires measures to ensure compliance with the designed method of control. For all of this work an accident database and index of symposia/conferences are of great help.

Unfortunately much of the information the engineer requires is only available in books, journals and papers. The publications on safety have been poorly indexed and abstracted, and are not even always available in the relevant libraries or companies. Additionally the engineer working on design, operational work and maintenance has little time to spend browsing through journals, etc. He requires electronic access to all abstracting services and databases, preferably databases that are interactive with his design and operational software.

THE AVAILABILITY OF SAFETY INFORMATION

The Institution of Chemical Engineers, the European Federation of Chemical Engineers and the American Institute of Chemical Engineers have provided symposia, conferences and bulletins on safety matters particularly in the 1960s, 70s and 80s. The papers presented have been of a high standard with only a few available on CD-ROM but additionally they have not been abstracted by the Institution or the international abstracting services. Tables 1 to 4 show the number of papers presented at these symposia, conferences and journals

Table 1. International Symposiums EFCE – Number of papers abstracted by databases

Publication	Number of Papers	Indexed by IChemE	HSE Line	SCI	CISDOC	NIOSH TIC	Science Direct	Compendex	CAS	ECHS	EINECS
1st to 3rd International Symposium on Loss Prevention.	Many	0	0	0	0	0	0	0	0	0	0
4th International Symposium on Loss Prevention. Harrogate 1983	96	0	10	0	0	5	0	0	0	0	0
5th International Symposium on Loss Prevention. Cannes 1986	70	0	1	0	0	0	0	0	0	0	0
6th International Symposium on Loss Prevention. Cannes 1989	119	0	0	2	0	0	0	55	0	0	0
7th International Symposium on Loss Prevention. Taormina 1992	71	0	2	0	0	0	0	0	0	0	0
8th International Symposium on Loss Prevention. Antwerp 1995	123	0	0	0	0	0	0	0	0	0	0
9th International Symposium on Loss Prevention. Barcelona 1998	130	0	0	0	0	0	0	0	0	0	0
10th International Symposium on Loss Prevention. Stockholm 2001	117	0	0	0	0	0	0	0	0	0	0

Table 2. Symposiums of the NW branch and conferences of the London branch – Number of papers abstracted by databases

Publication	Number of Papers	Indexed by IChemE	HSE Line	SCI	CISDOC	NIOSH TIC	Science Direct	Compendex	CAS	ECHS	EINECS
Hazards I to XV11 Symposium Series NW Branch 1960–2003	500	0	41	0	0	6	0	312	0	0	0
Hazards from pressure. Symposium Series No. 102 NW Branch 1987	21	0	3	0	0	0	0	0	0	0	0
Preventing Major Chemical and Related Process Accidents. Symposium Series No. 110. NW Branch 1988	56	0	1	0	0	0	0	0	0	0	0
Major Hazards Onshore and Offshore 1 1992. Symposium Series No. 130 NW Branch	45	0	16	1	1	0	0	45	0	0	0
Major Hazards onshore and offshore II 1995. Symposium Series No. 139 NW Branch	45	0	0	0	0	0	0	45	0	0	0
Management of Safety 1987, 1989, 1991, 1993 and 1995 London Branch	37	0	3	0	0	0	0	0	0	0	0

Table 3. Symposiums of the Institution of Chemical Engineers – Number of papers abstracted by databases

Publication	Number of Papers	Indexed by IChemE	HSE Line	SCI	CISDOC	NIOS TIC	Science Direct	Compendex	CAS	ECHS	EINECS
Major Loss Prevention in the Process Industries. 1971 Symposium Series No. 34	33	0	1	0	0	0	0	0	0	0	0
1st to 7th Symposium on Process Hazards with Special Reference to Plant Design 1960 to 1980 Symposium Series	About 100	0	12	0	0	0	0	0	0	0	0
Toxic Releases and their Biological Effects. 1976 Symposium Series 47	16	0	0	0	0	0	0	0	0	0	0
The Assessment of Major Hazards 1982. Symposium Series 71	24	0	0	0	0	0	0	0	0	0	0
The Assessment and Control of Major Hazards. 1985 Symposium Series No. 93	26	0	6	1	0	0	0	0	0	0	0
Safety Management Systems – Sharing Experiences in Process Safety. 1985 Symposium Series No. 44	6	0	0	0	0	0	0	0	0	0	0

(*Continued*)

Table 3. *Continued*

Publication	Number of Papers	Indexed by IChemE	HSE Line	SCI	CISDOC	NIOS TIC	Science Direct	Compendex	CAS	ECHS	EINECS
Runaway Reaction in Batch Reactors. 1984 Symposium Series No .85	29	0	0	0	0	0	0	0	0	0	0
Safety and Loss prevention in Chemical and Oil Processing Industries. 1990 Symposium Series No. 120	54	0	0	0	0	0	0	54	0	0	0
Piper Alpha — Lessons for Life-cycle Safety Management 1990. Symposium Series No. 122	14	0	0	0	0	0	0	14	0	0	0

Table 4. The Institution of Chemical Engineers Bulletins and journals on safety matters

Publication	Number of Papers	Indexed by IChemE	HSE Line	SCI	CISDOC	NIOSTIC	Science Direct	Compendex	ENICS
Process Safety and Environmental Protection Transaction Part B									
Volumes 68 to 72	106		}						
73 to 74/3			} 2	0	0	0	0	425	0
74/4 to 81	259	259	}						
Loss Prevention Bulletin									
000 to 126	699		740						
105 to 150	199								
151 to 173	61	61 listed but some titles only	for all issues from 1979	0	60	1	0	0	141

and the number abstracted in a selection of the abstracting services. Generally the abstracting service has merely noted that a symposium, etc. has taken place without the papers being abstracted. It can be said that very little safety information has been made available to the engineer in an abstract form and none in an interactive format with other software.

EXAMPLES OF SHARING INFORMATION

Some sharing of information on safety matters is carried out, in for example the Loss Prevention Bulletin. To be fully effective there must be a far more extensive sharing of information in industry.

A typical example of shared information followed the research work on oil[8–12] and chemical[13,14] marine tankers to prevent explosions when water-washing tanks. The oil tanker research was a result of three disastrous oil tanker explosions and resulted in the use of inert gas. Chemical tankers had not experienced this problem and research work to account for this defined the limits for safety which was shared with the marine industry. All of this necessary safety information is contained in The Safety of Life at Sea Convention[15].

Another notable case where lessons were learnt concerned the BOAC Comet passenger aircraft when three aircraft disintegrated in the air in 1954. The investigation involved the pressure testing to destruction of a whole aircraft in a water tank. The failure of the aircraft was found to be caused by fatigue cracks and this information was released to the whole industry. The industry and passengers all benefited from this shared information.

The explosion in an ethylene oxide distillation column[16] at Antwerp in 1987 was investigated and the company concerned called a meeting of all of the companies involved in its manufacture. The results of the investigation and the lessons learnt were made known to all manufacturers and to the public. Had a similar approach been carried out earlier when similar explosions occurred the probability is that other explosions would have been avoided and many lives saved and injuries prevented. No code or standard contains the lessons learnt from these explosions but a good accident database does.

The sharing of information is vital for improved safety in the industry. It must not be hampered by the legal profession who wish to apportion blame.

HOW WILL THE ENGINEER ACHIEVE THE ENHANCED DUTY OF CARE?

The international aviation industry[17] is generally acknowledged to have "... an institutionalised safety culture that is not replicated in any other transport industry sector. Much of this safety culture derives from an intensely developed international legal framework, which mandates co-operation between states, international organisations, national authorities and private companies to achieve global uniformity of standards and practices". As a result of this the fatal accident rate for passenger jet aircraft was reduced from more than five per million flights (5×10^{-6}) in 1950 to one per one million (1×10^{-6}) in 1980 and is currently below 0.4×10^{-6}. The rate is still declining. It remains the case that no UK aviation organisation has been charged with corporate manslaughter.

Chemists seeking information are very well served by the Royal Society of Chemistry and their RSC Journals Archive. They (and their forerunners) have all of their articles from 1841 to 1996 available on disc comprising 1.2 million pages of research from 220,000 articles. Consequently chemists have a powerful tool available for seeking information on chemicals. Additionally they have a unique database of unusual reactions in Bretherick's Handbook of Reactive Chemical Hazards[18] now on a compact disc. The Royal Society of Chemistry has thus provided professional chemists with the electronic tools to search for information on methods and hazards associated with their work. A detailed search software is to be added. It also makes available for the young chemistry graduate all of the information and past experience that he needs to avoid the hazards that befell many of the past chemists.

The Knovel literature database (available through the RSC and IChemE members websites) allows full text searching of Perry's "Chemical Engineers Handbook" and a number of excellent AIChE safety monographs, along with many other texts. This is a genuinely useful application of the web to make available specific safety information.

The professional chemical engineer needs these and other similar tools.

The sharing of information on the causes of accidents amongst all the participants in an industry is fundamental to this safety culture. Availability of the information learnt from accidents is the vitally important tool required by the engineer. It should not be necessary for the young engineer or scientist in industry to learn the hard way through personal experience. Information on the incident itself is not adequate; the information has to include the lessons learnt as well as the causes, any environmental damage and the emergency services used in the incident. Accident information is not the only data required. Databases containing abstracts of all the papers presented at symposia and other relevant conferences are urgently required.

The professional chemical engineer must persuade the Institution of Chemical Engineers that it should combine with industry and other associated bodies in providing this information in a usable format.

CONCLUSIONS

The codes, standards and expertise that once existed in companies have gone and they are unlikely to return. Past papers and symposiums of the institutions can assist the professional engineer but a comprehensive database, including an indexing and abstracting system, is urgently needed. Other bodies also need to update and maintain codes and standards to provide the comprehensive tools needed by the modern professional engineer.

Currently the need for commercial return on databases and a culture of not talking about accidents means that engineers in the chemical and process industries are not as well informed as would be 'reasonably practicable' if the necessary tools were in the public domain. In this context the practicality must be information held not only by the engineer's own knowledge but also by that of industry as a whole.

The aviation industry[17] has demonstrated an international approach to safety management that is "*... based on the fundamental principle that detailed investigation* *into the cause of accidents will ultimately prevent further accidents.*" It should be noted that they also say "*There is a strongly held view that the threat of criminal prosecution following accidents may hinder the post-accident learning process.*"

In the new self-regulation approach to safety the professional engineer must adopt a similar attitude to that of the aviation industry and be given the tools to carry out the work required of him in design, operations and maintenance work. This new approach is a challenge to industry and to the professional engineering institution. The tools must be a comprehensive set of codes, standards, indexes and databases all of which must contain lessons learnt from all incidents. These must be made available to all engineers in a format that they can readily use in design, risk assessment and in HAZOP. It is, in my opinion, the duty of the professional engineering institutions to ensure that theses tools are readily available for their members. Additionally the universities have to start teaching engineers the way to access these tools.

There is a Russian saying:

> "*If you only look to the past, you are blind in one eye. If you only look to the future you are blind in both eyes*"

The professional engineer must look in all directions, to the past to obtain the information from experienced engineers and to the future to use that information to improve safety in the process industries. The engineer must demand the right tools for the work he carries out. If you forget the past you will pay in the future.

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Database sites containing abstracts of documents used in the following tables

Abstracting service	Format	Availability
Institution of Chemical Engineers web site	www.icheme.org.uk	PSEP Abstracts No abstracts for LPB
HSELINE published by Silver Platter	Disc	Available at RSC
Science Citation Index (Thomson)	Web subscription	Available at RSC
International Labour Organisation (CISDOC)	Disc	Available at RSC
National Institute for Occupational Safety and Health (NIOSHTIC)	Disc	Available at RSC
Science Direct	Web subscription	Available at UCL
Compendix (Engineering Information Inc)	Web subscription	Available at UCL
Chemical Abstracts (CAS) 1977–2001	Discs	Available at RSC
Environmental Chemistry Health and Safety (ECHS) Elsevier Engineering Info. Inc.	 Disc	Available at RSC
EINECS + ECINC3 Environmental Chemistry Health and Safety (Elsevier) 1980–2004	 Disc	Available at RSC