Safety Programs and Accident Prevention

1 Introduction

Following is a report of findings based primarily on a literature survey. The purpose of the survey has been to research current thinking on techniques useful for the prevention of major industrial accidents/disasters. The increasingly complex technologies used in major industries as chemical processing, nuclear power generation, transportation, waste removal, mining and petroleum mean that while day-to-day operations are without incident that there is also the potential for serious disasters when usual safeguards are defeated by combinations of events. As an example, a mixture of decisions, deficient communication and abnormal climatic conditions precipitated the 1986 Challenger Space Shuttle disaster. Isolated, each of the factors was not in itself a cause; the combination precipitated the disaster where lives were lost and an otherwise successful program placed into question. Other major disasters have similar causative origins in that combinations of events rather than a single act or condition also caused their occurrence. Newspapers and popular magazines have featured numerous articles describing and discussing causes. Public outcry has led to the formation of investigative committees seeking to identify causes so that similar events will not reoccur. Restrictive legislation or regulation has resulted; with the goal of creating preventative measures.

Researchers have generated considerable scientific literature about disaster prevention. Prevailing thought in the research, scientific and academic communities is that legislation or regulation gives an illusion of security rather than offering real protection. One of the more prominent researchers and academicians, Professor James Reason, has summarized prevailing thought on origins of disasters in his 1990 and 1997 books, *Human Error* and *Managing the Risks of Organizational Accidents.* These works reflect his and others (e.g., Jens Rasmussen, Erik Hollnagel, Ron Westrum and Berndt Brehmer) findings on the human processes that take place before and during disasters. Others such as Bea (1998), Feyer, Williamson & Claims (1997), Grabowski & Roberts (1996), Isaac (1997), and Paté-Cornell (1993) report similar findings either in their analysis of specific disasters or in their research summaries. Key concepts are that disasters are caused by decisions well in advance, that the decisions are made by those in supervisory or management positions, that in making decisions risks are unknown or ignored, and that the decisions cause normal safety mechanisms (often referred to as “defenses”) to be inadequate.

Throughout the literature reviewed direct or indirect reference was made to management’s role in safety and disaster prevention. Direct reference was made in articles such as by Ansari & Modarress (1997), Harms-Ringdahl (1996), Kjellén (1996), Kuusisto (1996) and Rundmo (1994) to the effect that management participation and involvement in safety is critical to the success of safety programs. Indirect reference to management influence by others such as Horbury & Booth (1996), Kennedy (1995), and Ojanen, Seppäaä & Aaltonen (1988) includes mention of management’s role along with other factors such as attitudes of individual workers. For both sets of articles the role of management is described as a if not the most important contributing factor.

Expanding upon the role of management in guiding organizational behavior, attitude and efficiency are Westrum (1993) and Weick (1987) who discuss the concept of "organizational culture". Westrum describes organizational culture as "…those habits, folkways, and norms that shape action…". Both authors, along with Pidgeon (1998) and Toft & Reynolds (1997) see management as having an important role in the shaping of an organization's culture. In this case, the sub-set of an organization's culture is its "safety culture". When translated into day-to-day work activities, willingness to following safe practices and yet think critically (e.g., being able to recognize when normal procedures/practices may cause accidents or disasters) is an organization's safety culture.

Offering guidance in how to develop organizational culture (and in turn, safety culture) are consultants such as Simon and Leik (1999) of the United States and Cooper (1998) of the United Kingdom. In books and articles they describe techniques that managers may use to instill a culture within their organizations. Emphasis is on effective communication that contributes to recognizing that those at all levels in an organization hold common perceptions. The communication is then used to identify problems and find solutions. With a continued commitment to communication by all the habits, folkways and norms described by Westrum come to be viewed as common to all. Moving to Scandinavia, Seppäla (1997) evaluated Finnish and Swedish-speaking companies in Finland. Found was that national cultural values appear to influence organizational values within the two sets of companies. Companies where Swedish was spoken emphasized common needs such as the general work environment. The companies where Finnish was spoken emphasized individual responsibility. The two different styles of behavior being somewhat representative of each culture. The accident rates in the Swedish-speaking companies were one-third lower.

Scandinavian working life literature published in English focuses more on development of specific tools useful for accident prevention than in the broader and non-specific concept of safety culture. Harms-Ringdahl et al. (1997) summarized Scandinavian research and described a number of systems of safety analysis being researched. In Swedish, Kjellén & Tinnmannsvik's (1989) application of deviation analysis within SMORT is an example of the use of an analytical system to identify risks within an organization.

The above examples help to demonstrate that there is a wide array of solutions to risk and safety management issues and many causative factors (e.g., management decisions that unintentionally discourage/hinder safe work practices). Using the literature identified through the survey, the remainder of this paper will seek to describe some of the different solutions offered. The goal of the descriptions being to identify "tools" usable by organizations and regulators working with organizations.

2 Methodology

Emphasis in this research project has been to collect information through a review of literature. The initial literature search used the work of James Reason as a point of departure. Professor Reason's work *Human Error* (1990a) is frequently cited by others writing in the field of accident and accident prevention. Building upon the earlier research of others such as Rasmussen (e.g., 1983) he has developed concepts used and identified by other researchers. Reason repeats his and Rasmussen's core concepts in a number of articles published between the mid 1980's up to the present. Many are listed in the reference section. Using key words and concepts referenced by the two it is possible, using search engines, to identify literature covering the same or similar material. Almost all authors writing on disaster prevention directly or indirectly reference; this simplifies search engine use in when seeking relevant material.

Early into the project a focus group helped to identify topic areas of greatest interest to those working in the areas of accident and disaster prevention. Preliminary findings were presented and focus was refined. Several topic areas were identified as warranting further literature search. Their comments will be summarized in Section 4, Rationale, of this report.

The following databases were consulted during the literature search:

- ABI/Inform,
- Applied Sci & Tech Plus,
- Arbline,
- Arts & Humanities Citation Index,
- Ergonomics Abstracts,
- ERIC,
- Medline,
- PsycLIT,
- Science Citation Index,
- Social Science Citation Index,
- UMI, and
- UnCover.

The combined Science Citation Index and Social Science Citation Index database was used most frequently. This database contains the largest number of journals and abstracts, overlaps the coverage of others, and has the feature of cross-referencing by citations. Others such as UMI were useful because of their feature of providing reprints from journals not held by the university library. Key words used during searches were: safety, organizational, disaster, culture, Scandinavia, accident, injury, and prevention. The key word searches used the words individually or in combinations. Searches were also carried out by author when lines of research justified further investigation.

A total of 125 books or articles were selected for review and possible inclusion as references in this report. The potential number that could have been included was much larger. Time limitations restricted the review to the 125. Most of the 125 titles were subsequently used as references and may be found in the "References" section.

In addition to the literature survey one conference was attended. It was on risk behavior and risk management. General presentations and workshops provided useful background information. One person was interviewed, Lars Harms-Ringdahl. He is the primary author of a work on Scandinavian safety research and consequently was able to provide extremely helpful guidance on work in progress. Authors of three articles were contacted. The purpose for contact was to obtain additional information. The three selected for further contact had developed and/or used safety assessment systems that may be used by organizations or regulators. Two have responded with comment or additional material. The third changed employers and may have been on vacation when contact was attempted.

With the completion of the literature survey, material was sorted and this report of findings prepared.

3 Background

The subject area of safety and accident prevention is quite broad. Available literature is quite extensive and it would not be possible for one person to review it all in a reasonable period of time. Therefore, this review is selective and seeks to focus on the five areas/concepts listed below.

¶Major Accident/Disaster Prevention

À occurrence of a major disaster in any populated area has serious consequences (Toft and Reynolds, 1997)

- accounts of disasters stress the loss of life and subsequent suffering (Bhopal, 10 years after: Lessons learned, 1995)

® inquiries into the causes of disasters invariably determine that prevention was possible (Reason, 1997)

•Regulatory review/inspection as a means to prevent major disasters

¬ inquiries into disaster/major accident causation have found that regulatory bodies had the potential to prevent (Reason, 1997)

- this literature review will seek to identify "tools" that regulatory entities, such as fire departments, could use to identify (latent) conditions in advance of major accidents/disasters

¸Near miss or incident analysis as a preventative tool (Lucas, 1991)

¬ Reason (e.g., 1988,1990a,1991 and 1995) includes using analysis of events where accident/disaster was avoided as a way to prevent actual occurrence of disaster

- the relative frequency of near misses provides greater opportunity for prevention analysis (van der Schaaf, 1991)

[1]Evaluation of the effectiveness of a safety program

¬ safety programs of differing content and structure have different accident rates (Harms-Ringdahl,1993)

- there are numerous methods for evaluation of safety programs described in literature (e.g., Kuusisto, 1996; Smith, Cohen, Cohen & Cleveland, 1978)

°Root causes of major accidents/disasters

¬ recent literature emphasizes that causes, while immediately initiated by human operators, are almost always traceable to earlier decisions at organizational levels removed from immediate contact with production (e.g., Cooper, 1998; Hoffmann, Jacobs & Landy, 1995; Kjellén, 1996; Reason, 1997; Salminen, Saari, Saarela & Räsänen, 1993; Toft & Reynolds, 1997)

- there are a number of different systems for accident analysis that may be utilized (Glendon and McKenna, 1995)

® Scandinavian systems for accident analysis include assessing root causes (Harms-Ringdahl, 1993; Kjellén and Tinmannsivk, 1989; Kjellén and Hovden, 1993)

Prevailing opinion views human error in accident causation as being the result of organizational decisions and culture (Reason 1997). The conditions under which

tasks are performed as being the causative factor. While root cause may, as Reason maintains (1997), have origins in advance of an actual event it still is important to understand how human capacity and function played a part in the event. An understand of how workers err is important. Reason's 1990 work, *Human Error*, is considered the most definitive work on this topic. In it he discusses types of error and way that humans incorrectly process information and so err.

It is also helpful to note that background/orientation of reviewers/investigators appears to influence the description/analysis of causes of major accidents/disasters. Comments by Svenson and Sjöström (1997) mention difference in attribution of causes when comparing two methods of accident analysis. This is also apparent when reviewing descriptions of different safety systems and accident analysis - factors such as industry and background of developers appear to have shaped the composition of final products.

4 Rationale

Selection of the topic areas is based on the original proposal submitted to Brandforsk. In that proposal, emphasis was on assessment tools that could be used to determine the likelihood of organizational root causes of accidents/disasters. Mention was made of the developmental work on organizational root causes by James Reason.

The Brandforsk funding included the proviso that a reference group or advisory committee participate in the literature review process. The group met in May. A summary of research to date was submitted. The group expressed a desire to have more information in the following areas:

- near miss or incident investigation
- safety inspection/assessment systems
  - for regulatory bodies
  - for employers
- safety systems

The literature review was modified to include identification of safety systems and inspection systems. This final report is structure so as to address the three topic areas referenced above. Other areas mentions are addressed throughout the report as the three topic areas do cover the areas described previously. While examples from throughout the world were sought, some emphasis was placed on identifying Scandinavian systems and models. In seeking out Scandinavian research it was anticipated that materials structured to meet local demands might be found. Reports about Swedish and Scandinavian research were found and reviewed (Harms-Ringdahl, et al. 1997; Menckel and Kullinger 1996; Swedish Work Environment Fund 1994). The reports provided summaries that were useful in determining if additional material needed to be sought. For example, material concerning computer programs for hazard management in process industries was identified as being of probably value whereas material on safety analysis of dams was deemed as being of little immediate relevance. So, in that instance, additional material on the described programs was secured and no material on dam safety assessment was sought.

Material discussing incident reporting had already been obtained (e.g., O'Leary and Chappell 1996) and additional literature was ordered (e.g., van der Schaaf, Lucas, & Hale 1991 and Brazier 1994). This strategy ensured that all major trends in that subject area were identified.

5 "Incident" or "Near Miss" Reporting

1. 5.1 Introduction/Background

This material follows-up the report on the same topic submitted on 99/31/5 as part of the bi-weekly Summary of Activity Report. As mentioned at that time, additional material on the subject area had been ordered and arrival was anticipated during week 23. The bulk of the ordered material has arrived, arrival of the remaining is uncertain (e.g., the material was ordered from another library, is checked-out, and thus not immediately available.

The material on hand does represent a cross-section of literature and, as such, is of sufficient quantity and quality for a literature review.

2. 5.2 Overview – Incident or Near Miss Reporting

1. 5.2.1 General

Incident or near miss reporting as a safety program feature is not a new concept. Hallgren (1992) in his review of literature notes that works about operation of safety programs from the 1950's reference incident or near miss reporting. Similar reference to use of incident/near-miss reporting may be found elsewhere in safety literature (e.g., Petersen 1982 and Ridley 1994). Often cited are studies that have established a ratio between unsafe activities (e.g., incidents and near misses, minor accidents, injury accidents, serious accidents and accidents having one or more deaths. The ratios described vary widely between studies. Differences in definitions, industries and detail of data may account for the variations. A typical illustration that uses a pyramid to depict the ratio is shown in Figure 1. Irrespective of differences in ratios between studies, all agree that the number of incidents/near misses is much higher than the number of accidents/injuries. At the extreme end of this difference in numbers are the nuclear and airline industries; anything greater than an incident/near miss is a rarity that is usually considered to be a disaster. Reason (1997) argues that for such "high reliability" industries an incident/near miss reporting system is necessary since actual accidents are so infrequent that "lessons" from relatively minor accidents prevent needed organizational learning that is essential for avoidance of

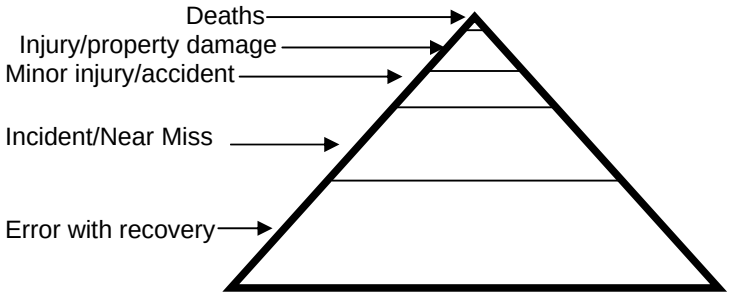

Figure 1 – Typical illustration of the "pyramid" or "iceberg" model depicting ratio of accidents, incidents/near misses, and errors with recovery (error with recovery is when an error is corrected rather than an accident being avoided due to the presence of a defense/safeguard).

major accidents/disasters. Note that the illustration includes errors with recovery. These events are different from incidents/near misses in that the error and correction

take place at almost the same time; in advance of the need to utilize safety features such as defenses or protective devices (as may be necessary with an incident/near miss).

The concept of using near miss/incident reporting is not always described in safety program literature or, mention is included almost as an afterthought. The ILO's (1988) work on safety in the chemical process industry is an example of this. There is reference to accident reporting, examples of safety plans are provided and other important material is present; there is no reference to incident/near miss reporting. This absence is in contrast to van der Schaaf, Lucas and Hale's (1991) book on incident reporting that emphasizes the value of such reporting in the chemical industry. Both give the same primary reason for publication; the poor organizational planning that led to major disasters during the 70's and 80's.

The use of incident/near miss reporting systems varies widely by industry and organization. Its use is an industry standard in aviation, medicine and nuclear power. Outside of those fields the use of a reporting system is largely dependent on management perception of the value of such a system. Often opined is that the use of an incident reporting system is directly related to management awareness of and participation in safety (e.g., Reason, 1991; Salminen, Saari, Saarela & Räsänen, 1993; and Toft and Reynolds 1997). The following sections provide an overview of usage within aviation, medicine, the nuclear industry, the process industry and in other industries.

2. 5.2.2 Aviation

Most frequently used as an example is the United States aviation safety reporting system (ASRS). It was established in the middle 70's in response to outcry over a particularly serious aviation disaster. Key features of this program are its anonymity provision, its administration by a neutral party (the U.S. National Aeronautics and Space Administration – NASA), worker/management support, and regular feedback given to the reporting population (through a newsletter and alert bulletins). Literature (O'Leary and Chappell 1996 and Reason 1997) describes the program as being highly successful in its mission of disaster prevention. The US system has served as a model for systems used by individual airlines and other countries.

3. 5.2.3 Medicine

Less discussed, perhaps due to concern over post-event misinterpretation of medical decisions, are medical incident reporting systems. For example, systems for treatment of trauma patients in the State of California are required by regulation (T22 1999) to have a quality control program. That requirement, while not using the exact term of incident reporting, includes an incident reporting and evaluation requirement (Ramon Johnson, M.D., personal communication April 1998). In this system, a physician committee within each organization (i.e., a hospital or other emergency facility) reviews cases in closed session where the goal is improvement rather than discipline.

In areas of medicine, such as anesthesiology, articles (e.g., Eagle, Davies and Reason 1992) allude to near miss/incident reporting and analysis as part of a quality system. As already mentioned in this part, the medical literature describing incident/near miss reporting is vaguely worded. Particularly in the United States, medical journals are concerned that articles might precipitate involvement in litigation and so use vague or

"coded" wording when referencing evaluation of events/decisions where human life was at risk.

4. 5.2.4 Nuclear industry

Reports and guidelines from The International Atomic Energy Agency typify near miss/incident reporting systems within this industry. The Agency's International Safety Advisory Group issued booklet 75-INSAG-4 (1991) on safety culture in nuclear power plants. The booklet outlines a comprehensive program intended to make certain that safety is given priority in individual nuclear plants and in operations made up of two or more plants. Incident reporting is described by wording such as: "What mechanism is available to staff to report errors even when they were immediately corrected or had no detectable effect? Do staff make occasional use of the mechanism provided?" (The quote is from the section on review questions for use during an independent evaluation of a safety system.) The safety program elements described in 75-INSAG-4 are repeated and expanded upon in later International Atomic Energy Agency (IAEA) publications (1995 and 1996). The 1996 publication, *ASCOT Guidelines Revised*, is detailed and gives a series of questions for evaluators to use when assessing safety. IAEA offers training on safety culture that includes a section on incident reporting an analysis. In this industry incident reporting is treated as a part of an organizational culture. Weick (1987) describes organizational culture as decentralized after being centralized. He says: " This is precisely what culture does. It creates a homogeneous set of assumptions and decision premises which, when they are invoked on a local and decentralized basis, preserve coordination and centralization." In IAEA's detailed set of organizational culture descriptions and performance standards a decentralized operation that uses centralized values is created.

Ives (1991) describes nuclear "near miss" reporting systems with which he is experienced. His example of a system where an established reporting mechanism was destroyed through a change in management demonstrates the necessity of management understanding and involvement in a reporting system. In his example high numbers of incident reports started to be used as a negative indicator of plant manager performance. The numbers of reports dropped to almost nothing and valuable preventative information was lost. The new management, in using reports as a rating tool, misinterpreted the nature and use of near miss reporting. Ives goes on to give other examples of the importance of near miss reporting in nuclear safety. Again, the concept of organization culture is evident in that a change in management disrupted a functioning culture by discarding established "premises and assumptions".

Reason (1988), when writing about Chernobyl, notes that poor dissemination of incident/near miss reports and/or ignoring such reports was one of the causes of that accident. From the literature, it is apparent that the nuclear industry makes incident/near miss reporting an integral part of its safety programs. In that industry, reporting and evaluating incidents/near misses allows learning from real experiences without the consequences of a disaster.

Within the United States nuclear industry, the Human Performance Evaluation System (HPES) is used (Harrison 1991). It was established and is administered by the Institute of Nuclear Power Operations. Nuclear plants in other countries participate. The system uses confidential reporting to a local contact who then forwards a report

and analysis to the Institute. The industry-wide feature of this program, had it been a part of the system describes by Ives, would have prevented the problem of management change affecting a reporting system's usefulness.

In Sweden there is extensive research with respect to human factors within the nuclear power industry. Incident reporting is an integrated part of safety programs and generally parallels the IAEA system design guidelines. There is ongoing research being carried out by several institutions. The different strategies being used by the different researchers means that more than one method is being studied. A more detailed description of incident reporting in Sweden thus risks leaving out most current work.

5. 5.2.5 Process industry

Use of near miss/incident reporting as a safety program element varies within the process industry. For example, the European Process Safety Center's (EPSC) work on safety program performance measurement edited by van Steen (1996) contains safety program descriptions from some contributors that make no reference to near miss/incident reporting. Then, there are descriptions from other contributors that treat the mechanism as an essential part of any effective processing industry safety program.

Overall industry interest in the practice is strong as evidenced by the publication of EPSC's guide and articles such as by Brazier (1994) in a publication for the processing industry. Brazier summarizes the results of a review of 13 different processing procedures and forms. In addition to material he collected from the processing industry, there descriptions from the nuclear and oil industries.

6. 5.2.6 Other

Articles and reports from Clarke (1998), Hallgren (1992), Harrison (1991), Menckel & Carter (1985a and 1985b), and Menckel et al. (1993) describe different programs in the oil, airline, baking, manufacturing, and medical care industries. Each program is structured differently. Hallgren's (1992) descriptions encompass the largest number of operations as he worked with companies from a wide range of Swedish industries. Thus his descriptions pertain to a large number of company programs.

With the exception of Harrison (who is proposing a program for the off shore oil industry), the articles describe systems that collect incident/near miss data over a limited period of time or from one interview/questionnaire. A committee analyzes reports or researchers prepare a summary. With this approach, there is always the possibility that more infrequently occurring events will not have taken place and consequently be omitted.

3. 5.3 **Terminology**

The terms *near miss* and *incident* have definitions that vary by the organization doing the defining. Seriousness of the event identified also varies. For example, nuclear incidents may be describing events that were close to a major disaster (Ives 1991) such as complete destruction of a plant whereas a medical incident might concern use of an outdated procedure during an emergency (Ramon Johnson, M.D., personal communication April 1998). Also, some systems classify an event as an incident/near

miss while others classify the same type of event as an accident (e.g., when on-site first aid was provided).

Certain industries tend to prefer one term to another. However, the preference is not exclusive. The two terms seem to be interchangeable and, for all intents and purposes, have the same meaning. However, because of industry preferences it may be advisable to establish common understanding of meaning in any communication with representatives from different industries. For example, different air transportation systems use *near miss* or *incident;* in contrast, the nuclear industry uses *incident* almost exclusively. If talking with representatives of both industries at the same time it would thus be prudent to establish common understanding of terms early on in communication. Brazier (1994) in reviewing the systems from 13 different companies notes that the different systems he was evaluating used the terms *accident*, *near-miss* and *incident*. When describing work with several hundred companies, Hallgren (1992) uses only the term *near accident*.

1. 5.3.1 Near miss

Harrison (1991) is recommending a confidential reporting system for the British offshore oil industry in his article about a reporting system. He describes *near miss* as "a near accident that could have involved a serious injury or has the potential for serious damage to property or the environment." From that definition, he appears to consider minor injury as possibly a near miss (e.g., no lost time is recorded and/or no treatment is provided by a medical professional).

2. 5.3.2 Incident reporting

The term *incident* is used by well-defined and established systems. In their article that describes the US aviation reporting system, O'Leary and Chappell (1996) use *incident*. Similarly, IAEA publications (1991, 1995 & 1996) use *incident* when describing the different parts of an effective organizational culture.

3. 5.3.3 Other

As noted earlier, Hallgren (1992) uses the term *near accident*. He takes his definition of the term from the deviation model developed at the Royal Institute of Technology (Kjellén, 1982 and 1996). He describes a near accident as "a course of events with a final phase but no injury phase." He does offer other definitions from the literature such as " a sudden event which could have resulted in personal injury," "a deviation with an obvious risk of injury," and "an accidental event which could have caused injury." He also includes examples of near accidents in "incident notebooks" that are part of the reporting system he describes. His reporting feature that has *near accidents* being recorded in an "incident notebook" thus includes the words *near miss* and *incident*.

Menckel and Carter (1985) and Carter and Menckel (1985) also use the term *near accident*. Definition is by description of some of the information recorded. Minor injuries not previously reported were also considered to be *near accidents*. Preference for the term *near accident* is strongest in Scandinavia.

4. 5.3.4 Definition for paper

For simplicity and brevity, *incident* will be used in the remainder of this document rather than any of the other terms described above.

4. 5.4 Literature describing reporting programs

1. 5.4.1 General descriptions

Content of literature describing incident reporting groups into three broad, overlapping areas: research reports, descriptions of one or more programs and general reference to incident reporting as a part of comprehensive safety programs. Common themes found in the literature surveyed include: the importance of confidentiality in programs that desire employee reporting of own errors, prompt action upon receipt of reports as a way to encourage reporting and feedback to the reporting community.

The number of articles written over the past 20 years is modest, particularly when compared with other topics within the field of safety. The literature that was available provided a paucity of detail with respect to the structure or design of incident reporting programs. Some articles were quite general. For example, Smith (1994) and Swartz (1994), while highly praising incident reporting as a safety program tool, offered little useful detail. Emphasis was on general quotes given by industry persons working with safety issues.

The book by van der Schaaf, Lucas and Hale (1991) is comprehensive and might, by itself, be used when designing an incident reporting program. Brazier's (1994) work compares and describes a number of company programs and is thus useful for its representative sample of program features. Many of the other articles consider one or more major points and are thus of some benefit when seeking to obtain an overall perspective.

No articles contained a statistical analysis of data that showed a decrease in accident rates after implementation of an incident reporting program. Anecdotal evidence was given in several to demonstrate that unsafe equipment or processes changed after review of incident reports. Thus, while those studying the topic or those using systems are supportive of incident reporting, there is no recent data that shows a significant reduction in accident/injury rates through incident reporting programs. A longitudinal study that collects measurable performance data does seem to be needed.

Contained on pages 7-10 is a table that summarizes literature specific to the topic of incident reporting. A total of 16 works are listed. Other material with information germane to incident reporting is listed in the reference section.

2. 5.4.2 Summary table

Table 1 – Summary of literature on incident reporting systems.

Author /date	Term(s) Used	Study or review	Description	Other
Brazier/1994	Near-miss (incidents include near-misses and accidents)	Study	Collected and analyzed near-miss reporting forms from 13 different companies in 4 industries. Describes types of data collected, reporting processes, and form designs. Describes typical uses of information collected. Confidentiality addressed.	Useful overview.
Carter & Menckel/ 1985	near-accident	Review	Report on Swedish research on near-accident reporting research. Studies used non-confidential interviews and a two to four week study/reporting period. Did not describe any of studies as showing that system reduced accident rates.	Appeared to use interviewing of workers as tool to record data. Not using confidential reporting system over long term.
Center for Chemical Process Safety/1994	near miss and incident	Review	Industry guidebook on safety in chemical processing industry. Mentions learning from near misses through an effective incident reporting system. Uses terms such as “blame culture” and “organizational learning” in connection with near miss reporting.	Closely follows Reason’s logic. Didn’t reference Reason.
Clarke/1998	Incident	Study	Questionnaire administered to British train drivers about their willingness to report hazardous incidents. Found that train driver were more willing to report certain types of hazards (usually of immediate danger) and also that willingness was influenced by perception of management attitudes towards safety/reporting.	Study on what workers said they would do rather than about what they did.

Author /date	Term(s) Used	Study or review	Description	Other
Hallgren/1992	near accident	Study	Large study involving several hundred Swedish industries. Uses a reporting pocket notebook that employees carry. Near accidents are written down and later given to supervisors. Used both in short-term campaigns and as a regular tool. Reports that changes in work due to reporting. Companies report accident reduction.	Largest study.
Harrison/1991	near miss and incident	Review	Paper on design of Confidential Human Factors Incident Reporting Schemes (CHFIRS) for the offshore oil industry. Describes typical system objectives, reviews existing systems in other industries, summarizes and makes recommendations for offshore oil industry.	Recommends a confidential reporting system. Notes maintaining confidentiality difficult. Notes alternatives such as group discussions of "hypothetical" events.
International Atomic energy Agency 1991/95/96	Incident	Guidelines	Three documents that contain safety guidelines for nuclear operations. Includes provision for near-miss reporting in any program. Gives guidelines for design of confidential system.	An overview of an industry standard.
Kirkwood/1997	near miss	Review	Emphasis of article is avoidance of legal liability under English legal system. Mentions using near miss reporting systems as one way to avoid liability by documenting efforts to identify and eliminate hazards.	Describes technique of "hindcasting" – imagining accident scenarios.
Kjellén/1983	near accident	Study	Part of a larger study of 6 company safety programs. Two had near accident reporting. Reports not confidential. Found to be positive although most reports about technical problems rather than human factors – researchers speculated that employees didn't report human error as frequently. No data but, felt to be positive. Felt that should be part of larger system and that companies studied could improve existing safety systems.	Recommended that confidentiality be included.

Author /date	Term(s) Used	Study or review	Description	Other
Menckel & Carter/1985	near-accident	Study	Part of a larger study on accident investigation at a bakery goods plant. In one unit researcher interviewed employees and administered a questionnaire about near accidents. Summarized and presented data to accident investigation group. Followed up. Observed change in attitude towards safety. Did not find reduction in accident rates.	Reporting depended on employee memory of events. Was not immediate recording after event. Study period was over two weeks. Employer elected not to continue system.
Menckel et al./1993	near-accident	Study	Two-week pilot study in long-term health care ward. Participants interviewed by researchers if had near-accident. Data collected daily. Researchers felt that data collected could be used as part of an accident prevention program. No data on accident reduction.	Study period short and probably not enough time to collect data on effect.
O'Leary & Chappell/1996	Incident	Review	Describes aviation industry programs. Gives examples. Useful description of functioning and effective programs.	Encourages confidentiality, impartial system & feedback.
Reason/1998	near miss or incident	Review	Article on safety culture. Review of many of Reason's ideas on organizational accidents. Introduces near miss/incident reporting as a feature of healthy organizational culture. Describes *a reporting culture* where employees can report errors without fear of punishment (uses the term a *just culture*). Distinguishes between errors and violations.	Narrative on difference between errors (not appropriate to discipline employee) and violations (appropriate to discipline employee) useful and complete.
Smith/1994	near miss or near-miss	Review	Quotes from safety directors of several US companies. Gives examples. No statistical analysis.	Gives brief descriptions of the features of some programs.

Author /date	Term(s) Used	Study or review	Description	Other
Swartz/1994	Incident	Review	Describes features of some US programs. Gives quotes. No statistical analysis.	Gives brief descriptions of some program elements.
van der Schaaf, Lucas & Hale/1991	near miss	Review	Book on near miss reporting systems. Includes work from several authors. Reason is among them. Only book on topic identified. Provides a useful overview.	Most comprehensive work reviewed on topic-area.

3. 5.4.3 Summary comment

Detail is omitted in the preceding table. Emphasis is on providing a general description that allows for a general comparison of content.

No consistent pattern with respect to incident reporting system content or format was identified. As mentioned in Section 5.4.1, a relatively small number of articles on the topic were identified. No statistical data was found in the literature that demonstrates a significant relationship between incident reporting and accident reduction. Anecdotal reports on programs such as the US aviation system run by NASA are, however, quite supportive and suggest that without incident reporting systems that accident rates would be much higher.

5. 5.5 **Information collected**

1. 5.5.1 Summary

Report content, review process and method of collection varied widely among the incident reporting systems described in the literature. As mentioned in the previous section, detail on any one system was not found in any one article. For example, articles about incident reporting over a limited time period describe how data was collected through interviews. Analysis was based on need and relevance as identified by the researchers and did not follow a set procedure. The one example of a form, a notebook developed by Hallgren (1992), was missing from the library copy that contains a description of that system.

On the following pages are tables summarizing article descriptions of data collected, processing of data and other relevant information.

2. 5.5.2 Summary tables

Table 2 – General Information (majority of material from Brazier, 1994)

Form Titles* *As is evident from form titles, definition of what is an incident varies from company to company.	• Personal injuries • Occupational disease • Property damage • Material loss • Process disruption • leaks of flammable or poisonous substances • fire or explosion • dangerous occurrences • environmental harm • near-misses • hazards
Person Completing Form* *Who completes a form and if more than one person must complete a report varies by company/organization.	• any worker involved in incident • any witness to incident • anyone injured by incident • anyone providing first-aid/medical treatment • the immediate supervisor • the supervisor of department where incident occurred
Form Design* *Most forms are a combination of multiple choice and written responses.	• Multiple choice • Written answers • Combination

Table 3 – Typical form content (majority of data from Brazier, 1994)

1	Personal Details* *Some of data listed here may be illegal to collect in some countries.	• Where person(s) normally works • Employer (reports by contractors & their employees) • Nationality • Date of birth • Occupation • Length of time in present assignment • Number of days works since last time off • Length of time worked before incident
2	Incident Description	• Date/time of incident • Work being performed at time of incident • Machines/equipment being used • Persons working in immediate area • Listing of permits issued • Supervisor • Environment/conditions that may have contributed
3	Training & experience of persons directly involved	
4	Other background material that may be required by an investigation	
5	Damages to property/equipment	
6	Injuries sustained	

Table 4 – Investigation and cause identification The structure of an investigation and subsequent cause identification varies. Factors that most often influence how an organization investigates and identifies are who investigates, management of confidentiality and how information is used.

Investigation • immediate supervisor • unit supervisor • safety officer • independent investigator - within company - outside of company	Types of data collected • events preceding incident • working conditions • contributory factors • hazards present • safety equipment/devices used • protective clothing worn • exact location of incident • procedures being followed • equipment failures or defects
Cause identification and summary Typical questions asked • any prior special instruction • job permits being used • any required permits omitted • procedures being followed • procedures adequate • underlying unsafe conditions • underlying unsafe acts	Typical areas of recommendation • new equipment needed • additional training needed • additional procedures needed • immediate changes needed • who is to follow-up • likely to happen again • potential severity • when changes to be completed

6. 5.6 Methods of collection

Methods of collection vary. Confidentiality and degree of importance the data is considered to have appears to dictate collection efficiency. While not providing statistical data, O'Leary and Chappell (1996) strongly feel that most affected by an incident complete an aviation incident report. They believe that this is so because: 1) the system is confidential and administered by an impartial third party and 2) summaries of incident reports are provided to the reporting population as a way to prevent similar, subsequent incidents. In contrast, Clarke (1998) when reporting on a study involving train drivers reports a return rate of 14% among one sub-group of subjects. This study was a short-term survey supported by the employer and did not include the feature of offering subsequent feedback to participants.

As described in Table 2, who completes and when a report is completed varies widely. Brazier's (1994) comment when describing design of incident reporting systems that "The lack of any standard procedures or guidance in publicly available literature has meant that companies have approached the subject differently" best summarizes system design. No consistent pattern of reporting was evident among the studies described in the literature.

7. 5.7 Means of collection

As with method of collection, the means of collection varied widely among the systems described in the literature. For example, Hallgren (1992) describes using a small report form contained in a booklet that fits into a shirt pocket. Workers complete the forms and place them into a collection box from which they are periodically removed for review by special or regular safety committees. The use of the forms may be part of a periodic campaign or be used on a regular basis. Alternate means of data collection include periodic interviews (Menckel et al. 1993), questionnaires (Clarke 1998), and an incident committee investigation (Menckel and Carter, 1985).

Irrespective of means of collection, is the importance of a high response rate. Reason (1998) emphasizes the importance of a complete record when seeking to design systems that are accident-resistant. Van der Schaaf (1991) stresses that incident reporting systems, to be effective, may only be used as a tool to measure an organization's safety performance. For example, including a discipline provision will immediately discourage participation.

8. 5.8 Confidentiality

As described previously, confidentiality, along with immediate feedback, is a key part of the incident reporting programs considered to be most successful. Where an operation is small, confidentiality may not be practical since the particulars of an incident report will also identify the reporting worker.

The concept of organizational culture, while recognized as an important part of all organizations (e.g., Mintzberg, Quinn and Ghoshal, 1998), gains greater importance in the context of incident reporting. Workers, in making a report of an incident, are less likely to fear discipline when they have observed that openness is valued over discipline for every deviation. Reason (1998) repeats this and offers the outline of a "just" system that workers can readily see is focused on improvement rather than punishment.

9. 5.9 Analysis/Use of Data

Throughout the literature surveyed, incident reporting data was described as a means to prevent more severe accidents and injuries. How that is to be accomplished varies. The absence of a uniform reporting format and wide circulation of data from reports prevents most communication between different organizations within the same industry (Brazier, 1994).

One author (Kirkwood, 1997), while encouraging reporting systems that don't fix blame, does emphasize that incident reporting is one way to avoid being charged with negligence in occupational injury/accident litigation.

Other literature reviewed encouraged using incident report findings to prevent serious accidents or injuries. How the data was used and analyzed varied almost by article. There does not seem to be consistent opinion as to the optimal way to use data. This may be partly because different types of operations have different types of risks and hazards. Management style and priorities may also be a factor (Kuusisto, 1996; Lucas, 1991;

Salminen, Saari, Saarela and Räsänen, 1993; Smith, Cohen, Cohen and Cleveland, 1978; Westrum 1993).

Van der Schaaf, Lucas and Hale (1991) stress the need to determine the intended use of an incident reporting system before designing and implementing a system. They list three possible purposes: system modeling, system monitoring, or motivation. Modeling being an understanding of system operation, particularly in unique or little understood areas. Monitoring being using incident reporting to determine how well a system is functioning. Motivation being the use of incident data to maintain a reasonable level of awareness despite the absence of serious accidents. In many cases, incident reporting systems fulfill some combination of these three purposes as most organization poses multiple and/or shifting needs.

10. 5.10 **Recommendations**

1. 5.10.1 First

In the survey of literature on incident reporting one article was identified that summarizes incident reporting systems (Brazier, 1994). The data was collected approximately 5 years ago and focuses on companies regulated by the British government's Health and Safety Executive. A survey that obtains data from a broader information base may provide a more complete and recent picture of incident reporting. Such a survey could obtain data from European, North American and multi-national companies. Results from such a survey could then be used to develop a system for testing as recommended in the second part.

2. 5.10.2 Second

The absence of statistical data that, for example, compares similar safety programs that have or don't have incident reporting systems does affect assessment of incident reporting systems. Smith, Cohen, Cohen and Cleveland (1978) when comparing high accident rate with similar low accident rate operations raise the question as to whether incident reporting can have a key role. They commented that both groups failed to analyze incidents; leaving open the issue of how much impact a well-organized incident reporting system might have on accident rates. Conversely, the American Institute of Chemical Engineers' Center for Chemical Process Safety book on preventing human error in process safety (1994) takes the opposite position on whether incident reporting is a valuable preventative tool. The book describes how the Three Mile Island disaster could have been avoided had information about a similar (but correctly managed) accident at the same type of plant been shared with the Three Mile Island plant operators. Finally, authors such as Hofmann, Jacobs and Landy (1995) in describing safety features within high reliability process industries seem to conclude that incident reporting systems may negatively impact safe work practices (their position being that any incident is a disaster in some industries). In sum, to more definitively prove or disprove the benefit of an incident reporting system comparison studies are needed. Several studies are recommended, as there are different types of incident reporting systems and assessment of each will provide a more complete picture. In incident reporting studies the following variables may benefit from study:

i. Confidentiality
ii. The influence of safety culture on report completeness
iii. Data collected
iv. Who completes reports
v. Investigation procedures

11. 5.11 Suggested program outline

Based upon comments and recommendations in support of incident reporting systems there are two designs that are immediately usable. One provides for confidentiality and assumes that the user organization is large enough so that identification of any worker making an incident report is unlikely. The second does not include a confidential reporting feature for organizations where confidentiality isn't desired or practical (i.e., a company is small).

1. 5.11.1 First Outline (confidential program)

Report Content:

- Detachable identification for follow-up questions by impartial reviewer (reporting person name, title and where may be contacted)
- Narrative description of incident – activity being performed, nature of incident and any other descriptor useful for analysis (e.g., procedure being followed, special equipment being used)
- Narrative description of problem causing incident
- Recommendations

Review/Analysis:

- A unit within the organization that is not responsible for enforcement of safety or personnel rules.
- A neutral entity outside of the organization such as an industry organization or academic institution

Action mechanism:

- Reporting system that provides management with data needed to make change
- Procedure for development and implementation of appropriate corrective action
- Publishing of investigation summaries and recommendation(s) so that all affected workers have prompt access to the information

Reporting form detail and design for flow of information would depend upon the industry/organization where the system is to be implemented. Tables 2 through 4 contain detail that may be added. Assumed is that the system would be continuously used rather than one where reporting would be for a limited period. This will avoid the possibility that serious, infrequent incidents are missed. The system developed for the United States Federal Aviation Administration and administered by the National Aeronautics and Space Administration as described by O'Leary and Chappell (1996) most closely matches the system described above.

2. 5.11.2 Second Outline (non-confidential)

Report content:

- Identification (reporting person name, title and where working)
- Narrative description of incident – activity being performed, nature of incident and any other descriptor useful for analysis (e.g., procedure being followed, special equipment being used)
- Narrative description of problem causing incident (may be supplemented with multiple-choice responses as appropriate)
- Recommendations

Review/Analysis:

- Immediate or unit supervisor
- Organization's safety officer or unit

Action mechanism:

- Reporting of review/analysis to management along with action taken or recommended action
- Noticing of review and action to workers during safety meetings, through postings of written summaries or both

This outline more closely follows models developed in Sweden as found in the literature review. Hallgren's (1992) model most closely fits this outline. In that model the worker completes a form that is placed into a collection box at the end of the day. While the report form may allow anonymity, the method of analysis (discussion during regular or special meetings) causes identification of the reporting individual to be possible in many companies. A similar model is described by Kjellén (1982) is lesser detail.

Models described by Menckel and Carter (1985), Carter and Menckel (1985) and Menckel et al. (1993) provide for interviews by researchers with reporting back to managers and supervisors. While confidentiality was not directly addressed, it was implied that by using an intermediary to collect data that identification of individual employees was unlikely. Thus, this method may be considered as lying between confidential and non-confidential reporting.

12. 5.12 **Summary**

The use of incident reporting as an integral part of an occupational safety system is not inconsistent with current research, standards and legislation. Harms-Ringdahl (1993), Kjellén (1982), Kjellén and Hovden (1993), and Menckel and Kullinger (1996) describe incident reporting when discussing safety systems and safety analysis. Other such as Guastello (1993) and Smith, Cohen, Cohen and Cleveland (1978) include incident reporting in their assessment of the different components of safety programs. The ISO 9000 series, while not specifically mentioning incident reporting, considers employee performance. When employee performance is related to uninterrupted production, all elements of safety are key elements of quality. An Arbetarskyddsstyrelsen (1994) publication also connects a Swedish safety ordinance to ISO provisions. Willkrans and Harlin-Sundin (1995) when writing about the affect of the same ordinance on small companies also raise the issue of incident reporting as a part of an overall safety program. Providing examples of effective, functioning incident reporting systems is the aviation

industry. On both sides of the Atlantic are examples of programs that workers in the airline industry view as effective, helpful and necessary.

Program structure/design options vary widely (possibly because incident reporting has not been as extensively researched as other areas of safety program design) from organization to organization. Aside from types of data collected, the most significant variable is whether or not reports are handled confidentially. The most common argument being that workers are reluctant to report their errors when their identity is likely to become know to managers and supervisors. Reporting to a neutral third party is the most common way to preserve confidentiality. The third party may be a separate unit within organization or a separate organization. In Sweden, the most commonly used neutral third party is an academic researcher who interviews workers, usually as part of a short-term project.

Understanding that there is a wide range of opinion as to incident reporting design and use is perhaps the most useful point identified in this literature survey. The absence of any one ideal system and realization that different circumstances/systems will dictate different design echoes this finding.

6 Safety Assessment/Inspection Systems

In this part methods that may be used to evaluate the effectiveness of safety programs/systems are reviewed. There is a large body of literature on this topic. One example of the number of different systems in use and being researched may be found in Hale and Hovden's (1998) review of organizational aspects of safety, health and environment. In that paper 34 "lines of research" are identified and described. Many of the research projects described include an assessment component. Self-assessment is a common feature in many safety programs (Toft and Reynolds, 1997).

In assessing safety within an organization there is a distinction between accidents involving individual workers and large accidents that might involve a unit or an entire plant. James Reason in the opening part of his book, *Managing the Risks of Organizational Accidents* (1997), makes a difference between accidents that happen to organizations and those that happen to individuals. He maintains that the nature of individual accidents has remained unchanged and that "organizational accidents are a product of recent times or, more specifically, a product of technological innovations which have radically altered the relationships between systems and their human elements" (p. 1). Reason goes on to state that an organizational accident breeches overlapping system "defenses"; another words, that a series of events (or actions) occur that result in a large-scale or organizational accident. With respect to an organization's overall safety system it may be seen that both individual and organizational accidents are the result of the breaching of defenses. Thus, when looking at safety systems and assessment of those systems it is more practical to treat individual accidents and organizational accidents as a combined threat. Risk that may be most efficiently managed by a single unified system rather than separately. For example, making certain that protective devices are in use and all workers are skilled in their use addresses individual and organizational risk simultaneously. In this example, absence of protective device defense(s) might result in an event that affects a single worker and does not disrupt work activity, or the result could be loss of control over a hazardous process or material with widespread consequences. In both extremes the "defense" was the same; the difference was in scale of outcome. This example does not seek to erase the distinction between individual and organizational accidents. Emphasis here is on the point that in literature reviewed there appeared to be a consensus of opinion that an effective safety system is one that seeks to manage *all* potential hazards. The same defense(s) can simultaneously manage the risk of individual or organizational accidents. Ridley's *Safety at Work* (1994) typifies the literature's treatment of this concept. The contributors in that book seek to provide a broad range of knowledge that can be used to manage individual and organizational risk.

Risk assessment or safety program assessment tools vary in complexity and composition. Engineering-oriented models may include mathematical constructs such as used by Papazoglou and Aneziris (1999) in their assessment of organizational and managerial factors affecting the safety of a chemical installation. Another assessment system, management oversight and risk tree (MORT), has been in use for over 2 decades

(Petersen, 1982; Hale and Hovden, 1998). This system is complex and time-consuming and is seldom used except when there is a need to analysis in depth.

A system developed in Sweden, SMORT (Kjellén and Tinmannsvik, 1989), that uses concepts from MORT is less time-consuming yet, retains many of the best features of MORT. The publication outlining SMORT (Kjellén and Tinmannsvik, 1989) includes a 30-page checklist for safety assessments. Libris lists 9 Swedish university and högskola libraries as having copies. SMORT, in addition to MORT, draws upon the occupational accident control deviation concept developed at the Occupation Accident Research Unit of the Royal Institute of Technology (Kjellén and Hovden, 1993). Use of SMORT (and other systems) is also described by Harm-Ringdahl (1993) in his book *Safety Analysis: Principals and Practice in Occupational Safety*. There is also a Swedish version of this work. Other systems of analysis, comparable to MORT, that includes use of a charting approach are being developed. Hale, Heming, Carthey & Kirwan (1997) of the Delft University Safety Science Group are in the process of evaluating application of their model.

A third approach is one developed by Alhemoud, Genaidy and Gunn (1997) that uses a questionnaire administered to workers for the assessment of safety program effectiveness. Ideally the questionnaire is completed individually by as many workers as possible within a work unit. A copy of that tool was obtained from the first author and may be found in Attachment I. This questionnaire has been used once in the field and would likely benefit from additional validation studies before being considered for placement into widespread use.

One assessment system that is in widespread use within the organization that funded its development is called Tripod Delta (Hudson et al., 1994). It is part of a multiple-system approach to safety described by its user, Shell, as extremely effective (Watts, 1999). The system, working within a framework, uses workers and supervisors to develop a list of assessment questions that are specific to a particular type of operation (e.g., an offshore drilling platform). Question development is by teams and requires training in relevant concepts before starting the development process. A computer system then selects some of the questions for use during a safety assessment. The questions are divided into 11 “General Fault Type” areas. These are: hardware, maintenance management, error-enforcing conditions, incompatible goals, communication, defenses, design, procedures, housekeeping, organization and training. There are approximately 20 questions from each of the 11 area for a total of approximately 220 questions. During a safety assessment of an operation the questions are answered by a team; some discussion may occur as a side-benefit of the questionnaire completion process. The completion process takes approximately 2 hours and responses are then transmitted to a central office for scoring. A profile that scores the 11 areas is generated and transmitted to management at the operation site. Managers are then required to analyze and determine what action is needed. (Hudson et al., 1994) While the system requires a significant initial investment of staff time, Shell feels that its use is more than justified in cost-avoidance savings. Shell plans on licensing the program for general use through authorized consultants (Watts, 1999).

A method frequently used by an organization's management in their assessment of safety programs and current risk is the accident rate (Petersen, 1982). In many operations raw accident data may not be enough to provide an accurate picture of safety program performance as rates may be so low as to provide insufficient information (van der Schaaf, 1991). In typical small operations the rate may be lower than the overall average (Johansson and Johansson, 1993). Reason (1997) points out that using accident rates as the primary measure of program performance omits infrequent events (that could have serious consequences) and minimizes risks present in modern technologies. The message evident in the literature is that accident data, while having considerable potential value, must be carefully analyzed. Patterns and types of injuries are likely to provide more important data than the total of all accidents (Ridley, 1994). Many of the assessment systems described previously in this part include accident and injury data as one part of a total assessment.

Kennedy and Kerwin (1997) describe safety culture, mentioned in a previous section, as being assessable by 13 different methods. They group the methods into 4 broad categories: a single quantitative score, scores in several categories that may be related to safety culture, identification of organizational problem areas and modeling/analysis of safety management system activities. A copy of a table by Kennedy and Kerwin that describes the 13 methods is included as Attachment II. The different methods, while assessing factors that is described in other literature as relating to safety culture must be interpreted and thus is open to misinterpretation (e.g., Horbury & Booth, 1996; Institute of Marine Engineers, 1998; International Atomic Energy Agency, 1995 & 1998; McDonald & Ryan, 1992; Reason, 1998a; Seppälä, 1997). Cooper (1998) references a system that is controlled and used by the consulting firm with which he is affiliated.

Industry or operation specific checklists are an assessment tool. These may either be developed internally, obtained from an outside source or be a combination of both. Usefulness will vary according to the skill and knowledge of those using the checklist. A copy of a list available through the Internet is included in Attachment III as an example. The example provided is general and was written for the North American economy. Other checklists that more exactly meet specific industries or conditions would likely be more effective than the example provided.

All of the systems described above require an investment of time and resources. Investment is necessary both for preparation and for actual site activities. This is typical of risk and safety management. Other systems reviewed during the literature search imposed similar time and resource requirements.

Existing Swedish and/or European Union legal requirements (e.g., ordinances, directives, regulations, rules or laws) place requirements upon organizations to have written safety programs and policies. The ability to demonstrate that the programs and polices are being used in an organization is also implied or stated. For example, the Council of the European Union Directive 96/082/EEC of 9 December 1996 (commonly referred to as the Seveso II Directive) describes the requirements for a system that will protect against

accidents involving dangerous substances. Complimenting the directive are semi-official documents that guide compliance with the Directive. Mitchison and Porter (1999), through the Institute for Informatics and Safety, have prepared guidelines for use by organizations during planning and preparation of the required systems, polices and procedures. For regulators, Papadakis and Porter (1999) have prepared a document that guides the "Competent Authorities" of member states on performance of required ongoing inspections and/or other measures of control. Thus, through the Seveso II Directive organizations and regulatory bodies have defined roles and responsibilities. Some of the assessment tools mentioned earlier in this section might be included in the hazard identification process required by Seveso II. For example SMORT (Kjellén and Tinmannsvik, 1989) or MORT (Petersen, 1982; Hale and Hovden, 1998) are effective for the identification of hazards and could be incorporated into required risk management activities.

One assessment system not mentioned earlier in this section, when used by trained professionals such as fire engineers or safety officers, does appear to have the potential to be a useful tool. Kuusisto (1966) describes it as "a preliminary method to identify the most urgent fields of activities to be improved" (p 781). It is an assessment system developed in the late 60's in the United States by Diekemper and Spartz (1970). Although developed several ago, the system continues to be valid and is periodically referenced in literature (e.g., Petersen, 1982; Mattila, Hyttinen & Rantanen, 1994). An advantage of this system is that the amount of time needed to complete the survey is lesser than with other systems. Kuusisto, when using the system, completed surveys in approximately 3 hours for each of the 6 operations surveyed in his study. The speed of completion is also a disadvantage in that serious problems can be missed both because the survey items are not detailed and the survey instrument is not industry specific. However, it does appear capable of identifying areas that would likely benefit from further attention. The survey includes interviewing organization management to assess their level of knowledge and understanding. Researchers such as Reason (1995a, 1998a) and Wilpert & Klumb (1993) emphasize the importance of management involvement in safety programs. That manager awareness and participation in safety positively affects worker perceptions and behaviors is described in a number of different ways within safety-related literature (e.g., Hendrick, 1994; Llory, 1997; Rundmo, Hestad & Ulleberg, 1998). Other possible variables that can influence worker safety perceptions such as housekeeping and cleanliness are assesses (Saari, 1997). The system developed by Diekemper and Spartz (1970) consists of a list of items divided into five categories:

- Organization and administration
- Industrial hazard control
- Fire control and industrial hygiene
- Supervisory participation, motivation and training
- Accident investigation, statistics and reporting procedures

Within each category are four to seven items that are scored. The minimum score is 0 and the maximum varies from 5 to 40. Each of the items is described in a separate list that may be referenced for guidance when assigning scores. Rating scores are calculated for each of the five categories and a total rating score may also be calculated. The scoring sheets have places for comments by reviewers. When the assessment is

completed it can be used in discussions with management and for planning improvements. Also, as mentioned before, identified problem areas can then be investigated in greater detail. In his comments about the tool, Kuusisto did caution that it was developed in the USA. Diekemper and Spartz's article appears to have been reviewed and possibly used by other staff of the Finnish Institute of Occupational Health. However, no English-language articles on its use in Finland were found. There are similarities between this system and the previously described Tripod Delta used by Shell. Both have categories. While there are more in the Shell system, similar descriptive wording is used in both. Recommended use of results is similar as both recommend management analysis of the results. The Shell system is being used in many different countries, this suggests that because of the similarities, the system developed by Diekemper and Spartz is usable in a number of different locations. A copy of Diekemper and Spartz's original article that describes and privdes the system may be found in Attachment IV.

Of all the assessment tools surveyed, the one developed by Diekemper and Spartz appears to offer the greatest potential for use here in Sweden. Its relative ease of completion within a reasonable period of time suggests that it might be a tool that regulators such as fire engineers and business employees could use in safety assessments. Some modification to meet Swedish conditions may be necessary. This would likely be best determined through surveying of fire engineers and encouraging their use of the modified survey.

7 Safety Programs

In Sweden all employers are required to have a safety program with specific features. That employers are required to provide a safe work environment has been required since before the turn of the century. Exactly what is required of employers has changed as a result of influences such as increased knowledge of hazards (e.g., awareness of chemical hazards) and events such as large-scale disasters or identification of an occupational disease. There are similar requirements in all countries in the world. Efficiency of enforcement varies with industrialized countries being the most active in the monitoring of employer compliance. For example, Sweden with its National Safety and Health Administration, Great Britain with its Health and Safety Executive and the United States with the Occupational Health and Safety Administration work closely with employers in making certain that there are healthy work environments. Thus, governmental requirements establish general conditions within which organizations have the latitude to use programs that reflect their working conditions and styles of operation.

Supporting employer efforts are research activities and informational reports that develop strategies and/or show how to comply with specific regulatory requirements (e.g., Arbetarskyddsstyrelsen, 1994; Johansson & Johansson, 1993; Kjellén, 1982; Swedish Work Environment Fund, 1994; Willkrans & Harlin-Sundin, 1995). Summaries of research activities describe a large number of studies and projects that offer a wide range of strategies for employers and/or regulators to draw upon when planning and operating safety program programs (Harms-Ringdahl et al., 1997; Menckel & Kullinger, 1996). Regulatory authorities are also able to draw upon studies that assesses effectiveness and/or efficiencies and suggest ways to enhance operations (e.g., Harms-Ringdahl & Ohlsson 1995). Other studies describe a design systems that seeks to minimize hazards (Kjellén, 1998). Already developed systems are available such as a safety program for small employers by Willkrans and Harlin-Sundin (1995) or Hallgren's (1992) near-accident reporting system. This broad range of approaches to safety and disaster prevention provides a range of choices that give managers the latitude to select a risk management strategy that most closely matches their and their organization's particular needs.

Are the programs able to meet governmental requirements plus prevent accidents ranging up to major disasters? Research and review reports are positive or take a neutral position by recommending further research (Emmett, 1996; Guastello,1993; Smith, Cohen, Cohen & Cleveland, 1978). Descriptions of individual programs cite decreased accident/injury rates as evidence of the effectiveness of the programs being used (e.g., Ball and Proctor, 1993; Hansen, 1994; Saari, 1988). These articles, and other literature not mentioned, do establish that there are any number of risk management programs that have the features necessary to reduce accident rates and prevent disasters.

Understanding and perceived value of safety is agreed upon among those working in the field of safety and disaster prevention. Management perception of the role of risk management in organizational operations is not as unanimous. Mintzberg, Quinn & Ghoshal (1998) in their book, *The Strategy Process: Revised European Edition*, do not

include safety or disaster prevention strategies in their descriptions corporate methods and techniques. In a sense, they are creating the impression that risk management is not a core element of profitable business operations. Jackson & Musselman (1984) in a basic text on business describe industrial accident prevention as follows:

> Research has been done to determine the causes of industrial accidents. The purpose has been to work out preventative procedures. The factors found to contribute to industrial accidents included the following:
>
> 1. Personal characteristics and attitudes of workers
> 2. Impersonal factors such as technical deficiencies in the work environment
>
> Personal deficiencies include lack of worker knowledge, improper attitudes, physical defects, and indifference to danger. Technical deficiencies include inadequate lighting and ventilation, poor design of equipment, improper materials-handling techniques, and ineffective safeguards on machinery. Four out of every five accidents are caused by personal rather than technical deficiencies. (p. 227)

Another part of the same section on safety says that one hidden cost of accidents is management time spent compiling information and reporting accidents. All of the descriptors used by Jackson & Musselman tend to give the impression that causes of industrial accidents and disasters are due to factors not readily controlled by management.

While many managers may perceive that accident and disaster causes are beyond their immediate ability to control this logic does seem to be in conflict with beliefs express by social psychologists. Elementary tests on social psychology that discuss leadership (what managers do) and conformity (what is expected of workers) can be used when considering risk management, safety and disaster prevention. Hogg and Vaughn (1998) describe conformity as a function of the individual's desire to follow the values of the group. In work settings safe behaviors can be considered as following group values; if the values of the group include thinking about safety and risk management when working. Leadership, the role of managers and supervisors, is described by Deaux, Dane & Wrightsman (1993) as the key dimensions of consideration and initiating structure. Consideration is characterized as the ability to communicate with group members. Initiating structure is defined as establishing organization, communication, and procedures. In research about establishing effective safety programs Rundmo (1996) reported that employee safety attitudes were partially influenced by management commitment and involvement. Commitment and involvement have elements that are comparable to consideration and initiating structure.

When the factors discussed in the preceding two paragraphs are compared a difference in the perceptions of the two groups (management authorities and safety experts/psychologists) is evident. Managers tend to view day-to-day risk management as beyond their control while safety experts/psychologists take the opposite view. A difference in attitudes between the two groups is not always present. Ball and Procter

(1993) in describing a successful safety program at a British steel company use wording that demonstrates that the managers of that organization include the dimensions of consideration and initiating structure. Leadership is exercised in a manner that has caused managers, supervisors and workers at all levels to view safety as being an integral part of operations. In more general terms, management's role in safety management is described as being crucial in eliciting behaviors needed to prevent accidents and disasters. Reason, Parker & Lawton (1998) treat management influence as more important than rules or procedures in encouraging workers to view safety as within their immediate control.

Helping managers to analyze accident causation through assessments of accidents and training is described by DeJoy (1994) as a strategy in disaster and accident management. Hallgren (1996), in writing about the prevention of industrial accidents, views Swedish labor laws as having a positive influence organizational safety. He describes requirements for safety programs that involve workers in safety planning and assessment; features that encourage communication between all levels of an industrial operation. Further research in safety management approaches is encouraged by Harms-Ringdahl (1997) through questions such as how day-to-day management is related to safety issues.

Available to employers is a smörgåsbord of safety programs and approaches. All having the potential to be effective. The key to safety program success is as described by Reason (1990a & b) is in the control of "resident pathogens" that lie dormant until causing organizational accidents. The term "resident pathogens" is his description of decisions made at higher levels in an organization. Decisions that create conditions that permit breaching of defenses designed to prevent accidents and disasters. With some variations in wording, Reason repeats this theme in his books and articles (e.g., 1991, 1993, 1997, 1998). His conclusions have been identified and described in a number of ways by others (e.g., Cooper, 1998; Glendon & McKenna, 1995; Hoffman, Jacobs & Landy, 1995; International Atomic Energy Agency, 1996; Kirwan, 1994; Paté-Cornell, 1993; Rundmo, Hestad & Ulleberg, 1998; Tallberg & Mattila, 1994; Wagenaar, Hudson & Reason, 1990). In his 1997 book on organizational disasters Reason goes on to say that even the safest organization is vulnerable to accidents and disasters. He describes an organization's safety program as moving within a "safety space" that is high-safety at one end and low-safety. The movement the result of change through influencing factors such as new technologies or procedures. Each change having potential influence on the location of the organization in the safety space. The resident pathogens mentioned earlier growing or increasing in number with the changes and with the effort made to detect and remove these potential threats to safety. His primary point being that just as an organization must continually assess its business strategies to remain competitive it must do the same with its safety strategies (programs). Reason describes how it is more difficult for an organization's management to remain focused on safety issues as it is a system that measures success by absence rather than by presence (e.g., profits).

Although managers of modern organizations are faced with innumerable demands upon their time it would also appear that one more demand is imposed. The demand that safety programs and systems be a regular part of their schedule. Their investment of time

will likely be repaid through time saved. Time that would have been required in the event of large-scale accidents or disasters.

8 Conclusions

1. The first conclusion concerns trial use of incident reporting systems. Incident reporting systems collect data on near accidents for use in prevention planning. This type of data is seen as useful as there are many more near accidents than actual accidents; yet the dynamics of the two are similar enough that comparison can have constructive outcome in identifying needed safe practices without the penalty of an actual accident. On pages 23 and 24 are descriptions of two types of incident reporting systems whose trial use is suggested. One uses confidentially collected reports and the other reports where the identity of the reporting person may be know by all in an organization. Variations of both types are also mentioned. In using both systems on a trial basis, data on how effective each system can be in reducing accident frequency can be collected. When testing both systems observations may also be made on the nature of data to be collected, design of reporting forms and design of systems. This will help to foster the development of standardized systems for better comparison of data. Comparable organizations will need to be used so that variables are controlled. This recommended research would draw upon previous Scandinavian research in this area.

2. A check list for safety system and program assessment developed by Diekemper & Spartz (1970) is described in Section 6 starting on page 26. The system can be used by fire engineers and company personnel to assess a site or organization safety program within a relatively short period of time. The results are structured as to allow discussion of results and for use as a planning tool for improvements. The system would benefit from revision to reflect Swedish safety needs and priorities. Revision may be carried out through the use of focus groups (fire engineers and/or company safety professionals) to develop a draft revision. The revised version could then be field-tested and results analyzed through a case-study.

3. Section 7 on safety programs mentions a wide range of programs and systems that may be used in developing, assessing and monitoring programs for accident and disaster prevention. While approaches, methods and design may vary without affect the desired goal: risk management and prevention. The variable that was most often identified as having the greatest influence upon successful outcome is active participation by management of all levels in safety/risk management programs. Exercising leadership has the effect of influencing positively influencing attitudes and behaviors at all lower level in an organization. In some of the studies reviewed the failure in a program to reduce accidents was attributed to the lack of management knowledge, participation and/or ongoing commitment. Suggested is an educational intervention designed to give managers the knowledge needed to be involved on an ongoing basis. Education of future managers is seen as an effective point of intervention. Seen is that those starting as managers will be more likely to develop and maintain knowledgeable involvement in safety than those already working as managers. Development of a course in safety for business programs such as MBA programs is suggested. The strategy being that this group will be in the best position to integrate safety skills in with all other skills being acquired. A second approach

will be to offer similar courses to current managers as part of business seminars that are currently offered. A case-study could assess whether there are changes in attitudes.

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