A Survey of Foreign Hazardous Materials Transportation Safety Research Since 1978

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ABSTRACT

Recent hazardous materials transportation research outside the United States and Canada is surveyed. The survey is limited to truck, rail, and air transportation and is based on publications within the past 5 years. Specific areas of research include vehicle and container technology, emergency response technology, traffic flow and accident information, risk assessment, and policy analysis regarding operations, emergency planning, and regulations. The results of computer searches and surveys of journals and periodicals are summarized, and references are included.

Safety in hazardous materials transportation is a subject of serious concern both to the industries involved and to the general public. Large-scale incidents such as the Spanish campsite disaster in 1978 when more than 200 people were killed by the explosion of a liquified petroleum gas tanker (1) have focused international attention on the gravity and importance of safety in the transport of hazardous materials. Although the subject has been extensively researched within the United States and Canada, quite a bit of work has also been done by other nations. If there is to be success in preventing or controlling incidents that not only endanger the public but also cost millions of dollars for cleanup and lost revenue, collective resources must be pooled. Thus it is the purpose of this study to survey the current developments outside the United States and Canada and to provide a bibliography of the literature that represents the thrust of the international community's approach to safety in hazardous materials transportation.

SCOPE

In the interests of being current, the survey is limited to truck, rail, and air transportation safety research conducted during the last 5 years. Topics such as pipelines, nuclear materials, hazardous waste, and marine transportation safety have such exclusive problems and extensive bibliographies that they were considered to be beyond the scope of the survey, to be addressed separately. Specific subtopics surveyed include vehicle and container technology, emergency response technology (including communications and containment), information (including traffic flow estimation and accident reporting), risk assessment, and policy analysis (including operations, emergency planning, and regulations). Release behavior and hazardous materials codes and classifications were generally excluded from the survey as topics too specific and technical for this broad overview of foreign developments.

APPROACH

A search of the Highway Research Information Service (HRIS) data base identified numerous monographs, conference proceedings, and technical reports that satisfied the criteria for inclusion in this survey. A Library of Congress search identified some additional documents. In addition, the appropriate issues of the following journals and periodicals were searched for pertinent articles: Accident Analysis and Prevention, Hazardous Cargo Bulletin, Hazardous Materials Intelligence Report, Hazardous Materials Management Journal, Hazardous Materials Newsletter, Journal of Hazardous Materials, Risk Analysis, and Transportation Research.

As expected, most of the published research originated in Great Britain, the Netherlands, and Sweden. However, Australia, Belgium, France, Italy, Spain, South Africa, and West Germany also published research that was included in the survey. Austria, East Germany, Finland, New Zealand, and the USSR experienced new developments in hazardous materials transportation safety that were reported in the literature. These articles were also included in the survey.

SUMMARY

A brief outline of the nature of the surveyed articles and papers and a complete bibliography follow.

Vehicle and Container Technology

The papers in which vehicle and tanker technology was discussed unanimously stress the need for improved construction to prevent puncture, allow pressure relief, and the like. The literature also stresses the importance of legislation in encouraging industry to exploit the latest advances in technology. The costs associated with replacing or improving older vehicles (tankers) may prove prohibitive in the face of competition. Careful legislation could provide the needed incentive.

H.G. Stinton of the Hampshire Fire Brigade Headquarters, Eastleigh, Great Britain, discusses the need for improved container design and legislative control in a report on the Spanish campsite disaster (1). He stresses that such an incident could have occurred in England. The circumstances surrounding the Spanish disaster were not particularly unique: A typical tanker carrying liquified petroleum gas (LPG) was traveling over main roads on a hot summer day. British tankers of similar construction would carry the same materials over comparable roads. British and Spanish regulations governing LPG transportation were also similar.

Stinton explores the lessons that should be learned from this disaster to avert future similar tragedies. He describes the various causes of the disaster: "The road vehicle was without a pressure relief valve, ...the road vehicle was over-loaded, ...corrosion had taken place in the high tensile steel tank due to carrying ammonia [and] ...the high ambient temperature, ...the road vehicle was without a current pressure test certificate." Stinton also points out that the tanker's lack of external impact protection contributed to the rupture. Although the safety record for LPG transport in the United Kingdom is fairly good, Stinton stresses that to be confident of avoiding such disasters, it is crucial to ensure that tankers carrying LPG products "are more adequately protected against impact than they are at present."

C. Swinbank discusses the use of intermediate bulk containers (IBCs) for the transport of hazardous materials (2). Because of the economy of their intermediate size, their application to the carriage of dangerous goods has recently attracted attention. Swinbank reports on initial studies regarding IBC use, which focus on establishing a definition of an IBC. He points out that IBCs carrying hazardous materials cannot properly be categorized as packages (per United Nations guidelines), portable tanks [per Intergovernmental Maritime Consultative Organization (IMCO) and the British Blue Book], or tank containers [per Reglement International Concernant le Transport des Marchandises Dangereuses (RID) and Accord Dangereuse Routier (ADR)]. "The United Nations Committee of Experts will need to determine whether IBCs can be recognized as a separate class of receptacle, and the constructional and/or test requirements which are necessary to ensure safety in transport and use." Swinbank emphasizes the considerable economic and technical significance of this UN work to manufacturers and users of IBCs worldwide.

The proceedings of three major conferences include papers that address the issues associated with vehicle and container technology. D.A. Beattie, at an October 1978 conference organized by Oyez International Business Communications (3), presented a paper describing tanker design as a compromise between several conflicting parameters. In a review of the conference published in the Hazardous Cargo Bulletin (4), the reviewer stresses that these compromises demonstrate that technology is not 100 percent foolproof in hazardous materials transportation. He emphasizes that the community must accept this fact and offers examples of the inherent uncertainty by quoting Beattie: "Transverse baffles will also ameliorate to some extent the side-to-side surges that can occur, [and] rubber (tank) linings may be adversely affected by switching products." The reviewer concludes these remarks on a rather pessimistic note: "Should it prove possible to replace these doubts with assurances, other problems will probably take their place."

The design of road vehicles and tankers was also addressed during the Symposium on the Transport of Hazardous Materials held in London in December 1977 (5,6). The papers delve into the complexities of recovery of damaged tankers as well as the need for improved analysis of incident reports as they relate to tanker design performance. The relatively low incidence of tank ruptures compared with the number of tanker journeys could have as much to do with safe driving practices as with impact-resistant tanker designs. Better analysis of incident reports would clarify the causes and help lead to truly improved tanker designs.

Finally, the Spring Conference on the Transport and Handling of Dangerous Goods held in Sweden in April 1978 included a number of papers in which vehicle technology was discussed (7). M. Lidstroem presented a discussion of the maneuverability and dynamics of heavy vehicles, and Y. Dagel, C. Lager, H.G. Linder, and L. Lindberg et al. offered views on the packing of dangerous goods.

Emergency Response Technology and Information

A number of different articles discuss what appears to be the key element to effective emergency response: an easily accessible and comprehensive identification and hazard information system. The implementation of such a system was hailed as a great advance at the Symposium on the Transport of Hazardous Materials (5,6). However, the development of a comprehensive international system incorporating both action and properties codes is identified as an ultimate goal. An information system approaching this goal is the BTK system developed in Belgium and described in the Hazardous Cargo Bulletin (8). The most outstanding feature of the BTK is that the code is structured to allow requests for information to be dispatched in Dutch, French, English, or German. Italian and Spanish will be added shortly, and additional capacity is provided to handle two more languages for a total of eight. The information is accessed by UN number, product name, or by internal BIG-number, and the computer returns with the corresponding Hazchem code. The operator can then select from 10 different program modules: type of hazard, emergency action, personal protection, properties, first aid, general precautions, remarks, experts, literature, and synonyms. Belgium thus has a multilingual computer-aided data system to help cope with hazardous materials incidents.

In "Son of Hazfile" (9) a microcomputer-based successor to the U.K. chemical emergency response computer data bank Hazfile is described. Called CHEMDATA, it is designed for use by U.K. fire brigades. The role of CHEMDATA is to supplement immediate emergency response guidance with comprehensive information on hazards, protection, and procedures. The system has been made more user friendly than Hazfile by building in easier commands and guidance messages and by reorienting data around the products rather than the manufacturer. In addition, after the initial hardware investment (microcomputer, disk drives, and printer) the operating costs will be minimal, making CHEMDATA more cost effective than Hazfile. The evolution of the various information systems available to the British fire services was also discussed at the Transchem 82 in Middlesborough, England, held June 2-3, 1982 (10).

Some practical procedural aspects of emergency response are described by H.G. Stinton in the Hazardous Cargo Bulletin (11). He discusses the correct response to averting and coping with flammable liquids, boiling liquid expanding vapor explosions (BLEVEs), and unconfined vapor cloud explosions (UVCEs). Stinton provides a technical discussion about the conditions that cause BLEVEs and UVCEs, and the disastrous effects of these phenomena, citing the Spanish campsite disaster as an example. He lists recommendations for emergency service response to incidents that could culminate with a liquid gas explosion, with particular emphasis on procedures for highly populated areas. Stinton discusses evacuation, fire control, crowd control, and the need for clearly defined roles for the various authorities who become involved in emergency response. He stresses that swift and proper response are the keys to averting disasters like the Spanish campfire incident.

In "Backing up the Hardware" (12) the labeling and other regulations on hazardous materials transport enforced on New Zealand Railways (NZR) to protect railway workers and ensure quick response in the event of an emergency are described. Despite its relatively small population, New Zealand operates an extensive network of railways. NZR builds its own rolling stock, including tanks for such hazardous materials as LPG, CO_2, and chlorine gas. Placards with hazard warning labels and emergency procedure guides are placed on both sides of all tank cars. Destination cards are placed at the ends of these cars, and consignment documentation requirements are designed to ensure that all of those concerned with the physical handling of the cars and their contents are aware of the hazardous nature of the cargo. Cars containing hazardous cargo may not be conveyed as part of express trains and must be segregated from the locomotive, guard's van, and cars containing other classes of hazardous goods for safety.

B. Gandham and P.J. Hills examine the feasibility of monitoring the movement of vehicles carrying hazardous substances over British roads (13). They discuss various methods of monitoring the movement of vehicles carrying hazardous freight, including radiolocation techniques, proximity-to-fixed-objects methods, and the dead-reckoning technique. The emergency services, local authorities, and the chemical industry contributed to determining the benefits of a monitoring system in general, and the costs versus benefits of such methods are discussed. The primary benefit of such monitoring would be the virtually instantaneous notification of the emergency services in the event of an accident. The decrease in response time this would represent could be crucial to the ability of the fire brigades to avert disaster. However, the cost of such a system would probably not justify even this benefit; the conclusion is that the money would be better spent on improving existing prevention schemes.

Risk Assessment

An underlying concern in the literature on risk assessment in hazardous materials transportation is the emotional public response elicited by hazardous materials transportation issues. Despite the relative safety of hazardous materials transportation (versus overall traffic statistics), the potential for disaster arouses significant public concern and attention. In addition, social, economic, and technological development have led to both an increase in hazardous materials traffic and increased load sizes. Thus a technological approach to hazard control and risk assessment is necessary. This was the theme of the October 1978 Oyez International Business Communications conference on managing the risks caused by the carriage of hazardous goods over land (3,4). Papers included a discussion by L.S. Fryer regarding the risk to the public from the transport of dangerous goods and the effect of accidents on the community, a paper by D.H. Napier that dealt with BLEVEs and techniques for minimizing hazards and achieving a fuller assessment of risk, and a paper by D.H. Slater that attempted to quantify the risks involved with hazardous materials transportation and the costs when accidents occur.

M. Benwell addressed the public perception and acceptance of risk at Transchem 81, held in Middlesborough, England, May 27-28, 1981 (14). Benwell pointed out that despite the relevance of public opinion toward decisions made to enhance public safety, little research has been done to predict public response to such decisions. She also stressed that public response is often irrational: The public expects the benefits of hazardous materials but may be unwilling to accept the risks associated with their transportation. Although the public may object that they are kept in ignorance of the risks they face, Benwell observed that programs for public education often cause alarm rather than lessen it. She contended that significant benefits could be achieved both for those engaged in the movement of hazardous materials and for the public if some concerted effort were made to help the public understand the actual risks associated with hazardous materials transportation.

At Transchem 82 (10) Somerhoff of the Hamburg Fire Department suggested that difficulties encountered by emergency services could be remedied if a systematic investigation of transport risks were conducted before the transport of hazardous goods and if all those involved with the transport were made to understand the risks at the outset. This, he contended, would significantly facilitate proper emergency response in the event that it were needed.

T.B. Meslin (15) discusses the specific risks involved with chlorine transport in France within the framework of a general model for evaluating risks associated with the transport of dangerous materials.

> Stated simply, the problem is to evaluate the number of accidental releases that could occur during transport of a product under a number of conditions, as well as the range of possible consequences. Consequences are measured by using such deliberately simplified indicators as the number of victims (death, injuries, and illnesses), which permit a synthetic evaluation of risk. Each protection measure under study is assigned a risk level. The overall cost of the various protection policies is calculated, so that it is possible to compare them and select the most cost effective, that is the one that presents the most satisfactory compromise between risk reduction and the increased cost of protection.

Because so few data are available that describe the causes and dynamics of accidents, an analysis of probabilities cannot be based on direct observation. Thus indirect models are used to simulate accidents. Meslin describes the process by which an assessment of the risks involved with any specific means of transporting any particular hazardous material can be made. He contends that it is possible with current technology to make rational choices concerning dangerous activities and institute measures to reduce the risk to the public.

Additional discussions of risk assessment appearing in the literature include papers by P.N. Anderson (16), who discusses means for assessing the risks associated with the handling and transport of hazardous chemicals, and by De Malherbe et al. (17), who discuss hazard identification, hazard analysis, risk analysis, and safety measures designed to reduce hazards. De Malherbe et al. also provide an introduction to the system analysis methodology of risk analysis.

Policy Analysis

A great number of papers have been written about the general topics that fall under the heading of policy analysis. Several have been published in which the regulation of hazardous materials transportation within a particular country and attempts to explain those regulations and compare them with international standards have been discussed. The significance of these is the diversity of their origins. It is clear that the regulation of hazardous materials transportation is internationally recognized as deserving public and government attention.

A paper from Sweden (18) outlines the principles behind the various international directives for safer transport of dangerous goods. Directives from the different sources are compared with regard to their being combined into a single international set of standards in the future. In addition, the Swedish system for internal transport of hazardous materials is discussed. H. Frostling, from Sweden, also discusses and compares the national and international regulations governing hazardous materials transportation (19).

The developments in technical regulations regarding the transport of new hazardous materials are discussed by G. Dobias et al. (20), from France. The regulations are updated by the Interministerial Committee for Transport of Dangerous Materials, whose charter is explained. Regulations and developments covering such diverse aspects of hazardous materials transportation as vehicle design, road routing, and professional training are also recounted.

J.C. Hillman discusses the need for increased regulation governing hazardous materials transportation in South Africa (21). Hillman examines the factors that could increase the likelihood that an accident would occur and makes recommendations as to how the dangers can be minimized through emergency response preparedness. He also discusses the merits of forthcoming new regulations and examines both the advantages of good regulation and the disadvantages of restrictive legislation.

The implications of national Dutch legislation for local municipal authorities are the subject of a paper by A.G. Kaag-Vanrp (22), who includes discussions of loading and delivery of dangerous materials; road, water, and rail routing; and emergency response.

Specific national regulations for the transport of hazardous materials by road are described in a Spanish paper (23), and the Italian regulations regarding road transport of hazardous materials are recounted by V. Rocco (24).

Numerous conference proceedings have been published that address policy issues associated with hazardous materials transportation. The proceedings of the Symposium on Transport of Hazardous Materials (5,6) includes discussions of routing of hazardous loads and lessons to be learned from incidents involving hazardous materials. The benefits to be gained from rerouting hazardous goods through rural rather than populated urban areas are enumerated. However, the point is made that expert advice in the event of an incident can be far from rural sites, whereas it may be immediately available in more populated areas.

The proceedings of the Conference on Chemical Distribution into the 80's (25) includes papers on a variety of policy issues. J.H. Locke offered a paper discussing the regulations and codes, K.L. Holland presented a paper on the role of the fire service in transportation of chemicals by road, vehicle labeling was discussed by P.N. Anderson, the selection and training of drivers for the handling of hazardous substances was described by H.J. Morley, and P.T. Mabbitt discussed the status of national and international regulations concerning the transport of dangerous goods by rail.

A broad variety of policy issues, from general regulations on transport of dangerous goods by A. Lindstedt to A. Hoengstroem's discussion of insurance matters in connection with handling and transport of dangerous goods, were presented at the Swedish Spring Conference on the Transport and Handling of Dangerous Goods (7). Other papers include a discussion of Swedish and international directions on transport of dangerous goods by rail, road, sea, and air by M. Baang et al.; a presentation of the views on packing of dangerous goods by L. Lindberg et al.; and an overview of the experiences of the fire services, the Swedish Board of Occupational Safety and Health, and the police on transport of dangerous goods by G. Schnell et al.

Australian policy regarding hazardous materials transportation was the theme of the National Seminar on the Transport of Dangerous Goods in Canberra (26). J.F. Wilding and I.E. Kolm both presented papers on the transport of dangerous goods in Australia, regulation was discussed by P. Brazil and R.P. Sammon and by H. Blackmore, and G.C. Uniacke offered views of the road transport industry.

In a number of papers presented at Transchem 79, the Sixth Symposium on the Safe Transportation of Hazardous Substances (27), various policy issues associated with hazardous materials transport are discussed. Some papers of unusual interest were ones on first aid and medical aspects by A.P. Wright, recovery of damaged chemical tankers by W.E. Clayton, and the role of the highway authority by M.R. Hilton. Transchem 81 (May 27-28, 1981) (14) and Transchem 82 (June 2-3, 1982) (10) also included interesting discussions of hazardous materials transportation regulations and public policy.

H.G. Stinton (1) examines some specific aspects of policy that should be addressed in the light of the Spanish campsite incident. The safest routing of vehicles carrying hazardous materials, the danger associated with transport of hazardous materials over roads through areas with dense holiday populations, and other issues associated with the medical response to such disasters are specified. Stinton places particular emphasis on the need for improved regulation: "Any preventive steps which are taken will only be truly effective if backed by legislation rather than voluntary agreement. Obviously any such legislation should be valid across Europe and not simply an internal measure in the United Kingdom."

Several countries have legislated new regulations restricting hazardous materials transportation, as reported in the literature. Both France and Austria have imposed restrictions that prevent the transport of specified hazardous materials through certain tunnels, for example, the French Prefectoral Decree 3302 of December 20, 1980, which includes regulations limiting access to the Mont Blanc tunnel on the French-Swiss border, and Austrian regulations limiting access to specified portions of the Arlberg Expressway, the Tavern Motorway, and the Flebertavern Road, including several tunnels (28). The regulations include limiting access during specific hours of the day as well as bans on the transport of certain hazardous materials.

New requirements imposed by the German Democratic Republic for the movement of hazardous goods into or through East Germany are described in the Hazardous Cargo Bulletin (29). Registration of and the provision of escorts for 80 hazardous substances are required, and the specified information must be provided up to 4 working days in advance. The regulations specify requirements for transport of hazardous materials both by road and by rail.

Finally, a Finnish study conducted on the transit traffic of Russian railway tank cars carrying hazardous cargos into and through Finland is reported in the Hazardous Cargo Bulletin (30). The study was conducted in response to the rapidly expanding flow of Russian railway tank cars carrying chemical and petroleum products through Finland. The greatest threat this traffic posed to public safety was identified as the poorly maintained state of some of the tank cars and the occasional congestion of the system at certain stations for extended periods of time. As a result of the study, specific inspection regulations have been instituted. The number of tank cars allowed in the system at one time has been limited by additional new regulations.

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